From: Eric Cole <Eric_Cole@fws.gov>
To: eplayser@silverstar.com
Cc: Steve_Kallin@fws.gov; Paul_Santavy@fws.gov; Doug.Brimeyer@wgf.state.wy.us
Subject: Response to Earle Layser elk hunting email
Date: Tuesday, November 22, 2011 10:41:05 AM

Dear Mr. Layser,

I recently received your email dated 11/12/11 concerning the lack of elk on the National Elk Refuge and apparent loss of hunter opportunity. I agree with you that migration patterns have changed since the south unit hunt was instituted in 2007, but overall, that change has not resulted in a reduction in hunter opportunity or harvest. As you correctly note, the number of elk occupying the south end of the refuge during the fall period has declined since 2007 (average of 4,000 during mid-november prior to 2007, and average of 900 during mid-november since 2007). Tracking of radio collared elk suggests that in most years the reduction in elk numbers on the south end of the refuge since 2007 has been the result of elk being pushed by south unit hunters into adjacent open hunt areas. In short, elk are still coming to the refuge, but they are not staying as long. There is also evidence that this movement pattern has resulted in higher harvest levels, not less. For example in 2010, 3 years since the institution of the south unit hunt, we had one of the highest elk harvests on NER ever documented. 2011 has been "remarkable" because the migration of elk and bison to the refuge has been delayed. My annual forage measurements, snow observations, and monitoring of collared elk suggest that the 2011 late migration has been the result of high forage production off the refuge on summer and transitional range, and until last week, lack of snow covering that forage up. Recent elk and bison movements to the refuge since the weather has changed seems to confirm that assertion.

In the future, changing open hunt areas and being more creative to achieve desired harvest levels may indeed be necessary. This is one of the main reasons that I intensively monitor elk movement patterns using radio and GPS collars. So far at least, we are happy with the results of the south unit hunt. Disturbing elk off the south end of the refuge, and conserving forage on the refuge for when it is more critically needed later in the winter will continue to be our strategy for the foreseeable future.

Thank you for your comments,

Eric Cole, Refuge Biologist

USFWS National Elk Refuge

P.O. Box 510

Jackson, WY 83001

Phone: (307) 733-9212 ext 7

Fax: (307) 733-9729Hello Eric --I disagree that it is "remarkable" that no elk are on the refuge at this date. Where are they safe from hunters pursuing them except at the extreme farthest end of the refuge immediately next to Jackson? It is not necessarily "snow cover" that is the reason for no elk on the refuge. Since the relatively recent 2007 change in allowing hunting on the southern-end of the refuge and intensified bison hunting, the pattern and timing of elk

migration onto the refuge has, in my observations, changed. The south-end hunting has resulted in disruption of a migration pattern that had developed over decades. I've hunted elk in-and-around Jackson since the 1970s, particulary in Area 75 and on the refuge. I can definitely tell you from my experience, the recent changes in the hunt area on the refuge and bison hunting has impacted elk migration timing. Yes, obviously, it keeps elk (and bison) from early use of the refuge's forage, but conversely, in my opinion, it has actually reduced opportunities for elk harvest. There is a daily picket line of bison hunters along the Gros Ventre River on the refuge blocking them, and when elk do come through onto the refuge (mostly at night now or up and around from the Natl Forest), there is no safe zone for them anymore (I've seen them huddling in large numbers around the buildings and homes); they are generally run back off the refuge. Which do you want: To "cull parts of the JH elk herd" or to "preserve forage" and reduce feeding costs? Doing both simultaneously requires more creativity than is currently being shown. The elk and bison are not stupid. The manner in which the hunt(s) are now conducted has, in my opinion, had the effect of reducing harvests. If you are growing more forage, as stated in the article, then it's time also to examine what effects the bison and south-end hunting has had on elkpopulation management, too. There's no incentive for elk to come onto the refuge while they are intensively pursued there, even if you have more forage available. If indeed there is more forage, why run them off of it? In the past, the forage and safe-zone had the affect of drawing the elk in; not anymore, not until the hunters clear out.Sincerely, Earle Layser

From: Steve Kallin <Steve_Kallin@fws.gov>
To: Dean_Rundle@fws.gov
Subject: Fw: 2/16/2012 National Elk Refuge Biological Update
Date: Thursday, February 16, 2012 2:07:25 PM

Quick follow-up to our conversation yesterday. The two hunting zones which impact the early elk season for the northern elk herd segments of concern, were converted to "branch antlered" bull only seasons the past two years.

Take care,

Steve Kallin

Project Leader

National Elk Refuge

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Jackson, WY 83001

Phone: (307) 733-9212, extension 2

Fax: (307) 733-9729

steve_kallin@fws.gov

Celebrating a Century: 1912-2012----- Forwarded by Steve Kallin/R6/FWS/DOI on 02/16/2012 01:04 PM -----

Eric Cole/R6/FWS/DOI02/16/2012 11:52 AM

To Barbara.Long@wyo.gov, Bill.Long@wyo.gov, elkmail@3rivers.net, Carol_Cunningham@nps.gov, Daniel Huckel/R1/FWS/DOI@FWS, Doug.Brimeyer@wyo.gov, John.Henningsen@wyo.gov, Katherine Spomer/R3/FWS/DOI@FWS, ldorsey@greateryellowstone.org, Lori Iverson/R6/FWS/DOI@FWS, Mark.Gocke@wyo.gov, env@jhnewsandguide.com, Sarah_Dewey@nps.gov, Scott.Smith@wyo.gov, steve_cain@nps.gov, Steve.Kilpatrick@wyo.gov, Terry_Roper@nps.gov, Wayne J King/R6/FWS/DOI@FWS, grte_dispatch@nps.gov, Tom Reed/R6/FWS/DOI@FWS, Thomas Roffe/R6/FWS/DOI@FWS, Steve Kallin/R6/FWS/DOI@FWS, Geneva_Chong@usgs.gov, Brandon.Scurlock@wyo.gov, kjohnson@springcreekranch.com, kaune@wcs.org, Amanda Soliday/R6/FWS/DOI@FWS, Fernando Escobedo/R6/FWS/DOI@FWS, jbohne@silverstar.com, carol.clark@wyo.gov, lori.johnson@wgf.state.wy.us, Elizabeth Sunshine/R6/FWS/DOI@FWS, JacksonHoleVC@gmail.com, Mike Jimenez/R6/FWS/DOI@FWS, braynes@bresnan.net, Susan.Patla@wyo.gov, ccolligan@greateryellowstone.org, Tim.Fuchs@wgf.state.wy.us, suowen1@hotmail.com, JHWPRTM@yahoo.com, wyobowbender@msn.com, kmmurphy02@fs.fed.us, marty_meyer@fws.gov, npreed@earthlink.net, adood@mt.gov, Lee C Jones/R6/FWS/DOI@FWS, rseidler@wcs.org, griffin0083@msn.com, Patti BennettTaylor/R6/FWS/DOI@FWS, Jill.Randall@wyo.gov, Paul Santavy/R6/FWS/DOI@FWS, Jeffrey Warren/R6/FWS/DOI@FWS, bsmith@wyoming.com, kirkhayenga62@hotmail.com, chuckschneebeck@gmail.com, louise@jhalliance.org, elizabeth_schooner@fws.gov, TureKaren@aol.com, Alyson.Courtemanch@wyo.gov, Natalie Fath/R6/FWS/DOI@FWS, carl.brown@wyo.gov, jacksonholeradionews@gmail.com

cc

Subject 2/16/2012 National Elk Refuge Biological Update

The annual NER elk classification count was conducted on 2/13/12, and there were 7,360 elk counted on feed. For comparison there were 7,746 elk counted on feed last year, and the 1982-2011 average number of elk counted on feed during the classification count is 7,322. The calf ratio was 16:100 cows, the mature bull ratio was 17:100 cows, and the spike bull ratio was 5:100 cows. All ratios were below long term averages, but not unprecedented. Generally, low calf and bull ratios are to be expected in relatively mild winters with more elk wintering off feed. We will have a clearer picture of overall Jackson Elk Herd numbers and herd ratios after WGFD summarizes helicopter count data from surrounding native winter ranges, probably sometime next week.

The annual bison classification count was conducted on 2/14/12, and there were 759 bison counted on feed. For comparison there were 883 bison counted on feed during last year's count, and the highest number of bison ever counted on feed was 971 in 2007. Ratios for bison on feed were 51 calves per 100 cows and 57 bulls per 100 cows. Overall Jackson Bison herd numbers and herd ratios will be compiled when results from WGFD flights become available.Wolves

The Pinnacle Peak Pack has been active on the south end of NER during the past week, with frequent sightings north of Miller Butte and east of the Jackson National Fish Hatchery. 14 gray colored wolves have commonly been observed together from the Pinnacle Peak Pack, and a single black wolf of unknown origin has been observed on and around Miller Butte.

Eric Cole, Refuge Biologist

USFWS National Elk Refuge

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From: Steve Kallin <Steve_Kallin@fws.gov>
To: tim.fuchs@wyo.gov; steve_cain@nps.gov
Subject: NER Season Setting Proposals for 2/29/2012 Meeting
Date: Tuesday, February 28, 2012 4:27:24 PM
Attachments: NERHuntProposals 2-29-2012.doc

Hi Tim & Steve:

Attached is an updated list of proposals for tomorrow's meeting based on our 2/21/12 discussion. I added #5 under "elk harvest" based on the information provided by the WGFD during our last discussion (Elk Refuge Harvest Totals 2008-2011). Although we likely will not be discussing the bison season, I included the bison recommendation to help explain the January 1 proposed closing date for Hunt Area 80.

NERHuntProposals 2-29-2012.doc

See you tomorrow morning,

Steve Kallin

Project Leader

National Elk Refuge

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Celebrating a Century: 1912-2012

United States Department of the Interior

FISH AND WILDLIFE SERVICE
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ANNUAL SEASON SETTING MEETING – 2/29/2012

National Elk Refuge proposals to increase elk harvest during the 2012 Hunting Season:

1. Extend elk hunting season on the NER, GTNP and Bridger-Teton NF through December 16, 2012.

2. Delay Winter Closure on Bridger-Teton National Forest (Hunt Area 80) until January 1, 2013 to allow access for elk hunters that have received a 2012 Refuge Permit until December 16, 2012.

3. Increase Area 80 Type 6 permits back to 2007 levels.

4. Offer an additional 75 cow permits in Hunt Area 75.

5. Maintain NER elk permits (initial and alternate draw) at the same level throughout the entire season.

National Elk Refuge proposal to increase bison harvest during the 2012 Hunting Season:

1. Delay Winter Closure on Bridger-Teton National Forest until January 1, 2013 for bison hunters.

From: Steve Kallin <Steve_Kallin@fws.gov>
To: Paul_Santavy@fws.gov
Subject: Hunt Season Meeting Notes for February 21, 2012
Date: Thursday, March 01, 2012 1:40:16 PM
Attachments: ProposalsDiscussionsToIncreaseBisonElkHarvest 2-21-2012.doc

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Paul:

FYI and use.

ProposalsDiscussionsToIncreaseBisonElkHarvest 2-21-2012.doc

Thanks,

Steve Kallin

Project Leader

National Elk Refuge

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Fax: (307) 733-9729

steve_kallin@fws.gov

Celebrating a Century: 1912-2012

DISCUSSION TOPICS and Meeting Notes– February 21, 2012

National Elk Refuge proposals to increase bison and elk harvest during the 2012 Hunting Seasons:

1. Extend elk hunting season on the NER, GTNP and BTNF in Area #80 through December 16, 2012.

    - Delay Winter Closure on Bridger-Teton National Forest until January 1, 2013.

    - Increase Area 80 Type 6 permits back to 2007 level;

2. Offer an additional 75 cow permits in Area 75.

3. Bison hunting season similar to 2011.

    - Other suggestions?

In Attendance:
NER : Steve Kallin, Eric Cole, Marty Meyer
GTNP: Steve Cain, Sarah Dewey
WGFD: Tim Fuchs, Doug Brimeyer, Bill Long

Discussions:

- GTNP agrees that we need to increase elk harvest. However, they are not willing to extend the elk hunting season on the Park to December 16 because of all the public pressure they have received to end the Elk Reduction Program.

-GTNP proposes to delay the start of the Elk Reduction Program until approximately October 20, or 1-2 weeks later that present (Oct. 8 opener in 2011). This may help reduce the public pressure to eliminate the Elk Reduction Program in the Park.

- GTNP would be willing to add 75 additional cow tags to Area #75 to help increase elk harvest.

-GTNP proposes to close the Elk Reduction Program in Area #79. Their rational is to help reduce harvest pressure on migratory elk from the Southern Yellowstone/Teton Wilderness herd segments. They have routinely observed a high initial harvest in Area #79 (opening weekend) followed by very low harvest until the migrants arrive. They hope that the migratory elk will linger longer in Area #79, utilize

transitional habitat, and arrive in the southern part of the valley late in the hunting season, making them less vulnerable to harvest by hunters.

-WGFD suggests issuing "Alternate Permits" on the Refuge throughout the hunting season by a Refuge Officer in the field. Bill Long believes this will increase the number of hunters who will actually hunt on the refuge and perhaps result in an increased harvest.

- WGFD suggests that we provide additional LEO presence in the 2012 Elk Hunting Season, especially if we are proposing to extend the elk season. The extended bison season already puts a strain on the limited NER law enforcement capacity. The WGFD provides LEO assistance to the NER. The NER will explore ways to increase federal LEO presence.

-WGFD explained they have been working with landowners, both ranchers and subdivision residents to increase harvest in hunt Area #78. Some landowners have been allowing hunting access and the WGFD has been hazing elk out of the area during the hunting season to increase harvest on adjacent areas.

-WGFD expressed concern with the low calf/cow ratios for elk on the NER. The February 2012 Classification Count revealed 16 calves per 100 cows. They believe this is inadequate to sustain a stable herd. Eric Cole provided a handout showing calves/100 cows on the NER from 1990 to present. Calves per 100 cows have fluctuated on the NER from 25 to 15 during this period. Even though the calf/cow ratio was between 15 and 18 from 2003 to 2005, the total number of elk wintering on the NER fluctuated between 4,969 and 7,997. An upward trend began in 2006 even though it was preceded by three years of low calf to cow ratios.

-WGFD provided a Google Earth map showing the location of two collared elk during the 2011 hunting season. Their locations were concentrated in existing NER closed areas in the southern hunt unit. Thes "sanctuaries" will be addressed in the CCP which is tentatively scheduled to be released for public comment in the summer of 2012. The NER is interested in changes to eliminate these "sanctuaries."

-WGFD provided a summary of elk harvest totals from 2008-2011 which showed the peak harvest period during weeks six through eight (approximately Nov. 12-15 through Dec. 2-5)

- WGFD are in the process of revising the Bison Hunting Regulations and are hopeful the following changes can be made:

-Bison hunting becomes a "draw system" where licenses must be purchased at the time of application. This would eliminate a repeat of the December/January 2010 situation when we had bison on the refuge but no hunters.

-Change the "once in a lifetime" bison restriction to "once every 5 years."

- Perhaps lower the price of a cow license from $400 to $200.

-NER: Steve conveyed the results of his discussion with Dale Dieter (BTNF) about delaying the winter closure on the BTNF east of the NER to accommodate elk and bison hunters in December to prevent developing a “sanctuary.” Dale is supportive but cannot significantly modify the Winter Travel Plan. He would be willing to “piggy-back” on existing permit/license system that would extend access to those hunters onto the BTNF through December. This could be done with the State Bison Hunting License and the NER Hunter Permit system.

-NER will reconsider providing elk hunter alternate permits in the field.

-NER cannot allow elk hunters to access the new HWY 89 parking area south of the Gros Ventre River because of capacity. Once that small parking area is filled, hunters would perhaps park on the highway shoulder or across the highway on the GTNP and cross the highway to the Refuge. Both of which would create an elevated safety risk. Will consider the option of enlarging/improving this parking area.

-NER mentioned possible additional funding which could become available for “research” and help augment the WGFD’s application for funding to collar summer elk in the northern herd segments.

-NER mentioned including a proposal for a limited elk bull hunt on the refuge in the CCP which is scheduled to be available for public comment in the summer of 2012.

From: Tim Fuchs <tim.fuchs@wyo.gov>
To: Steve_Kallin@fws.gov
Subject: Re: B-T National Forest Winter Closure Discussion, Tuesday, March 6 at 2:00 PM; Forest Supervisor"s Conference Room
Date: Thursday, March 01, 2012 2:56:26 PM

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no

On Thu, Mar 1, 2012 at 1:11 PM, <Steve_Kallin@fws.gov> wrote:

Tuesday, March 6 at 2:00 PM works for everyone to meet to discuss modifying the winter closure on the B-T adjacent to the east side of the Refuge. We will meet in the Forest Supervisor's Conference Room.

See you then,

Steve Kallin
Project Leader
National Elk Refuge
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675 East Broadway
Jackson, WY 83001
Phone: (307) 733-9212, extension 2
Fax: (307) 733-9729
steve_kallin@fws.gov

Celebrating a Century: 1912-2012

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From: Eric Cole <Eric_Cole@fws.gov>
To: Steve_Kallin@fws.gov; Paul_Santavy@fws.gov
Subject: Estimated number of elk from different summering segments
Date: Monday, March 05, 2012 3:21:21 PM
Attachments: 2012 Jackson Elk Herd pop estimate by Summer Segment.docx

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Steve,

The attached word document provides some estimates for the number of elk in the Jackson Elk Herd by summering segment. The overall herd numbers in table 1 are based on Smith's 1991 estimated summer segment percentages, which are now very likely out of date due to a decline in the number of elk that summer in Yellowstone and Teton Wilderness and an increase in the number of elk summering in southern GTNP and private lands south of the park. What is of greatest management interest is the estimated number of elk from each summering segment that would be subject to harvest in hunt area 80, and I believe that this is best represented by the elk that are on NER feedgrounds (table 2). I could try to generate an updated estimate of table 1, but I don't think that it would be worth the considerable time that it would take to do so given the uncertainty associated with the summer range associations of elk that winter off feedgrounds.

2012 Jackson Elk Herd pop estimate by Summer Segment.docx

Eric Cole, Refuge Biologist

USFWS National Elk Refuge

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MEMO:
3/5/12
To: Refuge Files
From: Eric Cole, Refuge Biologist
Subject: Estimating Number of Elk in Summering Segments

Steve Kallin asked if there was any information on the relative number of elk summering in the different herd segments. In 1991 Smith estimated the following summer segment herd percentages in the Jackson Elk Herd: 30% in Grand Teton National Park, 30% in the Gros Ventre Drainage, 25% in Yellowstone National Park, and 15% in Teton Wilderness. Table 1 uses Smith's summer segment percentages to estimate the total number of elk in each summering segment

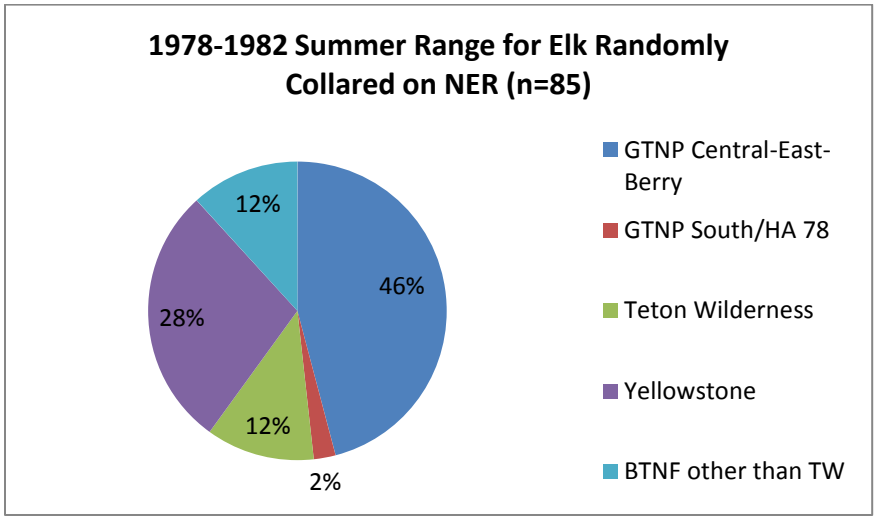
Table 1. Estimated number of elk in each summering segment of the Jackson Elk Herd based on Smith's 1991 estimated percentages and 2012 modeled population estimate.

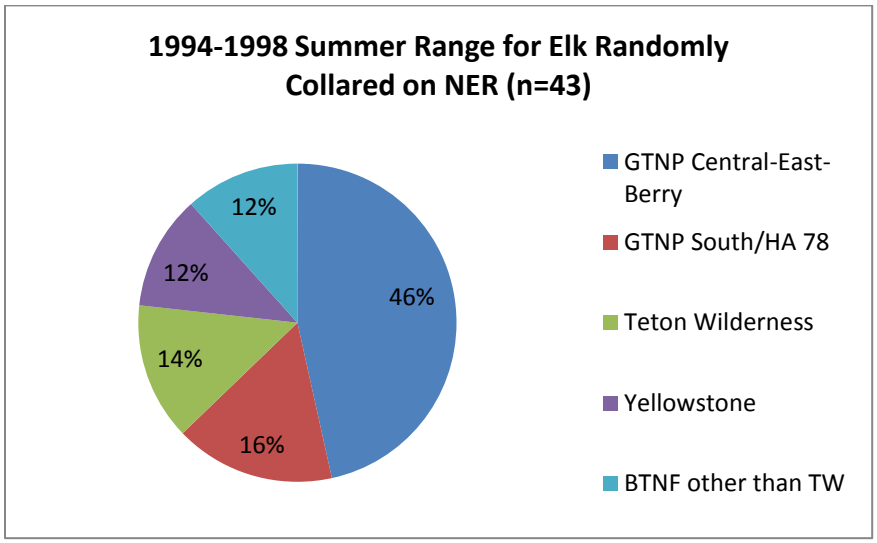
Summering Segment	Estimated Percentage	Estimated Number of Elk
Grand Teton	30	3,589
Gros Ventre Drainage	30	3,589
Yellowstone	25	2,991
Teton Wilderness	15	1,794
TOTAL	100	11,962

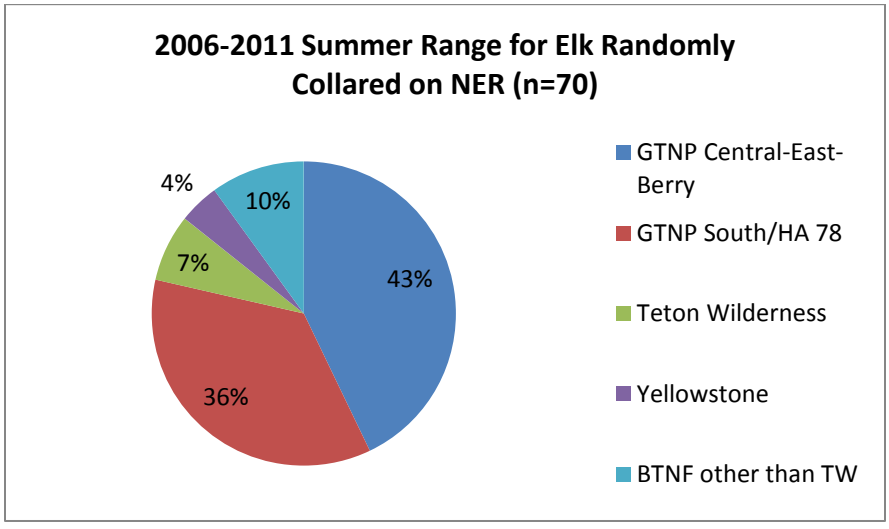
However, based on collars deployed on NER feedgrounds, there is considerable evidence that at least for elk that winter on NER, the number of elk that summer in YNP and Teton Wilderness has declined, and the number of elk summering in southern GTNP and Hunt Area 78 has increased (Pie Chart Figures). Furthermore, if the management issue is the number of elk that would be subject to harvest in Hunt Area 80, we are most interested in elk that winter on NER. Table 2 uses summer range percentages from collars that were deployed on NER feedgrounds between 2006 and 2011 to estimate the number of elk on each summer range that winter on NER.

Table 2. Estimated number of elk in each summering segment that winter on NER. Estimate derived from summer range percentages of elk collared on NER from 2006 to 2011, and the number of elk counted on NER feedgrounds during the 2012 classification count.

Summering Segment	Estimated Percentage	Estimated Number of Elk
Grand Teton National Park Central Valley, eastern GTNP, and Berry Creek	43	3,164
GTNP south of Moose and Hunt Area 78	36	2,650
Teton Wilderness	7	515
Yellowstone	4	294
Bridger Teton National Forest other than Teton Wilderness	10	736
Total	100	7,360


1978-1982 Summer Range for Elk Randomly Collared on NER (n=85)
46%
2%
12%
28%
12%
GTNP Central-East-Berry
GTNP South/HA 78
Teton Wilderness
Yellowstone
BTNF other than TW


1994-1998 Summer Range for Elk Randomly Collared on NER (n=43)
46%
16%
14%
12%
12%
GTNP Central-East-Berry
GTNP South/HA 78
Teton Wilderness
Yellowstone
BTNF other than TW


2006-2011 Summer Range for Elk Randomly Collared on NER (n=70)
43%
36%
7%
4%
10%
GTNP Central-East-Berry
GTNP South/HA 78
Teton Wilderness
Yellowstone
BTNF other than TW

From: Tim Fuchs <tim.fuchs@wyo.gov>
To: Steve_Kallin@fws.gov
Cc: Steve_Cain@nps.gov
Subject: Jackson Elk Seasons
Date: Monday, March 12, 2012 11:57:03 AM
Attachments: Jackson Elk.pdf

Steve,

I left a message, here is the strike through copy of our season proposals that show the changes for this year. As you can see we have proposed increasing the length of the hunt area 80 season for general and type 4 licenses by 10 days and have moved the boundary to the Curtis Canyon road for the season lasting from November 17-30. I will be in and out today, but let me know if you have any questions. Take care.

Tim

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2012 PROPOSED SEASONS E102 JACKSON ELK

Hunt Area	Type	Date of Seasons Opens	Closes	Limitations
70		Sept. 20	Oct. 31	General license; antlered elk, spikes excluded. SEE SECTION 7
		Nov. 1	Nov. ~~6~~ 4	General license; antlered elk, spikes excluded valid in that portion of Area 70 north and west of Pacific Creek and Mink Creek. SEE SECTION 7
71		Sept. 20	Nov. ~~6~~ 4	General license; antlered elk, spikes excluded. SEE SECTION 7
72				CLOSED
75	~~1~~	~~Oct. 8~~	~~Nov. 6~~	~~Limited quota; 25 licenses any elk, antlerless elk on hayfields and Antelope Flats portion of Area 75.. SEE SECTIONS 7 and 8~~
		~~Nov. 7~~	~~Dec. 4~~	~~Unused limited quota Type 1 licenses; any elk, antlerless elk on hayfields ; the Antelope Flats portion of Area 75 shall be closed. SEE SECTIONS 7 and 8~~
	4	Oct. ~~8~~ 6	Nov. ~~6~~ 16	Limited quota; ~~250~~ 350 licenses antlerless elk. SEE SECTIONS 7 and 8
		Nov.~~7~~ 17	Dec. ~~4~~ 2	Unused limited quota Type 4 licenses; antlerless elk; the Antelope Flats portion of Area 75 shall be closed. SEE SECTIONS 7 and 8
	6	Oct. ~~8~~6	Nov. ~~6~~16	Limited quota; ~~400~~ 350 licenses cow or calf. SEE SECTIONS 7 and 8
		Nov. ~~7~~ 17	Dec. ~~4~~ 2	Unused limited quota Type 6 licenses; cow or calf ~~antlerless elk~~1; the Antelope Flats portion of Area 75 shall be closed. SEE SECTIONS 7 and 8
77		Oct. ~~8~~ 6	Oct. ~~9~~ 7	General license and unused limited quota licenses, excluding limited quota cow or calf licenses and limited quota archery only licenses, valid for any elk; 70 National Elk Refuge permits may be issued only for youths 12 through 17 years of age. SEE SECTIONS 7 and 8
		Oct. ~~10~~ 8	Oct. ~~14~~ 14	General license and unused limited quota licenses, excluding limited quota cow or calf licenses and limited quota archery only licenses, any elk. SEE SECTIONS 7 and 8
		Oct. ~~15~~ 15	~~Dec. 11~~Dec. 16	General license and unused limited quota licenses; excluding limited quota archery only licenses, antlerless elk only. SEE SECTIONS 7 and 8
78	1	Sept. 26	~~Dec. 31~~Jan. 31	Limited quota; 50 licenses any elk. SEE SECTION 7
	4	~~Sept. 1~~Aug. 18	Sept. 9	Limited quota; ~~25~~ 50 licenses antlerless elk valid on private land; access to private land is limited. SEE SECTION 7
		Sept. 10	Jan. 31	Unused area 78 type 4 licenses valid in all of Area 78 SEE SECTIONS 7
	6	~~Sept.1~~Aug. 18	Sept. 9	Limited quota; 175 licenses cow or calf, valid on private land; access to private land is limited. SEE SECTION 7
		Sept. 10	Jan. 31	Unused area 78 Type 6 licenses valid in all of Area 78 SEE SECTIONS 7
79	~~1~~	~~Oct. 8~~	~~Nov. 6~~	~~Limited quota; 50 licenses any elk. SEE SECTIONS 7 and 8~~
	4	Oct. ~~8~~ 6	Nov. ~~6~~ 4	Limited quota; 25 licenses antlerless elk; also valid in Area 75. SEE SECTIONS 7 and 8
		Nov ~~7~~5	~~Dec 4~~ Nov. 16	Unused Area 79 Type 4 licenses valid in Area 75.~~The Antelope Flats portion of Area 75 shall be closed~~.SEE SECTIONS 7 and 8
		Nov. 17	Dec. 2	Unused Area 79 Type 4 licenses antlerless elk; valid in Area 75; the

Hunt Area	Type	Date of Seasons Opens	Closes	Limitations
				Antelope Flats portion of Area 75 shall be closed. SEE SECTIONS 7 and 8
80		Sept. 26	Oct. 31	General license; any elk. SEE SECTION 7
		Nov. 1	Nov. ~~6~~ 16	General license; antlerless elk. SEE SECTION 7
	4	Sept. 10	Nov. ~~6~~ 16	Limited quota; 25 licenses antlerless elk. SEE SECTION 7
		Nov.~~7~~17	Nov. 30	General license and Unused Area 80 Type 4 licenses valid for antlerless elk in that portion of Area 80 sou~~h t~~hof the Curtis Canyon Road (U.S.F.S. 30440) and the Goodwin Lake trail (U.S.F.S.3016).~~south of Twin Creek~~. SEE SECTION 5
81		Sept. 26	Oct. 25	General license; antlered elk, spikes excluded. SEE SECTION 7
82		Sept. 26	Oct. 25	General license; antlered elk, spikes excluded. SEE SECTION 7
	4	Sept. 10	Oct. 25	Limited quota; 25 licenses antlerless elk. SEE SECTION 7
83		Oct. 1	Oct. 25	General license; antlered elk, spikes excluded. SEE SECTION 7

Special Archery Seasons.

Hunt Area	Date of Seasons Opens	Closes
70, 71	Sept. 1	Sept. 19
78, 80-82	Sept. 1	Sept. 25

Summary of Proposed License Changes

Area	Type	Change from 2011
70,71	General	- ~~1~~ 2 day, ~~Spikes excluded added~~
75	1	Type 1 licenses eliminated -25 licenses
	4	~~+50~~+100 licenses
	6	-50 licenses
77	General HMA draw	- ~~1day~~ + 5 days
78	1	+~~25 licenses - area expanded west to Teton Pass~~ Valid through Jan 31
	4 and 6	~~+25 licenses Open Sept 1 on private land~~ Open Aug. 18
79	1	Type 1 licenses eliminated-50 licenses
	4	~~-25 licenses~~ -Closes ~~1~~ 2 days earlier

From: Steve Kallin <Steve_Kallin@fws.gov>
To: Tim Fuchs
Bcc: Dean Rundle/R6/FWS/DOI@FWS
Subject: Re: Jackson Elk Seasons
Date: Wednesday, March 14, 2012 5:36:01 AM
Attachments: Jackson Elk.pdf

Hi Tim:

Thanks for moving the Area 80 early closure date for General & Type 4 Licenses to November 16. We agree with this date change but would still request the closure boundary to return to Flat Creek as it had been from 2007-2010. Returning to the Flat Creek boundary will allow disturbance and eliminate a "safe zone" adjacent to the Refuge between the Curtis Canyon Road and Flat Creek until November 16. This will help improve the effectiveness of the cow elk harvest on the Refuge and Area 80 until the November 16 closure.

We would also request that you consider returning the Area 80 Limited Quota Type 6 tags to the 2009 or 2010 levels. A maximum of two Type 4 tags sold per year in Area 80 from 2008-2010. The Area 80 Type 4 licenses clearly do not sell. However the Area 80 Type 6 licenses do sell and in 2008 when 50 were sold, it resulted in an additional 15 antlerless elk harvested. In 2009 when 25 Type 6 licenses were sold, an additional 8 antlerless elk were harvested. Although these harvest numbers are modest, we believe that based on Refuge winter GPS collar data that approximately 90% of these additional harvested antlerless elk will come from the southern herd segments. We would anticipate that even with 50 Area 80 Type 6 permits, the harvest from the Southern Yellowstone and Teton Wilderness herd segments would be extremely low (1-3 antlerless elk) and would not adversely impact those herd segments. If you are procedurally unable to add Area 80 Type 6 licenses for the 2012 hunting season, we would ask you to consider adding them for the 2013 hunting season.

Thanks for considering these recommendations which we believe will help us meet the population objectives outlined in the Bison and Elk Management Plan.

I am in Denver today and will return to Jackson tomorrow. I will try to call you some time on Thursday.

Take care,

Steve Kallin

Project Leader

National Elk Refuge

PO Box 510

675 East Broadway

Jackson, WY 83001

Phone: (307) 733-9212, extension 2

Fax: (307) 733-9729

steve_kallin@fws.gov

Celebrating a Century: 1912-2012

Tim Fuchs <tim.fuchs@wyo.gov>03/12/2012 11:57 AM

To "Steve_Kallin@fws.gov" <steve_kallin@fws.gov>

cc "Steve_Cain@nps.gov" <steve_cain@nps.gov>

Subject Jackson Elk Seasons

Jackson Elk.pdf

2012 PROPOSED SEASONS E102 JACKSON ELK

Hunt Area	Type	Date of Seasons Opens	Closes	Limitations
70		Sept. 20	Oct. 31	General license; antlered elk, spikes excluded. SEE SECTION 7
		Nov. 1	Nov. ~~6~~ 4	General license; antlered elk, spikes excluded valid in that portion of Area 70 north and west of Pacific Creek and Mink Creek. SEE SECTION 7
71		Sept. 20	Nov. ~~6~~ 4	General license; antlered elk, spikes excluded. SEE SECTION 7
72				CLOSED
75	~~1~~	~~Oct. 8~~	~~Nov. 6~~	~~Limited quota; 25 licenses any elk, antlerless elk on hayfields and Antelope Flats portion of Area 75.. SEE SECTIONS 7 and 8~~
		~~Nov. 7~~	~~Dec. 4~~	~~Unused limited quota Type 1 licenses; any elk, antlerless elk on hayfields ; the Antelope Flats portion of Area 75 shall be closed. SEE SECTIONS 7 and 8~~
	4	Oct. ~~8~~ 6	Nov. ~~6~~ 16	Limited quota; ~~250~~ 350 licenses antlerless elk. SEE SECTIONS 7 and 8
		Nov.~~7~~ 17	Dec. ~~4~~ 2	Unused limited quota Type 4 licenses; antlerless elk; the Antelope Flats portion of Area 75 shall be closed. SEE SECTIONS 7 and 8
	6	Oct. ~~8~~6	Nov. ~~6~~16	Limited quota; ~~400~~ 350 licenses cow or calf. SEE SECTIONS 7 and 8
		Nov. ~~7~~ 17	Dec. ~~4~~ 2	Unused limited quota Type 6 licenses; cow or calf ~~antlerless elk~~1; the Antelope Flats portion of Area 75 shall be closed. SEE SECTIONS 7 and 8
77		Oct. ~~8~~ 6	Oct. ~~9~~ 7	General license and unused limited quota licenses, excluding limited quota cow or calf licenses and limited quota archery only licenses, valid for any elk; 70 National Elk Refuge permits may be issued only for youths 12 through 17 years of age. SEE SECTIONS 7 and 8
		Oct. ~~10~~ 8	Oct. ~~14~~ 14	General license and unused limited quota licenses, excluding limited quota cow or calf licenses and limited quota archery only licenses, any elk. SEE SECTIONS 7 and 8
		Oct. ~~15~~ 15	~~Dec. 11~~Dec. 16	General license and unused limited quota licenses; excluding limited quota archery only licenses, antlerless elk only. SEE SECTIONS 7 and 8
78	1	Sept. 26	~~Dec. 31~~Jan. 31	Limited quota; 50 licenses any elk. SEE SECTION 7
	4	~~Sept. 1~~Aug. 18	Sept. 9	Limited quota; ~~25~~ 50 licenses antlerless elk valid on private land; access to private land is limited. SEE SECTION 7
		Sept. 10	Jan. 31	Unused area 78 type 4 licenses valid in all of Area 78 SEE SECTIONS 7
	6	~~Sept.1~~Aug. 18	Sept. 9	Limited quota; 175 licenses cow or calf, valid on private land; access to private land is limited. SEE SECTION 7
		Sept. 10	Jan. 31	Unused area 78 Type 6 licenses valid in all of Area 78 SEE SECTIONS 7
79	~~1~~	~~Oct. 8~~	~~Nov. 6~~	~~Limited quota; 50 licenses any elk. SEE SECTIONS 7 and 8~~
	4	Oct. ~~8~~ 6	Nov. ~~6~~ 4	Limited quota; 25 licenses antlerless elk; also valid in Area 75. SEE SECTIONS 7 and 8
		Nov ~~7~~5	~~Dec 4~~ Nov. 16	Unused Area 79 Type 4 licenses valid in Area 75.~~The Antelope Flats portion of Area 75 shall be closed~~.SEE SECTIONS 7 and 8
		Nov. 17	Dec. 2	Unused Area 79 Type 4 licenses antlerless elk; valid in Area 75; the

Hunt Area	Type	Date of Seasons Opens	Closes	Limitations
				Antelope Flats portion of Area 75 shall be closed. SEE SECTIONS 7 and 8
80		Sept. 26	Oct. 31	General license; any elk. SEE SECTION 7
		Nov. 1	Nov. ~~6~~ 16	General license; antlerless elk. SEE SECTION 7
	4	Sept. 10	Nov. ~~6~~ 16	Limited quota; 25 licenses antlerless elk. SEE SECTION 7
		Nov.~~7~~17	Nov. 30	General license and Unused Area 80 Type 4 licenses valid for antlerless elk in that portion of Area 80 sou~~h t~~hof the Curtis Canyon Road (U.S.F.S. 30440) and the Goodwin Lake trail (U.S.F.S.3016).~~south of Twin Creek~~. SEE SECTION 5
81		Sept. 26	Oct. 25	General license; antlered elk, spikes excluded. SEE SECTION 7
82		Sept. 26	Oct. 25	General license; antlered elk, spikes excluded. SEE SECTION 7
	4	Sept. 10	Oct. 25	Limited quota; 25 licenses antlerless elk. SEE SECTION 7
83		Oct. 1	Oct. 25	General license; antlered elk, spikes excluded. SEE SECTION 7

Special Archery Seasons.

Hunt Area	Date of Seasons Opens	Closes
70, 71	Sept. 1	Sept. 19
78, 80-82	Sept. 1	Sept. 25

Summary of Proposed License Changes

Area	Type	Change from 2011
70,71	General	- ~~1~~ 2 day, ~~Spikes excluded added~~
75	1	Type 1 licenses eliminated -25 licenses
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79	1	Type 1 licenses eliminated-50 licenses
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NATIONAL ELK REFUGE BISON AND ELK WINTER FEEDING ADAPTIVE MANAGEMENT PLAN MEETING

7 April 2014 AGENDA

Participants:
National Elk Refuge
WGFD – Jackson region
Grand Teton NP
Forest Service

1) **12:30 – 12:35: Meeting Objectives.**
    a. **Review of Narrative for Bison Alternative Management Actions**
    b. **Desired conditions – begin prioritizing criteria to link to elk population**

2) **12:35 – 2:00: Bison Alternative Management Strategy development**
    a. Review management action narratives (in order, starts on pg. 25)
        i. *Population management* –
            1. January hunt extension – still uncertain what this actually means; need specific wording for this action (sorry, I think it has already been described and I simply didn't capture it in my notes) **(pg. 25)**
            2. Agency cull – current wording describing deadlines set by policy **(pg. 26)**
            3. Agency cull – quick review of bison harvest simulation; are people comfortable with the model and demographic rates used? **(pg. 26)**
            4. Fertility control – which strategy would this fall under?
            5. Fertility control – how do we word this action to account for 1) its prior rejection in the 2007 EIS and 2) the presumed advances since that time that would make this a reasonable action? **(pg. 26)**
        ii. *Hazing* –
            1. Combined Nowlin unit-specific action with an action to haze bison south of a defined line. **(pg. 26)**
            2. Included an action and descriptive sentence for agency-accompanied hunters in the southern units – which units are we talking about for this? Any other specificity to include in the description? **(pg. 26)**
        iii. *Habitat improvements* –
            1. Water source improvements – still needs some specificity for the proposed actions. **(pg. 27)**
        iv. *Public education/outreach* –
            1. See comments on **pg 27**.
            2. Should the agency outreach be its own EO action? **(pg. 28)**
        v. *Monitoring* –
            1. 'Assess influence of outfitters on hunter success'? **(pg. 28)**
3) **2:00 – 2:10: Break**

4) **2:10 – 4:30: Desired conditions – begin prioritizing criteria to link to elk population**
    a. Review Appendix I figure; six habitat objectives relevant to phase II elk population objective

Jackson Hole Bison Population Response to Harvest – a Simulation Study

Introduction

The current Jackson Hole Bison population is over objective as defined by the Wyoming Game and Fish Department and in the interagency Bison and Elk Management Plan (BEMP) (USFWS and NPS 2007). Hunter harvest is the primary management action used to manage this population; uncertainty exists as to the efficacy of this action. To better understanding the influence of current harvest levels on bison population, we created a simple recursion equation population model that included harvest. The model includes three stochastic processes – annual reproductive rate (the proportion of calves per female), harvest, and observation error. Survival (adult and calf) excluding mortality associated with hunter harvest, and the proportion of females in the population, were assumed to be constant. The number of bison, *N*, in year *t*+1 is predicted as

$$N_{t+1} = N_{obs,t}S_{AD} + fN_{t,obs}R_tS_{Calf} - H_t, \quad (1)$$

with variables defined as

$N_{obs,t}$ = the observed number of bison in year *t*.

S_{AD} = adult survival excluding hunter harvest, assumed constant at 0.92 (Fuller et al. 2007).

S_{Calf} = calf survival excluding hunter harvest, assumed constant at 0.76 (Kirkpatrick et al. 1996).

f = the proportion of females in the population, assumed constant at 0.592 based on WGFD postseason classification counts during 2007-2013.

R_t = the stochastically-varying annual reproductive rate, i.e., calf to cow ratio, which is normally-distributed with mean = 0.466 and SD = 0.054 (*N*(0.466, 0.054)) based on postseason surveys, 2003–2013.

H_t = the stochastically-varying annual hunter harvest, normally distributed with mean = 209 and SD = 45.5 (*N*(210, 45.5)) based on harvest data, 2007–2013.

We assumed density-independent growth rates based on observed population growth with no to minimal harvest, 1970–2007 (Fig. 1).

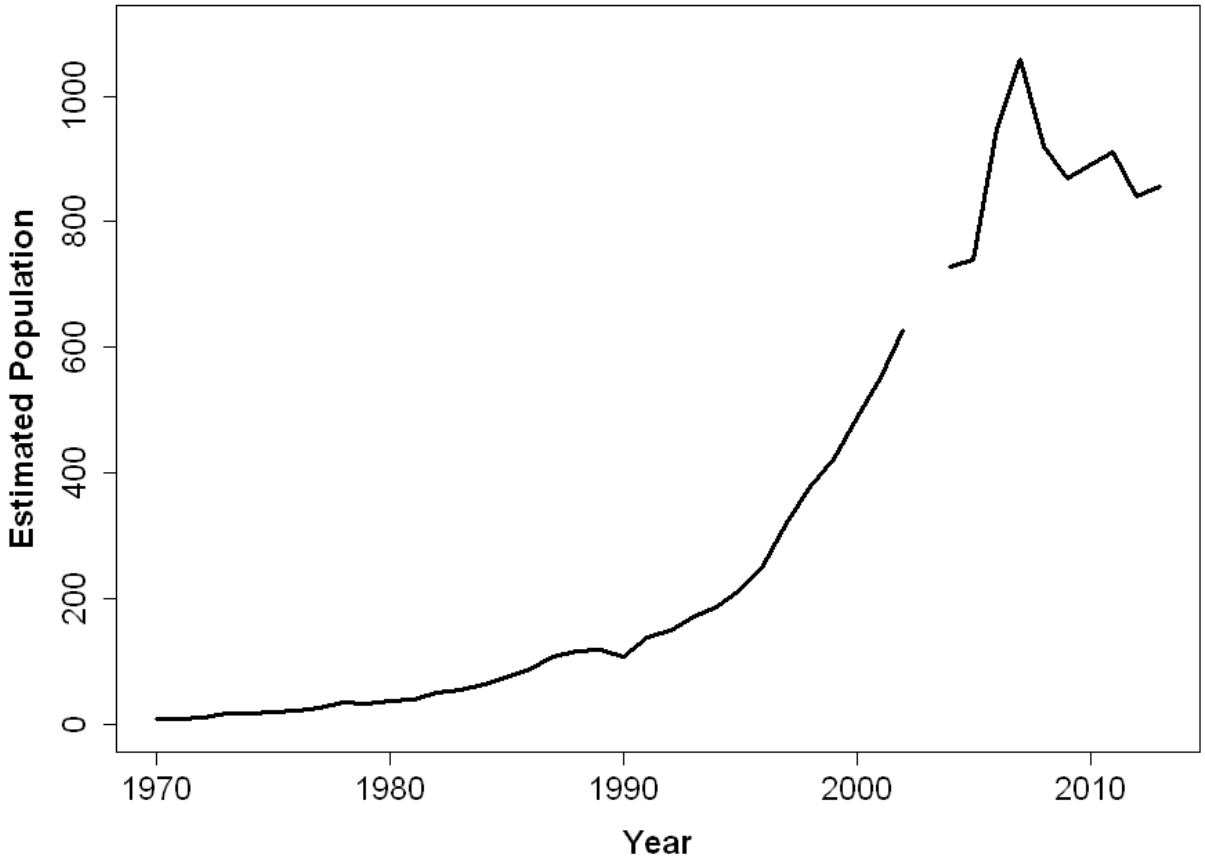

Fig. 1. Bison winter population in the Jackson Hole area, 1970–2013. Minimal to no harvest occurred from 1970–2007**.**

Observation error in the bison population survey, i.e., variation due to imperfect enumeration of the population of interest, was included in the model. If we assume observation error is log-normally distributed, observation error will be

$$N_{obs,t} = N_t V, \tag{2}$$

$$V = exp\left(Z\sigma_v - \frac{\sigma_v^2}{2}\right), \tag{3}$$

where *Z* is normally distributed with a mean of zero and a standard deviation of 1, and the standard deviation of the observation uncertainty is σ_V (Hilborn and Mangel 1997). We assumed observation uncertainty was relatively low and set $\sigma_V = 0.05$.

Results

Will include brief write-up with updated figures once final demographic rates are used in the simulation.

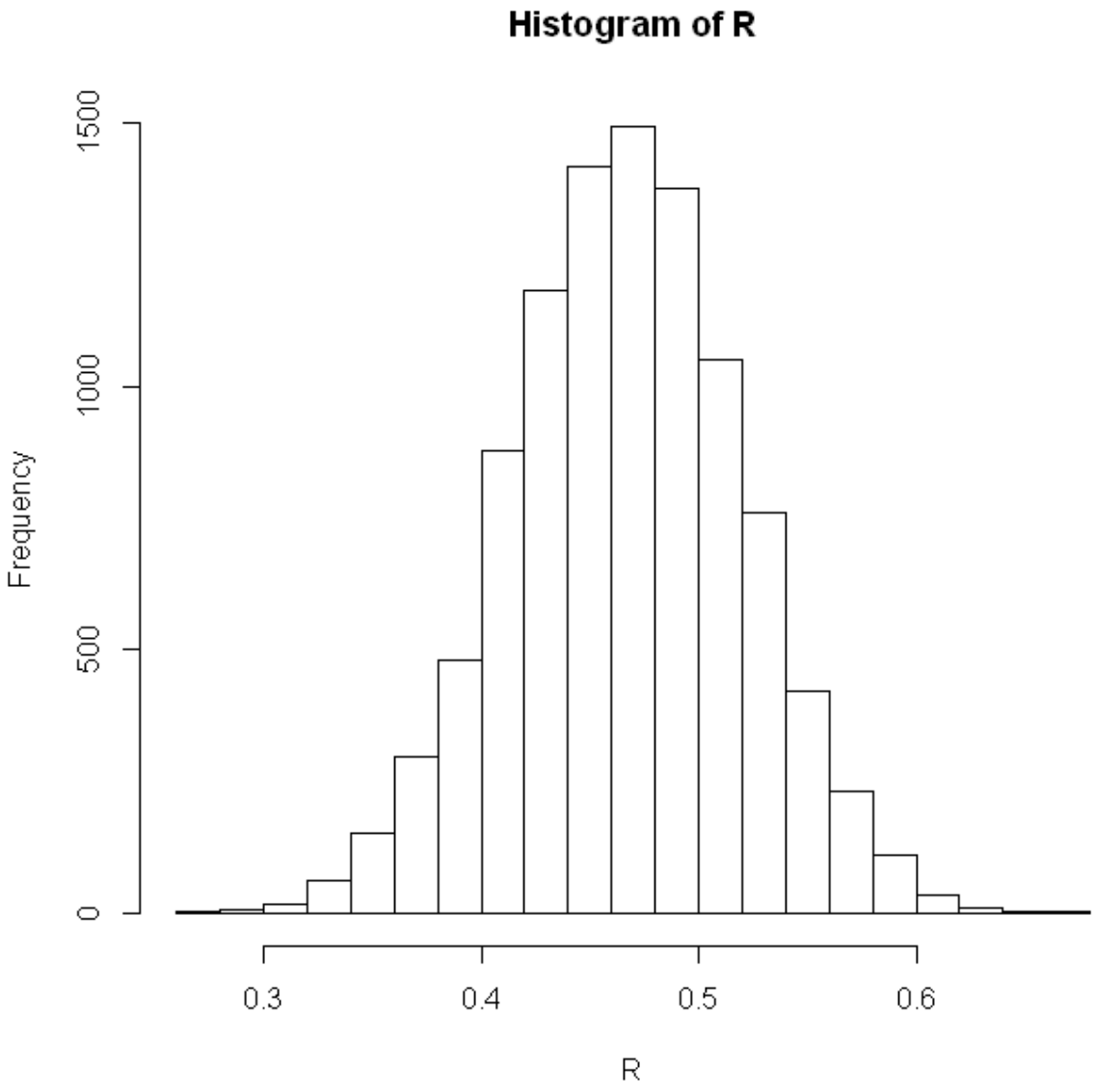

Figure 2. Histogram of simulated reproductive rate, i.e., calves/100 cows, (*n* = 10,000) assuming a normal distribution with mean = 0.466 and SD = 0.054.

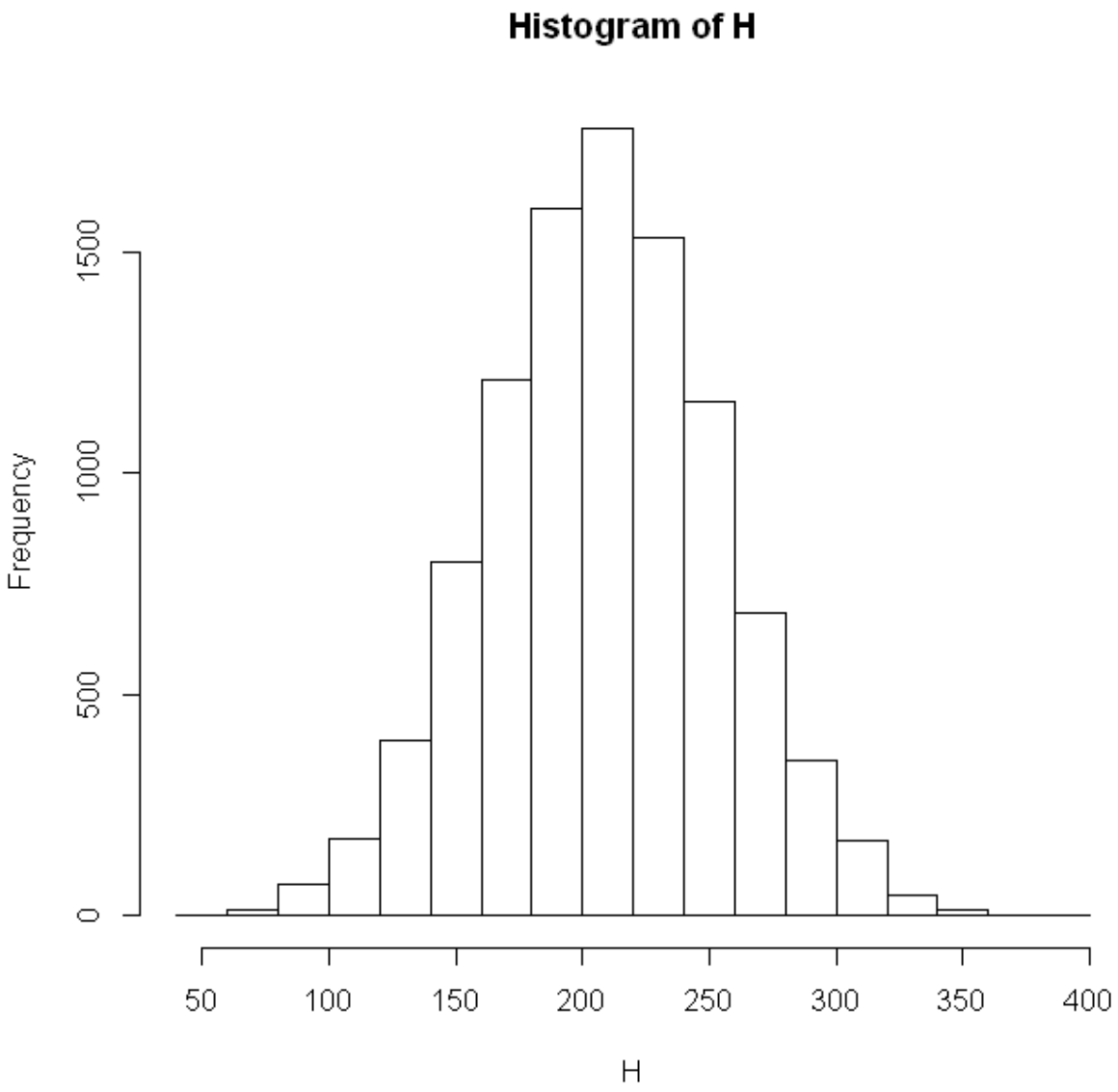

Figure 3. Histogram of simulated hunter harvest values (*n* = 10,000) assuming a normal distribution with mean = 209 and SD = 45.5.

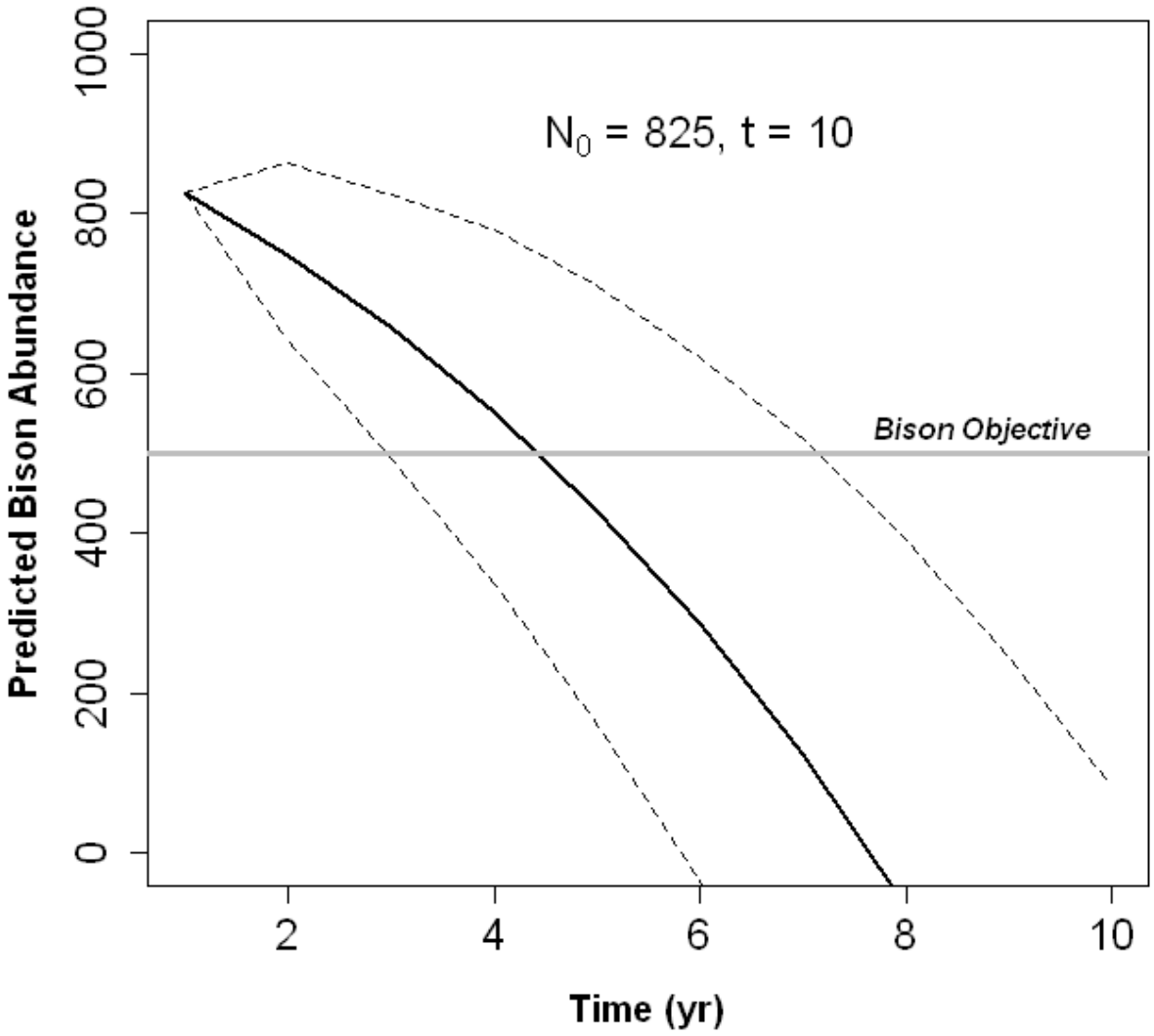

Figure 4. Projected Jackson Bison Herd population based on a stochastic population model with fixed annual adult and calf survival (0.95 and 0.76, respectively), fixed proportion of females in the population (0.592), and stochastically-varying annual reproductive rate (*N*(0.466, 0.054)) and harvest (*N*(210, 45.5)). Initial population (N_0) was 1000 bison. Horizontal gray line is the current population objective for the Jackson Bison Herd. Dashed lines represent the 90% confidence interval.

Literature Cited

Fuller, J. A., R. A. Garrott, P. J. White, K. E. Aune, T. J. Roffe, J. C. Rhyan. 2007. Reproduction and survival of Yellowstone bison. Journal of Wildlife Management 71:2365–2372.

Hilborn, R. and M. Mangel. 1997. The ecological detective: confronting models with data. Monographs in Population Biology 28. Princeton University Press, Princeton, NJ.

Kirkpatrick, J. F., J. C. McCarthy, D. F. Gudermuth, S. E. Shideler, and B. L. Lasley. 1996. An assessment of the reproductive biology of the Yellowstone bison (*Bison bison*) subpopulations using noncapture methods. Canadian Journal of Zoology 74:8–14.

[USFWS and NPS] U.S. Fish and Wildlife Service and National Park Service. 2007. Bison and elk management plan. National Elk Refuge and Grand Teton National Park.

From:	Jeffrey Warren
To:	Cris Dippel; Dale Deiter; Doug Brimeyer; Eric Cole; Kerry Murphy; Sarah Dewey; scott.smith1@wyo.gov; Steve Kallin; Steven (Steve) Cain; Tim Fuchs
Subject:	Updated bison popn projections, AM plan, agenda
Date:	Friday, March 21, 2014 5:21:39 PM
Attachments:	NER_draft_AMP_7_April_2014.docx NER_AMP_meeting_agenda_4_7_2014.docx NER_Bison_harvest_simulation.docx

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Hello all,

I wanted to share some updates with you as I will mostly be out of the office until our next meeting. I attached an updated bison population projection that includes demographic data specific to the Jackson Bison Herd (thanks again to Doug for that). I also attached an agenda and updated plan for our meeting April 7th. Originally I thought we'd move into drafting consequences tables after completing the bison management actions (which we should be able to do at our next meeting), but realized that we'll need to incorporate the 'desired conditions' objectives before consequences tables can be finished. That means we'll start working on which desired conditions we'll link to elk population after the bison actions are finished. To help move that along I've included some additional background information in the introduction to the plan and, based on my interpretation of the BEMP, selected a subset of habitat objectives to start our discussion with (see pg. 2 final full paragraph through line 5 page 3 and Appendix I figure).

I will be travelling next week, so if those of you whom I emailed questions to today can get to those by mid-week next week I'll update the plan prior to our meeting.

See you in April.

Cheers,

Jeff Warren
Wildlife Biologist
27650B South Valley Road
Lima, MT 59739
406 276-3536 ext. 304

"Without data, all you are is just another person with an opinion" – Unknown

"It's tough to make predictions, especially about the future" – Yogi Berra

NATIONAL ELK REFUGE ADAPTIVE BISON AND ELK MANAGEMENT PLAN

DRAFT

7 April 2014

DRAFT

Introduction

Include a summary of the actions in this plan that tier off of the BEMP vs. those that would trigger NEPA. This would include defining strategies succinctly and the threshold that would trigger NEPA. In this way we can move forward with actions that step down from the BEMP and have a trigger for initiating NEPA if, and only if, necessary.

1) Removed 'Grand Teton NP harvest' from the bison alternatives table because it was not in the BEMP and would therefore trigger NEPA and an act of Congress would be necessary (for a hunt, not a cull). A bison cull in GTNP would still trigger NEPA. Included agency cull (see below).
2) Test and slaughter for bison was reviewed and rejected in the BEMP – many reasons to not do it.
3) An agency bison cull would trigger NEPA
4) Herd-wide fertility control in bison would similarly trigger NEPA

Uncertainty regarding how to reach objectives for elk and bison populations, desired habitat conditions, and disease management in Jackson Hole remains after many years of study and debate. Determining an effective set of management actions to meet multiple and potentially competing objectives is needed. In an effort to address this, an adaptive management (AM) approach is being undertaken (Walters 1986). There are four essential elements to an adaptive management approach: 1) well defined and mutually agreed upon objectives, 2) clearly articulated management actions and strategies, 3) a model, or competing models, describing the dynamics of the system being managed, and 4) a monitoring program to quantify system response to management and allow estimation of the difference between the observed and predicted (from the model or models) system response. A fifth component, optimal decision making, is also included in some AM efforts. The AM approach is 'adaptive' because learning through management experiments (management actions implemented to change the state of the system) occurs. In single-model AM projects the learning results in better estimates of the effects included in the model, i.e., there is less uncertainty about how the system will respond to management actions. In multiple-model AM projects learning occurs through the competition of models in the model set. Each model provides a representation of a competing idea (hypothesis) about how the system works. The model that best predicts system response to management provides support that the hypothesis it represents is a better description of the system than the other hypotheses, reducing uncertainty about the system being managed.

Uncertainty abounds in wildlife conservation and management. For example, how abundance and distribution of bison and elk will respond to different management actions is only modestly predictable. Similarly, what level of elk and bison the area can support based on desired

DRAFT

conditions is largely unknown, and likely varies in response to environmental variation (e.g., weather, habitat heterogeneity). These types of uncertainty are often referred to as process error, i.e., imperfect knowledge of the biological system being managed. A second type of uncertainty is related to our inability to conduct a complete census of a population, i.e., partial observability (Williams 1997). This is sampling variation associated with wildlife monitoring, also commonly referred to as observation error (Hilborn and Mangel 1997). Process and observational error create uncertainty that limits a manager's ability to make informed management decisions.

The Bison and Elk AM plan will embrace existing uncertainty regarding drivers of bison and elk wintering abundance and distribution in the Jackson Hole area and on the National Elk Refuge (NER), provide further understanding of important limiting factors, and help guide management actions toward those that will have the most direct benefit to achieving stated goals and objectives. The Bison and Elk Management Plan (BEMP; USFWS and USNPS 2007a) provides goals, objectives, and strategies related to bison and elk population in the Jackson Hole area and within the NER. The AM plan is an extension of the BEMP, providing an adaptive management framework to achieve the goals and objectives of the BEMP. Therefore, the AM plan is considered a step-down plan to the BEMP and utilizes the goals and objectives within the BEMP. Strategies from the BEMP were incorporated into additional strategies considered during the development of the AM plan. The AM plan and associated efforts is an opportunity to collectively learn from ongoing work to manage elk and bison in the Jackson Hole area.

The BEMP contains four goals (Fig. 1) and 20 associated objectives (Appendix I). The AM plan relates to three of the four goals and 10 of the 20 objectives in the BEMP (Appendix I). Four of the objectives relevant to the AM plan relate to populations of elk and bison in the Jackson Hole area. The **Sustainable Populations** BEMP goal outlines a two-phase approach to reduce the number of elk on supplementary winter feed while achieving 1) WGFD population objectives for the Jackson Elk Herd (JEH) and 2) an elk sex ration in GTNP of 35 bulls for every 100 cows. The first phase sets initial population objectives at 5000 elk on winter feed. The second phase calls for elk populations that are adaptively managed to "achieve desired conditions, with animals relying predominantly on native habitat and cultivated forage". The bison population objective of 500 animals post-hunting season was determined based largely on maintaining genetic heterozygosity while minimizing other conflicts (USFWS and USNPS 2007a). Unlike the second phase elk objective, the bison objective is independent of desired habitat conditions.

Desired habitat conditions on the NER are defined in the BEMP and Comprehensive Conservation Plan (CCP; USFWS 2014). The former includes criteria based on area and condition

of aspen, cottonwood, and willow. The CCP includes criteria for sage-brush grasslands and wet meadow habitat on the NER (**Habitat Conservation** goal, *Habitat Problems* objective category; Appendix I). **Need more information on the criteria in the CCP for these habitats, and to include this information in the Appendix I figure. Do we briefly describe the link between wintering elk population and desired habitat conditions here?**

The Phase I objective of 5000 elk appears to have originated from Hobbs et al. (2003). This report, based on three simulation exercises, concluded that "in average SWE winters with average pre-winter precipitation and 500 bison, roughly 16,000 elk can find forage on the Greater Teton Ecosystem without incurring forage deficits and roughly 5,000 elk can find forage on the NER without incurring deficits." Hobbs et al. (2003) do not explicitly define winter in the report, but appendix B of the report describes the 'entire winter' as 'roughly November 1st to July 1st'. Presumably the numbers given in the report represent the number present throughout the winter period, although this is not explicitly stated. It is important to note that elk use stored energy reserves during winter, so incurring a forage deficit does not imply an immediate threat.

The number of elk on winter feed on the NER and bison in the JBH currently exceeds the Phase 1 objective from the existing BEMP (Fig. 1) (USFWS and NPS 2007). The JEH, which includes elk wintering on the NER, is within WGFD objective, while the JBH population is above objective. Therefore the primary issues for reaching Phase 1 population objectives are related to 1) distribution of elk during winter, and 2) abundance of bison.

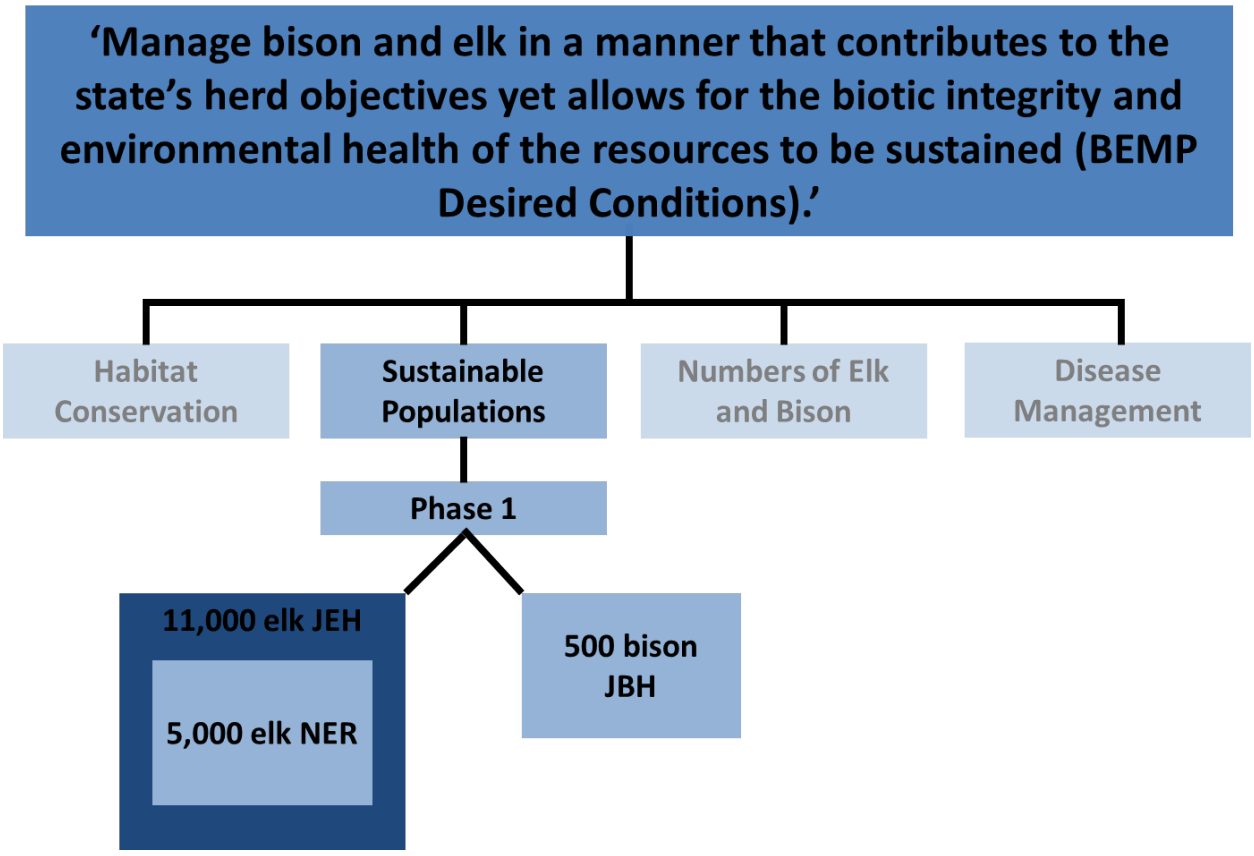

Figure 1. Hierarchical relationship among the vision, fundamental objectives and Phase 1 objective for elk and bison in the Bison and Elk Management Plan (USFWS and NPS 2007). The National Elk Refuge (NER) winter elk population objective is a sub-objective of the Jackson elk herd (JEH).

Population of Interest

A succinct and precise definition of the populations of interest is essential for developing models of system dynamics and appropriate monitoring, and determining if objectives are being met. Bison and elk populations of interest differ slightly in definition as stated in the BEMP objectives. The bison objective is for the post-hunt population within the Jackson Hole area (the Jackson Bison Herd [JBH]), inclusive of the NER. Conversely, the elk population objective for the NER is specific to the number of animals on feed at the refuge, and is a sub-objective within the broader Jackson Elk Herd (JEH) (Fig. 2) post-hunt objective set by the Wyoming Game and Fish Commission. Elk herd unit boundaries are determined by the Wyoming Game and Fish Department (WGFD) and represent population boundaries where there is an estimated annual interchange with surrounding herds of <10% (Emmerich et al. 2007). Approximately 65% of the JEH winters on the NER based on February classification counts (see below for definition of classification counts; USFWS & WGFD unpubl. data). The Jackson bison herd primarily winters on the NER (~90%), but range much further during the rest

of the year (USFWS & WGFD unpubl. data). **Geographic range of bison, figure, etc. It would be best to include a single figure that delineates the JEH and bison population; I emailed Kathryn Mellander (GTNP GIS manager) on 10/25 to see if she had a figure or shapefile of the Jackson bison herd's range. Haven't heard back from her as of 11/13 – could Sarah or Steve follow-up? I sent Kathryn another email 2/26/2014.**

Determining if the BEMP population objectives are being met requires periodic estimates of the populations of interest. There are two components to the population objectives that need to be considered — where animals are and when they are there. The BEMP bison population objective is the same for the JBH as it is for the NER, i.e., there is not a sub-objective specific to the refuge as there is for elk. Moreover, the bison population objective is less temporally specific than that for elk, the former being an annual post-hunt population objective and the latter being defined based on the number of animals on feed. This aspect of the elk objective increases the difficulty in estimating the population of interest due to movements of animals into and out of feedgrounds during winter feeding. More importantly, the amount of time elk are on feed varies among years.

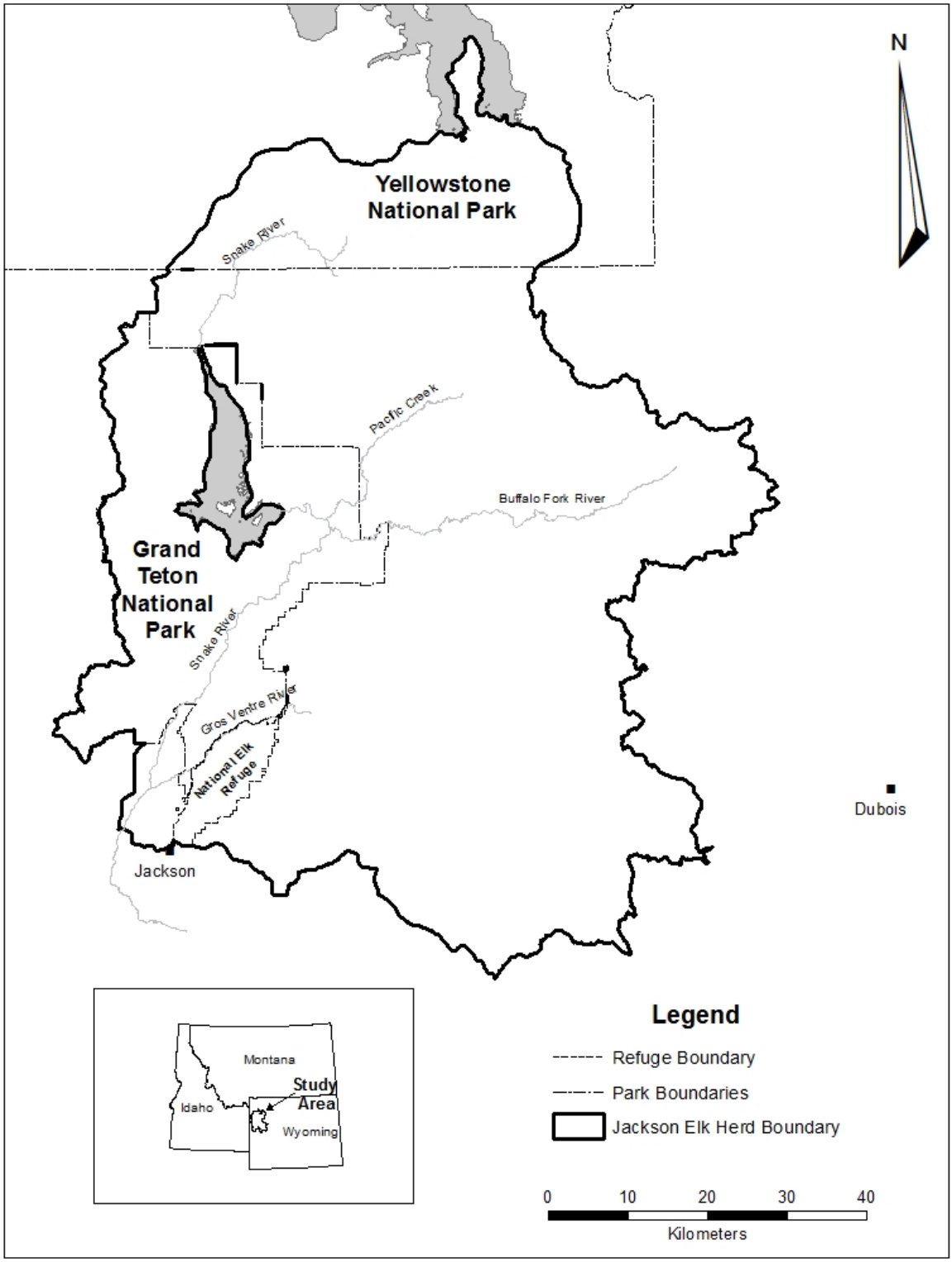

Figure 2. Jackson Elk Herd unit boundary, including the National Elk Refuge and Grand Teton and Yellowstone National Parks. <u>INCLUDE BISON RANGE IN THIS FIGURE.</u>

While not explicitly stated, the BEMP was written with an assumption that annual classification counts were to be used as the metric to determine if population objectives were being met, i.e., as a proxy for the number of elk on feed at the NER. Classification counts are a coordinated census of the JBH and JEH, collaboratively undertaken during early February by WGFD and the NER. These counts are undertaken during a single survey period and do not necessarily represent either peak or cumulative abundance (i.e., the greatest number counted on a single day during a winter, or the sum total of animals counted throughout a winter, respectively) of bison or elk on feed. Elk and bison are enumerated by age and sex classes, providing population class structure information as well as overall abundance. Elk classes recorded during the classification count are calf, cow (includes yearlings), spike bull, and mature bull; bison classes are calf, yearling cow, yearling bull, adult cow, adult bull. A 5-10% difference typically exists between the classification count estimate and the daily number of elk on feed during peak abundance. Peak elk abundance on the NER during 2007–2013 occurred late February through the first week of March (USFWS unpublish. feedline data) (Fig. 3). Proposed changes to a less conservative feeding program that would result in a later initiation of winter feeding (see **Development of Alternative Management Actions and Strategies** below) could increase the difference between when the classification count is conducted and peak numbers of elk on feed. A less conservative feeding program could also result in initiation of feeding on the NER after the classification count has been completed in some years. Lastly, the classification count may be replaced in the near future by survey (i.e., not a census) methodology used elsewhere in the state by WGFD for estimating elk abundance. The new survey methodology may not provide suitable NER-specific estimates of elk abundance for determining if refuge population objectives are being met.

Beyond logistical or methodological considerations, a single elk population estimate in time would not adequately capture the dynamic nature of elk abundance in relation to winter feeding on the NER. For example, 5000 elk on winter feed (the current BEMP Phase 1 objective) for three months would likely have a greater impact on NER habitats than 5000 elk on feed for a single month. The BEMP Phase 1 elk population objective is not defined by time, leaving it open for interpretation whether the objective was intended as a mean number of animals fed during a winter, a maximum number fed, or a cumulative number fed. To address this issue while staying within the implied intent of the BEMP, we chose elk-fed days (*EFD*; the cumulative number of elk fed during a feeding season) as the metric for determining if the elk population objective is being met. This number combines both the spatial and temporal aspect of animals on the NER, providing better accounting of potential effects than a single classification count. It is also believed that this is more consistent with winter carrying-capacity projections estimated in Hobbs et al. (2003). The Phase I objective of 5000 elk on feed is defined relative to elk-fed days as

$$EFD = d * 5000 \text{ elk},$$

where *d* is the mean number of days of feeding from 1995–2007 (64 days [SD = 22]). This time span was selected to maintain consistency with the data used in developing the BEMP. The benchmark historical *EFD* value is then 320,000. Bison-fed days (*BFD*) can similarly be calculated as 31,500 *BFD* for bison using *d* = 63 days (SD = 22) and substituting the population objective (500 bison). This latter value provides an important historical perspective on winter feeding of bison and can assist in determining efficacy of management actions toward accomplishing the bison objective; the population objective (500 bison) will be the definitive number used for determining if Phase 1 objective is being met.

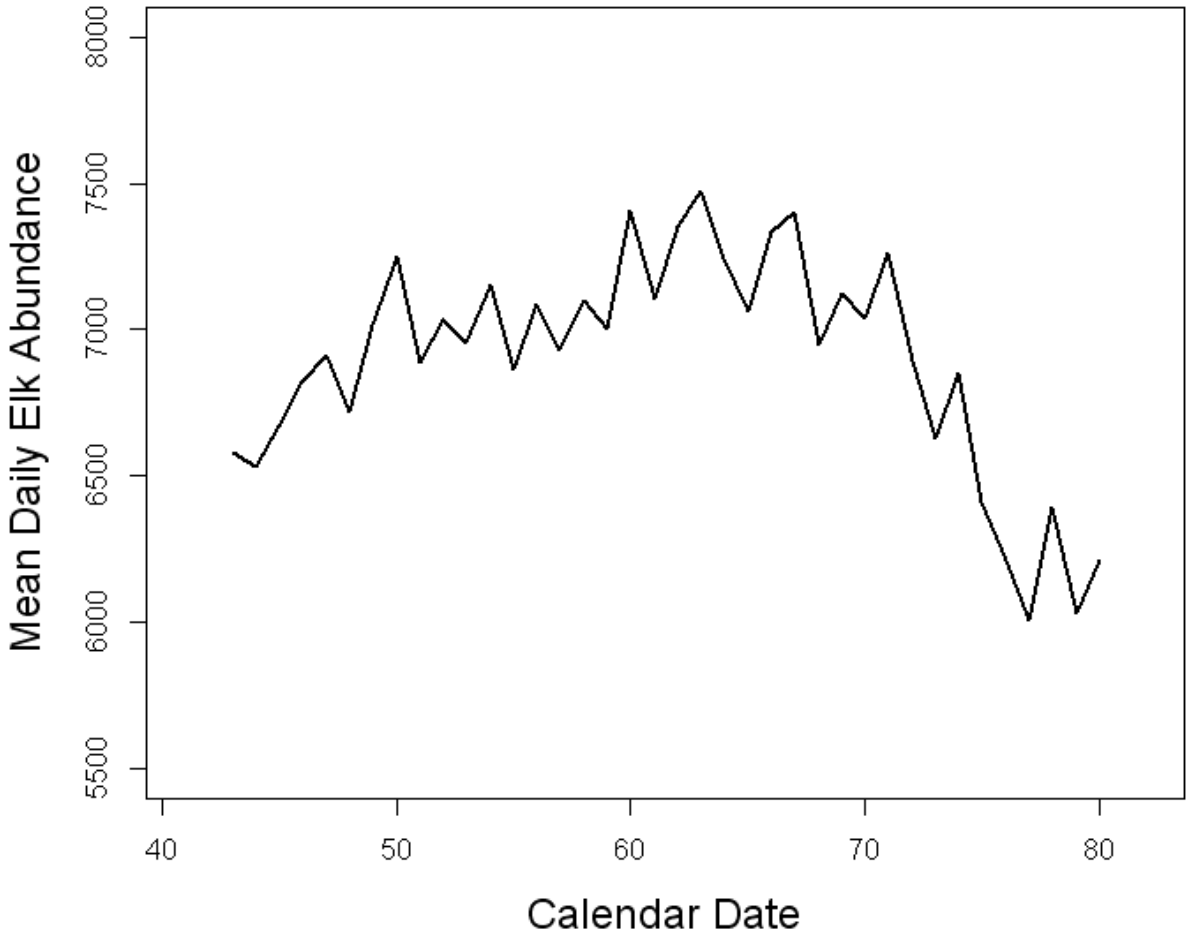

Figure 3. Mean daily elk abundance on the National Elk Refuge during winter feeding, 2007–2013. Data are from feedline counts for calendar dates where feeding occurred during all

years, i.e., February 12th (calendar date 43) through March 21st (calendar date 80). Counts were conducted from feeding equipment.

Limiting Factors

Limiting factors are demographic components that limit population growth of a species. Identifying limiting factors, perceived and documented, help us better define existing uncertainty regarding drivers of elk and bison population and potential management actions, and monitoring to link the two together. In the current situation where management aims to reduce or limit a population to a specified objective, our understanding of limiting factors can be capitalized on to regulate population. For example, elk population growth is highly sensitive to adult female survival (Nelson and Peek 1982, Raithel et al. 2007), and therefore increased hunter harvest on adult females is a common approach to reduce elk populations. In this scenario, increased hunter harvest of adult females is the management action that could be employed to reduce a population to objective. This assumes population abundance is the issue to be addressed. Conversely, if population distribution is the primary issue to be addressed management actions to alter animal distribution would be employed.

Winter distribution of elk and bison on and near the NER is influenced by winter feeding. The present feeding program is conservative in implementation of feeding to minimize elk 1) winter mortality of the most susceptible group, calves, and 2) comingling issues with cattle on adjacent private lands. Therefore, current feeding programs are minimizing a potential limiting factor – winter mortality**.** Moreover, winter feeding alters the distribution of elk and bison, which can result in localized concentrations of animals above stated objectives.

Development of Alternative Management Actions and Strategies

Alternative management actions were identified during a meeting of stakeholders at the NER 22 May 2013. Three lists of alternative actions, and constraints, were developed; one each for the JEH, NER winter elk population, and the JBH. Alternative actions for JEH and NER winter elk population were separated due to potential conflicts. A series of further meetings (25 July, 20 August, 12 September, 23 October 2013) were held to create management strategies, i.e., collections of actions that form complete and comparable alternatives (Gregory et al. 2012).

Reference case—It is often helpful to identify a reference alternative that captures the recent and ongoing management actions that have led to the current state of the system for comparing with new alternatives that are developed. Ongoing management actions include winter feeding, irrigation, harvest, and hazing.

Big game population objectives in Wyoming are evaluated and updated at least every five years. Objectives represent the preferred number of animals during winter within a herd unit (e.g., the Jackson Elk Herd) and are determined based upon multiple factors, including 1) available habitat to support the defined population, 2) hunting access, and 3) tolerance for wildlife on private lands by landowners (Tassell et al. 1995). Public input on proposed population objectives is obtained during public hearings. After the hearings the proposed population objectives are sent to the Wyoming Game and Fish Commission (a governor-appointed policy-making board) for review and approval. The NER, GTNP, and BTNF have actively participated in WGFD big game population objective review and revision processes in the past for both the JEH and JBH. These federal agencies will continue to participate in objective setting for the JEH and JBH populations.

The current JEH winter feeding program includes two groups of feedgrounds – one on, and managed by, the NER, and the second managed by WGFD. The latter are the Alkali, Fish Creek, and Patrol Cabin feedgrounds, collectively known as the Gros Ventre feedgrounds, located on US Forest Service land. Initiation of feeding is currently conservative, i.e., has the primary objectives of minimizing elk 1) winter mortality of the most susceptible group, calves, and 2) comingling issues with cattle on adjacent private lands. Winter feeding begins when available forage reaches approximately 300 lbs acre^{-1} at key index sites. Available winter forage for elk and bison on the NER is largely determined by snow conditions, rate of forage consumption during fall and winter, and biomass of forage produced during the previous growing season.

Forage biomass (metric tons) is correlated with the amount of precipitation (mm) during May–August ($\beta_{precip} = 50.31$, R^2 = 0.91; 1995 and 1998–2006 data), and secondarily affected by the number of irrigated acres. Refuge-wide herbaceous forage production averaged 14,387 (SD = 4125) tons during 1998–2013, and in recent years irrigation of approximately 3,600 acres has increased forage production by approximately 10% compared to what would have been produced with precipitation alone. Estimation of forage biomass is done annually based on sampling at index sites. Index sites are selected subjectively each by year based on presence of vegetation highly palatable to elk such as naturally sub-irrigated wet meadows, irrigated areas with significant green vegetation, and in years with adequate late summer/early fall precipitation, native dry grassland plant communities with basal green up.

During 1995–2013, mean initiation of winter feeding on the NER was 28 January, ranging from 30 December to 28 February. Mean termination of winter feeding during this same period was 3 April, ranging from 20 March to 20 April. Initiation and termination dates vary widely based on winter conditions. Excluding years in which feeding did not occur, mean initiation and termination dates for winter feeding during 1976–2013 at the Gros Ventre feedgrounds

occurred during the second week of January and first week of April, respectively (Table 1). This resulted in approximately 3 months of feeding each year.

Table 1. Winter feeding mean initiation and termination dates and total days for the Gros Ventre feedgrounds managed by Wyoming Game and Fish Department. Standard deviations are provided parenthetically.

Feedground	Initiation Date	Termination Date	Total Days
Alkali	10 January (18.8)	7 April (13.5)	89 (23.5)
Fish Creek	9 January (12.3)	4 April (17.1)	85 (21.0)
Patrol Cabin	11 January (13.5)	4 April (11.6)	84 (19.0)

Winter feeding coordination between the NER and WGFD occurs annually. Feeding in the Gros Ventre feedgrounds is targeted specifically to assist in keeping animals from moving to the NER; for example, animals are more likely to move to the NER if feeding is occurring there and not at the Gros Ventre feedgrounds, where the opposite up-slope migration is less likely. Termination of feeding at feedgrounds needs to be coordinated so animals moving to the NER after feeding ends on the Gros Ventre feedgrounds do not remain at the refuge. This coordination will continue regardless of the management strategy employed.

Bison are fed as necessary to ensure elk are adequately fed. Bison out-compete elk for forage resources, so the typical strategy is to keep bison at the northernmost NER feedground (McBride) by feeding them prior to feeding elk. Bison are fed separately from elk and are given a ration adequate to ensure they do not move to elk feeding areas. This also influences distribution of bison in the winter, reducing conflict associated with bison moving into 1) Jackson, and 2) the Nowlin unit of the NER where commercial sleigh rides occur.

Total harvest of the JEH was reduced over the last decade as the population objective was reached (Fig. 4). Elk hunting on NER (Hunt Area 77) typically begins in mid-October and ends in mid-December, with peak harvest in recent years occurring in late November to early December. From 2005 to 2011 an average of 393 (SD = 56) hunters harvested 161 (SD = 38) elk per year during the NER hunt.

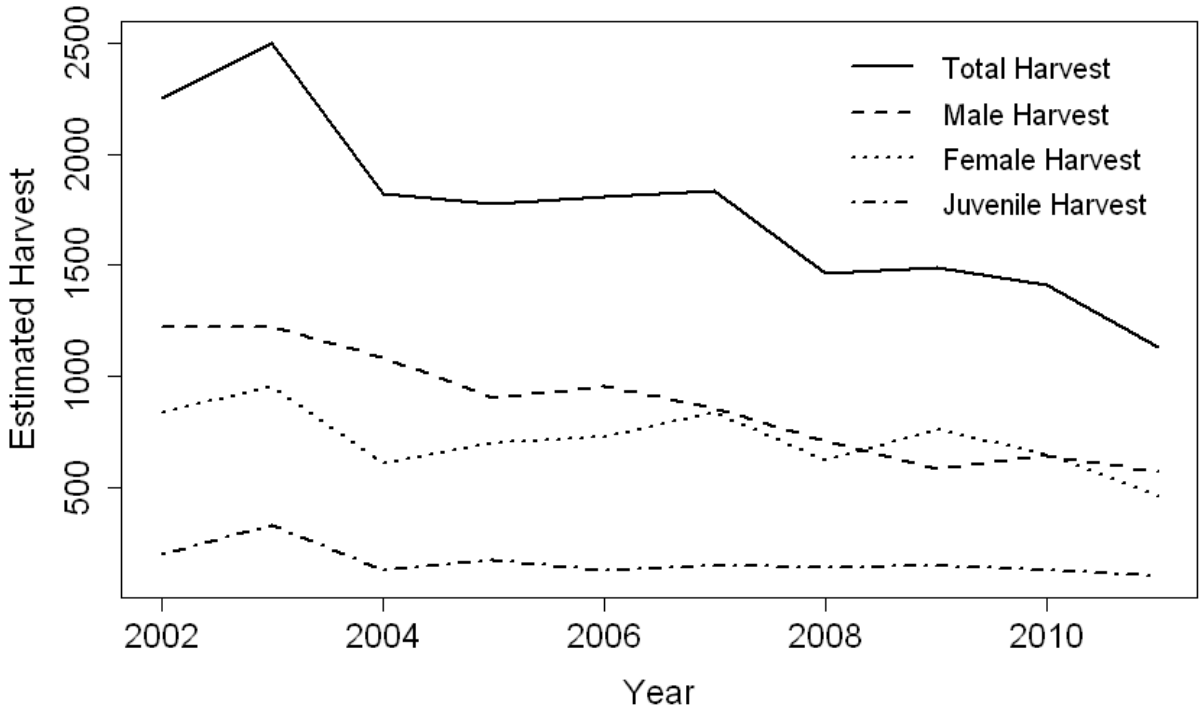

Figure 4. Jackson elk herd estimated harvest, 2002–2011.

Associated with harvest on the NER, "tag and drag" is a retrieval service currently provided by two licensed outfitters. They are also licensed to guide on the NER. This program will continue regardless of the management strategy employed.

Hazing of elk is currently only undertaken in spring to encourage elk (and bison) to move off of the NER. Attempts at post-hunting/pre-feeding hazing of elk to the north part of the refuge occurred (e.g., 2005–2006), but were largely ineffective with elk generally returning the following day to the south end of the NER. These efforts included hazing using ATVs, on foot, and on horseback. Reducing spring hazing to increase early-season harvest was considered as a potential action but not included due to 1) the perception that the loss of forage on the Refuge by resident elk during summer would offset gains due to increased harvest, 2) presence of wolves on the northern end of the Refuge may preclude the desired response of reduced hazing to keep elk on the north end of the Refuge, and 3) recently observed aspen recovery could be reduced if elk use increased on the north end of the Refuge.

Fencing of hay stacks and livestock feedline areas has historically been used to mitigate conflict on private lands. Fencing as mitigation on private land will continue in a targeted fashion. For example, a proposed mitigation in the Horse Creek area would involve a land trade with a

private landowner to move livestock winter feeding operations off of a south facing slope that is a movement corridor for elk. Fencing three sides of the private land would separate the corridor from the livestock feedline. Targeted fencing of golf course greens and sand traps fall through spring has been successful in some situations for mitigating elk and bison presence in these areas. It is important to note that the county has a 'wildlife-friendly' fence policy and does not support fencing impermeable to wildlife.

The outcome of the reference case described above for elk abundance and distribution during winter in the JEH is shown in table 2. Population objectives for the two feedground complexes are provided, as are annual elk abundances as measured during the classification count. The data presented in table 2 demonstrate the potential for reaching the Phase 1 NER winter elk population objective of 5,000 while remaining within the JEH objective of 11,000 (±10%).

Table 2. Annual distribution of wintering elk from the Jackson Elk Herd during February classification counts, 2011–2013, relative to the current objective.

	OBJECTIVE	2011	2012	2013	mean
NER	5,000	7,746	7,360	6,285	7,130
Gros Ventre	3,500	2,775	3,265	2,982	3,007
Native Range*	2,500	982	894	1,784	1,220
Total	11,000	11,503	11,519	11,051	11,357

*Excludes objectives for native range adjacent to Gros Ventre feedgrounds.

Bison numbers grew exponentially from the 1970s until recently, peaking at 1059 animals in 2007 (Fig. 5). Recent declines in the number of bison are largely attributable to increased hunter harvest on the NER. Bison hunting begins on August 15 and ends in early to mid-January; no bison hunting is allowed in GTNP, resulting in bison often staying in the park during the hunting season with only occasional movements onto the NER until severe winter conditions occur. Most bison harvest occurs on the NER, with some additional harvest on private and Bridger-Teton National Forest (BTNF) lands. Since the initiation of the bison hunt in 2007, typical harvest has been 220 bison per year. This level of harvest has been sufficient to arrest the exponential growth of the population, reducing bison numbers from the peak in 2007 to 855 animals in 2013 (Fig 5). Licensing changes for hunting Jackson Hole bison were enacted in 2014 to increase harvest, especially of bison females. These included a reduction in the bison female/calf license fee (from $416 to $263 for residents and from $2522 to $1022 for non-residents) and eliminating the once-in-a-lifetime restriction to a successful bison hunter to only those that successfully harvested a bull. Tribal bison harvest is currently defined in the BEMP to permit up to five animals for ceremonial purposes; tribal harvest generally occurs outside of the

state bison season. Translocation of bison to tribal lands outside of Teton County is not currently permitted due to disease (brucellosis) concerns.

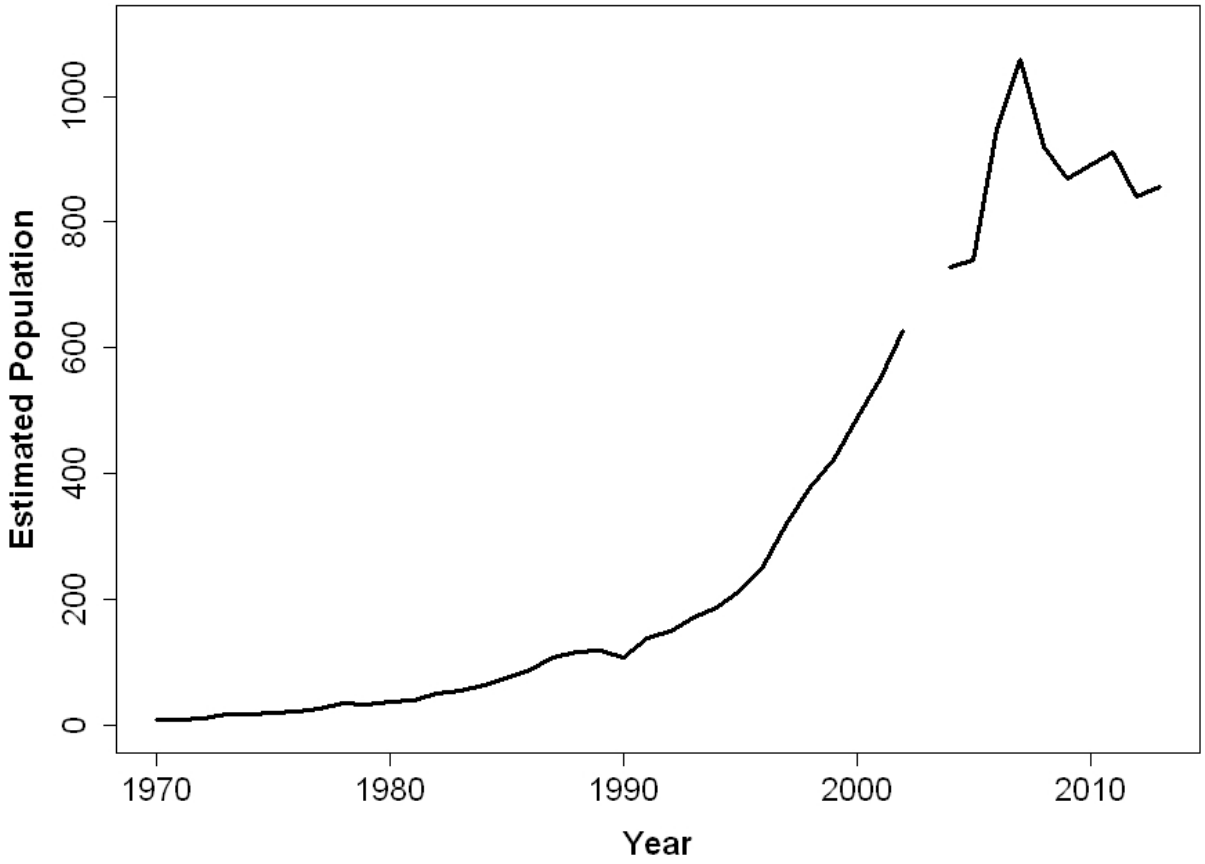

Figure 5. Bison winter population in the Jackson Hole area, 1970–2013.

Bison would likely occupy the refuge year-round without management intervention, but as a result of hazing by refuge staff and disturbance by hunters, peak bison activity on the NER occurs January–April each year. If bison fail to leave the NER following the cessation of supplemental feeding, they are typically hazed off the refuge using all-terrain vehicles (ATVs) in late April to early May. Hazing moves bison to Grand Teton National Park (GTNP), where they generally remain until mid-July. From July to early August bison that return to the refuge are hazed back to GTNP to protect forage for elk during the winter months. Hazing efforts in August cease within several days to weeks of the bison season in an effort to increase hunter harvest.

National Elk Refuge

Alternative management actions identified for meeting the NER winter elk population objective can be grouped into four categories, including 1) winter feeding management (both on and off the NER), 2) population management (harvest, culling, and fertility control), 3) habitat improvements (on and adjacent to the NER), and 4) mitigating private lands conflicts (leases/easements, incentives, fencing) (Table 3). The latter represent sequenced alternatives that would be necessary to implement due to wintering elk dispersing onto private lands adjacent to the NER in response to other management actions taken. A fifth group of alternatives associated with increasing public awareness (including local elected officials, e.g., county commissioners) of 'natural' levels of elk winter mortality were included after the meeting. These actions represent acknowledgement that the current feeding program results in reduced winter mortality, perhaps exacerbating already low public tolerance to increased winter mortality, whether episodic or perennial in nature. This group was expanded to include more targeted education and outreach efforts for landowners, sportsmen and agencies, and the WGFD Commission, depending on the strategy. Lastly, a group for each of monitoring and enforcement were included to allow proper accounting of projected costs associated with each management action strategy.

Table 3. National Elk Refuge winter elk population strategy table for identifying alternative management action strategies. Ongoing management actions that will be continued regardless of strategy selected are not included in the table; descriptions can be found in the 'Reference case' description within the text.

	Reference Case	NER-focused	Southern herd segment mngmnt	Late Season Harvest
Winter feeding management				
No change	**X**		**X**	**X**
Less conservative (NER)		**X**		
Population management				
No change	**X**			
Increase harvest objectives in Hunt Areas 77 & 78			**X**	
Late-season refuge hunt (Hunt Area 77)		**X**	**X**	**X**
Coordinated late-season hunt (Hunt Areas 75, 77, 78, 80)				**X**
Extend open period on Forest Service				**X**
Fertility control (Hunt Area 78 &			**X**	

GTNP South)				
Hunt Area 78 Hunter management program			**X**	
Habitat improvements				
No change	**X**			
Fire management on NER and adjacent public land		**X**	**X**	**X**
Private lands mitigation				
No change	**X**			
Incentivize steer operations		**X**		
Non-traditional landuse mitigation			**X**	
Public education/outreach (EO)				
No change	**X**			
Increase public EO (including local elected officials)		**X**	**X**	**X**
Increase landowner EO		**X**	**X**	
Increase sportsmen & agency EO			**X**	
Increase WGFD Commission EO		**X**	**X**	**X**
Monitoring	**X**			
No change		**X**	**X**	
Increase				
Enforcement				
No change	**X**			
Minor increase		**X**	**X**	
Major Increase				**X**

Winter feeding management—Management of winter feeding is a primary driver of elk distribution, and to a lesser extent abundance, in the Jackson Hole area. Feeding on the NER is initiated each year based on a series of factors, including the amount of forage on the NER, number of elk present, and snow conditions. Initiation of feeding is currently conservative (see *Reference case*, pg **5**). A less conservative approach would result in later initiation of feeding, therefore potentially increasing winter calf mortality and comingling. Including agronomic grassland plant communities without significant green vegetation and/or reducing the available forage threshold would result in a less conservative winter feeding program. Per capita ration levels would not change from the current level.

Implementing a less conservative feeding program could result in very limited, or no, feeding given certain winter conditions. However, the criteria for a less conservative feeding program

would not be such that it could be construed as 'emergency feeding', i.e., feeding only to preclude a catastrophic mortality event. Colorado, Idaho, and Utah provide examples of states that have emergency feeding policies. Existing evidence suggests that emergency feeding is not very effective (see review in Putman and Staines 2004). Moreover, the current feeding regime has been developed for non-emergency situations; a review of current rations and pellet composition would be necessary to adjust the program for emergency feeding.

Population management—Hunter harvest is the primary tool employed for population management of elk and bison in Wyoming. Increased harvest objectives on/near the NER would target the southern segment (Hunt Areas 77 & 78), which is currently more productive (i.e., higher cow-calf ratios) than other JEH segments. Doing this would help achieve JEH objective while minimizing harvest on migratory segments. In order to track hunter harvest there would need to be an increase in monitoring, e.g., hunter self-registration.

Elk hunting on the NER currently ends mid-December. Offering a late-season hunt (after 15 December) would assist in deterring elk from moving onto the refuge. Without coordinated hunts in adjacent units (Hunt Areas 75 [GTNP], 78 and 80), and extended open access on BTNF lands in Hunt Area 80, the NER hunt would likely be ineffective in also significantly increasing harvest. Late-season harvest in Hunt Area 80 would include migratory Yellowstone elk, a declining herd segment of conservation concern. These proposed coordinated efforts would need to be approved by the Commission, BTNF, and GTNP.

Fertility control in Hunt Area 78 and Grand Teton NP South would occur during summer. This action was considered and rejected in the 2007 BEMP, so therefore could not be undertaken on federal lands without vetting in the NEPA process. Moreover, this action would need approval by the WGFD Commission prior to the state undertaking fertility control. Research completed since signing of the BEMP indicates fertility control may be more tractable now than when it was considered during preparation of the BEMP. Killian et al. (2009) demonstrated effectiveness of GonaCon™, a gonadotropin-releasing hormone vaccine, in female elk. Dart-delivered 2 ml doses of 1000 µg GonaCon™ resulted in nearly complete infertility of females treated in September. Much of the early research on this immunocontraceptive vaccine was for use in white-tailed deer, with regulatory approval of GonaCon™ for use in female white-tailed deer by the U.S. Environmental Protection Agency granted in 2010. There are no known dangers to humans or wildlife from eating animals that have been treated with GonaCon™.

Most of the observed increase in segment population has occurred in the largely non-migratory Hunt Area 78 / Grand Teton NP south segment. Increased harvest in this segment would help address a number of issues, in addition to assisting in reaching Phase I objective. Harvest is

nearly as liberal as possible at this time; the greatest limitation is hunter opportunity in residentially-developed areas. Elk use in those areas is increasing, necessitating continued collaboration with homeowner associations to improve hunter access within residential developments. Many associations have covenants that exclude firearms, but archery may be an option where firearms are excluded. There is also a growing constituency for trophy bulls in these areas.

A hunter management program for Hunt Area 78 would coordinate private land access through a hunt manager as liaison to private landowners. This program would be modeled after similar programs in Montana, as well as several in Wyoming (Meteetse, Laramie Peaks, etc.).

Habitat improvements—Habitat improvements discussed so far have focused on fire treatments on range adjacent to the NER to increase attractiveness of these areas to wintering elk. Opportunities exist for managed fire in certain areas, but opportunities for prescribed fire are limited. Fire treatments in lynx habitat would not be possible, therefore it would be necessary to determine if a conifer stand was suitable lynx habitat as based on tree cover. Conversely, areas within sage grouse core habitat (i.e., within a 4 mile radius of a lek) have a 5% disturbance cap that would similarly preclude fire treatment. Areas mapped as wildland urban interface (WUI) are available for treatment, but treatments need to be defined as a fuels reduction.

There is potential to have fire management areas on the refuge, but the conflict with sage grouse on the northern portion of the NER, which is identified as sage grouse core habitat, would need to be addressed. The plan will therefore include prescribed fire even if it isn't a primary tool. These changes would represent a small, ephemeral gain at best in changes to habitat that may result in more elk wintering outside of the NER. Wildland fire use (i.e., wildfire to meet resource objectives) is authorized forest-wide in the BTNF. Much of the BTNF adjacent to the NER is within the Gros Ventre Wilderness, which is managed to allow "natural processes of ecological change to operate freely. The number, size and intensity of fires [are managed to] approximate the natural fire regime" (USFS 2013). Benefits from wildland fire use on adjacent national forest lands are therefore opportunistic in nature.

Private lands mitigation—Easements and leases have been proposed as a means to minimize livestock and elk conflict related to brucellosis. Easements would incentivize steer operations by purchasing from willing sellers the right to have cow/calf pairs. Easements should also consider all winter feeding of livestock (e.g., horses), certain agricultural crops that are attractants to elk (e.g., irrigated hay), as well as hunting access. These easements would be purchased and enforced through agencies and local land trusts. Leases in the Spring Gulch area

are not a suitable solution due to the current level of development; may be an option in Buffalo Valley assuming the weather allows animals to winter there. Leases/easements would need to include a statement that the individual would forfeit their right to make a depredation claim to WGFD.

Non-traditional landuse mitigation would differ from that described above for traditional landuses. For example, the Jackson Hole Conservation Alliance is working with subdivision landowners to install landscaping that is less attractive, and more resistant, to elk and deer. Similarly, WGFD assesses subdivisions to identify issues for mitigation, and provides input to real estate developers and in county planning documents. Also, targeted hazing in subdivisions and golf courses is ongoing and will continue on an as-needed basis.

Public education/outreach—Each partner agency will have the opportunity to become involved in the planning and execution of education and outreach (EO) efforts. Increased public EO efforts will be undertaken regardless of the strategy selected. These efforts will include increasing public awareness of, and tolerance for, natural levels of winter mortality in elk. This would be accomplished through local news releases and radio announcements, training for sleigh-ride contractors that includes information on winter mortality in unfed populations of elk, etc. Regular updates on the planning process and progress towards meeting objectives set out in the BEMP will also be provided to the public through NER media outlets. County Commissions will be included in public EO efforts to make sure they are aware, and supportive, of the agencies' efforts.

Landowner EO would differ between those engaged in more traditional agricultural landuse (i.e., ranching) and non-traditional landusers (i.e., residential developments, golf courses). The decision to change a livestock operation from cow/calf to steers (non-breeding) is a major decision. It is not expected that ranchers would respond to an article in the paper, news story on the radio or even a letter. This kind of effort will require primarily one-on-one interactions with an individual that has built relationships and trust within the community. This would require a private lands biologist to work with private landowners in the area. The position could be a shared position among agencies. Conversely, EO focused on homeowners in exurban developments will focus more on meetings with homeowners' associations, residential developers, etc., to provide information regarding living with wildlife, wildlife management and conservation, etc. All agencies will need to collaborate in initial efforts to reach key landowners and homeowner associations to convey the objectives and primary issues involved in managing elk and bison in Jackson Hole, as well as to express the importance of their involvement in the process. WFGD is currently doing this in some areas, e.g., Hunt Area 78.

Sportsmen EO would include meetings with local and regional sportsmen's clubs and ideally articles in club magazines, Wyoming Outdoors, etc. General newspaper articles could also help disseminate information. This could be largely accomplished with existing staff.

Agency EO is happening to some degree through AMP meetings. It would be helpful to focus on two different groups; field staff and Regional Office managers. Field staff are instrumental in achieving management actions on the ground, but also support changing public opinion in the local area through their personal interactions outside of work. Regional office EO is essential in building the necessary support to obtain project resources and have support when controversies are elevated to their level.

WGFD Commissioner EO will require personal contacts coordinated with WGFD. Top priority will be the commissioner for this area and perhaps others. This will include 1) tours of the NER and GTNP and 2) a briefing on alternative strategies resulting from the AMP.

Monitoring—**Draft once strategies are finalized.**

Enforcement—**Draft once strategies are finalized.**

Contstraints

Constraints that were identified for managing wintering elk population on the NER were diverse and included policy/regulatory, biological, social, and funding constraints, and combinations thereof (Table 4). The most common constraints were policy related (33%), followed by social (28%), biological (22%), and funding (17%) constraints. Many of the identified constraints could be identified in multiple groups; we largely identified constraints as belonging to a single group to simplify classification.

Table 4. Management constraints identified for the National Elk Refuge wintering elk population objective.

Policy constraints

Hunt end date (Feb. 1st)
Carcass disposal (Feb. 15th)
Commission structure (WGFD)
Forest Service access (Dec. 1st closure)
Easement limitation (NER boundary)
2007 EIS (rejected fertility control and test and slaughter; limits tribal harvest)

Social constraints

Hunter numbers
Winter mortality (social acceptance)
Public safety (ungulate/vehicle collisions)
Disease (cattle commingling)
Land-use conflicts (agricultural and residential)

Biological constraints

Disease
Sage grouse habitat conflicts
Fencing/wildlife conflicts
Migratory segment (maintain summer distribution goals)

Funding constraints

Easements
Fencing
Fertility control

National Elk Refuge Strategy Narratives

Management action strategies were divided into themes based on the focus of the grouped actions within a strategy. For example, the National Elk Refuge-Focused strategy targets winter elk distribution through management actions primarily taken on the refuge. The Southern Herd Segment Management strategy is a set of actions intended to reduce the number, and productivity, of the largely non-migratory elk in Hunt Areas 75 and 78 while minimizing the risk of harvest to migratory segments of the JEH. The Late Season Harvest strategy would increase harvest more generally in the JEH through coordinated late season hunts, with key caveats outlined below. Several actions were identified as necessary to continue, or implement, regardless of the strategy selected. Those to be continued are the 1) intra-seasonal management and coordination between the NER and WGFD Gros Ventre feedgrounds, 2) fencing for private lands mitigation, and 3) “tag and drag” and guided hunts on the NER and GTNP. New actions to be implemented across all strategies include 1) a late-season refuge hunt, 2) Fire management on NER and adjacent public land, 3) increased public education and outreach, and 4) increased WGFD Commission education and outreach.

National Elk Refuge-Focused Strategy

The NER-focused strategy is based on altering distribution of elk using management actions centered primarily on the refuge. This strategy implements actions to make the refuge less attractive to wintering elk primarily through a less conservative winter feeding program and initiation of a late-season hunt. This assumes that a proportion of elk that winter on the refuge can be conditioned to stay on adjacent winter range based on decreasing the incentive (later initiation of feeding) and increasing the disincentive (late season hunt) to moving onto the

refuge. Incentivizing steer operations on private lands would be undertaken to address the increased proportion of elk that may winter on adjacent private lands. Similarly, education and outreach to private landowners is included in this effort to increase acceptance of elk wintering on private lands adjacent to the NER. Increased enforcement on the NER would also be necessary due to the addition of the late-season hunt.

Southern Herd Segment Management Strategy

The southern herd segments (Hunt Area 78 and GTNP South) are increasing absolutely and proportionally within the JEH. Conversely, migratory segments (i.e., elk that summer in Yellowstone NP and Gros Ventre Wilderness) of the JEH are stable to declining. The Southern Herd Segment Management Strategy focuses management actions at slowing, or reversing, the growth of the southern herd segments. Proposed actions include increasing harvest through the development of a hunter management program, a program that also helps address private lands mitigation. Targeted fertility control on summer range would also be considered, but would need to go through the proper approval process (i.e., WGFD Commission). This action was considered and rejected in the BEMP. Increased outreach to sportsmen and agencies, and landowners, would be undertaken; the former is due to the potential for fertility control and the latter is for increasing awareness of landowners of the efforts to reduce the southern herd-segment. Increased harvest is localized by this strategy, minimizing the potential impact of increased harvest on the migratory segments. Increased enforcement on the NER would also be necessary due to the addition of the late-season hunt.

Late Season Harvest Strategy

The Late Season Harvest Strategy represents a broader, landscape scale approach to achieving the Phase I elk objective. A coordinated (i.e., NER, WGFD, GTNP, BTNF) late season hunt in Hunt Areas 75, 77–78, and 80 would occur. Approval would need to be obtained for extending, or moving, the current season in GTNP to allow later harvest. Lastly, the current December 1st closure to protect wintering ungulates in Hunt Area 80 on BTNF lands would need to be modified through an environmental review process to allow hunter access into that area. Currently the JEH could be reduced by approximately 1,000 animals before being below objective (11,000 ± 10%). A WGFD Commission approved reduction in the JEH could be investigated if the efforts of this strategy did not result in reaching the NER Phase I elk objective. An increase in enforcement would be necessary if this strategy was implemented.

National Elk Refuge Strategy Consequences

Considered but not included in the consequences table (covered in the EIS) – average annual private sector revenue; altered archeological resources;

Table 5. Predicted consequence table for the National Elk Refuge (NER) elk population on feed alternative management action strategies. *This table is not currently cited in the text*

Objective[a]/*Decision Consideration*[b]	Evaluation criteria	Reference Condition	NER-focused	Southern herd segment mngmnt	Late season harvest
Elk-fed days[a]	Years to reach objective				
Herd segment distribution[b]	Proportion long-distance migrants				
Financial[b]	Average annual additional costs to agencies ($000)				
	Commercial landuse additional costs				
Social[b]	Sportsman/outfitter support				
	Environmental group support				
	Commercial landowner support				
	Residential landowner support				
Safety[b]	Animal/vehicle collisions				

[a]The identified objective from the BEMP Phase I for this table is 5000 elk on winter feed at the NER, which has been converted to elk-fed days (see Population of Interest above).

[b]Additional decision considerations and evaluation criteria were identified by the working group for comparison among strategies.

Bison

Alternative management actions for bison on the NER and adjacent areas included several developed for the NER wintering elk population objective in addition to those solely developed for bison (Table 6). Most of the actions identified were related to bison harvest in an effort to influence hunter access or success.

Table 6. Bison population strategy table for identifying alternative management action strategies.

	Reference Case	Hunter Harvest	Supplemental Culling
Population management			
No change	**X**		
January hunt extension			
Improve late-season access to north end of NER for hunting and carcass retrieval		**X**	**X**
Parking lot origination management		**X**	**X**
Agency cull*			**X**
Herd-wide fertility control*			
Hazing			
No change			
Haze bison found south and east of Flat and Nowlin creeks		**X**	**X**
Agency-accompanied hunters		**X**	**X**
Habitat improvements			
No change	**X**		
Fire management on NER and adjacent public land		**X**	**X**
Water source improvements			
Private lands mitigation			
NER south-boundary improvement			
Public education/outreach (EO)			
No change			
Increase education and outreach			
Monitoring			
No change			
Enforcement			

No change
Increase

Population management—Hunter harvest of bison since 2007 has led to an appreciable reduction in the population (Fig. 5). Further efforts to increase hunter harvest are intended to reduce the number of years necessary to reach the bison population objective. Most of the actions identified are related to increasing opportunity and success at the existing level of hunter numbers. The current number of hunters each year is believed to be a maximum number allowable while still providing a quality, and safe, hunting experience.

January hunt extension.

Efforts to improve late-season access to the north end of the NER for hunting and carcass removal could facilitate increased harvest. Existing retrieval roads become impassable late in the hunting season due to snow, and can, for example, preclude hunters from using the West Parking Area or retrieving carcasses on the northern portion of the refuge. Keeping these roads open may be difficult in heavy snow years, requiring a bulldozer in some situations. Alternatively, over-the-snow vehicles could be considered for carcass retrieval on existing refuge roads. Hunter access easements across private lands on the northeast corner of the NER will be explored as another means of providing access to that portion of the refuge for hunting and carcass retrieval.

Hunters must originate from a designated parking area for hunting bison on the NER. All but one designated parking area are within the NER. Access to the northwest portion of the NER is via a parking area within and managed by GTNP in collaboration with the NER. Accessing the refuge for hunting from BTNF lands along the eastern boundary of the NER was historically not allowed. The refuge will continue to manage hunter distribution using parking-lot origination in an effort to encourage bison to move onto, and remain, on the refuge. Hunters with a NER permit will also be allowed to access the refuge from adjacent BTNF lands.

Culling of bison is currently not used as a population management action and is only employed in situations where public safety or private property are at risk (WGFC regulations, chapters 41 (2002) and 15 (2004)). Including an agency bison cull as a potential population management action in this plan does not imply agency approval at this time and would only receive further consideration upon meeting several criteria. Actions described in this plan to improve hunter success would need to be implemented and provided a minimum of **X** years to demonstrate effectiveness in achieving the bison population objective. If hunter harvest proves incapable of reducing the bison population or growth rate, the planning group (i.e., NER, WGFD, GTNP, and

BTNF) may pursue agency support for conducting an agency cull as a supplementary action to hunter harvest. Consideration of an agency cull would include meeting National Environmental Policy Act (NEPA) requirements. WGFD policy prevents elk hunting past January 31st to minimize hunter contact with **not sure how to word this, i.e., I don't know why the deadline reduces the potential for exposure/transmission of brucellosis to hunters** (bison have not been considered within this policy at this time). Between February 1st–15th WGFD personnel can harvest animals (**does this pertain only to elk?**) and the animals can be donated to area food banks; animals killed after February 15th must be disposed of in a landfill (**can we cite WGFD policy here?)**.

Need to define a threshold of years (?), but not hard numbers (?), retaining as much flexibility as possible. Simple population model would help us better understand what type of time horizon we're looking at. Include a projection so that we don't wait 20 years. Harvest >240 bison in 2013.

Herd-wide fertility control of bison was considered and rejected in the BEMP. A review of fertility control in wildlife, current at the time of approval of the BEMP, can be found in Appendix B of the final Environmental Impact Statement (EIS) (USFWS and USNPS 2007b). **Need to gather more details on the current state of knowledge for this technique – would it be possible to have the WGFD vet draft a few sentences, with current citations, for this purpose? Seems like this would have to occur on the feedline to be efficient and effective, which would trigger NEPA.** Bison primarily occur on federal lands, so proposed implementation of this action would necessitate following NEPA requirements. Jack Ryan (APHIS) has been working on bison fertility control.

Hazing—Reduction, or elimination, of winter feeding will likely result in bison having a broader winter distribution in Jackson Hole. This could lead to more frequent use of the Nowlin unit by bison; the Nowlin unit is where commercial sleigh rides are conducted. Moreover, increased bison use of the southern portion of the NER beyond the Nowlin unit increases the potential for bison to enter the town of Jackson. For public safety and to minimize conflict in the Nowlin unit, bison will be hazed north if found **south of the line originating at the eastern boundary of the NER at Twin Creek Ranch Road, west along Twin Creek Ranch Road to Nowlin Creek, northwest along Nowlin Creek to Flat Creek, and southwest along Flat Creek to Highway 89.**

Agency-accompanied hunters in the NER's south units (**Which units? Does this include Miller Barn?**) could be used to haze bison to the northern units.

Habitat improvements—Fire management on NER and adjacent public land to increase attractiveness for bison would be the same as described above for elk (**pg X**). The objective, however, differs in that the purpose of attracting and holding bison on the refuge would be primarily to increase susceptibility of bison to harvest.

Water sources on the east side of the NER would be improved to encourage bison use and potentially early season harvest. There are existing springs that have been improved in the past and these could potentially be improved more – how? Water hole 2 – 'improved spring'; already piped, maybe try deepening the bore. Lost Springs (GTNF) already puts out good cfs. Water hole 3 – could this be improved?

Private lands mitigation—Bison primarily occur on public lands (i.e., NER, GTNP, and Bridger-Teton National Forest), and when they do occur on private lands WGFD has the authority to haze or destroy bison for safety or private lands damage concerns (WGFC regulations, chapters 41 (2002) and 15 (2004)). There is the potential for increased private lands conflict due to bison if winter feeding is reduced or eliminated on NER. For example, bison may move further south when feeding does not occur, increasing the potential for bison in Jackson. To reduce the likelihood of bison moving from the Refuge into Jackson, a double cattle guard will be installed on Elk Refuge Road at the boundary with East Broadway and at the gate where the town accesses the municipal water wells.

Public education/outreach—Public education and outreach for bison management will be integrated into EO provided for elk management (see pg. X). There are several important differences between bison and elk management that need to be articulated. The bison feeding strategy is fundamentally different, with the objective of bison winter feeding to eliminate conflict with elk feeding. Winter feeding of bison precludes many conflicts that would occur if bison were more broadly distributed within Jackson Hole, e.g., bison in the town of Jackson and the associated public safety conflict. As winter feeding is reduced, or eliminated, efforts will be made to manage potential increased conflict, but public acceptance of increased conflict will be necessary. There are important biological differences between bison and elk that will be highlighted. For example, bison have approximately twice the reproductive rate of elk (**need a citation for this**). During the six-year (**is this correct?**) period taken to write the BEMP the bison population grew exponentially, increasing from 627 animals in 2002 to 1059 in 2007 (WGFD, unpubl. data). Finally, the bison population objective differs from the elk objective, with the former based primarily on maintaining genetic heterozygosity while minimizing conflict (USFWS and USNPS 2007a). **Are there specific management difficulties that have been experienced that should be highlighted here?**

Separate action for agencies similar to what we did for elk? Increased EO to state agencies (**are we primarily talking about DOL, or are there others? Is this related to increased conflict with agricultural producers?)** will be included as part of this action. The range of bison will likely expand as feeding is reduced/eliminated, potentially leading to more conflict on private agricultural lands.

Monitoring—Assess influence of commercial outfitters on hunter success; **need a narrative description of this. What are the reasons for it being exclusively in the bison strategy table?**

Enforcement—

Constraints

Constraints unique to bison management were largely related to disease transmission concerns and related policy (Table 7). For example, it is not currently possible to move bison out of the county, nor are bison currently allowed in the Gros Ventre near WGFD feedgrounds. Several identified alternative actions, fertility control and test and slaughter, were considered and rejected in the 2007 Environmental Impact Assessment (EIS) for the Bison and Elk Management Plan. The 2007 EIS similarly limits tribal harvest of bison. Moreover, there is uncertainty if an effective bison fertility control exists, which is a technological constraint. **What constraints from the NER wintering elk constraints table should be carried over to the bison constraints table?**

Table 7. Management constraints identified for the bison population objective.

Policy constraints
Hunt end date (Feb. 1st)
Carcass disposal (Feb. 15th)
Commission structure (WGFD)
Forest Service access (Dec. 1st closure)
Cumbersome hunt regulations
Hunter access (especially from north of the NER)
Easement limitation (NER boundary)
Current restriction on moving bison out of county
Social constraints
Public safety (ungulate/vehicle collisions)
Disease (cattle commingling)
Vendor numbers (are there enough for bison removals?)
Land-use conflicts (agricultural and residential)
Biological constraints

Disease
Sage grouse habitat conflicts (fire)
Fencing/wildlife conflicts
Grizzly bear conflicts (potential)

Funding constraints

Easements
Fencing
Fertility control

Technological constraints

Fertility control

Note/reminder from initial fall meeting Nov. 2012: "Three-pronged approach" 1) how to use hunters to reduce #s, 2) how to get more on native, 3) explicit metric for winter mortality that is acceptable.

Include a paragraph or two that describes 1) how phases are related to each other, 2) when we will claim we've been successful in Phase I, 3) how Phase II will be implemented (i.e., stepwise or all at once after success with Phase I, 4) whether meeting bison and elk objectives simultaneously will be necessary to begin implementing Phase II.

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APPENDIX I

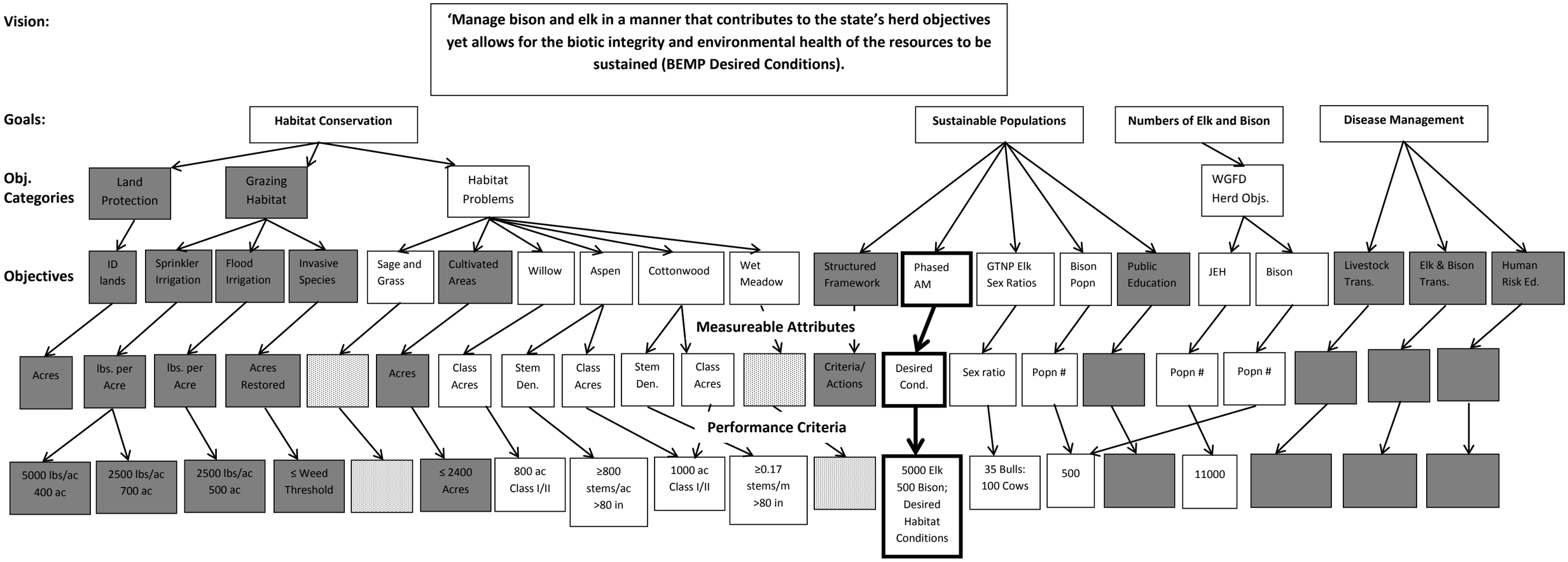

Figure 1.A1. Schematic representation of Bison and Elk Management Plan vision, goals, objective categories, objectives, measureable attributes and performance criteria. Bolded boxes and arrows represent the objective outlining the phased approach to population management by adaptively managing elk and bison populations for desired conditions. Stippled boxes represent measureable attributes and performance criteria for desired conditions defined in the National Elk Refuge Comprehensive Conservation Plan. Grayed-out boxes represent objectives, measurable attributes, and performance criteria wholly (e.g., public education) or largely (e.g., invasive species management) independent of desired conditions related to elk and bison population objectives, and therefore not considered in this plan.

NATIONAL ELK REFUGE ADAPTIVE BISON AND ELK MANAGEMENT PLAN

DRAFT
26 May 2015

DRAFT

INTRODUCTION

Winter feeding of elk in Jackson Hole began in 1910 and was originally initiated to reduce winter mortality of elk and minimize depredation of ranchers' hay. Today, the need for winter feeding of elk on the National Elk Refuge (NER) is a direct result of reduced access to significant parts of elk native winter range, loss of historic migration patterns, behavioral conditioning of elk to winter feeding, and the desire to maintain a population objective established in the context of supplemental feeding. Litigation in 1998 prompted cessation of bison hunting on NER due to insufficient environmental analysis. As a result, a ~~six~~ nine year planning effort was undertaken to address a suite of issues associated with inter-agency bison and elk management in the Jackson Hole area, culminating in 2007 with the Bison and Elk Management Plan (BEMP; USFWS 2007a, http://www.fws.gov/bisonandelkplan).

Comment [WJ1]: Another sentence or two for a smoother transitions to reason BEMP planning was started.

The BEMP considered six alternatives for bison and elk management focused on four broad goals: 1) sustaining native habitat; 2) promoting sustainable populations; 3) maintaining population sizes; and 4) preventing spread of disease. The selected alternative proposed to 1) maintain the Jackson Elk Herd (JEH) at the Wyoming Game and Fish Department's (WGFD) objective of 11,000 (± 10%), 2) establish a bison population objective of 500, 3) restore habitat on the NER and in Grand Teton National Park (NP), 4) continue hunting of bison and elk on the NER, 5) continue the elk reduction program in Grand Teton NP, 6) continue to vaccinate elk for brucellosis, and 7) develop an adaptive management plan for decreasing the need for supplemental feeding on the NER. The latter need, as articulated in the Sustainable Populations goal of the BEMP, provides the nexus for this Adaptive Management (AM) plan.

The Sustainable Populations BEMP goal is to 'contribute to elk and bison populations that are healthy and…at reduced risk from the adverse effect of non-endemic diseases'. The goal comprises four objectives, including the development of an AM plan to reduce reliance of elk and bison to winter feeding on the NER following a two-phased approach (Fig. 1). The first phase sets initial population objectives of 5,000 elk on winter feed at the NER and 500 bison in the Jackson Bison Herd (JBH). The second phase calls for elk populations that are adaptively managed to 'achieve desired conditions, with animals relying predominantly on native habitat and cultivated forage' (BEMP; USFWS 2007a).

Comment [WJ2]: Actually 5, but there are only 4 in Steve's figure that I stole.

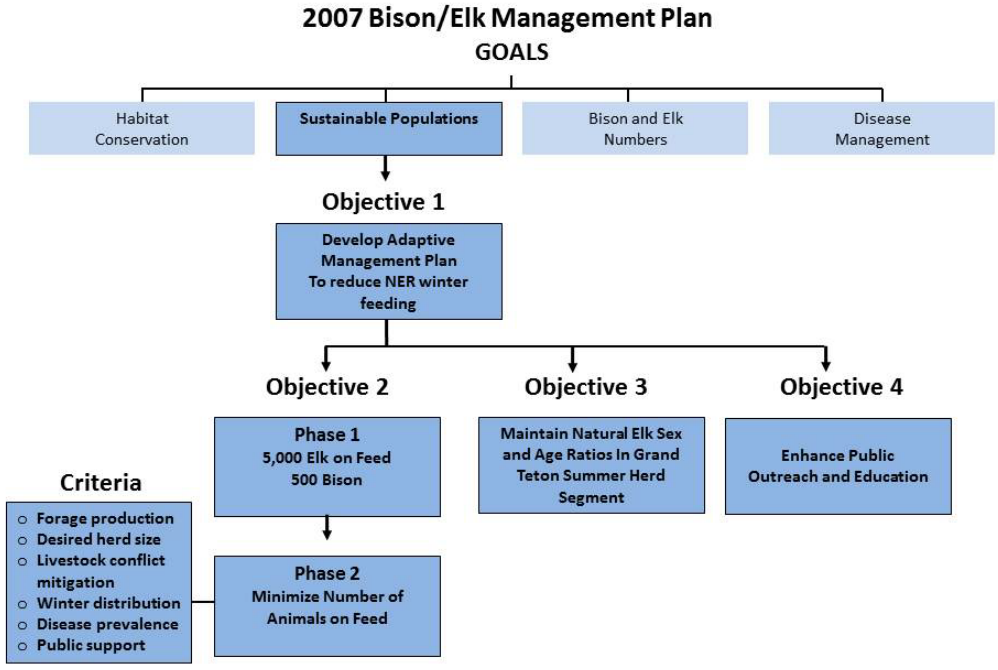

Figure 1. Relationship of Adaptive Management Plan to the Bison and Elk Management Plan (USFWS 2007a) goals, objectives, phases, and consideration criteria for reducing the reliance of elk and bison to supplemental feed.

The first phase objective of 5,000 elk was based on predictions of the Forage Accounting Model of Hobbs et al. (2003). Simulations indicated that 'in average SWE [snow-water equivalent] winters with average pre-winter precipitation and 500 bison, roughly 16,000 elk can find forage on the Greater Teton Ecosystem without incurring forage deficits and roughly 5,000 elk can find forage on the NER without incurring deficits.' The combined probability of experiencing average pre-winter precipitation and average winter SWE in the Jackson Hole area is **XX**%, based on [**what time series of climate data from what station**] (need to use Hobbs' data sources for this). Therefore, based on Forage Accounting Model predictions, 5,000 elk could winter without supplemental feed on the NER without incurring a forage deficit during **X** of 10 years on average. To achieve the objective of wintering elk relying 'predominantly on native habitat and cultivated forage', e.g., feeding occurring less than five of 10 winters, elk would incur a forage deficit **X** of 10 years on average. It is important to note that elk use stored energy reserves during winter, so incurring a forage deficit does not imply an immediate threat (Hobbs 1989, Cook 2002).

The second phase desired conditions on the NER relate to six considerations (i.e., criteria) as management action triggers for 'progressively transitioning from intensive supplemental winter feeding to greater reliance on free-standing forage' (BEMP; USFWS 2007a). These criteria are: 1) Level of forage production and availability on the National Elk Refuge, 2) Desired herd sizes and ratios, 3) Effective mitigation of bison-elk-cattle mingling (hereafter 'comingling') on private lands, 4) Winter distribution patterns of elk and bison, 5) Prevalence of brucellosis, chronic wasting disease, and other wildlife diseases, and 6) Public support. Explicit values that can be used as management triggers were defined in the BEMP for several, but not all, of the criteria. Forage production on irrigated areas of the NER, desired herd sizes and ratios, and winter distribution of elk and bison each have numerical objectives that can be used to trigger management actions based on assessment of those criteria. Conversely, co-mingling mitigation, disease mitigation, and public support lack numerical objectives that would facilitate creating triggers for management.

Two of the four criteria with explicit numerical objectives defined in the BEMP are currently being met. The NER is meeting or exceeding forage production objectives, and the JEH is within population objective. Current harvest rates have been successful in incrementally reducing the Jackson Bison Herd, making achievement of that objective likely given current management strategies. However, winter distribution of the JEH is not at objective, and distributional trends have resulted in being farther from the objective now than at the completion of the BEMP. A greater proportion of the JEH currently winter on the NER than when the BEMP planning process began in 2000.

Comment [WJ3]: I don't know about the bull:cow ratio in GTNP, or how best to include it here. To date it has been talked about very little.

Comment [WJ4]: **From Eric:** I am hesitant to bring up the bull:cow ratio in GTNP. It is yet another thing that some people will selectively latch onto as a reason to continue feeding, even though its relative importance is very low. If GTNP brings it up in the review process, then I guess we will have to deal with it.

Elk winter distribution

Winter distribution is inseparable from either bison-elk-cattle mingling or disease prevalence criteria, with feeding ameliorating the former and exacerbating the latter. Winter feeding minimizes co-mingling issues by concentrating elk and bison on publicly managed feedgrounds, minimizing the number of elk and bison on private lands adjacent to the NER. Conversely, concentrating elk on feedgrounds results in higher rates of endemic disease transmission (Murie 1951, Franson and Smith 1988, Samuel et al. 1991, Herriges et al. 1992, Smith and Roffe 1997), greater potential for amplification of prevalence of non-endemic diseases (e.g., chronic wasting disease [CWD]; Williams et al. 2002, Miller et al. 2004, Monello et al. 2014), and creates relatively unique disease issues for wild ungulates such as hoof rot (USFWS unpubl. data).

Management actions intended to distribute wintering bison and elk to meet BEMP objectives may initially result in an increase in private lands conflicts. Bison-elk-cattle mingling will increase as bison and elk disperse from the NER looking for alternative forage resources. Similarly, dispersing bison and elk may end up in residential areas or on/near public roadways.

Effective mitigation of co-mingling will take a suite of tools (e.g., private lands easements, fencing, hazing) to be employed throughout the life of this plan. WGFD currently monitors wildlife damage claim reports for the Jackson Region; this information provides an important baseline and metric for quantifying potential increases in private lands conflicts moving forward.

Comment [WJ5]: Set a threshold value of conflict complaint increase for easing back initiation criteria? E.g., if reducing initiation criteria from 300 to 150 lbs per acre available forage results in >100% increase in public conflict complaints in the Jackson Region change the next year to 200 lbs. acre as criterion.

The efficacy of reducing disease threat by achieving elk winter distribution objectives is disease-specific and varies due to the scale and time dependence of elk density on the NER versus native winter range. Assuming 7,500 wintering elk on the NER, estimated elk density is 77 elk per km^2 for the entire refuge, 370 elk per km^2 for the 5,000 acre supplemental feeding area, and 4,630 elk per km^2 for the 400 acre area on which elk are fed within any given day (USFWS, unpubl. data). For comparison, cow elk had a 0.08 (95% BCI=0.05, 0.12) annual incidence of CWD at an estimated 15-110 elk km^{-2} on native winter range in Rocky Mountain NP. We anticipate lower average elk densities in the JEH associated with AM plan implementation resulting from decreased elk use of feedgrounds and increased use of native winter range, but predicting the magnitude of disease transmission and prevalence reduction resulting from this change in elk distribution is difficult and disease-specific.

Comment [WJ6]: Other disease examples?

Supplemental feeding is a primary driver of the proportion of the JEH that winter on the NER. However, other factors such as weather, forage availability, predators, hunting, and migratory behavior also influence this metric (Fig. 2). At the completion of the BEMP it was believed that achieving the JEH population objective would be the primary means to reaching the phase 1 objective of 5,000 elk wintering on the NER. However, the proportion of the JEH that winter on the NER has increased, not decreased, since completion of the BEMP and achievement of the JEH population objective. The increase in the proportion of the JEH wintering on the NER also occurred concurrent with a relatively constant initiation criterion for winter feeding and high harvest pressure on the NER. It is therefore likely that factors other than winter feeding and harvest are contributing to the recent increase in the proportion of JEH elk wintering on the NER.

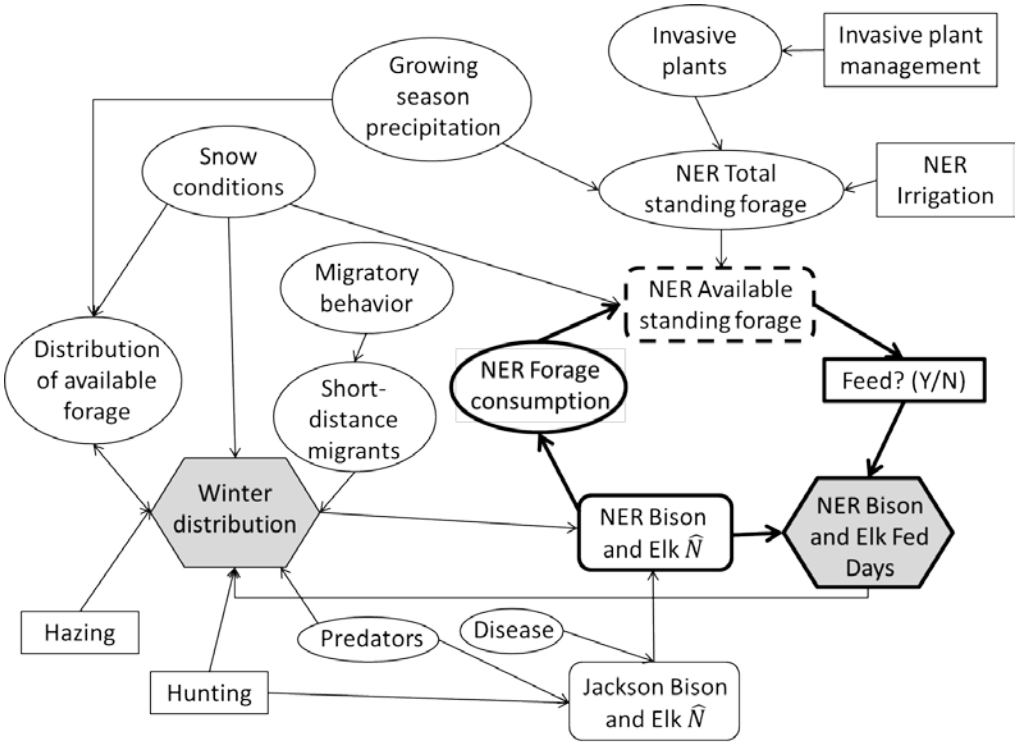

Figure 2. Influence diagram depicting factors (including management actions) influencing outcomes identified in the Bison and Elk Management Plan (BEMP; USFWS 2007a). Gray hexagons represent outcomes, rectangles represent management actions, rounded rectangles represent factors with numerical objectives, and ovals represent factors outside of management control. Bolded polygons and arrows represent outcomes and factors limited to the National Elk Refuge (NER). Available standing forage on the NER (dashed rectangle) is the BEMP criteria with a defined threshold to trigger initiation of supplemental winter feeding.

Several hypotheses have been posited for the observed increase in the proportion of the JEH currently wintering on the NER, including increased wolf presence on native range and an increasing segment of short-distance migratory elk in the JEH. Elk wintering on native range may have been displaced as the wolf population reintroduced into Yellowstone NP increased in abundance and their range expanded. Most native winter range of the JEH is north of the NER and south of Yellowstone NP. As predation pressure increased on more northerly winter range, elk moving to areas of lower predation risk likely moved south and encountered feeding operations at the NER. ~~If wolves are deterred by frequent presence of agency personnel~~

~~conducting feeding operations, feedgrounds may continue to attract elk due to lower predation risk than native range (citations; check Creel and Winnie 2005).~~

The JEH comprises both short-distance and long-distance migratory elk segments. Short-distance migratory (SDM) elk summer within 8–10 km west and northwest of the NER, winter predominantly on the NER, and migrate relatively late to winter range relative to long-distance migratory (LDM) elk (Cole et al. 2015). From 1978 to 2012 the proportion of the JEH comprising SDM elk increased from ≈1% to 41%, with the increase correlated with greater calf:cow ratios in SDM elk segments than LDM elk segments (Cole et al. 2015). The proportion of SDM elk in the JEH has simultaneously increased with the increasing proportion of the JEH that winter on the NER, leading to the hypothesis that the recent increase in the proportion of the JEH on the NER during winter is largely attributable to growth of the SDM elk segment.

The relationship between the observed increase in proportional winter use of the NER by wintering JEH elk and harvest pressure is less clear. "In recent years, hunting seasons have been designed to protect long-distance migratory (LDM) elk while increasing harvest of SDM elk. Since 2012, no limited quota any-elk licenses have been offered in the hunt areas that focused hunting pressure on LDM. Hunter numbers since 2012 (2012–2014) averaged 2,985 hunters. Although hunting seasons and quotas have become more conservative for the areas where LDM are more vulnerable, the hunt units for the SDM have been liberalized through the addition of license types and extending season lengths to the end of January (Hunt Area 78)" (Cole et al 2015). Despite these efforts to modify harvest pressure, the proportion of the JEH wintering in NER has increased significantly since 2000.

Comment [WJ7]: Need to paraphrase.

Elk calf winter survival and forage deficits

Elk calves are disproportionately susceptible to winter mortality compared to older elk age classes (citations), although factors that influence calf survival are not unique to this age class (Fig. 3). Calves have lower body fat reserves than adults at winter onset, which makes them more susceptible to limited forage supplies and starvation-related mortality. Lower surface area to volume ratio associated with smaller body size also facilitates heat loss and necessitates greater energy expenditures to maintain body temperature relative to adults. Inexperience can make elk calves more susceptible to predation by wolves and mountain lions. Weakened condition associated with nutritional stress can also increase susceptibility to predation, infectious diseases and parasitism (citations).

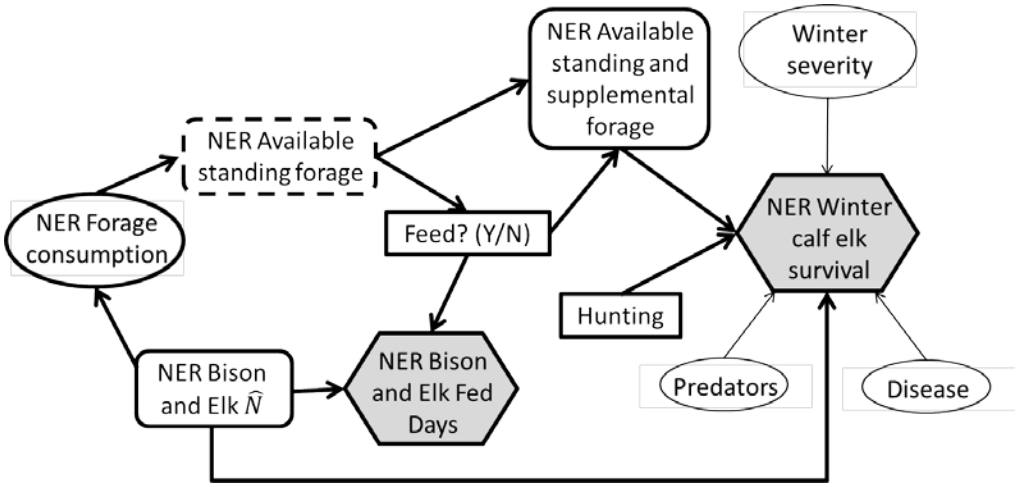

Figure 3. Influence diagram depicting factors (including management actions) influencing bison and elk fed days on the National Elk Refuge (see text for description) and winter calf elk survival. Gray hexagons represent outcomes, rectangles represent management actions, rounded rectangles represent factors with numerical objectives, and ovals represent factors outside of management control. Bolded polygons and arrows represent outcomes and factors limited to the National Elk Refuge (NER). Available standing forage on the NER (dashed rectangle) is the BEMP criteria with a defined threshold to trigger initiation of supplemental winter feeding.

Winter survival of calf elk is higher in feedground areas than on native winter range (Smith and Anderson 1998, Hobbs et al. 2003). The public has become accustomed to higher winter calf survival on the NER, and respond negatively during winters when survival is noticeably reduced (E. Cole, pers. comm.). While not explicitly defined as a desirable outcome in the BEMP, the Over-Winter Mortality Model of Hobbs et al. (2003) made predictions regarding elk mortality as a function of forage deficits. For example, the model predicted 4% calf mortality during an average winter with JEH population of 6,000 and 42% calf mortality during a severe winter with 18,000 elk in the JEH. Conversely, adult cow mortality ranged from 1% to 25% in the same scenarios. Making adjustments to the criterion used to initiation winter feeding will therefore likely disproportionately affect calf survival, making it an important demographic rate to monitor to help minimize unacceptable declines in elk calf winter survival while progressively transitioning bison and elk from intensive supplemental feeding. Moreover, it provides a means of validating models from Hobbs et al. (2003), which was integral in development of the BEMP.

Adaptive Management Plan Approach

The AM approach considers management as an ecological experiment, incorporating learning as part of management to reduce existing uncertainties regarding how the system responds to management actions (Macnab 1983, Walters 1986, Nichols and Williams 2006). Conflicting ideas of system dynamics can be formalized as competing models and tested through implementation of management actions designed as hypothesis tests (citation from AHM). Conversely, if a system is relatively well understood, the AM process may include a single model with management experiments intended to increase understanding of known primary system drivers. For example, winter feeding is believed to be a primary determinant of elk distribution in the Jackson Hole area, but considerable uncertainty exists regarding how elk behavior, and resultantly winter distribution, will respond to changes to winter feeding on the NER.

This AM plan acknowledges conditions identified within the BEMP relevant to this plan that are already being met, i.e., forage production on the NER and JEH population, and does not address them further. Similarly, current bison harvest management is likely to achieve the bison population objective in the near future, and therefore is also not considered further. The focus of this AM plan is altering the winter distribution of elk to minimize disease threat currently associated with winter feeding. This will result in progressively transitioning elk and bison from winter feed on the NER to being predominantly reliant on free-standing forage (USFWS 2007a). Considerable uncertainty exists regarding the timing of that transition, with conflicting objectives of minimizing bison-elk-cattle mingling on private lands, minimizing publicly unacceptable elk winter mortality events, and achieving winter distribution objectives to minimize threat of non-endemic diseases.

AM Plan Scale

Elk have been fed all but nine winters on the NER since 1912, and bison have been fed there since 1980. As a result, elk and bison have been conditioned to seek supplemental food on the NER, even when natural forage may be available. Considerable uncertainty exists regarding how to modify this behavior on both temporal and spatial scales. Elk demonstrate high fidelity to winter range (Smith and Robbins 1994) and are relatively long-lived (Houston 1982). For example, based on current estimates of annual JEH cow elk survival, nearly 40% of individuals alive in a given winter would be alive five years later (Cole et al. 2015). This results in generational time scales necessary for implementation of management actions and monitoring of response to those actions. To account for the expected lag in behavioral response to changes in winter feeding it is believed that those changes need to occur during 3–6 year treatment blocks (i.e., conduct 3–6 years of winter feeding with the same initiation criteria). More immediate progress toward 'progressively transitioning from intensive supplemental winter

feeding to greater reliance on free-standing forage' will be quantified based on the number of elk-fed and bison-fed days (EFD and BFD; see description below).

It is assumed individuals that have learned to rely on supplemental feed will be relatively tolerant of proposed changes to winter feeding. If this assumption is correct, changes to winter feeding will incrementally reduce the proportion of individuals in the JEH wintering on the NER by two primary mechanisms. First, an unknown proportion of adults will disperse from the NER in response to changes to winter feeding. This scenario provides the greatest potential for conflict as animals move off of the NER onto adjacent private lands in search of forage. Second, the proportion of individuals that learn to rely on winter feeding will be reduced. For example, shorter feed seasons will decrease the probability that calves will encounter, and learn to expect, winter feed on the NER. Over time this will lead to a greater percentage of elk utilizing native winter range instead of NER feedgrounds.

This plan is implementing the Winter Distribution management strategy, which includes primary management actions that will occur both on and near the NER (e.g., NER winter feeding changes and private lands co-mingling mitigation). The spatial focus of individual actions will therefore vary from the NER, Grand Teton NP, Bridger-Teton National Forest (NF), and on non-federal lands in collaboration with land owners and WGFD.

Management Actions

Alternative management actions were identified during meetings held at the NER in 2013 and 2014 with NER, Grand Teton NP, WGFD, and Bridger-Teton NF representatives. Actions were grouped into management strategies, i.e., collections of actions that form complete and comparable alternatives (Gregory et al. 2012). A summary of management actions and strategies is provided in Appendix I.

A diverse suite of potential management actions were considered and three primary strategies were created (Appendix I). The Winter Distribution strategy was selected for implementation within an AM framework because it was most consistent with the intent of the BEMP and the emphasis on winter feeding as a driver of winter elk distribution. This includes 1) alteration to the winter feeding initiation criteria, 2) continuation of late-season elk and bison hunts on NER, 3) increased private lands work to mitigate co-mingling, and 4) increased public outreach.

Winter feeding criteria—

Current feeding initiation criteria are based on monitoring available forage at key index sites. When average available forage declines below 300 lbs. per acre at key index sites, biologists have recommended to NER and WGFD managers that feeding should be initiated. Key index

Comment [WJ8]: Paragraph on the proposed changes, i.e., going from 300 lbs. per acre to 150 for 3-6 years (unless a more immediate response is observed), and brief discussion of how the measurement of available forage will be modified (2-3 sentences covering a less biased approach; the original approach works fine for the current feeding program, but if we need to go beyond 0 lbs. per acre to see a response we run into issues, can't have negative pounds per acre. Also will help to sample as close to the start of feeding as possible to reduce error associated with predicting when 300 lbs. acre is reached. The details will be provided in the monitoring section, so this can be brief and simply provide an outline of the proposed changes). I still like a pounds per acre criteria over a time-based criteria (i.e., 2 weeks after reaching 300 lbs. per acre) because the former is much more responsive to elk numbers and could delay the start of feeding more so than the latter as numbers of elk on the NER decline. The current termination of winter feeding criteria will be refined based on snowpack in native range adjacent to the NER (we discussed this briefly a while back – you thought some simple photo points in areas to the north could be an easy way to quantify percent open area and link to termination of feeding – please describe that with a sentence or two here). Criteria for the termination of winter feeding will be consistently applied during manipulation of initiation criteria. This assumes that when winter feeding ends is less influential in altering the behavioral response of elk than initiation of feeding, and eliminates confounding of behavioral response to initiation and termination criteria.

sites are not randomly selected, but instead represent areas with the highest quality forage, which are heavily used by elk. Future monitoring will include key index sites to facilitate comparison with past data collection, but will add additional spatially-balanced random sites stratified by plant community type to sample available forage in an unbiased manner. The feeding initiation threshold will be changed from 300 lbs. per acre to 150 lbs. per acre. We estimate that this will result in an average delay of **X** days in supplemental feeding initiation date at current NER elk and bison population levels.

Current feeding termination criteria are subjective. Typically the last day of supplemental feeding occurs within one week of the first day that snow pack reaches zero at the NER Headquarters snow monitoring site. Monitoring will be enhanced to better quantify feeding cessation date including the use of photo points to quantify percent snow versus bare ground on NER and southern GTNP, but average feeding cessation date will remain unchanged in the implementation of the AM plan.

Late-season elk and bison hunts—

Brief paragraph on current late season hunt management and any changes that may occur. I thought there wasn't much more that could be done on this front, so above stated there wouldn't be meaningful changes – if that is not the case need to correct that.

Private lands co-mingling mitigation—

Brief paragraph on proposed efforts to mitigate co-mingling – may be some text below useful for this. We need to make sure the co-mingling mitigation tools are articulated and implementable; this can be started as soon as possible so that when we start adjusting feeding to change elk distribution we are a bit ahead of the game.

Public outreach—

Brief paragraph on proposed PO efforts – may be some text below useful for this. Should also include the public conflict monitoring as our means to track this (same for private lands mitigation?).

OBJECTIVES

This adaptive management plan is a step down plan of the Bison and Elk Management Plan (USFWS 2007a), utilizing National Environmental Protection Act (NEPA) approved objectives from the BEMP. BEMP objectives relevant to this plan are:

Comment [CE9]: This still needs to be discussed with Steve K and cooperators. Changing criteria to 150 lbs. per acre is defensible and quantifiable but in my opinion is unlikely to result in significant response. Changes the criteria to zero lbs. per acre might elicit an elk behavioral response, but leaves us no room for further action, and has horrible public relations optics. I think that this is why Steve K. wanted the 2 week delay rather than the zero lbs. per acre criteria.

Comment [CE10]: Alternatively we go the way that Steve K wants and end feeding about 1 week earlier than average. This will have a significant effect on EFD and BFD, but will complicates our ability to evaluate the cause of any change in elk distribution that results from our management actions.

Comment [WJ11]: Steve K. or Cris.

Comment [WJ12]: Steve K. or Cris.

Comment [WJ13]: Steve K. or Laurie.

Comment [WJ14]: This seems redundant, and a bit out of place, but it may make it easier for the reader to go right to the heart of what this document is doing. It also gives us a place to explicitly state what we need to learn through management outcomes with this plan.

"By year one, develop a structured framework, in collaboration with the Wyoming Game and Fish Department, of adaptive management criteria and actions for transitioning from intensive supplemental winter feeding of bison and elk herds to greater reliance on natural forage on the refuge. Establish objective criteria for when supplemental feeding will begin and end in years when needed on the refuge."

"Implement a phased approach to reducing the number of animals on feed while achieving the state's population objectives. The first phase objective will be to reduce the number of elk on feed on the National Elk Refuge to approximately 5,000 and achieve a target population of approximately 500 bison. The second phase objective will be to adaptively manage bison and elk populations to achieve desired conditions, with animals relying predominantly on available native habitat (on refuge, park, and forest lands) and cultivated forage (on the refuge)."

The adaptive management process provides a framework for learning from management outcomes, i.e., learning is an objective of implementing adaptive management (DOI AM citation?). Therefore, the AM plan has additional objectives for increasing understanding of the relationship 1) between the timing of winter feeding initiation and elk winter distribution, and 2) calf winter survival and per capita available forage at initiation of winter feeding. The latter provides an indirect validation of the Hobbs et al. (2003) models and simulations that provided initial estimates of the number of elk the NER could support during winter without incurring forage deficits.

Comment [CE15]: I like this addition

MODELS OF SYSTEM DYNAMICS

Population of Interest

A succinct and precise definition of the populations of interest is essential for developing models of system dynamics and appropriate monitoring, and determining if objectives are being met. Bison and elk populations of interest differ slightly in definition as stated in the BEMP objectives. The bison objective is for the post-hunt population within the Jackson Hole area (the Jackson Bison Herd [JBH]), inclusive of the NER. Conversely, the elk population objective for the NER is specific to the number of animals on feed at the refuge, and is a sub-objective within the broader Jackson Elk Herd (JEH) (Fig. 4) post-hunt objective set by the Wyoming Game and Fish Commission (a governor-appointed policy-making board). Elk herd unit boundaries are determined by the WGFD and represent population boundaries where there is an estimated annual interchange with surrounding herds of <10% (Emmerich et al. 2007). Approximately 65% of the JEH winters on the NER based on February classification counts (see below for definition of classification counts; USFWS & WGFD unpubl. data). The

Jackson bison herd primarily winters on the NER (~90%), but range much further during the rest of the year (USFWS & WGFD unpubl. data) (Fig. 4).

Determining if the BEMP population objectives are being met requires periodic estimates of the populations of interest. There are two components to the population objectives that need to be considered — where animals are and when they are there. The BEMP bison population objective is the same for the JBH as it is for the NER, i.e., there is not a sub-objective specific to the NER as there is for elk. Moreover, the bison population objective is less temporally specific than that for elk, the former being an annual post-hunt population objective and the latter being defined based on the number of animals on feed. This aspect of the elk objective increases the difficulty in estimating the population of interest due to movements of animals into and out of feedgrounds during winter feeding. More importantly, the amount of time elk are on feed varies among years.

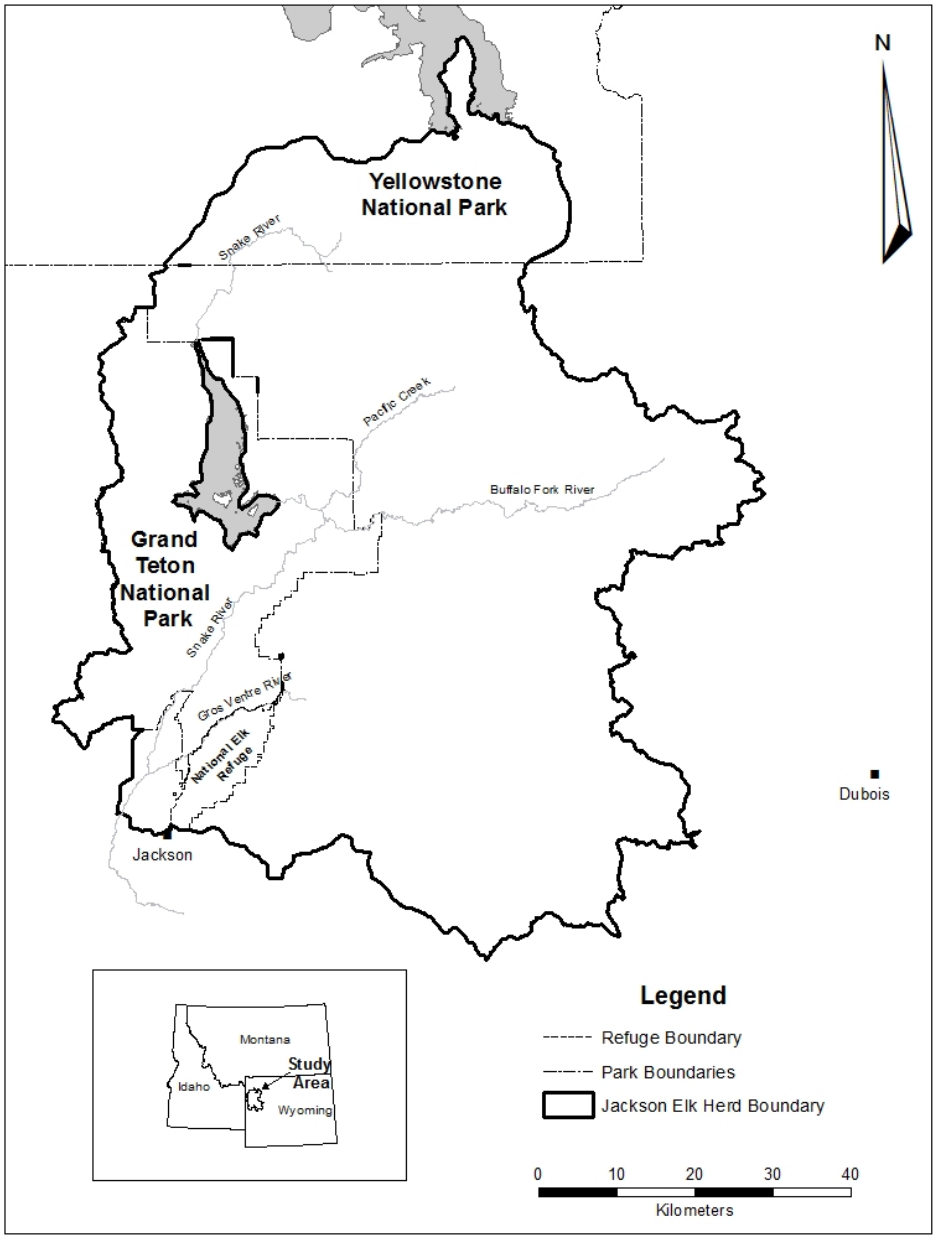

Figure 4. Jackson Elk Herd unit boundary, including the National Elk Refuge and Grand Teton and Yellowstone National Parks. <u>INCLUDE BISON RANGE IN THIS FIGURE.</u>

While not explicitly stated, the BEMP assumes annual classification counts would be used to determine if population objectives were being met, i.e., as a proxy for the number of elk on feed at the NER. Classification counts are a coordinated census of the JBH and JEH, collaboratively undertaken during early February by WGFD and the NER. These counts are undertaken during a single survey period and do not necessarily represent either peak or cumulative abundance (i.e., the greatest number of animals present on a single day during a winter, or the sum total of animals present throughout a winter, respectively) of bison or elk on feed. Elk and bison are enumerated by age and sex classes, providing population class structure information as well as overall abundance. A 5-10% difference typically exists between the classification count estimate and the daily number of elk on feed during peak abundance. Peak elk abundance on the NER during 2007–2013 occurred late February through the first week of March (USFWS unpublish. data) (Fig. 5). Proposed changes to winter feeding that would result in a later initiation of feeding could increase the difference between when the classification count is conducted and peak numbers of elk on feed. Proposed changes could also result in initiation of feeding on the NER after the classification count has been completed in some years. Lastly, the classification count may be replaced in the near future by survey (i.e., not a census) methodology used elsewhere in the state by WGFD for estimating elk abundance. The new survey methodology may not provide suitable NER-specific estimates of elk abundance for determining if NER population objectives are being met.

Beyond logistical or methodological considerations, a single elk population estimate in time would not adequately capture the dynamic nature of elk abundance in relation to winter feeding on the NER. For example, 5000 elk on winter feed (the current BEMP Phase 1 objective) for three months would likely have a greater impact on NER habitats than 5000 elk on feed for a single month. The BEMP Phase 1 elk population objective is not defined by time, leaving it open for interpretation whether the objective was intended as a mean number of animals fed during a winter, a maximum number fed, or a cumulative number fed. To address this issue while staying within the implied intent of the BEMP, we chose elk-fed days (*EFD*; the cumulative number of elk fed during a feeding season) for determining if the elk population objective is being met. This number combines both the spatial and temporal aspect of animals on the NER, providing better accounting of potential effects than a single classification count. It is also believed that this is more consistent with winter carrying-capacity projections estimated in Hobbs et al. (2003). The Phase I objective of 5000 elk on feed is defined relative to elk-fed days as

$$EFD = d * 5000 \text{ elk},$$

where *d* is the mean number of days of feeding from 1995–2007 (64 days [SD = 22]). This time span was selected to maintain consistency with the data used in developing the BEMP. The benchmark historical value is then 320,000 *EFD*. Bison-fed days (*BFD*) can similarly be calculated as 31,500 *BFD* for bison using *d* = 63 days (SD = 22) and the bison population objective of 500 animals. This latter value provides an important historical perspective on winter feeding of bison and can assist in determining efficacy of management actions toward accomplishing the bison objective; post-hunt bison abundance will be the definitive number used for determining if the bison population objective is being met.

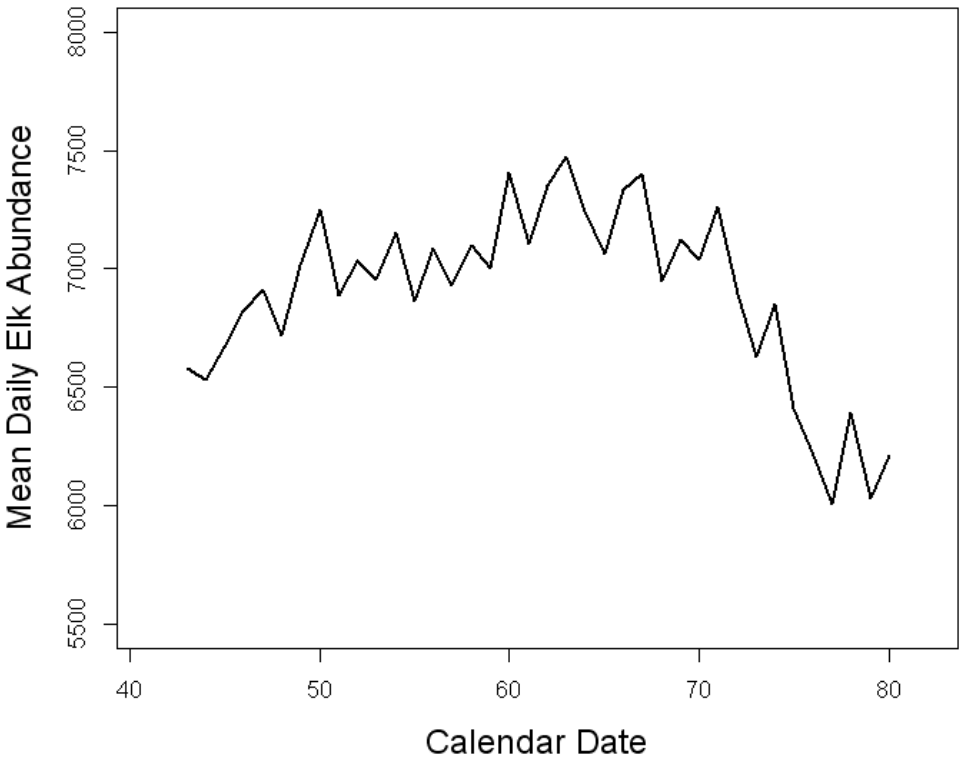

Figure 5. Mean daily elk abundance on the National Elk Refuge during winter feeding, 2007–2013. Data are from feedline counts for calendar dates where feeding occurred during all years, i.e., February 12th (calendar date 43) through March 21st (calendar date 80). Counts were conducted from feeding equipment.

Models

Models provide a simplified representation of the biological system being managed. Adaptive management uses models of the managed system to link the objective response (e.g., elk winter distribution) to changes in the system resulting from management actions (e.g., altered initiation of winter feeding).

Paragraph on sources of error if needed? Should include process error in calf survival model.

Elk winter distribution model

The proportion of the JEH that winter on the NER will be linked to factors hypothesized to influence elk winter distribution (Fig. 2) using a generalized linear mixed effects model (GLMM). A GLMM can account for a proportional response variable (i.e., constrained to the interval 0–1) using a log link and binomially-distributed errors. A GLMM also includes fixed and random effects, with the latter capturing residual model variance otherwise not explained by fixed effects. Year will be including as a random effect, providing several benefits. First, we don't assume years are independent and comprise all of the factor levels of interest. Instead, the effect of year is treated as a random variable, with individual year effects realizations of that distribution. This allows inference to non-sampled factor levels, i.e. years, by estimating a latent population-level proportion of elk expected to winter on the NER regardless of fixed effect influences. Thus, the random year effect can be considered a latent variable describing elk behavior manifested as observed winter distribution. Second, because year effects are not treated as independent, estimated effects of year on the proportion of JEH elk wintering on the NER are dependent on all factor levels, leading to greater precision when estimating individual year effects (Kéry 2010).

Comment [WJ16]: I'm not comfortable with this interpretation yet and need to think about it some more.

The full GLMM incorporating fixed effects for each factor identified as influencing elk winter distribution (Fig. 2) is:

$$P_t = \beta_{0(t)} + \beta_1 * AFI_t + \beta_2 * SDM_t + \beta_3 * WP_t + \beta_4 * GSP_t + \beta_5 * SWE_t + \varepsilon_t$$

Comment [WJ17]: This doesn't currently have a term for hunting, although our conceptual model above does. Need to decide if we want to include or exclude here.

where the random intercept and residual model variance are

$$B_{0(t)} \sim N(\mu_{\beta_0}, \sigma^2_{\beta_0}), \text{ and}$$

$$\varepsilon_t \sim N(0, \sigma^2), \text{ respectively.}$$

Fixed effects include 1) per capita available forage at initiation of winter feeding (*AFI*) , 2) proportion of the JEH that are short-distance migrants (*SDM*), 3) number of wolf packs present on JEH native winter range (*WP*), 4) growing season (May–August) precipitation for the Wyoming Snake Drainage climate division (*GSP*; a proxy for available forage on native winter range), and 5) snow water equivalent on 1 January at Thumb Divide (*SWE*; a proxy for early winter severity).

Elk calf winter survival and forage deficits

The Forage Accounting Model of Hobbs et al. (2003) has as an output weekly available forage biomass for the NER (sum of predictions for 30 × 30 m cells). These predictions account for snow conditions using a proxy of SWE and decrement total available biomass by 35% to account for unpalatable plants within the total estimate.

While calf survival is a function of multiple factors (Fig. 3), the primary management action influencing calf survival is supplemental winter feeding. Current winter feeding initiation criteria lead to calf survival generally higher than in unfed populations. Proposed feeding initiation criteria will result in later initiation of supplemental feed, which will be most influential to calf survival. There is currently little understanding regarding the relationship between initiation of winter feeding and calf survival, except that current feeding initiation criteria result in high calf survival. We believe a threshold level of available forage at initiation of winter feeding exists such that winter calf survival reaches an asymptote. Below this threshold, calf survival is hypothesized to decline quickly with reductions in available forage at winter feeding initiation. Available forage at the initiation of winter feeding will be related to on elk calf winter survival using a saturating function (i.e., Holling type-II functional response; Fig. 6) by

$$S_t = \frac{aAFI_t}{b + AFI_t}.$$

The parameters *a* and *b* determine how calf survival is related to available forage. Maximum calf survival is *a*, and *b* represents the value of available forage to an individual when survival is 50% of *a* (Hilborn and Mangel 1997).

Comment [WJ18]: Will need a more formal explanation of these variables and how they will be collected. May fit best in the monitoring section.

Comment [WJ19]: If we use Hobbs' model for predicting available forage these may be redundant.

Comment [WJ20]: Put in winter feeding initiation paragraph above? Then note where more samples are necessary to improve the precision of the estimates. Need to run this model from 2007 forward to see where, on average, feeding was initiated so we can make treatment adjustments as necessary. This would also allow us to look at the relationship between key index sites estimates and Hobbs' predictions. Need to consider validating Hobbs' model with field sampling Eric is currently designing to see if we can use the Hobbs model moving forward. This would take some time with stripping the Hobbs model down to our needs, identifying data sources, and developing a workflow process so weekly estimates of available forage can be calculated. Would only be able to use snow data from SNOTEL sites that have data available online, which shouldn't be too much of a problem.

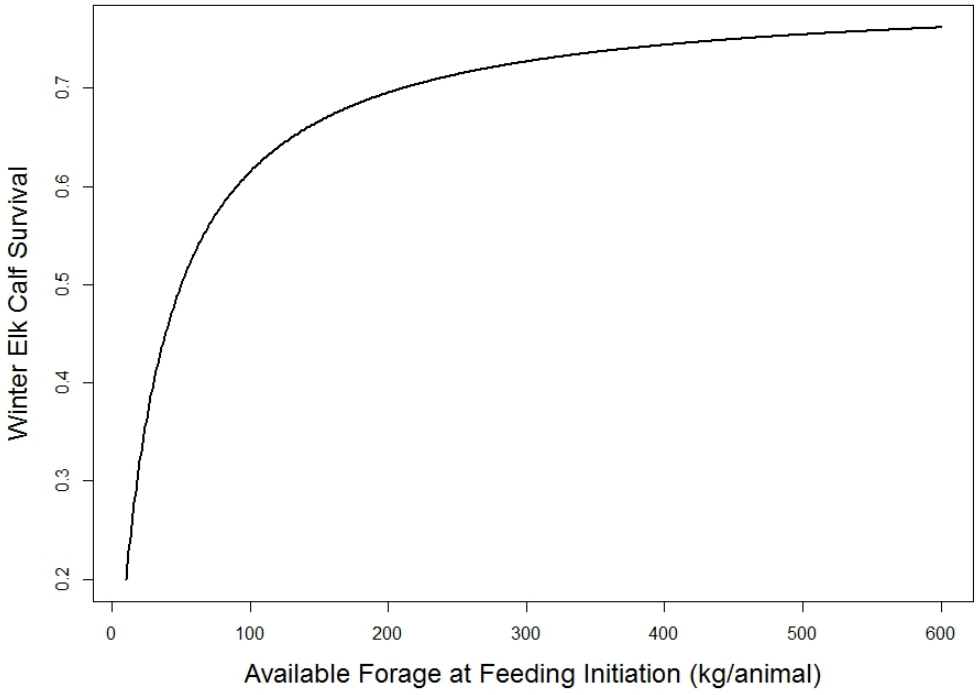

Figure 6. Hypothesized relationship between winter survival of elk calves and per capita available forage at initiation of winter feeding on the National Elk Refuge.

Although this approach doesn't capture forage deficits *per se*, it does provide a potentially sensitive proxy for this concept. It is assumed that a forage deficit for calves would occur at a point on the curve of the relationship between calf survival and available forage at initiation of supplemental feeding. Modeling the response of winter calf elk survival to changes in feeding initiation criteria facilitates our ability to maximize the influence of feeding initiation criteria on winter distribution while minimizing the likelihood of a large mortality event.

MONITORING

Feeding Initiation Monitoring: Using existing ocular estimate methods with 10 sub samples per monitoring sites to determine average available forage (lbs. per acre). Additional observers will be added to train people other than Eric Cole on methods and develop error estimates. Additional monitoring sites will be added to increase sample size, increase precision of

estimated available forage, and represent the entire south end of NER stratified by plant community type. Sampling will be weekly starting in late December and continuing until feeding is initiated (or perhaps for some time after feeding is initiated). The Hobbs forage accounting model will be run concurrent with field data collection, and field data will be used for model validation. Developing a relationship between field measurements and Hobbs model methods might lead to reliance on modeling techniques rather than field data collection to estimate available forage in future years.

Proportion of Elk Wintering on NER: NER and WGFD annual elk classification count trend data will typically collected in February each year will continue to be the way that we measure the proportion of elk wintering on NER relative to the rest of the JEH.

EFD and BFD: I assume derived from daily feedground estimates for each species cumulatively added across the number of days fed. Alternatively average of daily animals on feed multiplied by the total number of days. Alternatively classification count data for NER multiplied by total number of days fed. Precision of daily elk and bison estimates could be improved by using multiple observers several times per year or possibly conducting classification count like counts multiple times per year where only totals were obtained.

Elk Winter Mortality Monitoring: Current census of all elk winter mortalities on NER will continue (comparable data collection back to 1981). Calf mortality is key variable of interest, but total, calf, adult cow, mature bull, and spike bull age class mortality will continue to be monitored as well. Potential criticism is that if we anticipate movement of elk off NER as a result of changes to the feed program but only monitor elk mortality on NER, then we are not accounting for the effects of management actions on elk mortality. Costs are minmal and associated with in kind NER staff levels unless sampling were to be expanded off NER in which case costs would increase.

Elk Collaring: 30-40 adult cow elk will be collared on NER feedgrounds during February-March 2016. Elk will be collared with Telonics Irridium GPS collars. Approximate costs per collar including drop off mechanism and Iridium subscription $2,600 per collar. We will likely forgo VHF beacons on collars to avoid red tape associated with frequncey approval and extend collar life. Anticipated collar life 2-3 years. Approximately 10 additional elk per year in subsequent years will be captured to maintain 30-40 elk in the sample. GPS collar data will be used to: 1)Determine the summer range proportions of elk that winter on NER. 2) Evaluate elk behavioral response to changes in the feeding program ie when and where do elk leave NER. 3)Capture efforts will facilitate collection of important ancillary biological information (brucellosis seroprevalence, pregnancy rate, DNA samples, etc.)

Wolves: Given potential importance as a covariate, estimates of total wolf numbers and the total number of wolf packs in the JEH unit will continue to be important. Jurisdiction of monitoring data remains in flux due to litigation.

Disease: Given 'healthy- elk goal. Continued CWD monitoring in the JEH is warranted. Current baseline brucellosis seroprevelance for elk the winter in NER is needed. This would be facilitated by large scale elk capture in 2016 to deploy GPS collars. Costs to continue current level of CWD surveillance in the JEH is approximately $32,000 per year.

~~**Trumpeter Swans Using the Visitor Center Ponds:** I view this as the linchpin to evaluating the success of our activities on the refuge. The number of cattails in these ponds and their effect on Jackson Hole tourism is also keeping me awake at night. Estimated annual cost for monitoring: $222,000~~

Need to articulate that the primary issue to be addressed with this plan is how to alter elk behavior so that the desired winter distribution is achieved. Only once that is done can the questions regarding what number of elk the NER can support while achieving habitat objectives be visited. Already at JEH objective, and nearing JBH objective.

The bison population objective of 500 animals post-hunting season was determined based largely on maintaining genetic heterozygosity while minimizing other conflicts (USFWS 2007a). Unlike the second phase elk objective, the bison objective is independent of additional criteria defined as desired conditions.

APPENDIX I

Development of Alternative Management Actions and Strategies

Alternative management actions were identified during a meeting of stakeholders at the NER 22 May 2013. Alternative actions, and constraints, were developed for the NER winter elk population and the JBH. A series of further meetings (25 July, 20 August, 12 September, 23 October, and 13 November 2013, and 22 January, 24 February, and 7 April 2014) were held to create management strategies, i.e., collections of actions that form complete and comparable alternatives (Gregory et al. 2012).

Reference case—It is helpful to identify a reference alternative that captures the recent and ongoing management actions that have led to the current state of the system for comparing with new alternatives that are developed. Ongoing management actions include winter feeding, irrigation, harvest, and hazing.

Big game population objectives in Wyoming are evaluated and updated at least every five years. Objectives represent the preferred number of animals during winter within a herd unit (e.g., the Jackson Elk Herd) and are determined based upon multiple factors, including 1) available habitat to support the defined population, 2) hunting access, and 3) tolerance for wildlife on private lands by landowners (Tassell et al. 1995). Public input on proposed population objectives is obtained during public hearings. After the hearings the proposed population objectives are sent to the Wyoming Game and Fish Commission for review and approval. The NER, GTNP, and Bridger-Teton National Forest (BTNF) have participated in WGFD big game population objective review and revision processes in the past for both the JEH and JBH. These federal agencies will continue to participate in objective setting for the JEH and JBH populations.

The current JEH winter feeding program includes two groups of feedgrounds – one on, and managed by, the NER, and the second managed by WGFD. The latter are the Alkali, Fish Creek, and Patrol Cabin feedgrounds, collectively known as the Gros Ventre feedgrounds, located on BTNF lands. Initiation of feeding is currently conservative, i.e., has the primary objectives of minimizing elk 1) winter mortality of the most susceptible group, calves, and 2) comingling issues with cattle on adjacent private lands. Winter feeding begins when available forage reaches approximately 300 lbs acre^{-1} at key index sites. Available winter forage for elk and bison on the NER is largely determined by snow conditions, rate of forage consumption during fall and winter, and biomass of forage produced during the previous growing season.

Forage biomass (metric tons) is correlated with the amount of precipitation (mm) during May–August ($\beta_{precip} = 50.31$, R^2 = 0.91; 1995 and 1998–2006, NER unpubl. data), and secondarily affected by the number of irrigated acres. Refuge-wide herbaceous forage production averaged 14,387 (SD = 4125) tons during 1998–2013, and in recent years irrigation of approximately 3,600 acres has increased forage production by approximately 10% compared to what would have been produced with precipitation alone. Estimation of forage biomass is done annually based on sampling at index sites. Index sites are selected subjectively each year based on presence of vegetation highly palatable to elk such as naturally sub-irrigated wet meadows, irrigated areas with significant green vegetation, and in years with adequate late summer/early fall precipitation, native dry grassland plant communities with basal green up.

During 1995–2013, mean initiation of winter feeding on the NER was 28 January, ranging from 30 December to 28 February. Mean termination of winter feeding during this same period was 3 April, ranging from 20 March to 20 April. Initiation and termination dates vary widely based on winter conditions. Excluding years in which feeding did not occur, mean initiation and termination dates for winter feeding during 1976–2013 at the Gros Ventre feedgrounds occurred during the second week of January and first week of April, respectively (Table 1). This resulted in approximately 3 months of feeding each year.

Table 1. Winter feeding mean initiation and termination dates and total days for the Gros Ventre feedgrounds managed by Wyoming Game and Fish Department. Standard deviations are provided parenthetically.

Feedground	Initiation Date	Termination Date	Total Days
Alkali	10 January (18.8)	7 April (13.5)	89 (23.5)
Fish Creek	9 January (12.3)	4 April (17.1)	85 (21.0)
Patrol Cabin	11 January (13.5)	4 April (11.6)	84 (19.0)

Winter feeding coordination between the NER and WGFD occurs annually. Feeding in the Gros Ventre feedgrounds is targeted specifically to assist in keeping animals from moving to the NER; for example, animals are more likely to move to the NER if feeding is occurring there and not at the Gros Ventre feedgrounds, where the opposite up-slope migration is less likely. Termination of feeding at feedgrounds needs to be coordinated so animals moving to the NER after feeding ends on the Gros Ventre feedgrounds do not remain at the refuge. This coordination will continue regardless of the management strategy employed.

Bison are fed as necessary to ensure elk are adequately fed. Bison out-compete elk for forage resources, so the typical strategy is to keep bison at the northernmost NER feedground (McBride) by feeding them prior to feeding elk. Bison are fed separately from elk and are given a ration adequate to ensure they do not move to elk feeding areas. This also influences distribution of bison in the winter, reducing conflict associated with bison moving into 1) Jackson, and 2) the Nowlin unit of the NER where commercial sleigh rides occur.

Total harvest of the JEH was reduced over the last decade as the population objective was reached (Fig. 4). Elk hunting on the NER (Hunt Area 77) typically begins in mid-October and ends in mid-December, with peak harvest in recent years occurring in late November to early December. From 2005 to 2011 an average of 393 (SD = 56) hunters harvested 161 (SD = 38) elk per year during the NER hunt.

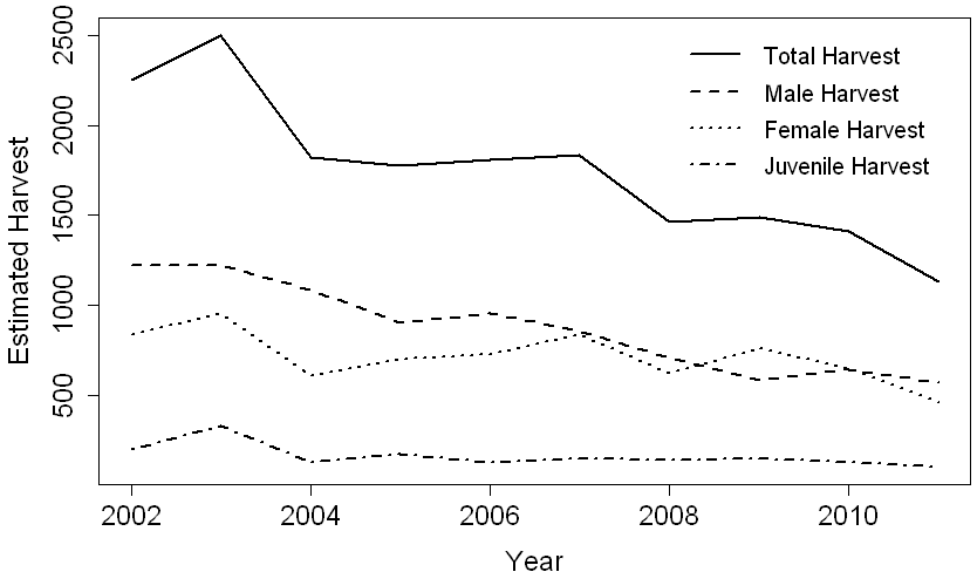

Figure 4. Jackson elk herd estimated harvest, 2002–2011.

Associated with harvest on the NER, "tag and drag" is a retrieval service currently provided by two licensed outfitters. They are also licensed to guide on the NER. This program will continue regardless of the management strategy employed.

Hazing of elk is currently only undertaken in spring to encourage elk (and bison) to move off of the NER. Attempts at post-hunting/pre-feeding hazing of elk to the north part of the refuge occurred (e.g., 2005–2006), but were largely ineffective with elk generally returning the following day to the south end of the NER. These efforts included hazing using ATVs, on foot, and on horseback. Reducing spring hazing to increase early-season harvest was considered as a potential action but not included due to 1) the perception that the loss of forage on the Refuge by resident elk during summer would offset gains due to increased harvest, 2) presence of wolves on the northern end of the Refuge may preclude the desired response of reduced hazing to keep elk on the north end of the Refuge, and 3) recently observed aspen recovery could be reduced if elk use increased on the north end of the Refuge.

Fencing of hay stacks and livestock feedline areas has historically been used to mitigate conflict on private lands. Fencing as mitigation on private land will continue in a targeted fashion. For

example, a proposed mitigation in the Horse Creek area would involve a land trade with a private landowner to move livestock winter feeding operations off of a south facing slope that is a movement corridor for elk. Fencing three sides of the private land would separate the corridor from the livestock feedline. Targeted fencing of golf course greens and sand traps fall through spring has been successful in some situations for mitigating elk and bison presence in these areas. It is important to note that the county has a 'wildlife-friendly' fence policy and does not support fencing impermeable to wildlife.

The outcome of the reference case described above for elk abundance and distribution during winter in the JEH is shown in table 2. Population objectives for the two feedground complexes are provided, as are annual elk abundances as measured during the classification count. The data presented in table 2 demonstrate the potential for reaching the Phase 1 NER winter elk population objective of 5,000 while remaining within the JEH objective of 11,000 (±10%).

Table 2. Annual distribution of wintering elk from the Jackson Elk Herd during February classification counts, 2011–2013, relative to the current objective.

	OBJECTIVE	2011	2012	2013	mean
NER	5,000	7,746	7,360	6,285	7,130
Gros Ventre	3,500	2,775	3,265	2,982	3,007
Native Range*	2,500	982	894	1,784	1,220
Total	11,000	11,503	11,519	11,051	11,357

*Excludes objectives for native range adjacent to Gros Ventre feedgrounds.

Bison numbers grew exponentially from the 1970s until recently, peaking at 1059 animals in 2007 (Fig. 5). Recent declines in the number of bison are largely attributable to increased hunter harvest on the NER. Bison hunting begins on August 15 and ends in early to mid-January; no bison hunting is allowed in GTNP, resulting in bison often staying in the park during the hunting season with only occasional movements onto the NER until severe winter conditions occur. Given this situation, harvest management balances extending the hunt as late in January as practicable without conflicting with winter feeding. The dynamic nature of winter conditions makes this unpredictable, and results in the use of emergency bison season extensions or reductions. For example, an emergency extension of the season (no later than 31 January) could occur if mild winter conditions precluded desired harvest levels earlier in the season. Conversely, an emergency closure may be necessary if winter weather conditions require feeding to commence before the predetermined season end date.

Most bison harvest occurs on the NER, with some additional harvest on private and BTNF lands. Since the initiation of the bison hunt in 2007, mean harvest has been 210 (SD = 45.5) bison per

year. This level of harvest has been sufficient to arrest the exponential growth of the population, reducing bison numbers from the peak in 2007 to 855 animals in 2013 (Fig 5). Licensing changes for hunting Jackson Hole bison were enacted in 2014 to increase harvest, especially of bison females. These included a reduction in the bison female/calf license fee (from $416 to $263 for residents and from $2522 to $1022 for non-residents) and eliminating the once-in-a-lifetime restriction on a successful bison hunter to only those that successfully harvested a bull. Tribal bison harvest is currently defined in the BEMP to permit up to five animals for ceremonial purposes; tribal harvest generally occurs outside of the state bison season. Translocation of bison to tribal lands outside of Teton County is not currently permitted due to brucellosis concerns.

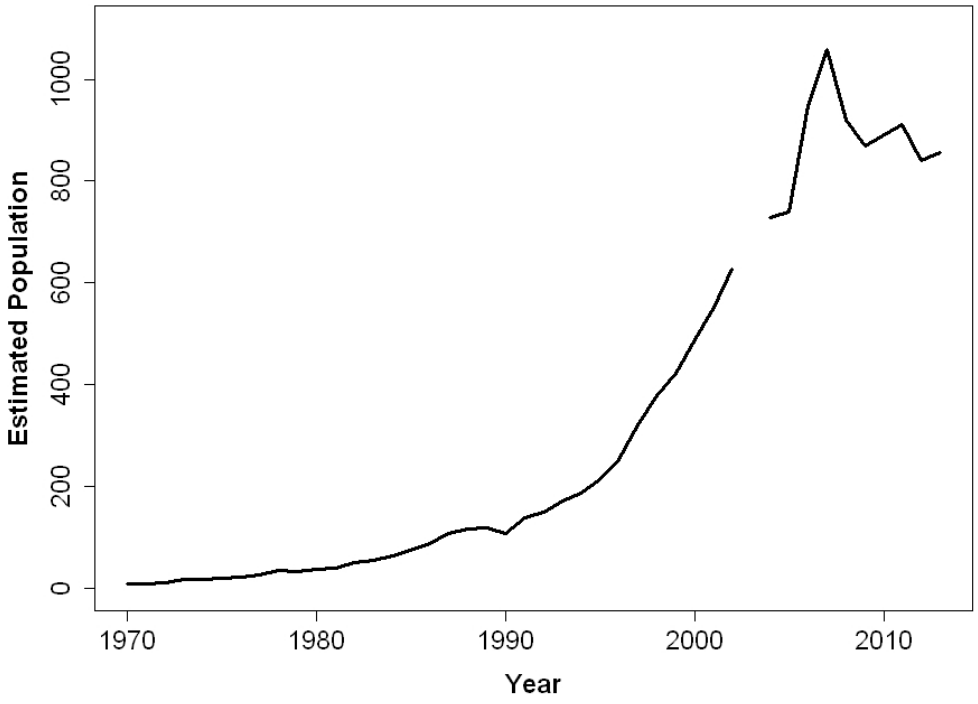

Figure 5. Bison winter population in the Jackson Hole area, 1970–2013.

Bison would likely occupy the Refuge year-round without management intervention, but as a result of hazing by refuge staff and disturbance by hunters, peak bison activity on the NER occurs January–April each year. If bison fail to leave the NER following the cessation of

supplemental feeding they are typically hazed off the Refuge using all-terrain vehicles (ATVs) in late April to early May. Hazing moves bison to GTNP, where they generally remain until mid-July. From July to early August bison that return to the NER are hazed back to GTNP to protect forage for elk during the winter months. Hazing efforts in August cease within several days to weeks of the bison season in an effort to increase hunter harvest.

National Elk Refuge

Alternative management actions identified for meeting the NER winter elk population objective can be grouped into four categories, including 1) winter feeding management (both on and off the NER), 2) population management (harvest, culling, and fertility control), 3) habitat improvements (on and adjacent to the NER), and 4) mitigating private lands conflicts (leases/easements, incentives, fencing) (Table 3). The latter represent sequenced alternatives that would be necessary to implement due to wintering elk dispersing onto private lands adjacent to the NER in response to other management actions taken. A fifth group of alternatives associated with increasing public awareness (including local elected officials, e.g., county commissioners) of 'natural' levels of elk winter mortality were included after the meeting. These actions represent acknowledgement that the current feeding program results in reduced winter mortality, perhaps exacerbating already low public tolerance to increased winter mortality, whether episodic or perennial in nature. This group was expanded to include more targeted education and outreach efforts for landowners, sportsmen and agencies, and the WGFD Commission, depending on the strategy. Lastly, a group for each of monitoring and enforcement were included to allow proper accounting of projected costs associated with each management action strategy.

Table 3. National Elk Refuge winter elk population strategy table for identifying alternative management action strategies. Ongoing management actions that will be continued regardless of strategy selected are not included in the table; descriptions can be found in the 'Reference case' description within the text.

	Reference Case	NER-focused	Southern herd segment mngmnt	Late Season Harvest
Winter feeding management				
No change	**X**		**X**	**X**
Less conservative (NER)		**X**		
Population management				
No change	**X**			
Increase harvest objectives in Hunt Areas 77 & 78			**X**	

Late-season refuge hunt (Hunt Area 77)		X	X	X
Coordinated late-season hunt (Hunt Areas 75, 77, 78, 80)				X
Extend open period on Forest Service				X
Fertility control (Hunt Area 78 & GTNP South)			X	
Hunt Area 78 Hunter management program			X	
Habitat improvements				
No change	X			
Fire management on NER and adjacent public land		X	X	X
Private lands mitigation				
No change	X			
Incentivize steer operations		X		
Non-traditional landuse mitigation			X	
Public education/outreach (EO)				
No change	X			
Increase public EO (including local elected officials)		X	X	X
Increase landowner EO		X	X	
Increase sportsmen & agency EO			X	
Increase WGFD Commission EO		X	X	X
Monitoring	X			
No change		X	X	
Increase				
Enforcement				
No change	X			
Minor increase		X	X	
Major Increase				X

Winter feeding management—Management of winter feeding is a primary driver of elk distribution, and to a lesser extent abundance, in the Jackson Hole area. Feeding on the NER is initiated each year based on a series of factors, including the amount of forage on the NER, number of elk present, and snow conditions. Initiation of feeding is currently conservative (see *Reference case*, pg **5**). A less conservative approach would result in later initiation of feeding,

therefore potentially increasing winter calf mortality and comingling. Including agronomic grassland plant communities without significant green vegetation and/or reducing the available forage threshold would result in a less conservative winter feeding program. Per capita ration levels would not change from the current level.

Implementing a less conservative feeding program could result in very limited, or no, feeding given certain winter conditions. However, the criteria for a less conservative feeding program would not be such that it could be construed as 'emergency feeding', i.e., feeding only to preclude a catastrophic mortality event. Colorado, Idaho, and Utah provide examples of states that have emergency feeding policies. Existing evidence suggests that emergency feeding is not very effective (see review in Putman and Staines 2004). Moreover, the current feeding regime has been developed for non-emergency situations; a review of current rations and pellet composition would be necessary to adjust the program for emergency feeding.

Population management—Hunter harvest is the primary tool employed for population management of elk and bison in Wyoming. Increased harvest objectives on/near the NER would target the southern segment (Hunt Areas 77 & 78), which is currently more productive (i.e., higher cow-calf ratios) than other JEH segments. Doing this would help achieve JEH objective while minimizing harvest on migratory segments. In order to track hunter harvest there would need to be an increase in monitoring, e.g., hunter self-registration.

Elk hunting on the NER currently ends mid-December. Offering a late-season hunt (after 15 December) would assist in deterring elk from moving onto the refuge. Without coordinated hunts in adjacent units (Hunt Areas 75 [GTNP], 78 and 80), and extended open access on BTNF lands in Hunt Area 80, the NER hunt would likely be ineffective in also significantly increasing harvest. Late-season harvest in Hunt Area 80 would include migratory Yellowstone elk, a declining herd segment of conservation concern. These proposed coordinated efforts would need to be approved by the Commission, BTNF, and GTNP.

Fertility control was considered and rejected in the 2007 BEMP, so therefore could not be undertaken on federal lands without vetting in the NEPA process. Moreover, this action would need approval by the WGFD Commission prior to the state undertaking fertility control on private lands in collaboration with landowners in Hunt Area 78 and Grand Teton NP South would occur during summer on private lands. Research completed since signing of the BEMP indicates fertility control may be more tractable now than when it was considered during preparation of the BEMP. Killian et al. (2009) demonstrated effectiveness of GonaCon™, a gonadotropin-releasing hormone vaccine, in female elk. Dart-delivered 2 ml doses of 1000 µg GonaCon™ resulted in nearly complete infertility of females treated in September. Much of the

early research on this immunocontraceptive vaccine was for use in white-tailed deer, with regulatory approval of GonaCon™ for use in female white-tailed deer by the U.S. Environmental Protection Agency granted in 2010. There are no known dangers to humans or wildlife from eating animals that have been treated with GonaCon™.

Most of the observed increase in segment population has occurred in the largely non-migratory Hunt Area 78 / Grand Teton NP south segment. Increased harvest in this segment would help address a number of issues, in addition to assisting in reaching Phase I objective. Harvest is nearly as liberal as possible at this time; the greatest limitation is hunter opportunity in residentially-developed areas. Elk use in those areas is increasing, necessitating continued collaboration with homeowner associations to improve hunter access within residential developments. Many associations have covenants that exclude firearms, but archery may be an option where firearms are excluded. There is also a growing constituency for trophy bulls in these areas.

A hunter management program for Hunt Area 78 would coordinate private land access through a hunt manager as liaison to private landowners. This program would be modeled after similar programs in Montana, as well as several in Wyoming (Meteetse, Laramie Peaks, etc.).

Habitat improvements—Habitat improvements discussed so far have focused on fire treatments on range adjacent to the NER to increase attractiveness of these areas to wintering elk. Opportunities exist for managed fire in certain areas, but opportunities for prescribed fire are limited. Fire treatments in lynx habitat would not be possible, therefore it would be necessary to determine if a conifer stand was suitable lynx habitat as based on tree cover. Conversely, areas within sage grouse core habitat (i.e., within a 4 mile radius of a lek) have a 5% disturbance cap that would similarly preclude fire treatment. Areas mapped as wildland urban interface (WUI) are available for treatment, but treatments need to be defined as a fuels reduction.

There is potential to have fire management areas on the refuge, but the conflict with sage grouse on the northern portion of the NER, which is identified as sage grouse core habitat, would need to be addressed. The plan will therefore include prescribed fire even if it isn't a primary tool. These changes would represent a small, ephemeral gain at best in changes to habitat that may result in more elk wintering outside of the NER. Wildland fire use (i.e., wildfire to meet resource objectives) is authorized forest-wide in the BTNF. Much of the BTNF adjacent to the NER is within the Gros Ventre Wilderness, which is managed to allow "natural processes of ecological change to operate freely. The number, size and intensity of fires [are managed to]

approximate the natural fire regime" (USFS 2013). Benefits from wildland fire use on adjacent national forest lands are therefore opportunistic in nature.

Private lands mitigation—Easements and leases have been proposed as a means to minimize livestock and elk conflict related to brucellosis. Easements would incentivize steer operations by purchasing from willing sellers the right to have cow/calf pairs. Easements should also consider all winter feeding of livestock (e.g., horses), certain agricultural crops that are attractants to elk (e.g., irrigated hay), as well as hunting access. These easements would be purchased and enforced through agencies and local land trusts. Leases in the Spring Gulch area are not a suitable solution due to the current level of development; may be an option in Buffalo Valley assuming the weather allows animals to winter there. Leases/easements would need to include a statement that the individual would forfeit their right to make a depredation claim to WGFD.

Non-traditional landuse mitigation would differ from that described above for traditional landuses. For example, the Jackson Hole Conservation Alliance is working with subdivision landowners to install landscaping that is less attractive, and more resistant, to elk and deer. Similarly, WGFD assesses subdivisions to identify issues for mitigation, and provides input to real estate developers and in county planning documents. Also, targeted hazing in subdivisions and golf courses is ongoing and will continue on an as-needed basis.

Public education/outreach—Each partner agency will have the opportunity to become involved in the planning and execution of education and outreach (EO) efforts. Increased public EO efforts will be undertaken regardless of the strategy selected. These efforts will include increasing public awareness of, and tolerance for, natural levels of winter mortality in elk. This would be accomplished through local news releases and radio announcements, training for sleigh-ride contractors that includes information on winter mortality in unfed populations of elk, etc. Regular updates on the planning process and progress towards meeting objectives set out in the BEMP will also be provided to the public through NER media outlets. County Commissions will be included in public EO efforts to make sure they are aware, and supportive, of the agencies' efforts.

Landowner EO would differ between those engaged in more traditional agricultural landuse (i.e., ranching) and non-traditional landusers (i.e., residential developments, golf courses). The decision to change a livestock operation from cow/calf to steers (non-breeding) is a major decision. It is not expected that ranchers would respond to an article in the paper, news story on the radio or even a letter. This kind of effort will require primarily one-on-one interactions with an individual that has built relationships and trust within the community. This would

require a private lands biologist to work with private landowners in the area. The position could be a shared position among agencies. Conversely, EO focused on homeowners in exurban developments will focus more on meetings with homeowners' associations, residential developers, etc., to provide information regarding living with wildlife, wildlife management and conservation, etc. All agencies will need to collaborate in initial efforts to reach key landowners and homeowner associations to convey the objectives and primary issues involved in managing elk and bison in Jackson Hole, as well as to express the importance of their involvement in the process. WFGD is currently doing this in some areas, e.g., Hunt Area 78.
Sportsmen EO would include meetings with local and regional sportsmen's clubs and ideally articles in club magazines, Wyoming Outdoors, etc. General newspaper articles could also help disseminate information. This could be largely accomplished with existing staff.

Agency EO is happening to some degree through AMP meetings. It would be helpful to focus on two different groups; field staff and Regional Office managers. Field staff are instrumental in achieving management actions on the ground, but also support changing public opinion in the local area through their personal interactions outside of work. Regional office EO is essential in building the necessary support to obtain project resources and have support when controversies are elevated to their level.

WGFD Commissioner EO will require personal contacts coordinated with WGFD. Top priority will be the commissioner for this area and perhaps others. This will include 1) tours of the NER and GTNP and 2) a briefing on alternative strategies resulting from the AMP.

Monitoring—**Draft once strategies are finalized.**

Enforcement—**Draft once strategies are finalized.**

Contstraints

Constraints that were identified for managing wintering elk population on the NER were diverse and included policy/regulatory, biological, social, and funding constraints, and combinations thereof (Table 4). The most common constraints were policy related (33%), followed by social (28%), biological (22%), and funding (17%) constraints. Many of the identified constraints could be identified in multiple groups; we largely identified constraints as belonging to a single group to simplify classification.

Table 4. Management constraints identified for the National Elk Refuge wintering elk population objective.

Policy constraints

Hunt end date (Feb. 1st)
Carcass disposal (Feb. 15th)
Commission structure (WGFD)
Forest Service access (Dec. 1st closure)
Easement limitation (NER boundary)
2007 EIS (rejected fertility control and test and slaughter; limits tribal harvest)

Social constraints

Hunter numbers
Winter mortality (social acceptance)
Public safety (ungulate/vehicle collisions)
Disease (cattle commingling)
Land-use conflicts (agricultural and residential)

Biological constraints

Disease
Sage grouse habitat conflicts
Fencing/wildlife conflicts
Migratory segment (maintain summer distribution goals)

Funding constraints

Easements
Fencing
Fertility control

National Elk Refuge Strategy Narratives

Management action strategies were divided into themes based on the focus of the grouped actions within a strategy. For example, the National Elk Refuge-Focused strategy targets winter elk distribution through management actions primarily taken on the refuge. The Southern Herd Segment Management strategy is a set of actions intended to reduce the number, and productivity, of the largely non-migratory elk in Hunt Areas 75 and 78 while minimizing the risk of harvest to migratory segments of the JEH. The Late Season Harvest strategy would increase harvest more generally in the JEH through coordinated late season hunts, with key caveats outlined below. Several actions were identified as necessary to continue, or implement, regardless of the strategy selected. Those to be continued are the 1) intra-seasonal management and coordination between the NER and WGFD Gros Ventre feedgrounds, 2) fencing for private lands mitigation, and 3) “tag and drag” and guided hunts on the NER and GTNP. New actions to be implemented across all strategies include 1) a late-season refuge hunt, 2) Fire management on NER and adjacent public land, 3) increased public education and outreach, and 4) increased WGFD Commission education and outreach.

National Elk Refuge-Focused Strategy

The NER-focused strategy is based on altering distribution of elk using management actions centered primarily on the refuge. This strategy implements actions to make the refuge less attractive to wintering elk primarily through a less conservative winter feeding program and initiation of a late-season hunt. This assumes that a proportion of elk that winter on the refuge can be conditioned to stay on adjacent winter range based on decreasing the incentive (later initiation of feeding) and increasing the disincentive (late season hunt) to moving onto the refuge. Incentivizing steer operations on private lands would be undertaken to address the increased proportion of elk that may winter on adjacent private lands. Similarly, education and outreach to private landowners is included in this effort to increase acceptance of elk wintering on private lands adjacent to the NER. Increased enforcement on the NER would also be necessary due to the addition of the late-season hunt.

Southern Herd Segment Management Strategy

The southern herd segments (Hunt Area 78 and GTNP South) are increasing absolutely and proportionally within the JEH. Conversely, migratory segments (i.e., elk that summer in Yellowstone NP and Gros Ventre Wilderness) of the JEH are stable to declining. The Southern Herd Segment Management Strategy focuses management actions at slowing, or reversing, the growth of the southern herd segments. Proposed actions include increasing harvest through the development of a hunter management program, a program that also helps address private lands mitigation. **Targeted fertility control on private land summer range could also be explored by WGFD, but would need to go through the proper approval process (i.e., WGFD Commission). This action was considered and rejected in the BEMP**. Increased outreach to sportsmen and agencies, and landowners, would be undertaken; the former is due to the potential for fertility control and the latter is for increasing awareness of landowners of the efforts to reduce the southern herd-segment. Increased harvest is localized by this strategy, minimizing the potential impact of increased harvest on the migratory segments. Increased enforcement on the NER would also be necessary due to the addition of the late-season hunt.

Late Season Harvest Strategy

The Late Season Harvest Strategy represents a broader, landscape scale approach to achieving the Phase I elk objective. A coordinated (i.e., NER, WGFD, GTNP, BTNF) late season hunt in Hunt Areas 75, 77–78, and 80 would occur. Approval would need to be obtained for extending, or moving, the current season in GTNP to allow later harvest. Lastly, the current December 1st closure to protect wintering ungulates in Hunt Area 80 on BTNF lands would need to be modified through an environmental review process to allow hunter access into that area. Currently the JEH could be reduced by approximately 1,000 animals before being below

objective (11,000 ± 10%). A WGFD Commission approved reduction in the JEH could be investigated if the efforts of this strategy did not result in reaching the NER Phase I elk objective. An increase in enforcement would be necessary if this strategy was implemented.

Bison

Alternative management actions for bison on the NER and adjacent areas included several developed for the NER wintering elk population objective in addition to those solely developed for bison (Table 6). Most of the actions identified were related to bison harvest in an effort to influence hunter access or success.

Table 6. Bison population strategy table for identifying alternative management action strategies.

	Reference Case	Hunter Harvest	Alternative Reduction Actions
Population management			
No change	**X**		
Improve late-season access to north end of NER for hunting and carcass retrieval		**X**	**X**
Parking lot origination management		**X**	**X**
Alternative reduction actions*			**X**
Hazing			
No change			
Haze bison found south and east of Flat and Nowlin creeks		**X**	**X**
Service-accompanied hunters		**X**	**X**
Habitat improvements			
No change	**X**		
Fire management on NER and adjacent public land		**X**	**X**
Water source improvements			
Private lands mitigation			
NER south-boundary improvement			
Public education/outreach (EO)			
No change	**X**		
Increase education and outreach		**X**	**X**
Monitoring			

No change

Enforcement

No change

Increase

*Beyond the scope of this plan and may require NEPA review.

Population management—Hunter harvest of bison since 2007 has led to an appreciable reduction in the population (Fig. 5). Further efforts to increase hunter harvest are intended to reduce the number of years necessary to reach the bison population objective. Most of the actions identified are related to increasing opportunity and success at the existing level of hunter numbers. The current number of hunters each year is believed to be a maximum number allowable while still providing a quality, and safe, hunting experience.

Efforts to improve late-season access to the north end of the NER for hunting and carcass removal could facilitate increased harvest. Existing retrieval roads become impassable late in the hunting season due to snow, and can, for example, preclude hunters from using the West Parking Area or retrieving carcasses on the northern portion of the refuge. Keeping these roads open may be difficult in heavy snow years, requiring a bulldozer in some situations. Alternatively, over-the-snow vehicles could be considered for carcass retrieval on existing refuge roads. Hunter access easements across private lands on the northeast corner of the NER will be explored as another means of providing access to that portion of the refuge for hunting and carcass retrieval.

Hunters must originate from a designated parking area for hunting bison on the NER. All but one designated parking area are within the NER. Access to the northwest portion of the NER is via a parking area within and managed by GTNP in collaboration with the NER. Accessing the refuge for hunting from BTNF lands along the eastern boundary of the NER was historically not allowed. The refuge will continue to manage hunter distribution using parking-lot origination in an effort to encourage bison to move onto, and remain, on the refuge. Hunters with a NER permit will also be allowed to access the refuge from adjacent BTNF lands.

Continuous review of population management actions implemented for reaching the bison population objective will be undertaken during the life of this plan. If management actions outlined in this plan prove ineffective for reaching the objective, other actions that fall outside the scope of this plan may be considered, e.g., agency cull, herd-wide fertility control. Such actions may require evaluation as per the NEPA.

Culling of bison is currently not used as a population management action. Including an agency bison cull as a potential population management action in this plan does not imply agency approval at this time and would only receive further consideration upon meeting several criteria. Consideration of an agency cull would include meeting National Environmental Policy Act (NEPA) requirements. WGFD policy prevents elk hunting past January 31st to minimize hunter exposure to *Brucella abortus* (the bacteria that causes brucellosis). This policy is specific to elk at this time, but the same concerns exist for late-season bison harvest. Between February 1st–15th WGFD personnel can harvest animals and the animals can be donated; animals killed after February 15th must be disposed of in a landfill.

Herd-wide fertility control of bison was considered and rejected in the BEMP. A review of fertility control in wildlife, current at the time of approval of the BEMP, can be found in Appendix B of the final Environmental Impact Statement (EIS) (USFWS and USNPS 2007b). **Need to gather more details on the current state of knowledge for this technique – would it be possible to have the WGFD vet draft a few sentences, with current citations, for this purpose? Seems like this would have to occur on the feedline to be efficient and effective, which would trigger NEPA.** Bison primarily occur on federal lands, so proposed implementation of this action would necessitate following NEPA requirements.

Hazing—Reduction, or elimination, of winter feeding will likely result in bison having a broader winter distribution in Jackson Hole. This could lead to more frequent use of the Nowlin unit by bison; the Nowlin unit is where commercial sleigh rides are conducted. Moreover, increased bison use of the southern portion of the NER beyond the Nowlin unit increases the potential for bison to enter the town of Jackson. For public safety and to minimize conflict in the Nowlin unit, bison will be hazed north if found south of a boundary starting at the Twin Creek Subdivision, west along Elk Refuge Road to Nowlin Gate, north and west along Hunter Retrieval Road 22 (an administrative road), north along Hunter Retrieval Road 22 to the Refuge Barns, west along Nowlin Creek to the confluence of Flat Creek, and north along Flat Creek to the northern boundary of the Jackson National Fish Hatchery.

Service-accompanied hunters in NER management units south of the bison hazing line defined above could be used to haze bison north of the hazing line.

Habitat improvements—Fire management on NER and adjacent public land to increase attractiveness for bison would be the same as described above for elk (**pg X**). The objective, however, differs in that the purpose of attracting and holding bison on the refuge would be primarily to increase susceptibility of bison to harvest.

Water sources on the east side of the NER would be modified to increase flow rates, improve bison access to water, encourage bison use and potentially increase early season harvest. Existing springs known as waterhole 2 and waterhole 3 currently have defunct bore hole pipes with limited water flows. These would be repaired or replaced to ensure late summer water flow and encourage bison use at these locations.

Private lands mitigation—Bison primarily occur on public lands (i.e., NER, GTNP, and Bridger-Teton National Forest), and when they do occur on private lands WGFD has the authority to haze or lethally remove bison for safety or private lands damage concerns (WGFC regulations, chapter 56). There is the potential for increased private lands conflict if winter feeding is reduced or eliminated on NER. For example, bison may move further south when feeding does not occur, increasing the potential for bison in Jackson. To reduce the likelihood of bison moving from the Refuge into Jackson, a double cattle guard will be installed on Elk Refuge Road at the boundary with East Broadway and at the gate where the town accesses the municipal water wells.

Public education/outreach—Public education and outreach for bison management will be integrated into EO provided for elk management (see pg. **X**). There are important differences between bison and elk biology and management that will be articulated. The bison population objective differs from the elk objective, with the former based primarily on maintaining genetic heterozygosity while minimizing conflict (USFWS and USNPS 2007a). Bison winter feeding is conducted primarily to eliminate conflict with elk on feedgrounds, which is fundamentally different than the objective for feeding elk to sustain the JEH through winter with minimal mortality. Winter feeding of bison precludes other conflicts that would occur if bison were more broadly distributed within Jackson Hole, e.g., bison in the town of Jackson and the associated public safety conflict. As winter feeding is reduced, or eliminated, efforts will be made to manage potential increased conflict, but public acceptance of increased conflict will be necessary. There are important biological differences between bison and elk that will be highlighted. For example, during 2007–2013 the JBH had greater than twice the ratio of calves to females in winter compared to elk of the JEH (0.47 [SD = 0.05] for bison and 0.22 [SD = 0.03] for elk; WGFD, unpubl. data). During the six-year period taken to complete the BEMP the bison population grew exponentially, increasing from 627 animals in 2002 to 1059 in 2007 (Fig. 5; WGFD, unpubl. data). Management challenges can also differ between bison and elk. Bison female-calf groups spend much of the year in GTNP, where no harvest is permitted, and move to the Refuge as winter conditions reduce forage availability in GTNP. Female-calf groups largely do not use BTNF lands adjacent to the NER or GTNP, which constrains population management using hunter harvest to a relatively limited area on the NER. This can lead to dense concentrations of animals and hunters on the NER, which can result in hunter conflict.

Increased EO to state agencies, e.g. the Department of Agriculture and state veterinarian, will be included as part of this action. The range of bison will likely expand as feeding is reduced/eliminated, potentially leading to more conflict on private agricultural and developed lands.

Monitoring— **Draft once strategies are finalized.**

Enforcement— **Draft once strategies are finalized.**

Constraints

Constraints unique to bison management were largely related to disease transmission concerns and related policy (Table 7). For example, it is not currently possible to move bison out of the county, nor are bison currently allowed in the Gros Ventre near WGFD feedgrounds. Several identified alternative actions, fertility control and test and slaughter, were considered and rejected in the 2007 Environmental Impact Assessment (EIS) for the Bison and Elk Management Plan. The 2007 EIS similarly limits tribal harvest of bison. Moreover, there is uncertainty if an effective bison fertility control exists, which is a technological constraint. **What constraints from the NER wintering elk constraints table should be carried over to the bison constraints table?**

Table 7. Management constraints identified for the bison population objective.

Policy constraints
Hunt end date (Feb. 1st)
Carcass disposal (Feb. 15th)
Commission structure (WGFD)
Forest Service access (Dec. 1st closure)
Cumbersome hunt regulations
Hunter access (especially from north of the NER)
Easement limitation (NER boundary)
Current restriction on moving bison out of county
Social constraints
Public safety (ungulate/vehicle collisions)
Disease (cattle commingling)
Vendor numbers (are there enough for bison removals?)
Land-use conflicts (agricultural and residential)
Biological constraints
Disease
Sage grouse habitat conflicts (fire)

Fencing/wildlife conflicts
Grizzly bear conflicts (potential)

Funding constraints

Easements
Fencing
Fertility control

Technological constraints

Fertility control

Note/reminder from initial fall meeting Nov. 2012: "Three-pronged approach" 1) how to use hunters to reduce #s, 2) how to get more on native, 3) explicit metric for winter mortality that is acceptable.

Include a paragraph or two that describes 1) how phases are related to each other, 2) when we will claim we've been successful in Phase I, 3) how Phase II will be implemented (i.e., stepwise or all at once after success with Phase I, 4) whether meeting bison and elk objectives simultaneously will be necessary to begin implementing Phase II.

Include a summary of the actions in this plan that tier off of the BEMP vs. those that would trigger NEPA. This would include defining strategies succinctly and the threshold that would trigger NEPA. In this way we can move forward with actions that step down from the BEMP and have a trigger for initiating NEPA if, and only if, necessary.

1) Removed 'Grand Teton NP harvest' from the bison alternatives table because it was not in the BEMP and would therefore trigger NEPA and an act of Congress would be necessary (for a hunt, not a cull). A bison cull in GTNP would still trigger NEPA. Included agency cull (see below).
2) Test and slaughter for bison was reviewed and rejected in the BEMP – many reasons to not do it.
3) An agency bison cull would trigger NEPA
4) Herd-wide fertility control in bison would similarly trigger NEPA
5) Elk fertility control in GTNP south? This is currently an action in an elk strategy that would trigger NEPA, yet we haven't excluded it from the main plan, simply stated it would need NEPA.

Influence diagram rules –

1) Bolded polygons and arrows represent NER specific outcomes, influences, factors, and measurable attributes.

2) Rectangles represent ongoing management actions that influence the outcome of interest, bison and elk fed days on the NER
3) Hexagon is an outcome (which are also an influence/factor)
4) Dashed rectangle represents a measureable attribute with a defined threshold to trigger a management decision to implement an action.
5) Rounded rectangles represent objectives measured with uncertainty
6) Factors that influence the outcome. Unpredictable, unmeasured, or both, i.e., beyond our control or ability to influence effectively.

Influence Diagram Narratives—If survival and distribution are related to EFD & BFD – assume that reductions in EFD & BFD are not due to significant reduction in populations but instead the need to change elk and bison behavior and distribution.

First influence diagram – defines bison and elk fed days, and winter distribution, as outcomes. Each of these outcomes is defined in the BEMP; the phase 1 objective for BFD and EFD are based on feeding 500 and 5,000 bison and elk, respectively, for an average length of time (see above). The phase 2 objective is to minimize BFD and EFD, up to and including no feeding, while supporting JBH and JEH objectives. Winter distribution of the JEH to support the current population objective (11,000 elk ± 10%) is defined in the BEMP (table X, above), including 5,000 elk wintering on the NER.

Ultimate question – how many elk can the refuge support while concurrently minimizing calf survival and winter feeding? That is the primary uncertainty and what we need to determine.

Second influence diagram – includes a third outcome not explicitly defined in the BEMP but identified during the development of this plan.

Note to include – triggers for start and end of winter feeding are 1) available standing forage on NER key index sites, and 2) snow cover on transitional areas, respectively. The latter could be quantified using fixed photo points to estimate percent bare ground at important transitional areas (e.g., Kelly hayfields).

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DRAFT Adaptive Management Plan (AMP) Completion and Implementation Schedule

May 26, 2015

	Planning Step	**Deadline**
1	Finalize management strategies and modeling to explain present conditions.	**July 15, 2015**
2	Develop monitoring plan to evaluate impacts of management strategies.	August 1
3	Develop Peer Review panel and contracts	August 1
4	Update Draft AMP with above info	August 15
5	Agency review of draft	September 15
6	Changes from Agency comments	October 1
7	Peer Review	November 1
8	Interagency Team review of Peer Comments, discussion and changes to AMP	December 1
9	Second agency review if significant changes occurred during Peer review process	**January 1, 2016**
10	Public Comment	February 1
11	Evaluate public comments and make changes to AMP as needed	February 15
12	GPS Collar 30-40 elk prior to strategy implementation ($100,000 Iridium platform)	February 15 to March 15
13	Final Signatures (FWS & NPS Regional Offices)	March 1
14	Public outreach	March 1
15	Initiate private lands conflicts mitigation actions	March 1
16	Implement enhanced forage monitoring	November 2016
17	Initiate changes in supplemental feeding protocol	**January 2017**
18	End feeding one week early	February 2017

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From:	Steve Kallin
To:	Tim Fuchs; Doug Brimeyer; Susan (Sue) Consolo-Murphy; Sarah Dewey; Dale Deiter; Kerry Murphy; Jeffrey Warren; Cris Dippel; Eric Cole; Steve Kallin; Steve Cain
Subject:	Preparation Materials for Next AMP Meeting; June 3, 2015, 12:30 PM
Date:	Tuesday, May 26, 2015 1:46:59 PM
Attachments:	NER_AMP_meeting_agenda_6_3_2015.docx NER_draft_AMP_26_May_2015.docx DRAFT AMP Completion and Implementation Schedule 5-26-2015.docx

Hi All:

The attached information is provided to help the AMP Team be as efficient and productive as possible during the next meeting. The goal of this meeting is to complete focused discussion on key topics so a more complete AMP can be drafted.

Attached are three documents to help you prepare for the upcoming AMP meeting.

1. **NER_AMP_meeting_agenda_6_3_2015.** Please refer to topics in the agenda as you review the Draft AMP. These topics will receive focused discussion.
2. **NER_draft_AMP_26_May_2015.** This is a very rough draft of the AMP. Please focus on pages 1-21; all following pages are a compilation of notes and discussions from previous meetings.
3. **DRAFT AMP Completion and Implementation Schedule 5-26-2015.** Please review this draft schedule and be ready to provide your thoughts concerning plan completion and implantation timing.

Thanks again for the important contributions you have and are making to this AMP process.

Look forward to seeing next Wednesday,

Steve Kallin
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BISON AND ELK ADAPTIVE MANAGEMENT PLAN MEETING

3 June 2015 AGENDA

Participants:
National Elk Refuge, WGFD – Jackson Region, Grand Teton NP, Forest Service

12:30 – 12:45: MEETING OBJECTIVES

1. **Review of draft AMP –** the plan provided to everyone is a very rough draft intended to provide an overview of the general direction we are proposing.
2. **Supplemental feeding initiation and termination criteria.**
3. **Monitoring**
4. **AM Plan Review**
5. **Draft Completion and Implementation Schedule**

1.) 12:45 – 1:30: Review of draft AMP

A. Overview of draft AMP by Jeff Warren

B. General discussion of the current direction, i.e., big-picture comments

C. Detailed discussion of several key AMP components

- Elk winter distribution **pg. 4**
- Elk calf winter survival and forage deficits **pg. 7**
- Are the stated assumptions acceptable? **pg. 4, paragraph 2**

2) 1:30 – 3:00: Supplemental feeding initiation and termination criteria

A. Two potential approaches to change initiation of supplemental feeding

- Initiation based on available forage, lower threshold values **pgs. 10–11**
- Keep current available forage threshold and delay specified number of days

B. Options for termination of supplemental feeding

3) 3:00 – 3:30: Monitoring

A. Does the monitoring listed below capture the primary needs of the AMP?

- Elk response to supplemental feeding changes
- Elk calf survival
- Conflicts on private lands
- Changes to disease prevalence

4) 3:30 – 3:45: AMP Peer review discussion

5) 3:45 – 4:00: Draft Completion and Implementation Schedule discussion

From:	Steve Kallin
To:	Brad Hovinga; Doug Brimeyer; Susan (Sue) Consolo-Murphy; Sarah Dewey; Dale Deiter; Kerry Murphy; Jeffrey Warren; Cris Dippel; Eric Cole; Steve Cain
Subject:	Draft Adaptive Management Plan Review for August 3, 2015 Team Meeting at 12:30 PM
Date:	Friday, July 24, 2015 3:46:42 PM
Attachments:	NER AMP Draft v2.0 7-24-15.docx

Hi AMP Team:

Attached is the latest draft of the AMP for your review prior to the August 3 meeting.

There are several sections that are incomplete in this document. I would like to invite the WGFD and GTNP to populate the budget table (using track changes) for your anticipated expenses and add additional expenses that may not be identified in the table. You should estimate how much you believe these specific activities will cost, not how much you believe you can obtain from your agency. The source of the funding will be determined at a later time.

Also, I believe GTNP would like to add information about vegetation restoration. Please add that info using "track changes" on pages 11 and 17.

A number of you will be unable to make the August 3 meeting. Incorporating your feedback and suggested changes into the August 3 discussion would be extremely valuable. Please send your feedback/changes to this document, using track changes, to me prior to the meeting.

Thank you again for all of your assistance. Look forward to seeing you on August 3!

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U.S. Fish and Wildlife Service National Park Service

BISON AND ELK
MANAGEMENT STEP DOWN PLAN

A Structured Framework for Reducing Reliance on Supplemental Winter Feeding

National Elk Refuge

Grand Teton National Park

DRAFT

July 24, 2015

BISON AND ELK

MANAGEMENT STEPDOWN PLAN

For the

National Elk Refuge,

Grand Teton National Park,

John D. Rockefeller, Jr. Memorial Parkway

Teton County, Wyoming

DRAFT

***Suggested Citation**:* U.S. Fish and Wildlife Service: 2015. Bison and elk management stepdown plan, National Elk Refuge and Grand Teton National Park. U.S. Department of the Interior, Washington D.C. Available online at:

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Appendix I. Summary of primary potential impacts associated with reduced supplemental feeding, as identified in alternative 4 environmental consequences section of the Final Bison and Elk Management Plan/Environmental Impact Statement (USFWS and USNPS 2007)**.** .....

Appendix 2. Monitoring Supplemental Materials: Feeding Initiation Methods**.....**

Appendix 3. Communication Plan**.....**

Appendix 4. Models.....

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EXECUTIVE SUMMARY [incomplete]

Comment [S1]: Steve K, my view on this is that it should be relatively short, because this is not a long document. I am thinking perhaps 2-3 pages max. What are your thoughts?

Overview

In 2007, the National Elk Refuge (NER) and Grand Teton National Park (GTNP) published a Record of Decision (ROD; USFWS and USNPS 2007a) for a bison and elk management plan. The Bison and Elk Management Plan (BEMP; USFWS and USNPS 2007b) was developed to guide management of the Jackson bison and elk herds on NER and GTNP lands, focused on four broad goals related to: 1) habitat conservation; 2) sustainable populations; 3) numbers of elk and bison; and 4) disease management. The final plan directed the NER and GTNP (in conjunction with the Wyoming Game and Fish Department; WGFD) to maintain the state's elk herd objective of 11,000, establish a bison population objective of 500, restore habitat on the NER and in GTNP, continue hunting bison and elk on the NER, continue the elk reduction program, when necessary in GTNP, continue to vaccinate elk for and effective vaccine becomes available, and develop a dynamic framework and adaptive management plan for decreasing the need for supplemental feeding on the NER. ***This Bison and Elk Management Stepdown Plan was developed to address the latter and specifically addresses the criteria for a structured framework referenced in the Record of Decision.***

Background

Winter feeding of elk in Jackson was originally initiated to reduce winter mortality of elk and minimize depredation of ranchers' hay. The loss of available winter range in Jackson Hole due to new ranching operations and a growing town resulted in significant numbers of elk dying during several severe winters in the late 1800s and early 1900s. This prompted local citizens and organizations, as well as state and federal officials in Jackson Hole, to begin feeding elk in the winter of 1910–11. Congress heeded the appeals for assistance and on August 10, 1912, established the National Elk Refuge. Today, the need for the refuge's winter elk feeding program is a direct result of reduced access to significant parts of elk native winter range, loss of historic migration patterns, behavioral conditioning of elk to winter feeding, and the desire to maintain a population objective established in the context of supplemental feeding.

Bison were extirpated outside Yellowstone National Park (YNP) by the mid-1880s but in 1948 were reintroduced to Jackson Hole when 20 bison from (YNP) were released near Moran, Wyoming. The herd remained small until discovering elk feedlines in 1980, when the population began sustained population growth. Bison and elk that winter on the NER are migratory and occupy summer ranges predominantly to the north.

Objectives

This adaptive management plan addresses several objectives under a broader BEMP goal of sustainable populations, which directed the agencies to: 1) Develop an adaptive management plan for reducing NER supplemental feeding; 2) [implement a] phased reduction of animals on feed: a) to 5,000 elk and 500 bison, and b) [to a point where] elk and bison rely predominantly on native habitat; 3) maintain natural elk bull-to-cow ratios in park summer herd; and 4) Enhance public outreach/education. The BEMP further stated that consideration criteria for implementing the 2nd phase of reduced feeding will include: 1) the level of forage production and availability on the National Elk Refuge and adjacent winter ranges, 2) maintenance of desired herd sizes and age/sex ratios, 3) the ability to effectively mitigate bison and elk livestock conflicts, such as co-mingling on private lands during high risk disease transmission periods, 4) maintaining desirable winter distribution patterns of elk and bison, 5) the prevalence of brucellosis, chronic wasting disease, and other wildlife diseases, and 6) public support. **In short, the overall objective of this plan is to provide a path for progressively**

Comment [S2]: Problem here

DRAFT

transitioning from winter feeding of elk and bison on the NER to greater reliance on free-standing forage, while maintaining population and herd ratio objectives.

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INTRODUCTION

In 2007, the National Elk Refuge (NER) and Grand Teton National Park (GTNP) published a Record of Decision (ROD; USFWS and USNPS 2007a) for a bison and elk management plan. The Bison and Elk Management Plan (BEMP; USFWS and USNPS 2007b) was developed to guide management of the Jackson bison and elk herds on NER and GTNP lands. It included directives for forthcoming development of adaptive management practices to address several objectives in the plan, including a desired future condition of elk and bison relying predominantly on native forage. This Bison and Elk Adaptive Management Plan has been developed expressly for that purpose.

Bison and Elk Populations

While Jackson Hole is probably best known for the splendor and ruggedness of the Teton Range, the Jackson bison and elk herds rank among the top characterizing features of the valley. Both figure prominently in Jackson Hole's history and culture, although bison were absent from the valley for about 100 years between the mid-1800s and mid-1900s.

The Jackson elk herd occupies approximately 8,000 km^2 in the upper Snake River watershed north of the town of Jackson (Fig. 1). Much of the herd is migratory, moving between distinct wintering and summer ranges. Primary wintering areas include the Buffalo Valley, lower elevations of the Gros Ventre River drainage, the National Elk Refuge (NER), and areas adjacent to the NER on Bridger-Teton National Forest (BTNF) lands. Summering areas occur throughout the herd's range and for convenience are divided into four geographic regions that include Grand Teton National Park (GTNP), Yellowstone National Park (YNP), the Gros Ventre drainage, and Teton Wilderness.

In the late 1800s, when elk populations all over North America were being extirpated, the residents of Jackson Hole protected elk from "tusk hunters" and large-scale commercial hunting operations. Elk are just as important to today's residents of the valley. Thousands of people each year have the opportunity to see elk at close range on the refuge while riding on horse-drawn sleighs. Thousands of pounds of shed elk antlers are sold at an annual antler auction each spring in the town square. Elk are important to backcountry users as well as to people that never leave the road. Jackson Hole is a popular destination for instate and out-of-state elk hunters. The draw of elk to visitors contributes significantly to the local economy.

Winter feeding of elk in Jackson Hole began in 1910 and was originally initiated to reduce winter mortality of elk and minimize depredation of ranchers' hay. According to historical reports, before Euro-American settlement some Jackson elk wintered in the southern portion of Jackson Hole (present location of the NER town of Jackson) and may have used areas outside Jackson Hole, including the Green River and Wind River basins to the south and east, respectively, and the Snake River basin to the southwest in what is now eastern Idaho (Allred 1950; Anderson 1958; Blair 1987; Barnes 1912; Sheldon 1927). Radio-collar studies have documented small numbers of Jackson elk wintering in each of these areas in recent times as well (*citations*). Over time, changes in land use and development in these areas, over hunting, and establishment of feedgrounds probably reduced the use of these areas by Jackson elk.

By the end of the 19th century the Jackson elk herd was believed to be largely confined to Jackson Hole and the immediately surrounding area, where wintering conditions are often harsh. Compounded by the loss of available winter range in Jackson Hole due to new ranching operations and a growing town, significant numbers of elk died during several severe winters in the late 1800s and early 1900s. This prompted local citizens and organizations, as well as state

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and federal officials in Jackson Hole, to begin feeding elk in the winter of 1910–11. Congress heeded the appeals for assistance and on August 10, 1912, appropriated $45,000 for the purchase of lands and maintenance of a "winter game (elk) reserve" (37 Stat. 293). The first winter census in the area was conducted in 1912 and showed about 20,000 elk residing in Jackson Hole and the Hoback River drainage.

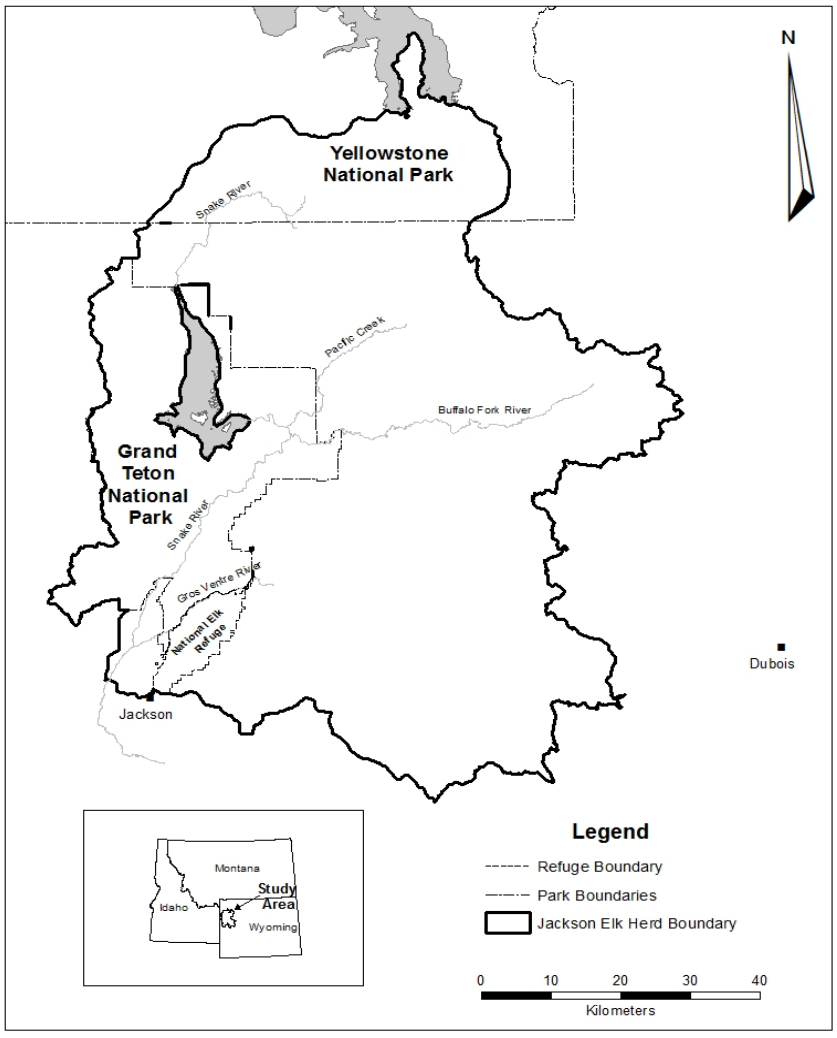

Figure 1. Jackson elk and bison herd ranges, including the National Elk Refuge, Grand Teton and Yellowstone National Parks, and Bridger-Teton National Forest. [include bison range, labels for continental divide and Bridger-Teton National Forest, and in Legend Jackson elk herd unit].

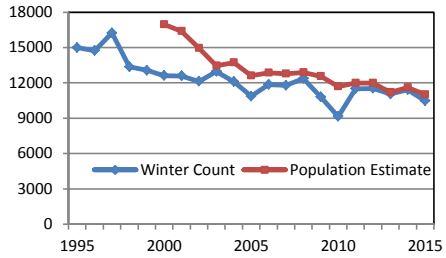

Figure 2. Winter counts and population estimates for the Jackson elk herd, 1995-2015.

Today, the need for the refuge's winter elk feeding program is a direct result of reduced access to significant parts of elk native winter range, loss of historic migration patterns, behavioral conditioning of elk to winter feeding, and the desire to maintain a population objective established in the context of supplemental feeding. Its population in recent times has fluctuated both above and below its herd objective of 11,000 adopted by the WGFD (Fig. 2)

An iconic symbol of the American West, bison are also popular with visitors and residents. Because so few opportunities remain to see bison in the wild, viewing and photographing them in Grand Teton National Park with the Teton Range in the background is a treasured opportunity for many of the valley's visitors. Similar to elk, there is also a high level of interest in bison hunting. Bison are of particular interest to nearby American Indian tribes and tribes in other parts of the United States because the animals are central to their culture and tradition.

Bison are native to Jackson Hole, as evidenced by the presence of prehistoric bison remains throughout the valley, but were extirpated outside Yellowstone National Park by the mid-1880s. In 1948, 20 bison from Yellowstone National Park (YNP) were reintroduced to the 1,500-acre Jackson Hole Wildlife Park near Moran. The Jackson Hole Wildlife Park was a private, non-profit organization sponsored by the New York Zoological Society, the Jackson Hole Preserve, Inc., and the Wyoming Game and Fish Department (WGFD). A population of 15–30 bison was maintained in a large enclosure there until 1963, when brucellosis was discovered in the herd (likely transferred with the original 20 animals from YNP). At that time, all the adult animals were destroyed, but four vaccinated yearlings and five vaccinated calves were retained. In 1964 twelve certified brucellosis free bison from Theodore Roosevelt National Park were added to the herd. In 1968 the herd (down to 11 animals) escaped the confines of the wildlife park, and a year later the decision was made to allow them to range freely. The expansion of GTNP in 1950 had enveloped the Wildlife Park, and allowing the bison to free range was and remains consistent with National Park Service wildlife management policy. The herd remained small and wintered mostly in the Snake River bottoms in GTNP until 1975, when it followed the winter environmental gradient to the NER and began wintering there. The use of standing forage by bison on the NER was viewed as natural behavior thus acceptable to managers. In 1980, however, bison discovered and utilized supplemental feed provided for elk, and they have continued to do so every winter since.

The discovery of supplemental feed by bison has had several consequences, including a significant increase in the population's growth rate (Fig 3). Bison on the elk feedlines have at times disrupted feeding operations and displaced and injured elk. To minimize conflicts between bison and elk, managers have provided separate feedlines for bison since 1984. As the population has grown, separating elk and bison on feedlines has become increasingly difficult, and a variety of feeding strategies are employed to help reduce displacement of elk.

As the herd has grown it has maintained fairly stable movement patterns, wintering almost entirely on the NER and summering within GTNP and adjacent lands on the BTNF (Fig. 1).

Planning History

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Jackson's bison and elk populations have been the subject of previous planning efforts. Elk management and research has been guided by the Jackson Hole Cooperative Elk Studies Group since it was established in 1953 [verify date]. The group consists of biologists and agency administrators from the National Elk Refuge, Grand Teton and Yellowstone National Parks, the Bridger-Teton National Forest, and Wyoming Game and Fish Department, who meet at least annually to coordinate management of the population and its habitat. Coordination of bison management began soon after they started frequenting the NER in 1976 and using supplemental feed provided to elk in 1980 (Fig. 3). Release of an "Interim" plan that called for maintaining a herd of 90-110 bison while data were gathered for a long term plan occurred in 1988. It was followed by implementation of a sport hunt administered by WGFD. This plan was halted after litigation in which the plan's violation of NEPA was successfully argued by plaintiffs.

In 1996, after considerable herd growth, a new long term management plan and environmental assessment for the Jackson bison herd was released (Fig 3). This plan had strong support and called for maintaining a herd size of 350-400 bison, but it was shelved a year later when plaintiffs from the earlier litigation successfully argued that, because the plan failed to consider the effects of feeding elk on bison management, it also violated NEPA and was not sufficient. This led to development of the draft bison and elk management plan and environmental impact statement from 2000-2006 and release of the final plan in 2007 (Fig 3).

The 2007 Bison and Elk Management Plan (BEMP; USFWS 2007) considered six alternatives for

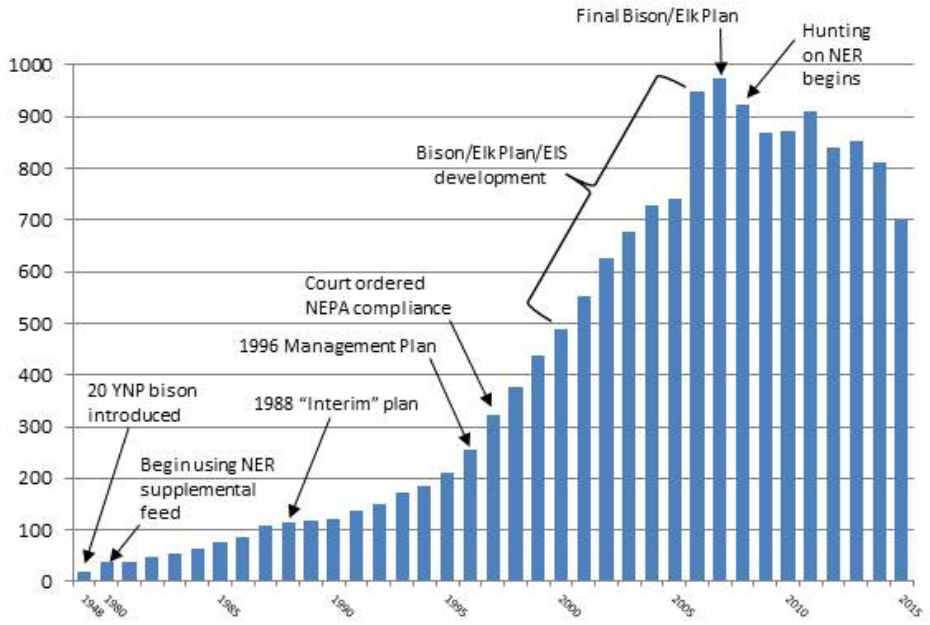

Figure 3. Population growth and planning history for the Jackson bison herd, 1948-2015.

bison and elk management focused on four broad goals related to: 1) habitat conservation; 2) sustainable populations; 3) numbers of elk and bison; and 4) disease management. The primary management scenarios presented in the alternatives included the status quo, terminating elk and bison hunting on the NER and the elk reduction program in GTNP, brucellosis vaccination options, restoring habitat, improving forage, and decreasing or phasing out supplemental winter feeding.

The final BEMP (USFWS 2007; www.fws.gov/bisonandelkplan) which set management direction for 15 years or until a subsequent plan is developed, proposed to maintain the state's elk herd objective of 11,000, establish a bison population objective of 500, restore habitat on the NER and in GTNP, continue hunting bison and elk on the NER, continue the elk reduction program in GTNP, when necessary, in concert with the parks enabling legislation (citation), continue to vaccinate elk for and effective vaccine becomes available, and develop a dynamic framework and adaptive management plan for decreasing the need for supplemental feeding on the NER. ***This Bison and Elk Management Stepdown Plan was developed to address the latter and specifically addresses the criteria for a structured framework listed on page 5 of the Record of Decision*** **(Fig. 4).** It does not address other on-going bison and elk management actions already prescribed by the BEMP.

The BEMP scheduled the completion of an Adaptive Management Plan for 2008. However, litigation challenging the BEMP in 2008 led to the decision to postpone its development until litigation was resolved. As of March 2015, two court rulings have upheld the 2007 BEMP and ROD. In a lawsuit against the BEMP and its author agencies (Defenders of Wildlife et al. v. the U.S. Department of Interior and State of Wyoming 2010), plaintiffs argued that the BEMP violated the National Wildlife Refuge System Improvement Act (National Wildlife Refuge System Improvement Act 1997) by disrupting the biological integrity of the Refuge, and that the plan and the accompanying EIS violated NEPA because they were insufficiently detailed to allow a reasonably complete discussion of mitigation. The crux of the plaintiff's argument was that the plan did not set a specific date for the cessation of supplemental feeding. In response, the agencies argued that the plan constituted a valid exercise of discretion and that it and the EIS were sufficiently detailed to satisfy the requirements of NEPA. In March 2010 the United States 4th District Court sided in favor of the agencies in this case. In 2011 the plaintiffs appealed this ruling to the United States 4th Circuit Court. The Circuit Court affirmed the District Court ruling (Defenders of Wildlife et al. v. the U.S. Department of Interior and State of Wyoming 2011).

National Environmental Protection Act Compliance

The 2007 BEMP/EIS and Final Record of Decision (ROD) satisfied NEPA requirements for current bison and elk management through a detailed analysis of alternative management actions and their likely effect on the environment, and substantial involvement of the public in the process. This adaptive management plan is does not duplicate or add to this process. It is designed to carefully tier off of the BEMP as a dynamic implementation guide to one part of the preferred alternative outlined in the BEMP ROD. As such, references to NEPA covered in the BEMP will be included where necessary in this document, and the discussion of any action that would require additional NEPA compliance will be explicitly stated as such in that context.

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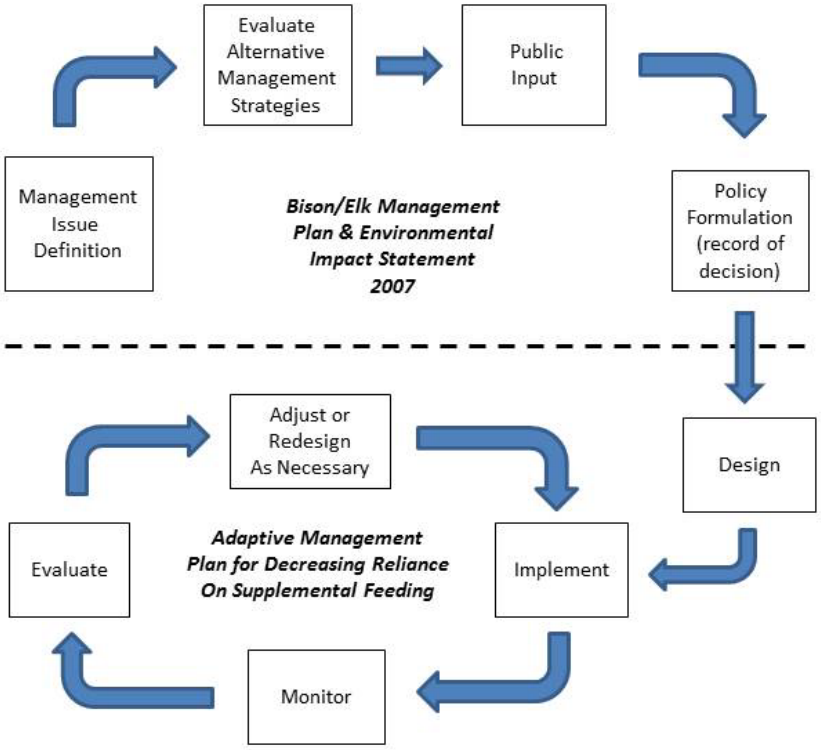

Figure 4. Adaptive management planning for supplemental feeding on the National Elk Refuge and its relationship to the 2007 Bison/Elk Management Plan and Environmental Assessment.

Adaptive Management Planning

Adaptive management plans have gained popularity in natural resource management planning because, by definition, they allow modifications of strategy based on monitoring results and outcomes toward reaching specific goals or objectives. There are four essential elements to an adaptive management approach: 1) well defined and mutually agreed upon objectives, 2 knowledge (including descriptive models) of the dynamics of the system being managed, 3) clearly articulated management actions and strategies, and 4) a monitoring program to evaluate responses of the system to management actions (Walters 1986).

This step-down plan utilizes adaptive management planning principles but is not intended to meet all of the adaptive management planning elements outlined in the Department of Interior Adaptive Management Technical Guide (2007). This Step-Down Plan is more accurately described as a "structured framework of adaptive management actions that progressively transitions from supplemental winter feeding to greater reliance on free-standing forage (BEMP ROD p.5).

OBJECTIVES

The management direction and desired conditions stated in the BEMP called for the NER and GTNP staffs to work with others (agencies, partners, etc) to "adaptively manage elk and bison in a manner that contributes to the State's herd objectives yet allows for the biotic integrity and environmental health of the resources to be sustained," so that the public can enjoy a variety of compatible wildlife-dependent recreational opportunities. Under the BEMP's 4 primary goals, 20 associated objectives were addressed (Table 1). This adaptive management plan addresses four objectives under the goal of sustainable populations (Fig. 5).

In Phase 1 of the second objective, the aim is to reduce the average number of elk on feed to 5,000 (while maintaining WGFD's 11,000 elk herd objective), and reduce the winter population of bison to the BEMP-adopted objective of 500. In Phase 2, the overall objective is to reduce the reliance of bison and elk on supplemental feed (USFWS and USNPS 2007a). Desired conditions include animals relying predominantly on native habitat and cultivated forage. Important consideration criteria for implementing Phase 2 will include: 1) the level of forage production and availability on the National Elk Refuge and adjacent winter ranges, 2) maintenance of desired herd sizes and age/sex ratios, 3) the ability to effectively mitigate bison and elk livestock conflicts, such as co-mingling on on private lands during high risk disease transmission periods, 4) maintaining desirable winter distribution patterns of elk and bison, 5) the prevalence of brucellosis, chronic wasting disease, and other wildlife diseases, and 6) public support. In short, the overall objective of this plan is to provide a path for progressively transitioning from winter feeding of elk and bison on the NER to greater reliance on free-standing forage, while maintaining population and herd ratio objectives.

Table 1. 2007 Bison/Elk Management Plan Goals and Objectives (Adaptive Management Plan objectives shaded)

Goal: Habitat Conservation

Objectives:

- Conserve important private lands.
- Increase forage production.
- Minimize non-native plants.
- Protect sagebrush grasslands.
- Restore willow, aspen, and cottonwood.
- Perpetuate natural mosaic of plant communities.

Goal: Sustainable Populations

Objectives:

- Develop adaptive management plan for reducing NER supplemental feeding.
- Phase reduction of animals on feed: 1) to 5,000 elk and 500 bison, and 2) elk and bison rely predominantly on native habitat.
- Maintain natural bull-to-cow ratios in park summer herd.
- Ensure a genetically viable bison herd with close to an even sex ratio.
- Enhance public outreach/education.

Goal: Elk and Bison Numbers

Objectives:

- Maintain state elk herd objective of 11,000.
- Maintain a genetically viable bison population of about 500 animals.

Goal: Disease Management

Objectives:

- Manage brucellosis transmission risk from elk and bison to livestock.
- Manage feeding to reduce brucellosis transmission among bison and elk.
- Educate hunters about wildlife disease human health hazards.

This Plan focuses on management actions to initially achieve Phase 1 objectives. However, if

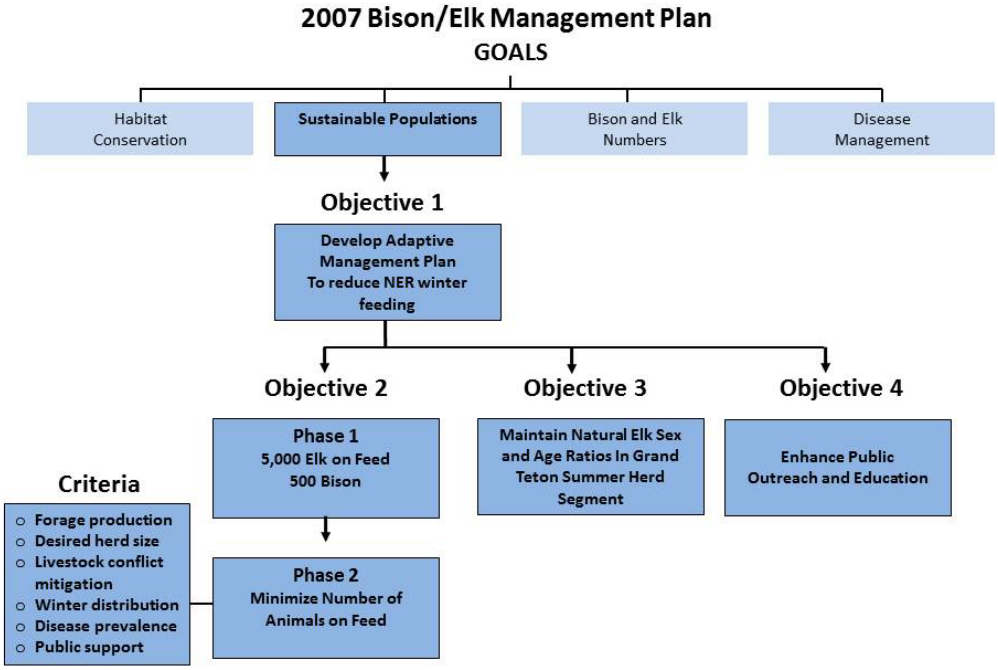

Figure 5. Relationship of Adaptive Management Plan to the 2007 Bison/Elk Management plan goals, phasing of objectives, and consideration criteria for reducing the reliance of elk and bison on supplemental feed during phase 2.

successful, these actions will continue to be used to achieve the Phase 2 objective of reducing reliance on supplemental feeding while considering the six criteria listed above.

MANAGEMENT ACTIONS AND STRATEGIES

Background

Elk have been fed for some period during nearly every winter on the National Elk Refuge since 1912, and bison have been fed there since 1980. The attraction of highly nutritious, easily accessible food during a time of year when natural forage is typically most limited is powerful to both species, and their knowledge of its existence has been passed down through generations. As a result, elk and bison have been strongly conditioned to seek supplemental food on the NER, even when natural forage is available and even abundant during some years. Because it is largely unprecedented, the concept of modifying this behavior on such a large scale is daunting and fraught with questions for which there is no answer. In some cases, the likelihood a specific management strategy's success will only be able to be roughly estimated, and unanticipated results are likely. The management stepdown approach will necessarily be one of investigation, constant evaluation, modifications to approach when indicated, and repeated trials (Fig 4). As such the approach will also be experimental, guided by rigorous analysis

and design, based on abundant empirical information, and monitored at an intensity commensurate with necessary decision making.

Since this plan is centrally tied to supplemental winter feeding on the NER, its focus will be on lands under NER authority. However, some strategies will also incorporate activities in GTNP, and on non-federal lands in collaboration with land owners and WGFD. Primary management practices that can be altered to achieve reduced reliance of bison and elk on supplemental feed fall into the 3 broad categories of 1) timing and intensity of winter feeding, 2) timing and intensity of hunting, and 3) herd segment specific and overall harvest levels.

Important Changes Since 2007

The BEMP was developed based on data collected and knowledge that existed up until its Record of Decision in 2007. Since then, important changes have taken place, some of which are advantageous to this effort, some of which are not.

A primary change that will facilitate meeting objectives under this plan is the reduction of the bison population from nearly 1,200 animals in 2007 to about 700 during winter 2014-2015 (Fig. 3) through hunting programs administered by WGFD. Licensing changes were enacted in 2014 to help increase harvest of female bison. These included a reduction in the bison cow/calf license fee (from $416 to $263 for residents and $2522 to $1022 for non-residents) and eliminating the once-in-a-lifetime restriction on a successful bison hunter to only those that successfully harvested a bull. Continued progress toward the 500 animal herd objective will require sustained harvest success.

During the same period, the Jackson elk herd has declined from nearly 13,000 to its objective of 11,000, but because the proportion of the Jackson Elk Herd that winters on NER has increased dramatically (Fig. 6), this will make achieving the Phase I objective of 5,000 elk on feed and any future elk population reductions more difficult. Preliminary modeling suggests that the increasing proportion of the Jackson Elk Herd wintering on NER has been associated with 1) changes in elk winter distribution associated with wolves and 2)high numbers of elk that summer immediately adjacent to NER (Cole and Foley et al. 2015).

Refuge-wide herbaceous forage production averaged 14,387 (SD = 4125) tons during 1998–2013. In recent years irrigation of approximately 3,600 acres has increased refuge-wide forage production by approximately 10% compared to what would have been produced with precipitation alone, and by 15% in the southern portion of NER which receives the greatest use by elk and bison.

Since 2007, the general awareness of climate change among the public has greatly increased. A strong, credible body of scientific evidence shows that climate change is occurring, is caused largely by human activities, and poses significant risks for a broad range of human and natural systems (National Academy of Science 2010). Ecological systems in the GYE are likely to be affected and associated changes will have implications for elk and bison management.

Current Management

Ongoing primary management actions on the NER include winter feeding, harvest, irrigation, and hazing. In GTNP, harvest of elk during the Elk Reduction Program takes place, when necessary, in collaboration with WGFD, and restoration of previously cultivated and irrigated sagebrush-grasslands is ongoing. Fundamental components of each of these will be briefly described below to provide a basis for comparison to adaptive management strategies that will follow.

Chronic Wasting Disease

Supplemental feeding has occurred in all but 9 winters on NER since 1912, and although this strategy minimizes winter elk mortality from starvation and contributes to Wyoming state elk

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herd objectives, elk occur at numbers and densities well in excess of carrying capacity (Smith et al. 2004, Lubow and Smith 2004). Considerable evidence suggests that Chronic Wasting Disease (CWD) transmission and prevalence are density dependent (Peters et al. 2000, Williams et al. 2002). Monello et al. (2014) found that elk densities of 15-110 per square km in Rocky Mountain National Park were associated with 13% CWD prevalence, and they predicted elk population declines when CWD prevalence exceeded 13%. NER elk densities commonly exceed 160 per square km (NER unpublished data), which suggests that the introduction of CWD to NER elk would have significant negative population effects over time.

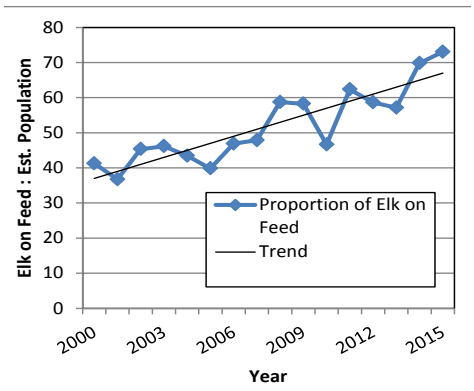

Figure 6. Increasing trend of National Elk Refuge elk on feed as a proportion of the Jackson Elk Herd estimated population size.

Winter Feeding

Initiation of feeding has the primary objectives of 1) minimizing elk winter mortality, focusing on calves since they are the most susceptible age class, and 2) minimizing comingling of elk with cattle on nearby adjacent private lands. Winter feeding begins when available forage reaches approximately 300 lbs/ac. Historic radio telemetry data and observations of elk movements indicate that when available forage delclines below 300 lbs/ac., some elk leave NER for surrounding private lands. Therefore, the purpose of this feeding trigger is to keep elk on the NER and prevent them from searching off-refuge for forage which increases the potential of comingling. This trigger is not a warning that a significant nutritional deficit threshold has been reached. Available winter forage for elk and bison on the NER is largely determined by biomass of forage produced during the previous growing season, rate of forage consumption during fall and winter, and how snow conditions affect forage availability.

Forage biomass estimates are calculated annually based on sampling at index sites. Index sites are selected subjectively each year based on presence of vegetation highly palatable to elk.

During 1995–2013, on average, initiation of NER winter feeding occurred on 28 January (range 30 December - 28 February), and feeding was terminated on 3 April (range 20 March - 20 April). Variation in feeding initiation and termination dates has been based on winter conditions and elk-cattle comingling problems on nearby private

Table 2. Annual distribution of wintering elk from the Jackson Elk Herd during February classification counts, 2011–2015, relative to the current objective.

	OBJECTIVE	2011	2012	2013	2014	2015	mean
NER	5,000	7,746	7,360	6,285	8,296	8,390	7,615
Gros Ventre	3,500	2,775	3,265	2,982	2,326	1,162	2,502
Native Range[1]	2,500	982	894	1,784	801	913	1,075
Total	11,000	11,503	11,519	11,051	11,423	10,465	11,192

[1]Excludes objectives for native range adjacent to Gros Ventre feedgrounds.

lands. Coordination of winter feeding dates on the NER and WGFD-operated Gros Ventre drainage feedgrounds (Alkali, Patrol Cabin) occurs annually to help minimize movement of elk between these areas. This coordination will continue regardless of the management strategy employed. The relationship of recent elk numbers and objectives for NER and WGFD-operated feedgrounds and native range is shown in Table 2.

Bison are fed as necessary to help minimize disruption to elk feeding operations. Bison will readily displace elk from feedlines, so since bison started using feedlines in 1980 refuge staff have developed a strategy of keeping most bison at the northernmost feedground (McBride) by feeding them there prior to feeding elk. Bison are provided a ration consistent with encouraging them to stay in this area away from elk feeding areas. This has also reduced conflicts associated with bison moving into Jackson or to the Nowlin area of the NER where commercial sleigh rides occur.

Harvest

Total harvest of the JEH was gradually reduced over the last decade as the population neared objective (Fig. 7). Elk hunting on the NER (Hunt Area 77) typically begins in mid-October and ends in mid-December, with peak harvest in recent years occurring in late November to early December. From 2005 to 2011 an average of 393 (SD = 56, range 329-457) hunters harvested 161 (SD = 38, range 126-225) elk per year during the NER hunt.

The 1950 legislation that created Grand Teton National Park provided for a controlled reduction of elk, when necessary, in specific portions of the park, primarily east of the Snake River. Elk reduction programs have taken place in the park each year since 1950 except two (1959, 1960), when GTNP and WGFD officials agreed a reduction was not necessary (Figure 8). Season dates have varied over the years but recently have run from mid-October to early-December. The GTNP harvest accounts for about 25% of the JEH overall harvest, thus has been an important factor in regulating the population. Increased natural regulation, likely a result of increases in grizzly bears and wolves over the last 20 years, has decreased the need for large harvests in the park.

Bison hunting begins on August 15 and ends in early to mid-January. Most harvest occurs on the NER, with some additional harvest on private and BTNF lands. Since resuming the bison hunt in 2007, mean harvest has been 210 (SD = 45.5, range 139-301) bison per year. This level of harvest has been sufficient to arrest the exponential growth of the population, reducing bison numbers from the peak in 2007 to about 700 animals in winter 2015 (Fig 3). Tribal bison harvest of up to 5 animals for ceremonial purposes was authorized in the BEMP. Translocation of wild bison to lands outside of Teton County is not currently permitted due to brucellosis concerns.

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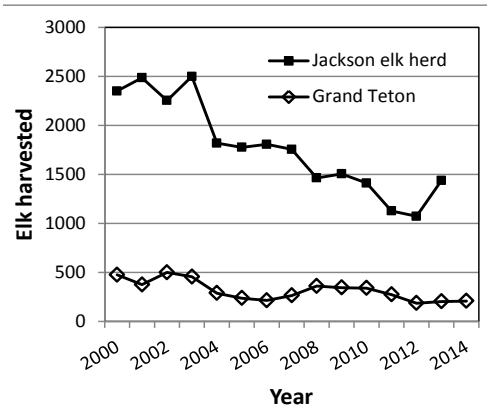

Figure 7. Estimated elk harvests for Grand Teton National Park and the Jackson elk herd (including the park) 2000–2014.

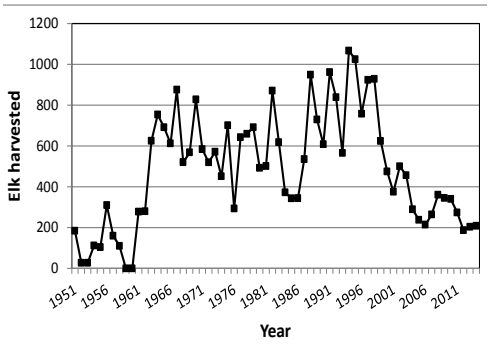

Figure 8. Elk harvest in Grand Teton National Park, 1950-2015.

Bison hunting is not allowed in GTNP because of long standing National Park Service policy that prohibits most hunting in national parks. Bison quickly learned to take advantage of the parks safety, which has made obtaining hunter harvest goals difficult. Many bison stay in the park during the hunting season, with only occasional short term movements to the NER, until severe winter conditions occur. In response, NER and WGFD managers attempt to balance extending the hunt as late in January as practicable without conflicting with winter feeding. The unpredictable nature of winter conditions that time of year makes this a risky proposition, and can result in the use of emergency season extensions or reductions.

Hazing

Elk and bison are hazed in spring to encourage movement off of NER winter ranges. Methods used have included ATVs, on foot, and on horseback, but recently ATV use has been found most effective. It's possible that some elk and bison might remain on the NER year around without hazing. If animals fail to leave the NER following the termination of feeding and adequate green-up has occurred, they are typically hazed to the north in late April to early May. Elk will stay off the NER until fall migration, and bison will generally remain in GTNP until mid-July. From July to early August bison often make forays back to the NER and are hazed back to GTNP to protect winter forage. Hazing efforts in August cease several days to weeks before the bison hunting season in an effort to increase hunter harvest.

Vegetation Restoration and Protection

The BEMP identified approximately 4,000 acreas of previously irrigated and cultivated grasslands in GTNP in need of restoration to native sagebrush grasslands community. Substantial progress in this endeavor has been made since 2007, including: [GTNP folks please add short description of methodological research and implementation, followed by what remains to be accomplished]

Private Lands Mitigation

Fencing of hay stacks and livestock feedlines has been historically used to mitigate particularly difficult conflicts on private lands. Targeted fencing of golf course greens and sand traps fall through spring has also been successful in some situations for mitigating elk and bison presence and associated damage in these areas. It is important to note that the county has a 'wildlife-friendly' fence policy and does not support extensive fencing that is impermeable to wildlife.

Methods, Assumptions, and Constraints Common to All Strategies

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Measuring the success of strategies toward objectives will require knowledge of several bison and elk herd attributes, particularly population sizes. Measurements of the Jackson bison herd will be based on the annual mid-winter census and sex and age classification survey performed by NER, GTNP, and WGDF biologists. This survey occurs one day in early February and includes ground counts of animals on feed at the NER and aerial counts of outlying bison across their winter ranges on the refuge, park, and Bridger-Teton National Forest.

Elk population estimates will also be based on mid-winter aerial and ground counts. However, the mid-winter counts are undertaken during a single survey period and do not necessarily represent either peak or cumulative abundance of elk on feed. Rather than basing progress toward the number of elk on feed for the entire season on those present during the day of the survey only, we will use a more meaningful measurement. Since we are more interested in the intensity of elk feeding throughout the entire feeding period, which includes both the number of animals on feed and the duration of feeding, we will use a measurement of elk-fed-days (EFD; the total number of elk fed per day per season) as a gauge of feeding intensity (see monitoring section). For example, if 5,000 were elk fed for 100 days during the winter, feeding intensity for that winter would equal 5,000 elk X 100 days = 50,000 EFD, whereas if 5,000 elk were fed for 50 days, EFD would equal 25,000.

We determined feeding intensity benchmarks for bison and elk-fed based on an actual average of 64 days of feeding from 1995-2007. Based on the Phase I objectives of 500 bison and 5,000 elk, fed-days benchmarks would be 64 x 500 = 32,000 for bison and 64 x 5,000 = 320,000 for elk. These values will assist in determining efficacy of strategies toward reducing reliance of both species on supplemental winter feeding.

Implementation of the AMP will have successfully attained the objective of "transitioning from intensive supplemental winter feeding to greater reliance on free-standing forage" when supplemental feeding was not used for more than 50% of the years in a 5 year period.

Comment [S3]: SK's draft.

Initial success of AMP implementation will be a consistent decline in the 3-year running average of elk and bison fed days from the established baseline. While the BEMP did provide specific measurement criteria for the definition of "transitioning from intensive supplemental winter feeding to greater reliance on free-standing forage" we will consider this objective met when the 3-year running average of elk and bison fed days is <50% of baseline for 5 years in a row.

Comment [S4]: SC's alterative in this paragraph, recognizing that the 50% number is the crux and a glaring target.

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Table 3. Summary of potential Adaptive Management Plan constraints.

Policy

- ESA[1] Lynx – limits on habitat impacts
- Greater Sage Grouse – core area protection
- 2007 BEMP/EIS (federal actions/lands)
  - No fertility control
  - No test and slaughter
  - Limited tribal harvest
- Bison/elk hunt end date (Feb. 1st)
  - WGFD, brucelosis safety
- Carcass disposal (Feb. 15th)
  - WGFD, brucellosis safety
- Forest Service winter closure (Dec. 1st – April 30th)
- Easement limitation (NER boundary)

Winter Feeding

- Only during non-hunting periods

Harvest

- State regulations

Vegetation Restoration/Protection

- Bison/elk distribution
- Exotic plant species management

Private Lands

- Owner agreements

Social

- Hunter density (safety; hunt quality)
- Elk/bison winter mortality levels
- Public safety (ungulate/vehicle collisions)
- Disease
- Land-use conflicts (agricultural and residential)

Biological

- Disease (bison/elk/cattle commingling)
- Sage grouse habitat conflicts
- Fencing/wildlife conflicts
- Elk herd distribution
  - summer segment distribution goals

Funding

- Easement purchase
- Plan implementation

[1]Endangered Species Act

Several management constraints are common to the strategies discussed below (Table 3). Many law and policy constraints are applicable but we include here only those most pertinent. Endangered Species Act (16 USC 1531 et seq.) requirements for wolves, grizzly bears, lynx, and others apply. Lynx requirements for maintaining certain habitat types could limit methods used and areas considered for habitat improvements in GTNP. Similarly, compliance with the Wyoming greater sage-grouse core area protection executive order (2011-5) could restrict habitat manipulations. NEPA compliance conducted as part of the BEMP/EIS constrains what federal actions can be taken as a part of this plan. State regulations constrain late (winter) hunt and carcass disposal timing to protect against brucellosis contamination, since February-April represent the period bison and elk are most likely to transmit the disease. Restrictions on hunting timing also result from BTNF winter range closures, immediately east of the NER and elsewhere, December 1 to April 30. Additional details about these and other constraints will be included in discussions about specific strategies that follow.

Strategies

This section will describe the management action this AMP proposes to implement. As such, it unveils the heart of management changes necessary to begin the process of transitioning to more reliance of bison and elk on native forage during winter. Fundamentally, the strategies discussed in this plan represent an experiment designed to achieve Phase I objectives of 5,000 elk and 500 bison on NER and are a first step towards reducing reliance on supplemental feeding while meeting the sustainable population goals identified in the AMP.

Initial strategies for achieving sustainable population goals identified in the BEMP (Table 1) are presented by objective below. The primary management actions available to the agencies to achieve phase I objectives are modifications to winter feeding and hunting seasons. To a lesser

extent, vegetation protection and restoration can be important, particularly for improving long-term ecological balance and enhancing natural production of native forage. Private lands are also an integral component as changes in elk and bison distribution occur and new challenges develop. The likely consequences of implementing these strategies were evaluated in the BEMP. The most relevant of these are summarized in Appendix 1.

Objective: *[Implement] a phased reduction of animals on feed: 1) to 5,000 elk and 500 bison, and 2) [to an extent where] elk and bison rely predominantly on native habitat* (Table 1).

This objective is what the need for an adaptive management plan – **this document** – is central to. As previously mentioned, the concept of reducing winter feeding after more than 100 years of the practice, and the associated behavioral conditioning of elk and bison to its presence, represents a formidable challenge that must be approached cautiously and systematically. The strategies discussed below have been developed in this context, with appropriate feedback mechanisms through rigorous monitoring and frequent evaluation. Inability to meet this objective under the strategies presented here would trigger a thorough evaluation and development of more aggressive strategies.

Chronic Wasting Disease

In 2014 WGFD began the revision process for the Wyoming CWD Management Plan (2006). WGFD has cooperated with federal agencies and other stakeholders to revise the plan, and NER and USFWS Region 6 Wildlife Health Office staff participated in several meetings associated with this effort. One goal of the CWD Management Plan update is to develop specific management responses should CWD be detected on or adjacent to State or NER elk feedgrounds. Early detection of CWD in the JEH is essential to ensure an effective management response.

Since 1997 NER has cooperated with Wyoming Game and Fish Department (WGFD) to conduct surveillance for CWD in the JEH unit. Although this effort indicates that CWD is not currently found in the JEH, continued surveillance at sample sizes sufficient to detect 1% prevalence with 95% confidence annually will be critical to ensure a timely management response and limit the long-term population effects of the disease (USFWS and NPS 2007). Given that CWD has been detected within 40 miles of the JEH in moose, within 70 miles in deer, and within 175 miles in elk, this level of surveillance is warranted.

Winter Feeding

Winter feeding actions that could be modified include starting date, ending date, and daily ration. To modify elk and bison behavior in the long run, delaying initiation of feeding is likely to have the greatest impact by gradually conditioning them to expect feed later on average, with the desired outcome of building a cohort of animals that rely primarily on native winter range and are not food conditioned. To reduce supplemental feeding overall, ending feeding early would also help decrease the amount of feed provided per animal per year. Both would help decrease the total elk/bison fed days, the parameter we will use to measure progress toward reducing supplemental feeding.

Initially, supplemental feeding will be delayed by approximately 2 weeks, depending on several variables (Table 4, Fig. 9). Time of season could influence this interval, most likely shortening it as the feeding initiation date gets later. During the last 20 years, feeding initiation dates, which have been based on forage availability, have varied from December 30 to February 28. Delaying feeding by two weeks in January, for example, is likely to be more successful than doing so in February, when food stress and tendency for animals to move to private lands is greater. Forage availability could also have an influence, particularly if a freeze thaw event resulted in an acute and large reduction in available forage.

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Both time of season and forage availability considerations would be affected by the numbers of elk and bison on the NER. And finally, the distribution of animals, particularly on private, livestock producing lands, would be considered.

A primary concern of manipulating feeding is elk winter mortality, particularly among calves. As food becomes limited in winter, calves are usually the first to suffer because of being displaced by more dominant animals. Monitoring programs will include measures of calf mortality and it will be an influencing parameter in feedback mechanisms. The BEMP anticipated that elk mortality could increase from 1-2% overall to 1-5% (Appendix 1).

Initially, the termination of feeding, which is now based on a snow cover index and subjective evaluation of available forage, will occur about a week earlier. The combination of a 2 week delay in feed initiation and 1 week advance in termination would shorten the feeding season by 3 weeks on average, or 32% based on an average feeding season length of 9.3 weeks from 1995-2015.

The AMP winter feeding strategy would include the establishment of additional key forage index sites and on-going measurements at those sites throughout the winter.

Harvest

Currently the Jackson elk herd is at the Wyoming Game and Fish Commission established objective of 11,000 animals, which means there is less flexibility in manipulation of harvest regimes than there would be if the herd was above objective. Initially there would be little change in elk harvest programs on the NER, with the exception of allowing a limited number of any elk permits throughout the season, considering allowing bow hunting near developed areas (roads and buildings) and shifting the season about a week later (Table 4). Allowing a limited number of any elk permits would be consistent with providing sport hunting recreation on National Wildlife Refuges (citation, NWR system act) and the NER (citation, CMP?), and possibly encourage more hunters to participate in antlerless elk hunts. Monitoring programs and consideration of bull ratios in the GTNP summer segment (since most park bulls migrate to the NER) would help inform levels of take proposed. Bow hunting in areas currently closed to firearms will likely increase harvest by eliminating “no-hunt” areas which can become sanctuaries for large numbers of elk. Shifting the hunt one week later is consistent with later migrations and will improve harvest effectiveness.

General elk harvest patterns in GTNP would continue to be based on need for harvest, summer segment population estimates, and mitigation for impacts on other resources and visitor activities.

Elk herd population objectives are reviewed every five years by the Wyoming Game and Fish Commission and adjusted as necessary. Serious consideration should be given to reducing the Jackson Elk Herd population objective. Lowering the population would help compensate for reduced use of traditional native winter range and increased growth of short-distance migrants which has lead to significant increases of winter elk concentrations on the NER.

The annual fall/winter arrival of elk to the NER during the past several decades has been occurring progressively later. This trend may necessitate extending the elk hunting season later into the year to achieve harvest objectives.

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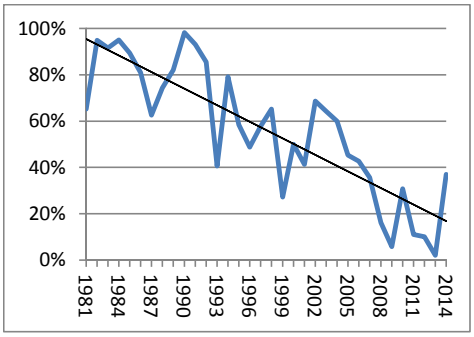

Figure ?. The annual fall/winter arrival of elk to the NER during the past several decades has been occurring progressively later. This trend may necessitate extending the elk hunting season later into the year to achieve harvest objectives.

Bison hunts on the NER (bison hunting is prohibited in GTNP) would see little initial change (Table 4). Consideration would be given to later hunt end dates commensurate with delayed feeding, and possible escorted hunting in the South Unit to help with distribution or discouraging bison from attempting to leave the NER via the south boundary into the town of Jackson. If progress toward reaching the herd objective of 500 animals continues and the objective is reached in the near future, State quotas will likely be reduced and management flexibility will increase.

A cattle guard will be installed on the Refuge Road near the east end of Broadway Avenue to help prevent bison and elk herds from entering the Town of Jackson. This will reduce the potential for dangerous human/wildlife interactions.

Serious consideration should be given to reducing the bison herd population objective in the future. This would lower winter forage consumption on the NER and help reduce elk and bison winter concentrations.

The current bison herd objective is ". . . maintain and ensure a genetically viable population of approximately 500 animals (five-year average), with as close to an even sex ratio as possible to maximize maintenance of genetic variation over time. . ." (BEMP p. 136).

The Jackson bison herd is not considered part of the U.S. Fish and Wildlife Service's meta-population approach to bison conservation because of its high prevalence of brucellosis. This disease prevents the export of Jackson bison to other DOI conservation herds.

The 500 bison population objective was set primarily to preserve existing genetic diversity assuming extremely limited natural genetic transfer with the Yellowstone or other DOI bison conservation herds. Genetic diversity can be maintained for a Jackson bison herd less than 500 if bison with desirable genetic diversity are periodically imported from other DOI bison conservation herds.

Currently, the effectiveness of NER late-season harvest regimes is affected by December 1st winter closures immediately east of the refuge on BTNF lands. Extensive elk telemetry data suggest that delaying the winter closures could aid elk management objectives. NER officials will work with BTNF and WGFD officials to explore the possibility of allowing hunting in limited areas after December 1st in the future.

Annual herd-wide population estimates, elk summer herd segment estimates, temporal and spatial harvest patterns, and animal-fed-days would be monitored, and the resulting information would be used to inform ongoing evaluation of adaptive elk and bison management harvest programs (Figs. 9 and 10).

Hazing

No change in hazing practices is anticipated initially under this adaptive management framework.

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Private Lands Mitigation

Delaying the onset of NER feeding is likely to result in changes in bison and elk distribution (Appendix 1). Some elk or bison may move to private lands in search of forage. Of greatest concern is the potential for elk or bison to commingle with cattle of cow/calf operations, where brucellosis transmission could have considerable consequences, in the worst case requiring depopulation of the cattle herd.

Several strategies would be employed to mitigate potential problems (Table 4), including providing incentives for non-breeding cattle operations (because brucellosis transmission to slaughter-bound cattle is not economically important), increased fencing in some limited areas to separate elk/bison from livestock feed lines, haze elk/bison away from livestock feed lines and purchase private lands easements to prevent co-mingling. A vital component in implementing these mitigation measures is to establish three seasonal Wildlife Conflict Technician positions which are supervised by the WGFD. These Technicians are also critical to the success of an expanded monitoring program vital to the AMP (see Monitoring section below).

A database will be established to track non-agricultural conflicts on private lands to determine trends which will help evaluate the effectiveness of AMP mitigation efforts.

Preventing elk and especially bison from entering the Town of Jackson is essential in minimizing safety and private property conflicts. Currently, bison are hazed northward when they drift south of Miller Butte. A double cattle guard will be installed on the Refuge Road just north of Broadway Avenue. This barrier is designed to prevent elk/bison from entering the Town of Jackson.

Vegetation Restoration/Protection

[NER and GTNP staff to draft material]

Objective: *Maintain natural bull-to-cow ratios in park summer herd* (Table 1).

National Park Service management policy (NPS 2006) provides guidance for maintaining naturally regulated wildlife populations, free from the impacts of humans, to the greatest extent possible. The final BEMP identified a goal of maintaining park elk bull:cow ratios (a common way of expressing sex and age ratios in wild ungulate populations) near 35 adult bulls per 100 adult cows, based on estimates of what this ratio would be in a herd free from the effects of human harvest. The sex and age ratios of most North American elk populations are affected by sport hunting and herd managers generally maintain lower bull ratios.

Harvest

Based on bull ratios in the park summer herd that were chronically below 35 bulls:100 cows, permit types for the park's elk reduction program (ERP) went to antlerless only in 2012. ERP permit structures in the park will remain antlerless only unless the bull ratios consistently exceed 35:100 cows. Park and refuge officials will work together to support this goal, recognizing that bulls harvested on the NER are most likely from the park summer herd segment.

A private lands Hunting Coordinator Position would be established and supervised by the WGFD to promote and coordinate hunting activity focused on Southern Herd Segment harvest in and around private lands in the Spring Gulch Area north to Moose, WY (Hunt Area 78).

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Table 4 [incomplete]. Comparison of current and adaptive primary management components and parameters.

Action	Current Management	Adaptive Management	Comments
Winter Feeding:			
Feed	Pelleted alfalfa	Pelleted alfalfa	No change
Ration	8 lbs/day/elk 20 lbs/day/bison	8 lbs/day/elk 20 lbs/day/bison	No change, to minimize calf mortality
Start criteria:			
Available standing forage	300 lbs/acre, as measured at traditional key index sites	Generally 2 weeks later; index sites to be increased in number and distribution	Influencing factors: - time of season - forage availability - numbers of elk/bison on NER - elk/bison distribution
End criteria:			
Available forage	Based on a snow cover index and subjective estimate of when residual or new forage is adequate	Generally 1 week earlier	Development of more objective criteria for future implemen-tation ongoing
Monitoring:			
Animals on feed	Mid-winter census	Elk/bison fed days[1]	
Proportion of JEH on NER feed	Mid-winter census	Mid-winter census	
Calf mortality threshold		<= 10%	
Elk/bison distribution - visual			
Elk/bison distribution – collars			
Winter mortality			
Elk summer range proportions			
Harvest, National Elk Refuge elk:			
Frequency	Annual	Annual	
Begin Date	2nd week October	3rd week October	Modified as necessary
End Date	2nd week December	3rd week December	Modified as necessary
Structure	- 1 week initial drawing - 1 week left over 1st served - partial week alternate	- 1 week initial drawing - 1 week left over 1st served - partial week alternate - daily 1st served alternates	

[1]Number elk and bison on feed per day, totaled by feeding season.

Table 4, continued. Comparison of current and adaptive primary management components and parameters.

Action	Current Management	Adaptive Management	Comments
Harvest, National Elk Refuge elk:			
Refuge permit types	- 1st week any elk - Antlerless only remainder of season	- Primarily antlerless only - limited any elk permits throughout season	
Access	Restrict access to specific locations	Restrict access to specific locations	
Hunt area boundaries		Consider expanding to allow bow hunting near developed areas	
Harvest, National Elk Refuge bison:			
Frequency	Annual	Annual	
Begin date	August 15th	August 15th	Modified as necessary
End date	2nd or 3rd week January	Consider later dates as appropriate	Modified as necessary
structure	As per WGFD	As per WGFD	
Refuge permit types	Any bison or cow/calf per state license	Any bison or cow/calf per state license	
access	Restrict access to specific locations	Restrict access to specific locations	
Hunt area boundaries	Limited to north of Nowlin Creek area	Consider escorted hunting in South Unit as needed	Guided hunts in South Unit when authorized
Harvest, Grand Teton NP elk:			
Frequency	As needed	As needed	
Begin Date	3rd week October	3rd week October	Modified as necessary
End Date	2nd week December	2nd week December	Modified as necessary
License types	Antlerless only	Antlerless only[1]	
Special regulations:	Cartridge limits	Cartridge limits	
	Bear spray required	Bear spray required	
	Hunter safety card required	Hunter safety card required	
Harvest, Bridger-Teton NF, Elk Hunt Area 80:			
Begin Date			
End Date		December 15	Would require change in winter closure dates

[1]Any elk licenses could be offered if bull ratios in the park consistently exceed BEMP criteria.

Table 4, continued. Comparison of current and adaptive primary management components and parameters.

Action	Current Management	Adaptive Management	Comments
Harvest, Elk Hunt Area 78			
Structure			Changes at discretion of WGFD
License types			
Private Lands Mitigation:			
Cattle commingling		Incentives for non-breeding operation	
Hay depredation		Increased fencing	
Landscape damage			
Easement acquisition			
Vegetation Restoration/ Protection: Elk Refuge			
Vegetation Restoration/ Protection: Grand Teton			

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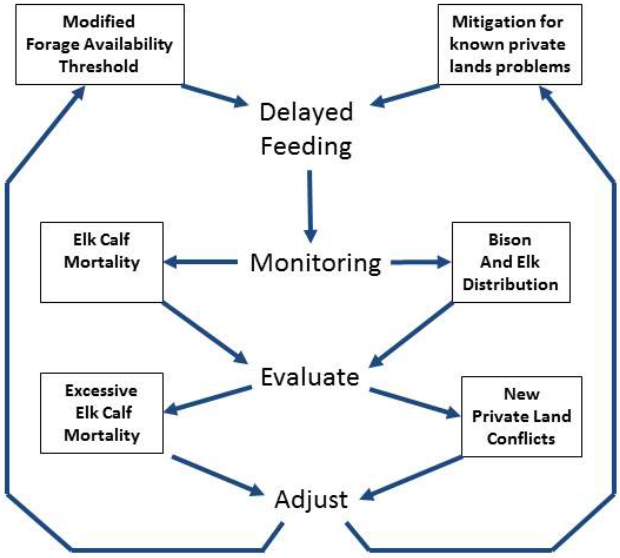

Figure 9. [example] Framework for delayed feeding strategy and adaptive management.

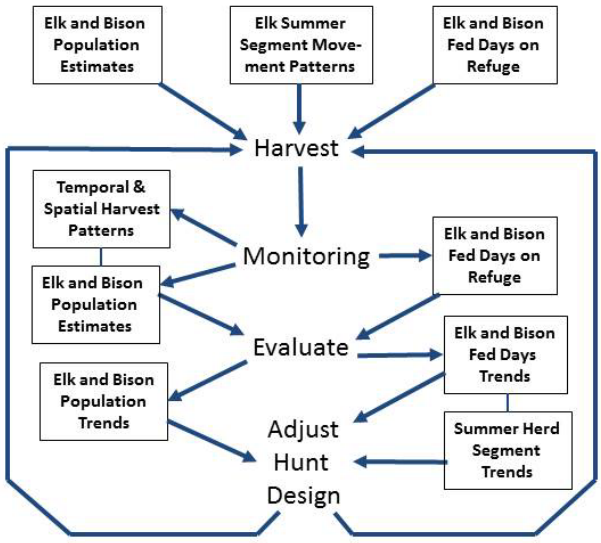

Figure 10. [example] Framework for harvest strategy and adaptive management.

Strategies Considered But Rejected

The BEMP considered several additional strategies for elk and bison management that, for a variety of reasons, were not selected for implementation in the preferred alternative and Record of Decision. The agencies reconsidered a subset of these during the development of this AMP (Table 5). Since they were not part of the ROD, additional NEPA compliance would be necessary to incorporate any of them into this adaptive management plan, and thus they are not being considered at this time.

Table 5. Strategies considered but rejected.

Strategy Considered	Reason Rejected
Fertility control in elk	Judged not reasonable or feasible in BEMP, primarily due to major technical, social, and financial hurdles[1]. For AMP discussed primarily with regard to the difficult to harvest herd segment in Hunt Area 78 on private lands, where federal agencies have no jurisdiction.
Fertility control in bison	Impacts discussed at length in BEMP[2]. Not considered for AMP because current hunting programs appear effective at slowly moving the herd toward the 500 animal herd objective.
Agency reduction of bison or elk	Not considered necessary or desirable on federal lands because current hunting programs that utilize sport hunters are effective at meeting herd objectives.
Altering rations of supplemental feed	Rejected as a strategy because reducing daily feed ration below 8 lbs/elk would be enough feed to encourage elk to remain on NER but would result in unacceptably high elk calf mortality rates.

MODELS OF SYSTEM DYNAMICS

Models provide a simplified representation of the biological system being managed. Adaptive management uses models of the managed system to link the objective response (e.g., elk winter distribution) to changes in the system resulting from management actions (e.g., altered initiation and cessation of winter feeding). Fig. 11 describes possible factors that affect winter elk distribution (the proportion of elk on NER feedgrounds versus native winter range). Models will be used to identify the relative influence of our principal management strategy (a reduction in feed season length) and other factors on winter elk distribution (Appendix 3). Over time this will allow us to assess whether changes in elk distribution were the result of our management actions or due to factors outside of our control.

An increase in calf elk winter mortality is a potential result of reduced feed season length. Fig. 12 portrays factors that influence winter calf elk survival on NER.

Models will be used to assess the effects of available forage on winter calf elk survival (Appendix 4). Over time this will allow us to assess the effects of our principal management strategy (reducing feed season length) relative to other factors on elk calf survival and potentially adjust our management actions based on model results.

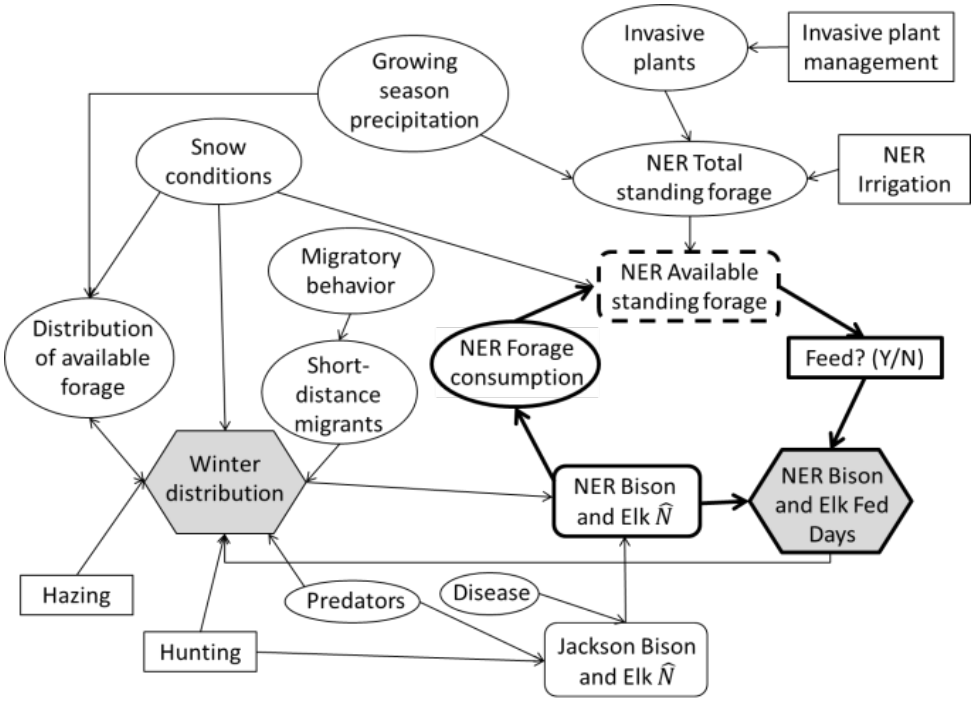

Figure 11. Influence diagram depicting factors (including management actions) influencing outcomes identified in the Bison and Elk Management Plan (BEMP; USFWS 2007a). Gray hexagons represent outcomes, rectangles represent management actions, rounded rectangles represent factors with numerical objectives, and ovals represent factors outside of management control. Bolded polygons and arrows represent outcomes and factors limited to the National Elk Refuge (NER). Available standing forage on the NER (dashed rectangle) is the BEMP criteria with a defined threshold to trigger initiation of supplemental winter feeding.

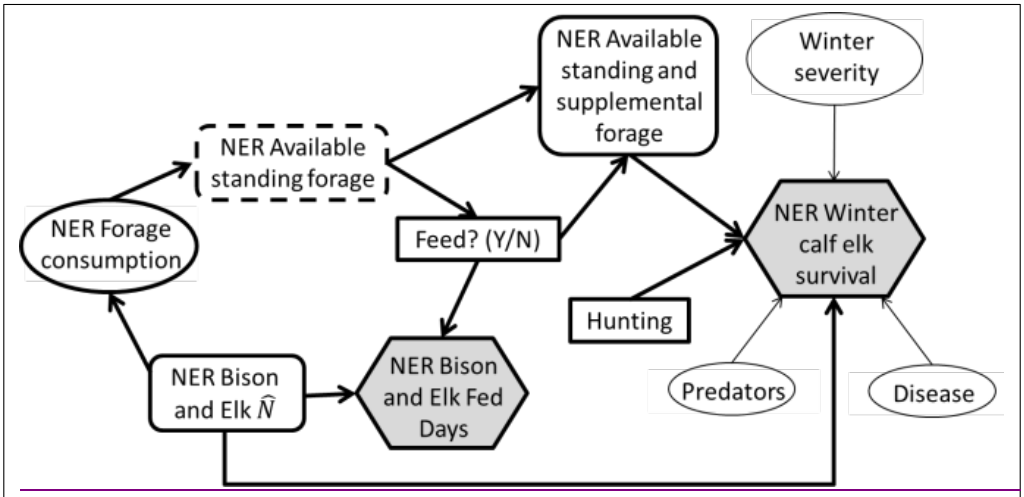

Figure 12. Influence diagram depicting factors (including management actions) influencing bison and elk fed days on the National Elk Refuge (see text for description) and winter calf elk survival. Gray hexagons represent outcomes, rectangles represent management actions, rounded rectangles represent factors with numerical objectives, and ovals represent factors outside of management control. Bolded polygons and arrows represent outcomes and factors limited to the National Elk Refuge (NER). Available standing forage on the NER (dashed rectangle) is the BEMP criteria with a defined threshold to trigger initiation of supplemental winter feeding.

MONITORING

Feeding Initiation Monitoring

NER uses weekly field estimates of the amount of forage available to elk to determine feeding initiation date. Currently measurements are taken at key index sites representing areas preferred by elk on NER (see supplemental materials at end of this section). These methods will be enhanced by 1) increasing the number of sampled sites to better represent the total amount of forage available to elk on the southern half of NER; 2) increasing the precision of estimates at each site by increasing the number of observers; and 3) extending the monitoring period later in the winter to assess the relationship between available forage and elk and bison distribution.

To better represent the total amount of forage available on the southern half of NER, a subsample of current key index sites will be retained to facilitate comparison with historic data, but additional random sample sites stratified by elk habitat preference will be added. Historic elk distribution mapping and elk GPS collar data (NER unpublished data) suggest that the areas most preferred by elk on southern NER are associated with moderate to high forage production and green vegetation. Because the distribution of forage production and greenness characteristics vary annually based on irrigation and precipitation patterns, we will annually map areas preferred and not preferred by elk and sample sites will be randomly selected within each of these mapped categories. At least 3 historic key index sites, 3 random sites in areas preferred by elk, and 3 sites in areas not preferred by elk will be sampled each week from late December through the initiation of supplemental feeding.

Currently the NER biologist is the only person trained in the techniques used to estimate available forage (see supplemental materials). At least 2 additional personnel will be trained in these techniques. This will provide a backup in the event of future personnel changes and will facilitate error estimates of the available forage measurements at each site.

Currently NER and WYGFD biologists monitor available forage conditions at least weekly from late December until average available forage at key index sites nears the threshold level of 300 lbs. per acre and feeding is initiated. The principal AMP strategy is to delay the initiation of supplemental feeding by 2 weeks after average forage production reaches the 300 lbs. per acre level at key index sites. Therefore the monitoring period will be extended to include the intervening 2 weeks.

Proportion of Elk Wintering on NER

A principal AMP goal is to reduce the number of elk wintering on NER. Our strategy will be to effect redistribution of elk to native winter range from NER over time via shortening the duration of the feed season, and thus slowly conditioning elk to seek food elsewhere. As feeding periods are shortened, the probability of younger elk age classes discovering NER feedgrounds will be reduced, and, hypothetically, that proportion of the JEH that utilizes NER feedgrounds will decline over time. We will measure this effect by examining changes in the winter distribution of the JEH. WGFD annual trend/classification count data provide a multi-year baseline data set to measure changes in the winter distribution of the JEH and categorizes observations by location. In each year, we will calculate the proportion of total classified elk in the JEH that are classified on NER feedgrounds. We will compare the 3-year running average post AMP implementation to the pre-implementation baseline. The pretreatment baseline will be comprised of data from 2008-2016, a time period that represents BEMP implementation prior to AMP actions (Figure 13).

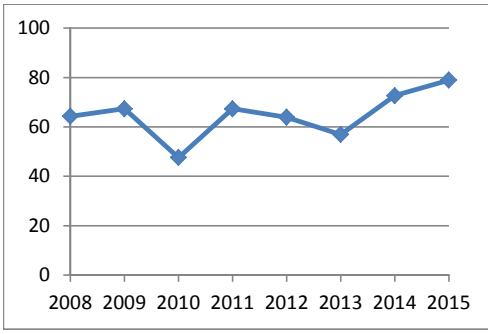

Figure13. Proportion of the Jackson Elk Herd that was classified on NER feedgrounds in the period following implementation of the Bison and Elk Management Plan and prior to the implementation of the Adaptive Management Plan (2008-2015). These values represent the pretreatment baseline which will be compared to the 3 year running average post AMP implementation.

Elk Fed Days and Bison Fed Days

The BEMP and AMP implicitly assume that the transmission rate and prevalence of elk and bison diseases are density dependent and positively correlated with the number of elk and bison utilizing feedgrounds and the number of days they are fed. We further assume the variables elk-fed-eays (EFD) and bison-fed-days (BFD) are a proxy for these conditions. EFD and BFD will be calculated annually for each species based on the following formulas:

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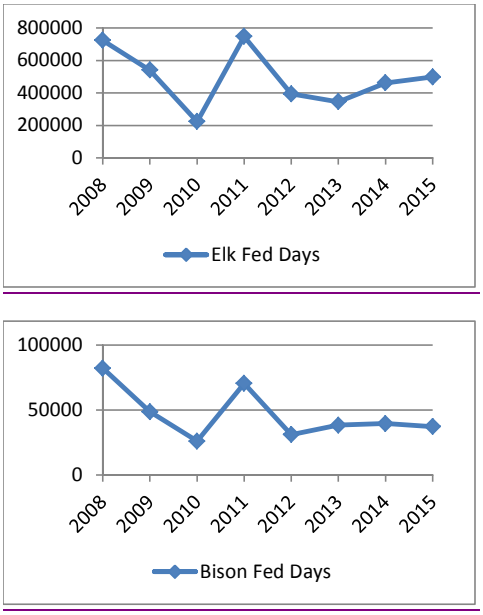

Figure14. Elk Fed Days (EFD) and Bison Fed Days (BFD) in the period following implementation of the Bison and Elk Management Plan and prior to the implementation of the Adaptive Management Plan (2008-2015). These values represent the pretreatment baseline which will be compared to the 3 year running average EFD and BFD post AMP implementation.

EFD= ∑ Total elk counted on feed during daily feedground counts for duration of feed season

BFD= ∑ Total bison counted on feed during daily feedground counts for duration of feed season

Because EFD and BFD are influenced by feed season length and the number of animals on feed, the AMP strategy of delaying the initiation of supplemental feeding will inherently reduce the number of EFD and BFD through a reduction in average feed season length. We believe that EFD will be further reduced by encouraging a greater proportion of the Jackson Elk Herd to winter on native winter range, thereby reducing the number of elk occupying NER feedgrounds. We will evaluate changes in EFD and BFD by comparing the 3-year running average post AMP implementation compared to mean EFD and BFD from 2008-2015. The running average is an appropriate comparison because it will help account for wide annual variation in EFD and BFD associated with winter severity (Fig. 14)

Elk Winter Mortality Monitoring

NER has used consistent methods to monitor winter elk mortality since 1982. Each winter NER biologists and other refuge staff conduct a survey of all non-hunting related winter elk mortalities that occur on NER from November through April. Mortalities are tallied by age/sex class and percent mortality is calculated using the corresponding number of elk classified on NER feedgrounds as the denominator. We will continue to monitor elk winter mortality using the same methods post AMP implementation, which will allow trend comparisons to the pre AMP baseline (Figure 15). Under the AMP framework, we believe the 3 year running averages for total and calf winter elk mortality will be within the range of variation exhibited by the pre AMP baseline. Historic monitoring suggests that calf and total mortality are sensitive to winter severity and disease outbreaks, and that winter mortality occasionally exceeds >3% total mortality and >10% calf mortality. Post AMP mortality in excess of these levels may warrant shortening the 2-week feeding initiation delay in subsequent years.

Elk Collaring

One of the AMP's principal strategies is to shorten the length of the feed season to encourage elk use of native winter range, but we anticipate that this strategy will also result in an increase in elk conflicts on surrounding private land in the town of Jackson and the Spring Gulch areas. To quantify this effect and provide real time information to WGFD and NER managers to facilitate a response, we propose maintaining a sample of 50 GPS collars on elk that winter on NER throughout the AMP implementation period.

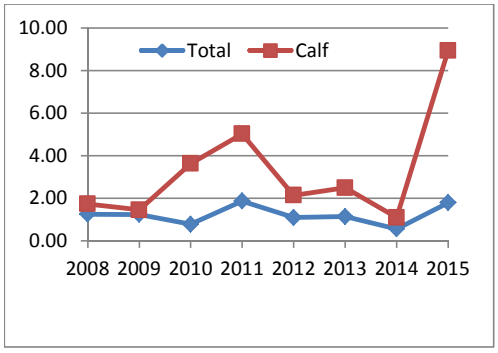

Figure15. Total and calf elk winter mortality (%) on NER in the period following implementation of the Bison and Elk Management Plan and prior to the implementation of the Adaptive Management Plan (2008-2015). These values represent the pretreatment baseline which will be compared to the 3 year running average post AMP implementation.

Forty -five elk represents approximately 0.5% (1 in 200) of the NER winter elk population. This sample size will not be sufficient to detect all elk movements from NER to surrounding private lands, particularly movements by small groups of mature bull elk, but it will be sufficient to detect and quantify significant movements of cow/calf/yearling elk groups compared to pre-AMP baseline data.

NER has elk GPS collar data available from the 2008-2013, which represents the post BMP, pre AMP baseline period. We hypothesize that elk movements from NER to surrounding private lands will increase during the AMP implementation period compared to the pre-treatment baseline. This will be tested by comparing the number of incidents that elk left NER for surrounding private lands (per elk/per year), and the proportion of elk GPS fixes on NER versus private lands during time periods of interest. The principal time period of interest is late December-March because this represents the period after the NER elk hunting season, and prior to and during NER feeding operations. This is the season when changes to the NER feeding program would be most likely to result in elk distribution changes.

Fifty adult cow elk will be captured on NER feedgrounds during February-March 2016 and Telonics Iridium GPS collars will be deployed with a 90 minute fix collection interval. Given 83% annual survival for adult cow elk in the Jackson Elk Herd (Cole and Foley et al. 2015) and 3 year collar life, approximately 10 additional elk will need to be collared each year in winter 2017 and 2018 to maintain the 50 elk desired sample size.

Ancillary data that will be collected and analyzed during the elk capture and collar data analysis process includes brucellosis seroprevalence, pregnancy rate, and elk summer range determination for comparison to the findings of Cole and Foley et al. (2015).

Disease

The primary purpose of limiting reliance on supplemental feeding is to reduce the prevalence of endemic elk and bison diseases and mitigate transmission risk associated with the introduction of novel diseases. We hypothesize that brucellosis seroprevalence will decline post AMP implementation. There are no recent brucellosis seroprevalence data for elk on the National Elk Refuge, but >50 elk will be captured during elk collaring operations in winter 2016, and each elk will be tested for Brucellosis exposure. The 2016 Brucellosis seroprevalence rate will be the pre-treatment baseline to evaluate post AMP change.

Chronic wasting disease (CWD) has been monitored in the JEH since 1997, and since 2008 it has been monitored with sufficient sample size to detect 1% prevalence with 95% confidence. No CWD positive cases have been detected in the JEH, which given the long term persistence of the disease, provides overwhelming evidence that CWD is not currently endemic to the JEH. However, most evidence suggests that the distribution of CWD is increasing and that its introduction to the JEH is inevitable. Early detection is critical to ensure an adequate

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management response, and therefore ongoing monitoring at sample sizes sufficient to detect 1% CWD prevalence with 95% confidence is necessary. CWD is sampled by testing tissues collected primarily from hunter harvested elk, and past experience suggests that 2 full time technicians working from September-December are necessary to ensure minimum sample size. Typical costs associated with 2 technicians are $32,000 per year.

EVALUATION/FUTURE MANAGEMENT

Modifying elk and bison behavior while reducing supplemental feeding will require a long-term, sustained commitment. Change is unlikely to happen fast, and interpreting effects of adaptive management actions will be complicated by varying environmental conditions from year to year. Consequently, we anticipate that the strategies outlined in this plan will be in place for a minimum of 5 years. Actions completed each year, the results of monitoring programs, and any proposed changes in course will be presented in an annual adaptive management update/report, completed by NER staff by the end of March for the previous year.

Investigating the potential effects of climate change on elk and bison management will be important in the long-term. During implementation of this plan, we will collect a variety of data that can be drawn upon for this purpose.

PUBLIC OUTREACH AND EDUCATION

The practice of winter feeding is inexorably woven into the historic fabric of Jackson Hole. Elk are identified with the rich and unique legacy for which Jackson Hole is known around the world. De-emphasizing the supplemental feeding program will be a major paradigm shift for the residents of Jackson Hole, Teton County, and the State of Wyoming.

An effective Public Outreach and Education program is essential for effective AMP implementation. The practice of feeding elk evokes passionate responses from those that oppose and those that support this practice. The general public and especially key stakeholder groups must understand the biological needs for and strategies of the AMP in order to gain general consent to modify longstanding elk/bison herd management methods.

A detail communication plan to guide outreach and education efforts can be found in Appendix 3.

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SCHEDULE

Table 6. Adaptive Management Plan proposed schedule.

Action	Date
GPS Collar 30-40 elk prior to strategy implementation (Iridium platform)	February 2016
Public outreach and education	March 2016
Initiate private lands conflicts mitigation contacts/actions	March 1, 2016
Implement enhanced forage monitoring	March 1, 2016
Initiate changes in supplemental feeding protocol	January 2017
Monitoring/Evaluation/Annual Report	June 2017

Table 7. Anticipated schedule of annual Adaptive Management Plan activities.

Activity	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
Elk and bison classification		x										
Irrigation						x	x	x	x			
Forage estimates	x	x	x	x								x
Etc…..												

[This table just for example. We could do the same with longer term schedule using years instead of months at the top if desired/necessary.]

BUDGET

Table 8. [incomplete]. Estimated Adaptive Management Plan budget above current expenditures, years 1-5.

Agency / Activity	Year 1	2	3	4	5
National Elk Refuge:					
Monitoring:					
Seasonal Biological Technician (0.5 FTE, GS-7)	24,000	25,000	26,000	27,000	28,000
Bison/elk fed days					
Mid-winter census					
Elk summer herd segment distribution[1]					
Expanded standing forage estimates[1]					
Chronic Wasting Disease, 2 seasonal biot-techs	32,000	32,000	32,000	32,000	32,000
Winter bison/elk distribution					
Irrigation					
50 Elk radio telemetry collars; Iridium Platform	$115,000	$25,000	$25,000	$25,000	$25,000
Bison barrier at NER south entrance	$80,000	$1,000	$1,000	$1,000	$1,000
Adaptive Management Plan annual reporting	$2,000	$2,000	$2,000	$2,000	$2,000
Private lands:					
Easements / Acquisition					
Damage reimbursements (Wyoming)					
Conflict mitigation coordination (Wyoming)	$91,000	$91,000	$91,000	$91,000	$91,000
Vegetation restoration/protection[1]					
Public Outreach and Education	$11,000	$1,000	$1,000	$1,000	$1,000
Subtotal					
Grand Teton National Park:					
Monitoring:					
Summer elk classification/distribution					
Hunter harvest					
Harvest age distribution					
Transition range forage production/utilization					
Vegetation Restoration/Protection					
Temporary bison fencing					
Hayfields restoration					
Exotic plant mitigation					
monitoring					
Elk Reduction Program					
Subtotal					
Wyoming Game and Fish Department:[2]					
Private lands:					
elk harvest coordination					
Easements / Acquisition					
Damage reimbursements					
Conflict mitigation coordination					
Add additional lines and categories as needed					
Subtotal					
Grand Total					

[1] See detail in Appendix

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APPENDIX 1. Summary of primary potential impacts associated with reduced supplemental feeding, as identified in alternative 4 environmental consequences section of the Final Bison and Elk Management Plan/Environmental Impact Statement (USFWS and USNPS 2007).

Populations

- Jackson elk herd objective of 11,000 would be maintained.
- New Jackson bison herd objective of 500 established.

Winter Feeding

- Supplemental feeding could be delayed or could occur earlier compared to current practices.
- Changes [to feeding program could] include alterations in the timing of feeding and providing supplemental feed in fewer years.
- Ration or pellet composition might need to be changed.
- Supplemental feeding would be initiated according to established criteria, including pre-winter forage production, assessments of forage utilization (done jointly by WGFD and NER personnel), elk condition and movements, and potentially on the January 1 index of winter severity calculations for elk (Farnes, Heydon, and Hansen 1999).
- Mechanical means could be used to increase forage access for elk after snow crusting events.
- Changes in the refuge supplemental feeding program could begin to affect elk nutrition (negligible adverse effect on NER elk from lower nutrition).
- Displacement of elk by bison during competition for standing forage would decrease as the bison herd is reduced.
- Aggressive social interactions involving competition for food among elk and bison would increase overall as feeding periods are reduced.

Winter Distribution

- Elk densities on the NER would decline due to more reliance on standing forage and wider distribution.
- Elk use of lands surrounding the NER would increase, including:
    - USFS lands east of the NER
    - Gros Ventre feedgrounds possibly
    - Southern GTNP
    - State feedgrounds south of the NER
- Most of winter distribution shift would involve elk in the Yellowstone, Teton Wilderness, and Gros Ventre segments.
- As ungulate numbers decreased and supplemental feeding was reduced, competition and aggressive social interactions on the refuge would also be reduced.
- Elk and bison distribution would increase as the animals relied more on native winter range.
- Fewer animals would be present on the refuge.

Mortality

- As supplemental feeding is reduced, natural factors such as climate and native forage availability would have a greater influence on numbers, movements, distribution, and mortality.
- More elk would be subject to natural factors affecting mortality, including loss of body condition, predation, and starvation.
- Increased mortality on and off the refuge would mainly affect older elk and calves, and some prime bulls entering the winter energetically stressed due to rut activities.

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- Late winter calf ratios could decrease as a result of higher winter calf mortality
- Average winter mortality on the refuge would increase from 1%–2% annually to an estimated 1%–5%.
- Overall, a higher total winter mortality rate of approximately 5% could be expected.

Disease

- Reductions in supplemental feeding or elk numbers would reduce the potential for impacts due to tuberculosis, septicemic pasturelosis, and CWD.
- The health and sustainability of the Jackson elk herd would be increased gradually as supplemental feeding was reduced and there was greater reliance on standing forage and wider ungulate distribution.
- Health and sustainability of the Jackson elk herd would be enhanced in the long term.
- Wider distribution of elk would result in moderate reductions in both the prevalence and potential transmission of brucellosis, as well as potential for spread of diseases not yet in the population.

Private Lands

- The agencies would work closely with the WGFD and landowners, including livestock producers, to coordinate actions that would prevent conflicts due to elk dispersal and to defray costs of managing potential conflicts. Preventing access to food/hay rewards on private lands would be vital for effective management.
- Private land conservation easements within NER boundaries would promote wider distribution.

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APPENDIX 2. Monitoring Supplemental Materials: Feeding Initiation Methods

At each sample site, 10 subplots will be measured at every 5 steps along the random bearing determined for each site. At each subplot a 13.27" diameter metal sampling ring will be placed on the ground. The amount of forage available to elk within the sampling ring (dry weight in grams) will be visually estimated. The 13.27" diameter subplot allows easy conversion from grams to lbs. per acre (each gram is equivalent to 100 lbs. per acre). During annual forage production sampling, refuge biologist Eric Cole has made approximately 1,000 of these visual estimates per year for 17 years, and 33% of Cole's estimates have been verified by clipping and weighing. Therefore, Cole will be the principal estimator, but additional personnel will be trained in these techniques to provide redundancy in the event of personnel changes, and to increase the number of observers to facilitate estimation of error.

Estimating available forage within the sample ring at each subplot is relatively straightforward when snow cover is limited, but estimating how much of the forage is accessible to elk when snow is dense, deep and crusted can be subjective. To decrease the subjectivity of the estimation process, if the area under the sample ring is covered with snow, only forage that can be exposed with a gloved hand will be included in the estimate of available forage. Forage that is fouled with manure and/or flush with the ground due to trampling and/or encrusted in ice will not be included in the estimate of available forage.

At each subplot the estimate of available forage (dry weight g) will be converted to an equivalent lbs./acre value (1 gram=100 lbs./acre). The arithmetic mean of available forage (lbs./acre) for the 10 subplots provides an estimate of available forage for each index site. There are 3 sample site categories: 1) Historic Key Index Sites that have been used since 2007, 2) New randomly selected sites within areas preferred by elk, and 3) New randomly selected sites in areas not preferred by elk. Historic key index sites were not randomly selected, but were instead selected to represent areas most preferred by elk on the south end of NER. These were the sites used to determine when supplemental feeding would be initiated from 2007 until the implementation of the AMP. To facilitate comparison with pre-AMP data, we will continue to use mean lbs. per acre across historic key index sites to determine the 300 lbs. per acre threshold. However, post AMP implementation we will delay feeding initiation by 2 weeks once the 300 lbs./acre level has been reached. We will concurrently sample at randomly selected sites stratified on an annual basis between areas highly preferred and not highly preferred by elk. This will enable us to quantify the relationship between mean forage availability at historic key index sites and random sites over time.

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APPENDIX 3. Communication Plan

Communication Goals

Prior to the Adaptive Management Plan's Implementation

- Utilize a variety of outreach methods to inform the public on the goals and timing of the Adaptive Management Plan's implementation and possible effects on wintering herds.
- Utilize a variety of outreach methods to inform the public on public comment opportunities.
- Identify and coordinate key messages and outreach with USFWS regional and national offices, State and federal agency partners, non-profits, elected officials, and other identified audiences.

During the Adaptive Management Plan's Implementation

- Continue to utilize a variety of outreach methods to describe current management actions as well as measurable and noticeable changes on the landscape, in animal behavior, or in animal health.
- Provide a comprehensive overview of the Adaptive Management Plan by providing links and references to previous outreach and background information.

Communication Objectives

- Work with current media contacts to promote news of the Adaptive Management Plan via print, radio, Web, and social media platforms.
- Utilize new media and social media tools to provide information on why the Adaptive Management Plan was developed, what public comment opportunities exist, and how the plan is being implemented.
- Plan, coordinate, and execute public meetings to allow for public comment and questions on the plan.
- Develop and provide methods for the public to submit written comments on the Adaptive Management Plan.
- Monitor print media on Refuge elk and bison management to see how Adaptive Management Plan objectives and reactions are being portrayed to the public.

Current Outreach Resources

- National Elk Refuge web site
- National Elk Refuge news release list
- (approximately 300 contacts)
- National Elk Refuge Twitter site (1,039 followers)
- Bison and Elk Management Plan web site (http://www.fws.gov/bisonandelkplan/)
- Space for an 11" x 17" poster in the Visitor Center on Refuge management topics
- Display panels in the Visitor Center theater for temporary displays

Available Supporting Outreach Resources

- USFWS Mountain–Prairie External Affairs staff
- USFWS Mountain–Prairie web site, including the
- "Top Stories" feature

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- USFWS Mountain–Prairie Twitter site USFWS Mountain-Prairie Region Facebook page
- USFWS National Wildlife Refuge System
- Facebook page
- USFWS Facebook page

Previous Outreach Efforts

- NER routinely writes and disseminates news releases on Refuge management activities, including the Comprehensive Conservation Plan, supplemental feeding, herd health monitoring, and forage production.
- Post the above news stories as Content.
- Management System (CMS) articles.
- Post CMS news story promos so they prominently appear on the home page, linking readers to the articles.
- Send out Twitter messages linking viewers back to the news stories.
- Prepare, upload and provide links to Adobe PDF versions of news stories with addtional photos where additonal images are available and/or help understand or visualize the content.
- Utilized the Conservation link on the web Content
- Management System to post information about the Bison and Elk Management Plan and the draft Comprehensive Conservation Plan.
- Retained and provided a link to the original Bison and Elk Management web page (http://www.fws.gov/bisonandelkplan/) that was developed during the planning process. The web site includes links to the Final Plan/EIS, Record of Decision, Federal Register Notice of Availability for both the Record of Decision and Final Plan/EIS, associated news releases, public meeting highlights, and other related documents. Note: the National Elk Refuge does not manage the site.

Additional Outreach Opportunities

- Public meetings in Jackson and other identified locations.
- Service produced video; video could be posted to the National Elk Refuge's multimedia web page, or USFWS Mountain–Prairie home page "Top Video" feature.
- Live radio interview on KHOL (Jackson, WY radio)
- Wyoming Public Radio interview with Refuge management staff
- Interviews with local print media sources
- Updates at community leader meetings such as Rotary Club, Jackson Hole Chamber of Commerce board meetings, and interagency breakfast meetings (with Federal agencies and local elected officials).

Target Audiences

Internal

- Regional and National USFWS Leadership
- Refuge permanent staff
- Refuge seasonal staff
- Refuge volunteers

External

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- Congressional representatives
- State of Wyoming leadership
- Federal agency partners, particulary Grand Teton National Park and the Bridger–Teton National Forest
- Wyoming Game & Fish Department
- Other NER partners, including county and town agencies and local nonprofit organizations
- Local elected officials
- Private landowners in proximity to the National
- Elk Refuge or neighboring Federal lands
- Tribes
- Local and state media
- Local public

Key Outreach Topics

- Overview of BEMP objectives
- Strategy to change elk/bison behavior
- Threat of disease
- Natural mortality rates
- Anticipated winter distribution changes for bison/elk
- Mitigate negative effects on private lands
- Change elk behavior and distribution while avoiding increased mortality.
- Explain the historic reasons a supplemental feeding program began and why it was continued.
- Explain the NER's limited large ungulate carrying capacity and the disproportionate impact of bison on available forage; 3 elk = 1 bison.

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APPENDIX 4. Models

Elk winter distribution model

The proportion of the JEH that winter on the NER will be linked to factors hypothesized to influence elk winter distribution (Fig. 2) using a generalized linear mixed effects model (GLMM). A GLMM can account for a proportional response variable (i.e., constrained to the interval 0–1) using a log link and binomially-distributed errors. A GLMM also includes fixed and random effects, with the latter capturing residual model variance otherwise not explained by fixed effects. Year will be including as a random effect, providing several benefits. First, we don't assume years are independent and comprise all of the factor levels of interest. Instead, the effect of year is treated as a random variable, with individual year effects realizations of that distribution. This allows inference to non-sampled factor levels, i.e. years, by estimating a latent population-level proportion of elk expected to winter on the NER regardless of fixed effect influences. Thus, the random year effect can be considered a latent variable describing elk behavior manifested as observed winter distribution. Second, because year effects are not treated as independent, estimated effects of year on the proportion of JEH elk wintering on the NER are dependent on all factor levels, leading to greater precision when estimating individual year effects (Kéry 2010).

The full GLMM incorporating fixed effects for each factor identified as influencing elk winter distribution (Fig. 2) is:

$$P_t = \beta_{0(t)} + \beta_1 * AFI_t + \beta_2 * SDM_t + \beta_3 * WP_t + \beta_4 * GSP_t + \beta_5 * SWE_t + \varepsilon_t$$

where the random intercept and residual model variance are

$B_{0(t)} \sim N(\mu_{\beta_0}, \sigma^2_{\beta_0})$, and

$\varepsilon_t \sim N(0, \sigma^2)$, respectively.

Fixed effects include 1) per capita available forage at initiation of winter feeding (*AFI*) , 2) proportion of the JEH that are short-distance migrants (*SDM*), 3) number of wolf packs present on JEH native winter range (*WP*), 4) growing season (May–August) precipitation for the Wyoming Snake Drainage climate division (*GSP*; a proxy for available forage on native winter range), and 5) snow water equivalent on 1 January at Thumb Divide (*SWE*; a proxy for early winter severity).

Elk calf winter survival and forage deficits

The Forage Accounting Model of Hobbs et al. (2003) has as an output weekly available forage biomass for the NER (sum of predictions for 30 × 30 m cells). These predictions account for snow conditions using a proxy of SWE and decrement total available biomass by 35% to account for unpalatable plants within the total estimate.

While calf survival is a function of multiple factors (Fig. 3), the primary management action influencing calf survival is supplemental winter feeding. Current winter feeding initiation criteria lead to calf survival generally higher than in unfed populations. Proposed feeding initiation criteria will result in later

Comment [WJ5]: I'm not comfortable with this interpretation yet and need to think about it some more.

Comment [WJ6]: This doesn't currently have a term for hunting, although our conceptual model above does. Need to decide if we want to include or exclude here.

Comment [WJ7]: Will need a more formal explanation of these variables and how they will be collected. May fit best in the monitoring section.

Comment [WJ8]: If we use Hobbs' model for predicting available forage these may be redundant.

Comment [WJ9]: Put in winter feeding initiation paragraph above? Then note where more samples are necessary to improve the precision of the estimates. Need to run this model from 2007 forward to see where, on average, feeding was initiated so we can make treatment adjustments as necessary. This would also allow us to look at the relationship between key index sites estimates and Hobbs' predictions. Need to consider validating Hobbs' model with field sampling Eric is currently designing to see if we can use the Hobbs model moving forward. This would take some time with stripping the Hobbs model down to our needs, identifying data sources, and developing a workflow process so weekly estimates of available forage can be calculated. Would only be able to use snow data from SNOTEL sites that have data available online, which shouldn't be too much of a problem.

Comment [KD10]: Need a citation here.

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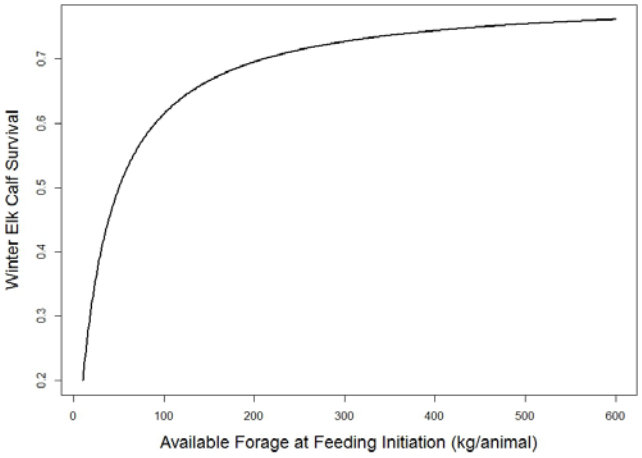
initiation of supplemental feed, which will be most influential to calf survival. There is currently little understanding regarding the relationship between initiation of winter feeding and calf survival, except that current feeding initiation criteria result in high calf survival. We believe a threshold level of available forage at initiation of winter feeding exists such that winter calf survival reaches an asymptote. Below this threshold, calf survival is hypothesized to decline quickly with reductions in available forage at winter feeding initiation. Available forage at the initiation of winter feeding will be related to on elk calf winter survival using a saturating function (i.e., Holling type-II functional response; Fig. 6) by

$$S_t = \frac{aAFI_t}{b + AFI_t}.$$

The parameters *a* and *b* determine how calf survival is related to available forage. Maximum calf survival is *a*, and *b* represents the value of available forage to an individual when survival is 50% of *a* (Hilborn and Mangel 1997).

Although this approach doesn't capture forage deficits *per se*, it does provide a potentially sensitive proxy for this concept. It is assumed that a forage deficit for calves would occur at a point on the curve of the relationship between calf survival and available forage at initiation of supplemental feeding. Modeling the response of winter calf elk survival to changes in feeding initiation criteria facilitates our ability to maximize the influence of feeding initiation criteria on winter distribution while minimizing the likelihood of a large mortality event.



Hypothesized relationship between winter survival of elk calves and per capita available forage at initiation of winter feeding on the National Elk Refuge.

U.S. Fish and Wildlife Service National Park Service

BISON AND ELK
MANAGEMENT STEP DOWN PLAN

A Structured Framework for Reducing Reliance on Supplemental Winter Feeding

National Elk Refuge

Grand Teton National Park

DRAFT

July 24, 2015

BISON AND ELK

MANAGEMENT STEPDOWN PLAN

For the

National Elk Refuge,

Grand Teton National Park,

John D. Rockefeller, Jr. Memorial Parkway

Teton County, Wyoming

DRAFT

***Suggested Citation**:* U.S. Fish and Wildlife Service: 2015. Bison and elk management stepdown plan, National Elk Refuge and Grand Teton National Park. U.S. Department of the Interior, Washington D.C. Available online at:

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Appendix I. Summary of primary potential impacts associated with reduced supplemental feeding, as identified in alternative 4 environmental consequences section of the Final Bison and Elk Management Plan/Environmental Impact Statement (USFWS and USNPS 2007)**.** .....

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EXECUTIVE SUMMARY [incomplete]

Comment [S1]: Steve K, my view on this is that it should be relatively short, because this is not a long document. I am thinking perhaps 2-3 pages max. What are your thoughts?

Overview

In 2007, the National Elk Refuge (NER) and Grand Teton National Park (GTNP) published a Record of Decision (ROD; USFWS and USNPS 2007a) for a bison and elk management plan. The Bison and Elk Management Plan (BEMP; USFWS and USNPS 2007b) was developed to guide management of the Jackson bison and elk herds on NER and GTNP lands, focused on four broad goals related to: 1) habitat conservation; 2) sustainable populations; 3) numbers of elk and bison; and 4) disease management. The final plan directed the NER and GTNP (in conjunction with the Wyoming Game and Fish Department; WGFD) to maintain the state's elk herd objective of 11,000, establish a bison population objective of 500, restore habitat on the NER and in GTNP, continue hunting bison and elk on the NER, continue the elk reduction program, when necessary in GTNP, continue to vaccinate elk for and effective vaccine becomes available, and develop a dynamic framework and adaptive management plan for decreasing the need for supplemental feeding on the NER. ***This Bison and Elk Management Stepdown Plan was developed to address the latter and specifically addresses the criteria for a structured framework referenced in the Record of Decision.***

Background

Winter feeding of elk in Jackson was originally initiated to reduce winter mortality of elk and minimize depredation of ranchers' hay. The loss of available winter range in Jackson Hole due to new ranching operations and a growing town resulted in significant numbers of elk dying during several severe winters in the late 1800s and early 1900s. This prompted local citizens and organizations, as well as state and federal officials in Jackson Hole, to begin feeding elk in the winter of 1910–11. Congress heeded the appeals for assistance and on August 10, 1912, established the National Elk Refuge. Today, the need for the refuge's winter elk feeding program is a direct result of reduced access to significant parts of elk native winter range, loss of historic migration patterns, behavioral conditioning of elk to winter feeding, and the desire to maintain a population objective established in the context of supplemental feeding.

Bison were extirpated outside Yellowstone National Park (YNP) by the mid-1880s but in 1948 were reintroduced to Jackson Hole when 20 bison from (YNP) were released near Moran, Wyoming. The herd remained small until discovering elk feedlines in 1980, when the population began sustained population growth. Bison and elk that winter on the NER are migratory and occupy summer ranges predominantly to the north.

Objectives

This adaptive management plan addresses several objectives under a broader BEMP goal of sustainable populations, which directed the agencies to: 1) Develop an adaptive management plan for reducing NER supplemental feeding; 2) [implement a] phased reduction of animals on feed: a) to 5,000 elk and 500 bison, and b) [to a point where] elk and bison rely predominantly on native habitat; 3) maintain natural elk bull-to-cow ratios in park summer herd; and 4) Enhance public outreach/education. The BEMP further stated that consideration criteria for implementing the 2nd phase of reduced feeding will include: 1) the level of forage production and availability on the National Elk Refuge and adjacent winter ranges, 2) maintenance of desired herd sizes and age/sex ratios, 3) the ability to effectively mitigate bison and elk livestock conflicts, such as co-mingling on private lands during high risk disease transmission periods, 4) maintaining desirable winter distribution patterns of elk and bison, 5) the prevalence of brucellosis, chronic wasting disease, and other wildlife diseases, and 6) public support. **In short, the overall objective of this plan is to provide a path for progressively**

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transitioning from winter feeding of elk and bison on the NER to greater reliance on free-standing forage, while maintaining population and herd ratio objectives.

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INTRODUCTION

In 2007, the National Elk Refuge (NER) and Grand Teton National Park (GTNP) published a Record of Decision (ROD; USFWS and USNPS 2007a) for a bison and elk management plan. The Bison and Elk Management Plan (BEMP; USFWS and USNPS 2007b) was developed to guide management of the Jackson bison and elk herds on NER and GTNP lands. It included directives for forthcoming development of adaptive management practices to address several objectives in the plan, including a desired future condition of elk and bison relying predominantly on native forage. This Bison and Elk Adaptive Management Plan has been developed expressly for that purpose.

Bison and Elk Populations

While Jackson Hole is probably best known for the splendor and ruggedness of the Teton Range, the Jackson bison and elk herds rank among the top characterizing features of the valley. Both figure prominently in Jackson Hole's history and culture, although bison were absent from the valley for about 100 years between the mid-1800s and mid-1900s.

The Jackson elk herd occupies approximately 8,000 km^2 in the upper Snake River watershed north of the town of Jackson (Fig. 1). Much of the herd is migratory, moving between distinct wintering and summer ranges. Primary wintering areas include the Buffalo Valley, lower elevations of the Gros Ventre River drainage, the National Elk Refuge (NER), and areas adjacent to the NER on Bridger-Teton National Forest (BTNF) lands. Summering areas occur throughout the herd's range and for convenience are divided into four geographic regions that include Grand Teton National Park (GTNP), Yellowstone National Park (YNP), the Gros Ventre drainage, and Teton Wilderness.

In the late 1800s, when elk populations all over North America were being extirpated, the residents of Jackson Hole protected elk from "tusk hunters" and large-scale commercial hunting operations. Elk are just as important to today's residents of the valley. Thousands of people each year have the opportunity to see elk at close range on the refuge while riding on horse-drawn sleighs. Thousands of pounds of shed elk antlers are sold at an annual antler auction each spring in the town square. Elk are important to backcountry users as well as to people that never leave the road. Jackson Hole is a popular destination for instate and out-of-state elk hunters. The draw of elk to visitors contributes significantly to the local economy.

Winter feeding of elk in Jackson Hole began in 1910 and was originally initiated to reduce winter mortality of elk and minimize depredation of ranchers' hay. According to historical reports, before Euro-American settlement some Jackson elk wintered in the southern portion of Jackson Hole (present location of the NER town of Jackson) and may have used areas outside Jackson Hole, including the Green River and Wind River basins to the south and east, respectively, and the Snake River basin to the southwest in what is now eastern Idaho (Allred 1950; Anderson 1958; Blair 1987; Barnes 1912; Sheldon 1927). Radio-collar studies have documented small numbers of Jackson elk wintering in each of these areas in recent times as well (*citations*). Over time, changes in land use and development in these areas, over hunting, and establishment of feedgrounds probably reduced the use of these areas by Jackson elk.

By the end of the 19th century the Jackson elk herd was believed to be largely confined to Jackson Hole and the immediately surrounding area, where wintering conditions are often harsh. Compounded by the loss of available winter range in Jackson Hole due to new ranching operations and a growing town, significant numbers of elk died during several severe winters in the late 1800s and early 1900s. This prompted local citizens and organizations, as well as state

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and federal officials in Jackson Hole, to begin feeding elk in the winter of 1910–11. Congress heeded the appeals for assistance and on August 10, 1912, appropriated $45,000 for the purchase of lands and maintenance of a "winter game (elk) reserve" (37 Stat. 293). The first winter census in the area was conducted in 1912 and showed about 20,000 elk residing in Jackson Hole and the Hoback River drainage.

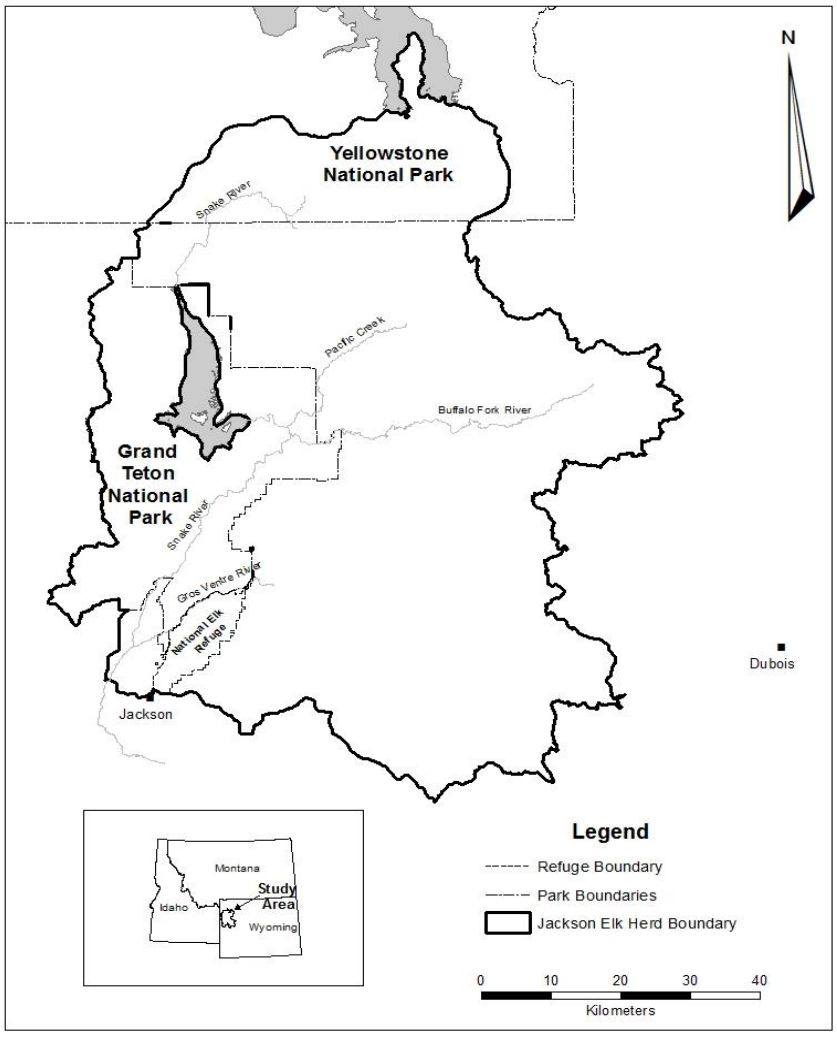

Figure 1. Jackson elk and bison herd ranges, including the National Elk Refuge, Grand Teton and Yellowstone National Parks, and Bridger-Teton National Forest. [include bison range, labels for continental divide and Bridger-Teton National Forest, and in Legend Jackson elk herd unit].

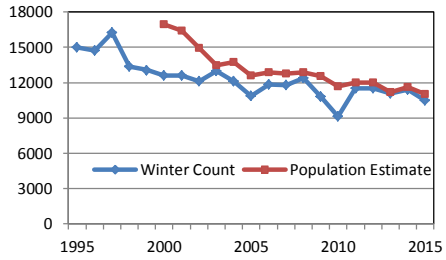

Figure 2. Winter counts and population estimates for the Jackson elk herd, 1995-2015.

Today, the need for the refuge's winter elk feeding program is a direct result of reduced access to significant parts of elk native winter range, loss of historic migration patterns, behavioral conditioning of elk to winter feeding, and the desire to maintain a population objective established in the context of supplemental feeding. Its population in recent times has fluctuated both above and below its herd objective of 11,000 adopted by the WGFD (Fig. 2)

An iconic symbol of the American West, bison are also popular with visitors and residents. Because so few opportunities remain to see bison in the wild, viewing and photographing them in Grand Teton National Park with the Teton Range in the background is a treasured opportunity for many of the valley's visitors. Similar to elk, there is also a high level of interest in bison hunting. Bison are of particular interest to nearby American Indian tribes and tribes in other parts of the United States because the animals are central to their culture and tradition.

Bison are native to Jackson Hole, as evidenced by the presence of prehistoric bison remains throughout the valley, but were extirpated outside Yellowstone National Park by the mid-1880s. In 1948, 20 bison from Yellowstone National Park (YNP) were reintroduced to the 1,500-acre Jackson Hole Wildlife Park near Moran. The Jackson Hole Wildlife Park was a private, non-profit organization sponsored by the New York Zoological Society, the Jackson Hole Preserve, Inc., and the Wyoming Game and Fish Department (WGFD). A population of 15–30 bison was maintained in a large enclosure there until 1963, when brucellosis was discovered in the herd (likely transferred with the original 20 animals from YNP). At that time, all the adult animals were destroyed, but four vaccinated yearlings and five vaccinated calves were retained. In 1964 twelve certified brucellosis free bison from Theodore Roosevelt National Park were added to the herd. In 1968 the herd (down to 11 animals) escaped the confines of the wildlife park, and a year later the decision was made to allow them to range freely. The expansion of GTNP in 1950 had enveloped the Wildlife Park, and allowing the bison to free range was and remains consistent with National Park Service wildlife management policy. The herd remained small and wintered mostly in the Snake River bottoms in GTNP until 1975, when it followed the winter environmental gradient to the NER and began wintering there. The use of standing forage by bison on the NER was viewed as natural behavior thus acceptable to managers. In 1980, however, bison discovered and utilized supplemental feed provided for elk, and they have continued to do so every winter since.

The discovery of supplemental feed by bison has had several consequences, including a significant increase in the population's growth rate (Fig 3). Bison on the elk feedlines have at times disrupted feeding operations and displaced and injured elk. To minimize conflicts between bison and elk, managers have provided separate feedlines for bison since 1984. As the population has grown, separating elk and bison on feedlines has become increasingly difficult, and a variety of feeding strategies are employed to help reduce displacement of elk.

As the herd has grown it has maintained fairly stable movement patterns, wintering almost entirely on the NER and summering within GTNP and adjacent lands on the BTNF (Fig. 1).

Planning History

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Jackson's bison and elk populations have been the subject of previous planning efforts. Elk management and research has been guided by the Jackson Hole Cooperative Elk Studies Group since it was established in 1953 [verify date]. The group consists of biologists and agency administrators from the National Elk Refuge, Grand Teton and Yellowstone National Parks, the Bridger-Teton National Forest, and Wyoming Game and Fish Department, who meet at least annually to coordinate management of the population and its habitat. Coordination of bison management began soon after they started frequenting the NER in 1976 and using supplemental feed provided to elk in 1980 (Fig. 3). Release of an "Interim" plan that called for maintaining a herd of 90-110 bison while data were gathered for a long term plan occurred in 1988. It was followed by implementation of a sport hunt administered by WGFD. This plan was halted after litigation in which the plan's violation of NEPA was successfully argued by plaintiffs.

In 1996, after considerable herd growth, a new long term management plan and environmental assessment for the Jackson bison herd was released (Fig 3). This plan had strong support and called for maintaining a herd size of 350-400 bison, but it was shelved a year later when plaintiffs from the earlier litigation successfully argued that, because the plan failed to consider the effects of feeding elk on bison management, it also violated NEPA and was not sufficient. This led to development of the draft bison and elk management plan and environmental impact statement from 2000-2006 and release of the final plan in 2007 (Fig 3).

The 2007 Bison and Elk Management Plan (BEMP; USFWS 2007) considered six alternatives for

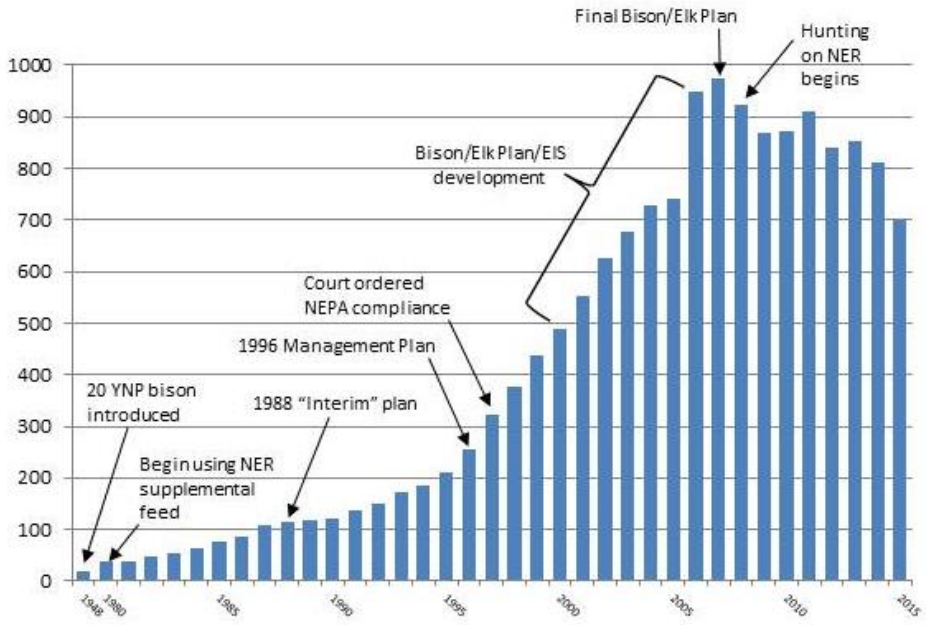

Figure 3. Population growth and planning history for the Jackson bison herd, 1948-2015.

bison and elk management focused on four broad goals related to: 1) habitat conservation; 2) sustainable populations; 3) numbers of elk and bison; and 4) disease management. The primary management scenarios presented in the alternatives included the status quo, terminating elk and bison hunting on the NER and the elk reduction program in GTNP, brucellosis vaccination options, restoring habitat, improving forage, and decreasing or phasing out supplemental winter feeding.

The final BEMP (USFWS 2007; www.fws.gov/bisonandelkplan) which set management direction for 15 years or until a subsequent plan is developed, proposed to maintain the state's elk herd objective of 11,000, establish a bison population objective of 500, restore habitat on the NER and in GTNP, continue hunting bison and elk on the NER, continue the elk reduction program in GTNP, when necessary, in concert with the parks enabling legislation (citation), continue to vaccinate elk for and effective vaccine becomes available, and develop a dynamic framework and adaptive management plan for decreasing the need for supplemental feeding on the NER. ***This Bison and Elk Management Stepdown Plan was developed to address the latter and specifically addresses the criteria for a structured framework listed on page 5 of the Record of Decision*** **(Fig. 4).** It does not address other on-going bison and elk management actions already prescribed by the BEMP.

The BEMP scheduled the completion of an Adaptive Management Plan for 2008. However, litigation challenging the BEMP in 2008 led to the decision to postpone its development until litigation was resolved. As of March 2015, two court rulings have upheld the 2007 BEMP and ROD. In a lawsuit against the BEMP and its author agencies (Defenders of Wildlife et al. v. the U.S. Department of Interior and State of Wyoming 2010), plaintiffs argued that the BEMP violated the National Wildlife Refuge System Improvement Act (National Wildlife Refuge System Improvement Act 1997) by disrupting the biological integrity of the Refuge, and that the plan and the accompanying EIS violated NEPA because they were insufficiently detailed to allow a reasonably complete discussion of mitigation. The crux of the plaintiff's argument was that the plan did not set a specific date for the cessation of supplemental feeding. In response, the agencies argued that the plan constituted a valid exercise of discretion and that it and the EIS were sufficiently detailed to satisfy the requirements of NEPA. In March 2010 the United States 4th District Court sided in favor of the agencies in this case. In 2011 the plaintiffs appealed this ruling to the United States 4th Circuit Court. The Circuit Court affirmed the District Court ruling (Defenders of Wildlife et al. v. the U.S. Department of Interior and State of Wyoming 2011).

National Environmental Protection Act Compliance

The 2007 BEMP/EIS and Final Record of Decision (ROD) satisfied NEPA requirements for current bison and elk management through a detailed analysis of alternative management actions and their likely effect on the environment, and substantial involvement of the public in the process. This adaptive management plan is does not duplicate or add to this process. It is designed to carefully tier off of the BEMP as a dynamic implementation guide to one part of the preferred alternative outlined in the BEMP ROD. As such, references to NEPA covered in the BEMP will be included where necessary in this document, and the discussion of any action that would require additional NEPA compliance will be explicitly stated as such in that context.

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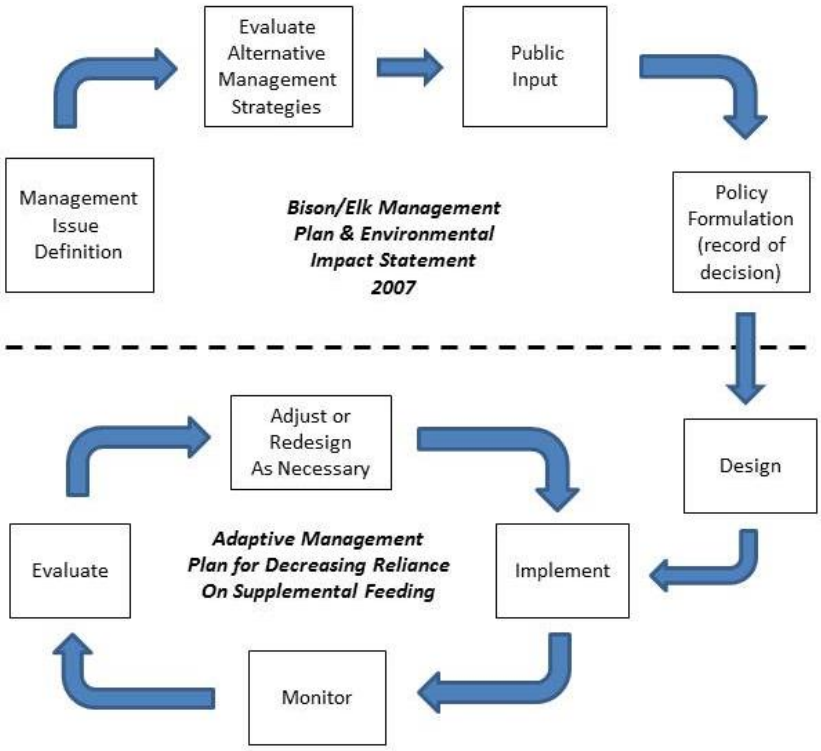

Figure 4. Adaptive management planning for supplemental feeding on the National Elk Refuge and its relationship to the 2007 Bison/Elk Management Plan and Environmental Assessment.

Adaptive Management Planning

Adaptive management plans have gained popularity in natural resource management planning because, by definition, they allow modifications of strategy based on monitoring results and outcomes toward reaching specific goals or objectives. There are four essential elements to an adaptive management approach: 1) well defined and mutually agreed upon objectives, 2 knowledge (including descriptive models) of the dynamics of the system being managed, 3) clearly articulated management actions and strategies, and 4) a monitoring program to evaluate responses of the system to management actions (Walters 1986).

This step-down plan utilizes adaptive management planning principles but is not intended to meet all of the adaptive management planning elements outlined in the Department of Interior Adaptive Management Technical Guide (2007). This Step-Down Plan is more accurately described as a "structured framework of adaptive management actions that progressively transitions from supplemental winter feeding to greater reliance on free-standing forage (BEMP ROD p.5).

OBJECTIVES

The management direction and desired conditions stated in the BEMP called for the NER and GTNP staffs to work with others (agencies, partners, etc) to "adaptively manage elk and bison in a manner that contributes to the State's herd objectives yet allows for the biotic integrity and environmental health of the resources to be sustained," so that the public can enjoy a variety of compatible wildlife-dependent recreational opportunities. Under the BEMP's 4 primary goals, 20 associated objectives were addressed (Table 1). This adaptive management plan addresses four objectives under the goal of sustainable populations (Fig. 5).

In Phase 1 of the second objective, the aim is to reduce the average number of elk on feed to 5,000 (while maintaining WGFD's 11,000 elk herd objective), and reduce the winter population of bison to the BEMP-adopted objective of 500. In Phase 2, the overall objective is to reduce the reliance of bison and elk on supplemental feed (USFWS and USNPS 2007a). Desired conditions include animals relying predominantly on native habitat and cultivated forage. Important consideration criteria for implementing Phase 2 will include: 1) the level of forage production and availability on the National Elk Refuge and adjacent winter ranges, 2) maintenance of desired herd sizes and age/sex ratios, 3) the ability to effectively mitigate bison and elk livestock conflicts, such as co-mingling on on private lands during high risk disease transmission periods, 4) maintaining desirable winter distribution patterns of elk and bison, 5) the prevalence of brucellosis, chronic wasting disease, and other wildlife diseases, and 6) public support. In short, the overall objective of this plan is to provide a path for progressively transitioning from winter feeding of elk and bison on the NER to greater reliance on free-standing forage, while maintaining population and herd ratio objectives.

Table 1. 2007 Bison/Elk Management Plan Goals and Objectives (Adaptive Management Plan objectives shaded)

Goal: Habitat Conservation

Objectives:

- Conserve important private lands.
- Increase forage production.
- Minimize non-native plants.
- Protect sagebrush grasslands.
- Restore willow, aspen, and cottonwood.
- Perpetuate natural mosaic of plant communities.

Goal: Sustainable Populations

Objectives:

- Develop adaptive management plan for reducing NER supplemental feeding.
- Phase reduction of animals on feed: 1) to 5,000 elk and 500 bison, and 2) elk and bison rely predominantly on native habitat.
- Maintain natural bull-to-cow ratios in park summer herd.
- Ensure a genetically viable bison herd with close to an even sex ratio.
- Enhance public outreach/education.

Goal: Elk and Bison Numbers

Objectives:

- Maintain state elk herd objective of 11,000.
- Maintain a genetically viable bison population of about 500 animals.

Goal: Disease Management

Objectives:

- Manage brucellosis transmission risk from elk and bison to livestock.
- Manage feeding to reduce brucellosis transmission among bison and elk.
- Educate hunters about wildlife disease human health hazards.

This Plan focuses on management actions to initially achieve Phase 1 objectives. However, if

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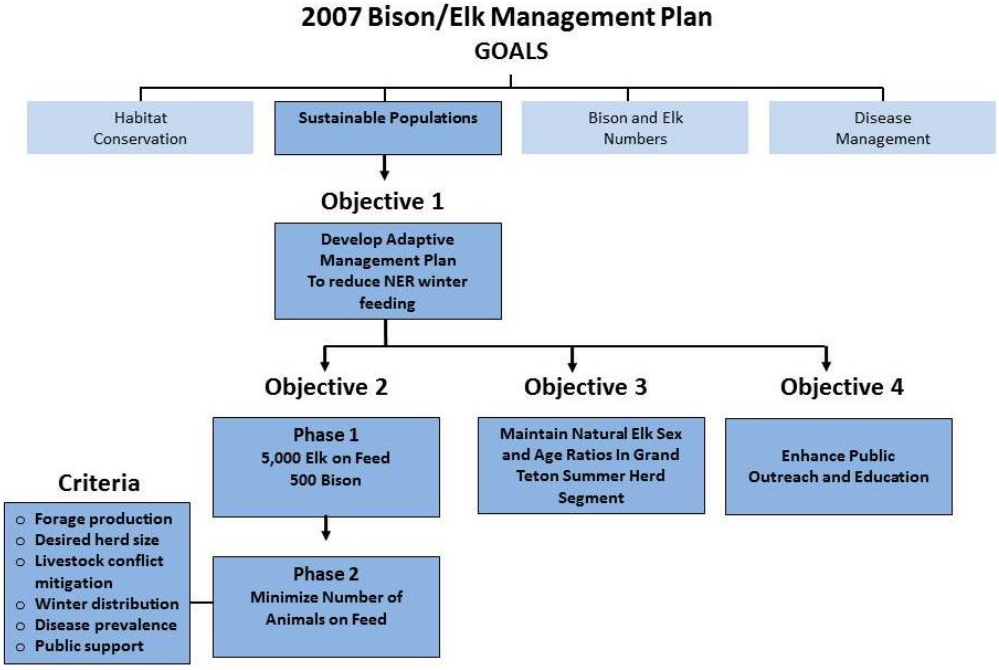

Figure 5. Relationship of Adaptive Management Plan to the 2007 Bison/Elk Management plan goals, phasing of objectives, and consideration criteria for reducing the reliance of elk and bison on supplemental feed during phase 2.

successful, these actions will continue to be used to achieve the Phase 2 objective of reducing reliance on supplemental feeding while considering the six criteria listed above.

MANAGEMENT ACTIONS AND STRATEGIES

Background

Elk have been fed for some period during nearly every winter on the National Elk Refuge since 1912, and bison have been fed there since 1980. The attraction of highly nutritious, easily accessible food during a time of year when natural forage is typically most limited is powerful to both species, and their knowledge of its existence has been passed down through generations. As a result, elk and bison have been strongly conditioned to seek supplemental food on the NER, even when natural forage is available and even abundant during some years. Because it is largely unprecedented, the concept of modifying this behavior on such a large scale is daunting and fraught with questions for which there is no answer. In some cases, the likelihood a specific management strategy's success will only be able to be roughly estimated, and unanticipated results are likely. The management stepdown approach will necessarily be one of investigation, constant evaluation, modifications to approach when indicated, and repeated trials (Fig 4). As such the approach will also be experimental, guided by rigorous analysis

and design, based on abundant empirical information, and monitored at an intensity commensurate with necessary decision making.

Since this plan is centrally tied to supplemental winter feeding on the NER, its focus will be on lands under NER authority. However, some strategies will also incorporate activities in GTNP, and on non-federal lands in collaboration with land owners and WGFD. Primary management practices that can be altered to achieve reduced reliance of bison and elk on supplemental feed fall into the 3 broad categories of 1) timing and intensity of winter feeding, 2) timing and intensity of hunting, and 3) herd segment specific and overall harvest levels.

Important Changes Since 2007

The BEMP was developed based on data collected and knowledge that existed up until its Record of Decision in 2007. Since then, important changes have taken place, some of which are advantageous to this effort, some of which are not.

A primary change that will facilitate meeting objectives under this plan is the reduction of the bison population from nearly 1,200 animals in 2007 to about 700 during winter 2014-2015 (Fig. 3) through hunting programs administered by WGFD. Licensing changes were enacted in 2014 to help increase harvest of female bison. These included a reduction in the bison cow/calf license fee (from $416 to $263 for residents and $2522 to $1022 for non-residents) and eliminating the once-in-a-lifetime restriction on a successful bison hunter to only those that successfully harvested a bull. Continued progress toward the 500 animal herd objective will require sustained harvest success.

During the same period, the Jackson elk herd has declined from nearly 13,000 to its objective of 11,000, but because the proportion of the Jackson Elk Herd that winters on NER has increased dramatically (Fig. 6), this will make achieving the Phase I objective of 5,000 elk on feed and any future elk population reductions more difficult. Preliminary modeling suggests that the increasing proportion of the Jackson Elk Herd wintering on NER has been associated with 1) changes in elk winter distribution associated with wolves and 2)high numbers of elk that summer immediately adjacent to NER (Cole and Foley et al. 2015).

Refuge-wide herbaceous forage production averaged 14,387 (SD = 4125) tons during 1998–2013. In recent years irrigation of approximately 3,600 acres has increased refuge-wide forage production by approximately 10% compared to what would have been produced with precipitation alone, and by 15% in the southern portion of NER which receives the greatest use by elk and bison.

Since 2007, the general awareness of climate change among the public has greatly increased. A strong, credible body of scientific evidence shows that climate change is occurring, is caused largely by human activities, and poses significant risks for a broad range of human and natural systems (National Academy of Science 2010). Ecological systems in the GYE are likely to be affected and associated changes will have implications for elk and bison management.

Current Management

Ongoing primary management actions on the NER include winter feeding, harvest, irrigation, and hazing. In GTNP, harvest of elk during the Elk Reduction Program takes place, when necessary, in collaboration with WGFD, and restoration of previously cultivated and irrigated sagebrush-grasslands is ongoing. Fundamental components of each of these will be briefly described below to provide a basis for comparison to adaptive management strategies that will follow.

Chronic Wasting Disease

Supplemental feeding has occurred in all but 9 winters on NER since 1912, and although this strategy minimizes winter elk mortality from starvation and contributes to Wyoming state elk

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herd objectives, elk occur at numbers and densities well in excess of carrying capacity (Smith et al. 2004, Lubow and Smith 2004). Considerable evidence suggests that Chronic Wasting Disease (CWD) transmission and prevalence are density dependent (Peters et al. 2000, Williams et al. 2002). Monello et al. (2014) found that elk densities of 15-110 per square km in Rocky Mountain National Park were associated with 13% CWD prevalence, and they predicted elk population declines when CWD prevalence exceeded 13%. NER elk densities commonly exceed 160 per square km (NER unpublished data), which suggests that the introduction of CWD to NER elk would have significant negative population effects over time.

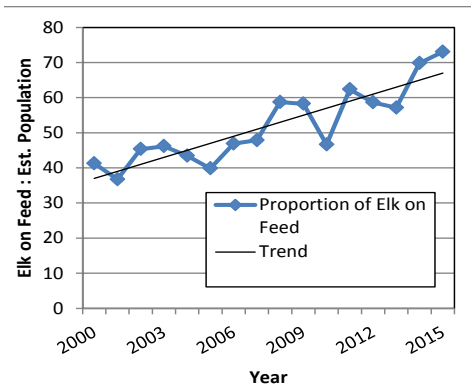

Figure 6. Increasing trend of National Elk Refuge elk on feed as a proportion of the Jackson Elk Herd estimated population size.

Winter Feeding

Initiation of feeding has the primary objectives of 1) minimizing elk winter mortality, focusing on calves since they are the most susceptible age class, and 2) minimizing comingling of elk with cattle on nearby adjacent private lands. Winter feeding begins when available forage reaches approximately 300 lbs/ac. Historic radio telemetry data and observations of elk movements indicate that when available forage delclines below 300 lbs/ac., some elk leave NER for surrounding private lands. Therefore, the purpose of this feeding trigger is to keep elk on the NER and prevent them from searching off-refuge for forage which increases the potential of comingling. This trigger is not a warning that a significant nutritional deficit threshold has been reached. Available winter forage for elk and bison on the NER is largely determined by biomass of forage produced during the previous growing season, rate of forage consumption during fall and winter, and how snow conditions affect forage availability.

Forage biomass estimates are calculated annually based on sampling at index sites. Index sites are selected subjectively each year based on presence of vegetation highly palatable to elk.

During 1995–2013, on average, initiation of NER winter feeding occurred on 28 January (range 30 December - 28 February), and feeding was terminated on 3 April (range 20 March - 20 April). Variation in feeding initiation and termination dates has been based on winter conditions and elk-cattle comingling problems on nearby private

Table 2. Annual distribution of wintering elk from the Jackson Elk Herd during February classification counts, 2011–2015, relative to the current objective.

	OBJECTIVE	2011	2012	2013	2014	2015	mean
NER	5,000	7,746	7,360	6,285	8,296	8,390	7,615
Gros Ventre	3,500	2,775	3,265	2,982	2,326	1,162	2,502
Native Range[1]	2,500	982	894	1,784	801	913	1,075
Total	11,000	11,503	11,519	11,051	11,423	10,465	11,192

[1]Excludes objectives for native range adjacent to Gros Ventre feedgrounds.

lands. Coordination of winter feeding dates on the NER and WGFD-operated Gros Ventre drainage feedgrounds (Alkali, Patrol Cabin) occurs annually to help minimize movement of elk between these areas. This coordination will continue regardless of the management strategy employed. The relationship of recent elk numbers and objectives for NER and WGFD-operated feedgrounds and native range is shown in Table 2.

Bison are fed as necessary to help minimize disruption to elk feeding operations. Bison will readily displace elk from feedlines, so since bison started using feedlines in 1980 refuge staff have developed a strategy of keeping most bison at the northernmost feedground (McBride) by feeding them there prior to feeding elk. Bison are provided a ration consistent with encouraging them to stay in this area away from elk feeding areas. This has also reduced conflicts associated with bison moving into Jackson or to the Nowlin area of the NER where commercial sleigh rides occur.

Harvest

Total harvest of the JEH was gradually reduced over the last decade as the population neared objective (Fig. 7). Elk hunting on the NER (Hunt Area 77) typically begins in mid-October and ends in mid-December, with peak harvest in recent years occurring in late November to early December. From 2005 to 2011 an average of 393 (SD = 56, range 329-457) hunters harvested 161 (SD = 38, range 126-225) elk per year during the NER hunt.

The 1950 legislation that created Grand Teton National Park provided for a controlled reduction of elk, when necessary, in specific portions of the park, primarily east of the Snake River. Elk reduction programs have taken place in the park each year since 1950 except two (1959, 1960), when GTNP and WGFD officials agreed a reduction was not necessary (Figure 8). Season dates have varied over the years but recently have run from mid-October to early-December. The GTNP harvest accounts for about 25% of the JEH overall harvest, thus has been an important factor in regulating the population. Increased natural regulation, likely a result of increases in grizzly bears and wolves over the last 20 years, has decreased the need for large harvests in the park.

Bison hunting begins on August 15 and ends in early to mid-January. Most harvest occurs on the NER, with some additional harvest on private and BTNF lands. Since resuming the bison hunt in 2007, mean harvest has been 210 (SD = 45.5, range 139-301) bison per year. This level of harvest has been sufficient to arrest the exponential growth of the population, reducing bison numbers from the peak in 2007 to about 700 animals in winter 2015 (Fig 3). Tribal bison harvest of up to 5 animals for ceremonial purposes was authorized in the BEMP. Translocation of wild bison to lands outside of Teton County is not currently permitted due to brucellosis concerns.

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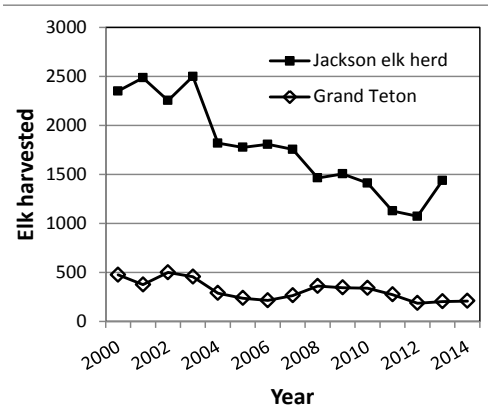

Figure 7. Estimated elk harvests for Grand Teton National Park and the Jackson elk herd (including the park) 2000–2014.

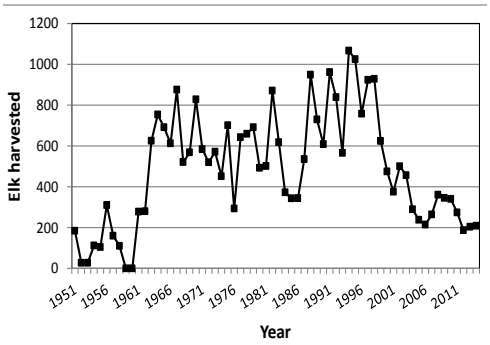

Figure 8. Elk harvest in Grand Teton National Park, 1950-2015.

Bison hunting is not allowed in GTNP because of long standing National Park Service policy that prohibits most hunting in national parks. Bison quickly learned to take advantage of the parks safety, which has made obtaining hunter harvest goals difficult. Many bison stay in the park during the hunting season, with only occasional short term movements to the NER, until severe winter conditions occur. In response, NER and WGFD managers attempt to balance extending the hunt as late in January as practicable without conflicting with winter feeding. The unpredictable nature of winter conditions that time of year makes this a risky proposition, and can result in the use of emergency season extensions or reductions.

Hazing

Elk and bison are hazed in spring to encourage movement off of NER winter ranges. Methods used have included ATVs, on foot, and on horseback, but recently ATV use has been found most effective. It's possible that some elk and bison might remain on the NER year around without hazing. If animals fail to leave the NER following the termination of feeding and adequate green-up has occurred, they are typically hazed to the north in late April to early May. Elk will stay off the NER until fall migration, and bison will generally remain in GTNP until mid-July. From July to early August bison often make forays back to the NER and are hazed back to GTNP to protect winter forage. Hazing efforts in August cease several days to weeks before the bison hunting season in an effort to increase hunter harvest.

Vegetation Restoration and Protection

The BEMP identified approximately 4,000 acreas of previously irrigated and cultivated grasslands in GTNP in need of restoration to native sagebrush grasslands community. Substantial progress in this endeavor has been made since 2007, including: [GTNP folks please add short description of methodological research and implementation, followed by what remains to be accomplished]

Private Lands Mitigation

Fencing of hay stacks and livestock feedlines has been historically used to mitigate particularly difficult conflicts on private lands. Targeted fencing of golf course greens and sand traps fall through spring has also been successful in some situations for mitigating elk and bison presence and associated damage in these areas. It is important to note that the county has a 'wildlife-friendly' fence policy and does not support extensive fencing that is impermeable to wildlife.

Methods, Assumptions, and Constraints Common to All Strategies

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Measuring the success of strategies toward objectives will require knowledge of several bison and elk herd attributes, particularly population sizes. Measurements of the Jackson bison herd will be based on the annual mid-winter census and sex and age classification survey performed by NER, GTNP, and WGDF biologists. This survey occurs one day in early February and includes ground counts of animals on feed at the NER and aerial counts of outlying bison across their winter ranges on the refuge, park, and Bridger-Teton National Forest.

Elk population estimates will also be based on mid-winter aerial and ground counts. However, the mid-winter counts are undertaken during a single survey period and do not necessarily represent either peak or cumulative abundance of elk on feed. Rather than basing progress toward the number of elk on feed for the entire season on those present during the day of the survey only, we will use a more meaningful measurement. Since we are more interested in the intensity of elk feeding throughout the entire feeding period, which includes both the number of animals on feed and the duration of feeding, we will use a measurement of elk-fed-days (EFD; the total number of elk fed per day per season) as a gauge of feeding intensity (see monitoring section). For example, if 5,000 were elk fed for 100 days during the winter, feeding intensity for that winter would equal 5,000 elk X 100 days = 50,000 EFD, whereas if 5,000 elk were fed for 50 days, EFD would equal 25,000.

We determined feeding intensity benchmarks for bison and elk-fed based on an actual average of 64 days of feeding from 1995-2007. Based on the Phase I objectives of 500 bison and 5,000 elk, fed-days benchmarks would be 64 x 500 = 32,000 for bison and 64 x 5,000 = 320,000 for elk. These values will assist in determining efficacy of strategies toward reducing reliance of both species on supplemental winter feeding.

Implementation of the AMP will have successfully attained the objective of "transitioning from intensive supplemental winter feeding to greater reliance on free-standing forage" when supplemental feeding was not used for more than 50% of the years in a 5 year period.

Comment [S3]: SK's draft.

Initial success of AMP implementation will be a consistent decline in the 3-year running average of elk and bison fed days from the established baseline. While the BEMP did provide specific measurement criteria for the definition of "transitioning from intensive supplemental winter feeding to greater reliance on free-standing forage" we will consider this objective met when the 3-year running average of elk and bison fed days is <50% of baseline for 5 years in a row.

Comment [S4]: SC's alterative in this paragraph, recognizing that the 50% number is the crux and a glaring target.

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Table 3. Summary of potential Adaptive Management Plan constraints.

Policy

- ESA[1] Lynx – limits on habitat impacts
- Greater Sage Grouse – core area protection
- 2007 BEMP/EIS (federal actions/lands)
  - No fertility control
  - No test and slaughter
  - Limited tribal harvest
- Bison/elk hunt end date (Feb. 1st)
  - WGFD, brucelosis safety
- Carcass disposal (Feb. 15th)
  - WGFD, brucellosis safety
- Forest Service winter closure (Dec. 1st – April 30th)
- Easement limitation (NER boundary)

Winter Feeding

- Only during non-hunting periods

Harvest

- State regulations

Vegetation Restoration/Protection

- Bison/elk distribution
- Exotic plant species management

Private Lands

- Owner agreements

Social

- Hunter density (safety; hunt quality)
- Elk/bison winter mortality levels
- Public safety (ungulate/vehicle collisions)
- Disease
- Land-use conflicts (agricultural and residential)

Biological

- Disease (bison/elk/cattle commingling)
- Sage grouse habitat conflicts
- Fencing/wildlife conflicts
- Elk herd distribution
  - summer segment distribution goals

Funding

- Easement purchase
- Plan implementation

[1]Endangered Species Act

Several management constraints are common to the strategies discussed below (Table 3). Many law and policy constraints are applicable but we include here only those most pertinent. Endangered Species Act (16 USC 1531 et seq.) requirements for wolves, grizzly bears, lynx, and others apply. Lynx requirements for maintaining certain habitat types could limit methods used and areas considered for habitat improvements in GTNP. Similarly, compliance with the Wyoming greater sage-grouse core area protection executive order (2011-5) could restrict habitat manipulations. NEPA compliance conducted as part of the BEMP/EIS constrains what federal actions can be taken as a part of this plan. State regulations constrain late (winter) hunt and carcass disposal timing to protect against brucellosis contamination, since February-April represent the period bison and elk are most likely to transmit the disease. Restrictions on hunting timing also result from BTNF winter range closures, immediately east of the NER and elsewhere, December 1 to April 30. Additional details about these and other constraints will be included in discussions about specific strategies that follow.

Strategies

This section will describe the management action this AMP proposes to implement. As such, it unveils the heart of management changes necessary to begin the process of transitioning to more reliance of bison and elk on native forage during winter. Fundamentally, the strategies discussed in this plan represent an experiment designed to achieve Phase I objectives of 5,000 elk and 500 bison on NER and are a first step towards reducing reliance on supplemental feeding while meeting the sustainable population goals identified in the AMP.

Initial strategies for achieving sustainable population goals identified in the BEMP (Table 1) are presented by objective below. The primary management actions available to the agencies to achieve phase I objectives are modifications to winter feeding and hunting seasons. To a lesser

extent, vegetation protection and restoration can be important, particularly for improving long-term ecological balance and enhancing natural production of native forage. Private lands are also an integral component as changes in elk and bison distribution occur and new challenges develop. The likely consequences of implementing these strategies were evaluated in the BEMP. The most relevant of these are summarized in Appendix 1.

Objective: *[Implement] a phased reduction of animals on feed: 1) to 5,000 elk and 500 bison, and 2) [to an extent where] elk and bison rely predominantly on native habitat* (Table 1).

This objective is what the need for an adaptive management plan – **this document** – is central to. As previously mentioned, the concept of reducing winter feeding after more than 100 years of the practice, and the associated behavioral conditioning of elk and bison to its presence, represents a formidable challenge that must be approached cautiously and systematically. The strategies discussed below have been developed in this context, with appropriate feedback mechanisms through rigorous monitoring and frequent evaluation. Inability to meet this objective under the strategies presented here would trigger a thorough evaluation and development of more aggressive strategies.

Chronic Wasting Disease

In 2014 WGFD began the revision process for the Wyoming CWD Management Plan (2006). WGFD has cooperated with federal agencies and other stakeholders to revise the plan, and NER and USFWS Region 6 Wildlife Health Office staff participated in several meetings associated with this effort. One goal of the CWD Management Plan update is to develop specific management responses should CWD be detected on or adjacent to State or NER elk feedgrounds. Early detection of CWD in the JEH is essential to ensure an effective management response.

Since 1997 NER has cooperated with Wyoming Game and Fish Department (WGFD) to conduct surveillance for CWD in the JEH unit. Although this effort indicates that CWD is not currently found in the JEH, continued surveillance at sample sizes sufficient to detect 1% prevalence with 95% confidence annually will be critical to ensure a timely management response and limit the long-term population effects of the disease (USFWS and NPS 2007). Given that CWD has been detected within 40 miles of the JEH in moose, within 70 miles in deer, and within 175 miles in elk, this level of surveillance is warranted.

Winter Feeding

Winter feeding actions that could be modified include starting date, ending date, and daily ration. To modify elk and bison behavior in the long run, delaying initiation of feeding is likely to have the greatest impact by gradually conditioning them to expect feed later on average, with the desired outcome of building a cohort of animals that rely primarily on native winter range and are not food conditioned. To reduce supplemental feeding overall, ending feeding early would also help decrease the amount of feed provided per animal per year. Both would help decrease the total elk/bison fed days, the parameter we will use to measure progress toward reducing supplemental feeding.

Initially, supplemental feeding will be delayed by approximately 2 weeks, depending on several variables (Table 4, Fig. 9). Time of season could influence this interval, most likely shortening it as the feeding initiation date gets later. During the last 20 years, feeding initiation dates, which have been based on forage availability, have varied from December 30 to February 28. Delaying feeding by two weeks in January, for example, is likely to be more successful than doing so in February, when food stress and tendency for animals to move to private lands is greater. Forage availability could also have an influence, particularly if a freeze thaw event resulted in an acute and large reduction in available forage.

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Both time of season and forage availability considerations would be affected by the numbers of elk and bison on the NER. And finally, the distribution of animals, particularly on private, livestock producing lands, would be considered.

A primary concern of manipulating feeding is elk winter mortality, particularly among calves. As food becomes limited in winter, calves are usually the first to suffer because of being displaced by more dominant animals. Monitoring programs will include measures of calf mortality and it will be an influencing parameter in feedback mechanisms. The BEMP anticipated that elk mortality could increase from 1-2% overall to 1-5% (Appendix 1).

Initially, the termination of feeding, which is now based on a snow cover index and subjective evaluation of available forage, will occur about a week earlier. The combination of a 2 week delay in feed initiation and 1 week advance in termination would shorten the feeding season by 3 weeks on average, or 32% based on an average feeding season length of 9.3 weeks from 1995-2015.

The AMP winter feeding strategy would include the establishment of additional key forage index sites and on-going measurements at those sites throughout the winter.

Harvest

Currently the Jackson elk herd is at the Wyoming Game and Fish Commission established objective of 11,000 animals, which means there is less flexibility in manipulation of harvest regimes than there would be if the herd was above objective. Initially there would be little change in elk harvest programs on the NER, with the exception of allowing a limited number of any elk permits throughout the season, considering allowing bow hunting near developed areas (roads and buildings) and shifting the season about a week later (Table 4). Allowing a limited number of any elk permits would be consistent with providing sport hunting recreation on National Wildlife Refuges (citation, NWR system act) and the NER (citation, CMP?), and possibly encourage more hunters to participate in antlerless elk hunts. Monitoring programs and consideration of bull ratios in the GTNP summer segment (since most park bulls migrate to the NER) would help inform levels of take proposed. Bow hunting in areas currently closed to firearms will likely increase harvest by eliminating "no-hunt" areas which can become sanctuaries for large numbers of elk. Shifting the hunt one week later is consistent with later migrations and will improve harvest effectiveness.

General elk harvest patterns in GTNP would continue to be based on need for harvest, summer segment population estimates, and mitigation for impacts on other resources and visitor activities.

Elk herd population objectives are reviewed every five years by the Wyoming Game and Fish Commission and adjusted as necessary. Serious consideration should be given to reducing the Jackson Elk Herd population objective. Lowering the population would help compensate for reduced use of traditional native winter range and increased growth of short-distance migrants which has lead to significant increases of winter elk concentrations on the NER.

The annual fall/winter arrival of elk to the NER during the past several decades has been occurring progressively later. This trend may necessitate extending the elk hunting season later into the year to achieve harvest objectives.

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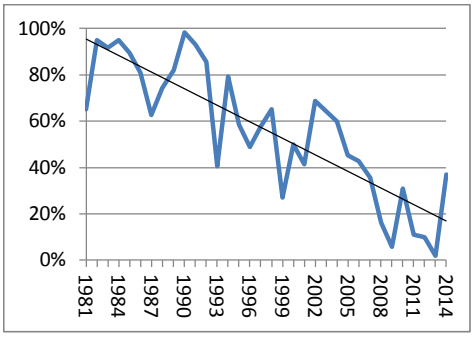

Figure ?. The annual fall/winter arrival of elk to the NER during the past several decades has been occurring progressively later. This trend may necessitate extending the elk hunting season later into the year to achieve harvest objectives.

Bison hunts on the NER (bison hunting is prohibited in GTNP) would see little initial change (Table 4). Consideration would be given to later hunt end dates commensurate with delayed feeding, and possible escorted hunting in the South Unit to help with distribution or discouraging bison from attempting to leave the NER via the south boundary into the town of Jackson. If progress toward reaching the herd objective of 500 animals continues and the objective is reached in the near future, State quotas will likely be reduced and management flexibility will increase.

A cattle guard will be installed on the Refuge Road near the east end of Broadway Avenue to help prevent bison and elk herds from entering the Town of Jackson. This will reduce the potential for dangerous human/wildlife interactions.

Serious consideration should be given to reducing the bison herd population objective in the future. This would lower winter forage consumption on the NER and help reduce elk and bison winter concentrations.

The current bison herd objective is ". . . maintain and ensure a genetically viable population of approximately 500 animals (five-year average), with as close to an even sex ratio as possible to maximize maintenance of genetic variation over time. . ." (BEMP p. 136).

The Jackson bison herd is not considered part of the U.S. Fish and Wildlife Service's meta-population approach to bison conservation because of its high prevalence of brucellosis. This disease prevents the export of Jackson bison to other DOI conservation herds.

The 500 bison population objective was set primarily to preserve existing genetic diversity assuming extremely limited natural genetic transfer with the Yellowstone or other DOI bison conservation herds. Genetic diversity can be maintained for a Jackson bison herd less than 500 if bison with desirable genetic diversity are periodically imported from other DOI bison conservation herds.

Currently, the effectiveness of NER late-season harvest regimes is affected by December 1st winter closures immediately east of the refuge on BTNF lands. Extensive elk telemetry data suggest that delaying the winter closures could aid elk management objectives. NER officials will work with BTNF and WGFD officials to explore the possibility of allowing hunting in limited areas after December 1st in the future.

Annual herd-wide population estimates, elk summer herd segment estimates, temporal and spatial harvest patterns, and animal-fed-days would be monitored, and the resulting information would be used to inform ongoing evaluation of adaptive elk and bison management harvest programs (Figs. 9 and 10).

Hazing

No change in hazing practices is anticipated initially under this adaptive management framework.

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Private Lands Mitigation

Delaying the onset of NER feeding is likely to result in changes in bison and elk distribution (Appendix 1). Some elk or bison may move to private lands in search of forage. Of greatest concern is the potential for elk or bison to commingle with cattle of cow/calf operations, where brucellosis transmission could have considerable consequences, in the worst case requiring depopulation of the cattle herd.

Several strategies would be employed to mitigate potential problems (Table 4), including providing incentives for non-breeding cattle operations (because brucellosis transmission to slaughter-bound cattle is not economically important), increased fencing in some limited areas to separate elk/bison from livestock feed lines, haze elk/bison away from livestock feed lines and purchase private lands easements to prevent co-mingling. A vital component in implementing these mitigation measures is to establish three seasonal Wildlife Conflict Technician positions which are supervised by the WGFD. These Technicians are also critical to the success of an expanded monitoring program vital to the AMP (see Monitoring section below).

A database will be established to track non-agricultural conflicts on private lands to determine trends which will help evaluate the effectiveness of AMP mitigation efforts.

Preventing elk and especially bison from entering the Town of Jackson is essential in minimizing safety and private property conflicts. Currently, bison are hazed northward when they drift south of Miller Butte. A double cattle guard will be installed on the Refuge Road just north of Broadway Avenue. This barrier is designed to prevent elk/bison from entering the Town of Jackson.

Vegetation Restoration/Protection

[NER and GTNP staff to draft material]

Objective: *Maintain natural bull-to-cow ratios in park summer herd* (Table 1).

National Park Service management policy (NPS 2006) provides guidance for maintaining naturally regulated wildlife populations, free from the impacts of humans, to the greatest extent possible. The final BEMP identified a goal of maintaining park elk bull:cow ratios (a common way of expressing sex and age ratios in wild ungulate populations) near 35 adult bulls per 100 adult cows, based on estimates of what this ratio would be in a herd free from the effects of human harvest. The sex and age ratios of most North American elk populations are affected by sport hunting and herd managers generally maintain lower bull ratios.

Harvest

Based on bull ratios in the park summer herd that were chronically below 35 bulls:100 cows, permit types for the park's elk reduction program (ERP) went to antlerless only in 2012. ERP permit structures in the park will remain antlerless only unless the bull ratios consistently exceed 35:100 cows. Park and refuge officials will work together to support this goal, recognizing that bulls harvested on the NER are most likely from the park summer herd segment.

A private lands Hunting Coordinator Position would be established and supervised by the WGFD to promote and coordinate hunting activity focused on Southern Herd Segment harvest in and around private lands in the Spring Gulch Area north to Moose, WY (Hunt Area 78).

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Table 4 [incomplete]. Comparison of current and adaptive primary management components and parameters.

Action	Current Management	Adaptive Management	Comments
Winter Feeding:			
Feed	Pelleted alfalfa	Pelleted alfalfa	No change
Ration	8 lbs/day/elk 20 lbs/day/bison	8 lbs/day/elk 20 lbs/day/bison	No change, to minimize calf mortality
Start criteria:			
Available standing forage	300 lbs/acre, as measured at traditional key index sites	Generally 2 weeks later; index sites to be increased in number and distribution	Influencing factors: - time of season - forage availability - numbers of elk/bison on NER - elk/bison distribution
End criteria:			
Available forage	Based on a snow cover index and subjective estimate of when residual or new forage is adequate	Generally 1 week earlier	Development of more objective criteria for future implemen-tation ongoing
Monitoring:			
Animals on feed	Mid-winter census	Elk/bison fed days[1]	
Proportion of JEH on NER feed	Mid-winter census	Mid-winter census	
Calf mortality threshold		<= 10%	
Elk/bison distribution - visual			
Elk/bison distribution – collars			
Winter mortality			
Elk summer range proportions			
Harvest, National Elk Refuge elk:			
Frequency	Annual	Annual	
Begin Date	2nd week October	3rd week October	Modified as necessary
End Date	2nd week December	3rd week December	Modified as necessary
Structure	- 1 week initial drawing - 1 week left over 1st served - partial week alternate	- 1 week initial drawing - 1 week left over 1st served - partial week alternate - daily 1st served alternates	

[1]Number elk and bison on feed per day, totaled by feeding season.

Table 4, continued. Comparison of current and adaptive primary management components and parameters.

Action	Current Management	Adaptive Management	Comments
Harvest, National Elk Refuge elk:			
Refuge permit types	- 1st week any elk - Antlerless only remainder of season	- Primarily antlerless only - limited any elk permits throughout season	
Access	Restrict access to specific locations	Restrict access to specific locations	
Hunt area boundaries		Consider expanding to allow bow hunting near developed areas	
Harvest, National Elk Refuge bison:			
Frequency	Annual	Annual	
Begin date	August 15th	August 15th	Modified as necessary
End date	2nd or 3rd week January	Consider later dates as appropriate	Modified as necessary
structure	As per WGFD	As per WGFD	
Refuge permit types	Any bison or cow/calf per state license	Any bison or cow/calf per state license	
access	Restrict access to specific locations	Restrict access to specific locations	
Hunt area boundaries	Limited to north of Nowlin Creek area	Consider escorted hunting in South Unit as needed	Guided hunts in South Unit when authorized
Harvest, Grand Teton NP elk:			
Frequency	As needed	As needed	
Begin Date	3rd week October	3rd week October	Modified as necessary
End Date	2nd week December	2nd week December	Modified as necessary
License types	Antlerless only	Antlerless only[1]	
Special regulations:	Cartridge limits	Cartridge limits	
	Bear spray required	Bear spray required	
	Hunter safety card required	Hunter safety card required	
Harvest, Bridger-Teton NF, Elk Hunt Area 80:			
Begin Date			
End Date		December 15	Would require change in winter closure dates

[1]Any elk licenses could be offered if bull ratios in the park consistently exceed BEMP criteria.

Table 4, continued. Comparison of current and adaptive primary management components and parameters.

Action	Current Management	Adaptive Management	Comments
Harvest, Elk Hunt Area 78			
Structure			Changes at discretion of WGFD
License types			
Private Lands Mitigation:			
Cattle commingling		Incentives for non-breeding operation	
Hay depredation		Increased fencing	
Landscape damage			
Easement acquisition			
Vegetation Restoration/ Protection: Elk Refuge			
Vegetation Restoration/ Protection: Grand Teton			

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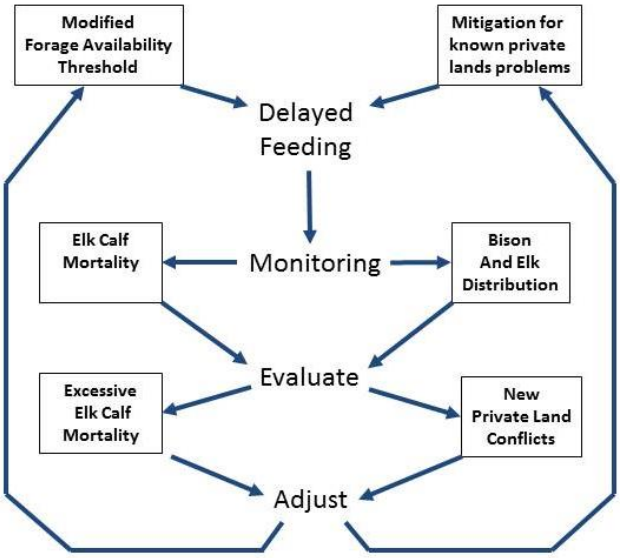

Figure 9. [example] Framework for delayed feeding strategy and adaptive management.

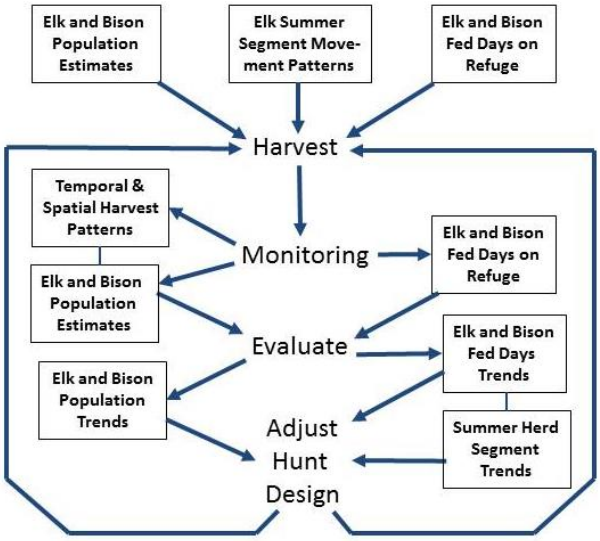

Figure 10. [example] Framework for harvest strategy and adaptive management.

Strategies Considered But Rejected

The BEMP considered several additional strategies for elk and bison management that, for a variety of reasons, were not selected for implementation in the preferred alternative and Record of Decision. The agencies reconsidered a subset of these during the development of this AMP (Table 5). Since they were not part of the ROD, additional NEPA compliance would be necessary to incorporate any of them into this adaptive management plan, and thus they are not being considered at this time.

Table 5. Strategies considered but rejected.

Strategy Considered	Reason Rejected
Fertility control in elk	Judged not reasonable or feasible in BEMP, primarily due to major technical, social, and financial hurdles[1]. For AMP discussed primarily with regard to the difficult to harvest herd segment in Hunt Area 78 on private lands, where federal agencies have no jurisdiction.
Fertility control in bison	Impacts discussed at length in BEMP[2]. Not considered for AMP because current hunting programs appear effective at slowly moving the herd toward the 500 animal herd objective.
Agency reduction of bison or elk	Not considered necessary or desirable on federal lands because current hunting programs that utilize sport hunters are effective at meeting herd objectives.
Altering rations of supplemental feed	Rejected as a strategy because reducing daily feed ration below 8 lbs/elk would be enough feed to encourage elk to remain on NER but would result in unacceptably high elk calf mortality rates.

MODELS OF SYSTEM DYNAMICS

Models provide a simplified representation of the biological system being managed. Adaptive management uses models of the managed system to link the objective response (e.g., elk winter distribution) to changes in the system resulting from management actions (e.g., altered initiation and cessation of winter feeding). Fig. 11 describes possible factors that affect winter elk distribution (the proportion of elk on NER feedgrounds versus native winter range). Models will be used to identify the relative influence of our principal management strategy (a reduction in feed season length) and other factors on winter elk distribution (Appendix 3). Over time this will allow us to assess whether changes in elk distribution were the result of our management actions or due to factors outside of our control.

An increase in calf elk winter mortality is a potential result of reduced feed season length. Fig. 12 portrays factors that influence winter calf elk survival on NER.

Models will be used to assess the effects of available forage on winter calf elk survival (Appendix 4). Over time this will allow us to assess the effects of our principal management strategy (reducing feed season length) relative to other factors on elk calf survival and potentially adjust our management actions based on model results.

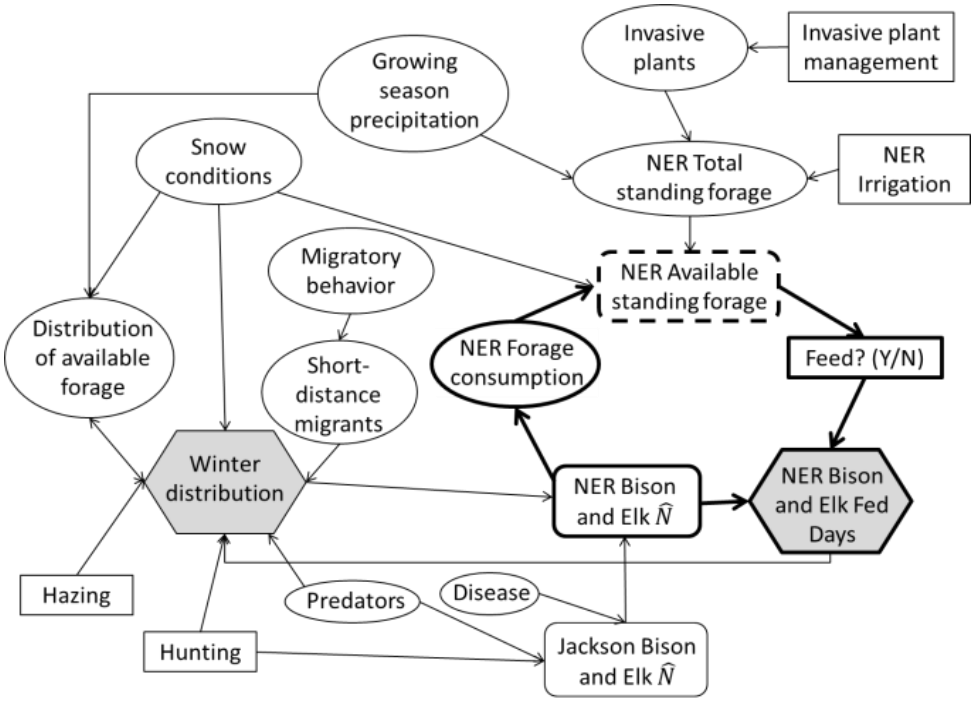

Figure 11. Influence diagram depicting factors (including management actions) influencing outcomes identified in the Bison and Elk Management Plan (BEMP; USFWS 2007a). Gray hexagons represent outcomes, rectangles represent management actions, rounded rectangles represent factors with numerical objectives, and ovals represent factors outside of management control. Bolded polygons and arrows represent outcomes and factors limited to the National Elk Refuge (NER). Available standing forage on the NER (dashed rectangle) is the BEMP criteria with a defined threshold to trigger initiation of supplemental winter feeding.

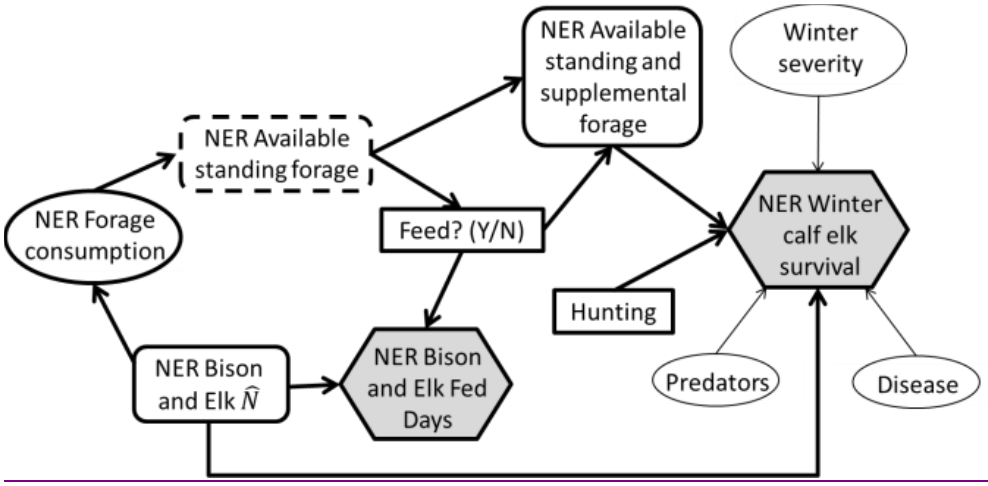

Figure 12. Influence diagram depicting factors (including management actions) influencing bison and elk fed days on the National Elk Refuge (see text for description) and winter calf elk survival. Gray hexagons represent outcomes, rectangles represent management actions, rounded rectangles represent factors with numerical objectives, and ovals represent factors outside of management control. Bolded polygons and arrows represent outcomes and factors limited to the National Elk Refuge (NER). Available standing forage on the NER (dashed rectangle) is the BEMP criteria with a defined threshold to trigger initiation of supplemental winter feeding.

MONITORING

Feeding Initiation Monitoring

NER uses weekly field estimates of the amount of forage available to elk to determine feeding initiation date. Currently measurements are taken at key index sites representing areas preferred by elk on NER (see supplemental materials at end of this section). These methods will be enhanced by 1) increasing the number of sampled sites to better represent the total amount of forage available to elk on the southern half of NER; 2) increasing the precision of estimates at each site by increasing the number of observers; and 3) extending the monitoring period later in the winter to assess the relationship between available forage and elk and bison distribution.

To better represent the total amount of forage available on the southern half of NER, a subsample of current key index sites will be retained to facilitate comparison with historic data, but additional random sample sites stratified by elk habitat preference will be added. Historic elk distribution mapping and elk GPS collar data (NER unpublished data) suggest that the areas most preferred by elk on southern NER are associated with moderate to high forage production and green vegetation. Because the distribution of forage production and greenness characteristics vary annually based on irrigation and precipitation patterns, we will annually map areas preferred and not preferred by elk and sample sites will be randomly selected within each of these mapped categories. At least 3 historic key index sites, 3 random sites in areas preferred by elk, and 3 sites in areas not preferred by elk will be sampled each week from late December through the initiation of supplemental feeding.

Currently the NER biologist is the only person trained in the techniques used to estimate available forage (see supplemental materials). At least 2 additional personnel will be trained in these techniques. This will provide a backup in the event of future personnel changes and will facilitate error estimates of the available forage measurements at each site.

Currently NER and WYGFD biologists monitor available forage conditions at least weekly from late December until average available forage at key index sites nears the threshold level of 300 lbs. per acre and feeding is initiated. The principal AMP strategy is to delay the initiation of supplemental feeding by 2 weeks after average forage production reaches the 300 lbs. per acre level at key index sites. Therefore the monitoring period will be extended to include the intervening 2 weeks.

Proportion of Elk Wintering on NER

A principal AMP goal is to reduce the number of elk wintering on NER. Our strategy will be to effect redistribution of elk to native winter range from NER over time via shortening the duration of the feed season, and thus slowly conditioning elk to seek food elsewhere. As feeding periods are shortened, the probability of younger elk age classes discovering NER feedgrounds will be reduced, and, hypothetically, that proportion of the JEH that utilizes NER feedgrounds will decline over time. We will measure this effect by examining changes in the winter distribution of the JEH. WGFD annual trend/classification count data provide a multi-year baseline data set to measure changes in the winter distribution of the JEH and categorizes observations by location. In each year, we will calculate the proportion of total classified elk in the JEH that are classified on NER feedgrounds. We will compare the 3-year running average post AMP implementation to the pre-implementation baseline. The pretreatment baseline will be comprised of data from 2008-2016, a time period that represents BEMP implementation prior to AMP actions (Figure 13).

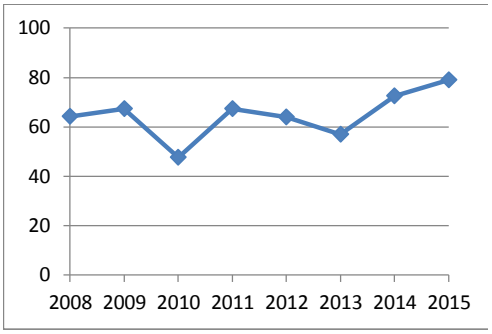

Figure13. Proportion of the Jackson Elk Herd that was classified on NER feedgrounds in the period following implementation of the Bison and Elk Management Plan and prior to the implementation of the Adaptive Management Plan (2008-2015). These values represent the pretreatment baseline which will be compared to the 3 year running average post AMP implementation.

Elk Fed Days and Bison Fed Days

The BEMP and AMP implicitly assume that the transmission rate and prevalence of elk and bison diseases are density dependent and positively correlated with the number of elk and bison utilizing feedgrounds and the number of days they are fed. We further assume the variables elk-fed-eays (EFD) and bison-fed-days (BFD) are a proxy for these conditions. EFD and BFD will be calculated annually for each species based on the following formulas:

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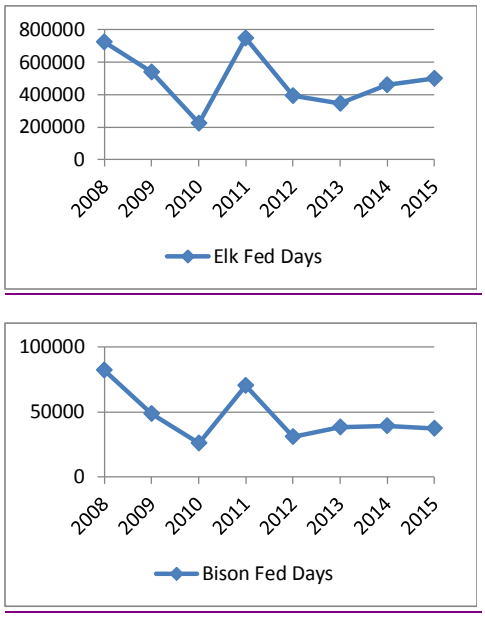

Figure14. Elk Fed Days (EFD) and Bison Fed Days (BFD) in the period following implementation of the Bison and Elk Management Plan and prior to the implementation of the Adaptive Management Plan (2008-2015). These values represent the pretreatment baseline which will be compared to the 3 year running average EFD and BFD post AMP implementation.

EFD= ∑ Total elk counted on feed during daily feedground counts for duration of feed season

BFD= ∑ Total bison counted on feed during daily feedground counts for duration of feed season

Because EFD and BFD are influenced by feed season length and the number of animals on feed, the AMP strategy of delaying the initiation of supplemental feeding will inherently reduce the number of EFD and BFD through a reduction in average feed season length. We believe that EFD will be further reduced by encouraging a greater proportion of the Jackson Elk Herd to winter on native winter range, thereby reducing the number of elk occupying NER feedgrounds. We will evaluate changes in EFD and BFD by comparing the 3-year running average post AMP implementation compared to mean EFD and BFD from 2008-2015. The running average is an appropriate comparison because it will help account for wide annual variation in EFD and BFD associated with winter severity (Fig. 14)

Elk Winter Mortality Monitoring

NER has used consistent methods to monitor winter elk mortality since 1982. Each winter NER biologists and other refuge staff conduct a survey of all non-hunting related winter elk mortalities that occur on NER from November through April. Mortalities are tallied by age/sex class and percent mortality is calculated using the corresponding number of elk classified on NER feedgrounds as the denominator. We will continue to monitor elk winter mortality using the same methods post AMP implementation, which will allow trend comparisons to the pre AMP baseline (Figure 15). Under the AMP framework, we believe the 3 year running averages for total and calf winter elk mortality will be within the range of variation exhibited by the pre AMP baseline. Historic monitoring suggests that calf and total mortality are sensitive to winter severity and disease outbreaks, and that winter mortality occasionally exceeds >3% total mortality and >10% calf mortality. Post AMP mortality in excess of these levels may warrant shortening the 2-week feeding initiation delay in subsequent years.

Elk Collaring

One of the AMP's principal strategies is to shorten the length of the feed season to encourage elk use of native winter range, but we anticipate that this strategy will also result in an increase in elk conflicts on surrounding private land in the town of Jackson and the Spring Gulch areas. To quantify this effect and provide real time information to WGFD and NER managers to facilitate a response, we propose maintaining a sample of 50 GPS collars on elk that winter on NER throughout the AMP implementation period.

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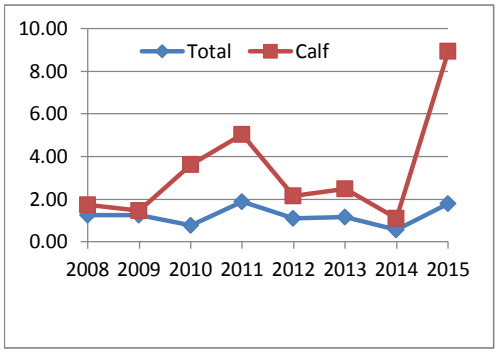

Figure15. Total and calf elk winter mortality (%) on NER in the period following implementation of the Bison and Elk Management Plan and prior to the implementation of the Adaptive Management Plan (2008-2015). These values represent the pretreatment baseline which will be compared to the 3 year running average post AMP implementation.

Forty -five elk represents approximately 0.5% (1 in 200) of the NER winter elk population. This sample size will not be sufficient to detect all elk movements from NER to surrounding private lands, particularly movements by small groups of mature bull elk, but it will be sufficient to detect and quantify significant movements of cow/calf/yearling elk groups compared to pre-AMP baseline data.

NER has elk GPS collar data available from the 2008-2013, which represents the post BMP, pre AMP baseline period. We hypothesize that elk movements from NER to surrounding private lands will increase during the AMP implementation period compared to the pre-treatment baseline. This will be tested by comparing the number of incidents that elk left NER for surrounding private lands (per elk/per year), and the proportion of elk GPS fixes on NER versus private lands during time periods of interest. The principal time period of interest is late December-March because this represents the period after the NER elk hunting season, and prior to and during NER feeding operations. This is the season when changes to the NER feeding program would be most likely to result in elk distribution changes.

Fifty adult cow elk will be captured on NER feedgrounds during February-March 2016 and Telonics Iridium GPS collars will be deployed with a 90 minute fix collection interval. Given 83% annual survival for adult cow elk in the Jackson Elk Herd (Cole and Foley et al. 2015) and 3 year collar life, approximately 10 additional elk will need to be collared each year in winter 2017 and 2018 to maintain the 50 elk desired sample size.

Ancillary data that will be collected and analyzed during the elk capture and collar data analysis process includes brucellosis seroprevalence, pregnancy rate, and elk summer range determination for comparison to the findings of Cole and Foley et al. (2015).

Disease

The primary purpose of limiting reliance on supplemental feeding is to reduce the prevalence of endemic elk and bison diseases and mitigate transmission risk associated with the introduction of novel diseases. We hypothesize that brucellosis seroprevalence will decline post AMP implementation. There are no recent brucellosis seroprevalence data for elk on the National Elk Refuge, but >50 elk will be captured during elk collaring operations in winter 2016, and each elk will be tested for Brucellosis exposure. The 2016 Brucellosis seroprevalence rate will be the pre-treatment baseline to evaluate post AMP change.

Chronic wasting disease (CWD) has been monitored in the JEH since 1997, and since 2008 it has been monitored with sufficient sample size to detect 1% prevalence with 95% confidence. No CWD positive cases have been detected in the JEH, which given the long term persistence of the disease, provides overwhelming evidence that CWD is not currently endemic to the JEH. However, most evidence suggests that the distribution of CWD is increasing and that its introduction to the JEH is inevitable. Early detection is critical to ensure an adequate

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management response, and therefore ongoing monitoring at sample sizes sufficient to detect 1% CWD prevalence with 95% confidence is necessary. CWD is sampled by testing tissues collected primarily from hunter harvested elk, and past experience suggests that 2 full time technicians working from September-December are necessary to ensure minimum sample size. Typical costs associated with 2 technicians are $32,000 per year.

EVALUATION/FUTURE MANAGEMENT

Modifying elk and bison behavior while reducing supplemental feeding will require a long-term, sustained commitment. Change is unlikely to happen fast, and interpreting effects of adaptive management actions will be complicated by varying environmental conditions from year to year. Consequently, we anticipate that the strategies outlined in this plan will be in place for a minimum of 5 years. Actions completed each year, the results of monitoring programs, and any proposed changes in course will be presented in an annual adaptive management update/report, completed by NER staff by the end of March for the previous year.

Investigating the potential effects of climate change on elk and bison management will be important in the long-term. During implementation of this plan, we will collect a variety of data that can be drawn upon for this purpose.

PUBLIC OUTREACH AND EDUCATION

The practice of winter feeding is inexorably woven into the historic fabric of Jackson Hole. Elk are identified with the rich and unique legacy for which Jackson Hole is known around the world. De-emphasizing the supplemental feeding program will be a major paradigm shift for the residents of Jackson Hole, Teton County, and the State of Wyoming.

An effective Public Outreach and Education program is essential for effective AMP implementation. The practice of feeding elk evokes passionate responses from those that oppose and those that support this practice. The general public and especially key stakeholder groups must understand the biological needs for and strategies of the AMP in order to gain general consent to modify longstanding elk/bison herd management methods.

A detail communication plan to guide outreach and education efforts can be found in Appendix 3.

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SCHEDULE

Table 6. Adaptive Management Plan proposed schedule.

Action	Date
GPS Collar 30-40 elk prior to strategy implementation (Iridium platform)	February 2016
Public outreach and education	March 2016
Initiate private lands conflicts mitigation contacts/actions	March 1, 2016
Implement enhanced forage monitoring	March 1, 2016
Initiate changes in supplemental feeding protocol	January 2017
Monitoring/Evaluation/Annual Report	June 2017

Table 7. Anticipated schedule of annual Adaptive Management Plan activities.

Activity	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
Elk and bison classification		x										
Irrigation						x	x	x	x			
Forage estimates	x	x	x	x								x
Etc…..												

[This table just for example. We could do the same with longer term schedule using years instead of months at the top if desired/necessary.]

BUDGET

Table 8. [incomplete]. Estimated Adaptive Management Plan budget above current expenditures, years 1-5.

Agency / Activity	Year 1	2	3	4	5
National Elk Refuge:					
Monitoring:					
Seasonal Biological Technician (0.5 FTE, GS-7)	24,000	25,000	26,000	27,000	28,000
Bison/elk fed days					
Mid-winter census					
Elk summer herd segment distribution[1]					
Expanded standing forage estimates[1]					
Chronic Wasting Disease, 2 seasonal biot-techs	32,000	32,000	32,000	32,000	32,000
Winter bison/elk distribution					
Irrigation					
50 Elk radio telemetry collars; Iridium Platform	$115,000	$25,000	$25,000	$25,000	$25,000
Bison barrier at NER south entrance	$80,000	$1,000	$1,000	$1,000	$1,000
Adaptive Management Plan annual reporting	$2,000	$2,000	$2,000	$2,000	$2,000
Private lands:					
Easements / Acquisition					
Damage reimbursements (Wyoming)					
Conflict mitigation coordination (Wyoming)	$91,000	$91,000	$91,000	$91,000	$91,000
Vegetation restoration/protection[1]					
Public Outreach and Education	$11,000	$1,000	$1,000	$1,000	$1,000
Subtotal					
Grand Teton National Park:					
Monitoring:					
Summer elk classification/distribution					
Hunter harvest					
Harvest age distribution					
Transition range forage production/utilization					
Vegetation Restoration/Protection					
Temporary bison fencing					
Hayfields restoration					
Exotic plant mitigation					
monitoring					
Elk Reduction Program					
Subtotal					
Wyoming Game and Fish Department:[2]					
Private lands:					
elk harvest coordination					
Easements / Acquisition					
Damage reimbursements					
Conflict mitigation coordination					
Add additional lines and categories as needed					
Subtotal					
Grand Total					

[1] See detail in Appendix

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APPENDIX 1. Summary of primary potential impacts associated with reduced supplemental feeding, as identified in alternative 4 environmental consequences section of the Final Bison and Elk Management Plan/Environmental Impact Statement (USFWS and USNPS 2007).

Populations

- Jackson elk herd objective of 11,000 would be maintained.
- New Jackson bison herd objective of 500 established.

Winter Feeding

- Supplemental feeding could be delayed or could occur earlier compared to current practices.
- Changes [to feeding program could] include alterations in the timing of feeding and providing supplemental feed in fewer years.
- Ration or pellet composition might need to be changed.
- Supplemental feeding would be initiated according to established criteria, including pre-winter forage production, assessments of forage utilization (done jointly by WGFD and NER personnel), elk condition and movements, and potentially on the January 1 index of winter severity calculations for elk (Farnes, Heydon, and Hansen 1999).
- Mechanical means could be used to increase forage access for elk after snow crusting events.
- Changes in the refuge supplemental feeding program could begin to affect elk nutrition (negligible adverse effect on NER elk from lower nutrition).
- Displacement of elk by bison during competition for standing forage would decrease as the bison herd is reduced.
- Aggressive social interactions involving competition for food among elk and bison would increase overall as feeding periods are reduced.

Winter Distribution

- Elk densities on the NER would decline due to more reliance on standing forage and wider distribution.
- Elk use of lands surrounding the NER would increase, including:
    - USFS lands east of the NER
    - Gros Ventre feedgrounds possibly
    - Southern GTNP
    - State feedgrounds south of the NER
- Most of winter distribution shift would involve elk in the Yellowstone, Teton Wilderness, and Gros Ventre segments.
- As ungulate numbers decreased and supplemental feeding was reduced, competition and aggressive social interactions on the refuge would also be reduced.
- Elk and bison distribution would increase as the animals relied more on native winter range.
- Fewer animals would be present on the refuge.

Mortality

- As supplemental feeding is reduced, natural factors such as climate and native forage availability would have a greater influence on numbers, movements, distribution, and mortality.
- More elk would be subject to natural factors affecting mortality, including loss of body condition, predation, and starvation.
- Increased mortality on and off the refuge would mainly affect older elk and calves, and some prime bulls entering the winter energetically stressed due to rut activities.

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- Late winter calf ratios could decrease as a result of higher winter calf mortality
- Average winter mortality on the refuge would increase from 1%–2% annually to an estimated 1%–5%.
- Overall, a higher total winter mortality rate of approximately 5% could be expected.

Disease

- Reductions in supplemental feeding or elk numbers would reduce the potential for impacts due to tuberculosis, septicemic pasturelosis, and CWD.
- The health and sustainability of the Jackson elk herd would be increased gradually as supplemental feeding was reduced and there was greater reliance on standing forage and wider ungulate distribution.
- Health and sustainability of the Jackson elk herd would be enhanced in the long term.
- Wider distribution of elk would result in moderate reductions in both the prevalence and potential transmission of brucellosis, as well as potential for spread of diseases not yet in the population.

Private Lands

- The agencies would work closely with the WGFD and landowners, including livestock producers, to coordinate actions that would prevent conflicts due to elk dispersal and to defray costs of managing potential conflicts. Preventing access to food/hay rewards on private lands would be vital for effective management.
- Private land conservation easements within NER boundaries would promote wider distribution.

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APPENDIX 2. Monitoring Supplemental Materials: Feeding Initiation Methods

At each sample site, 10 subplots will be measured at every 5 steps along the random bearing determined for each site. At each subplot a 13.27" diameter metal sampling ring will be placed on the ground. The amount of forage available to elk within the sampling ring (dry weight in grams) will be visually estimated. The 13.27" diameter subplot allows easy conversion from grams to lbs. per acre (each gram is equivalent to 100 lbs. per acre). During annual forage production sampling, refuge biologist Eric Cole has made approximately 1,000 of these visual estimates per year for 17 years, and 33% of Cole's estimates have been verified by clipping and weighing. Therefore, Cole will be the principal estimator, but additional personnel will be trained in these techniques to provide redundancy in the event of personnel changes, and to increase the number of observers to facilitate estimation of error.

Estimating available forage within the sample ring at each subplot is relatively straightforward when snow cover is limited, but estimating how much of the forage is accessible to elk when snow is dense, deep and crusted can be subjective. To decrease the subjectivity of the estimation process, if the area under the sample ring is covered with snow, only forage that can be exposed with a gloved hand will be included in the estimate of available forage. Forage that is fouled with manure and/or flush with the ground due to trampling and/or encrusted in ice will not be included in the estimate of available forage.

At each subplot the estimate of available forage (dry weight g) will be converted to an equivalent lbs./acre value (1 gram=100 lbs./acre). The arithmetic mean of available forage (lbs./acre) for the 10 subplots provides an estimate of available forage for each index site. There are 3 sample site categories: 1) Historic Key Index Sites that have been used since 2007, 2) New randomly selected sites within areas preferred by elk, and 3) New randomly selected sites in areas not preferred by elk. Historic key index sites were not randomly selected, but were instead selected to represent areas most preferred by elk on the south end of NER. These were the sites used to determine when supplemental feeding would be initiated from 2007 until the implementation of the AMP. To facilitate comparison with pre-AMP data, we will continue to use mean lbs. per acre across historic key index sites to determine the 300 lbs. per acre threshold. However, post AMP implementation we will delay feeding initiation by 2 weeks once the 300 lbs./acre level has been reached. We will concurrently sample at randomly selected sites stratified on an annual basis between areas highly preferred and not highly preferred by elk. This will enable us to quantify the relationship between mean forage availability at historic key index sites and random sites over time.

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APPENDIX 3. Communication Plan

Communication Goals

Prior to the Adaptive Management Plan's Implementation

- Utilize a variety of outreach methods to inform the public on the goals and timing of the Adaptive Management Plan's implementation and possible effects on wintering herds.
- Utilize a variety of outreach methods to inform the public on public comment opportunities.
- Identify and coordinate key messages and outreach with USFWS regional and national offices, State and federal agency partners, non-profits, elected officials, and other identified audiences.

During the Adaptive Management Plan's Implementation

- Continue to utilize a variety of outreach methods to describe current management actions as well as measurable and noticeable changes on the landscape, in animal behavior, or in animal health.
- Provide a comprehensive overview of the Adaptive Management Plan by providing links and references to previous outreach and background information.

Communication Objectives

- Work with current media contacts to promote news of the Adaptive Management Plan via print, radio, Web, and social media platforms.
- Utilize new media and social media tools to provide information on why the Adaptive Management Plan was developed, what public comment opportunities exist, and how the plan is being implemented.
- Plan, coordinate, and execute public meetings to allow for public comment and questions on the plan.
- Develop and provide methods for the public to submit written comments on the Adaptive Management Plan.
- Monitor print media on Refuge elk and bison management to see how Adaptive Management Plan objectives and reactions are being portrayed to the public.

Current Outreach Resources

- National Elk Refuge web site
- National Elk Refuge news release list
- (approximately 300 contacts)
- National Elk Refuge Twitter site (1,039 followers)
- Bison and Elk Management Plan web site (http://www.fws.gov/bisonandelkplan/)
- Space for an 11" x 17" poster in the Visitor Center on Refuge management topics
- Display panels in the Visitor Center theater for temporary displays

Available Supporting Outreach Resources

- USFWS Mountain–Prairie External Affairs staff
- USFWS Mountain–Prairie web site, including the
- "Top Stories" feature

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- USFWS Mountain–Prairie Twitter site USFWS Mountain-Prairie Region Facebook page
- USFWS National Wildlife Refuge System
- Facebook page
- USFWS Facebook page

Previous Outreach Efforts

- NER routinely writes and disseminates news releases on Refuge management activities, including the Comprehensive Conservation Plan, supplemental feeding, herd health monitoring, and forage production.
- Post the above news stories as Content.
- Management System (CMS) articles.
- Post CMS news story promos so they prominently appear on the home page, linking readers to the articles.
- Send out Twitter messages linking viewers back to the news stories.
- Prepare, upload and provide links to Adobe PDF versions of news stories with addtional photos where additonal images are available and/or help understand or visualize the content.
- Utilized the Conservation link on the web Content
- Management System to post information about the Bison and Elk Management Plan and the draft Comprehensive Conservation Plan.
- Retained and provided a link to the original Bison and Elk Management web page (http://www.fws.gov/bisonandelkplan/) that was developed during the planning process. The web site includes links to the Final Plan/EIS, Record of Decision, Federal Register Notice of Availability for both the Record of Decision and Final Plan/EIS, associated news releases, public meeting highlights, and other related documents. Note: the National Elk Refuge does not manage the site.

Additional Outreach Opportunities

- Public meetings in Jackson and other identified locations.
- Service produced video; video could be posted to the National Elk Refuge's multimedia web page, or USFWS Mountain–Prairie home page "Top Video" feature.
- Live radio interview on KHOL (Jackson, WY radio)
- Wyoming Public Radio interview with Refuge management staff
- Interviews with local print media sources
- Updates at community leader meetings such as Rotary Club, Jackson Hole Chamber of Commerce board meetings, and interagency breakfast meetings (with Federal agencies and local elected officials).

Target Audiences

Internal

- Regional and National USFWS Leadership
- Refuge permanent staff
- Refuge seasonal staff
- Refuge volunteers

External

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- Congressional representatives
- State of Wyoming leadership
- Federal agency partners, particulary Grand Teton National Park and the Bridger–Teton National Forest
- Wyoming Game & Fish Department
- Other NER partners, including county and town agencies and local nonprofit organizations
- Local elected officials
- Private landowners in proximity to the National
- Elk Refuge or neighboring Federal lands
- Tribes
- Local and state media
- Local public

Key Outreach Topics

- Overview of BEMP objectives
- Strategy to change elk/bison behavior
- Threat of disease
- Natural mortality rates
- Anticipated winter distribution changes for bison/elk
- Mitigate negative effects on private lands
- Change elk behavior and distribution while avoiding increased mortality.
- Explain the historic reasons a supplemental feeding program began and why it was continued.
- Explain the NER's limited large ungulate carrying capacity and the disproportionate impact of bison on available forage; 3 elk = 1 bison.

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APPENDIX 4. Models

Elk winter distribution model

The proportion of the JEH that winter on the NER will be linked to factors hypothesized to influence elk winter distribution (Fig. 2) using a generalized linear mixed effects model (GLMM). A GLMM can account for a proportional response variable (i.e., constrained to the interval 0–1) using a log link and binomially-distributed errors. A GLMM also includes fixed and random effects, with the latter capturing residual model variance otherwise not explained by fixed effects. Year will be including as a random effect, providing several benefits. First, we don't assume years are independent and comprise all of the factor levels of interest. Instead, the effect of year is treated as a random variable, with individual year effects realizations of that distribution. This allows inference to non-sampled factor levels, i.e. years, by estimating a latent population-level proportion of elk expected to winter on the NER regardless of fixed effect influences. Thus, the random year effect can be considered a latent variable describing elk behavior manifested as observed winter distribution. Second, because year effects are not treated as independent, estimated effects of year on the proportion of JEH elk wintering on the NER are dependent on all factor levels, leading to greater precision when estimating individual year effects (Kéry 2010).

The full GLMM incorporating fixed effects for each factor identified as influencing elk winter distribution (Fig. 2) is:

$$P_t = \beta_{0(t)} + \beta_1 * AFI_t + \beta_2 * SDM_t + \beta_3 * WP_t + \beta_4 * GSP_t + \beta_5 * SWE_t + \varepsilon_t$$

where the random intercept and residual model variance are

$B_{0(t)} \sim N(\mu_{\beta_0}, \sigma^2_{\beta_0})$, and

$\varepsilon_t \sim N(0, \sigma^2)$, respectively.

Fixed effects include 1) per capita available forage at initiation of winter feeding (*AFI*) , 2) proportion of the JEH that are short-distance migrants (*SDM*), 3) number of wolf packs present on JEH native winter range (*WP*), 4) growing season (May–August) precipitation for the Wyoming Snake Drainage climate division (*GSP*; a proxy for available forage on native winter range), and 5) snow water equivalent on 1 January at Thumb Divide (*SWE*; a proxy for early winter severity).

Elk calf winter survival and forage deficits

The Forage Accounting Model of Hobbs et al. (2003) has as an output weekly available forage biomass for the NER (sum of predictions for 30 × 30 m cells). These predictions account for snow conditions using a proxy of SWE and decrement total available biomass by 35% to account for unpalatable plants within the total estimate.

While calf survival is a function of multiple factors (Fig. 3), the primary management action influencing calf survival is supplemental winter feeding. Current winter feeding initiation criteria lead to calf survival generally higher than in unfed populations. Proposed feeding initiation criteria will result in later

Comment [WJ5]: I'm not comfortable with this interpretation yet and need to think about it some more.

Comment [WJ6]: This doesn't currently have a term for hunting, although our conceptual model above does. Need to decide if we want to include or exclude here.

Comment [WJ7]: Will need a more formal explanation of these variables and how they will be collected. May fit best in the monitoring section.

Comment [WJ8]: If we use Hobbs' model for predicting available forage these may be redundant.

Comment [WJ9]: Put in winter feeding initiation paragraph above? Then note where more samples are necessary to improve the precision of the estimates. Need to run this model from 2007 forward to see where, on average, feeding was initiated so we can make treatment adjustments as necessary. This would also allow us to look at the relationship between key index sites estimates and Hobbs' predictions. Need to consider validating Hobbs' model with field sampling Eric is currently designing to see if we can use the Hobbs model moving forward. This would take some time with stripping the Hobbs model down to our needs, identifying data sources, and developing a workflow process so weekly estimates of available forage can be calculated. Would only be able to use snow data from SNOTEL sites that have data available online, which shouldn't be too much of a problem.

Comment [KD10]: Need a citation here.

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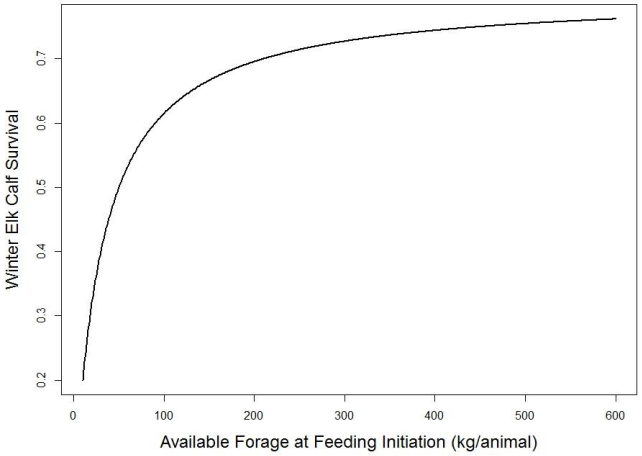
initiation of supplemental feed, which will be most influential to calf survival. There is currently little understanding regarding the relationship between initiation of winter feeding and calf survival, except that current feeding initiation criteria result in high calf survival. We believe a threshold level of available forage at initiation of winter feeding exists such that winter calf survival reaches an asymptote. Below this threshold, calf survival is hypothesized to decline quickly with reductions in available forage at winter feeding initiation. Available forage at the initiation of winter feeding will be related to on elk calf winter survival using a saturating function (i.e., Holling type-II functional response; Fig. 6) by

$$S_t = \frac{aAFI_t}{b + AFI_t}.$$

The parameters *a* and *b* determine how calf survival is related to available forage. Maximum calf survival is *a*, and *b* represents the value of available forage to an individual when survival is 50% of *a* (Hilborn and Mangel 1997).

Although this approach doesn't capture forage deficits *per se*, it does provide a potentially sensitive proxy for this concept. It is assumed that a forage deficit for calves would occur at a point on the curve of the relationship between calf survival and available forage at initiation of supplemental feeding. Modeling the response of winter calf elk survival to changes in feeding initiation criteria facilitates our ability to maximize the influence of feeding initiation criteria on winter distribution while minimizing the likelihood of a large mortality event.



Hypothesized relationship between winter survival of elk calves and per capita available forage at initiation of winter feeding on the National Elk Refuge.

From:	Steve Kallin
To:	Brad Hovinga; Doug Brimeyer
Subject:	Additional AMP Versions
Date:	Friday, July 24, 2015 4:35:25 PM
Attachments:	NER AMP Draft v2.0 7-24-15.pdf NER AMP Draft v2.0 7-24-15 for WGFD.doc NER AMP Draft v2.0 7-24-15.docx

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Brad/Doug:

Give these a try and let me know if these work.

Read a bit in Word about documents from a questionable source (of course the Feds would qualify), which may need to be opened in "Protected View." With all the security stuff on our FWS servers, it may be triggering an alert. Hopefully the .docx will work this time.

Sorry for the inconvenience. Have a great weekend!

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U.S. Fish and Wildlife Service National Park Service

BISON AND ELK
MANAGEMENT STEP DOWN PLAN

A Structured Framework for Reducing Reliance on Supplemental Winter Feeding

National Elk Refuge

Grand Teton National Park

DRAFT

July 24, 2015

BISON AND ELK

MANAGEMENT STEPDOWN PLAN

For the

National Elk Refuge,

Grand Teton National Park,

John D. Rockefeller, Jr. Memorial Parkway

Teton County, Wyoming

DRAFT

***Suggested Citation**:* U.S. Fish and Wildlife Service: 2015. Bison and elk management stepdown plan, National Elk Refuge and Grand Teton National Park. U.S. Department of the Interior, Washington D.C. Available online at:

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EXECUTIVE SUMMARY [incomplete]

Comment [S1]: Steve K, my view on this is that it should be relatively short, because this is not a long document. I am thinking perhaps 2-3 pages max. What are your thoughts?

Overview

In 2007, the National Elk Refuge (NER) and Grand Teton National Park (GTNP) published a Record of Decision (ROD; USFWS and USNPS 2007a) for a bison and elk management plan. The Bison and Elk Management Plan (BEMP; USFWS and USNPS 2007b) was developed to guide management of the Jackson bison and elk herds on NER and GTNP lands, focused on four broad goals related to: 1) habitat conservation; 2) sustainable populations; 3) numbers of elk and bison; and 4) disease management. The final plan directed the NER and GTNP (in conjunction with the Wyoming Game and Fish Department; WGFD) to maintain the state's elk herd objective of 11,000, establish a bison population objective of 500, restore habitat on the NER and in GTNP, continue hunting bison and elk on the NER, continue the elk reduction program, when necessary in GTNP, continue to vaccinate elk for and effective vaccine becomes available, and develop a dynamic framework and adaptive management plan for decreasing the need for supplemental feeding on the NER. ***This Bison and Elk Management Stepdown Plan was developed to address the latter and specifically addresses the criteria for a structured framework referenced in the Record of Decision.***

Background

Winter feeding of elk in Jackson was originally initiated to reduce winter mortality of elk and minimize depredation of ranchers' hay. The loss of available winter range in Jackson Hole due to new ranching operations and a growing town resulted in significant numbers of elk dying during several severe winters in the late 1800s and early 1900s. This prompted local citizens and organizations, as well as state and federal officials in Jackson Hole, to begin feeding elk in the winter of 1910–11. Congress heeded the appeals for assistance and on August 10, 1912, established the National Elk Refuge. Today, the need for the refuge's winter elk feeding program is a direct result of reduced access to significant parts of elk native winter range, loss of historic migration patterns, behavioral conditioning of elk to winter feeding, and the desire to maintain a population objective established in the context of supplemental feeding.

Bison were extirpated outside Yellowstone National Park (YNP) by the mid-1880s but in 1948 were reintroduced to Jackson Hole when 20 bison from (YNP) were released near Moran, Wyoming. The herd remained small until discovering elk feedlines in 1980, when the population began sustained population growth. Bison and elk that winter on the NER are migratory and occupy summer ranges predominantly to the north.

Objectives

Comment [S2]: Problem here

This adaptive management plan addresses several objectives under a broader BEMP goal of sustainable populations, which directed the agencies to: 1) Develop an adaptive management plan for reducing NER supplemental feeding; 2) [implement a] phased reduction of animals on feed: a) to 5,000 elk and 500 bison, and b) [to a point where] elk and bison rely predominantly on native habitat; 3) maintain natural elk bull-to-cow ratios in park summer herd; and 4) Enhance public outreach/education. The BEMP further stated that consideration criteria for implementing the 2nd phase of reduced feeding will include: 1) the level of forage production and availability on the National Elk Refuge and adjacent winter ranges, 2) maintenance of desired herd sizes and age/sex ratios, 3) the ability to effectively mitigate bison and elk livestock conflicts, such as co-mingling on private lands during high risk disease transmission periods, 4) maintaining desirable winter distribution patterns of elk and bison, 5) the

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prevalence of brucellosis, chronic wasting disease, and other wildlife diseases, and 6) public support. **In short, the overall objective of this plan is to provide a path for progressively transitioning from winter feeding of elk and bison on the NER to greater reliance on free-standing forage, while maintaining population and herd ratio objectives.**

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INTRODUCTION

In 2007, the National Elk Refuge (NER) and Grand Teton National Park (GTNP) published a Record of Decision (ROD; USFWS and USNPS 2007a) for a bison and elk management plan. The Bison and Elk Management Plan (BEMP; USFWS and USNPS 2007b) was developed to guide management of the Jackson bison and elk herds on NER and GTNP lands. It included directives for forthcoming development of adaptive management practices to address several objectives in the plan, including a desired future condition of elk and bison relying predominantly on native forage. This Bison and Elk Adaptive Management Plan has been developed expressly for that purpose.

Bison and Elk Populations

While Jackson Hole is probably best known for the splendor and ruggedness of the Teton Range, the Jackson bison and elk herds rank among the top characterizing features of the valley. Both figure prominently in Jackson Hole's history and culture, although bison were absent from the valley for about 100 years between the mid-1800s and mid-1900s.

The Jackson elk herd occupies approximately 8,000 km^2 in the upper Snake River watershed north of the town of Jackson (Fig. 1). Much of the herd is migratory, moving between distinct wintering and summer ranges. Primary wintering areas include the Buffalo Valley, lower elevations of the Gros Ventre River drainage, the National Elk Refuge (NER), and areas adjacent to the NER on Bridger-Teton National Forest (BTNF) lands. Summering areas occur throughout the herd's range and for convenience are divided into four geographic regions that include Grand Teton National Park (GTNP), Yellowstone National Park (YNP), the Gros Ventre drainage, and Teton Wilderness.

In the late 1800s, when elk populations all over North America were being extirpated, the residents of Jackson Hole protected elk from "tusk hunters" and large-scale commercial hunting operations. Elk are just as important to today's residents of the valley. Thousands of people each year have the opportunity to see elk at close range on the refuge while riding on horse-drawn sleighs. Thousands of pounds of shed elk antlers are sold at an annual antler auction each spring in the town square. Elk are important to backcountry users as well as to people that never leave the road. Jackson Hole is a popular destination for instate and out-of-state elk hunters. The draw of elk to visitors contributes significantly to the local economy.

Winter feeding of elk in Jackson Hole began in 1910 and was originally initiated to reduce winter mortality of elk and minimize depredation of ranchers' hay. According to historical reports, before Euro-American settlement some Jackson elk wintered in the southern portion of Jackson Hole (present location of the NER town of Jackson) and may have used areas outside Jackson Hole, including the Green River and Wind River basins to the south and east, respectively, and the Snake River basin to the southwest in what is now eastern Idaho (Allred 1950; Anderson 1958; Blair 1987; Barnes 1912; Sheldon 1927). Radio-collar studies have documented small numbers of Jackson elk wintering in each of these areas in recent times as well (*citations*). Over time, changes in land use and development in these areas, over hunting, and establishment of feedgrounds probably reduced the use of these areas by Jackson elk.

By the end of the 19th century the Jackson elk herd was believed to be largely confined to Jackson Hole and the immediately surrounding area, where wintering conditions are often harsh. Compounded by the loss of available winter range in Jackson Hole due to new ranching operations and a growing town, significant numbers of elk died during several severe winters in the late 1800s and early 1900s. This prompted local citizens and organizations, as well as state

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and federal officials in Jackson Hole, to begin feeding elk in the winter of 1910–11. Congress heeded the appeals for assistance and on August 10, 1912, appropriated $45,000 for the purchase of lands and maintenance of a "winter game (elk) reserve" (37 Stat. 293). The first winter census in the area was conducted in 1912 and showed about 20,000 elk residing in Jackson Hole and the Hoback River drainage.

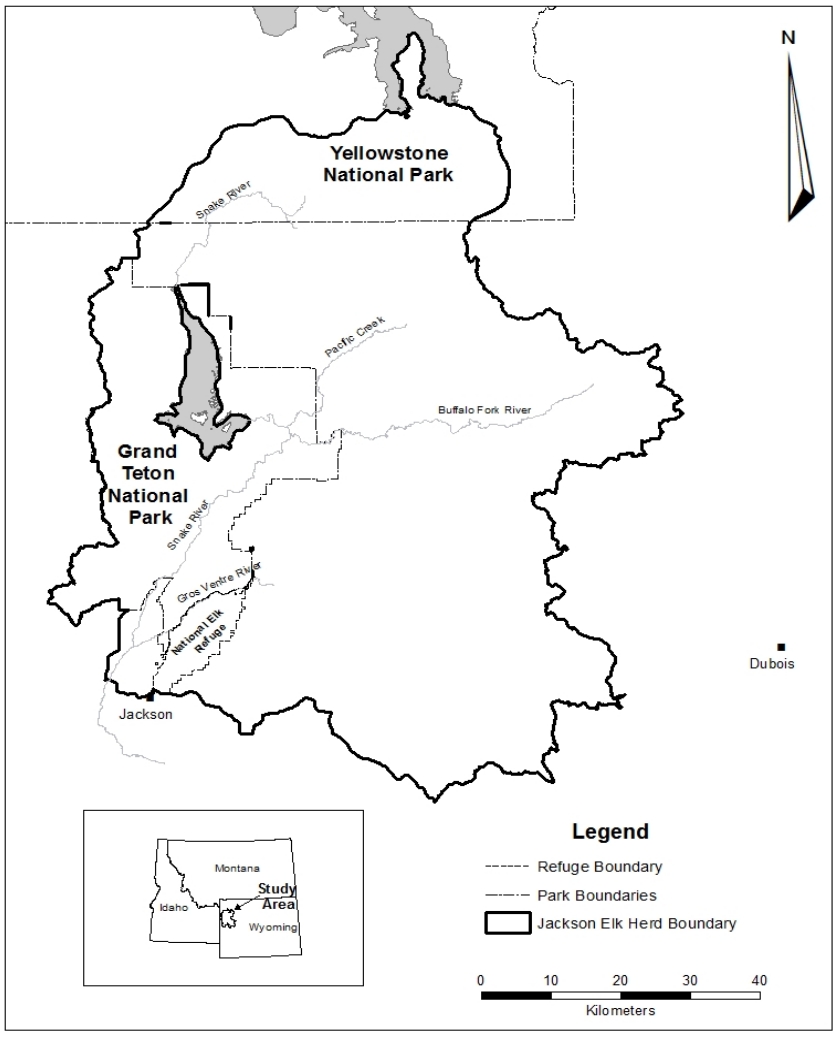

Figure 1. Jackson elk and bison herd ranges, including the National Elk Refuge, Grand Teton and Yellowstone National Parks, and Bridger-Teton National Forest. [include bison range, labels for continental divide and Bridger-Teton National Forest, and in Legend Jackson elk herd unit].

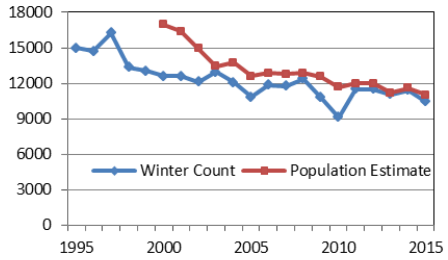

Figure 2. Winter counts and population estimates for the Jackson elk herd, 1995-2015.

Today, the need for the refuge's winter elk feeding program is a direct result of reduced access to significant parts of elk native winter range, loss of historic migration patterns, behavioral conditioning of elk to winter feeding, and the desire to maintain a population objective established in the context of supplemental feeding. Its population in recent times has fluctuated both above and below its herd objective of 11,000 adopted by the WGFD (Fig. 2)

An iconic symbol of the American West, bison are also popular with visitors and residents. Because so few opportunities remain to see bison in the wild, viewing and photographing them in Grand Teton National Park with the Teton Range in the background is a treasured opportunity for many of the valley's visitors. Similar to elk, there is also a high level of interest in bison hunting. Bison are of particular interest to nearby American Indian tribes and tribes in other parts of the United States because the animals are central to their culture and tradition.

Bison are native to Jackson Hole, as evidenced by the presence of prehistoric bison remains throughout the valley, but were extirpated outside Yellowstone National Park by the mid-1880s. In 1948, 20 bison from Yellowstone National Park (YNP) were reintroduced to the 1,500-acre Jackson Hole Wildlife Park near Moran. The Jackson Hole Wildlife Park was a private, non-profit organization sponsored by the New York Zoological Society, the Jackson Hole Preserve, Inc., and the Wyoming Game and Fish Department (WGFD). A population of 15–30 bison was maintained in a large enclosure there until 1963, when brucellosis was discovered in the herd (likely transferred with the original 20 animals from YNP). At that time, all the adult animals were destroyed, but four vaccinated yearlings and five vaccinated calves were retained. In 1964 twelve certified brucellosis free bison from Theodore Roosevelt National Park were added to the herd. In 1968 the herd (down to 11 animals) escaped the confines of the wildlife park, and a year later the decision was made to allow them to range freely. The expansion of GTNP in 1950 had enveloped the Wildlife Park, and allowing the bison to free range was and remains consistent with National Park Service wildlife management policy. The herd remained small and wintered mostly in the Snake River bottoms in GTNP until 1975, when it followed the winter environmental gradient to the NER and began wintering there. The use of standing forage by bison on the NER was viewed as natural behavior thus acceptable to managers. In 1980, however, bison discovered and utilized supplemental feed provided for elk, and they have continued to do so every winter since.

The discovery of supplemental feed by bison has had several consequences, including a significant increase in the population's growth rate (Fig 3). Bison on the elk feedlines have at times disrupted feeding operations and displaced and injured elk. To minimize conflicts between bison and elk, managers have provided separate feedlines for bison since 1984. As the population has grown, separating elk and bison on feedlines has become increasingly difficult, and a variety of feeding strategies are employed to help reduce displacement of elk.

As the herd has grown it has maintained fairly stable movement patterns, wintering almost entirely on the NER and summering within GTNP and adjacent lands on the BTNF (Fig. 1).

Planning History

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Jackson's bison and elk populations have been the subject of previous planning efforts. Elk management and research has been guided by the Jackson Hole Cooperative Elk Studies Group since it was established in 1953 [verify date]. The group consists of biologists and agency administrators from the National Elk Refuge, Grand Teton and Yellowstone National Parks, the Bridger-Teton National Forest, and Wyoming Game and Fish Department, who meet at least annually to coordinate management of the population and its habitat. Coordination of bison management began soon after they started frequenting the NER in 1976 and using supplemental feed provided to elk in 1980 (Fig. 3). Release of an "Interim" plan that called for maintaining a herd of 90-110 bison while data were gathered for a long term plan occurred in 1988. It was followed by implementation of a sport hunt administered by WGFD. This plan was halted after litigation in which the plan's violation of NEPA was successfully argued by plaintiffs.

In 1996, after considerable herd growth, a new long term management plan and environmental assessment for the Jackson bison herd was released (Fig 3). This plan had strong support and called for maintaining a herd size of 350-400 bison, but it was shelved a year later when plaintiffs from the earlier litigation successfully argued that, because the plan failed to consider the effects of feeding elk on bison management, it also violated NEPA and was not sufficient. This led to development of the draft bison and elk management plan and environmental impact statement from 2000-2006 and release of the final plan in 2007 (Fig 3).

The 2007 Bison and Elk Management Plan (BEMP; USFWS 2007) considered six alternatives for

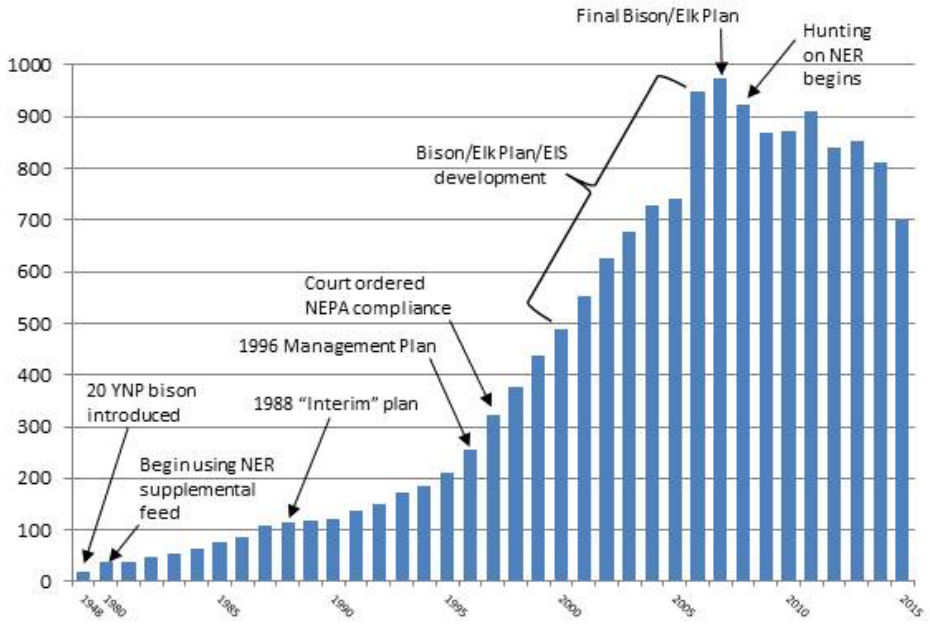

Figure 3. Population growth and planning history for the Jackson bison herd, 1948-2015.

bison and elk management focused on four broad goals related to: 1) habitat conservation; 2) sustainable populations; 3) numbers of elk and bison; and 4) disease management. The primary management scenarios presented in the alternatives included the status quo, terminating elk and bison hunting on the NER and the elk reduction program in GTNP, brucellosis vaccination options, restoring habitat, improving forage, and decreasing or phasing out supplemental winter feeding.

The final BEMP (USFWS 2007; www.fws.gov/bisonandelkplan) which set management direction for 15 years or until a subsequent plan is developed, proposed to maintain the state's elk herd objective of 11,000, establish a bison population objective of 500, restore habitat on the NER and in GTNP, continue hunting bison and elk on the NER, continue the elk reduction program in GTNP, when necessary, in concert with the parks enabling legislation (citation), continue to vaccinate elk for and effective vaccine becomes available, and develop a dynamic framework and adaptive management plan for decreasing the need for supplemental feeding on the NER. ***This Bison and Elk Management Stepdown Plan was developed to address the latter and specifically addresses the criteria for a structured framework listed on page 5 of the Record of Decision*** **(Fig. 4).** It does not address other on-going bison and elk management actions already prescribed by the BEMP.

The BEMP scheduled the completion of an Adaptive Management Plan for 2008. However, litigation challenging the BEMP in 2008 led to the decision to postpone its development until litigation was resolved. As of March 2015, two court rulings have upheld the 2007 BEMP and ROD. In a lawsuit against the BEMP and its author agencies (Defenders of Wildlife et al. v. the U.S. Department of Interior and State of Wyoming 2010), plaintiffs argued that the BEMP violated the National Wildlife Refuge System Improvement Act (National Wildlife Refuge System Improvement Act 1997) by disrupting the biological integrity of the Refuge, and that the plan and the accompanying EIS violated NEPA because they were insufficiently detailed to allow a reasonably complete discussion of mitigation. The crux of the plaintiff's argument was that the plan did not set a specific date for the cessation of supplemental feeding. In response, the agencies argued that the plan constituted a valid exercise of discretion and that it and the EIS were sufficiently detailed to satisfy the requirements of NEPA. In March 2010 the United States 4th District Court sided in favor of the agencies in this case. In 2011 the plaintiffs appealed this ruling to the United States 4th Circuit Court. The Circuit Court affirmed the District Court ruling (Defenders of Wildlife et al. v. the U.S. Department of Interior and State of Wyoming 2011).

National Environmental Protection Act Compliance

The 2007 BEMP/EIS and Final Record of Decision (ROD) satisfied NEPA requirements for current bison and elk management through a detailed analysis of alternative management actions and their likely effect on the environment, and substantial involvement of the public in the process. This adaptive management plan is does not duplicate or add to this process. It is designed to carefully tier off of the BEMP as a dynamic implementation guide to one part of the preferred alternative outlined in the BEMP ROD. As such, references to NEPA covered in the BEMP will be included where necessary in this document, and the discussion of any action that would require additional NEPA compliance will be explicitly stated as such in that context.

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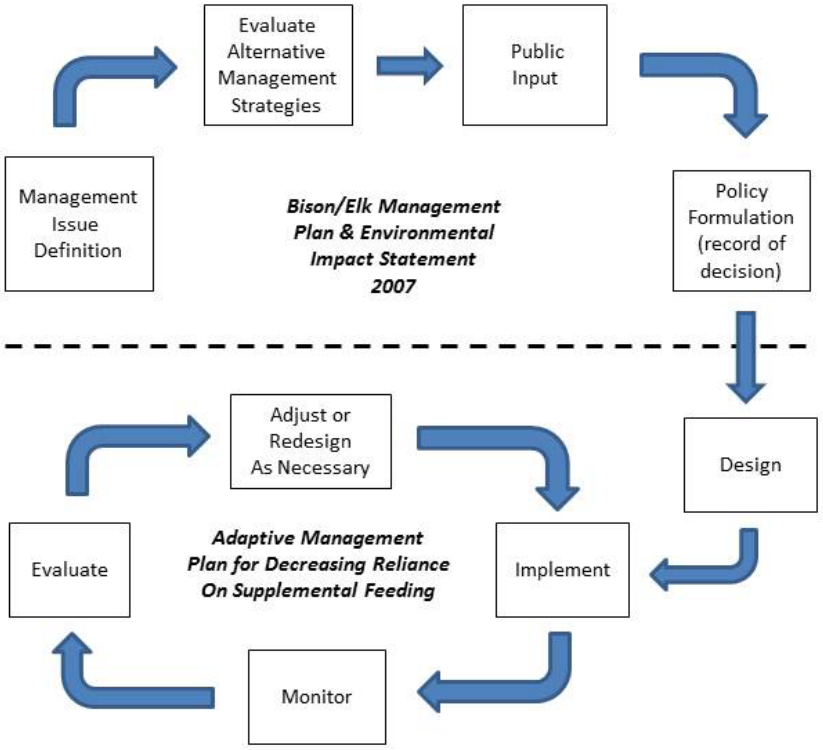

Figure 4. Adaptive management planning for supplemental feeding on the National Elk Refuge and its relationship to the 2007 Bison/Elk Management Plan and Environmental Assessment.

Adaptive Management Planning

Adaptive management plans have gained popularity in natural resource management planning because, by definition, they allow modifications of strategy based on monitoring results and outcomes toward reaching specific goals or objectives. There are four essential elements to an adaptive management approach: 1) well defined and mutually agreed upon objectives, 2 knowledge (including descriptive models) of the dynamics of the system being managed, 3) clearly articulated management actions and strategies, and 4) a monitoring program to evaluate responses of the system to management actions (Walters 1986).

This step-down plan utilizes adaptive management planning principles but is not intended to meet all of the adaptive management planning elements outlined in the Department of Interior Adaptive Management Technical Guide (2007). This Step-Down Plan is more accurately described as a "structured framework of adaptive management actions that progressively transitions from supplemental winter feeding to greater reliance on free-standing forage (BEMP ROD p.5).

OBJECTIVES

The management direction and desired conditions stated in the BEMP called for the NER and GTNP staffs to work with others (agencies, partners, etc) to "adaptively manage elk and bison in a manner that contributes to the State's herd objectives yet allows for the biotic integrity and environmental health of the resources to be sustained," so that the public can enjoy a variety of compatible wildlife-dependent recreational opportunities. Under the BEMP's 4 primary goals, 20 associated objectives were addressed (Table 1). This adaptive management plan addresses four objectives under the goal of sustainable populations (Fig. 5).

In Phase 1 of the second objective, the aim is to reduce the average number of elk on feed to 5,000 (while maintaining WGFD's 11,000 elk herd objective), and reduce the winter population of bison to the BEMP-adopted objective of 500. In Phase 2, the overall objective is to reduce the reliance of bison and elk on supplemental feed (USFWS and USNPS 2007a). Desired conditions include animals relying predominantly on native habitat and cultivated forage. Important consideration criteria for implementing Phase 2 will include: 1) the level of forage production and availability on the National Elk Refuge and adjacent winter ranges, 2) maintenance of desired herd sizes and age/sex ratios, 3) the ability to effectively mitigate bison and elk livestock conflicts, such as co-mingling on on private lands during high risk disease transmission periods, 4) maintaining desirable winter distribution patterns of elk and bison, 5) the prevalence of brucellosis, chronic wasting disease, and other wildlife diseases, and 6) public support. In short, the overall objective of this plan is to provide a path for progressively transitioning from winter feeding of elk and bison on the NER to greater reliance on free-standing forage, while maintaining population and herd ratio objectives.

Table 1. 2007 Bison/Elk Management Plan Goals and Objectives (Adaptive Management Plan objectives shaded)

Goal: Habitat Conservation

Objectives:

- Conserve important private lands.
- Increase forage production.
- Minimize non-native plants.
- Protect sagebrush grasslands.
- Restore willow, aspen, and cottonwood.
- Perpetuate natural mosaic of plant communities.

Goal: Sustainable Populations

Objectives:

- Develop adaptive management plan for reducing NER supplemental feeding.
- Phase reduction of animals on feed: 1) to 5,000 elk and 500 bison, and 2) elk and bison rely predominantly on native habitat.
- Maintain natural bull-to-cow ratios in park summer herd.
- Ensure a genetically viable bison herd with close to an even sex ratio.
- Enhance public outreach/education.

Goal: Elk and Bison Numbers

Objectives:

- Maintain state elk herd objective of 11,000.
- Maintain a genetically viable bison population of about 500 animals.

Goal: Disease Management

Objectives:

- Manage brucellosis transmission risk from elk and bison to livestock.
- Manage feeding to reduce brucellosis transmission among bison and elk.
- Educate hunters about wildlife disease human health hazards.

This Plan focuses on management actions to initially achieve Phase 1 objectives. However, if successful, these actions will continue to be used

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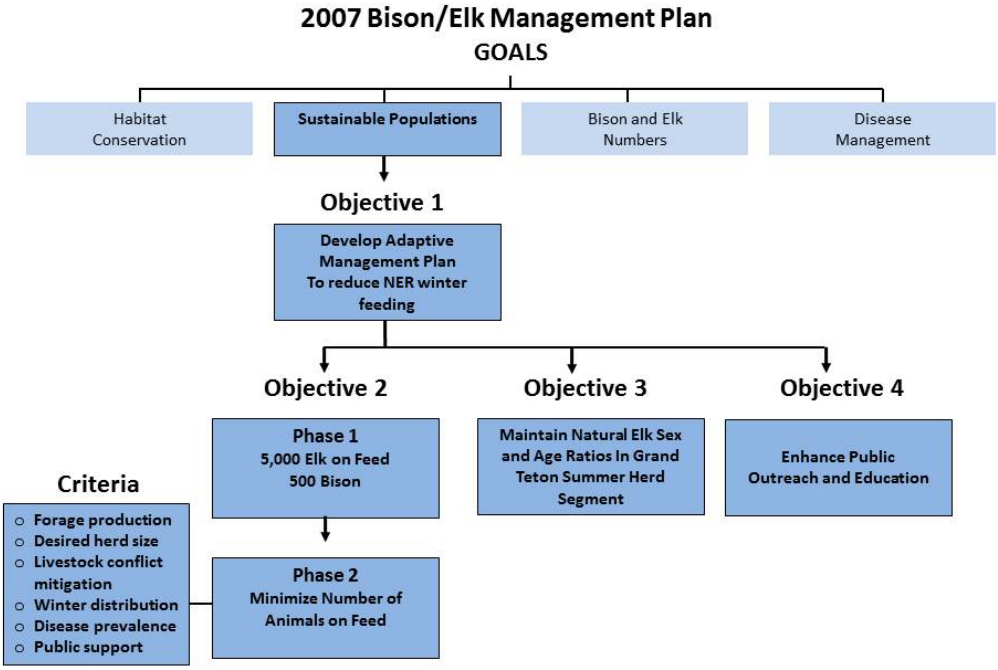

Figure 5. Relationship of Adaptive Management Plan to the 2007 Bison/Elk Management plan goals, phasing of objectives, and consideration criteria for reducing the reliance of elk and bison on supplemental feed during phase 2.

to achieve the Phase 2 objective of reducing reliance on supplemental feeding while considering the six criteria listed above.

MANAGEMENT ACTIONS AND STRATEGIES

Background

Elk have been fed for some period during nearly every winter on the National Elk Refuge since 1912, and bison have been fed there since 1980. The attraction of highly nutritious, easily accessible food during a time of year when natural forage is typically most limited is powerful to both species, and their knowledge of its existence has been passed down through generations. As a result, elk and bison have been strongly conditioned to seek supplemental food on the NER, even when natural forage is available and even abundant during some years. Because it is largely unprecedented, the concept of modifying this behavior on such a large scale is daunting and fraught with questions for which there is no answer. In some cases, the likelihood a specific management strategy's success will only be able to be roughly estimated, and unanticipated results are likely. The management stepdown approach will necessarily be one of investigation, constant evaluation, modifications to approach when indicated, and repeated trials (Fig 4). As such the approach will also be experimental, guided by rigorous analysis

and design, based on abundant empirical information, and monitored at an intensity commensurate with necessary decision making.

Since this plan is centrally tied to supplemental winter feeding on the NER, its focus will be on lands under NER authority. However, some strategies will also incorporate activities in GTNP, and on non-federal lands in collaboration with land owners and WGFD. Primary management practices that can be altered to achieve reduced reliance of bison and elk on supplemental feed fall into the 3 broad categories of 1) timing and intensity of winter feeding, 2) timing and intensity of hunting, and 3) herd segment specific and overall harvest levels.

Important Changes Since 2007

The BEMP was developed based on data collected and knowledge that existed up until its Record of Decision in 2007. Since then, important changes have taken place, some of which are advantageous to this effort, some of which are not.

A primary change that will facilitate meeting objectives under this plan is the reduction of the bison population from nearly 1,200 animals in 2007 to about 700 during winter 2014-2015 (Fig. 3) through hunting programs administered by WGFD. Licensing changes were enacted in 2014 to help increase harvest of female bison. These included a reduction in the bison cow/calf license fee (from $416 to $263 for residents and $2522 to $1022 for non-residents) and eliminating the once-in-a-lifetime restriction on a successful bison hunter to only those that successfully harvested a bull. Continued progress toward the 500 animal herd objective will require sustained harvest success.

During the same period, the Jackson elk herd has declined from nearly 13,000 to its objective of 11,000, but because the proportion of the Jackson Elk Herd that winters on NER has increased dramatically (Fig. 6), this will make achieving the Phase I objective of 5,000 elk on feed and any future elk population reductions more difficult. Preliminary modeling suggests that the increasing proportion of the Jackson Elk Herd wintering on NER has been associated with 1) changes in elk winter distribution associated with wolves and 2)high numbers of elk that summer immediately adjacent to NER (Cole and Foley et al. 2015).

Refuge-wide herbaceous forage production averaged 14,387 (SD = 4125) tons during 1998–2013. In recent years irrigation of approximately 3,600 acres has increased refuge-wide forage production by approximately 10% compared to what would have been produced with precipitation alone, and by 15% in the southern portion of NER which receives the greatest use by elk and bison.

Since 2007, the general awareness of climate change among the public has greatly increased. A strong, credible body of scientific evidence shows that climate change is occurring, is caused largely by human activities, and poses significant risks for a broad range of human and natural systems (National Academy of Science 2010). Ecological systems in the GYE are likely to be affected and associated changes will have implications for elk and bison management.

Current Management

Ongoing primary management actions on the NER include winter feeding, harvest, irrigation, and hazing. In GTNP, harvest of elk during the Elk Reduction Program takes place, when necessary, in collaboration with WGFD, and restoration of previously cultivated and irrigated sagebrush-grasslands is ongoing. Fundamental components of each of these will be briefly described below to provide a basis for comparison to adaptive management strategies that will follow.

Chronic Wasting Disease

Supplemental feeding has occurred in all but 9 winters on NER since 1912, and although this strategy minimizes winter elk mortality from starvation and contributes to Wyoming state elk

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herd objectives, elk occur at numbers and densities well in excess of carrying capacity (Smith et al. 2004, Lubow and Smith 2004). Considerable evidence suggests that Chronic Wasting Disease (CWD) transmission and prevalence are density dependent (Peters et al. 2000, Williams et al. 2002). Monello et al. (2014) found that elk densities of 15-110 per square km in Rocky Mountain National Park were associated with 13% CWD prevalence, and they predicted elk population declines when CWD prevalence exceeded 13%. NER elk densities commonly exceed 160 per square km (NER unpublished data), which suggests that the introduction of CWD to NER elk would have significant negative population effects over time.

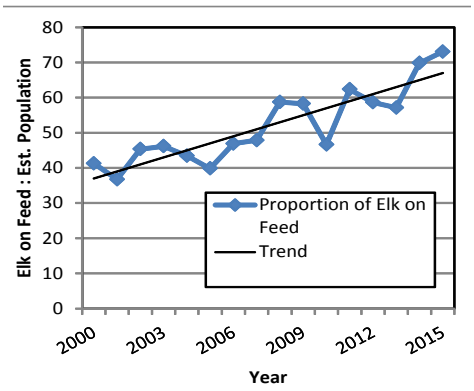

Figure 6. Increasing trend of National Elk Refuge elk on feed as a proportion of the Jackson Elk Herd estimated population size.

Winter Feeding

Initiation of feeding has the primary objectives of 1) minimizing elk winter mortality, focusing on calves since they are the most susceptible age class, and 2) minimizing comingling of elk with cattle on nearby adjacent private lands. Winter feeding begins when available forage reaches approximately 300 lbs/ac. Historic radio telemetry data and observations of elk movements indicate that when available forage delclines below 300 lbs/ac., some elk leave NER for surrounding private lands. Therefore, the purpose of this feeding trigger is to keep elk on the NER and prevent them from searching off-refuge for forage which increases the potential of comingling. This trigger is not a warning that a significant nutritional deficit threshold has been reached. Available winter forage for elk and bison on the NER is largely determined by biomass of forage produced during the previous growing season, rate of forage consumption during fall and winter, and how snow conditions affect forage availability.

Forage biomass estimates are calculated annually based on sampling at index sites. Index sites are selected subjectively each year based on presence of vegetation highly palatable to elk.

During 1995–2013, on average, initiation of NER winter feeding occurred on 28 January (range 30 December - 28 February), and feeding was terminated on 3 April (range 20 March - 20 April). Variation in feeding initiation and termination dates has been based on winter conditions and elk-cattle comingling problems on nearby private

Table 2. Annual distribution of wintering elk from the Jackson Elk Herd during February classification counts, 2011–2015, relative to the current objective.

	OBJECTIVE	2011	2012	2013	2014	2015	mean
NER	5,000	7,746	7,360	6,285	8,296	8,390	7,615
Gros Ventre	3,500	2,775	3,265	2,982	2,326	1,162	2,502
Native Range[1]	2,500	982	894	1,784	801	913	1,075
Total	11,000	11,503	11,519	11,051	11,423	10,465	11,192

[1]Excludes objectives for native range adjacent to Gros Ventre feedgrounds.

lands. Coordination of winter feeding dates on the NER and WGFD-operated Gros Ventre drainage feedgrounds (Alkali, Patrol Cabin) occurs annually to help minimize movement of elk between these areas. This coordination will continue regardless of the management strategy employed. The relationship of recent elk numbers and objectives for NER and WGFD-operated feedgrounds and native range is shown in Table 2.

Bison are fed as necessary to help minimize disruption to elk feeding operations. Bison will readily displace elk from feedlines, so since bison started using feedlines in 1980 refuge staff have developed a strategy of keeping most bison at the northernmost feedground (McBride) by feeding them there prior to feeding elk. Bison are provided a ration consistent with encouraging them to stay in this area away from elk feeding areas. This has also reduced conflicts associated with bison moving into Jackson or to the Nowlin area of the NER where commercial sleigh rides occur.

Harvest

Total harvest of the JEH was gradually reduced over the last decade as the population neared objective (Fig. 7). Elk hunting on the NER (Hunt Area 77) typically begins in mid-October and ends in mid-December, with peak harvest in recent years occurring in late November to early December. From 2005 to 2011 an average of 393 (SD = 56, range 329-457) hunters harvested 161 (SD = 38, range 126-225) elk per year during the NER hunt.

The 1950 legislation that created Grand Teton National Park provided for a controlled reduction of elk, when necessary, in specific portions of the park, primarily east of the Snake River. Elk reduction programs have taken place in the park each year since 1950 except two (1959, 1960), when GTNP and WGFD officials agreed a reduction was not necessary (Figure 8). Season dates have varied over the years but recently have run from mid-October to early-December. The GTNP harvest accounts for about 25% of the JEH overall harvest, thus has been an important factor in regulating the population. Increased natural regulation, likely a result of increases in grizzly bears and wolves over the last 20 years, has decreased the need for large harvests in the park.

Bison hunting begins on August 15 and ends in early to mid-January. Most harvest occurs on the NER, with some additional harvest on private and BTNF lands. Since resuming the bison hunt in 2007, mean harvest has been 210 (SD = 45.5, range 139-301) bison per year. This level of harvest has been sufficient to arrest the exponential growth of the population, reducing bison numbers from the peak in 2007 to about 700 animals in winter 2015 (Fig 3). Tribal bison harvest of up to 5 animals for ceremonial purposes was authorized in the BEMP. Translocation of wild bison to lands outside of Teton County is not currently permitted due to brucellosis concerns.

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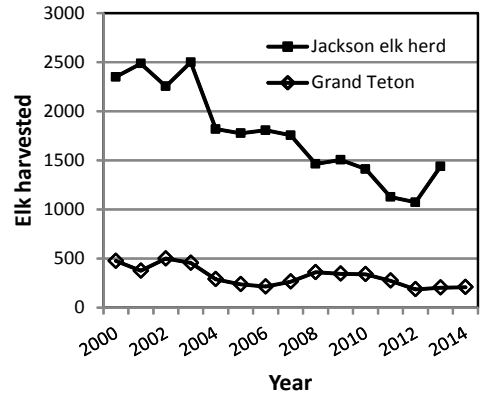

Figure 7. Estimated elk harvests for Grand Teton National Park and the Jackson elk herd (including the park) 2000–2014.

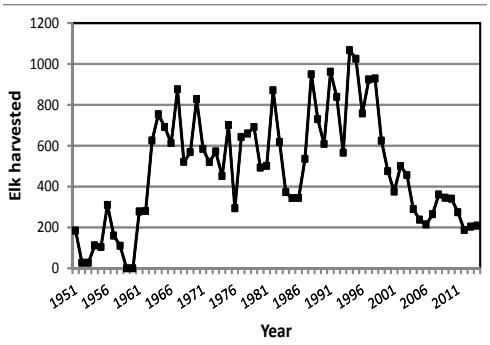

Figure 8. Elk harvest in Grand Teton National Park, 1950-2015.

Bison hunting is not allowed in GTNP because of long standing National Park Service policy that prohibits most hunting in national parks. Bison quickly learned to take advantage of the parks safety, which has made obtaining hunter harvest goals difficult. Many bison stay in the park during the hunting season, with only occasional short term movements to the NER, until severe winter conditions occur. In response, NER and WGFD managers attempt to balance extending the hunt as late in January as practicable without conflicting with winter feeding. The unpredictable nature of winter conditions that time of year makes this a risky proposition, and can result in the use of emergency season extensions or reductions.

Hazing

Elk and bison are hazed in spring to encourage movement off of NER winter ranges. Methods used have included ATVs, on foot, and on horseback, but recently ATV use has been found most effective. It's possible that some elk and bison might remain on the NER year around without hazing. If animals fail to leave the NER following the termination of feeding and adequate green-up has occurred, they are typically hazed to the north in late April to early May. Elk will stay off the NER until fall migration, and bison will generally remain in GTNP until mid-July. From July to early August bison often make forays back to the NER and are hazed back to GTNP to protect winter forage. Hazing efforts in August cease several days to weeks before the bison hunting season in an effort to increase hunter harvest.

Vegetation Restoration and Protection

The BEMP identified approximately 4,000 acreas of previously irrigated and cultivated grasslands in GTNP in need of restoration to native sagebrush grasslands community. Substantial progress in this endeavor has been made since 2007, including: [GTNP folks please add short description of methodological research and implementation, followed by what remains to be accomplished]

Private Lands Mitigation

Fencing of hay stacks and livestock feedlines has been historically used to mitigate particularly difficult conflicts on private lands. Targeted fencing of golf course greens and sand traps fall through spring has also been successful in some situations for mitigating elk and bison presence and associated damage in these areas. It is important to note that the county has a 'wildlife-friendly' fence policy and does not support extensive fencing that is impermeable to wildlife.

Methods, Assumptions, and Constraints Common to All Strategies

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Measuring the success of strategies toward objectives will require knowledge of several bison and elk herd attributes, particularly population sizes. Measurements of the Jackson bison herd will be based on the annual mid-winter census and sex and age classification survey performed by NER, GTNP, and WGDF biologists. This survey occurs one day in early February and includes ground counts of animals on feed at the NER and aerial counts of outlying bison across their winter ranges on the refuge, park, and Bridger-Teton National Forest.

Elk population estimates will also be based on mid-winter aerial and ground counts. However, the mid-winter counts are undertaken during a single survey period and do not necessarily represent either peak or cumulative abundance of elk on feed. Rather than basing progress toward the number of elk on feed for the entire season on those present during the day of the survey only, we will use a more meaningful measurement. Since we are more interested in the intensity of elk feeding throughout the entire feeding period, which includes both the number of animals on feed and the duration of feeding, we will use a measurement of elk-fed-days (EFD; the total number of elk fed per day per season) as a gauge of feeding intensity (see monitoring section). For example, if 5,000 were elk fed for 100 days during the winter, feeding intensity for that winter would equal 5,000 elk X 100 days = 50,000 EFD, whereas if 5,000 elk were fed for 50 days, EFD would equal 25,000.

We determined feeding intensity benchmarks for bison and elk-fed based on an actual average of 64 days of feeding from 1995-2007. Based on the Phase I objectives of 500 bison and 5,000 elk, fed-days benchmarks would be 64 x 500 = 32,000 for bison and 64 x 5,000 = 320,000 for elk. These values will assist in determining efficacy of strategies toward reducing reliance of both species on supplemental winter feeding.

Implementation of the AMP will have successfully attained the objective of "transitioning from intensive supplemental winter feeding to greater reliance on free-standing forage" when supplemental feeding was not used for more than 50% of the years in a 5 year period.

Comment [S3]: SK's draft.

Initial success of AMP implementation will be a consistent decline in the 3-year running average of elk and bison fed days from the established baseline. While the BEMP did provide specific measurement criteria for the definition of "transitioning from intensive supplemental winter feeding to greater reliance on free-standing forage" we will consider this objective met when the 3-year running average of elk and bison fed days is <50% of baseline for 5 years in a row.

Comment [S4]: SC's alterative in this paragraph, recognizing that the 50% number is the crux and a glaring target.

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Table 3. Summary of potential Adaptive Management Plan constraints.

Policy

- ESA[1] Lynx – limits on habitat impacts
- Greater Sage Grouse – core area protection
- 2007 BEMP/EIS (federal actions/lands)
  - No fertility control
  - No test and slaughter
  - Limited tribal harvest
- Bison/elk hunt end date (Feb. 1st)
  - WGFD, brucelosis safety
- Carcass disposal (Feb. 15th)
  - WGFD, brucellosis safety
- Forest Service winter closure (Dec. 1st – April 30th)
- Easement limitation (NER boundary)

Winter Feeding

- Only during non-hunting periods

Harvest

- State regulations

Vegetation Restoration/Protection

- Bison/elk distribution
- Exotic plant species management

Private Lands

- Owner agreements

Social

- Hunter density (safety; hunt quality)
- Elk/bison winter mortality levels
- Public safety (ungulate/vehicle collisions)
- Disease
- Land-use conflicts (agricultural and residential)

Biological

- Disease (bison/elk/cattle commingling)
- Sage grouse habitat conflicts
- Fencing/wildlife conflicts
- Elk herd distribution
  - summer segment distribution goals

Funding

- Easement purchase
- Plan implementation

[1]Endangered Species Act

Several management constraints are common to the strategies discussed below (Table 3). Many law and policy constraints are applicable but we include here only those most pertinent. Endangered Species Act (16 USC 1531 et seq.) requirements for wolves, grizzly bears, lynx, and others apply. Lynx requirements for maintaining certain habitat types could limit methods used and areas considered for habitat improvements in GTNP. Similarly, compliance with the Wyoming greater sage-grouse core area protection executive order (2011-5) could restrict habitat manipulations. NEPA compliance conducted as part of the BEMP/EIS constrains what federal actions can be taken as a part of this plan. State regulations constrain late (winter) hunt and carcass disposal timing to protect against brucellosis contamination, since February-April represent the period bison and elk are most likely to transmit the disease. Restrictions on hunting timing also result from BTNF winter range closures, immediately east of the NER and elsewhere, December 1 to April 30. Additional details about these and other constraints will be included in discussions about specific strategies that follow.

Strategies

This section will describe the management action this AMP proposes to implement. As such, it unveils the heart of management changes necessary to begin the process of transitioning to more reliance of bison and elk on native forage during winter. Fundamentally, the strategies discussed in this plan represent an experiment designed to achieve Phase I objectives of 5,000 elk and 500 bison on NER and are a first step towards reducing reliance on supplemental feeding while meeting the sustainable population goals identified in the AMP.

Initial strategies for achieving sustainable population goals identified in the BEMP (Table 1) are presented by objective below. The primary management actions available to the agencies to achieve phase I objectives are modifications to winter feeding and hunting seasons. To a lesser

extent, vegetation protection and restoration can be important, particularly for improving long-term ecological balance and enhancing natural production of native forage. Private lands are also an integral component as changes in elk and bison distribution occur and new challenges develop. The likely consequences of implementing these strategies were evaluated in the BEMP. The most relevant of these are summarized in Appendix 1.

Objective: *[Implement] a phased reduction of animals on feed: 1) to 5,000 elk and 500 bison, and 2) [to an extent where] elk and bison rely predominantly on native habitat* (Table 1).

This objective is what the need for an adaptive management plan – **this document** – is central to. As previously mentioned, the concept of reducing winter feeding after more than 100 years of the practice, and the associated behavioral conditioning of elk and bison to its presence, represents a formidable challenge that must be approached cautiously and systematically. The strategies discussed below have been developed in this context, with appropriate feedback mechanisms through rigorous monitoring and frequent evaluation. Inability to meet this objective under the strategies presented here would trigger a thorough evaluation and development of more aggressive strategies.

Chronic Wasting Disease

In 2014 WGFD began the revision process for the Wyoming CWD Management Plan (2006). WGFD has cooperated with federal agencies and other stakeholders to revise the plan, and NER and USFWS Region 6 Wildlife Health Office staff participated in several meetings associated with this effort. One goal of the CWD Management Plan update is to develop specific management responses should CWD be detected on or adjacent to State or NER elk feedgrounds. Early detection of CWD in the JEH is essential to ensure an effective management response.

Since 1997 NER has cooperated with Wyoming Game and Fish Department (WGFD) to conduct surveillance for CWD in the JEH unit. Although this effort indicates that CWD is not currently found in the JEH, continued surveillance at sample sizes sufficient to detect 1% prevalence with 95% confidence annually will be critical to ensure a timely management response and limit the long-term population effects of the disease (USFWS and NPS 2007). Given that CWD has been detected within 40 miles of the JEH in moose, within 70 miles in deer, and within 175 miles in elk, this level of surveillance is warranted.

Winter Feeding

Winter feeding actions that could be modified include starting date, ending date, and daily ration. To modify elk and bison behavior in the long run, delaying initiation of feeding is likely to have the greatest impact by gradually conditioning them to expect feed later on average, with the desired outcome of building a cohort of animals that rely primarily on native winter range and are not food conditioned. To reduce supplemental feeding overall, ending feeding early would also help decrease the amount of feed provided per animal per year. Both would help decrease the total elk/bison fed days, the parameter we will use to measure progress toward reducing supplemental feeding.

Initially, supplemental feeding will be delayed by approximately 2 weeks, depending on several variables (Table 4, Fig. 9). Time of season could influence this interval, most likely shortening it as the feeding initiation date gets later. During the last 20 years, feeding initiation dates, which have been based on forage availability, have varied from December 30 to February 28. Delaying feeding by two weeks in January, for example, is likely to be more successful than doing so in February, when food stress and tendency for animals to move to private lands is greater. Forage availability could also have an influence, particularly if a freeze thaw event resulted in an acute and large reduction in available forage.

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Both time of season and forage availability considerations would be affected by the numbers of elk and bison on the NER. And finally, the distribution of animals, particularly on private, livestock producing lands, would be considered.

A primary concern of manipulating feeding is elk winter mortality, particularly among calves. As food becomes limited in winter, calves are usually the first to suffer because of being displaced by more dominant animals. Monitoring programs will include measures of calf mortality and it will be an influencing parameter in feedback mechanisms. The BEMP anticipated that elk mortality could increase from 1-2% overall to 1-5% (Appendix 1).

Initially, the termination of feeding, which is now based on a snow cover index and subjective evaluation of available forage, will occur about a week earlier. The combination of a 2 week delay in feed initiation and 1 week advance in termination would shorten the feeding season by 3 weeks on average, or 32% based on an average feeding season length of 9.3 weeks from 1995-2015.

The AMP winter feeding strategy would include the establishment of additional key forage index sites and on-going measurements at those sites throughout the winter.

Harvest

Currently the Jackson elk herd is at the Wyoming Game and Fish Commission established objective of 11,000 animals, which means there is less flexibility in manipulation of harvest regimes than there would be if the herd was above objective. Initially there would be little change in elk harvest programs on the NER, with the exception of allowing a limited number of any elk permits throughout the season, considering allowing bow hunting near developed areas (roads and buildings) and shifting the season about a week later (Table 4). Allowing a limited number of any elk permits would be consistent with providing sport hunting recreation on National Wildlife Refuges (citation, NWR system act) and the NER (citation, CMP?), and possibly encourage more hunters to participate in antlerless elk hunts. Monitoring programs and consideration of bull ratios in the GTNP summer segment (since most park bulls migrate to the NER) would help inform levels of take proposed. Bow hunting in areas currently closed to firearms will likely increase harvest by eliminating “no-hunt” areas which can become sanctuaries for large numbers of elk. Shifting the hunt one week later is consistent with later migrations and will improve harvest effectiveness.

General elk harvest patterns in GTNP would continue to be based on need for harvest, summer segment population estimates, and mitigation for impacts on other resources and visitor activities.

Elk herd population objectives are reviewed every five years by the Wyoming Game and Fish Commission and adjusted as necessary. Serious consideration should be given to reducing the Jackson Elk Herd population objective. Lowering the population would help compensate for reduced use of traditional native winter range and increased growth of short-distance migrants which has lead to significant increases of winter elk concentrations on the NER.

The annual fall/winter arrival of elk to the NER during the past several decades has been occurring progressively later. This trend may necessitate extending the elk hunting season later into the year to achieve harvest objectives.

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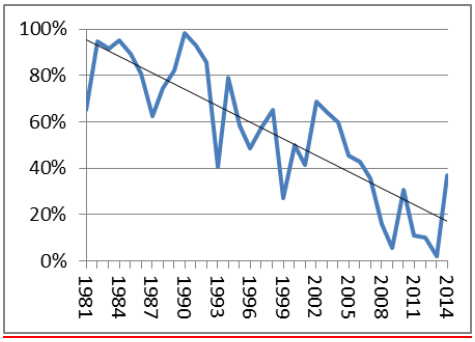

Figure ?. The annual fall/winter arrival of elk to the NER during the past several decades has been occurring progressively later. This trend may necessitate extending the elk hunting season later into the year to achieve harvest objectives.

Bison hunts on the NER (bison hunting is prohibited in GTNP) would see little initial change (Table 4). Consideration would be given to later hunt end dates commensurate with delayed feeding, and possible escorted hunting in the South Unit to help with distribution or discouraging bison from attempting to leave the NER via the south boundary into the town of Jackson. If progress toward reaching the herd objective of 500 animals continues and the objective is reached in the near future, State quotas will likely be reduced and management flexibility will increase.

A cattle guard will be installed on the Refuge Road near the east end of Broadway Avenue to help prevent bison and elk herds from entering the Town of Jackson. This will reduce the potential for dangerous human/wildlife interactions.

Serious consideration should be given to reducing the bison herd population objective in the future. This would lower winter forage consumption on the NER and help reduce elk and bison winter concentrations.

The current bison herd objective is ". . . maintain and ensure a genetically viable population of approximately 500 animals (five-year average), with as close to an even sex ratio as possible to maximize maintenance of genetic variation over time. . ." (BEMP p. 136).

The Jackson bison herd is not considered part of the U.S. Fish and Wildlife Service's meta-population approach to bison conservation because of its high prevalence of brucellosis. This disease prevents the export of Jackson bison to other DOI conservation herds.

The 500 bison population objective was set primarily to preserve existing genetic diversity assuming extremely limited natural genetic transfer with the Yellowstone or other DOI bison conservation herds. Genetic diversity can be maintained for a Jackson bison herd less than 500 if bison with desirable genetic diversity are periodically imported from other DOI bison conservation herds.

Currently, the effectiveness of NER late-season harvest regimes is affected by December 1st winter closures immediately east of the refuge on BTNF lands. Extensive elk telemetry data suggest that delaying the winter closures could aid elk management objectives. NER officials will work with BTNF and WGFD officials to explore the possibility of allowing hunting in limited areas after December 1st in the future.

Annual herd-wide population estimates, elk summer herd segment estimates, temporal and spatial harvest patterns, and animal-fed-days would be monitored, and the resulting information would be used to inform ongoing evaluation of adaptive elk and bison management harvest programs (Figs. 9 and 10).

Hazing

No change in hazing practices is anticipated initially under this adaptive management framework.

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Private Lands Mitigation

Delaying the onset of NER feeding is likely to result in changes in bison and elk distribution (Appendix 1). Some elk or bison may move to private lands in search of forage. Of greatest concern is the potential for elk or bison to commingle with cattle of cow/calf operations, where brucellosis transmission could have considerable consequences, in the worst case requiring depopulation of the cattle herd.

Several strategies would be employed to mitigate potential problems (Table 4), including providing incentives for non-breeding cattle operations (because brucellosis transmission to slaughter-bound cattle is not economically important), increased fencing in some limited areas to separate elk/bison from livestock feed lines, haze elk/bison away from livestock feed lines and purchase private lands easements to prevent co-mingling. A vital component in implementing these mitigation measures is to establish three seasonal Wildlife Conflict Technician positions which are supervised by the WGFD. These Technicians are also critical to the success of an expanded monitoring program vital to the AMP (see Monitoring section below).

A database will be established to track non-agricultural conflicts on private lands to determine trends which will help evaluate the effectiveness of AMP mitigation efforts.

Preventing elk and especially bison from entering the Town of Jackson is essential in minimizing safety and private property conflicts. Currently, bison are hazed northward when they drift south of Miller Butte. A double cattle guard will be installed on the Refuge Road just north of Broadway Avenue. This barrier is designed to prevent elk/bison from entering the Town of Jackson.

Vegetation Restoration/Protection

[NER and GTNP staff to draft material]

Objective: *Maintain natural bull-to-cow ratios in park summer herd* (Table 1).

National Park Service management policy (NPS 2006) provides guidance for maintaining naturally regulated wildlife populations, free from the impacts of humans, to the greatest extent possible. The final BEMP identified a goal of maintaining park elk bull:cow ratios (a common way of expressing sex and age ratios in wild ungulate populations) near 35 adult bulls per 100 adult cows, based on estimates of what this ratio would be in a herd free from the effects of human harvest. The sex and age ratios of most North American elk populations are affected by sport hunting and herd managers generally maintain lower bull ratios.

Harvest

Based on bull ratios in the park summer herd that were chronically below 35 bulls:100 cows, permit types for the park's elk reduction program (ERP) went to antlerless only in 2012. ERP permit structures in the park will remain antlerless only unless the bull ratios consistently exceed 35:100 cows. Park and refuge officials will work together to support this goal, recognizing that bulls harvested on the NER are most likely from the park summer herd segment.

A private lands Hunting Coordinator Position would be established and supervised by the WGFD to promote and coordinate hunting activity focused on Southern Herd Segment harvest in and around private lands in the Spring Gulch Area north to Moose, WY (Hunt Area 78).

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Table 4 [incomplete]. Comparison of current and adaptive primary management components and parameters.

Action	Current Management	Adaptive Management	Comments
Winter Feeding:			
Feed	Pelleted alfalfa	Pelleted alfalfa	No change
Ration	8 lbs/day/elk 20 lbs/day/bison	8 lbs/day/elk 20 lbs/day/bison	No change, to minimize calf mortality
Start criteria:			
Available standing forage	300 lbs/acre, as measured at traditional key index sites	Generally 2 weeks later; index sites to be increased in number and distribution	Influencing factors: - time of season - forage availability - numbers of elk/bison on NER - elk/bison distribution
End criteria:			
Available forage	Based on a snow cover index and subjective estimate of when residual or new forage is adequate	Generally 1 week earlier	Development of more objective criteria for future implemen-tation ongoing
Monitoring:			
Animals on feed	Mid-winter census	Elk/bison fed days[1]	
Proportion of JEH on NER feed	Mid-winter census	Mid-winter census	
Calf mortality threshold		<= 10%	
Elk/bison distribution - visual			
Elk/bison distribution – collars			
Winter mortality			
Elk summer range proportions			
Harvest, National Elk Refuge elk:			
Frequency	Annual	Annual	
Begin Date	2nd week October	3rd week October	Modified as necessary
End Date	2nd week December	3rd week December	Modified as necessary
Structure	- 1 week initial drawing - 1 week left over 1st served - partial week alternate	- 1 week initial drawing - 1 week left over 1st served - partial week alternate - daily 1st served alternates	

[1]Number elk and bison on feed per day, totaled by feeding season.

Table 4, continued. Comparison of current and adaptive primary management components and parameters.

Action	Current Management	Adaptive Management	Comments
Harvest, National Elk Refuge elk:			
Refuge permit types	- 1st week any elk - Antlerless only remainder of season	- Primarily antlerless only - limited any elk permits throughout season	
Access	Restrict access to specific locations	Restrict access to specific locations	
Hunt area boundaries		Consider expanding to allow bow hunting near developed areas	
Harvest, National Elk Refuge bison:			
Frequency	Annual	Annual	
Begin date	August 15th	August 15th	Modified as necessary
End date	2nd or 3rd week January	Consider later dates as appropriate	Modified as necessary
structure	As per WGFD	As per WGFD	
Refuge permit types	Any bison or cow/calf per state license	Any bison or cow/calf per state license	
access	Restrict access to specific locations	Restrict access to specific locations	
Hunt area boundaries	Limited to north of Nowlin Creek area	Consider escorted hunting in South Unit as needed	Guided hunts in South Unit when authorized
Harvest, Grand Teton NP elk:			
Frequency	As needed	As needed	
Begin Date	3rd week October	3rd week October	Modified as necessary
End Date	2nd week December	2nd week December	Modified as necessary
License types	Antlerless only	Antlerless only[1]	
Special regulations:	Cartridge limits	Cartridge limits	
	Bear spray required	Bear spray required	
	Hunter safety card required	Hunter safety card required	
Harvest, Bridger-Teton NF, Elk Hunt Area 80:			
Begin Date			
End Date		December 15	Would require change in winter closure dates

[1] Any elk licenses could be offered if bull ratios in the park consistently exceed BEMP criteria.

Table 4, continued. Comparison of current and adaptive primary management components and parameters.

Action	Current Management	Adaptive Management	Comments
Harvest, Elk Hunt Area 78			
Structure			Changes at discretion of WGFD
License types			
Private Lands Mitigation:			
Cattle commingling		Incentives for non-breeding operation	
Hay depredation		Increased fencing	
Landscape damage			
Easement acquisition			
Vegetation Restoration/ Protection: Elk Refuge			
Vegetation Restoration/ Protection: Grand Teton			

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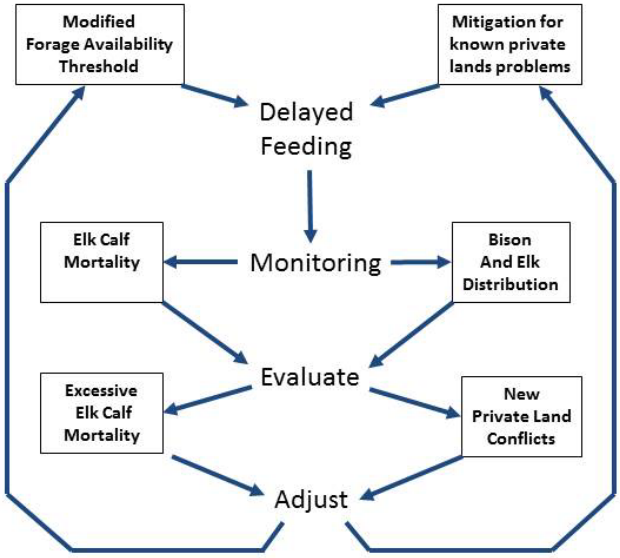

Figure 9. [example] Framework for delayed feeding strategy and adaptive management.

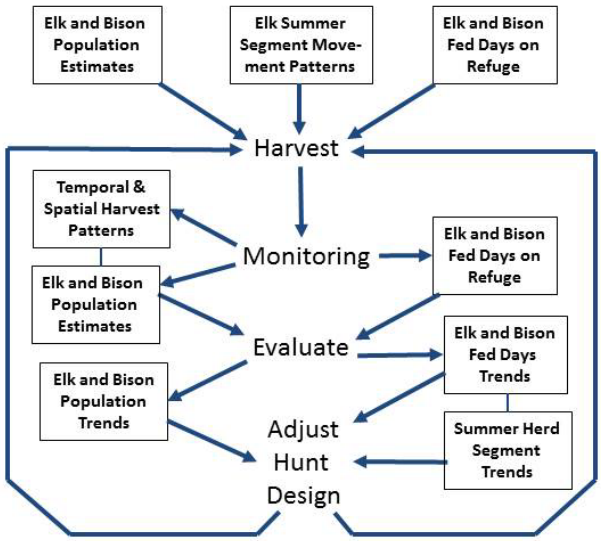

Figure 10. [example] Framework for harvest strategy and adaptive management.

Strategies Considered But Rejected

The BEMP considered several additional strategies for elk and bison management that, for a variety of reasons, were not selected for implementation in the preferred alternative and Record of Decision. The agencies reconsidered a subset of these during the development of this AMP (Table 5). Since they were not part of the ROD, additional NEPA compliance would be necessary to incorporate any of them into this adaptive management plan, and thus they are not being considered at this time.

Table 5. Strategies considered but rejected.

Strategy Considered	Reason Rejected
Fertility control in elk	Judged not reasonable or feasible in BEMP, primarily due to major technical, social, and financial hurdles[1]. For AMP discussed primarily with regard to the difficult to harvest herd segment in Hunt Area 78 on private lands, where federal agencies have no jurisdiction.
Fertility control in bison	Impacts discussed at length in BEMP[2]. Not considered for AMP because current hunting programs appear effective at slowly moving the herd toward the 500 animal herd objective.
Agency reduction of bison or elk	Not considered necessary or desirable on federal lands because current hunting programs that utilize sport hunters are effective at meeting herd objectives.
Altering rations of supplemental feed	Rejected as a strategy because reducing daily feed ration below 8 lbs/elk would be enough feed to encourage elk to remain on NER but would result in unacceptably high elk calf mortality rates.

MODELS OF SYSTEM DYNAMICS

Models provide a simplified representation of the biological system being managed. Adaptive management uses models of the managed system to link the objective response (e.g., elk winter distribution) to changes in the system resulting from management actions (e.g., altered initiation and cessation of winter feeding). Fig. 11 describes possible factors that affect winter elk distribution (the proportion of elk on NER feedgrounds versus native winter range). Models will be used to identify the relative influence of our principal management strategy (a reduction in feed season length) and other factors on winter elk distribution (Appendix 3). Over time this will allow us to assess whether changes in elk distribution were the result of our management actions or due to factors outside of our control.

An increase in calf elk winter mortality is a potential result of reduced feed season length. Fig. 12 portrays factors that influence winter calf elk survival on NER.

Models will be used to assess the effects of available forage on winter calf elk survival (Appendix 4). Over time this will allow us to assess the effects of our principal management strategy (reducing feed season length) relative to other factors on elk calf survival and potentially adjust our management actions based on model results.

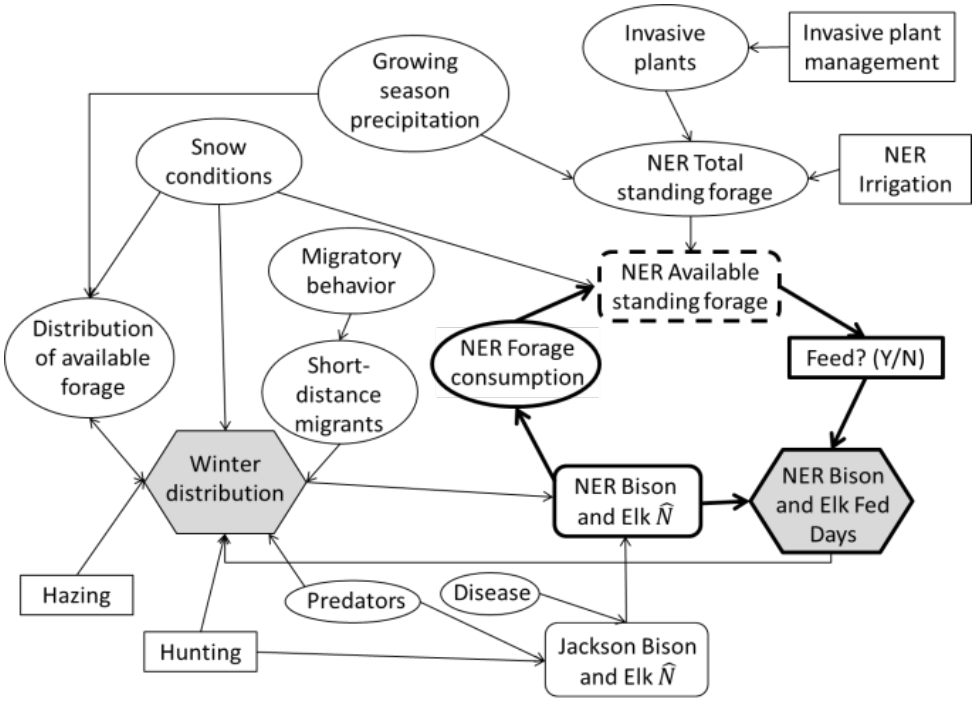

Figure 11. Influence diagram depicting factors (including management actions) influencing outcomes identified in the Bison and Elk Management Plan (BEMP; USFWS 2007a). Gray hexagons represent outcomes, rectangles represent management actions, rounded rectangles represent factors with numerical objectives, and ovals represent factors outside of management control. Bolded polygons and arrows represent outcomes and factors limited to the National Elk Refuge (NER). Available standing forage on the NER (dashed rectangle) is the BEMP criteria with a defined threshold to trigger initiation of supplemental winter feeding.

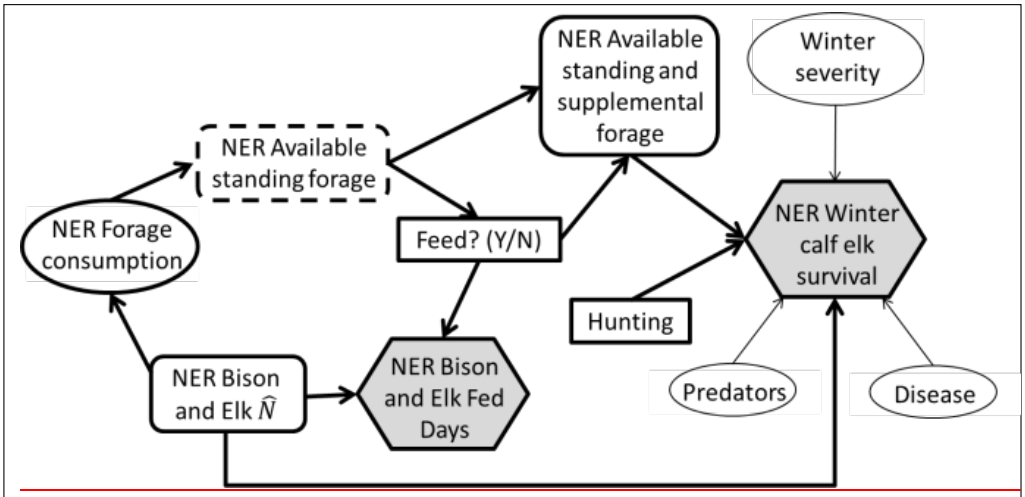

Figure 12. Influence diagram depicting factors (including management actions) influencing bison and elk fed days on the National Elk Refuge (see text for description) and winter calf elk survival. Gray hexagons represent outcomes, rectangles represent management actions, rounded rectangles represent factors with numerical objectives, and ovals represent factors outside of management control. Bolded polygons and arrows represent outcomes and factors limited to the National Elk Refuge (NER). Available standing forage on the NER (dashed rectangle) is the BEMP criteria with a defined threshold to trigger initiation of supplemental winter feeding.

MONITORING

Feeding Initiation Monitoring

NER uses weekly field estimates of the amount of forage available to elk to determine feeding initiation date. Currently measurements are taken at key index sites representing areas preferred by elk on NER (see supplemental materials at end of this section). These methods will be enhanced by 1) increasing the number of sampled sites to better represent the total amount of forage available to elk on the southern half of NER; 2) increasing the precision of estimates at each site by increasing the number of observers; and 3) extending the monitoring period later in the winter to assess the relationship between available forage and elk and bison distribution.

To better represent the total amount of forage available on the southern half of NER, a subsample of current key index sites will be retained to facilitate comparison with historic data, but additional random sample sites stratified by elk habitat preference will be added. Historic elk distribution mapping and elk GPS collar data (NER unpublished data) suggest that the areas most preferred by elk on southern NER are associated with moderate to high forage production and green vegetation. Because the distribution of forage production and greenness characteristics vary annually based on irrigation and precipitation patterns, we will annually map areas preferred and not preferred by elk and sample sites will be randomly selected within each of these mapped categories. At least 3 historic key index sites, 3 random sites in areas

preferred by elk, and 3 sites in areas not preferred by elk will be sampled each week from late December through the initiation of supplemental feeding.

Currently the NER biologist is the only person trained in the techniques used to estimate available forage (see supplemental materials). At least 2 additional personnel will be trained in these techniques. This will provide a backup in the event of future personnel changes and will facilitate error estimates of the available forage measurements at each site.

Currently NER and WYGFD biologists monitor available forage conditions at least weekly from late December until average available forage at key index sites nears the threshold level of 300 lbs. per acre and feeding is initiated. The principal AMP strategy is to delay the initiation of supplemental feeding by 2 weeks after average forage production reaches the 300 lbs. per acre level at key index sites. Therefore the monitoring period will be extended to include the intervening 2 weeks.

Proportion of Elk Wintering on NER

A principal AMP goal is to reduce the number of elk wintering on NER. Our strategy will be to effect redistribution of elk to native winter range from NER over time via shortening the duration of the feed season, and thus slowly conditioning elk to seek food elsewhere. As feeding periods are shortened, the probability of younger elk age classes discovering NER feedgrounds will be reduced, and, hypothetically, that proportion of the JEH that utilizes NER feedgrounds will decline over time. We will measure this effect by examining changes in the winter distribution of the JEH. WGFD annual trend/classification count data provide a multi-year baseline data set to measure changes in the winter distribution of the JEH and categorizes observations by location. In each year, we will calculate the proportion of total classified elk in the JEH that are classified on NER feedgrounds. We will compare the 3-year running average post AMP implementation to the pre-implementation baseline. The pretreatment baseline will be comprised of data from 2008-2016, a time period that represents BEMP implementation prior to AMP actions (Figure 13).

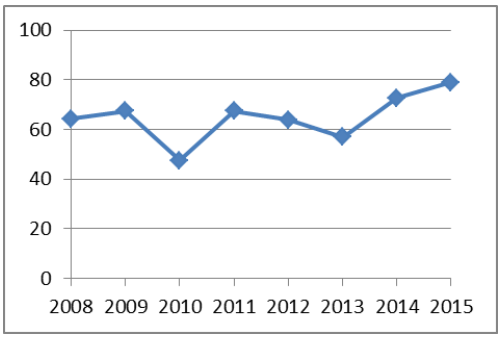

Figure13. Proportion of the Jackson Elk Herd that was classified on NER feedgrounds in the period following implementation of the Bison and Elk Management Plan and prior to the implementation of the Adaptive Management Plan (2008-2015). These values represent the pretreatment baseline which will be compared to the 3 year running average post AMP implementation.

Elk Fed Days and Bison Fed Days

The BEMP and AMP implicitly assume that the transmission rate and prevalence of elk and bison diseases are density dependent and positively correlated with the number of elk and bison utilizing feedgrounds and the number of days they are fed. We further assume the variables elk-fed-eays (EFD) and bison-fed-days (BFD) are a proxy for these conditions. EFD and BFD will be calculated annually for each species based on the following formulas:

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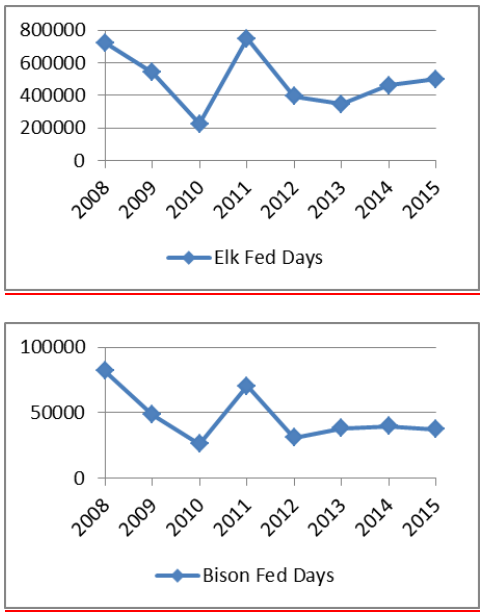

Figure14. Elk Fed Days (EFD) and Bison Fed Days (BFD) in the period following implementation of the Bison and Elk Management Plan and prior to the implementation of the Adaptive Management Plan (2008-2015). These values represent the pretreatment baseline which will be compared to the 3 year running average EFD and BFD post AMP implementation.

EFD= ∑ Total elk counted on feed during daily feedground counts for duration of feed season

BFD= ∑ Total bison counted on feed during daily feedground counts for duration of feed season

Because EFD and BFD are influenced by feed season length and the number of animals on feed, the AMP strategy of delaying the initiation of supplemental feeding will inherently reduce the number of EFD and BFD through a reduction in average feed season length. We believe that EFD will be further reduced by encouraging a greater proportion of the Jackson Elk Herd to winter on native winter range, thereby reducing the number of elk occupying NER feedgrounds. We will evaluate changes in EFD and BFD by comparing the 3-year running average post AMP implementation compared to mean EFD and BFD from 2008-2015. The running average is an appropriate comparison because it will help account for wide annual variation in EFD and BFD associated with winter severity (Fig. 14)

Elk Winter Mortality Monitoring

NER has used consistent methods to monitor winter elk mortality since 1982. Each winter NER biologists and other refuge staff conduct a survey of all non-hunting related winter elk mortalities that occur on NER from November through April. Mortalities are tallied by age/sex class and percent mortality is calculated using the corresponding number of elk classified on NER feedgrounds as the denominator. We will continue to monitor elk winter mortality using the same methods post AMP implementation, which will allow trend comparisons to the pre AMP baseline (Figure 15). Under the AMP framework, we believe the 3 year running averages for total and calf winter elk mortality will be within the range of variation exhibited by the pre AMP baseline. Historic monitoring suggests that calf and total mortality are sensitive to winter severity and disease outbreaks, and that winter mortality occasionally exceeds >3% total mortality and >10% calf mortality. Post AMP mortality in excess of these levels may warrant shortening the 2-week feeding initiation delay in subsequent years.

Elk Collaring

One of the AMP's principal strategies is to shorten the length of the feed season to encourage elk use of native winter range, but we anticipate that this strategy will also result in an increase in elk conflicts on surrounding private land in the town of Jackson and the Spring Gulch areas. To quantify this effect and provide real time information to WGFD and NER managers to facilitate a response, we propose maintaining a sample of 50 GPS collars on elk that winter on NER throughout the AMP implementation period.

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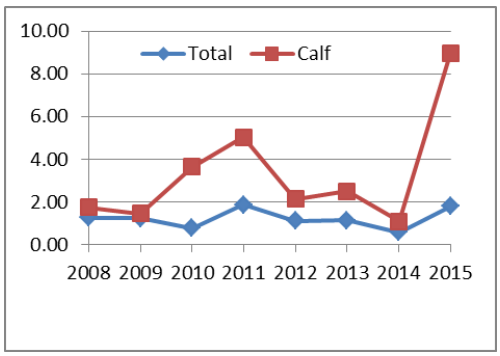

Figure15. Total and calf elk winter mortality (%) on NER in the period following implementation of the Bison and Elk Management Plan and prior to the implementation of the Adaptive Management Plan (2008-2015). These values represent the pretreatment baseline which will be compared to the 3 year running average post AMP implementation.

Forty -five elk represents approximately 0.5% (1 in 200) of the NER winter elk population. This sample size will not be sufficient to detect all elk movements from NER to surrounding private lands, particularly movements by small groups of mature bull elk, but it will be sufficient to detect and quantify significant movements of cow/calf/yearling elk groups compared to pre-AMP baseline data.

NER has elk GPS collar data available from the 2008-2013, which represents the post BMP, pre AMP baseline period. We hypothesize that elk movements from NER to surrounding private lands will increase during the AMP implementation period compared to the pre-treatment baseline. This will be tested by comparing the number of incidents that elk left NER for surrounding private lands (per elk/per year), and the proportion of elk GPS fixes on NER versus private lands during time periods of interest. The principal time period of interest is late December-March because this represents the period after the NER elk hunting season, and prior to and during NER feeding operations. This is the season when changes to the NER feeding program would be most likely to result in elk distribution changes.

Fifty adult cow elk will be captured on NER feedgrounds during February-March 2016 and Telonics Iridium GPS collars will be deployed with a 90 minute fix collection interval. Given 83% annual survival for adult cow elk in the Jackson Elk Herd (Cole and Foley et al. 2015) and 3 year collar life, approximately 10 additional elk will need to be collared each year in winter 2017 and 2018 to maintain the 50 elk desired sample size.

Ancillary data that will be collected and analyzed during the elk capture and collar data analysis process includes brucellosis seroprevalence, pregnancy rate, and elk summer range determination for comparison to the findings of Cole and Foley et al. (2015).

Disease

The primary purpose of limiting reliance on supplemental feeding is to reduce the prevalence of endemic elk and bison diseases and mitigate transmission risk associated with the introduction of novel diseases. We hypothesize that brucellosis seroprevalence will decline post AMP implementation. There are no recent brucellosis seroprevalence data for elk on the National Elk Refuge, but >50 elk will be captured during elk collaring operations in winter 2016, and each elk will be tested for Brucellosis exposure. The 2016 Brucellosis seroprevalence rate will be the pre-treatment baseline to evaluate post AMP change.

Chronic wasting disease (CWD) has been monitored in the JEH since 1997, and since 2008 it has been monitored with sufficient sample size to detect 1% prevalence with 95% confidence. No CWD positive cases have been detected in the JEH, which given the long term persistence of the disease, provides overwhelming evidence that CWD is not currently endemic to the JEH. However, most evidence suggests that the distribution of CWD is increasing and that its introduction to the JEH is inevitable. Early detection is critical to ensure an adequate

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management response, and therefore ongoing monitoring at sample sizes sufficient to detect 1% CWD prevalence with 95% confidence is necessary. CWD is sampled by testing tissues collected primarily from hunter harvested elk, and past experience suggests that 2 full time technicians working from September-December are necessary to ensure minimum sample size. Typical costs associated with 2 technicians are $32,000 per year.

EVALUATION/FUTURE MANAGEMENT

Modifying elk and bison behavior while reducing supplemental feeding will require a long-term, sustained commitment. Change is unlikely to happen fast, and interpreting effects of adaptive management actions will be complicated by varying environmental conditions from year to year. Consequently, we anticipate that the strategies outlined in this plan will be in place for a minimum of 5 years. Actions completed each year, the results of monitoring programs, and any proposed changes in course will be presented in an annual adaptive management update/report, completed by NER staff by the end of March for the previous year.

Investigating the potential effects of climate change on elk and bison management will be important in the long-term. During implementation of this plan, we will collect a variety of data that can be drawn upon for this purpose.

PUBLIC OUTREACH AND EDUCATION

The practice of winter feeding is inexorably woven into the historic fabric of Jackson Hole. Elk are identified with the rich and unique legacy for which Jackson Hole is known around the world. De-emphasizing the supplemental feeding program will be a major paradigm shift for the residents of Jackson Hole, Teton County, and the State of Wyoming.

An effective Public Outreach and Education program is essential for effective AMP implementation. The practice of feeding elk evokes passionate responses from those that oppose and those that support this practice. The general public and especially key stakeholder groups must understand the biological needs for and strategies of the AMP in order to gain general consent to modify longstanding elk/bison herd management methods.

A detail communication plan to guide outreach and education efforts can be found in Appendix 3.

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SCHEDULE

Table 6. Adaptive Management Plan proposed schedule.

Action	Date
GPS Collar 30-40 elk prior to strategy implementation (Iridium platform)	February 2016
Public outreach and education	March 2016
Initiate private lands conflicts mitigation contacts/actions	March 1, 2016
Implement enhanced forage monitoring	March 1, 2016
Initiate changes in supplemental feeding protocol	January 2017
Monitoring/Evaluation/Annual Report	June 2017

Table 7. Anticipated schedule of annual Adaptive Management Plan activities.

Activity	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
Elk and bison classification		x										
Irrigation						x	x	x	x			
Forage estimates	x	x	x	x								x
Etc…..												

[This table just for example. We could do the same with longer term schedule using years instead of months at the top if desired/necessary.]

BUDGET

Table 8. [incomplete]. Estimated Adaptive Management Plan budget above current expenditures, years 1-5.

Agency / Activity	Year 1	2	3	4	5
National Elk Refuge:					
Monitoring:					
Seasonal Biological Technician (0.5 FTE, GS-7)	24,000	25,000	26,000	27,000	28,000
Bison/elk fed days					
Mid-winter census					
Elk summer herd segment distribution[1]					
Expanded standing forage estimates[1]					
Chronic Wasting Disease, 2 seasonal biot-techs	32,000	32,000	32,000	32,000	32,000
Winter bison/elk distribution					
Irrigation					
50 Elk radio telemetry collars; Iridium Platform	$115,000	$25,000	$25,000	$25,000	$25,000
Bison barrier at NER south entrance	$80,000	$1,000	$1,000	$1,000	$1,000
Adaptive Management Plan annual reporting	$2,000	$2,000	$2,000	$2,000	$2,000
Private lands:					
Easements / Acquisition					
Damage reimbursements (Wyoming)					
Conflict mitigation coordination (Wyoming)	$91,000	$91,000	$91,000	$91,000	$91,000
Vegetation restoration/protection[1]					
Public Outreach and Education	$11,000	$1,000	$1,000	$1,000	$1,000
Subtotal					
Grand Teton National Park:					
Monitoring:					
Summer elk classification/distribution					
Hunter harvest					
Harvest age distribution					
Transition range forage production/utilization					
Vegetation Restoration/Protection					
Temporary bison fencing					
Hayfields restoration					
Exotic plant mitigation					
monitoring					
Elk Reduction Program					
Subtotal					
Wyoming Game and Fish Department:[2]					
Private lands:					
elk harvest coordination					
Easements / Acquisition					
Damage reimbursements					
Conflict mitigation coordination					
Add additional lines and categories as needed					
Subtotal					
Grand Total					

[1] See detail in Appendix

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APPENDIX 1. Summary of primary potential impacts associated with reduced supplemental feeding, as identified in alternative 4 environmental consequences section of the Final Bison and Elk Management Plan/Environmental Impact Statement (USFWS and USNPS 2007).

Populations

- Jackson elk herd objective of 11,000 would be maintained.
- New Jackson bison herd objective of 500 established.

Winter Feeding

- Supplemental feeding could be delayed or could occur earlier compared to current practices.
- Changes [to feeding program could] include alterations in the timing of feeding and providing supplemental feed in fewer years.
- Ration or pellet composition might need to be changed.
- Supplemental feeding would be initiated according to established criteria, including pre-winter forage production, assessments of forage utilization (done jointly by WGFD and NER personnel), elk condition and movements, and potentially on the January 1 index of winter severity calculations for elk (Farnes, Heydon, and Hansen 1999).
- Mechanical means could be used to increase forage access for elk after snow crusting events.
- Changes in the refuge supplemental feeding program could begin to affect elk nutrition (negligible adverse effect on NER elk from lower nutrition).
- Displacement of elk by bison during competition for standing forage would decrease as the bison herd is reduced.
- Aggressive social interactions involving competition for food among elk and bison would increase overall as feeding periods are reduced.

Winter Distribution

- Elk densities on the NER would decline due to more reliance on standing forage and wider distribution.
- Elk use of lands surrounding the NER would increase, including:
    - USFS lands east of the NER
    - Gros Ventre feedgrounds possibly
    - Southern GTNP
    - State feedgrounds south of the NER
- Most of winter distribution shift would involve elk in the Yellowstone, Teton Wilderness, and Gros Ventre segments.
- As ungulate numbers decreased and supplemental feeding was reduced, competition and aggressive social interactions on the refuge would also be reduced.
- Elk and bison distribution would increase as the animals relied more on native winter range.
- Fewer animals would be present on the refuge.

Mortality

- As supplemental feeding is reduced, natural factors such as climate and native forage availability would have a greater influence on numbers, movements, distribution, and mortality.
- More elk would be subject to natural factors affecting mortality, including loss of body condition, predation, and starvation.
- Increased mortality on and off the refuge would mainly affect older elk and calves, and some prime bulls entering the winter energetically stressed due to rut activities.

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- Late winter calf ratios could decrease as a result of higher winter calf mortality
- Average winter mortality on the refuge would increase from 1%–2% annually to an estimated 1%–5%.
- Overall, a higher total winter mortality rate of approximately 5% could be expected.

Disease

- Reductions in supplemental feeding or elk numbers would reduce the potential for impacts due to tuberculosis, septicemic pasturelosis, and CWD.
- The health and sustainability of the Jackson elk herd would be increased gradually as supplemental feeding was reduced and there was greater reliance on standing forage and wider ungulate distribution.
- Health and sustainability of the Jackson elk herd would be enhanced in the long term.
- Wider distribution of elk would result in moderate reductions in both the prevalence and potential transmission of brucellosis, as well as potential for spread of diseases not yet in the population.

Private Lands

- The agencies would work closely with the WGFD and landowners, including livestock producers, to coordinate actions that would prevent conflicts due to elk dispersal and to defray costs of managing potential conflicts. Preventing access to food/hay rewards on private lands would be vital for effective management.
- Private land conservation easements within NER boundaries would promote wider distribution.

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APPENDIX 2. Monitoring Supplemental Materials: Feeding Initiation Methods

At each sample site, 10 subplots will be measured at every 5 steps along the random bearing determined for each site. At each subplot a 13.27" diameter metal sampling ring will be placed on the ground. The amount of forage available to elk within the sampling ring (dry weight in grams) will be visually estimated. The 13.27" diameter subplot allows easy conversion from grams to lbs. per acre (each gram is equivalent to 100 lbs. per acre). During annual forage production sampling, refuge biologist Eric Cole has made approximately 1,000 of these visual estimates per year for 17 years, and 33% of Cole's estimates have been verified by clipping and weighing. Therefore, Cole will be the principal estimator, but additional personnel will be trained in these techniques to provide redundancy in the event of personnel changes, and to increase the number of observers to facilitate estimation of error.

Estimating available forage within the sample ring at each subplot is relatively straightforward when snow cover is limited, but estimating how much of the forage is accessible to elk when snow is dense, deep and crusted can be subjective. To decrease the subjectivity of the estimation process, if the area under the sample ring is covered with snow, only forage that can be exposed with a gloved hand will be included in the estimate of available forage. Forage that is fouled with manure and/or flush with the ground due to trampling and/or encrusted in ice will not be included in the estimate of available forage.

At each subplot the estimate of available forage (dry weight g) will be converted to an equivalent lbs./acre value (1 gram=100 lbs./acre). The arithmetic mean of available forage (lbs./acre) for the 10 subplots provides an estimate of available forage for each index site. There are 3 sample site categories: 1) Historic Key Index Sites that have been used since 2007, 2) New randomly selected sites within areas preferred by elk, and 3) New randomly selected sites in areas not preferred by elk. Historic key index sites were not randomly selected, but were instead selected to represent areas most preferred by elk on the south end of NER. These were the sites used to determine when supplemental feeding would be initiated from 2007 until the implementation of the AMP. To facilitate comparison with pre-AMP data, we will continue to use mean lbs. per acre across historic key index sites to determine the 300 lbs. per acre threshold. However, post AMP implementation we will delay feeding initiation by 2 weeks once the 300 lbs./acre level has been reached. We will concurrently sample at randomly selected sites stratified on an annual basis between areas highly preferred and not highly preferred by elk. This will enable us to quantify the relationship between mean forage availability at historic key index sites and random sites over time.

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APPENDIX 3. Communication Plan

Communication Goals

Prior to the Adaptive Management Plan's Implementation

- Utilize a variety of outreach methods to inform the public on the goals and timing of the Adaptive Management Plan's implementation and possible effects on wintering herds.
- Utilize a variety of outreach methods to inform the public on public comment opportunities.
- Identify and coordinate key messages and outreach with USFWS regional and national offices, State and federal agency partners, non-profits, elected officials, and other identified audiences.

During the Adaptive Management Plan's Implementation

- Continue to utilize a variety of outreach methods to describe current management actions as well as measurable and noticeable changes on the landscape, in animal behavior, or in animal health.
- Provide a comprehensive overview of the Adaptive Management Plan by providing links and references to previous outreach and background information.

Communication Objectives

- Work with current media contacts to promote news of the Adaptive Management Plan via print, radio, Web, and social media platforms.
- Utilize new media and social media tools to provide information on why the Adaptive Management Plan was developed, what public comment opportunities exist, and how the plan is being implemented.
- Plan, coordinate, and execute public meetings to allow for public comment and questions on the plan.
- Develop and provide methods for the public to submit written comments on the Adaptive Management Plan.
- Monitor print media on Refuge elk and bison management to see how Adaptive Management Plan objectives and reactions are being portrayed to the public.

Current Outreach Resources

- National Elk Refuge web site
- National Elk Refuge news release list
- (approximately 300 contacts)
- National Elk Refuge Twitter site (1,039 followers)
- Bison and Elk Management Plan web site (http://www.fws.gov/bisonandelkplan/)
- Space for an 11" x 17" poster in the Visitor Center on Refuge management topics
- Display panels in the Visitor Center theater for temporary displays

Available Supporting Outreach Resources

- USFWS Mountain–Prairie External Affairs staff

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- USFWS Mountain–Prairie web site, including the
- "Top Stories" feature
- USFWS Mountain–Prairie Twitter site USFWS Mountain-Prairie Region Facebook page
- USFWS National Wildlife Refuge System
- Facebook page
- USFWS Facebook page

Previous Outreach Efforts

- NER routinely writes and disseminates news releases on Refuge management activities, including the Comprehensive Conservation Plan, supplemental feeding, herd health monitoring, and forage production.
- Post the above news stories as Content.
- Management System (CMS) articles.
- Post CMS news story promos so they prominently appear on the home page, linking readers to the articles.
- Send out Twitter messages linking viewers back to the news stories.
- Prepare, upload and provide links to Adobe PDF versions of news stories with addtional photos where additonal images are available and/or help understand or visualize the content.
- Utilized the Conservation link on the web Content
- Management System to post information about the Bison and Elk Management Plan and the draft Comprehensive Conservation Plan.
- Retained and provided a link to the original Bison and Elk Management web page (http://www.fws.gov/bisonandelkplan/) that was developed during the planning process. The web site includes links to the Final Plan/EIS, Record of Decision, Federal Register Notice of Availability for both the Record of Decision and Final Plan/EIS, associated news releases, public meeting highlights, and other related documents. Note: the National Elk Refuge does not manage the site.

Additional Outreach Opportunities

- Public meetings in Jackson and other identified locations.
- Service produced video; video could be posted to the National Elk Refuge's multimedia web page, or USFWS Mountain–Prairie home page "Top Video" feature.
- Live radio interview on KHOL (Jackson, WY radio)
- Wyoming Public Radio interview with Refuge management staff
- Interviews with local print media sources
- Updates at community leader meetings such as Rotary Club, Jackson Hole Chamber of Commerce board meetings, and interagency breakfast meetings (with Federal agencies and local elected officials).

Target Audiences

Internal

- Regional and National USFWS Leadership
- Refuge permanent staff
- Refuge seasonal staff
- Refuge volunteers

External

- Congressional representatives
- State of Wyoming leadership
- Federal agency partners, particulary Grand Teton National Park and the Bridger–Teton National Forest
- Wyoming Game & Fish Department
- Other NER partners, including county and town agencies and local nonprofit organizations
- Local elected officials
- Private landowners in proximity to the National
- Elk Refuge or neighboring Federal lands
- Tribes
- Local and state media
- Local public

Key Outreach Topics

- Overview of BEMP objectives
- Strategy to change elk/bison behavior
- Threat of disease
- Natural mortality rates
- Anticipated winter distribution changes for bison/elk
- Mitigate negative effects on private lands
- Change elk behavior and distribution while avoiding increased mortality.
- Explain the historic reasons a supplemental feeding program began and why it was continued.
- Explain the NER's limited large ungulate carrying capacity and the disproportionate impact of bison on available forage; 3 elk = 1 bison.

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APPENDIX 4. Models

Elk winter distribution model

The proportion of the JEH that winter on the NER will be linked to factors hypothesized to influence elk winter distribution (Fig. 2) using a generalized linear mixed effects model (GLMM). A GLMM can account for a proportional response variable (i.e., constrained to the interval 0–1) using a log link and binomially-distributed errors. A GLMM also includes fixed and random effects, with the latter capturing residual model variance otherwise not explained by fixed effects. Year will be including as a random effect, providing several benefits. First, we don't assume years are independent and comprise all of the factor levels of interest. Instead, the effect of year is treated as a random variable, with individual year effects realizations of that distribution. This allows inference to non-sampled factor levels, i.e. years, by estimating a latent population-level proportion of elk expected to winter on the NER regardless of fixed effect influences. Thus, the random year effect can be considered a latent variable describing elk behavior manifested as observed winter distribution. Second, because year effects are not treated as independent, estimated effects of year on the proportion of JEH elk wintering on the NER are dependent on all factor levels, leading to greater precision when estimating individual year effects (Kéry 2010).

The full GLMM incorporating fixed effects for each factor identified as influencing elk winter distribution (Fig. 2) is:

$$P_t = \beta_{0(t)} + \beta_1 * AFI_t + \beta_2 * SDM_t + \beta_3 * WP_t + \beta_4 * GSP_t + \beta_5 * SWE_t + \varepsilon_t$$

where the random intercept and residual model variance are

$B_{0(t)} \sim N(\mu_{\beta_0}, \sigma^2_{\beta_0})$, and

$\varepsilon_t \sim N(0, \sigma^2)$, respectively.

Fixed effects include 1) per capita available forage at initiation of winter feeding (*AFI*) , 2) proportion of the JEH that are short-distance migrants (*SDM*), 3) number of wolf packs present on JEH native winter range (*WP*), 4) growing season (May–August) precipitation for the Wyoming Snake Drainage climate division (*GSP*; a proxy for available forage on native winter range), and 5) snow water equivalent on 1 January at Thumb Divide (*SWE*; a proxy for early winter severity).

Elk calf winter survival and forage deficits

The Forage Accounting Model of Hobbs et al. (2003) has as an output weekly available forage biomass for the NER (sum of predictions for 30 × 30 m cells). These predictions account for snow conditions using a proxy of SWE and decrement total available biomass by 35% to account for unpalatable plants within the total estimate.

Comment [WJ5]: I'm not comfortable with this interpretation yet and need to think about it some more.

Comment [WJ6]: Will need a more formal explanation of these variables and how they will be collected. May fit best in the monitoring section.

Comment [WJ7]: If we use Hobbs' model for predicting available forage these may be redundant.

Comment [WJ8]: Put in winter feeding initiation paragraph above? Then note where more samples are necessary to improve the precision of the estimates. Need to run this model from 2007 forward to see where, on average, feeding was initiated so we can make treatment adjustments as necessary. This would also allow us to look at the relationship between key index sites estimates and Hobbs' predictions. Need to consider validating Hobbs' model with field sampling Eric is currently designing to see if we can use the Hobbs model moving forward. This would take some time with stripping the Hobbs model down to our needs, identifying data sources, and developing a workflow process so weekly estimates of available forage can be calculated. Would only be able to use snow data from SNOTEL sites that have data available online, which shouldn't be too much of a problem.

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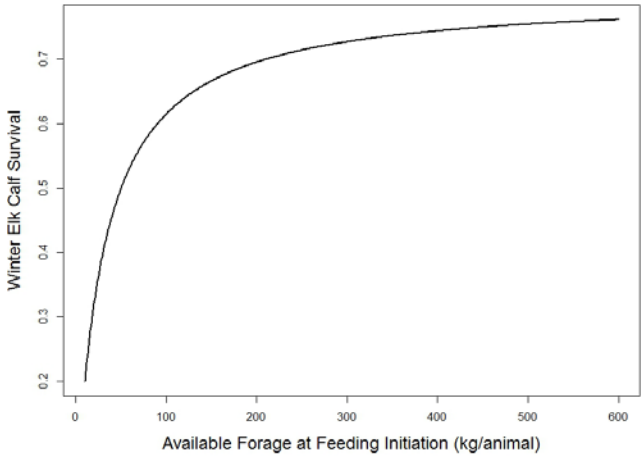
While calf survival is a function of multiple factors (Fig. 3), the primary management action influencing calf survival is supplemental winter feeding. Current winter feeding initiation criteria lead to calf survival generally higher than in unfed populations. Proposed feeding initiation criteria will result in later initiation of supplemental feed, which will be most influential to calf survival. There is currently little understanding regarding the relationship between initiation of winter feeding and calf survival, except that current feeding initiation criteria result in high calf survival. We believe a threshold level of available forage at initiation of winter feeding exists such that winter calf survival reaches an asymptote. Below this threshold, calf survival is hypothesized to decline quickly with reductions in available forage at winter feeding initiation. Available forage at the initiation of winter feeding will be related to on elk calf winter survival using a saturating function (i.e., Holling type-II functional response; Fig. 6) by

Comment [KD9]: Need a citation here.

$$S_t = \frac{aAFI_t}{b + AFI_t},$$

The parameters *a* and *b* determine how calf survival is related to available forage. Maximum calf survival is *a*, and *b* represents the value of available forage to an individual when survival is 50% of *a* (Hilborn and Mangel 1997).

Although this approach doesn't capture forage deficits *per se*, it does provide a potentially sensitive proxy for this concept. It is assumed that a forage deficit for calves would occur at a point on the curve of the relationship between calf survival and available forage at initiation of supplemental feeding. Modeling the response of winter calf elk survival to changes in feeding initiation criteria facilitates our ability to maximize the influence of feeding initiation criteria on winter distribution while minimizing the likelihood of a large mortality event.



Hypothesized relationship between winter survival of elk calves and per capita available forage at initiation of winter feeding on the National Elk Refuge.

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U.S. Fish and Wildlife Service National Park Service

BISON AND ELK
MANAGEMENT STEP DOWN PLAN

A Structured Framework for Reducing Reliance on Supplemental Winter Feeding

National Elk Refuge

Grand Teton National Park

DRAFT

July 24, 2015

BISON AND ELK

MANAGEMENT STEPDOWN PLAN

For the

National Elk Refuge,

Grand Teton National Park,

John D. Rockefeller, Jr. Memorial Parkway

Teton County, Wyoming

DRAFT

***Suggested Citation**:* U.S. Fish and Wildlife Service: 2015. Bison and elk management stepdown plan, National Elk Refuge and Grand Teton National Park. U.S. Department of the Interior, Washington D.C. Available online at:

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Appendix 3. Communication Plan**.....**

Appendix 4. Models.....

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EXECUTIVE SUMMARY [incomplete]

Comment [S1]: Steve K, my view on this is that it should be relatively short, because this is not a long document. I am thinking perhaps 2-3 pages max. What are your thoughts?

Overview

In 2007, the National Elk Refuge (NER) and Grand Teton National Park (GTNP) published a Record of Decision (ROD; USFWS and USNPS 2007a) for a bison and elk management plan. The Bison and Elk Management Plan (BEMP; USFWS and USNPS 2007b) was developed to guide management of the Jackson bison and elk herds on NER and GTNP lands, focused on four broad goals related to: 1) habitat conservation; 2) sustainable populations; 3) numbers of elk and bison; and 4) disease management. The final plan directed the NER and GTNP (in conjunction with the Wyoming Game and Fish Department; WGFD) to maintain the state's elk herd objective of 11,000, establish a bison population objective of 500, restore habitat on the NER and in GTNP, continue hunting bison and elk on the NER, continue the elk reduction program, when necessary in GTNP, continue to vaccinate elk for and effective vaccine becomes available, and develop a dynamic framework and adaptive management plan for decreasing the need for supplemental feeding on the NER. ***This Bison and Elk Management Stepdown Plan was developed to address the latter and specifically addresses the criteria for a structured framework referenced in the Record of Decision.***

Background

Winter feeding of elk in Jackson was originally initiated to reduce winter mortality of elk and minimize depredation of ranchers' hay. The loss of available winter range in Jackson Hole due to new ranching operations and a growing town resulted in significant numbers of elk dying during several severe winters in the late 1800s and early 1900s. This prompted local citizens and organizations, as well as state and federal officials in Jackson Hole, to begin feeding elk in the winter of 1910–11. Congress heeded the appeals for assistance and on August 10, 1912, established the National Elk Refuge. Today, the need for the refuge's winter elk feeding program is a direct result of reduced access to significant parts of elk native winter range, loss of historic migration patterns, behavioral conditioning of elk to winter feeding, and the desire to maintain a population objective established in the context of supplemental feeding.

Bison were extirpated outside Yellowstone National Park (YNP) by the mid-1880s but in 1948 were reintroduced to Jackson Hole when 20 bison from (YNP) were released near Moran, Wyoming. The herd remained small until discovering elk feedlines in 1980, when the population began sustained population growth. Bison and elk that winter on the NER are migratory and occupy summer ranges predominantly to the north.

Objectives

This adaptive management plan addresses several objectives under a broader BEMP goal of sustainable populations, which directed the agencies to: 1) Develop an adaptive management plan for reducing NER supplemental feeding; 2) [implement a] phased reduction of animals on feed: a) to 5,000 elk and 500 bison, and b) [to a point where] elk and bison rely predominantly on native habitat; 3) maintain natural elk bull-to-cow ratios in park summer herd; and 4) Enhance public outreach/education. The BEMP further stated that consideration criteria for implementing the 2nd phase of reduced feeding will include: 1) the level of forage production and availability on the National Elk Refuge and adjacent winter ranges, 2) maintenance of desired herd sizes and age/sex ratios, 3) the ability to effectively mitigate bison and elk livestock conflicts, such as co-mingling on private lands during high risk disease transmission periods, 4) maintaining desirable winter distribution patterns of elk and bison, 5) the prevalence of brucellosis, chronic wasting disease, and other wildlife diseases, and 6) public support. **In short, the overall objective of this plan is to provide a path for progressively**

Comment [S2]: Problem here

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transitioning from winter feeding of elk and bison on the NER to greater reliance on free-standing forage, while maintaining population and herd ratio objectives.

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INTRODUCTION

In 2007, the National Elk Refuge (NER) and Grand Teton National Park (GTNP) published a Record of Decision (ROD; USFWS and USNPS 2007a) for a bison and elk management plan. The Bison and Elk Management Plan (BEMP; USFWS and USNPS 2007b) was developed to guide management of the Jackson bison and elk herds on NER and GTNP lands. It included directives for forthcoming development of adaptive management practices to address several objectives in the plan, including a desired future condition of elk and bison relying predominantly on native forage. This Bison and Elk Adaptive Management Plan has been developed expressly for that purpose.

Bison and Elk Populations

While Jackson Hole is probably best known for the splendor and ruggedness of the Teton Range, the Jackson bison and elk herds rank among the top characterizing features of the valley. Both figure prominently in Jackson Hole's history and culture, although bison were absent from the valley for about 100 years between the mid-1800s and mid-1900s.

The Jackson elk herd occupies approximately 8,000 km^2 in the upper Snake River watershed north of the town of Jackson (Fig. 1). Much of the herd is migratory, moving between distinct wintering and summer ranges. Primary wintering areas include the Buffalo Valley, lower elevations of the Gros Ventre River drainage, the National Elk Refuge (NER), and areas adjacent to the NER on Bridger-Teton National Forest (BTNF) lands. Summering areas occur throughout the herd's range and for convenience are divided into four geographic regions that include Grand Teton National Park (GTNP), Yellowstone National Park (YNP), the Gros Ventre drainage, and Teton Wilderness.

In the late 1800s, when elk populations all over North America were being extirpated, the residents of Jackson Hole protected elk from "tusk hunters" and large-scale commercial hunting operations. Elk are just as important to today's residents of the valley. Thousands of people each year have the opportunity to see elk at close range on the refuge while riding on horse-drawn sleighs. Thousands of pounds of shed elk antlers are sold at an annual antler auction each spring in the town square. Elk are important to backcountry users as well as to people that never leave the road. Jackson Hole is a popular destination for instate and out-of-state elk hunters. The draw of elk to visitors contributes significantly to the local economy.

Winter feeding of elk in Jackson Hole began in 1910 and was originally initiated to reduce winter mortality of elk and minimize depredation of ranchers' hay. According to historical reports, before Euro-American settlement some Jackson elk wintered in the southern portion of Jackson Hole (present location of the NER town of Jackson) and may have used areas outside Jackson Hole, including the Green River and Wind River basins to the south and east, respectively, and the Snake River basin to the southwest in what is now eastern Idaho (Allred 1950; Anderson 1958; Blair 1987; Barnes 1912; Sheldon 1927). Radio-collar studies have documented small numbers of Jackson elk wintering in each of these areas in recent times as well (*citations*). Over time, changes in land use and development in these areas, over hunting, and establishment of feedgrounds probably reduced the use of these areas by Jackson elk.

By the end of the 19th century the Jackson elk herd was believed to be largely confined to Jackson Hole and the immediately surrounding area, where wintering conditions are often harsh. Compounded by the loss of available winter range in Jackson Hole due to new ranching operations and a growing town, significant numbers of elk died during several severe winters in the late 1800s and early 1900s. This prompted local citizens and organizations, as well as state

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and federal officials in Jackson Hole, to begin feeding elk in the winter of 1910–11. Congress heeded the appeals for assistance and on August 10, 1912, appropriated $45,000 for the purchase of lands and maintenance of a "winter game (elk) reserve" (37 Stat. 293). The first winter census in the area was conducted in 1912 and showed about 20,000 elk residing in Jackson Hole and the Hoback River drainage.

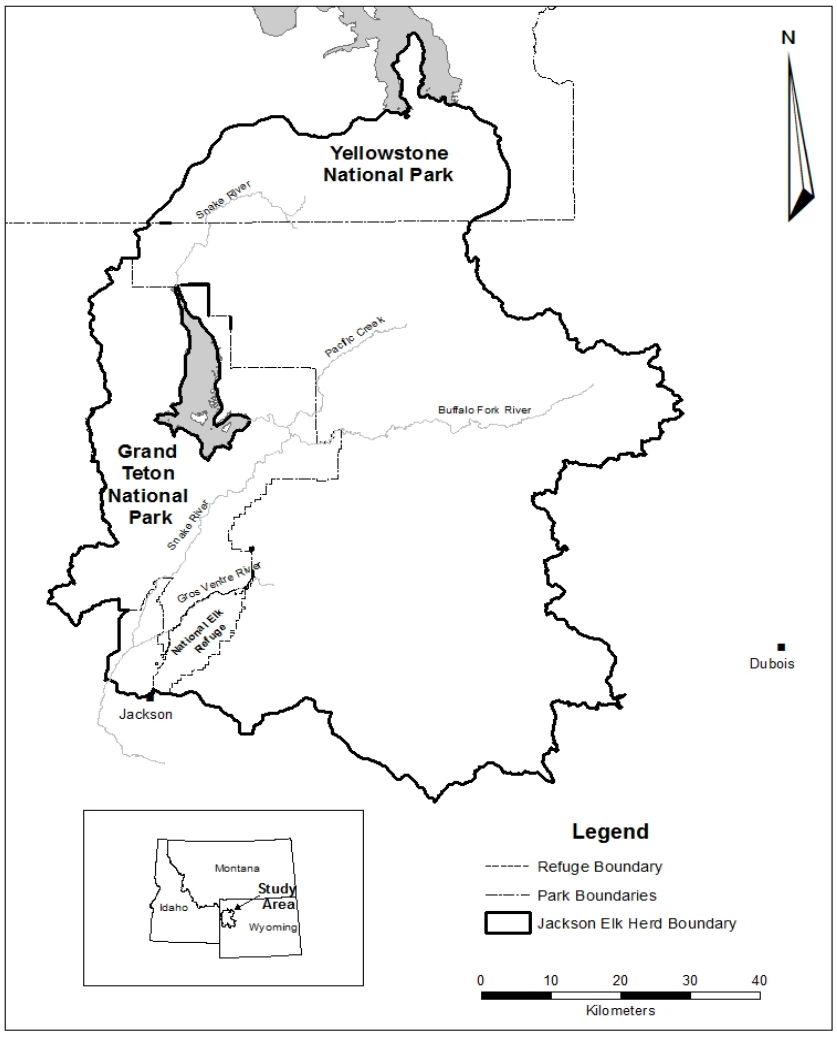

Figure 1. Jackson elk and bison herd ranges, including the National Elk Refuge, Grand Teton and Yellowstone National Parks, and Bridger-Teton National Forest. [include bison range, labels for continental divide and Bridger-Teton National Forest, and in Legend Jackson elk herd unit].

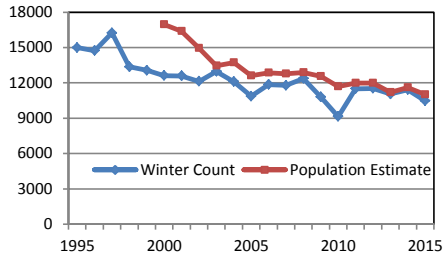

Figure 2. Winter counts and population estimates for the Jackson elk herd, 1995-2015.

Today, the need for the refuge's winter elk feeding program is a direct result of reduced access to significant parts of elk native winter range, loss of historic migration patterns, behavioral conditioning of elk to winter feeding, and the desire to maintain a population objective established in the context of supplemental feeding. Its population in recent times has fluctuated both above and below its herd objective of 11,000 adopted by the WGFD (Fig. 2)

An iconic symbol of the American West, bison are also popular with visitors and residents. Because so few opportunities remain to see bison in the wild, viewing and photographing them in Grand Teton National Park with the Teton Range in the background is a treasured opportunity for many of the valley's visitors. Similar to elk, there is also a high level of interest in bison hunting. Bison are of particular interest to nearby American Indian tribes and tribes in other parts of the United States because the animals are central to their culture and tradition.

Bison are native to Jackson Hole, as evidenced by the presence of prehistoric bison remains throughout the valley, but were extirpated outside Yellowstone National Park by the mid-1880s. In 1948, 20 bison from Yellowstone National Park (YNP) were reintroduced to the 1,500-acre Jackson Hole Wildlife Park near Moran. The Jackson Hole Wildlife Park was a private, non-profit organization sponsored by the New York Zoological Society, the Jackson Hole Preserve, Inc., and the Wyoming Game and Fish Department (WGFD). A population of 15–30 bison was maintained in a large enclosure there until 1963, when brucellosis was discovered in the herd (likely transferred with the original 20 animals from YNP). At that time, all the adult animals were destroyed, but four vaccinated yearlings and five vaccinated calves were retained. In 1964 twelve certified brucellosis free bison from Theodore Roosevelt National Park were added to the herd. In 1968 the herd (down to 11 animals) escaped the confines of the wildlife park, and a year later the decision was made to allow them to range freely. The expansion of GTNP in 1950 had enveloped the Wildlife Park, and allowing the bison to free range was and remains consistent with National Park Service wildlife management policy. The herd remained small and wintered mostly in the Snake River bottoms in GTNP until 1975, when it followed the winter environmental gradient to the NER and began wintering there. The use of standing forage by bison on the NER was viewed as natural behavior thus acceptable to managers. In 1980, however, bison discovered and utilized supplemental feed provided for elk, and they have continued to do so every winter since.

The discovery of supplemental feed by bison has had several consequences, including a significant increase in the population's growth rate (Fig 3). Bison on the elk feedlines have at times disrupted feeding operations and displaced and injured elk. To minimize conflicts between bison and elk, managers have provided separate feedlines for bison since 1984. As the population has grown, separating elk and bison on feedlines has become increasingly difficult, and a variety of feeding strategies are employed to help reduce displacement of elk.

As the herd has grown it has maintained fairly stable movement patterns, wintering almost entirely on the NER and summering within GTNP and adjacent lands on the BTNF (Fig. 1).

Planning History

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Jackson's bison and elk populations have been the subject of previous planning efforts. Elk management and research has been guided by the Jackson Hole Cooperative Elk Studies Group since it was established in 1953 [verify date]. The group consists of biologists and agency administrators from the National Elk Refuge, Grand Teton and Yellowstone National Parks, the Bridger-Teton National Forest, and Wyoming Game and Fish Department, who meet at least annually to coordinate management of the population and its habitat. Coordination of bison management began soon after they started frequenting the NER in 1976 and using supplemental feed provided to elk in 1980 (Fig. 3). Release of an "Interim" plan that called for maintaining a herd of 90-110 bison while data were gathered for a long term plan occurred in 1988. It was followed by implementation of a sport hunt administered by WGFD. This plan was halted after litigation in which the plan's violation of NEPA was successfully argued by plaintiffs.

In 1996, after considerable herd growth, a new long term management plan and environmental assessment for the Jackson bison herd was released (Fig 3). This plan had strong support and called for maintaining a herd size of 350-400 bison, but it was shelved a year later when plaintiffs from the earlier litigation successfully argued that, because the plan failed to consider the effects of feeding elk on bison management, it also violated NEPA and was not sufficient. This led to development of the draft bison and elk management plan and environmental impact statement from 2000-2006 and release of the final plan in 2007 (Fig 3).

The 2007 Bison and Elk Management Plan (BEMP; USFWS 2007) considered six alternatives for

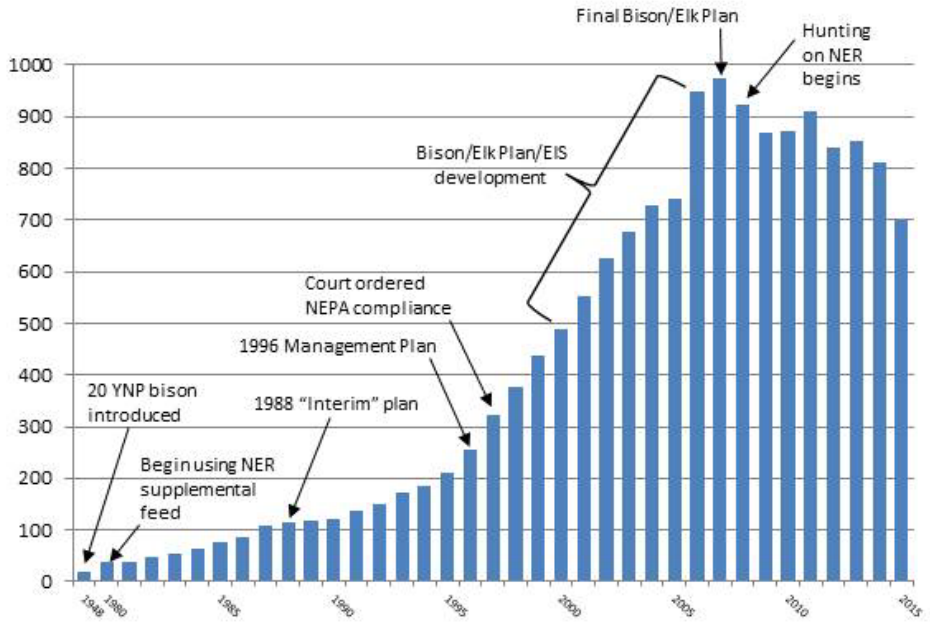

Figure 3. Population growth and planning history for the Jackson bison herd, 1948-2015.

bison and elk management focused on four broad goals related to: 1) habitat conservation; 2) sustainable populations; 3) numbers of elk and bison; and 4) disease management. The primary management scenarios presented in the alternatives included the status quo, terminating elk and bison hunting on the NER and the elk reduction program in GTNP, brucellosis vaccination options, restoring habitat, improving forage, and decreasing or phasing out supplemental winter feeding.

The final BEMP (USFWS 2007; www.fws.gov/bisonandelkplan) which set management direction for 15 years or until a subsequent plan is developed, proposed to maintain the state's elk herd objective of 11,000, establish a bison population objective of 500, restore habitat on the NER and in GTNP, continue hunting bison and elk on the NER, continue the elk reduction program in GTNP, when necessary, in concert with the parks enabling legislation (citation), continue to vaccinate elk for and effective vaccine becomes available, and develop a dynamic framework and adaptive management plan for decreasing the need for supplemental feeding on the NER. ***This Bison and Elk Management Stepdown Plan was developed to address the latter and specifically addresses the criteria for a structured framework listed on page 5 of the Record of Decision*** **(Fig. 4).** It does not address other on-going bison and elk management actions already prescribed by the BEMP.

The BEMP scheduled the completion of an Adaptive Management Plan for 2008. However, litigation challenging the BEMP in 2008 led to the decision to postpone its development until litigation was resolved. As of March 2015, two court rulings have upheld the 2007 BEMP and ROD. In a lawsuit against the BEMP and its author agencies (Defenders of Wildlife et al. v. the U.S. Department of Interior and State of Wyoming 2010), plaintiffs argued that the BEMP violated the National Wildlife Refuge System Improvement Act (National Wildlife Refuge System Improvement Act 1997) by disrupting the biological integrity of the Refuge, and that the plan and the accompanying EIS violated NEPA because they were insufficiently detailed to allow a reasonably complete discussion of mitigation. The crux of the plaintiff's argument was that the plan did not set a specific date for the cessation of supplemental feeding. In response, the agencies argued that the plan constituted a valid exercise of discretion and that it and the EIS were sufficiently detailed to satisfy the requirements of NEPA. In March 2010 the United States 4th District Court sided in favor of the agencies in this case. In 2011 the plaintiffs appealed this ruling to the United States 4th Circuit Court. The Circuit Court affirmed the District Court ruling (Defenders of Wildlife et al. v. the U.S. Department of Interior and State of Wyoming 2011).

National Environmental Protection Act Compliance

The 2007 BEMP/EIS and Final Record of Decision (ROD) satisfied NEPA requirements for current bison and elk management through a detailed analysis of alternative management actions and their likely effect on the environment, and substantial involvement of the public in the process. This adaptive management plan is does not duplicate or add to this process. It is designed to carefully tier off of the BEMP as a dynamic implementation guide to one part of the preferred alternative outlined in the BEMP ROD. As such, references to NEPA covered in the BEMP will be included where necessary in this document, and the discussion of any action that would require additional NEPA compliance will be explicitly stated as such in that context.

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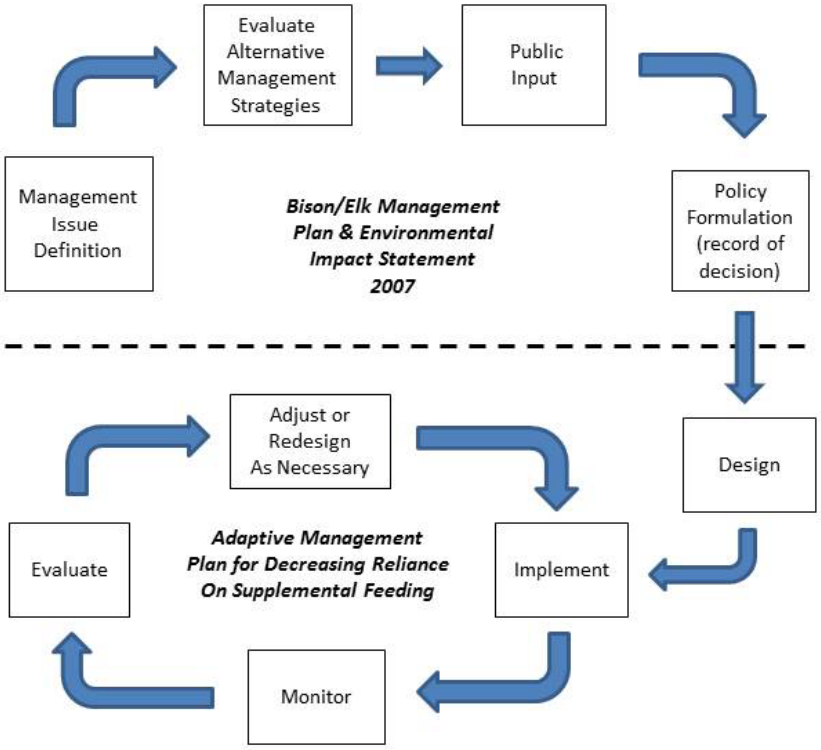

Figure 4. Adaptive management planning for supplemental feeding on the National Elk Refuge and its relationship to the 2007 Bison/Elk Management Plan and Environmental Assessment.

Adaptive Management Planning

Adaptive management plans have gained popularity in natural resource management planning because, by definition, they allow modifications of strategy based on monitoring results and outcomes toward reaching specific goals or objectives. There are four essential elements to an adaptive management approach: 1) well defined and mutually agreed upon objectives, 2 knowledge (including descriptive models) of the dynamics of the system being managed, 3) clearly articulated management actions and strategies, and 4) a monitoring program to evaluate responses of the system to management actions (Walters 1986).

This step-down plan utilizes adaptive management planning principles but is not intended to meet all of the adaptive management planning elements outlined in the Department of Interior Adaptive Management Technical Guide (2007). This Step-Down Plan is more accurately described as a "structured framework of adaptive management actions that progressively transitions from supplemental winter feeding to greater reliance on free-standing forage (BEMP ROD p.5).

OBJECTIVES

The management direction and desired conditions stated in the BEMP called for the NER and GTNP staffs to work with others (agencies, partners, etc) to "adaptively manage elk and bison in a manner that contributes to the State's herd objectives yet allows for the biotic integrity and environmental health of the resources to be sustained," so that the public can enjoy a variety of compatible wildlife-dependent recreational opportunities. Under the BEMP's 4 primary goals, 20 associated objectives were addressed (Table 1). This adaptive management plan addresses four objectives under the goal of sustainable populations (Fig. 5).

In Phase 1 of the second objective, the aim is to reduce the average number of elk on feed to 5,000 (while maintaining WGFD's 11,000 elk herd objective), and reduce the winter population of bison to the BEMP-adopted objective of 500. In Phase 2, the overall objective is to reduce the reliance of bison and elk on supplemental feed (USFWS and USNPS 2007a). Desired conditions include animals relying predominantly on native habitat and cultivated forage. Important consideration criteria for implementing Phase 2 will include: 1) the level of forage production and availability on the National Elk Refuge and adjacent winter ranges, 2) maintenance of desired herd sizes and age/sex ratios, 3) the ability to effectively mitigate bison and elk livestock conflicts, such as co-mingling on on private lands during high risk disease transmission periods, 4) maintaining desirable winter distribution patterns of elk and bison, 5) the prevalence of brucellosis, chronic wasting disease, and other wildlife diseases, and 6) public support. In short, the overall objective of this plan is to provide a path for progressively transitioning from winter feeding of elk and bison on the NER to greater reliance on free-standing forage, while maintaining population and herd ratio objectives.

Table 1. 2007 Bison/Elk Management Plan Goals and Objectives (Adaptive Management Plan objectives shaded)

Goal: Habitat Conservation

Objectives:

- Conserve important private lands.
- Increase forage production.
- Minimize non-native plants.
- Protect sagebrush grasslands.
- Restore willow, aspen, and cottonwood.
- Perpetuate natural mosaic of plant communities.

Goal: Sustainable Populations

Objectives:

- Develop adaptive management plan for reducing NER supplemental feeding.
- Phase reduction of animals on feed: 1) to 5,000 elk and 500 bison, and 2) elk and bison rely predominantly on native habitat.
- Maintain natural bull-to-cow ratios in park summer herd.
- Ensure a genetically viable bison herd with close to an even sex ratio.
- Enhance public outreach/education.

Goal: Elk and Bison Numbers

Objectives:

- Maintain state elk herd objective of 11,000.
- Maintain a genetically viable bison population of about 500 animals.

Goal: Disease Management

Objectives:

- Manage brucellosis transmission risk from elk and bison to livestock.
- Manage feeding to reduce brucellosis transmission among bison and elk.
- Educate hunters about wildlife disease human health hazards.

This Plan focuses on management actions to initially achieve Phase 1 objectives. However, if

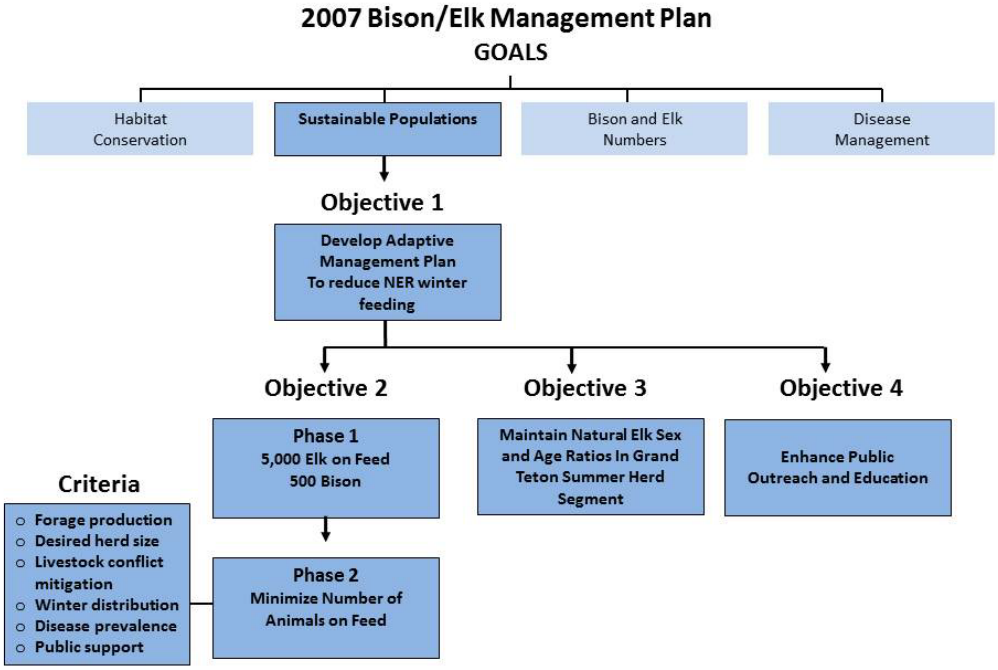

Figure 5. Relationship of Adaptive Management Plan to the 2007 Bison/Elk Management plan goals, phasing of objectives, and consideration criteria for reducing the reliance of elk and bison on supplemental feed during phase 2.

successful, these actions will continue to be used to achieve the Phase 2 objective of reducing reliance on supplemental feeding while considering the six criteria listed above.

MANAGEMENT ACTIONS AND STRATEGIES

Background

Elk have been fed for some period during nearly every winter on the National Elk Refuge since 1912, and bison have been fed there since 1980. The attraction of highly nutritious, easily accessible food during a time of year when natural forage is typically most limited is powerful to both species, and their knowledge of its existence has been passed down through generations. As a result, elk and bison have been strongly conditioned to seek supplemental food on the NER, even when natural forage is available and even abundant during some years. Because it is largely unprecedented, the concept of modifying this behavior on such a large scale is daunting and fraught with questions for which there is no answer. In some cases, the likelihood a specific management strategy's success will only be able to be roughly estimated, and unanticipated results are likely. The management stepdown approach will necessarily be one of investigation, constant evaluation, modifications to approach when indicated, and repeated trials (Fig 4). As such the approach will also be experimental, guided by rigorous analysis

and design, based on abundant empirical information, and monitored at an intensity commensurate with necessary decision making.

Since this plan is centrally tied to supplemental winter feeding on the NER, its focus will be on lands under NER authority. However, some strategies will also incorporate activities in GTNP, and on non-federal lands in collaboration with land owners and WGFD. Primary management practices that can be altered to achieve reduced reliance of bison and elk on supplemental feed fall into the 3 broad categories of 1) timing and intensity of winter feeding, 2) timing and intensity of hunting, and 3) herd segment specific and overall harvest levels.

Important Changes Since 2007

The BEMP was developed based on data collected and knowledge that existed up until its Record of Decision in 2007. Since then, important changes have taken place, some of which are advantageous to this effort, some of which are not.

A primary change that will facilitate meeting objectives under this plan is the reduction of the bison population from nearly 1,200 animals in 2007 to about 700 during winter 2014-2015 (Fig. 3) through hunting programs administered by WGFD. Licensing changes were enacted in 2014 to help increase harvest of female bison. These included a reduction in the bison cow/calf license fee (from $416 to $263 for residents and $2522 to $1022 for non-residents) and eliminating the once-in-a-lifetime restriction on a successful bison hunter to only those that successfully harvested a bull. Continued progress toward the 500 animal herd objective will require sustained harvest success.

During the same period, the Jackson elk herd has declined from nearly 13,000 to its objective of 11,000, but because the proportion of the Jackson Elk Herd that winters on NER has increased dramatically (Fig. 6), this will make achieving the Phase I objective of 5,000 elk on feed and any future elk population reductions more difficult. Preliminary modeling suggests that the increasing proportion of the Jackson Elk Herd wintering on NER has been associated with 1) changes in elk winter distribution associated with wolves and 2)high numbers of elk that summer immediately adjacent to NER (Cole and Foley et al. 2015).

Refuge-wide herbaceous forage production averaged 14,387 (SD = 4125) tons during 1998–2013. In recent years irrigation of approximately 3,600 acres has increased refuge-wide forage production by approximately 10% compared to what would have been produced with precipitation alone, and by 15% in the southern portion of NER which receives the greatest use by elk and bison.

Since 2007, the general awareness of climate change among the public has greatly increased. A strong, credible body of scientific evidence shows that climate change is occurring, is caused largely by human activities, and poses significant risks for a broad range of human and natural systems (National Academy of Science 2010). Ecological systems in the GYE are likely to be affected and associated changes will have implications for elk and bison management.

Current Management

Ongoing primary management actions on the NER include winter feeding, harvest, irrigation, and hazing. In GTNP, harvest of elk during the Elk Reduction Program takes place, when necessary, in collaboration with WGFD, and restoration of previously cultivated and irrigated sagebrush-grasslands is ongoing. Fundamental components of each of these will be briefly described below to provide a basis for comparison to adaptive management strategies that will follow.

Chronic Wasting Disease

Supplemental feeding has occurred in all but 9 winters on NER since 1912, and although this strategy minimizes winter elk mortality from starvation and contributes to Wyoming state elk

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herd objectives, elk occur at numbers and densities well in excess of carrying capacity (Smith et al. 2004, Lubow and Smith 2004). Considerable evidence suggests that Chronic Wasting Disease (CWD) transmission and prevalence are density dependent (Peters et al. 2000, Williams et al. 2002). Monello et al. (2014) found that elk densities of 15-110 per square km in Rocky Mountain National Park were associated with 13% CWD prevalence, and they predicted elk population declines when CWD prevalence exceeded 13%. NER elk densities commonly exceed 160 per square km (NER unpublished data), which suggests that the introduction of CWD to NER elk would have significant negative population effects over time.

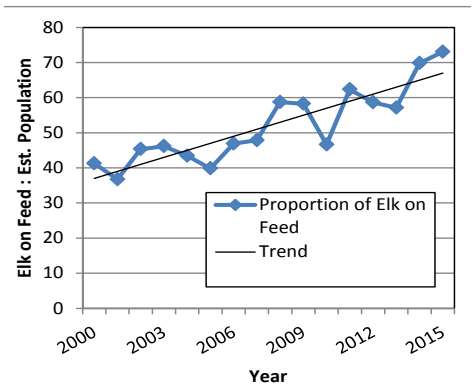

Figure 6. Increasing trend of National Elk Refuge elk on feed as a proportion of the Jackson Elk Herd estimated population size.

Winter Feeding

Initiation of feeding has the primary objectives of 1) minimizing elk winter mortality, focusing on calves since they are the most susceptible age class, and 2) minimizing comingling of elk with cattle on nearby adjacent private lands. Winter feeding begins when available forage reaches approximately 300 lbs/ac. Historic radio telemetry data and observations of elk movements indicate that when available forage delclines below 300 lbs/ac., some elk leave NER for surrounding private lands. Therefore, the purpose of this feeding trigger is to keep elk on the NER and prevent them from searching off-refuge for forage which increases the potential of comingling. This trigger is not a warning that a significant nutritional deficit threshold has been reached. Available winter forage for elk and bison on the NER is largely determined by biomass of forage produced during the previous growing season, rate of forage consumption during fall and winter, and how snow conditions affect forage availability.

Forage biomass estimates are calculated annually based on sampling at index sites. Index sites are selected subjectively each year based on presence of vegetation highly palatable to elk.

During 1995–2013, on average, initiation of NER winter feeding occurred on 28 January (range 30 December - 28 February), and feeding was terminated on 3 April (range 20 March - 20 April). Variation in feeding initiation and termination dates has been based on winter conditions and elk-cattle comingling problems on nearby private

Table 2. Annual distribution of wintering elk from the Jackson Elk Herd during February classification counts, 2011–2015, relative to the current objective.

	OBJECTIVE	2011	2012	2013	2014	2015	mean
NER	5,000	7,746	7,360	6,285	8,296	8,390	7,615
Gros Ventre	3,500	2,775	3,265	2,982	2,326	1,162	2,502
Native Range[1]	2,500	982	894	1,784	801	913	1,075
Total	11,000	11,503	11,519	11,051	11,423	10,465	11,192

[1]Excludes objectives for native range adjacent to Gros Ventre feedgrounds.

lands. Coordination of winter feeding dates on the NER and WGFD-operated Gros Ventre drainage feedgrounds (Alkali, Patrol Cabin) occurs annually to help minimize movement of elk between these areas. This coordination will continue regardless of the management strategy employed. The relationship of recent elk numbers and objectives for NER and WGFD-operated feedgrounds and native range is shown in Table 2.

Bison are fed as necessary to help minimize disruption to elk feeding operations. Bison will readily displace elk from feedlines, so since bison started using feedlines in 1980 refuge staff have developed a strategy of keeping most bison at the northernmost feedground (McBride) by feeding them there prior to feeding elk. Bison are provided a ration consistent with encouraging them to stay in this area away from elk feeding areas. This has also reduced conflicts associated with bison moving into Jackson or to the Nowlin area of the NER where commercial sleigh rides occur.

Harvest

Total harvest of the JEH was gradually reduced over the last decade as the population neared objective (Fig. 7). Elk hunting on the NER (Hunt Area 77) typically begins in mid-October and ends in mid-December, with peak harvest in recent years occurring in late November to early December. From 2005 to 2011 an average of 393 (SD = 56, range 329-457) hunters harvested 161 (SD = 38, range 126-225) elk per year during the NER hunt.

The 1950 legislation that created Grand Teton National Park provided for a controlled reduction of elk, when necessary, in specific portions of the park, primarily east of the Snake River. Elk reduction programs have taken place in the park each year since 1950 except two (1959, 1960), when GTNP and WGFD officials agreed a reduction was not necessary (Figure 8). Season dates have varied over the years but recently have run from mid-October to early-December. The GTNP harvest accounts for about 25% of the JEH overall harvest, thus has been an important factor in regulating the population. Increased natural regulation, likely a result of increases in grizzly bears and wolves over the last 20 years, has decreased the need for large harvests in the park.

Bison hunting begins on August 15 and ends in early to mid-January. Most harvest occurs on the NER, with some additional harvest on private and BTNF lands. Since resuming the bison hunt in 2007, mean harvest has been 210 (SD = 45.5, range 139-301) bison per year. This level of harvest has been sufficient to arrest the exponential growth of the population, reducing bison numbers from the peak in 2007 to about 700 animals in winter 2015 (Fig 3). Tribal bison harvest of up to 5 animals for ceremonial purposes was authorized in the BEMP. Translocation of wild bison to lands outside of Teton County is not currently permitted due to brucellosis concerns.

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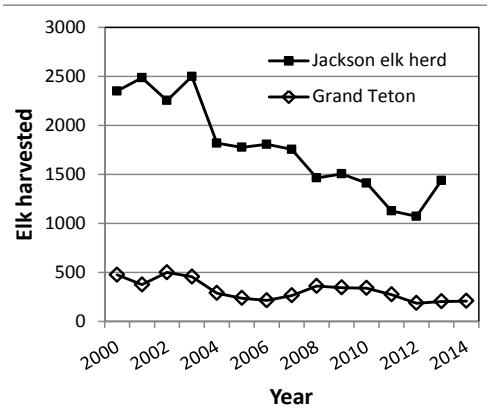

Figure 7. Estimated elk harvests for Grand Teton National Park and the Jackson elk herd (including the park) 2000–2014.

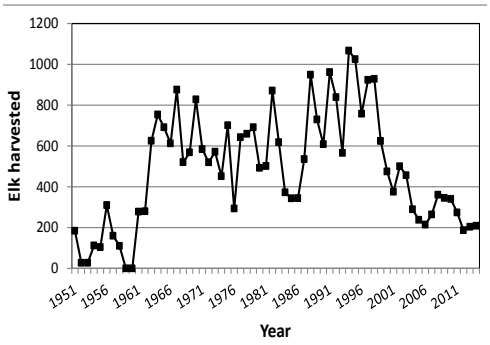

Figure 8. Elk harvest in Grand Teton National Park, 1950-2015.

Bison hunting is not allowed in GTNP because of long standing National Park Service policy that prohibits most hunting in national parks. Bison quickly learned to take advantage of the parks safety, which has made obtaining hunter harvest goals difficult. Many bison stay in the park during the hunting season, with only occasional short term movements to the NER, until severe winter conditions occur. In response, NER and WGFD managers attempt to balance extending the hunt as late in January as practicable without conflicting with winter feeding. The unpredictable nature of winter conditions that time of year makes this a risky proposition, and can result in the use of emergency season extensions or reductions.

Hazing

Elk and bison are hazed in spring to encourage movement off of NER winter ranges. Methods used have included ATVs, on foot, and on horseback, but recently ATV use has been found most effective. It's possible that some elk and bison might remain on the NER year around without hazing. If animals fail to leave the NER following the termination of feeding and adequate green-up has occurred, they are typically hazed to the north in late April to early May. Elk will stay off the NER until fall migration, and bison will generally remain in GTNP until mid-July. From July to early August bison often make forays back to the NER and are hazed back to GTNP to protect winter forage. Hazing efforts in August cease several days to weeks before the bison hunting season in an effort to increase hunter harvest.

Vegetation Restoration and Protection

The BEMP identified approximately 4,000 acreas of previously irrigated and cultivated grasslands in GTNP in need of restoration to native sagebrush grasslands community. Substantial progress in this endeavor has been made since 2007, including: [GTNP folks please add short description of methodological research and implementation, followed by what remains to be accomplished]

Private Lands Mitigation

Fencing of hay stacks and livestock feedlines has been historically used to mitigate particularly difficult conflicts on private lands. Targeted fencing of golf course greens and sand traps fall through spring has also been successful in some situations for mitigating elk and bison presence and associated damage in these areas. It is important to note that the county has a 'wildlife-friendly' fence policy and does not support extensive fencing that is impermeable to wildlife.

Methods, Assumptions, and Constraints Common to All Strategies

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Measuring the success of strategies toward objectives will require knowledge of several bison and elk herd attributes, particularly population sizes. Measurements of the Jackson bison herd will be based on the annual mid-winter census and sex and age classification survey performed by NER, GTNP, and WGDF biologists. This survey occurs one day in early February and includes ground counts of animals on feed at the NER and aerial counts of outlying bison across their winter ranges on the refuge, park, and Bridger-Teton National Forest.

Elk population estimates will also be based on mid-winter aerial and ground counts. However, the mid-winter counts are undertaken during a single survey period and do not necessarily represent either peak or cumulative abundance of elk on feed. Rather than basing progress toward the number of elk on feed for the entire season on those present during the day of the survey only, we will use a more meaningful measurement. Since we are more interested in the intensity of elk feeding throughout the entire feeding period, which includes both the number of animals on feed and the duration of feeding, we will use a measurement of elk-fed-days (EFD; the total number of elk fed per day per season) as a gauge of feeding intensity (see monitoring section). For example, if 5,000 were elk fed for 100 days during the winter, feeding intensity for that winter would equal 5,000 elk X 100 days = 50,000 EFD, whereas if 5,000 elk were fed for 50 days, EFD would equal 25,000.

We determined feeding intensity benchmarks for bison and elk-fed based on an actual average of 64 days of feeding from 1995-2007. Based on the Phase I objectives of 500 bison and 5,000 elk, fed-days benchmarks would be 64 x 500 = 32,000 for bison and 64 x 5,000 = 320,000 for elk. These values will assist in determining efficacy of strategies toward reducing reliance of both species on supplemental winter feeding.

Implementation of the AMP will have successfully attained the objective of "transitioning from intensive supplemental winter feeding to greater reliance on free-standing forage" when supplemental feeding was not used for more than 50% of the years in a 5 year period.

Comment [S3]: SK's draft.

Initial success of AMP implementation will be a consistent decline in the 3-year running average of elk and bison fed days from the established baseline. While the BEMP did provide specific measurement criteria for the definition of "transitioning from intensive supplemental winter feeding to greater reliance on free-standing forage" we will consider this objective met when the 3-year running average of elk and bison fed days is <50% of baseline for 5 years in a row.

Comment [S4]: SC's alterative in this paragraph, recognizing that the 50% number is the crux and a glaring target.

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Table 3. Summary of potential Adaptive Management Plan constraints.

Policy

- ESA[1] Lynx – limits on habitat impacts
- Greater Sage Grouse – core area protection
- 2007 BEMP/EIS (federal actions/lands)
  - No fertility control
  - No test and slaughter
  - Limited tribal harvest
- Bison/elk hunt end date (Feb. 1st)
  - WGFD, brucelosis safety
- Carcass disposal (Feb. 15th)
  - WGFD, brucellosis safety
- Forest Service winter closure (Dec. 1st – April 30th)
- Easement limitation (NER boundary)

Winter Feeding

- Only during non-hunting periods

Harvest

- State regulations

Vegetation Restoration/Protection

- Bison/elk distribution
- Exotic plant species management

Private Lands

- Owner agreements

Social

- Hunter density (safety; hunt quality)
- Elk/bison winter mortality levels
- Public safety (ungulate/vehicle collisions)
- Disease
- Land-use conflicts (agricultural and residential)

Biological

- Disease (bison/elk/cattle commingling)
- Sage grouse habitat conflicts
- Fencing/wildlife conflicts
- Elk herd distribution
  - summer segment distribution goals

Funding

- Easement purchase
- Plan implementation

[1]Endangered Species Act

Several management constraints are common to the strategies discussed below (Table 3). Many law and policy constraints are applicable but we include here only those most pertinent. Endangered Species Act (16 USC 1531 et seq.) requirements for wolves, grizzly bears, lynx, and others apply. Lynx requirements for maintaining certain habitat types could limit methods used and areas considered for habitat improvements in GTNP. Similarly, compliance with the Wyoming greater sage-grouse core area protection executive order (2011-5) could restrict habitat manipulations. NEPA compliance conducted as part of the BEMP/EIS constrains what federal actions can be taken as a part of this plan. State regulations constrain late (winter) hunt and carcass disposal timing to protect against brucellosis contamination, since February-April represent the period bison and elk are most likely to transmit the disease. Restrictions on hunting timing also result from BTNF winter range closures, immediately east of the NER and elsewhere, December 1 to April 30. Additional details about these and other constraints will be included in discussions about specific strategies that follow.

Strategies

This section will describe the management action this AMP proposes to implement. As such, it unveils the heart of management changes necessary to begin the process of transitioning to more reliance of bison and elk on native forage during winter. Fundamentally, the strategies discussed in this plan represent an experiment designed to achieve Phase I objectives of 5,000 elk and 500 bison on NER and are a first step towards reducing reliance on supplemental feeding while meeting the sustainable population goals identified in the AMP.

Initial strategies for achieving sustainable population goals identified in the BEMP (Table 1) are presented by objective below. The primary management actions available to the agencies to achieve phase I objectives are modifications to winter feeding and hunting seasons. To a lesser

extent, vegetation protection and restoration can be important, particularly for improving long-term ecological balance and enhancing natural production of native forage. Private lands are also an integral component as changes in elk and bison distribution occur and new challenges develop. The likely consequences of implementing these strategies were evaluated in the BEMP. The most relevant of these are summarized in Appendix 1.

Objective: *[Implement] a phased reduction of animals on feed: 1) to 5,000 elk and 500 bison, and 2) [to an extent where] elk and bison rely predominantly on native habitat* (Table 1).

This objective is what the need for an adaptive management plan – **this document** – is central to. As previously mentioned, the concept of reducing winter feeding after more than 100 years of the practice, and the associated behavioral conditioning of elk and bison to its presence, represents a formidable challenge that must be approached cautiously and systematically. The strategies discussed below have been developed in this context, with appropriate feedback mechanisms through rigorous monitoring and frequent evaluation. Inability to meet this objective under the strategies presented here would trigger a thorough evaluation and development of more aggressive strategies.

Chronic Wasting Disease

In 2014 WGFD began the revision process for the Wyoming CWD Management Plan (2006). WGFD has cooperated with federal agencies and other stakeholders to revise the plan, and NER and USFWS Region 6 Wildlife Health Office staff participated in several meetings associated with this effort. One goal of the CWD Management Plan update is to develop specific management responses should CWD be detected on or adjacent to State or NER elk feedgrounds. Early detection of CWD in the JEH is essential to ensure an effective management response.

Since 1997 NER has cooperated with Wyoming Game and Fish Department (WGFD) to conduct surveillance for CWD in the JEH unit. Although this effort indicates that CWD is not currently found in the JEH, continued surveillance at sample sizes sufficient to detect 1% prevalence with 95% confidence annually will be critical to ensure a timely management response and limit the long-term population effects of the disease (USFWS and NPS 2007). Given that CWD has been detected within 40 miles of the JEH in moose, within 70 miles in deer, and within 175 miles in elk, this level of surveillance is warranted.

Winter Feeding

Winter feeding actions that could be modified include starting date, ending date, and daily ration. To modify elk and bison behavior in the long run, delaying initiation of feeding is likely to have the greatest impact by gradually conditioning them to expect feed later on average, with the desired outcome of building a cohort of animals that rely primarily on native winter range and are not food conditioned. To reduce supplemental feeding overall, ending feeding early would also help decrease the amount of feed provided per animal per year. Both would help decrease the total elk/bison fed days, the parameter we will use to measure progress toward reducing supplemental feeding.

Initially, supplemental feeding will be delayed by approximately 2 weeks, depending on several variables (Table 4, Fig. 9). Time of season could influence this interval, most likely shortening it as the feeding initiation date gets later. During the last 20 years, feeding initiation dates, which have been based on forage availability, have varied from December 30 to February 28. Delaying feeding by two weeks in January, for example, is likely to be more successful than doing so in February, when food stress and tendency for animals to move to private lands is greater. Forage availability could also have an influence, particularly if a freeze thaw event resulted in an acute and large reduction in available forage.

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Both time of season and forage availability considerations would be affected by the numbers of elk and bison on the NER. And finally, the distribution of animals, particularly on private, livestock producing lands, would be considered.

A primary concern of manipulating feeding is elk winter mortality, particularly among calves. As food becomes limited in winter, calves are usually the first to suffer because of being displaced by more dominant animals. Monitoring programs will include measures of calf mortality and it will be an influencing parameter in feedback mechanisms. The BEMP anticipated that elk mortality could increase from 1-2% overall to 1-5% (Appendix 1).

Initially, the termination of feeding, which is now based on a snow cover index and subjective evaluation of available forage, will occur about a week earlier. The combination of a 2 week delay in feed initiation and 1 week advance in termination would shorten the feeding season by 3 weeks on average, or 32% based on an average feeding season length of 9.3 weeks from 1995-2015.

The AMP winter feeding strategy would include the establishment of additional key forage index sites and on-going measurements at those sites throughout the winter.

Harvest

Currently the Jackson elk herd is at the Wyoming Game and Fish Commission established objective of 11,000 animals, which means there is less flexibility in manipulation of harvest regimes than there would be if the herd was above objective. Initially there would be little change in elk harvest programs on the NER, with the exception of allowing a limited number of any elk permits throughout the season, considering allowing bow hunting near developed areas (roads and buildings) and shifting the season about a week later (Table 4). Allowing a limited number of any elk permits would be consistent with providing sport hunting recreation on National Wildlife Refuges (citation, NWR system act) and the NER (citation, CMP?), and possibly encourage more hunters to participate in antlerless elk hunts. Monitoring programs and consideration of bull ratios in the GTNP summer segment (since most park bulls migrate to the NER) would help inform levels of take proposed. Bow hunting in areas currently closed to firearms will likely increase harvest by eliminating “no-hunt” areas which can become sanctuaries for large numbers of elk. Shifting the hunt one week later is consistent with later migrations and will improve harvest effectiveness.

General elk harvest patterns in GTNP would continue to be based on need for harvest, summer segment population estimates, and mitigation for impacts on other resources and visitor activities.

Elk herd population objectives are reviewed every five years by the Wyoming Game and Fish Commission and adjusted as necessary. Serious consideration should be given to reducing the Jackson Elk Herd population objective. Lowering the population would help compensate for reduced use of traditional native winter range and increased growth of short-distance migrants which has lead to significant increases of winter elk concentrations on the NER.

The annual fall/winter arrival of elk to the NER during the past several decades has been occurring progressively later. This trend may necessitate extending the elk hunting season later into the year to achieve harvest objectives.

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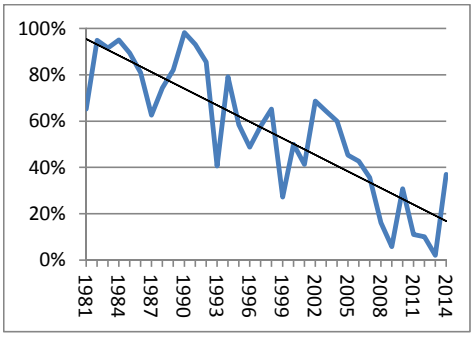

Figure ?. The annual fall/winter arrival of elk to the NER during the past several decades has been occurring progressively later. This trend may necessitate extending the elk hunting season later into the year to achieve harvest objectives.

Bison hunts on the NER (bison hunting is prohibited in GTNP) would see little initial change (Table 4). Consideration would be given to later hunt end dates commensurate with delayed feeding, and possible escorted hunting in the South Unit to help with distribution or discouraging bison from attempting to leave the NER via the south boundary into the town of Jackson. If progress toward reaching the herd objective of 500 animals continues and the objective is reached in the near future, State quotas will likely be reduced and management flexibility will increase.

A cattle guard will be installed on the Refuge Road near the east end of Broadway Avenue to help prevent bison and elk herds from entering the Town of Jackson. This will reduce the potential for dangerous human/wildlife interactions.

Serious consideration should be given to reducing the bison herd population objective in the future. This would lower winter forage consumption on the NER and help reduce elk and bison winter concentrations.

The current bison herd objective is ". . . maintain and ensure a genetically viable population of approximately 500 animals (five-year average), with as close to an even sex ratio as possible to maximize maintenance of genetic variation over time. . ." (BEMP p. 136).

The Jackson bison herd is not considered part of the U.S. Fish and Wildlife Service's meta-population approach to bison conservation because of its high prevalence of brucellosis. This disease prevents the export of Jackson bison to other DOI conservation herds.

The 500 bison population objective was set primarily to preserve existing genetic diversity assuming extremely limited natural genetic transfer with the Yellowstone or other DOI bison conservation herds. Genetic diversity can be maintained for a Jackson bison herd less than 500 if bison with desirable genetic diversity are periodically imported from other DOI bison conservation herds.

Currently, the effectiveness of NER late-season harvest regimes is affected by December 1st winter closures immediately east of the refuge on BTNF lands. Extensive elk telemetry data suggest that delaying the winter closures could aid elk management objectives. NER officials will work with BTNF and WGFD officials to explore the possibility of allowing hunting in limited areas after December 1st in the future.

Annual herd-wide population estimates, elk summer herd segment estimates, temporal and spatial harvest patterns, and animal-fed-days would be monitored, and the resulting information would be used to inform ongoing evaluation of adaptive elk and bison management harvest programs (Figs. 9 and 10).

Hazing

No change in hazing practices is anticipated initially under this adaptive management framework.

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Private Lands Mitigation

Delaying the onset of NER feeding is likely to result in changes in bison and elk distribution (Appendix 1). Some elk or bison may move to private lands in search of forage. Of greatest concern is the potential for elk or bison to commingle with cattle of cow/calf operations, where brucellosis transmission could have considerable consequences, in the worst case requiring depopulation of the cattle herd.

Several strategies would be employed to mitigate potential problems (Table 4), including providing incentives for non-breeding cattle operations (because brucellosis transmission to slaughter-bound cattle is not economically important), increased fencing in some limited areas to separate elk/bison from livestock feed lines, haze elk/bison away from livestock feed lines and purchase private lands easements to prevent co-mingling. A vital component in implementing these mitigation measures is to establish three seasonal Wildlife Conflict Technician positions which are supervised by the WGFD. These Technicians are also critical to the success of an expanded monitoring program vital to the AMP (see Monitoring section below).

A database will be established to track non-agricultural conflicts on private lands to determine trends which will help evaluate the effectiveness of AMP mitigation efforts.

Preventing elk and especially bison from entering the Town of Jackson is essential in minimizing safety and private property conflicts. Currently, bison are hazed northward when they drift south of Miller Butte. A double cattle guard will be installed on the Refuge Road just north of Broadway Avenue. This barrier is designed to prevent elk/bison from entering the Town of Jackson.

Vegetation Restoration/Protection

[NER and GTNP staff to draft material]

Objective: *Maintain natural bull-to-cow ratios in park summer herd* (Table 1).

National Park Service management policy (NPS 2006) provides guidance for maintaining naturally regulated wildlife populations, free from the impacts of humans, to the greatest extent possible. The final BEMP identified a goal of maintaining park elk bull:cow ratios (a common way of expressing sex and age ratios in wild ungulate populations) near 35 adult bulls per 100 adult cows, based on estimates of what this ratio would be in a herd free from the effects of human harvest. The sex and age ratios of most North American elk populations are affected by sport hunting and herd managers generally maintain lower bull ratios.

Harvest

Based on bull ratios in the park summer herd that were chronically below 35 bulls:100 cows, permit types for the park's elk reduction program (ERP) went to antlerless only in 2012. ERP permit structures in the park will remain antlerless only unless the bull ratios consistently exceed 35:100 cows. Park and refuge officials will work together to support this goal, recognizing that bulls harvested on the NER are most likely from the park summer herd segment.

A private lands Hunting Coordinator Position would be established and supervised by the WGFD to promote and coordinate hunting activity focused on Southern Herd Segment harvest in and around private lands in the Spring Gulch Area north to Moose, WY (Hunt Area 78).

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Table 4 [incomplete]. Comparison of current and adaptive primary management components and parameters.

Action	Current Management	Adaptive Management	Comments
Winter Feeding:			
Feed	Pelleted alfalfa	Pelleted alfalfa	No change
Ration	8 lbs/day/elk 20 lbs/day/bison	8 lbs/day/elk 20 lbs/day/bison	No change, to minimize calf mortality
Start criteria:			
Available standing forage	300 lbs/acre, as measured at traditional key index sites	Generally 2 weeks later; index sites to be increased in number and distribution	Influencing factors: - time of season - forage availability - numbers of elk/bison on NER - elk/bison distribution
End criteria:			
Available forage	Based on a snow cover index and subjective estimate of when residual or new forage is adequate	Generally 1 week earlier	Development of more objective criteria for future implemen-tation ongoing
Monitoring:			
Animals on feed	Mid-winter census	Elk/bison fed days[1]	
Proportion of JEH on NER feed	Mid-winter census	Mid-winter census	
Calf mortality threshold		<= 10%	
Elk/bison distribution - visual			
Elk/bison distribution – collars			
Winter mortality			
Elk summer range proportions			
Harvest, National Elk Refuge elk:			
Frequency	Annual	Annual	
Begin Date	2nd week October	3rd week October	Modified as necessary
End Date	2nd week December	3rd week December	Modified as necessary
Structure	- 1 week initial drawing - 1 week left over 1st served - partial week alternate	- 1 week initial drawing - 1 week left over 1st served - partial week alternate - daily 1st served alternates	

[1]Number elk and bison on feed per day, totaled by feeding season.

Table 4, continued. Comparison of current and adaptive primary management components and parameters.

Action	Current Management	Adaptive Management	Comments
Harvest, National Elk Refuge elk:			
Refuge permit types	- 1st week any elk - Antlerless only remainder of season	- Primarily antlerless only - limited any elk permits throughout season	
Access	Restrict access to specific locations	Restrict access to specific locations	
Hunt area boundaries		Consider expanding to allow bow hunting near developed areas	
Harvest, National Elk Refuge bison:			
Frequency	Annual	Annual	
Begin date	August 15th	August 15th	Modified as necessary
End date	2nd or 3rd week January	Consider later dates as appropriate	Modified as necessary
structure	As per WGFD	As per WGFD	
Refuge permit types	Any bison or cow/calf per state license	Any bison or cow/calf per state license	
access	Restrict access to specific locations	Restrict access to specific locations	
Hunt area boundaries	Limited to north of Nowlin Creek area	Consider escorted hunting in South Unit as needed	Guided hunts in South Unit when authorized
Harvest, Grand Teton NP elk:			
Frequency	As needed	As needed	
Begin Date	3rd week October	3rd week October	Modified as necessary
End Date	2nd week December	2nd week December	Modified as necessary
License types	Antlerless only	Antlerless only[1]	
Special regulations:	Cartridge limits	Cartridge limits	
	Bear spray required	Bear spray required	
	Hunter safety card required	Hunter safety card required	
Harvest, Bridger-Teton NF, Elk Hunt Area 80:			
Begin Date			
End Date		December 15	Would require change in winter closure dates

[1]Any elk licenses could be offered if bull ratios in the park consistently exceed BEMP criteria.

Table 4, continued. Comparison of current and adaptive primary management components and parameters.

Action	Current Management	Adaptive Management	Comments
Harvest, Elk Hunt Area 78			
Structure			Changes at discretion of WGFD
License types			
Private Lands Mitigation:			
Cattle commingling		Incentives for non-breeding operation	
Hay depredation		Increased fencing	
Landscape damage			
Easement acquisition			
Vegetation Restoration/ Protection: Elk Refuge			
Vegetation Restoration/ Protection: Grand Teton			

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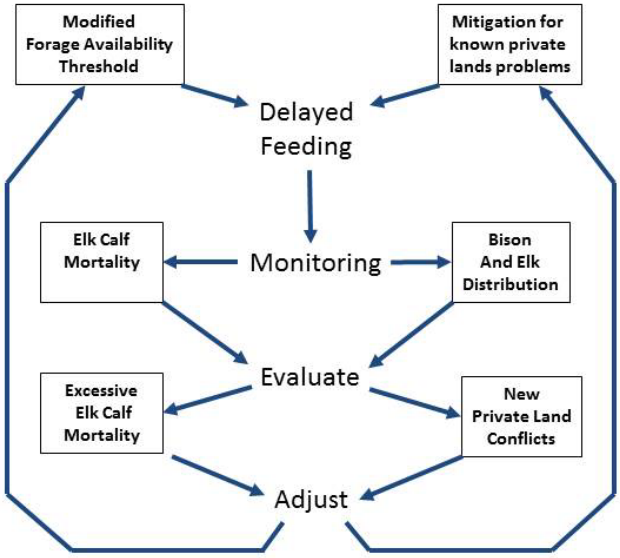

Figure 9. [example] Framework for delayed feeding strategy and adaptive management.

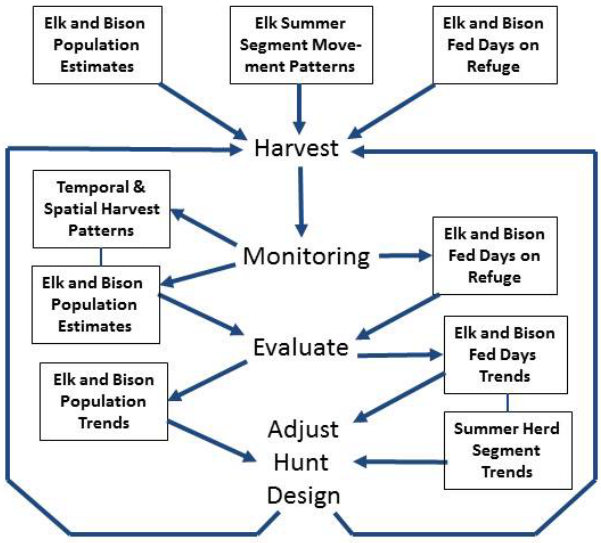

Figure 10. [example] Framework for harvest strategy and adaptive management.

Strategies Considered But Rejected

The BEMP considered several additional strategies for elk and bison management that, for a variety of reasons, were not selected for implementation in the preferred alternative and Record of Decision. The agencies reconsidered a subset of these during the development of this AMP (Table 5). Since they were not part of the ROD, additional NEPA compliance would be necessary to incorporate any of them into this adaptive management plan, and thus they are not being considered at this time.

Table 5. Strategies considered but rejected.

Strategy Considered	Reason Rejected
Fertility control in elk	Judged not reasonable or feasible in BEMP, primarily due to major technical, social, and financial hurdles[1]. For AMP discussed primarily with regard to the difficult to harvest herd segment in Hunt Area 78 on private lands, where federal agencies have no jurisdiction.
Fertility control in bison	Impacts discussed at length in BEMP[2]. Not considered for AMP because current hunting programs appear effective at slowly moving the herd toward the 500 animal herd objective.
Agency reduction of bison or elk	Not considered necessary or desirable on federal lands because current hunting programs that utilize sport hunters are effective at meeting herd objectives.
Altering rations of supplemental feed	Rejected as a strategy because reducing daily feed ration below 8 lbs/elk would be enough feed to encourage elk to remain on NER but would result in unacceptably high elk calf mortality rates.

MODELS OF SYSTEM DYNAMICS

Models provide a simplified representation of the biological system being managed. Adaptive management uses models of the managed system to link the objective response (e.g., elk winter distribution) to changes in the system resulting from management actions (e.g., altered initiation and cessation of winter feeding). Fig. 11 describes possible factors that affect winter elk distribution (the proportion of elk on NER feedgrounds versus native winter range). Models will be used to identify the relative influence of our principal management strategy (a reduction in feed season length) and other factors on winter elk distribution (Appendix 3). Over time this will allow us to assess whether changes in elk distribution were the result of our management actions or due to factors outside of our control.

An increase in calf elk winter mortality is a potential result of reduced feed season length. Fig. 12 portrays factors that influence winter calf elk survival on NER.

Models will be used to assess the effects of available forage on winter calf elk survival (Appendix 4). Over time this will allow us to assess the effects of our principal management strategy (reducing feed season length) relative to other factors on elk calf survival and potentially adjust our management actions based on model results.

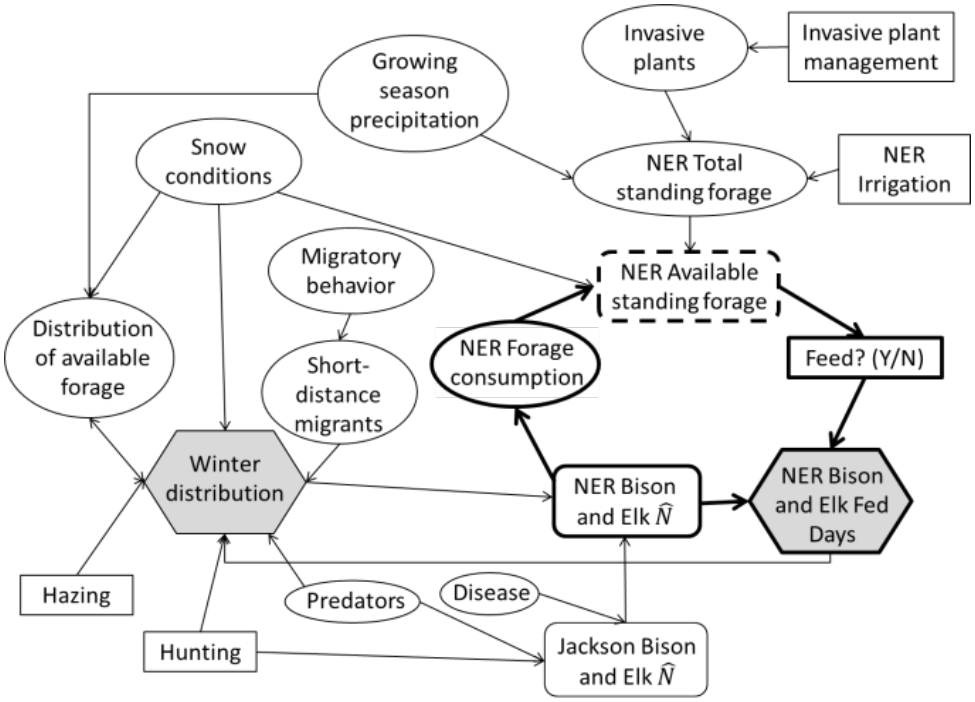

Figure 11. Influence diagram depicting factors (including management actions) influencing outcomes identified in the Bison and Elk Management Plan (BEMP; USFWS 2007a). Gray hexagons represent outcomes, rectangles represent management actions, rounded rectangles represent factors with numerical objectives, and ovals represent factors outside of management control. Bolded polygons and arrows represent outcomes and factors limited to the National Elk Refuge (NER). Available standing forage on the NER (dashed rectangle) is the BEMP criteria with a defined threshold to trigger initiation of supplemental winter feeding.

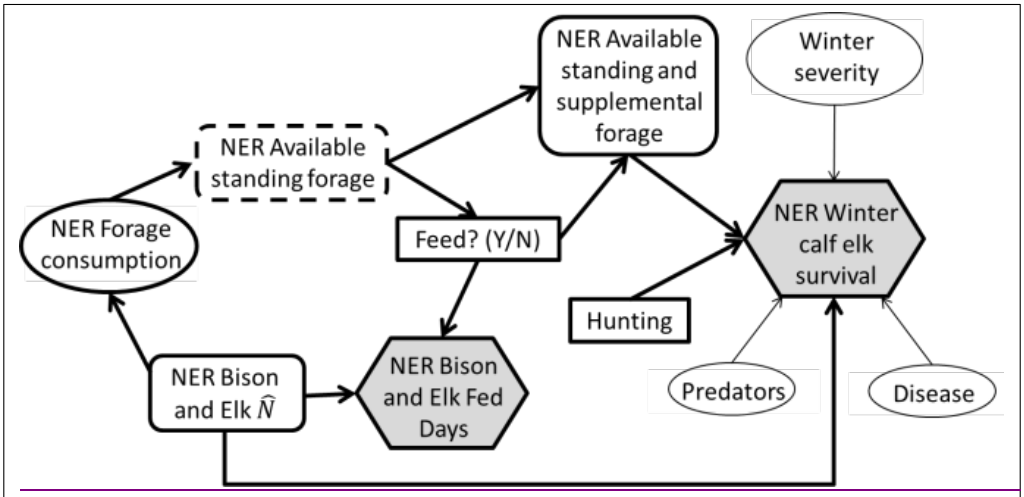

Figure 12. Influence diagram depicting factors (including management actions) influencing bison and elk fed days on the National Elk Refuge (see text for description) and winter calf elk survival. Gray hexagons represent outcomes, rectangles represent management actions, rounded rectangles represent factors with numerical objectives, and ovals represent factors outside of management control. Bolded polygons and arrows represent outcomes and factors limited to the National Elk Refuge (NER). Available standing forage on the NER (dashed rectangle) is the BEMP criteria with a defined threshold to trigger initiation of supplemental winter feeding.

MONITORING

Feeding Initiation Monitoring

NER uses weekly field estimates of the amount of forage available to elk to determine feeding initiation date. Currently measurements are taken at key index sites representing areas preferred by elk on NER (see supplemental materials at end of this section). These methods will be enhanced by 1) increasing the number of sampled sites to better represent the total amount of forage available to elk on the southern half of NER; 2) increasing the precision of estimates at each site by increasing the number of observers; and 3) extending the monitoring period later in the winter to assess the relationship between available forage and elk and bison distribution.

To better represent the total amount of forage available on the southern half of NER, a subsample of current key index sites will be retained to facilitate comparison with historic data, but additional random sample sites stratified by elk habitat preference will be added. Historic elk distribution mapping and elk GPS collar data (NER unpublished data) suggest that the areas most preferred by elk on southern NER are associated with moderate to high forage production and green vegetation. Because the distribution of forage production and greenness characteristics vary annually based on irrigation and precipitation patterns, we will annually map areas preferred and not preferred by elk and sample sites will be randomly selected within each of these mapped categories. At least 3 historic key index sites, 3 random sites in areas preferred by elk, and 3 sites in areas not preferred by elk will be sampled each week from late December through the initiation of supplemental feeding.

Currently the NER biologist is the only person trained in the techniques used to estimate available forage (see supplemental materials). At least 2 additional personnel will be trained in these techniques. This will provide a backup in the event of future personnel changes and will facilitate error estimates of the available forage measurements at each site.

Currently NER and WYGFD biologists monitor available forage conditions at least weekly from late December until average available forage at key index sites nears the threshold level of 300 lbs. per acre and feeding is initiated. The principal AMP strategy is to delay the initiation of supplemental feeding by 2 weeks after average forage production reaches the 300 lbs. per acre level at key index sites. Therefore the monitoring period will be extended to include the intervening 2 weeks.

Proportion of Elk Wintering on NER

A principal AMP goal is to reduce the number of elk wintering on NER. Our strategy will be to effect redistribution of elk to native winter range from NER over time via shortening the duration of the feed season, and thus slowly conditioning elk to seek food elsewhere. As feeding periods are shortened, the probability of younger elk age classes discovering NER feedgrounds will be reduced, and, hypothetically, that proportion of the JEH that utilizes NER feedgrounds will decline over time. We will measure this effect by examining changes in the winter distribution of the JEH. WGFD annual trend/classification count data provide a multi-year baseline data set to measure changes in the winter distribution of the JEH and categorizes observations by location. In each year, we will calculate the proportion of total classified elk in the JEH that are classified on NER feedgrounds. We will compare the 3-year running average post AMP implementation to the pre-implementation baseline. The pretreatment baseline will be comprised of data from 2008-2016, a time period that represents BEMP implementation prior to AMP actions (Figure 13).

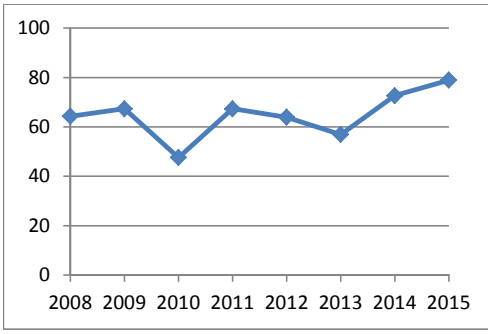

Figure13. Proportion of the Jackson Elk Herd that was classified on NER feedgrounds in the period following implementation of the Bison and Elk Management Plan and prior to the implementation of the Adaptive Management Plan (2008-2015). These values represent the pretreatment baseline which will be compared to the 3 year running average post AMP implementation.

Elk Fed Days and Bison Fed Days

The BEMP and AMP implicitly assume that the transmission rate and prevalence of elk and bison diseases are density dependent and positively correlated with the number of elk and bison utilizing feedgrounds and the number of days they are fed. We further assume the variables elk-fed-eays (EFD) and bison-fed-days (BFD) are a proxy for these conditions. EFD and BFD will be calculated annually for each species based on the following formulas:

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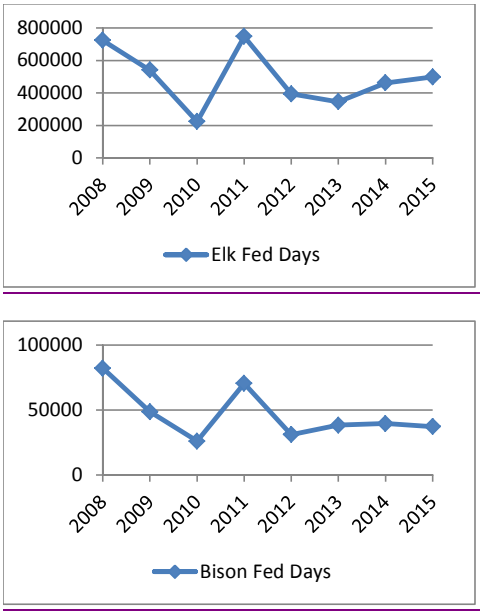

Figure14. Elk Fed Days (EFD) and Bison Fed Days (BFD) in the period following implementation of the Bison and Elk Management Plan and prior to the implementation of the Adaptive Management Plan (2008-2015). These values represent the pretreatment baseline which will be compared to the 3 year running average EFD and BFD post AMP implementation.

EFD= ∑ Total elk counted on feed during daily feedground counts for duration of feed season

BFD= ∑ Total bison counted on feed during daily feedground counts for duration of feed season

Because EFD and BFD are influenced by feed season length and the number of animals on feed, the AMP strategy of delaying the initiation of supplemental feeding will inherently reduce the number of EFD and BFD through a reduction in average feed season length. We believe that EFD will be further reduced by encouraging a greater proportion of the Jackson Elk Herd to winter on native winter range, thereby reducing the number of elk occupying NER feedgrounds. We will evaluate changes in EFD and BFD by comparing the 3-year running average post AMP implementation compared to mean EFD and BFD from 2008-2015. The running average is an appropriate comparison because it will help account for wide annual variation in EFD and BFD associated with winter severity (Fig. 14)

Elk Winter Mortality Monitoring

NER has used consistent methods to monitor winter elk mortality since 1982. Each winter NER biologists and other refuge staff conduct a survey of all non-hunting related winter elk mortalities that occur on NER from November through April. Mortalities are tallied by age/sex class and percent mortality is calculated using the corresponding number of elk classified on NER feedgrounds as the denominator. We will continue to monitor elk winter mortality using the same methods post AMP implementation, which will allow trend comparisons to the pre AMP baseline (Figure 15). Under the AMP framework, we believe the 3 year running averages for total and calf winter elk mortality will be within the range of variation exhibited by the pre AMP baseline. Historic monitoring suggests that calf and total mortality are sensitive to winter severity and disease outbreaks, and that winter mortality occasionally exceeds >3% total mortality and >10% calf mortality. Post AMP mortality in excess of these levels may warrant shortening the 2-week feeding initiation delay in subsequent years.

Elk Collaring

One of the AMP's principal strategies is to shorten the length of the feed season to encourage elk use of native winter range, but we anticipate that this strategy will also result in an increase in elk conflicts on surrounding private land in the town of Jackson and the Spring Gulch areas. To quantify this effect and provide real time information to WGFD and NER managers to facilitate a response, we propose maintaining a sample of 50 GPS collars on elk that winter on NER throughout the AMP implementation period.

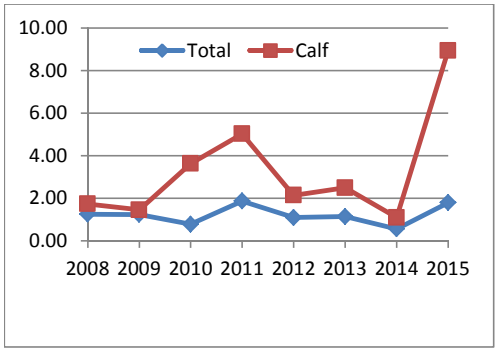

Figure15. Total and calf elk winter mortality (%) on NER in the period following implementation of the Bison and Elk Management Plan and prior to the implementation of the Adaptive Management Plan (2008-2015). These values represent the pretreatment baseline which will be compared to the 3 year running average post AMP implementation.

Forty -five elk represents approximately 0.5% (1 in 200) of the NER winter elk population. This sample size will not be sufficient to detect all elk movements from NER to surrounding private lands, particularly movements by small groups of mature bull elk, but it will be sufficient to detect and quantify significant movements of cow/calf/yearling elk groups compared to pre-AMP baseline data.

NER has elk GPS collar data available from the 2008-2013, which represents the post BMP, pre AMP baseline period. We hypothesize that elk movements from NER to surrounding private lands will increase during the AMP implementation period compared to the pre-treatment baseline. This will be tested by comparing the number of incidents that elk left NER for surrounding private lands (per elk/per year), and the proportion of elk GPS fixes on NER versus private lands during time periods of interest. The principal time period of interest is late December-March because this represents the period after the NER elk hunting season, and prior to and during NER feeding operations. This is the season when changes to the NER feeding program would be most likely to result in elk distribution changes.

Fifty adult cow elk will be captured on NER feedgrounds during February-March 2016 and Telonics Iridium GPS collars will be deployed with a 90 minute fix collection interval. Given 83% annual survival for adult cow elk in the Jackson Elk Herd (Cole and Foley et al. 2015) and 3 year collar life, approximately 10 additional elk will need to be collared each year in winter 2017 and 2018 to maintain the 50 elk desired sample size.

Ancillary data that will be collected and analyzed during the elk capture and collar data analysis process includes brucellosis seroprevalence, pregnancy rate, and elk summer range determination for comparison to the findings of Cole and Foley et al. (2015).

Disease

The primary purpose of limiting reliance on supplemental feeding is to reduce the prevalence of endemic elk and bison diseases and mitigate transmission risk associated with the introduction of novel diseases. We hypothesize that brucellosis seroprevalence will decline post AMP implementation. There are no recent brucellosis seroprevalence data for elk on the National Elk Refuge, but >50 elk will be captured during elk collaring operations in winter 2016, and each elk will be tested for Brucellosis exposure. The 2016 Brucellosis seroprevalence rate will be the pre-treatment baseline to evaluate post AMP change.

Chronic wasting disease (CWD) has been monitored in the JEH since 1997, and since 2008 it has been monitored with sufficient sample size to detect 1% prevalence with 95% confidence. No CWD positive cases have been detected in the JEH, which given the long term persistence of the disease, provides overwhelming evidence that CWD is not currently endemic to the JEH. However, most evidence suggests that the distribution of CWD is increasing and that its introduction to the JEH is inevitable. Early detection is critical to ensure an adequate

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management response, and therefore ongoing monitoring at sample sizes sufficient to detect 1% CWD prevalence with 95% confidence is necessary. CWD is sampled by testing tissues collected primarily from hunter harvested elk, and past experience suggests that 2 full time technicians working from September-December are necessary to ensure minimum sample size. Typical costs associated with 2 technicians are $32,000 per year.

EVALUATION/FUTURE MANAGEMENT

Modifying elk and bison behavior while reducing supplemental feeding will require a long-term, sustained commitment. Change is unlikely to happen fast, and interpreting effects of adaptive management actions will be complicated by varying environmental conditions from year to year. Consequently, we anticipate that the strategies outlined in this plan will be in place for a minimum of 5 years. Actions completed each year, the results of monitoring programs, and any proposed changes in course will be presented in an annual adaptive management update/report, completed by NER staff by the end of March for the previous year.

Investigating the potential effects of climate change on elk and bison management will be important in the long-term. During implementation of this plan, we will collect a variety of data that can be drawn upon for this purpose.

PUBLIC OUTREACH AND EDUCATION

The practice of winter feeding is inexorably woven into the historic fabric of Jackson Hole. Elk are identified with the rich and unique legacy for which Jackson Hole is known around the world. De-emphasizing the supplemental feeding program will be a major paradigm shift for the residents of Jackson Hole, Teton County, and the State of Wyoming.

An effective Public Outreach and Education program is essential for effective AMP implementation. The practice of feeding elk evokes passionate responses from those that oppose and those that support this practice. The general public and especially key stakeholder groups must understand the biological needs for and strategies of the AMP in order to gain general consent to modify longstanding elk/bison herd management methods.

A detail communication plan to guide outreach and education efforts can be found in Appendix 3.

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SCHEDULE

Table 6. Adaptive Management Plan proposed schedule.

Action	Date
GPS Collar 30-40 elk prior to strategy implementation (Iridium platform)	February 2016
Public outreach and education	March 2016
Initiate private lands conflicts mitigation contacts/actions	March 1, 2016
Implement enhanced forage monitoring	March 1, 2016
Initiate changes in supplemental feeding protocol	January 2017
Monitoring/Evaluation/Annual Report	June 2017

Table 7. Anticipated schedule of annual Adaptive Management Plan activities.

Activity	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
Elk and bison classification		x										
Irrigation						x	x	x	x			
Forage estimates	x	x	x	x								x
Etc…..												

[This table just for example. We could do the same with longer term schedule using years instead of months at the top if desired/necessary.]

BUDGET

Table 8. [incomplete]. Estimated Adaptive Management Plan budget above current expenditures, years 1-5.

Agency / Activity	Year 1	2	3	4	5
National Elk Refuge:					
Monitoring:					
Seasonal Biological Technician (0.5 FTE, GS-7)	24,000	25,000	26,000	27,000	28,000
Bison/elk fed days					
Mid-winter census					
Elk summer herd segment distribution[1]					
Expanded standing forage estimates[1]					
Chronic Wasting Disease, 2 seasonal biot-techs	32,000	32,000	32,000	32,000	32,000
Winter bison/elk distribution					
Irrigation					
50 Elk radio telemetry collars; Iridium Platform	$115,000	$25,000	$25,000	$25,000	$25,000
Bison barrier at NER south entrance	$80,000	$1,000	$1,000	$1,000	$1,000
Adaptive Management Plan annual reporting	$2,000	$2,000	$2,000	$2,000	$2,000
Private lands:					
Easements / Acquisition					
Damage reimbursements (Wyoming)					
Conflict mitigation coordination (Wyoming)	$91,000	$91,000	$91,000	$91,000	$91,000
Vegetation restoration/protection[1]					
Public Outreach and Education	$11,000	$1,000	$1,000	$1,000	$1,000
Subtotal					
Grand Teton National Park:					
Monitoring:					
Summer elk classification/distribution					
Hunter harvest					
Harvest age distribution					
Transition range forage production/utilization					
Vegetation Restoration/Protection					
Temporary bison fencing					
Hayfields restoration					
Exotic plant mitigation					
monitoring					
Elk Reduction Program					
Subtotal					
Wyoming Game and Fish Department:[2]					
Private lands:					
elk harvest coordination					
Easements / Acquisition					
Damage reimbursements					
Conflict mitigation coordination					
Add additional lines and categories as needed					
Subtotal					
Grand Total					

[1] See detail in Appendix

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APPENDIX 1. Summary of primary potential impacts associated with reduced supplemental feeding, as identified in alternative 4 environmental consequences section of the Final Bison and Elk Management Plan/Environmental Impact Statement (USFWS and USNPS 2007).

Populations

- Jackson elk herd objective of 11,000 would be maintained.
- New Jackson bison herd objective of 500 established.

Winter Feeding

- Supplemental feeding could be delayed or could occur earlier compared to current practices.
- Changes [to feeding program could] include alterations in the timing of feeding and providing supplemental feed in fewer years.
- Ration or pellet composition might need to be changed.
- Supplemental feeding would be initiated according to established criteria, including pre-winter forage production, assessments of forage utilization (done jointly by WGFD and NER personnel), elk condition and movements, and potentially on the January 1 index of winter severity calculations for elk (Farnes, Heydon, and Hansen 1999).
- Mechanical means could be used to increase forage access for elk after snow crusting events.
- Changes in the refuge supplemental feeding program could begin to affect elk nutrition (negligible adverse effect on NER elk from lower nutrition).
- Displacement of elk by bison during competition for standing forage would decrease as the bison herd is reduced.
- Aggressive social interactions involving competition for food among elk and bison would increase overall as feeding periods are reduced.

Winter Distribution

- Elk densities on the NER would decline due to more reliance on standing forage and wider distribution.
- Elk use of lands surrounding the NER would increase, including:
    - USFS lands east of the NER
    - Gros Ventre feedgrounds possibly
    - Southern GTNP
    - State feedgrounds south of the NER
- Most of winter distribution shift would involve elk in the Yellowstone, Teton Wilderness, and Gros Ventre segments.
- As ungulate numbers decreased and supplemental feeding was reduced, competition and aggressive social interactions on the refuge would also be reduced.
- Elk and bison distribution would increase as the animals relied more on native winter range.
- Fewer animals would be present on the refuge.

Mortality

- As supplemental feeding is reduced, natural factors such as climate and native forage availability would have a greater influence on numbers, movements, distribution, and mortality.
- More elk would be subject to natural factors affecting mortality, including loss of body condition, predation, and starvation.
- Increased mortality on and off the refuge would mainly affect older elk and calves, and some prime bulls entering the winter energetically stressed due to rut activities.

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- Late winter calf ratios could decrease as a result of higher winter calf mortality
- Average winter mortality on the refuge would increase from 1%–2% annually to an estimated 1%–5%.
- Overall, a higher total winter mortality rate of approximately 5% could be expected.

Disease

- Reductions in supplemental feeding or elk numbers would reduce the potential for impacts due to tuberculosis, septicemic pasturelosis, and CWD.
- The health and sustainability of the Jackson elk herd would be increased gradually as supplemental feeding was reduced and there was greater reliance on standing forage and wider ungulate distribution.
- Health and sustainability of the Jackson elk herd would be enhanced in the long term.
- Wider distribution of elk would result in moderate reductions in both the prevalence and potential transmission of brucellosis, as well as potential for spread of diseases not yet in the population.

Private Lands

- The agencies would work closely with the WGFD and landowners, including livestock producers, to coordinate actions that would prevent conflicts due to elk dispersal and to defray costs of managing potential conflicts. Preventing access to food/hay rewards on private lands would be vital for effective management.
- Private land conservation easements within NER boundaries would promote wider distribution.

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APPENDIX 2. Monitoring Supplemental Materials: Feeding Initiation Methods

At each sample site, 10 subplots will be measured at every 5 steps along the random bearing determined for each site. At each subplot a 13.27" diameter metal sampling ring will be placed on the ground. The amount of forage available to elk within the sampling ring (dry weight in grams) will be visually estimated. The 13.27" diameter subplot allows easy conversion from grams to lbs. per acre (each gram is equivalent to 100 lbs. per acre). During annual forage production sampling, refuge biologist Eric Cole has made approximately 1,000 of these visual estimates per year for 17 years, and 33% of Cole's estimates have been verified by clipping and weighing. Therefore, Cole will be the principal estimator, but additional personnel will be trained in these techniques to provide redundancy in the event of personnel changes, and to increase the number of observers to facilitate estimation of error.

Estimating available forage within the sample ring at each subplot is relatively straightforward when snow cover is limited, but estimating how much of the forage is accessible to elk when snow is dense, deep and crusted can be subjective. To decrease the subjectivity of the estimation process, if the area under the sample ring is covered with snow, only forage that can be exposed with a gloved hand will be included in the estimate of available forage. Forage that is fouled with manure and/or flush with the ground due to trampling and/or encrusted in ice will not be included in the estimate of available forage.

At each subplot the estimate of available forage (dry weight g) will be converted to an equivalent lbs./acre value (1 gram=100 lbs./acre). The arithmetic mean of available forage (lbs./acre) for the 10 subplots provides an estimate of available forage for each index site. There are 3 sample site categories: 1) Historic Key Index Sites that have been used since 2007, 2) New randomly selected sites within areas preferred by elk, and 3) New randomly selected sites in areas not preferred by elk. Historic key index sites were not randomly selected, but were instead selected to represent areas most preferred by elk on the south end of NER. These were the sites used to determine when supplemental feeding would be initiated from 2007 until the implementation of the AMP. To facilitate comparison with pre-AMP data, we will continue to use mean lbs. per acre across historic key index sites to determine the 300 lbs. per acre threshold. However, post AMP implementation we will delay feeding initiation by 2 weeks once the 300 lbs./acre level has been reached. We will concurrently sample at randomly selected sites stratified on an annual basis between areas highly preferred and not highly preferred by elk. This will enable us to quantify the relationship between mean forage availability at historic key index sites and random sites over time.

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APPENDIX 3. Communication Plan

Communication Goals

Prior to the Adaptive Management Plan's Implementation

- Utilize a variety of outreach methods to inform the public on the goals and timing of the Adaptive Management Plan's implementation and possible effects on wintering herds.
- Utilize a variety of outreach methods to inform the public on public comment opportunities.
- Identify and coordinate key messages and outreach with USFWS regional and national offices, State and federal agency partners, non-profits, elected officials, and other identified audiences.

During the Adaptive Management Plan's Implementation

- Continue to utilize a variety of outreach methods to describe current management actions as well as measurable and noticeable changes on the landscape, in animal behavior, or in animal health.
- Provide a comprehensive overview of the Adaptive Management Plan by providing links and references to previous outreach and background information.

Communication Objectives

- Work with current media contacts to promote news of the Adaptive Management Plan via print, radio, Web, and social media platforms.
- Utilize new media and social media tools to provide information on why the Adaptive Management Plan was developed, what public comment opportunities exist, and how the plan is being implemented.
- Plan, coordinate, and execute public meetings to allow for public comment and questions on the plan.
- Develop and provide methods for the public to submit written comments on the Adaptive Management Plan.
- Monitor print media on Refuge elk and bison management to see how Adaptive Management Plan objectives and reactions are being portrayed to the public.

Current Outreach Resources

- National Elk Refuge web site
- National Elk Refuge news release list
- (approximately 300 contacts)
- National Elk Refuge Twitter site (1,039 followers)
- Bison and Elk Management Plan web site (http://www.fws.gov/bisonandelkplan/)
- Space for an 11" x 17" poster in the Visitor Center on Refuge management topics
- Display panels in the Visitor Center theater for temporary displays

Available Supporting Outreach Resources

- USFWS Mountain–Prairie External Affairs staff
- USFWS Mountain–Prairie web site, including the
- "Top Stories" feature

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- USFWS Mountain–Prairie Twitter site USFWS Mountain-Prairie Region Facebook page
- USFWS National Wildlife Refuge System
- Facebook page
- USFWS Facebook page

Previous Outreach Efforts

- NER routinely writes and disseminates news releases on Refuge management activities, including the Comprehensive Conservation Plan, supplemental feeding, herd health monitoring, and forage production.
- Post the above news stories as Content.
- Management System (CMS) articles.
- Post CMS news story promos so they prominently appear on the home page, linking readers to the articles.
- Send out Twitter messages linking viewers back to the news stories.
- Prepare, upload and provide links to Adobe PDF versions of news stories with addtional photos where additonal images are available and/or help understand or visualize the content.
- Utilized the Conservation link on the web Content
- Management System to post information about the Bison and Elk Management Plan and the draft Comprehensive Conservation Plan.
- Retained and provided a link to the original Bison and Elk Management web page (http://www.fws.gov/bisonandelkplan/) that was developed during the planning process. The web site includes links to the Final Plan/EIS, Record of Decision, Federal Register Notice of Availability for both the Record of Decision and Final Plan/EIS, associated news releases, public meeting highlights, and other related documents. Note: the National Elk Refuge does not manage the site.

Additional Outreach Opportunities

- Public meetings in Jackson and other identified locations.
- Service produced video; video could be posted to the National Elk Refuge's multimedia web page, or USFWS Mountain–Prairie home page "Top Video" feature.
- Live radio interview on KHOL (Jackson, WY radio)
- Wyoming Public Radio interview with Refuge management staff
- Interviews with local print media sources
- Updates at community leader meetings such as Rotary Club, Jackson Hole Chamber of Commerce board meetings, and interagency breakfast meetings (with Federal agencies and local elected officials).

Target Audiences

Internal

- Regional and National USFWS Leadership
- Refuge permanent staff
- Refuge seasonal staff
- Refuge volunteers

External

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- Congressional representatives
- State of Wyoming leadership
- Federal agency partners, particulary Grand Teton National Park and the Bridger–Teton National Forest
- Wyoming Game & Fish Department
- Other NER partners, including county and town agencies and local nonprofit organizations
- Local elected officials
- Private landowners in proximity to the National
- Elk Refuge or neighboring Federal lands
- Tribes
- Local and state media
- Local public

Key Outreach Topics

- Overview of BEMP objectives
- Strategy to change elk/bison behavior
- Threat of disease
- Natural mortality rates
- Anticipated winter distribution changes for bison/elk
- Mitigate negative effects on private lands
- Change elk behavior and distribution while avoiding increased mortality.
- Explain the historic reasons a supplemental feeding program began and why it was continued.
- Explain the NER's limited large ungulate carrying capacity and the disproportionate impact of bison on available forage; 3 elk = 1 bison.

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APPENDIX 4. Models

Elk winter distribution model

The proportion of the JEH that winter on the NER will be linked to factors hypothesized to influence elk winter distribution (Fig. 2) using a generalized linear mixed effects model (GLMM). A GLMM can account for a proportional response variable (i.e., constrained to the interval 0–1) using a log link and binomially-distributed errors. A GLMM also includes fixed and random effects, with the latter capturing residual model variance otherwise not explained by fixed effects. Year will be including as a random effect, providing several benefits. First, we don't assume years are independent and comprise all of the factor levels of interest. Instead, the effect of year is treated as a random variable, with individual year effects realizations of that distribution. This allows inference to non-sampled factor levels, i.e. years, by estimating a latent population-level proportion of elk expected to winter on the NER regardless of fixed effect influences. Thus, the random year effect can be considered a latent variable describing elk behavior manifested as observed winter distribution. Second, because year effects are not treated as independent, estimated effects of year on the proportion of JEH elk wintering on the NER are dependent on all factor levels, leading to greater precision when estimating individual year effects (Kéry 2010).

The full GLMM incorporating fixed effects for each factor identified as influencing elk winter distribution (Fig. 2) is:

$$P_t = \beta_{0(t)} + \beta_1 * AFI_t + \beta_2 * SDM_t + \beta_3 * WP_t + \beta_4 * GSP_t + \beta_5 * SWE_t + \varepsilon_t$$

where the random intercept and residual model variance are

$B_{0(t)} \sim N(\mu_{\beta_0}, \sigma^2_{\beta_0})$, and

$\varepsilon_t \sim N(0, \sigma^2)$, respectively.

Fixed effects include 1) per capita available forage at initiation of winter feeding (*AFI*) , 2) proportion of the JEH that are short-distance migrants (*SDM*), 3) number of wolf packs present on JEH native winter range (*WP*), 4) growing season (May–August) precipitation for the Wyoming Snake Drainage climate division (*GSP*; a proxy for available forage on native winter range), and 5) snow water equivalent on 1 January at Thumb Divide (*SWE*; a proxy for early winter severity).

Elk calf winter survival and forage deficits

The Forage Accounting Model of Hobbs et al. (2003) has as an output weekly available forage biomass for the NER (sum of predictions for 30 × 30 m cells). These predictions account for snow conditions using a proxy of SWE and decrement total available biomass by 35% to account for unpalatable plants within the total estimate.

While calf survival is a function of multiple factors (Fig. 3), the primary management action influencing calf survival is supplemental winter feeding. Current winter feeding initiation criteria lead to calf survival generally higher than in unfed populations. Proposed feeding initiation criteria will result in later

Comment [WJ5]: I'm not comfortable with this interpretation yet and need to think about it some more.

Comment [WJ6]: This doesn't currently have a term for hunting, although our conceptual model above does. Need to decide if we want to include or exclude here.

Comment [WJ7]: Will need a more formal explanation of these variables and how they will be collected. May fit best in the monitoring section.

Comment [WJ8]: If we use Hobbs' model for predicting available forage these may be redundant.

Comment [WJ9]: Put in winter feeding initiation paragraph above? Then note where more samples are necessary to improve the precision of the estimates. Need to run this model from 2007 forward to see where, on average, feeding was initiated so we can make treatment adjustments as necessary. This would also allow us to look at the relationship between key index sites estimates and Hobbs' predictions. Need to consider validating Hobbs' model with field sampling Eric is currently designing to see if we can use the Hobbs model moving forward. This would take some time with stripping the Hobbs model down to our needs, identifying data sources, and developing a workflow process so weekly estimates of available forage can be calculated. Would only be able to use snow data from SNOTEL sites that have data available online, which shouldn't be too much of a problem.

Comment [KD10]: Need a citation here.

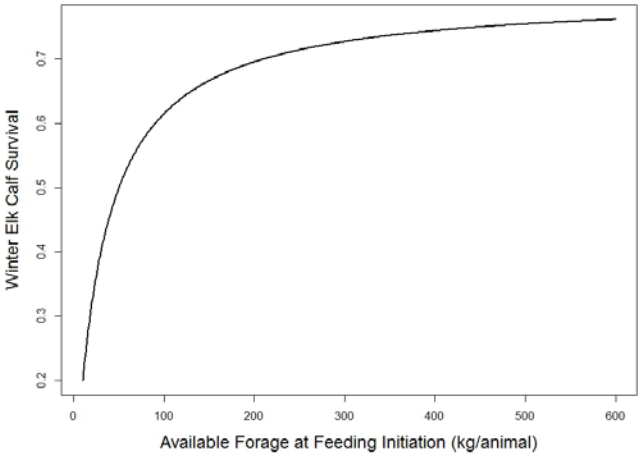
DRAFT

initiation of supplemental feed, which will be most influential to calf survival. There is currently little understanding regarding the relationship between initiation of winter feeding and calf survival, except that current feeding initiation criteria result in high calf survival. We believe a threshold level of available forage at initiation of winter feeding exists such that winter calf survival reaches an asymptote. Below this threshold, calf survival is hypothesized to decline quickly with reductions in available forage at winter feeding initiation. Available forage at the initiation of winter feeding will be related to on elk calf winter survival using a saturating function (i.e., Holling type-II functional response; Fig. 6) by

$$S_t = \frac{aAFI_t}{b + AFI_t}.$$

The parameters *a* and *b* determine how calf survival is related to available forage. Maximum calf survival is *a*, and *b* represents the value of available forage to an individual when survival is 50% of *a* (Hilborn and Mangel 1997).

Although this approach doesn't capture forage deficits *per se*, it does provide a potentially sensitive proxy for this concept. It is assumed that a forage deficit for calves would occur at a point on the curve of the relationship between calf survival and available forage at initiation of supplemental feeding. Modeling the response of winter calf elk survival to changes in feeding initiation criteria facilitates our ability to maximize the influence of feeding initiation criteria on winter distribution while minimizing the likelihood of a large mortality event.



Hypothesized relationship between winter survival of elk calves and per capita available forage at initiation of winter feeding on the National Elk Refuge.

From:	Steve Kallin
To:	Brad Hovinga
Cc:	doug.brimeyer@wyo.gov
Subject:	RE: FW: Bison & Elk Management Plan (BEMP) Step Down Plan Meeting
Date:	Monday, May 23, 2016 2:36:44 PM
Attachments:	NER AMP Draft v2.2 8-24-15.pdf

Hi Brad:

I saved the Word document in a pdf format. I believe that's what we did last time. Let me know if this works.

Thanks,

Steve Kallin
Project Leader
National Elk Refuge
PO Box 510
675 East Broadway
Jackson, WY 83001
Phone: (307) 201-5409
Fax: (307) 733-9729
steve_kallin@fws.gov

From: Brad Hovinga [mailto:brad.hovinga@wyo.gov]
Sent: Monday, May 23, 2016 2:04 PM
To: Steve Kallin
Subject: Re: FW: Bison & Elk Management Plan (BEMP) Step Down Plan Meeting

Steve - for what ever reason, I cannot open the file. Seems like we had this problem before, although I can't remember what we did about it.....

On Mon, May 23, 2016 at 1:43 PM, Steve Kallin <steve_kallin@fws.gov> wrote:
Sorry! I forgot to attach the draft plan.

Steve Kallin
Project Leader
National Elk Refuge
PO Box 510
675 East Broadway
Jackson, WY 83001
Phone: (307) 201-5409
Fax: (307) 733-9729
steve_kallin@fws.gov

From: Steve Kallin [mailto:steve_kallin@fws.gov]
Sent: Monday, May 23, 2016 11:49 AM
To: Dale Deiter (ddeiter@fs.fed.us); 'Murphy, Kerry M -FS'; 'sarah_dewey@nps.gov'; David Gustine; Brad Hovinga (brad.hovinga@wyo.gov); 'doug.brimeyer@wyo.gov'; 'Steve Cain'; Cris Dippel; Eric Cole; Steve Kallin
Subject: Bison & Elk Management Plan (BEMP) Step Down Plan Meeting

Hello Everyone:

We are ready to resume the agency planning effort for the BEMP Step Down Plan. Please provide your availability through the doodle poll link below and complete at your earliest opportunity. We hope to schedule this meeting early next month, so it would be very helpful to complete the poll in the next several days.

http://doodle.com/poll/7ywxn4t9q79s8739

Attached is a copy of the latest DRAFT Step Down Plan (August 24, 2015) in case you would like to refresh your memory after our long hiatus. I will be sending out a meeting agenda later this week.

Thank you for your continued support and contribution to this planning effort. I am optimistic a draft ready for agency review can be completed in several meetings.

Take care,

Steve Kallin
Project Leader
National Elk Refuge
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675 East Broadway
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--

Brad Hovinga
Wyoming Game and Fish Department
Regional Wildlife Supervisor
Jackson Region
Jackson, WY
(307) 733-2321

E-Mail to and from me, in connection with the transaction of public business, is subject to the Wyoming Public Records Act and may be disclosed to third parties.

From:	Steve Kallin
To:	Brad Hovinga; Doug Brimeyer; Susan (Sue) Consolo-Murphy; Sarah Dewey; Dale Deiter; Kerry Murphy; Jeffrey Warren; Cris Dippel; Eric Cole; Steve Cain
Subject:	Draft Adaptive Management Plan Review for August 3, 2015 Team Meeting at 12:30 PM
Date:	Friday, July 24, 2015 3:47:01 PM
Attachments:	NER AMP Draft v2.0 7-24-15.docx

Hi AMP Team:

Attached is the latest draft of the AMP for your review prior to the August 3 meeting.

There are several sections that are incomplete in this document. I would like to invite the WGFD and GTNP to populate the budget table (using track changes) for your anticipated expenses and add additional expenses that may not be identified in the table. You should estimate how much you believe these specific activities will cost, not how much you believe you can obtain from your agency. The source of the funding will be determined at a later time.

Also, I believe GTNP would like to add information about vegetation restoration. Please add that info using "track changes" on pages 11 and 17.

A number of you will be unable to make the August 3 meeting. Incorporating your feedback and suggested changes into the August 3 discussion would be extremely valuable. Please send your feedback/changes to this document, using track changes, to me prior to the meeting.

Thank you again for all of your assistance. Look forward to seeing you on August 3!

Steve Kallin
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U.S. Fish and Wildlife Service National Park Service

BISON AND ELK
MANAGEMENT STEP DOWN PLAN

A Structured Framework for Reducing Reliance on Supplemental Winter Feeding

National Elk Refuge

Grand Teton National Park

DRAFT

July 24, 2015

BISON AND ELK

MANAGEMENT STEPDOWN PLAN

For the

National Elk Refuge,

Grand Teton National Park,

John D. Rockefeller, Jr. Memorial Parkway

Teton County, Wyoming

DRAFT

***Suggested Citation**:* U.S. Fish and Wildlife Service: 2015. Bison and elk management stepdown plan, National Elk Refuge and Grand Teton National Park. U.S. Department of the Interior, Washington D.C. Available online at:

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Appendix I. Summary of primary potential impacts associated with reduced supplemental feeding, as identified in alternative 4 environmental consequences section of the Final Bison and Elk Management Plan/Environmental Impact Statement (USFWS and USNPS 2007)**.** .....

Appendix 2. Monitoring Supplemental Materials: Feeding Initiation Methods**.....**

Appendix 3. Communication Plan**.....**

Appendix 4. Models.....

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EXECUTIVE SUMMARY [incomplete]

Comment [S1]: Steve K, my view on this is that it should be relatively short, because this is not a long document. I am thinking perhaps 2-3 pages max. What are your thoughts?

Overview

In 2007, the National Elk Refuge (NER) and Grand Teton National Park (GTNP) published a Record of Decision (ROD; USFWS and USNPS 2007a) for a bison and elk management plan. The Bison and Elk Management Plan (BEMP; USFWS and USNPS 2007b) was developed to guide management of the Jackson bison and elk herds on NER and GTNP lands, focused on four broad goals related to: 1) habitat conservation; 2) sustainable populations; 3) numbers of elk and bison; and 4) disease management. The final plan directed the NER and GTNP (in conjunction with the Wyoming Game and Fish Department; WGFD) to maintain the state's elk herd objective of 11,000, establish a bison population objective of 500, restore habitat on the NER and in GTNP, continue hunting bison and elk on the NER, continue the elk reduction program, when necessary in GTNP, continue to vaccinate elk for and effective vaccine becomes available, and develop a dynamic framework and adaptive management plan for decreasing the need for supplemental feeding on the NER. ***This Bison and Elk Management Stepdown Plan was developed to address the latter and specifically addresses the criteria for a structured framework referenced in the Record of Decision.***

Background

Winter feeding of elk in Jackson was originally initiated to reduce winter mortality of elk and minimize depredation of ranchers' hay. The loss of available winter range in Jackson Hole due to new ranching operations and a growing town resulted in significant numbers of elk dying during several severe winters in the late 1800s and early 1900s. This prompted local citizens and organizations, as well as state and federal officials in Jackson Hole, to begin feeding elk in the winter of 1910–11. Congress heeded the appeals for assistance and on August 10, 1912, established the National Elk Refuge. Today, the need for the refuge's winter elk feeding program is a direct result of reduced access to significant parts of elk native winter range, loss of historic migration patterns, behavioral conditioning of elk to winter feeding, and the desire to maintain a population objective established in the context of supplemental feeding.

Bison were extirpated outside Yellowstone National Park (YNP) by the mid-1880s but in 1948 were reintroduced to Jackson Hole when 20 bison from (YNP) were released near Moran, Wyoming. The herd remained small until discovering elk feedlines in 1980, when the population began sustained population growth. Bison and elk that winter on the NER are migratory and occupy summer ranges predominantly to the north.

Objectives

This adaptive management plan addresses several objectives under a broader BEMP goal of sustainable populations, which directed the agencies to: 1) Develop an adaptive management plan for reducing NER supplemental feeding; 2) [implement a] phased reduction of animals on feed: a) to 5,000 elk and 500 bison, and b) [to a point where] elk and bison rely predominantly on native habitat; 3) maintain natural elk bull-to-cow ratios in park summer herd; and 4) Enhance public outreach/education. The BEMP further stated that consideration criteria for implementing the 2nd phase of reduced feeding will include: 1) the level of forage production and availability on the National Elk Refuge and adjacent winter ranges, 2) maintenance of desired herd sizes and age/sex ratios, 3) the ability to effectively mitigate bison and elk livestock conflicts, such as co-mingling on private lands during high risk disease transmission periods, 4) maintaining desirable winter distribution patterns of elk and bison, 5) the prevalence of brucellosis, chronic wasting disease, and other wildlife diseases, and 6) public support. **In short, the overall objective of this plan is to provide a path for progressively**

Comment [S2]: Problem here

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transitioning from winter feeding of elk and bison on the NER to greater reliance on free-standing forage, while maintaining population and herd ratio objectives.

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INTRODUCTION

In 2007, the National Elk Refuge (NER) and Grand Teton National Park (GTNP) published a Record of Decision (ROD; USFWS and USNPS 2007a) for a bison and elk management plan. The Bison and Elk Management Plan (BEMP; USFWS and USNPS 2007b) was developed to guide management of the Jackson bison and elk herds on NER and GTNP lands. It included directives for forthcoming development of adaptive management practices to address several objectives in the plan, including a desired future condition of elk and bison relying predominantly on native forage. This Bison and Elk Adaptive Management Plan has been developed expressly for that purpose.

Bison and Elk Populations

While Jackson Hole is probably best known for the splendor and ruggedness of the Teton Range, the Jackson bison and elk herds rank among the top characterizing features of the valley. Both figure prominently in Jackson Hole's history and culture, although bison were absent from the valley for about 100 years between the mid-1800s and mid-1900s.

The Jackson elk herd occupies approximately 8,000 km^2 in the upper Snake River watershed north of the town of Jackson (Fig. 1). Much of the herd is migratory, moving between distinct wintering and summer ranges. Primary wintering areas include the Buffalo Valley, lower elevations of the Gros Ventre River drainage, the National Elk Refuge (NER), and areas adjacent to the NER on Bridger-Teton National Forest (BTNF) lands. Summering areas occur throughout the herd's range and for convenience are divided into four geographic regions that include Grand Teton National Park (GTNP), Yellowstone National Park (YNP), the Gros Ventre drainage, and Teton Wilderness.

In the late 1800s, when elk populations all over North America were being extirpated, the residents of Jackson Hole protected elk from "tusk hunters" and large-scale commercial hunting operations. Elk are just as important to today's residents of the valley. Thousands of people each year have the opportunity to see elk at close range on the refuge while riding on horse-drawn sleighs. Thousands of pounds of shed elk antlers are sold at an annual antler auction each spring in the town square. Elk are important to backcountry users as well as to people that never leave the road. Jackson Hole is a popular destination for instate and out-of-state elk hunters. The draw of elk to visitors contributes significantly to the local economy.

Winter feeding of elk in Jackson Hole began in 1910 and was originally initiated to reduce winter mortality of elk and minimize depredation of ranchers' hay. According to historical reports, before Euro-American settlement some Jackson elk wintered in the southern portion of Jackson Hole (present location of the NER town of Jackson) and may have used areas outside Jackson Hole, including the Green River and Wind River basins to the south and east, respectively, and the Snake River basin to the southwest in what is now eastern Idaho (Allred 1950; Anderson 1958; Blair 1987; Barnes 1912; Sheldon 1927). Radio-collar studies have documented small numbers of Jackson elk wintering in each of these areas in recent times as well (*citations*). Over time, changes in land use and development in these areas, over hunting, and establishment of feedgrounds probably reduced the use of these areas by Jackson elk.

By the end of the 19th century the Jackson elk herd was believed to be largely confined to Jackson Hole and the immediately surrounding area, where wintering conditions are often harsh. Compounded by the loss of available winter range in Jackson Hole due to new ranching operations and a growing town, significant numbers of elk died during several severe winters in the late 1800s and early 1900s. This prompted local citizens and organizations, as well as state

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and federal officials in Jackson Hole, to begin feeding elk in the winter of 1910–11. Congress heeded the appeals for assistance and on August 10, 1912, appropriated $45,000 for the purchase of lands and maintenance of a "winter game (elk) reserve" (37 Stat. 293). The first winter census in the area was conducted in 1912 and showed about 20,000 elk residing in Jackson Hole and the Hoback River drainage.

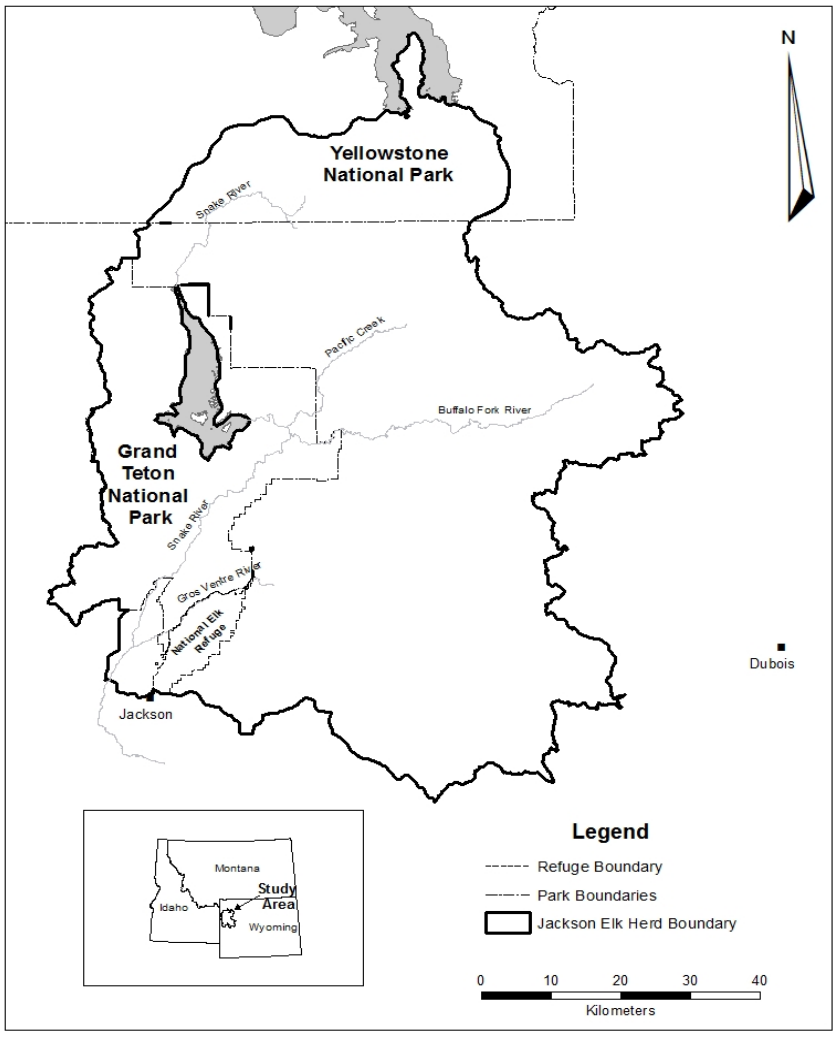

Figure 1. Jackson elk and bison herd ranges, including the National Elk Refuge, Grand Teton and Yellowstone National Parks, and Bridger-Teton National Forest. [include bison range, labels for continental divide and Bridger-Teton National Forest, and in Legend Jackson elk herd unit].

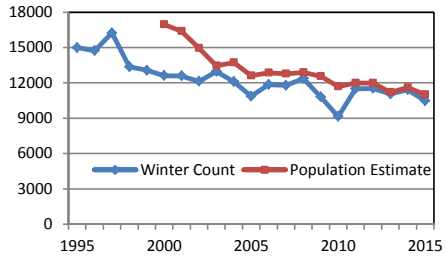

Figure 2. Winter counts and population estimates for the Jackson elk herd, 1995-2015.

Today, the need for the refuge's winter elk feeding program is a direct result of reduced access to significant parts of elk native winter range, loss of historic migration patterns, behavioral conditioning of elk to winter feeding, and the desire to maintain a population objective established in the context of supplemental feeding. Its population in recent times has fluctuated both above and below its herd objective of 11,000 adopted by the WGFD (Fig. 2)

An iconic symbol of the American West, bison are also popular with visitors and residents. Because so few opportunities remain to see bison in the wild, viewing and photographing them in Grand Teton National Park with the Teton Range in the background is a treasured opportunity for many of the valley's visitors. Similar to elk, there is also a high level of interest in bison hunting. Bison are of particular interest to nearby American Indian tribes and tribes in other parts of the United States because the animals are central to their culture and tradition.

Bison are native to Jackson Hole, as evidenced by the presence of prehistoric bison remains throughout the valley, but were extirpated outside Yellowstone National Park by the mid-1880s. In 1948, 20 bison from Yellowstone National Park (YNP) were reintroduced to the 1,500-acre Jackson Hole Wildlife Park near Moran. The Jackson Hole Wildlife Park was a private, non-profit organization sponsored by the New York Zoological Society, the Jackson Hole Preserve, Inc., and the Wyoming Game and Fish Department (WGFD). A population of 15–30 bison was maintained in a large enclosure there until 1963, when brucellosis was discovered in the herd (likely transferred with the original 20 animals from YNP). At that time, all the adult animals were destroyed, but four vaccinated yearlings and five vaccinated calves were retained. In 1964 twelve certified brucellosis free bison from Theodore Roosevelt National Park were added to the herd. In 1968 the herd (down to 11 animals) escaped the confines of the wildlife park, and a year later the decision was made to allow them to range freely. The expansion of GTNP in 1950 had enveloped the Wildlife Park, and allowing the bison to free range was and remains consistent with National Park Service wildlife management policy. The herd remained small and wintered mostly in the Snake River bottoms in GTNP until 1975, when it followed the winter environmental gradient to the NER and began wintering there. The use of standing forage by bison on the NER was viewed as natural behavior thus acceptable to managers. In 1980, however, bison discovered and utilized supplemental feed provided for elk, and they have continued to do so every winter since.

The discovery of supplemental feed by bison has had several consequences, including a significant increase in the population's growth rate (Fig 3). Bison on the elk feedlines have at times disrupted feeding operations and displaced and injured elk. To minimize conflicts between bison and elk, managers have provided separate feedlines for bison since 1984. As the population has grown, separating elk and bison on feedlines has become increasingly difficult, and a variety of feeding strategies are employed to help reduce displacement of elk.

As the herd has grown it has maintained fairly stable movement patterns, wintering almost entirely on the NER and summering within GTNP and adjacent lands on the BTNF (Fig. 1).

Planning History

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Jackson's bison and elk populations have been the subject of previous planning efforts. Elk management and research has been guided by the Jackson Hole Cooperative Elk Studies Group since it was established in 1953 [verify date]. The group consists of biologists and agency administrators from the National Elk Refuge, Grand Teton and Yellowstone National Parks, the Bridger-Teton National Forest, and Wyoming Game and Fish Department, who meet at least annually to coordinate management of the population and its habitat. Coordination of bison management began soon after they started frequenting the NER in 1976 and using supplemental feed provided to elk in 1980 (Fig. 3). Release of an "Interim" plan that called for maintaining a herd of 90-110 bison while data were gathered for a long term plan occurred in 1988. It was followed by implementation of a sport hunt administered by WGFD. This plan was halted after litigation in which the plan's violation of NEPA was successfully argued by plaintiffs.

In 1996, after considerable herd growth, a new long term management plan and environmental assessment for the Jackson bison herd was released (Fig 3). This plan had strong support and called for maintaining a herd size of 350-400 bison, but it was shelved a year later when plaintiffs from the earlier litigation successfully argued that, because the plan failed to consider the effects of feeding elk on bison management, it also violated NEPA and was not sufficient. This led to development of the draft bison and elk management plan and environmental impact statement from 2000-2006 and release of the final plan in 2007 (Fig 3).

The 2007 Bison and Elk Management Plan (BEMP; USFWS 2007) considered six alternatives for

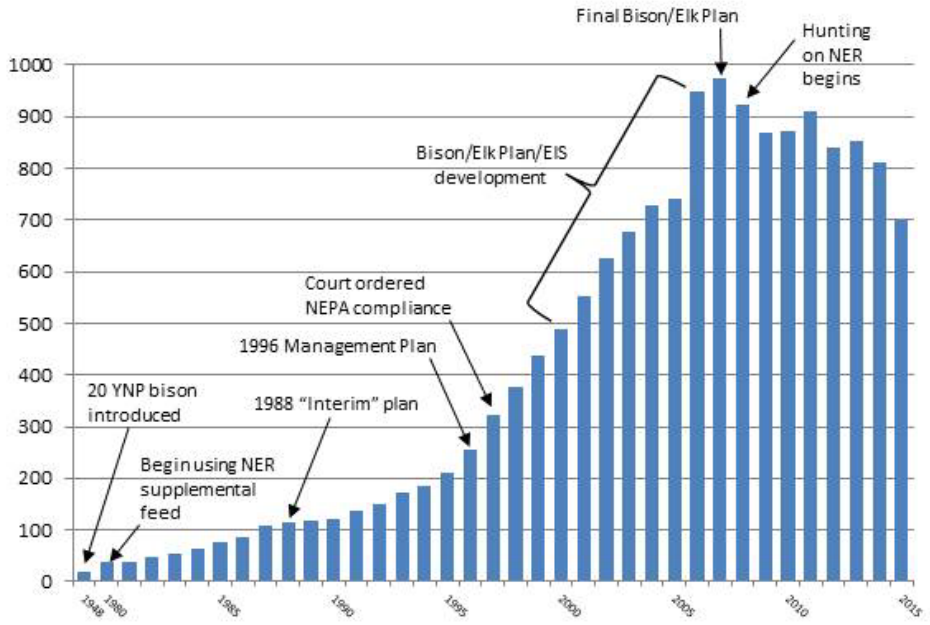

Figure 3. Population growth and planning history for the Jackson bison herd, 1948-2015.

bison and elk management focused on four broad goals related to: 1) habitat conservation; 2) sustainable populations; 3) numbers of elk and bison; and 4) disease management. The primary management scenarios presented in the alternatives included the status quo, terminating elk and bison hunting on the NER and the elk reduction program in GTNP, brucellosis vaccination options, restoring habitat, improving forage, and decreasing or phasing out supplemental winter feeding.

The final BEMP (USFWS 2007; www.fws.gov/bisonandelkplan) which set management direction for 15 years or until a subsequent plan is developed, proposed to maintain the state's elk herd objective of 11,000, establish a bison population objective of 500, restore habitat on the NER and in GTNP, continue hunting bison and elk on the NER, continue the elk reduction program in GTNP, when necessary, in concert with the parks enabling legislation (citation), continue to vaccinate elk for and effective vaccine becomes available, and develop a dynamic framework and adaptive management plan for decreasing the need for supplemental feeding on the NER. ***This Bison and Elk Management Stepdown Plan was developed to address the latter and specifically addresses the criteria for a structured framework listed on page 5 of the Record of Decision*** **(Fig. 4).** It does not address other on-going bison and elk management actions already prescribed by the BEMP.

The BEMP scheduled the completion of an Adaptive Management Plan for 2008. However, litigation challenging the BEMP in 2008 led to the decision to postpone its development until litigation was resolved. As of March 2015, two court rulings have upheld the 2007 BEMP and ROD. In a lawsuit against the BEMP and its author agencies (Defenders of Wildlife et al. v. the U.S. Department of Interior and State of Wyoming 2010), plaintiffs argued that the BEMP violated the National Wildlife Refuge System Improvement Act (National Wildlife Refuge System Improvement Act 1997) by disrupting the biological integrity of the Refuge, and that the plan and the accompanying EIS violated NEPA because they were insufficiently detailed to allow a reasonably complete discussion of mitigation. The crux of the plaintiff's argument was that the plan did not set a specific date for the cessation of supplemental feeding. In response, the agencies argued that the plan constituted a valid exercise of discretion and that it and the EIS were sufficiently detailed to satisfy the requirements of NEPA. In March 2010 the United States 4th District Court sided in favor of the agencies in this case. In 2011 the plaintiffs appealed this ruling to the United States 4th Circuit Court. The Circuit Court affirmed the District Court ruling (Defenders of Wildlife et al. v. the U.S. Department of Interior and State of Wyoming 2011).

National Environmental Protection Act Compliance

The 2007 BEMP/EIS and Final Record of Decision (ROD) satisfied NEPA requirements for current bison and elk management through a detailed analysis of alternative management actions and their likely effect on the environment, and substantial involvement of the public in the process. This adaptive management plan is does not duplicate or add to this process. It is designed to carefully tier off of the BEMP as a dynamic implementation guide to one part of the preferred alternative outlined in the BEMP ROD. As such, references to NEPA covered in the BEMP will be included where necessary in this document, and the discussion of any action that would require additional NEPA compliance will be explicitly stated as such in that context.

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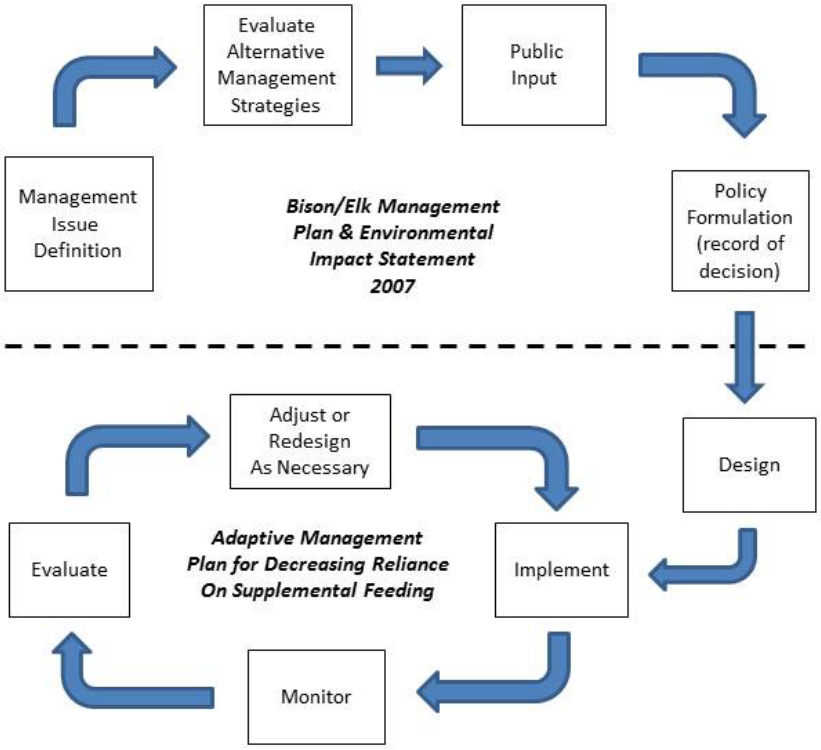

Figure 4. Adaptive management planning for supplemental feeding on the National Elk Refuge and its relationship to the 2007 Bison/Elk Management Plan and Environmental Assessment.

Adaptive Management Planning

Adaptive management plans have gained popularity in natural resource management planning because, by definition, they allow modifications of strategy based on monitoring results and outcomes toward reaching specific goals or objectives. There are four essential elements to an adaptive management approach: 1) well defined and mutually agreed upon objectives, 2 knowledge (including descriptive models) of the dynamics of the system being managed, 3) clearly articulated management actions and strategies, and 4) a monitoring program to evaluate responses of the system to management actions (Walters 1986).

This step-down plan utilizes adaptive management planning principles but is not intended to meet all of the adaptive management planning elements outlined in the Department of Interior Adaptive Management Technical Guide (2007). This Step-Down Plan is more accurately described as a "structured framework of adaptive management actions that progressively transitions from supplemental winter feeding to greater reliance on free-standing forage (BEMP ROD p.5).

OBJECTIVES

The management direction and desired conditions stated in the BEMP called for the NER and GTNP staffs to work with others (agencies, partners, etc) to "adaptively manage elk and bison in a manner that contributes to the State's herd objectives yet allows for the biotic integrity and environmental health of the resources to be sustained," so that the public can enjoy a variety of compatible wildlife-dependent recreational opportunities. Under the BEMP's 4 primary goals, 20 associated objectives were addressed (Table 1). This adaptive management plan addresses four objectives under the goal of sustainable populations (Fig. 5).

In Phase 1 of the second objective, the aim is to reduce the average number of elk on feed to 5,000 (while maintaining WGFD's 11,000 elk herd objective), and reduce the winter population of bison to the BEMP-adopted objective of 500. In Phase 2, the overall objective is to reduce the reliance of bison and elk on supplemental feed (USFWS and USNPS 2007a). Desired conditions include animals relying predominantly on native habitat and cultivated forage. Important consideration criteria for implementing Phase 2 will include: 1) the level of forage production and availability on the National Elk Refuge and adjacent winter ranges, 2) maintenance of desired herd sizes and age/sex ratios, 3) the ability to effectively mitigate bison and elk livestock conflicts, such as co-mingling on on private lands during high risk disease transmission periods, 4) maintaining desirable winter distribution patterns of elk and bison, 5) the prevalence of brucellosis, chronic wasting disease, and other wildlife diseases, and 6) public support. In short, the overall objective of this plan is to provide a path for progressively transitioning from winter feeding of elk and bison on the NER to greater reliance on free-standing forage, while maintaining population and herd ratio objectives.

Table 1. 2007 Bison/Elk Management Plan Goals and Objectives (Adaptive Management Plan objectives shaded)

Goal: Habitat Conservation

Objectives:

- Conserve important private lands.
- Increase forage production.
- Minimize non-native plants.
- Protect sagebrush grasslands.
- Restore willow, aspen, and cottonwood.
- Perpetuate natural mosaic of plant communities.

Goal: Sustainable Populations

Objectives:

- Develop adaptive management plan for reducing NER supplemental feeding.
- Phase reduction of animals on feed: 1) to 5,000 elk and 500 bison, and 2) elk and bison rely predominantly on native habitat.
- Maintain natural bull-to-cow ratios in park summer herd.
- Ensure a genetically viable bison herd with close to an even sex ratio.
- Enhance public outreach/education.

Goal: Elk and Bison Numbers

Objectives:

- Maintain state elk herd objective of 11,000.
- Maintain a genetically viable bison population of about 500 animals.

Goal: Disease Management

Objectives:

- Manage brucellosis transmission risk from elk and bison to livestock.
- Manage feeding to reduce brucellosis transmission among bison and elk.
- Educate hunters about wildlife disease human health hazards.

This Plan focuses on management actions to initially achieve Phase 1 objectives. However, if

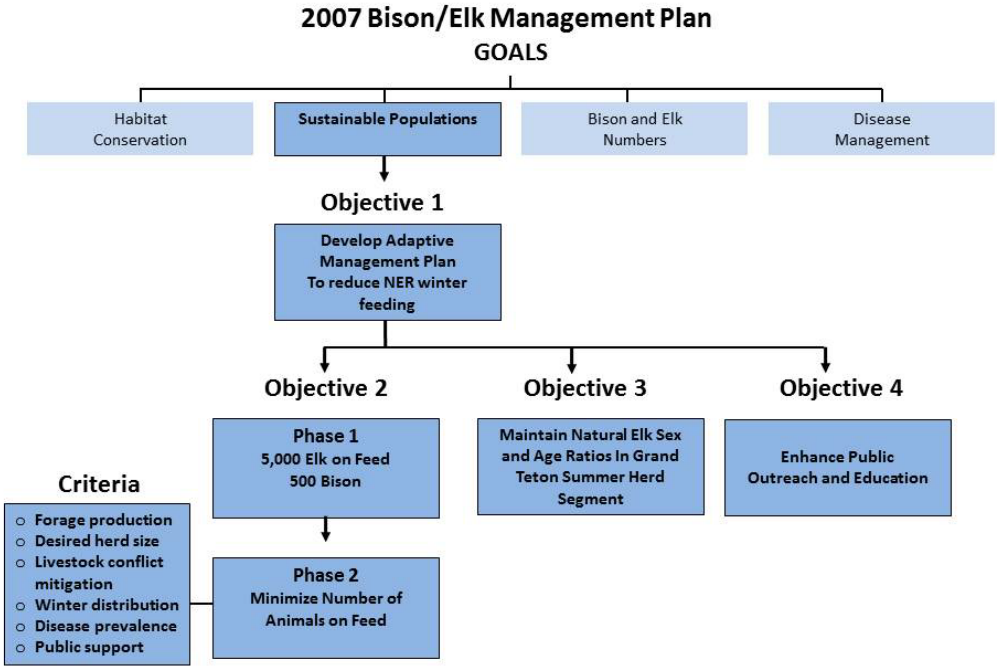

Figure 5. Relationship of Adaptive Management Plan to the 2007 Bison/Elk Management plan goals, phasing of objectives, and consideration criteria for reducing the reliance of elk and bison on supplemental feed during phase 2.

successful, these actions will continue to be used to achieve the Phase 2 objective of reducing reliance on supplemental feeding while considering the six criteria listed above.

MANAGEMENT ACTIONS AND STRATEGIES

Background

Elk have been fed for some period during nearly every winter on the National Elk Refuge since 1912, and bison have been fed there since 1980. The attraction of highly nutritious, easily accessible food during a time of year when natural forage is typically most limited is powerful to both species, and their knowledge of its existence has been passed down through generations. As a result, elk and bison have been strongly conditioned to seek supplemental food on the NER, even when natural forage is available and even abundant during some years. Because it is largely unprecedented, the concept of modifying this behavior on such a large scale is daunting and fraught with questions for which there is no answer. In some cases, the likelihood a specific management strategy's success will only be able to be roughly estimated, and unanticipated results are likely. The management stepdown approach will necessarily be one of investigation, constant evaluation, modifications to approach when indicated, and repeated trials (Fig 4). As such the approach will also be experimental, guided by rigorous analysis

and design, based on abundant empirical information, and monitored at an intensity commensurate with necessary decision making.

Since this plan is centrally tied to supplemental winter feeding on the NER, its focus will be on lands under NER authority. However, some strategies will also incorporate activities in GTNP, and on non-federal lands in collaboration with land owners and WGFD. Primary management practices that can be altered to achieve reduced reliance of bison and elk on supplemental feed fall into the 3 broad categories of 1) timing and intensity of winter feeding, 2) timing and intensity of hunting, and 3) herd segment specific and overall harvest levels.

Important Changes Since 2007

The BEMP was developed based on data collected and knowledge that existed up until its Record of Decision in 2007. Since then, important changes have taken place, some of which are advantageous to this effort, some of which are not.

A primary change that will facilitate meeting objectives under this plan is the reduction of the bison population from nearly 1,200 animals in 2007 to about 700 during winter 2014-2015 (Fig. 3) through hunting programs administered by WGFD. Licensing changes were enacted in 2014 to help increase harvest of female bison. These included a reduction in the bison cow/calf license fee (from $416 to $263 for residents and $2522 to $1022 for non-residents) and eliminating the once-in-a-lifetime restriction on a successful bison hunter to only those that successfully harvested a bull. Continued progress toward the 500 animal herd objective will require sustained harvest success.

During the same period, the Jackson elk herd has declined from nearly 13,000 to its objective of 11,000, but because the proportion of the Jackson Elk Herd that winters on NER has increased dramatically (Fig. 6), this will make achieving the Phase I objective of 5,000 elk on feed and any future elk population reductions more difficult. Preliminary modeling suggests that the increasing proportion of the Jackson Elk Herd wintering on NER has been associated with 1) changes in elk winter distribution associated with wolves and 2)high numbers of elk that summer immediately adjacent to NER (Cole and Foley et al. 2015).

Refuge-wide herbaceous forage production averaged 14,387 (SD = 4125) tons during 1998–2013. In recent years irrigation of approximately 3,600 acres has increased refuge-wide forage production by approximately 10% compared to what would have been produced with precipitation alone, and by 15% in the southern portion of NER which receives the greatest use by elk and bison.

Since 2007, the general awareness of climate change among the public has greatly increased. A strong, credible body of scientific evidence shows that climate change is occurring, is caused largely by human activities, and poses significant risks for a broad range of human and natural systems (National Academy of Science 2010). Ecological systems in the GYE are likely to be affected and associated changes will have implications for elk and bison management.

Current Management

Ongoing primary management actions on the NER include winter feeding, harvest, irrigation, and hazing. In GTNP, harvest of elk during the Elk Reduction Program takes place, when necessary, in collaboration with WGFD, and restoration of previously cultivated and irrigated sagebrush-grasslands is ongoing. Fundamental components of each of these will be briefly described below to provide a basis for comparison to adaptive management strategies that will follow.

Chronic Wasting Disease

Supplemental feeding has occurred in all but 9 winters on NER since 1912, and although this strategy minimizes winter elk mortality from starvation and contributes to Wyoming state elk

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herd objectives, elk occur at numbers and densities well in excess of carrying capacity (Smith et al. 2004, Lubow and Smith 2004). Considerable evidence suggests that Chronic Wasting Disease (CWD) transmission and prevalence are density dependent (Peters et al. 2000, Williams et al. 2002). Monello et al. (2014) found that elk densities of 15-110 per square km in Rocky Mountain National Park were associated with 13% CWD prevalence, and they predicted elk population declines when CWD prevalence exceeded 13%. NER elk densities commonly exceed 160 per square km (NER unpublished data), which suggests that the introduction of CWD to NER elk would have significant negative population effects over time.

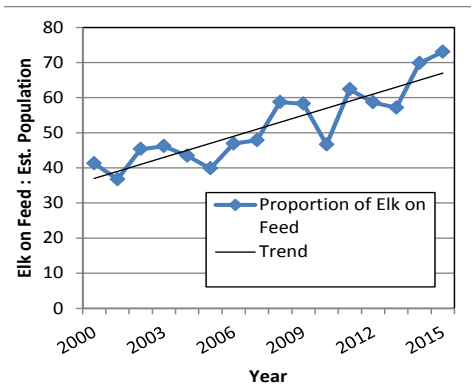

Figure 6. Increasing trend of National Elk Refuge elk on feed as a proportion of the Jackson Elk Herd estimated population size.

Winter Feeding

Initiation of feeding has the primary objectives of 1) minimizing elk winter mortality, focusing on calves since they are the most susceptible age class, and 2) minimizing comingling of elk with cattle on nearby adjacent private lands. Winter feeding begins when available forage reaches approximately 300 lbs/ac. Historic radio telemetry data and observations of elk movements indicate that when available forage delclines below 300 lbs/ac., some elk leave NER for surrounding private lands. Therefore, the purpose of this feeding trigger is to keep elk on the NER and prevent them from searching off-refuge for forage which increases the potential of comingling. This trigger is not a warning that a significant nutritional deficit threshold has been reached. Available winter forage for elk and bison on the NER is largely determined by biomass of forage produced during the previous growing season, rate of forage consumption during fall and winter, and how snow conditions affect forage availability.

Forage biomass estimates are calculated annually based on sampling at index sites. Index sites are selected subjectively each year based on presence of vegetation highly palatable to elk.

During 1995–2013, on average, initiation of NER winter feeding occurred on 28 January (range 30 December - 28 February), and feeding was terminated on 3 April (range 20 March - 20 April). Variation in feeding initiation and termination dates has been based on winter conditions and elk-cattle comingling problems on nearby private

Table 2. Annual distribution of wintering elk from the Jackson Elk Herd during February classification counts, 2011–2015, relative to the current objective.

	OBJECTIVE	2011	2012	2013	2014	2015	mean
NER	5,000	7,746	7,360	6,285	8,296	8,390	7,615
Gros Ventre	3,500	2,775	3,265	2,982	2,326	1,162	2,502
Native Range[1]	2,500	982	894	1,784	801	913	1,075
Total	11,000	11,503	11,519	11,051	11,423	10,465	11,192

[1]Excludes objectives for native range adjacent to Gros Ventre feedgrounds.

lands. Coordination of winter feeding dates on the NER and WGFD-operated Gros Ventre drainage feedgrounds (Alkali, Patrol Cabin) occurs annually to help minimize movement of elk between these areas. This coordination will continue regardless of the management strategy employed. The relationship of recent elk numbers and objectives for NER and WGFD-operated feedgrounds and native range is shown in Table 2.

Bison are fed as necessary to help minimize disruption to elk feeding operations. Bison will readily displace elk from feedlines, so since bison started using feedlines in 1980 refuge staff have developed a strategy of keeping most bison at the northernmost feedground (McBride) by feeding them there prior to feeding elk. Bison are provided a ration consistent with encouraging them to stay in this area away from elk feeding areas. This has also reduced conflicts associated with bison moving into Jackson or to the Nowlin area of the NER where commercial sleigh rides occur.

Harvest

Total harvest of the JEH was gradually reduced over the last decade as the population neared objective (Fig. 7). Elk hunting on the NER (Hunt Area 77) typically begins in mid-October and ends in mid-December, with peak harvest in recent years occurring in late November to early December. From 2005 to 2011 an average of 393 (SD = 56, range 329-457) hunters harvested 161 (SD = 38, range 126-225) elk per year during the NER hunt.

The 1950 legislation that created Grand Teton National Park provided for a controlled reduction of elk, when necessary, in specific portions of the park, primarily east of the Snake River. Elk reduction programs have taken place in the park each year since 1950 except two (1959, 1960), when GTNP and WGFD officials agreed a reduction was not necessary (Figure 8). Season dates have varied over the years but recently have run from mid-October to early-December. The GTNP harvest accounts for about 25% of the JEH overall harvest, thus has been an important factor in regulating the population. Increased natural regulation, likely a result of increases in grizzly bears and wolves over the last 20 years, has decreased the need for large harvests in the park.

Bison hunting begins on August 15 and ends in early to mid-January. Most harvest occurs on the NER, with some additional harvest on private and BTNF lands. Since resuming the bison hunt in 2007, mean harvest has been 210 (SD = 45.5, range 139-301) bison per year. This level of harvest has been sufficient to arrest the exponential growth of the population, reducing bison numbers from the peak in 2007 to about 700 animals in winter 2015 (Fig 3). Tribal bison harvest of up to 5 animals for ceremonial purposes was authorized in the BEMP. Translocation of wild bison to lands outside of Teton County is not currently permitted due to brucellosis concerns.

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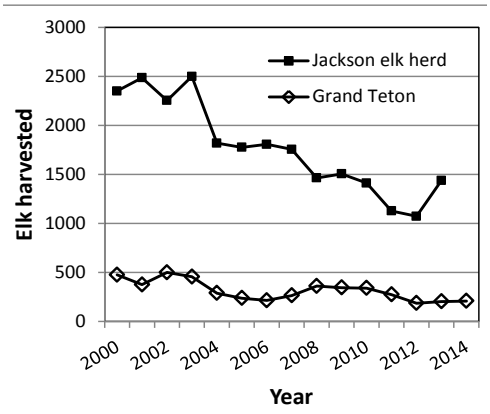

Figure 7. Estimated elk harvests for Grand Teton National Park and the Jackson elk herd (including the park) 2000–2014.

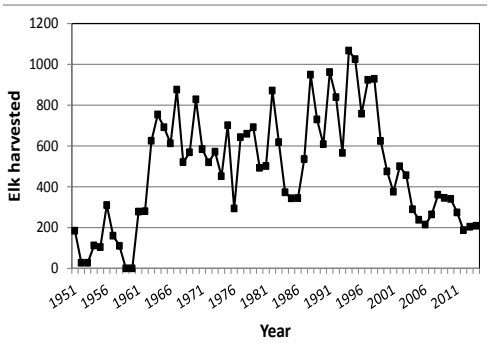

Figure 8. Elk harvest in Grand Teton National Park, 1950-2015.

Bison hunting is not allowed in GTNP because of long standing National Park Service policy that prohibits most hunting in national parks. Bison quickly learned to take advantage of the parks safety, which has made obtaining hunter harvest goals difficult. Many bison stay in the park during the hunting season, with only occasional short term movements to the NER, until severe winter conditions occur. In response, NER and WGFD managers attempt to balance extending the hunt as late in January as practicable without conflicting with winter feeding. The unpredictable nature of winter conditions that time of year makes this a risky proposition, and can result in the use of emergency season extensions or reductions.

Hazing

Elk and bison are hazed in spring to encourage movement off of NER winter ranges. Methods used have included ATVs, on foot, and on horseback, but recently ATV use has been found most effective. It's possible that some elk and bison might remain on the NER year around without hazing. If animals fail to leave the NER following the termination of feeding and adequate green-up has occurred, they are typically hazed to the north in late April to early May. Elk will stay off the NER until fall migration, and bison will generally remain in GTNP until mid-July. From July to early August bison often make forays back to the NER and are hazed back to GTNP to protect winter forage. Hazing efforts in August cease several days to weeks before the bison hunting season in an effort to increase hunter harvest.

Vegetation Restoration and Protection

The BEMP identified approximately 4,000 acreas of previously irrigated and cultivated grasslands in GTNP in need of restoration to native sagebrush grasslands community. Substantial progress in this endeavor has been made since 2007, including: [GTNP folks please add short description of methodological research and implementation, followed by what remains to be accomplished]

Private Lands Mitigation

Fencing of hay stacks and livestock feedlines has been historically used to mitigate particularly difficult conflicts on private lands. Targeted fencing of golf course greens and sand traps fall through spring has also been successful in some situations for mitigating elk and bison presence and associated damage in these areas. It is important to note that the county has a 'wildlife-friendly' fence policy and does not support extensive fencing that is impermeable to wildlife.

Methods, Assumptions, and Constraints Common to All Strategies

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Measuring the success of strategies toward objectives will require knowledge of several bison and elk herd attributes, particularly population sizes. Measurements of the Jackson bison herd will be based on the annual mid-winter census and sex and age classification survey performed by NER, GTNP, and WGDF biologists. This survey occurs one day in early February and includes ground counts of animals on feed at the NER and aerial counts of outlying bison across their winter ranges on the refuge, park, and Bridger-Teton National Forest.

Elk population estimates will also be based on mid-winter aerial and ground counts. However, the mid-winter counts are undertaken during a single survey period and do not necessarily represent either peak or cumulative abundance of elk on feed. Rather than basing progress toward the number of elk on feed for the entire season on those present during the day of the survey only, we will use a more meaningful measurement. Since we are more interested in the intensity of elk feeding throughout the entire feeding period, which includes both the number of animals on feed and the duration of feeding, we will use a measurement of elk-fed-days (EFD; the total number of elk fed per day per season) as a gauge of feeding intensity (see monitoring section). For example, if 5,000 were elk fed for 100 days during the winter, feeding intensity for that winter would equal 5,000 elk X 100 days = 50,000 EFD, whereas if 5,000 elk were fed for 50 days, EFD would equal 25,000.

We determined feeding intensity benchmarks for bison and elk-fed based on an actual average of 64 days of feeding from 1995-2007. Based on the Phase I objectives of 500 bison and 5,000 elk, fed-days benchmarks would be 64 x 500 = 32,000 for bison and 64 x 5,000 = 320,000 for elk. These values will assist in determining efficacy of strategies toward reducing reliance of both species on supplemental winter feeding.

Implementation of the AMP will have successfully attained the objective of "transitioning from intensive supplemental winter feeding to greater reliance on free-standing forage" when supplemental feeding was not used for more than 50% of the years in a 5 year period.

Comment [S3]: SK's draft.

Initial success of AMP implementation will be a consistent decline in the 3-year running average of elk and bison fed days from the established baseline. While the BEMP did provide specific measurement criteria for the definition of "transitioning from intensive supplemental winter feeding to greater reliance on free-standing forage" we will consider this objective met when the 3-year running average of elk and bison fed days is <50% of baseline for 5 years in a row.

Comment [S4]: SC's alterative in this paragraph, recognizing that the 50% number is the crux and a glaring target.

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Table 3. Summary of potential Adaptive Management Plan constraints.

Policy

- ESA[1] Lynx – limits on habitat impacts
- Greater Sage Grouse – core area protection
- 2007 BEMP/EIS (federal actions/lands)
  - No fertility control
  - No test and slaughter
  - Limited tribal harvest
- Bison/elk hunt end date (Feb. 1st)
  - WGFD, brucelosis safety
- Carcass disposal (Feb. 15th)
  - WGFD, brucellosis safety
- Forest Service winter closure (Dec. 1st – April 30th)
- Easement limitation (NER boundary)

Winter Feeding

- Only during non-hunting periods

Harvest

- State regulations

Vegetation Restoration/Protection

- Bison/elk distribution
- Exotic plant species management

Private Lands

- Owner agreements

Social

- Hunter density (safety; hunt quality)
- Elk/bison winter mortality levels
- Public safety (ungulate/vehicle collisions)
- Disease
- Land-use conflicts (agricultural and residential)

Biological

- Disease (bison/elk/cattle commingling)
- Sage grouse habitat conflicts
- Fencing/wildlife conflicts
- Elk herd distribution
  - summer segment distribution goals

Funding

- Easement purchase
- Plan implementation

[1]Endangered Species Act

Several management constraints are common to the strategies discussed below (Table 3). Many law and policy constraints are applicable but we include here only those most pertinent. Endangered Species Act (16 USC 1531 et seq.) requirements for wolves, grizzly bears, lynx, and others apply. Lynx requirements for maintaining certain habitat types could limit methods used and areas considered for habitat improvements in GTNP. Similarly, compliance with the Wyoming greater sage-grouse core area protection executive order (2011-5) could restrict habitat manipulations. NEPA compliance conducted as part of the BEMP/EIS constrains what federal actions can be taken as a part of this plan. State regulations constrain late (winter) hunt and carcass disposal timing to protect against brucellosis contamination, since February-April represent the period bison and elk are most likely to transmit the disease. Restrictions on hunting timing also result from BTNF winter range closures, immediately east of the NER and elsewhere, December 1 to April 30. Additional details about these and other constraints will be included in discussions about specific strategies that follow.

Strategies

This section will describe the management action this AMP proposes to implement. As such, it unveils the heart of management changes necessary to begin the process of transitioning to more reliance of bison and elk on native forage during winter. Fundamentally, the strategies discussed in this plan represent an experiment designed to achieve Phase I objectives of 5,000 elk and 500 bison on NER and are a first step towards reducing reliance on supplemental feeding while meeting the sustainable population goals identified in the AMP.

Initial strategies for achieving sustainable population goals identified in the BEMP (Table 1) are presented by objective below. The primary management actions available to the agencies to achieve phase I objectives are modifications to winter feeding and hunting seasons. To a lesser

extent, vegetation protection and restoration can be important, particularly for improving long-term ecological balance and enhancing natural production of native forage. Private lands are also an integral component as changes in elk and bison distribution occur and new challenges develop. The likely consequences of implementing these strategies were evaluated in the BEMP. The most relevant of these are summarized in Appendix 1.

Objective: *[Implement] a phased reduction of animals on feed: 1) to 5,000 elk and 500 bison, and 2) [to an extent where] elk and bison rely predominantly on native habitat* (Table 1).

This objective is what the need for an adaptive management plan – **this document** – is central to. As previously mentioned, the concept of reducing winter feeding after more than 100 years of the practice, and the associated behavioral conditioning of elk and bison to its presence, represents a formidable challenge that must be approached cautiously and systematically. The strategies discussed below have been developed in this context, with appropriate feedback mechanisms through rigorous monitoring and frequent evaluation. Inability to meet this objective under the strategies presented here would trigger a thorough evaluation and development of more aggressive strategies.

Chronic Wasting Disease

In 2014 WGFD began the revision process for the Wyoming CWD Management Plan (2006). WGFD has cooperated with federal agencies and other stakeholders to revise the plan, and NER and USFWS Region 6 Wildlife Health Office staff participated in several meetings associated with this effort. One goal of the CWD Management Plan update is to develop specific management responses should CWD be detected on or adjacent to State or NER elk feedgrounds. Early detection of CWD in the JEH is essential to ensure an effective management response.

Since 1997 NER has cooperated with Wyoming Game and Fish Department (WGFD) to conduct surveillance for CWD in the JEH unit. Although this effort indicates that CWD is not currently found in the JEH, continued surveillance at sample sizes sufficient to detect 1% prevalence with 95% confidence annually will be critical to ensure a timely management response and limit the long-term population effects of the disease (USFWS and NPS 2007). Given that CWD has been detected within 40 miles of the JEH in moose, within 70 miles in deer, and within 175 miles in elk, this level of surveillance is warranted.

Winter Feeding

Winter feeding actions that could be modified include starting date, ending date, and daily ration. To modify elk and bison behavior in the long run, delaying initiation of feeding is likely to have the greatest impact by gradually conditioning them to expect feed later on average, with the desired outcome of building a cohort of animals that rely primarily on native winter range and are not food conditioned. To reduce supplemental feeding overall, ending feeding early would also help decrease the amount of feed provided per animal per year. Both would help decrease the total elk/bison fed days, the parameter we will use to measure progress toward reducing supplemental feeding.

Initially, supplemental feeding will be delayed by approximately 2 weeks, depending on several variables (Table 4, Fig. 9). Time of season could influence this interval, most likely shortening it as the feeding initiation date gets later. During the last 20 years, feeding initiation dates, which have been based on forage availability, have varied from December 30 to February 28. Delaying feeding by two weeks in January, for example, is likely to be more successful than doing so in February, when food stress and tendency for animals to move to private lands is greater. Forage availability could also have an influence, particularly if a freeze thaw event resulted in an acute and large reduction in available forage.

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Both time of season and forage availability considerations would be affected by the numbers of elk and bison on the NER. And finally, the distribution of animals, particularly on private, livestock producing lands, would be considered.

A primary concern of manipulating feeding is elk winter mortality, particularly among calves. As food becomes limited in winter, calves are usually the first to suffer because of being displaced by more dominant animals. Monitoring programs will include measures of calf mortality and it will be an influencing parameter in feedback mechanisms. The BEMP anticipated that elk mortality could increase from 1-2% overall to 1-5% (Appendix 1).

Initially, the termination of feeding, which is now based on a snow cover index and subjective evaluation of available forage, will occur about a week earlier. The combination of a 2 week delay in feed initiation and 1 week advance in termination would shorten the feeding season by 3 weeks on average, or 32% based on an average feeding season length of 9.3 weeks from 1995-2015.

The AMP winter feeding strategy would include the establishment of additional key forage index sites and on-going measurements at those sites throughout the winter.

Harvest

Currently the Jackson elk herd is at the Wyoming Game and Fish Commission established objective of 11,000 animals, which means there is less flexibility in manipulation of harvest regimes than there would be if the herd was above objective. Initially there would be little change in elk harvest programs on the NER, with the exception of allowing a limited number of any elk permits throughout the season, considering allowing bow hunting near developed areas (roads and buildings) and shifting the season about a week later (Table 4). Allowing a limited number of any elk permits would be consistent with providing sport hunting recreation on National Wildlife Refuges (citation, NWR system act) and the NER (citation, CMP?), and possibly encourage more hunters to participate in antlerless elk hunts. Monitoring programs and consideration of bull ratios in the GTNP summer segment (since most park bulls migrate to the NER) would help inform levels of take proposed. Bow hunting in areas currently closed to firearms will likely increase harvest by eliminating “no-hunt” areas which can become sanctuaries for large numbers of elk. Shifting the hunt one week later is consistent with later migrations and will improve harvest effectiveness.

General elk harvest patterns in GTNP would continue to be based on need for harvest, summer segment population estimates, and mitigation for impacts on other resources and visitor activities.

Elk herd population objectives are reviewed every five years by the Wyoming Game and Fish Commission and adjusted as necessary. Serious consideration should be given to reducing the Jackson Elk Herd population objective. Lowering the population would help compensate for reduced use of traditional native winter range and increased growth of short-distance migrants which has lead to significant increases of winter elk concentrations on the NER.

The annual fall/winter arrival of elk to the NER during the past several decades has been occurring progressively later. This trend may necessitate extending the elk hunting season later into the year to achieve harvest objectives.

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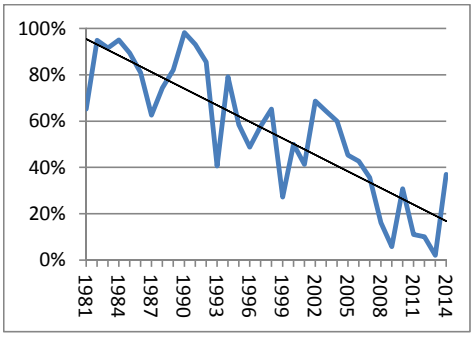

Figure ?. The annual fall/winter arrival of elk to the NER during the past several decades has been occurring progressively later. This trend may necessitate extending the elk hunting season later into the year to achieve harvest objectives.

Bison hunts on the NER (bison hunting is prohibited in GTNP) would see little initial change (Table 4). Consideration would be given to later hunt end dates commensurate with delayed feeding, and possible escorted hunting in the South Unit to help with distribution or discouraging bison from attempting to leave the NER via the south boundary into the town of Jackson. If progress toward reaching the herd objective of 500 animals continues and the objective is reached in the near future, State quotas will likely be reduced and management flexibility will increase.

A cattle guard will be installed on the Refuge Road near the east end of Broadway Avenue to help prevent bison and elk herds from entering the Town of Jackson. This will reduce the potential for dangerous human/wildlife interactions.

Serious consideration should be given to reducing the bison herd population objective in the future. This would lower winter forage consumption on the NER and help reduce elk and bison winter concentrations.

The current bison herd objective is ". . . maintain and ensure a genetically viable population of approximately 500 animals (five-year average), with as close to an even sex ratio as possible to maximize maintenance of genetic variation over time. . ." (BEMP p. 136).

The Jackson bison herd is not considered part of the U.S. Fish and Wildlife Service's meta-population approach to bison conservation because of its high prevalence of brucellosis. This disease prevents the export of Jackson bison to other DOI conservation herds.

The 500 bison population objective was set primarily to preserve existing genetic diversity assuming extremely limited natural genetic transfer with the Yellowstone or other DOI bison conservation herds. Genetic diversity can be maintained for a Jackson bison herd less than 500 if bison with desirable genetic diversity are periodically imported from other DOI bison conservation herds.

Currently, the effectiveness of NER late-season harvest regimes is affected by December 1st winter closures immediately east of the refuge on BTNF lands. Extensive elk telemetry data suggest that delaying the winter closures could aid elk management objectives. NER officials will work with BTNF and WGFD officials to explore the possibility of allowing hunting in limited areas after December 1st in the future.

Annual herd-wide population estimates, elk summer herd segment estimates, temporal and spatial harvest patterns, and animal-fed-days would be monitored, and the resulting information would be used to inform ongoing evaluation of adaptive elk and bison management harvest programs (Figs. 9 and 10).

Hazing

No change in hazing practices is anticipated initially under this adaptive management framework.

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Private Lands Mitigation

Delaying the onset of NER feeding is likely to result in changes in bison and elk distribution (Appendix 1). Some elk or bison may move to private lands in search of forage. Of greatest concern is the potential for elk or bison to commingle with cattle of cow/calf operations, where brucellosis transmission could have considerable consequences, in the worst case requiring depopulation of the cattle herd.

Several strategies would be employed to mitigate potential problems (Table 4), including providing incentives for non-breeding cattle operations (because brucellosis transmission to slaughter-bound cattle is not economically important), increased fencing in some limited areas to separate elk/bison from livestock feed lines, haze elk/bison away from livestock feed lines and purchase private lands easements to prevent co-mingling. A vital component in implementing these mitigation measures is to establish three seasonal Wildlife Conflict Technician positions which are supervised by the WGFD. These Technicians are also critical to the success of an expanded monitoring program vital to the AMP (see Monitoring section below).

A database will be established to track non-agricultural conflicts on private lands to determine trends which will help evaluate the effectiveness of AMP mitigation efforts.

Preventing elk and especially bison from entering the Town of Jackson is essential in minimizing safety and private property conflicts. Currently, bison are hazed northward when they drift south of Miller Butte. A double cattle guard will be installed on the Refuge Road just north of Broadway Avenue. This barrier is designed to prevent elk/bison from entering the Town of Jackson.

Vegetation Restoration/Protection

[NER and GTNP staff to draft material]

Objective: *Maintain natural bull-to-cow ratios in park summer herd* (Table 1).

National Park Service management policy (NPS 2006) provides guidance for maintaining naturally regulated wildlife populations, free from the impacts of humans, to the greatest extent possible. The final BEMP identified a goal of maintaining park elk bull:cow ratios (a common way of expressing sex and age ratios in wild ungulate populations) near 35 adult bulls per 100 adult cows, based on estimates of what this ratio would be in a herd free from the effects of human harvest. The sex and age ratios of most North American elk populations are affected by sport hunting and herd managers generally maintain lower bull ratios.

Harvest

Based on bull ratios in the park summer herd that were chronically below 35 bulls:100 cows, permit types for the park's elk reduction program (ERP) went to antlerless only in 2012. ERP permit structures in the park will remain antlerless only unless the bull ratios consistently exceed 35:100 cows. Park and refuge officials will work together to support this goal, recognizing that bulls harvested on the NER are most likely from the park summer herd segment.

A private lands Hunting Coordinator Position would be established and supervised by the WGFD to promote and coordinate hunting activity focused on Southern Herd Segment harvest in and around private lands in the Spring Gulch Area north to Moose, WY (Hunt Area 78).

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Table 4 [incomplete]. Comparison of current and adaptive primary management components and parameters.

Action	Current Management	Adaptive Management	Comments
Winter Feeding:			
Feed	Pelleted alfalfa	Pelleted alfalfa	No change
Ration	8 lbs/day/elk 20 lbs/day/bison	8 lbs/day/elk 20 lbs/day/bison	No change, to minimize calf mortality
Start criteria:			
Available standing forage	300 lbs/acre, as measured at traditional key index sites	Generally 2 weeks later; index sites to be increased in number and distribution	Influencing factors: - time of season - forage availability - numbers of elk/bison on NER - elk/bison distribution
End criteria:			
Available forage	Based on a snow cover index and subjective estimate of when residual or new forage is adequate	Generally 1 week earlier	Development of more objective criteria for future implemen-tation ongoing
Monitoring:			
Animals on feed	Mid-winter census	Elk/bison fed days[1]	
Proportion of JEH on NER feed	Mid-winter census	Mid-winter census	
Calf mortality threshold		<= 10%	
Elk/bison distribution - visual			
Elk/bison distribution – collars			
Winter mortality			
Elk summer range proportions			
Harvest, National Elk Refuge elk:			
Frequency	Annual	Annual	
Begin Date	2nd week October	3rd week October	Modified as necessary
End Date	2nd week December	3rd week December	Modified as necessary
Structure	- 1 week initial drawing - 1 week left over 1st served - partial week alternate	- 1 week initial drawing - 1 week left over 1st served - partial week alternate - daily 1st served alternates	

[1]Number elk and bison on feed per day, totaled by feeding season.

Table 4, continued. Comparison of current and adaptive primary management components and parameters.

Action	Current Management	Adaptive Management	Comments
Harvest, National Elk Refuge elk:			
Refuge permit types	- 1st week any elk - Antlerless only remainder of season	- Primarily antlerless only - limited any elk permits throughout season	
Access	Restrict access to specific locations	Restrict access to specific locations	
Hunt area boundaries		Consider expanding to allow bow hunting near developed areas	
Harvest, National Elk Refuge bison:			
Frequency	Annual	Annual	
Begin date	August 15th	August 15th	Modified as necessary
End date	2nd or 3rd week January	Consider later dates as appropriate	Modified as necessary
structure	As per WGFD	As per WGFD	
Refuge permit types	Any bison or cow/calf per state license	Any bison or cow/calf per state license	
access	Restrict access to specific locations	Restrict access to specific locations	
Hunt area boundaries	Limited to north of Nowlin Creek area	Consider escorted hunting in South Unit as needed	Guided hunts in South Unit when authorized
Harvest, Grand Teton NP elk:			
Frequency	As needed	As needed	
Begin Date	3rd week October	3rd week October	Modified as necessary
End Date	2nd week December	2nd week December	Modified as necessary
License types	Antlerless only	Antlerless only[1]	
Special regulations:	Cartridge limits	Cartridge limits	
	Bear spray required	Bear spray required	
	Hunter safety card required	Hunter safety card required	
Harvest, Bridger-Teton NF, Elk Hunt Area 80:			
Begin Date			
End Date		December 15	Would require change in winter closure dates

[1]Any elk licenses could be offered if bull ratios in the park consistently exceed BEMP criteria.

Table 4, continued. Comparison of current and adaptive primary management components and parameters.

Action	Current Management	Adaptive Management	Comments
Harvest, Elk Hunt Area 78			
Structure			Changes at discretion of WGFD
License types			
Private Lands Mitigation:			
Cattle commingling		Incentives for non-breeding operation	
Hay depredation		Increased fencing	
Landscape damage			
Easement acquisition			
Vegetation Restoration/ Protection: Elk Refuge			
Vegetation Restoration/ Protection: Grand Teton			

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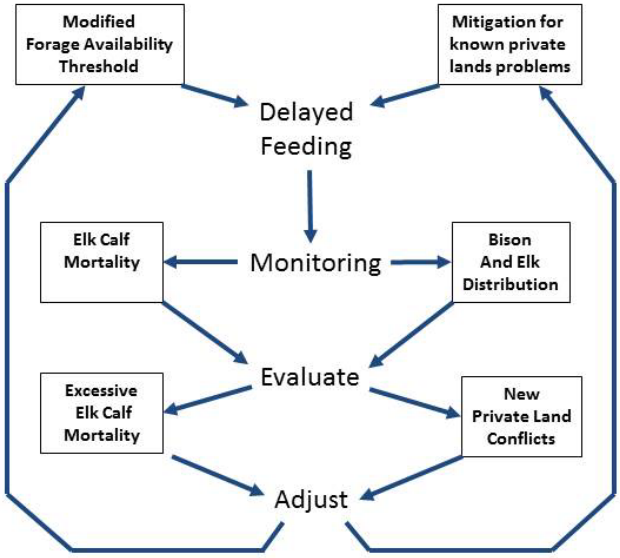

Figure 9. [example] Framework for delayed feeding strategy and adaptive management.

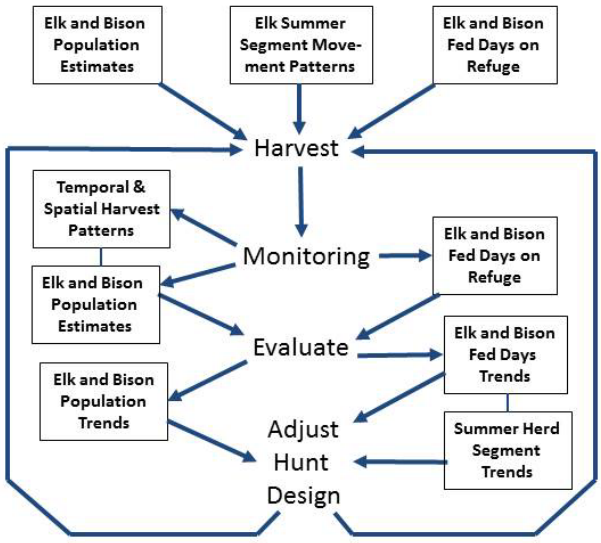

Figure 10. [example] Framework for harvest strategy and adaptive management.

Strategies Considered But Rejected

The BEMP considered several additional strategies for elk and bison management that, for a variety of reasons, were not selected for implementation in the preferred alternative and Record of Decision. The agencies reconsidered a subset of these during the development of this AMP (Table 5). Since they were not part of the ROD, additional NEPA compliance would be necessary to incorporate any of them into this adaptive management plan, and thus they are not being considered at this time.

Table 5. Strategies considered but rejected.

Strategy Considered	Reason Rejected
Fertility control in elk	Judged not reasonable or feasible in BEMP, primarily due to major technical, social, and financial hurdles[1]. For AMP discussed primarily with regard to the difficult to harvest herd segment in Hunt Area 78 on private lands, where federal agencies have no jurisdiction.
Fertility control in bison	Impacts discussed at length in BEMP[2]. Not considered for AMP because current hunting programs appear effective at slowly moving the herd toward the 500 animal herd objective.
Agency reduction of bison or elk	Not considered necessary or desirable on federal lands because current hunting programs that utilize sport hunters are effective at meeting herd objectives.
Altering rations of supplemental feed	Rejected as a strategy because reducing daily feed ration below 8 lbs/elk would be enough feed to encourage elk to remain on NER but would result in unacceptably high elk calf mortality rates.

MODELS OF SYSTEM DYNAMICS

Models provide a simplified representation of the biological system being managed. Adaptive management uses models of the managed system to link the objective response (e.g., elk winter distribution) to changes in the system resulting from management actions (e.g., altered initiation and cessation of winter feeding). Fig. 11 describes possible factors that affect winter elk distribution (the proportion of elk on NER feedgrounds versus native winter range). Models will be used to identify the relative influence of our principal management strategy (a reduction in feed season length) and other factors on winter elk distribution (Appendix 3). Over time this will allow us to assess whether changes in elk distribution were the result of our management actions or due to factors outside of our control.

An increase in calf elk winter mortality is a potential result of reduced feed season length. Fig. 12 portrays factors that influence winter calf elk survival on NER.

Models will be used to assess the effects of available forage on winter calf elk survival (Appendix 4). Over time this will allow us to assess the effects of our principal management strategy (reducing feed season length) relative to other factors on elk calf survival and potentially adjust our management actions based on model results.

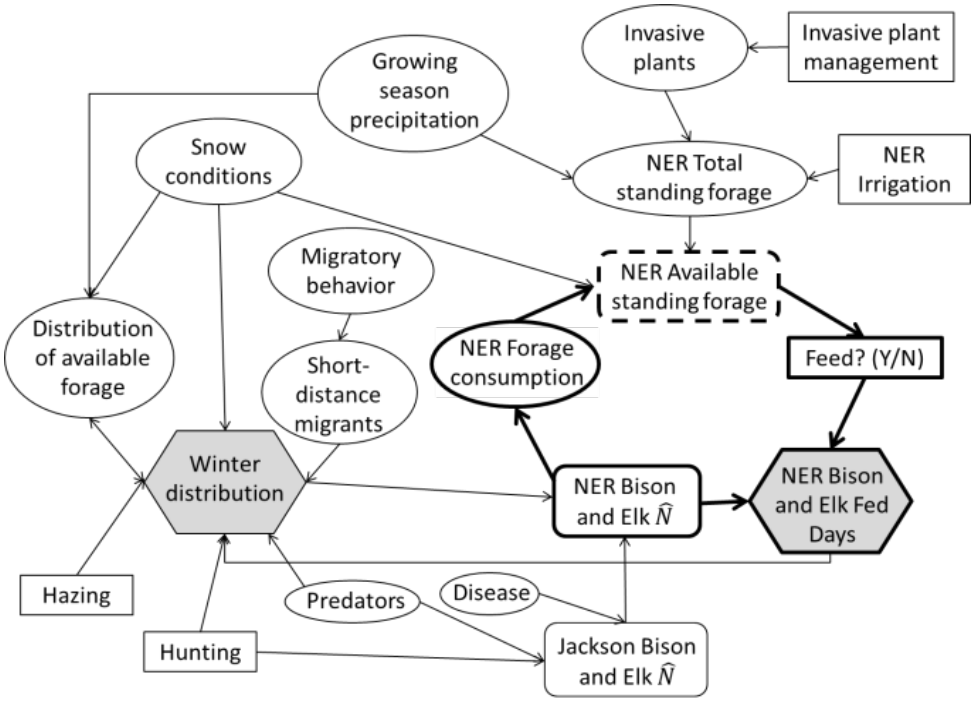

Figure 11. Influence diagram depicting factors (including management actions) influencing outcomes identified in the Bison and Elk Management Plan (BEMP; USFWS 2007a). Gray hexagons represent outcomes, rectangles represent management actions, rounded rectangles represent factors with numerical objectives, and ovals represent factors outside of management control. Bolded polygons and arrows represent outcomes and factors limited to the National Elk Refuge (NER). Available standing forage on the NER (dashed rectangle) is the BEMP criteria with a defined threshold to trigger initiation of supplemental winter feeding.

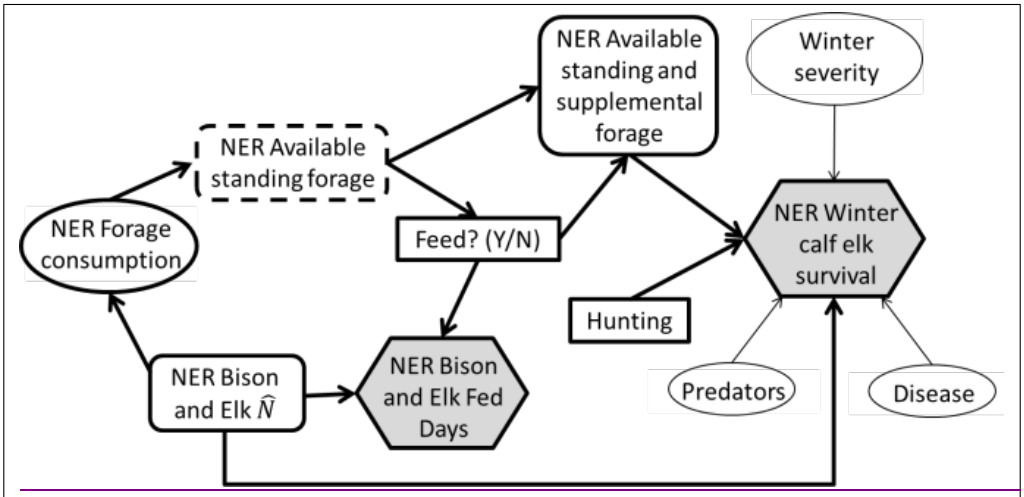

Figure 12. Influence diagram depicting factors (including management actions) influencing bison and elk fed days on the National Elk Refuge (see text for description) and winter calf elk survival. Gray hexagons represent outcomes, rectangles represent management actions, rounded rectangles represent factors with numerical objectives, and ovals represent factors outside of management control. Bolded polygons and arrows represent outcomes and factors limited to the National Elk Refuge (NER). Available standing forage on the NER (dashed rectangle) is the BEMP criteria with a defined threshold to trigger initiation of supplemental winter feeding.

MONITORING

Feeding Initiation Monitoring

NER uses weekly field estimates of the amount of forage available to elk to determine feeding initiation date. Currently measurements are taken at key index sites representing areas preferred by elk on NER (see supplemental materials at end of this section). These methods will be enhanced by 1) increasing the number of sampled sites to better represent the total amount of forage available to elk on the southern half of NER; 2) increasing the precision of estimates at each site by increasing the number of observers; and 3) extending the monitoring period later in the winter to assess the relationship between available forage and elk and bison distribution.

To better represent the total amount of forage available on the southern half of NER, a subsample of current key index sites will be retained to facilitate comparison with historic data, but additional random sample sites stratified by elk habitat preference will be added. Historic elk distribution mapping and elk GPS collar data (NER unpublished data) suggest that the areas most preferred by elk on southern NER are associated with moderate to high forage production and green vegetation. Because the distribution of forage production and greenness characteristics vary annually based on irrigation and precipitation patterns, we will annually map areas preferred and not preferred by elk and sample sites will be randomly selected within each of these mapped categories. At least 3 historic key index sites, 3 random sites in areas preferred by elk, and 3 sites in areas not preferred by elk will be sampled each week from late December through the initiation of supplemental feeding.

Currently the NER biologist is the only person trained in the techniques used to estimate available forage (see supplemental materials). At least 2 additional personnel will be trained in these techniques. This will provide a backup in the event of future personnel changes and will facilitate error estimates of the available forage measurements at each site.

Currently NER and WYGFD biologists monitor available forage conditions at least weekly from late December until average available forage at key index sites nears the threshold level of 300 lbs. per acre and feeding is initiated. The principal AMP strategy is to delay the initiation of supplemental feeding by 2 weeks after average forage production reaches the 300 lbs. per acre level at key index sites. Therefore the monitoring period will be extended to include the intervening 2 weeks.

Proportion of Elk Wintering on NER

A principal AMP goal is to reduce the number of elk wintering on NER. Our strategy will be to effect redistribution of elk to native winter range from NER over time via shortening the duration of the feed season, and thus slowly conditioning elk to seek food elsewhere. As feeding periods are shortened, the probability of younger elk age classes discovering NER feedgrounds will be reduced, and, hypothetically, that proportion of the JEH that utilizes NER feedgrounds will decline over time. We will measure this effect by examining changes in the winter distribution of the JEH. WGFD annual trend/classification count data provide a multi-year baseline data set to measure changes in the winter distribution of the JEH and categorizes observations by location. In each year, we will calculate the proportion of total classified elk in the JEH that are classified on NER feedgrounds. We will compare the 3-year running average post AMP implementation to the pre-implementation baseline. The pretreatment baseline will be comprised of data from 2008-2016, a time period that represents BEMP implementation prior to AMP actions (Figure 13).

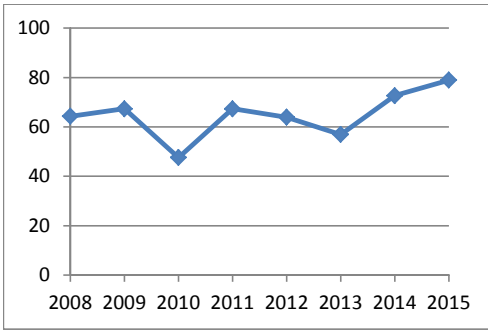

Figure13. Proportion of the Jackson Elk Herd that was classified on NER feedgrounds in the period following implementation of the Bison and Elk Management Plan and prior to the implementation of the Adaptive Management Plan (2008-2015). These values represent the pretreatment baseline which will be compared to the 3 year running average post AMP implementation.

Elk Fed Days and Bison Fed Days

The BEMP and AMP implicitly assume that the transmission rate and prevalence of elk and bison diseases are density dependent and positively correlated with the number of elk and bison utilizing feedgrounds and the number of days they are fed. We further assume the variables elk-fed-eays (EFD) and bison-fed-days (BFD) are a proxy for these conditions. EFD and BFD will be calculated annually for each species based on the following formulas:

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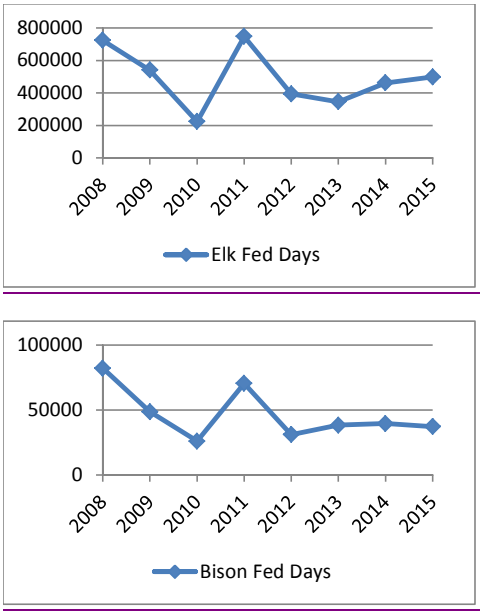

Figure14. Elk Fed Days (EFD) and Bison Fed Days (BFD) in the period following implementation of the Bison and Elk Management Plan and prior to the implementation of the Adaptive Management Plan (2008-2015). These values represent the pretreatment baseline which will be compared to the 3 year running average EFD and BFD post AMP implementation.

EFD= ∑ Total elk counted on feed during daily feedground counts for duration of feed season

BFD= ∑ Total bison counted on feed during daily feedground counts for duration of feed season

Because EFD and BFD are influenced by feed season length and the number of animals on feed, the AMP strategy of delaying the initiation of supplemental feeding will inherently reduce the number of EFD and BFD through a reduction in average feed season length. We believe that EFD will be further reduced by encouraging a greater proportion of the Jackson Elk Herd to winter on native winter range, thereby reducing the number of elk occupying NER feedgrounds. We will evaluate changes in EFD and BFD by comparing the 3-year running average post AMP implementation compared to mean EFD and BFD from 2008-2015. The running average is an appropriate comparison because it will help account for wide annual variation in EFD and BFD associated with winter severity (Fig. 14)

Elk Winter Mortality Monitoring

NER has used consistent methods to monitor winter elk mortality since 1982. Each winter NER biologists and other refuge staff conduct a survey of all non-hunting related winter elk mortalities that occur on NER from November through April. Mortalities are tallied by age/sex class and percent mortality is calculated using the corresponding number of elk classified on NER feedgrounds as the denominator. We will continue to monitor elk winter mortality using the same methods post AMP implementation, which will allow trend comparisons to the pre AMP baseline (Figure 15). Under the AMP framework, we believe the 3 year running averages for total and calf winter elk mortality will be within the range of variation exhibited by the pre AMP baseline. Historic monitoring suggests that calf and total mortality are sensitive to winter severity and disease outbreaks, and that winter mortality occasionally exceeds >3% total mortality and >10% calf mortality. Post AMP mortality in excess of these levels may warrant shortening the 2-week feeding initiation delay in subsequent years.

Elk Collaring

One of the AMP's principal strategies is to shorten the length of the feed season to encourage elk use of native winter range, but we anticipate that this strategy will also result in an increase in elk conflicts on surrounding private land in the town of Jackson and the Spring Gulch areas. To quantify this effect and provide real time information to WGFD and NER managers to facilitate a response, we propose maintaining a sample of 50 GPS collars on elk that winter on NER throughout the AMP implementation period.

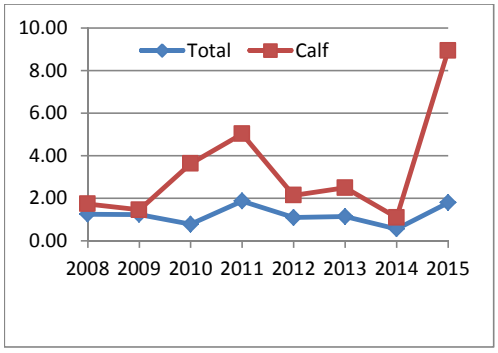

Figure15. Total and calf elk winter mortality (%) on NER in the period following implementation of the Bison and Elk Management Plan and prior to the implementation of the Adaptive Management Plan (2008-2015). These values represent the pretreatment baseline which will be compared to the 3 year running average post AMP implementation.

Forty -five elk represents approximately 0.5% (1 in 200) of the NER winter elk population. This sample size will not be sufficient to detect all elk movements from NER to surrounding private lands, particularly movements by small groups of mature bull elk, but it will be sufficient to detect and quantify significant movements of cow/calf/yearling elk groups compared to pre-AMP baseline data.

NER has elk GPS collar data available from the 2008-2013, which represents the post BMP, pre AMP baseline period. We hypothesize that elk movements from NER to surrounding private lands will increase during the AMP implementation period compared to the pre-treatment baseline. This will be tested by comparing the number of incidents that elk left NER for surrounding private lands (per elk/per year), and the proportion of elk GPS fixes on NER versus private lands during time periods of interest. The principal time period of interest is late December-March because this represents the period after the NER elk hunting season, and prior to and during NER feeding operations. This is the season when changes to the NER feeding program would be most likely to result in elk distribution changes.

Fifty adult cow elk will be captured on NER feedgrounds during February-March 2016 and Telonics Iridium GPS collars will be deployed with a 90 minute fix collection interval. Given 83% annual survival for adult cow elk in the Jackson Elk Herd (Cole and Foley et al. 2015) and 3 year collar life, approximately 10 additional elk will need to be collared each year in winter 2017 and 2018 to maintain the 50 elk desired sample size.

Ancillary data that will be collected and analyzed during the elk capture and collar data analysis process includes brucellosis seroprevalence, pregnancy rate, and elk summer range determination for comparison to the findings of Cole and Foley et al. (2015).

Disease

The primary purpose of limiting reliance on supplemental feeding is to reduce the prevalence of endemic elk and bison diseases and mitigate transmission risk associated with the introduction of novel diseases. We hypothesize that brucellosis seroprevalence will decline post AMP implementation. There are no recent brucellosis seroprevalence data for elk on the National Elk Refuge, but >50 elk will be captured during elk collaring operations in winter 2016, and each elk will be tested for Brucellosis exposure. The 2016 Brucellosis seroprevalence rate will be the pre-treatment baseline to evaluate post AMP change.

Chronic wasting disease (CWD) has been monitored in the JEH since 1997, and since 2008 it has been monitored with sufficient sample size to detect 1% prevalence with 95% confidence. No CWD positive cases have been detected in the JEH, which given the long term persistence of the disease, provides overwhelming evidence that CWD is not currently endemic to the JEH. However, most evidence suggests that the distribution of CWD is increasing and that its introduction to the JEH is inevitable. Early detection is critical to ensure an adequate

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management response, and therefore ongoing monitoring at sample sizes sufficient to detect 1% CWD prevalence with 95% confidence is necessary. CWD is sampled by testing tissues collected primarily from hunter harvested elk, and past experience suggests that 2 full time technicians working from September-December are necessary to ensure minimum sample size. Typical costs associated with 2 technicians are $32,000 per year.

EVALUATION/FUTURE MANAGEMENT

Modifying elk and bison behavior while reducing supplemental feeding will require a long-term, sustained commitment. Change is unlikely to happen fast, and interpreting effects of adaptive management actions will be complicated by varying environmental conditions from year to year. Consequently, we anticipate that the strategies outlined in this plan will be in place for a minimum of 5 years. Actions completed each year, the results of monitoring programs, and any proposed changes in course will be presented in an annual adaptive management update/report, completed by NER staff by the end of March for the previous year.

Investigating the potential effects of climate change on elk and bison management will be important in the long-term. During implementation of this plan, we will collect a variety of data that can be drawn upon for this purpose.

PUBLIC OUTREACH AND EDUCATION

The practice of winter feeding is inexorably woven into the historic fabric of Jackson Hole. Elk are identified with the rich and unique legacy for which Jackson Hole is known around the world. De-emphasizing the supplemental feeding program will be a major paradigm shift for the residents of Jackson Hole, Teton County, and the State of Wyoming.

An effective Public Outreach and Education program is essential for effective AMP implementation. The practice of feeding elk evokes passionate responses from those that oppose and those that support this practice. The general public and especially key stakeholder groups must understand the biological needs for and strategies of the AMP in order to gain general consent to modify longstanding elk/bison herd management methods.

A detail communication plan to guide outreach and education efforts can be found in Appendix 3.

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SCHEDULE

Table 6. Adaptive Management Plan proposed schedule.

Action	Date
GPS Collar 30-40 elk prior to strategy implementation (Iridium platform)	February 2016
Public outreach and education	March 2016
Initiate private lands conflicts mitigation contacts/actions	March 1, 2016
Implement enhanced forage monitoring	March 1, 2016
Initiate changes in supplemental feeding protocol	January 2017
Monitoring/Evaluation/Annual Report	June 2017

Table 7. Anticipated schedule of annual Adaptive Management Plan activities.

Activity	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
Elk and bison classification		x										
Irrigation						x	x	x	x			
Forage estimates	x	x	x	x								x
Etc…..												

[This table just for example. We could do the same with longer term schedule using years instead of months at the top if desired/necessary.]

BUDGET

Table 8. [incomplete]. Estimated Adaptive Management Plan budget above current expenditures, years 1-5.

Agency / Activity	Year 1	2	3	4	5
National Elk Refuge:					
Monitoring:					
Seasonal Biological Technician (0.5 FTE, GS-7)	24,000	25,000	26,000	27,000	28,000
Bison/elk fed days					
Mid-winter census					
Elk summer herd segment distribution[1]					
Expanded standing forage estimates[1]					
Chronic Wasting Disease, 2 seasonal biot-techs	32,000	32,000	32,000	32,000	32,000
Winter bison/elk distribution					
Irrigation					
50 Elk radio telemetry collars; Iridium Platform	$115,000	$25,000	$25,000	$25,000	$25,000
Bison barrier at NER south entrance	$80,000	$1,000	$1,000	$1,000	$1,000
Adaptive Management Plan annual reporting	$2,000	$2,000	$2,000	$2,000	$2,000
Private lands:					
Easements / Acquisition					
Damage reimbursements (Wyoming)					
Conflict mitigation coordination (Wyoming)	$91,000	$91,000	$91,000	$91,000	$91,000
Vegetation restoration/protection[1]					
Public Outreach and Education	$11,000	$1,000	$1,000	$1,000	$1,000
Subtotal					
Grand Teton National Park:					
Monitoring:					
Summer elk classification/distribution					
Hunter harvest					
Harvest age distribution					
Transition range forage production/utilization					
Vegetation Restoration/Protection					
Temporary bison fencing					
Hayfields restoration					
Exotic plant mitigation					
monitoring					
Elk Reduction Program					
Subtotal					
Wyoming Game and Fish Department:[2]					
Private lands:					
elk harvest coordination					
Easements / Acquisition					
Damage reimbursements					
Conflict mitigation coordination					
Add additional lines and categories as needed					
Subtotal					
Grand Total					

[1] See detail in Appendix

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APPENDIX 1. Summary of primary potential impacts associated with reduced supplemental feeding, as identified in alternative 4 environmental consequences section of the Final Bison and Elk Management Plan/Environmental Impact Statement (USFWS and USNPS 2007).

Populations

- Jackson elk herd objective of 11,000 would be maintained.
- New Jackson bison herd objective of 500 established.

Winter Feeding

- Supplemental feeding could be delayed or could occur earlier compared to current practices.
- Changes [to feeding program could] include alterations in the timing of feeding and providing supplemental feed in fewer years.
- Ration or pellet composition might need to be changed.
- Supplemental feeding would be initiated according to established criteria, including pre-winter forage production, assessments of forage utilization (done jointly by WGFD and NER personnel), elk condition and movements, and potentially on the January 1 index of winter severity calculations for elk (Farnes, Heydon, and Hansen 1999).
- Mechanical means could be used to increase forage access for elk after snow crusting events.
- Changes in the refuge supplemental feeding program could begin to affect elk nutrition (negligible adverse effect on NER elk from lower nutrition).
- Displacement of elk by bison during competition for standing forage would decrease as the bison herd is reduced.
- Aggressive social interactions involving competition for food among elk and bison would increase overall as feeding periods are reduced.

Winter Distribution

- Elk densities on the NER would decline due to more reliance on standing forage and wider distribution.
- Elk use of lands surrounding the NER would increase, including:
    - USFS lands east of the NER
    - Gros Ventre feedgrounds possibly
    - Southern GTNP
    - State feedgrounds south of the NER
- Most of winter distribution shift would involve elk in the Yellowstone, Teton Wilderness, and Gros Ventre segments.
- As ungulate numbers decreased and supplemental feeding was reduced, competition and aggressive social interactions on the refuge would also be reduced.
- Elk and bison distribution would increase as the animals relied more on native winter range.
- Fewer animals would be present on the refuge.

Mortality

- As supplemental feeding is reduced, natural factors such as climate and native forage availability would have a greater influence on numbers, movements, distribution, and mortality.
- More elk would be subject to natural factors affecting mortality, including loss of body condition, predation, and starvation.
- Increased mortality on and off the refuge would mainly affect older elk and calves, and some prime bulls entering the winter energetically stressed due to rut activities.

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- Late winter calf ratios could decrease as a result of higher winter calf mortality
- Average winter mortality on the refuge would increase from 1%–2% annually to an estimated 1%–5%.
- Overall, a higher total winter mortality rate of approximately 5% could be expected.

Disease

- Reductions in supplemental feeding or elk numbers would reduce the potential for impacts due to tuberculosis, septicemic pasturelosis, and CWD.
- The health and sustainability of the Jackson elk herd would be increased gradually as supplemental feeding was reduced and there was greater reliance on standing forage and wider ungulate distribution.
- Health and sustainability of the Jackson elk herd would be enhanced in the long term.
- Wider distribution of elk would result in moderate reductions in both the prevalence and potential transmission of brucellosis, as well as potential for spread of diseases not yet in the population.

Private Lands

- The agencies would work closely with the WGFD and landowners, including livestock producers, to coordinate actions that would prevent conflicts due to elk dispersal and to defray costs of managing potential conflicts. Preventing access to food/hay rewards on private lands would be vital for effective management.
- Private land conservation easements within NER boundaries would promote wider distribution.

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APPENDIX 2. Monitoring Supplemental Materials: Feeding Initiation Methods

At each sample site, 10 subplots will be measured at every 5 steps along the random bearing determined for each site. At each subplot a 13.27" diameter metal sampling ring will be placed on the ground. The amount of forage available to elk within the sampling ring (dry weight in grams) will be visually estimated. The 13.27" diameter subplot allows easy conversion from grams to lbs. per acre (each gram is equivalent to 100 lbs. per acre). During annual forage production sampling, refuge biologist Eric Cole has made approximately 1,000 of these visual estimates per year for 17 years, and 33% of Cole's estimates have been verified by clipping and weighing. Therefore, Cole will be the principal estimator, but additional personnel will be trained in these techniques to provide redundancy in the event of personnel changes, and to increase the number of observers to facilitate estimation of error.

Estimating available forage within the sample ring at each subplot is relatively straightforward when snow cover is limited, but estimating how much of the forage is accessible to elk when snow is dense, deep and crusted can be subjective. To decrease the subjectivity of the estimation process, if the area under the sample ring is covered with snow, only forage that can be exposed with a gloved hand will be included in the estimate of available forage. Forage that is fouled with manure and/or flush with the ground due to trampling and/or encrusted in ice will not be included in the estimate of available forage.

At each subplot the estimate of available forage (dry weight g) will be converted to an equivalent lbs./acre value (1 gram=100 lbs./acre). The arithmetic mean of available forage (lbs./acre) for the 10 subplots provides an estimate of available forage for each index site. There are 3 sample site categories: 1) Historic Key Index Sites that have been used since 2007, 2) New randomly selected sites within areas preferred by elk, and 3) New randomly selected sites in areas not preferred by elk. Historic key index sites were not randomly selected, but were instead selected to represent areas most preferred by elk on the south end of NER. These were the sites used to determine when supplemental feeding would be initiated from 2007 until the implementation of the AMP. To facilitate comparison with pre-AMP data, we will continue to use mean lbs. per acre across historic key index sites to determine the 300 lbs. per acre threshold. However, post AMP implementation we will delay feeding initiation by 2 weeks once the 300 lbs./acre level has been reached. We will concurrently sample at randomly selected sites stratified on an annual basis between areas highly preferred and not highly preferred by elk. This will enable us to quantify the relationship between mean forage availability at historic key index sites and random sites over time.

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APPENDIX 3. Communication Plan

Communication Goals

Prior to the Adaptive Management Plan's Implementation

- Utilize a variety of outreach methods to inform the public on the goals and timing of the Adaptive Management Plan's implementation and possible effects on wintering herds.
- Utilize a variety of outreach methods to inform the public on public comment opportunities.
- Identify and coordinate key messages and outreach with USFWS regional and national offices, State and federal agency partners, non-profits, elected officials, and other identified audiences.

During the Adaptive Management Plan's Implementation

- Continue to utilize a variety of outreach methods to describe current management actions as well as measurable and noticeable changes on the landscape, in animal behavior, or in animal health.
- Provide a comprehensive overview of the Adaptive Management Plan by providing links and references to previous outreach and background information.

Communication Objectives

- Work with current media contacts to promote news of the Adaptive Management Plan via print, radio, Web, and social media platforms.
- Utilize new media and social media tools to provide information on why the Adaptive Management Plan was developed, what public comment opportunities exist, and how the plan is being implemented.
- Plan, coordinate, and execute public meetings to allow for public comment and questions on the plan.
- Develop and provide methods for the public to submit written comments on the Adaptive Management Plan.
- Monitor print media on Refuge elk and bison management to see how Adaptive Management Plan objectives and reactions are being portrayed to the public.

Current Outreach Resources

- National Elk Refuge web site
- National Elk Refuge news release list
- (approximately 300 contacts)
- National Elk Refuge Twitter site (1,039 followers)
- Bison and Elk Management Plan web site (http://www.fws.gov/bisonandelkplan/)
- Space for an 11" x 17" poster in the Visitor Center on Refuge management topics
- Display panels in the Visitor Center theater for temporary displays

Available Supporting Outreach Resources

- USFWS Mountain–Prairie External Affairs staff
- USFWS Mountain–Prairie web site, including the
- "Top Stories" feature

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- USFWS Mountain–Prairie Twitter site USFWS Mountain-Prairie Region Facebook page
- USFWS National Wildlife Refuge System
- Facebook page
- USFWS Facebook page

Previous Outreach Efforts

- NER routinely writes and disseminates news releases on Refuge management activities, including the Comprehensive Conservation Plan, supplemental feeding, herd health monitoring, and forage production.
- Post the above news stories as Content.
- Management System (CMS) articles.
- Post CMS news story promos so they prominently appear on the home page, linking readers to the articles.
- Send out Twitter messages linking viewers back to the news stories.
- Prepare, upload and provide links to Adobe PDF versions of news stories with addtional photos where additonal images are available and/or help understand or visualize the content.
- Utilized the Conservation link on the web Content
- Management System to post information about the Bison and Elk Management Plan and the draft Comprehensive Conservation Plan.
- Retained and provided a link to the original Bison and Elk Management web page (http://www.fws.gov/bisonandelkplan/) that was developed during the planning process. The web site includes links to the Final Plan/EIS, Record of Decision, Federal Register Notice of Availability for both the Record of Decision and Final Plan/EIS, associated news releases, public meeting highlights, and other related documents. Note: the National Elk Refuge does not manage the site.

Additional Outreach Opportunities

- Public meetings in Jackson and other identified locations.
- Service produced video; video could be posted to the National Elk Refuge's multimedia web page, or USFWS Mountain–Prairie home page "Top Video" feature.
- Live radio interview on KHOL (Jackson, WY radio)
- Wyoming Public Radio interview with Refuge management staff
- Interviews with local print media sources
- Updates at community leader meetings such as Rotary Club, Jackson Hole Chamber of Commerce board meetings, and interagency breakfast meetings (with Federal agencies and local elected officials).

Target Audiences

Internal

- Regional and National USFWS Leadership
- Refuge permanent staff
- Refuge seasonal staff
- Refuge volunteers

External

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- Congressional representatives
- State of Wyoming leadership
- Federal agency partners, particulary Grand Teton National Park and the Bridger–Teton National Forest
- Wyoming Game & Fish Department
- Other NER partners, including county and town agencies and local nonprofit organizations
- Local elected officials
- Private landowners in proximity to the National
- Elk Refuge or neighboring Federal lands
- Tribes
- Local and state media
- Local public

Key Outreach Topics

- Overview of BEMP objectives
- Strategy to change elk/bison behavior
- Threat of disease
- Natural mortality rates
- Anticipated winter distribution changes for bison/elk
- Mitigate negative effects on private lands
- Change elk behavior and distribution while avoiding increased mortality.
- Explain the historic reasons a supplemental feeding program began and why it was continued.
- Explain the NER's limited large ungulate carrying capacity and the disproportionate impact of bison on available forage; 3 elk = 1 bison.

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APPENDIX 4. Models

Elk winter distribution model

The proportion of the JEH that winter on the NER will be linked to factors hypothesized to influence elk winter distribution (Fig. 2) using a generalized linear mixed effects model (GLMM). A GLMM can account for a proportional response variable (i.e., constrained to the interval 0–1) using a log link and binomially-distributed errors. A GLMM also includes fixed and random effects, with the latter capturing residual model variance otherwise not explained by fixed effects. Year will be including as a random effect, providing several benefits. First, we don't assume years are independent and comprise all of the factor levels of interest. Instead, the effect of year is treated as a random variable, with individual year effects realizations of that distribution. This allows inference to non-sampled factor levels, i.e. years, by estimating a latent population-level proportion of elk expected to winter on the NER regardless of fixed effect influences. Thus, the random year effect can be considered a latent variable describing elk behavior manifested as observed winter distribution. Second, because year effects are not treated as independent, estimated effects of year on the proportion of JEH elk wintering on the NER are dependent on all factor levels, leading to greater precision when estimating individual year effects (Kéry 2010).

The full GLMM incorporating fixed effects for each factor identified as influencing elk winter distribution (Fig. 2) is:

$$P_t = \beta_{0(t)} + \beta_1 * AFI_t + \beta_2 * SDM_t + \beta_3 * WP_t + \beta_4 * GSP_t + \beta_5 * SWE_t + \varepsilon_t$$

where the random intercept and residual model variance are

$B_{0(t)} \sim N(\mu_{\beta_0}, \sigma^2_{\beta_0})$, and

$\varepsilon_t \sim N(0, \sigma^2)$, respectively.

Fixed effects include 1) per capita available forage at initiation of winter feeding (*AFI*) , 2) proportion of the JEH that are short-distance migrants (*SDM*), 3) number of wolf packs present on JEH native winter range (*WP*), 4) growing season (May–August) precipitation for the Wyoming Snake Drainage climate division (*GSP*; a proxy for available forage on native winter range), and 5) snow water equivalent on 1 January at Thumb Divide (*SWE*; a proxy for early winter severity).

Elk calf winter survival and forage deficits

The Forage Accounting Model of Hobbs et al. (2003) has as an output weekly available forage biomass for the NER (sum of predictions for 30 × 30 m cells). These predictions account for snow conditions using a proxy of SWE and decrement total available biomass by 35% to account for unpalatable plants within the total estimate.

While calf survival is a function of multiple factors (Fig. 3), the primary management action influencing calf survival is supplemental winter feeding. Current winter feeding initiation criteria lead to calf survival generally higher than in unfed populations. Proposed feeding initiation criteria will result in later

Comment [WJ5]: I'm not comfortable with this interpretation yet and need to think about it some more.

Comment [WJ6]: This doesn't currently have a term for hunting, although our conceptual model above does. Need to decide if we want to include or exclude here.

Comment [WJ7]: Will need a more formal explanation of these variables and how they will be collected. May fit best in the monitoring section.

Comment [WJ8]: If we use Hobbs' model for predicting available forage these may be redundant.

Comment [WJ9]: Put in winter feeding initiation paragraph above? Then note where more samples are necessary to improve the precision of the estimates. Need to run this model from 2007 forward to see where, on average, feeding was initiated so we can make treatment adjustments as necessary. This would also allow us to look at the relationship between key index sites estimates and Hobbs' predictions. Need to consider validating Hobbs' model with field sampling Eric is currently designing to see if we can use the Hobbs model moving forward. This would take some time with stripping the Hobbs model down to our needs, identifying data sources, and developing a workflow process so weekly estimates of available forage can be calculated. Would only be able to use snow data from SNOTEL sites that have data available online, which shouldn't be too much of a problem.

Comment [KD10]: Need a citation here.

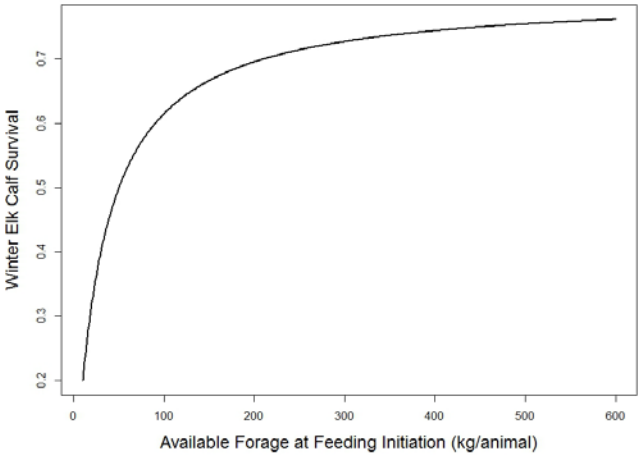
DRAFT

initiation of supplemental feed, which will be most influential to calf survival. There is currently little understanding regarding the relationship between initiation of winter feeding and calf survival, except that current feeding initiation criteria result in high calf survival. We believe a threshold level of available forage at initiation of winter feeding exists such that winter calf survival reaches an asymptote. Below this threshold, calf survival is hypothesized to decline quickly with reductions in available forage at winter feeding initiation. Available forage at the initiation of winter feeding will be related to on elk calf winter survival using a saturating function (i.e., Holling type-II functional response; Fig. 6) by

$$S_t = \frac{aAFI_t}{b + AFI_t}.$$

The parameters *a* and *b* determine how calf survival is related to available forage. Maximum calf survival is *a*, and *b* represents the value of available forage to an individual when survival is 50% of *a* (Hilborn and Mangel 1997).

Although this approach doesn't capture forage deficits *per se*, it does provide a potentially sensitive proxy for this concept. It is assumed that a forage deficit for calves would occur at a point on the curve of the relationship between calf survival and available forage at initiation of supplemental feeding. Modeling the response of winter calf elk survival to changes in feeding initiation criteria facilitates our ability to maximize the influence of feeding initiation criteria on winter distribution while minimizing the likelihood of a large mortality event.



Hypothesized relationship between winter survival of elk calves and per capita available forage at initiation of winter feeding on the National Elk Refuge.

From:	Steve Kallin
To:	Brad Hovinga; Doug Brimeyer; Susan (Sue) Consolo-Murphy; Sarah Dewey; Dale Deiter; Kerry Murphy; Jeffrey Warren; Cris Dippel; Eric Cole; Steve Cain
Subject:	Draft Adaptive Management Plan Review for August 3, 2015 Team Meeting at 12:30 PM
Date:	Friday, July 24, 2015 3:47:01 PM
Attachments:	NER AMP Draft v2.0 7-24-15.docx

Hi AMP Team:

Attached is the latest draft of the AMP for your review prior to the August 3 meeting.

There are several sections that are incomplete in this document. I would like to invite the WGFD and GTNP to populate the budget table (using track changes) for your anticipated expenses and add additional expenses that may not be identified in the table. You should estimate how much you believe these specific activities will cost, not how much you believe you can obtain from your agency. The source of the funding will be determined at a later time.

Also, I believe GTNP would like to add information about vegetation restoration. Please add that info using "track changes" on pages 11 and 17.

A number of you will be unable to make the August 3 meeting. Incorporating your feedback and suggested changes into the August 3 discussion would be extremely valuable. Please send your feedback/changes to this document, using track changes, to me prior to the meeting.

Thank you again for all of your assistance. Look forward to seeing you on August 3!

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U.S. Fish and Wildlife Service National Park Service

BISON AND ELK
MANAGEMENT STEP DOWN PLAN

A Structured Framework for Reducing Reliance on Supplemental Winter Feeding

National Elk Refuge

Grand Teton National Park

DRAFT

July 24, 2015

BISON AND ELK

MANAGEMENT STEPDOWN PLAN

For the

National Elk Refuge,

Grand Teton National Park,

John D. Rockefeller, Jr. Memorial Parkway

Teton County, Wyoming

DRAFT

***Suggested Citation**:* U.S. Fish and Wildlife Service: 2015. Bison and elk management stepdown plan, National Elk Refuge and Grand Teton National Park. U.S. Department of the Interior, Washington D.C. Available online at:

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Appendix 2. Monitoring Supplemental Materials: Feeding Initiation Methods**.....**

Appendix 3. Communication Plan**.....**

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DRAFT

EXECUTIVE SUMMARY [incomplete]

Comment [S1]: Steve K, my view on this is that it should be relatively short, because this is not a long document. I am thinking perhaps 2-3 pages max. What are your thoughts?

Overview

In 2007, the National Elk Refuge (NER) and Grand Teton National Park (GTNP) published a Record of Decision (ROD; USFWS and USNPS 2007a) for a bison and elk management plan. The Bison and Elk Management Plan (BEMP; USFWS and USNPS 2007b) was developed to guide management of the Jackson bison and elk herds on NER and GTNP lands, focused on four broad goals related to: 1) habitat conservation; 2) sustainable populations; 3) numbers of elk and bison; and 4) disease management. The final plan directed the NER and GTNP (in conjunction with the Wyoming Game and Fish Department; WGFD) to maintain the state's elk herd objective of 11,000, establish a bison population objective of 500, restore habitat on the NER and in GTNP, continue hunting bison and elk on the NER, continue the elk reduction program, when necessary in GTNP, continue to vaccinate elk for and effective vaccine becomes available, and develop a dynamic framework and adaptive management plan for decreasing the need for supplemental feeding on the NER. ***This Bison and Elk Management Stepdown Plan was developed to address the latter and specifically addresses the criteria for a structured framework referenced in the Record of Decision.***

Background

Winter feeding of elk in Jackson was originally initiated to reduce winter mortality of elk and minimize depredation of ranchers' hay. The loss of available winter range in Jackson Hole due to new ranching operations and a growing town resulted in significant numbers of elk dying during several severe winters in the late 1800s and early 1900s. This prompted local citizens and organizations, as well as state and federal officials in Jackson Hole, to begin feeding elk in the winter of 1910–11. Congress heeded the appeals for assistance and on August 10, 1912, established the National Elk Refuge. Today, the need for the refuge's winter elk feeding program is a direct result of reduced access to significant parts of elk native winter range, loss of historic migration patterns, behavioral conditioning of elk to winter feeding, and the desire to maintain a population objective established in the context of supplemental feeding.

Bison were extirpated outside Yellowstone National Park (YNP) by the mid-1880s but in 1948 were reintroduced to Jackson Hole when 20 bison from (YNP) were released near Moran, Wyoming. The herd remained small until discovering elk feedlines in 1980, when the population began sustained population growth. Bison and elk that winter on the NER are migratory and occupy summer ranges predominantly to the north.

Objectives

This adaptive management plan addresses several objectives under a broader BEMP goal of sustainable populations, which directed the agencies to: 1) Develop an adaptive management plan for reducing NER supplemental feeding; 2) [implement a] phased reduction of animals on feed: a) to 5,000 elk and 500 bison, and b) [to a point where] elk and bison rely predominantly on native habitat; 3) maintain natural elk bull-to-cow ratios in park summer herd; and 4) Enhance public outreach/education. The BEMP further stated that consideration criteria for implementing the 2nd phase of reduced feeding will include: 1) the level of forage production and availability on the National Elk Refuge and adjacent winter ranges, 2) maintenance of desired herd sizes and age/sex ratios, 3) the ability to effectively mitigate bison and elk livestock conflicts, such as co-mingling on private lands during high risk disease transmission periods, 4) maintaining desirable winter distribution patterns of elk and bison, 5) the prevalence of brucellosis, chronic wasting disease, and other wildlife diseases, and 6) public support. **In short, the overall objective of this plan is to provide a path for progressively**

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transitioning from winter feeding of elk and bison on the NER to greater reliance on free-standing forage, while maintaining population and herd ratio objectives.

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INTRODUCTION

In 2007, the National Elk Refuge (NER) and Grand Teton National Park (GTNP) published a Record of Decision (ROD; USFWS and USNPS 2007a) for a bison and elk management plan. The Bison and Elk Management Plan (BEMP; USFWS and USNPS 2007b) was developed to guide management of the Jackson bison and elk herds on NER and GTNP lands. It included directives for forthcoming development of adaptive management practices to address several objectives in the plan, including a desired future condition of elk and bison relying predominantly on native forage. This Bison and Elk Adaptive Management Plan has been developed expressly for that purpose.

Bison and Elk Populations

While Jackson Hole is probably best known for the splendor and ruggedness of the Teton Range, the Jackson bison and elk herds rank among the top characterizing features of the valley. Both figure prominently in Jackson Hole's history and culture, although bison were absent from the valley for about 100 years between the mid-1800s and mid-1900s.

The Jackson elk herd occupies approximately 8,000 km^2 in the upper Snake River watershed north of the town of Jackson (Fig. 1). Much of the herd is migratory, moving between distinct wintering and summer ranges. Primary wintering areas include the Buffalo Valley, lower elevations of the Gros Ventre River drainage, the National Elk Refuge (NER), and areas adjacent to the NER on Bridger-Teton National Forest (BTNF) lands. Summering areas occur throughout the herd's range and for convenience are divided into four geographic regions that include Grand Teton National Park (GTNP), Yellowstone National Park (YNP), the Gros Ventre drainage, and Teton Wilderness.

In the late 1800s, when elk populations all over North America were being extirpated, the residents of Jackson Hole protected elk from "tusk hunters" and large-scale commercial hunting operations. Elk are just as important to today's residents of the valley. Thousands of people each year have the opportunity to see elk at close range on the refuge while riding on horse-drawn sleighs. Thousands of pounds of shed elk antlers are sold at an annual antler auction each spring in the town square. Elk are important to backcountry users as well as to people that never leave the road. Jackson Hole is a popular destination for instate and out-of-state elk hunters. The draw of elk to visitors contributes significantly to the local economy.

Winter feeding of elk in Jackson Hole began in 1910 and was originally initiated to reduce winter mortality of elk and minimize depredation of ranchers' hay. According to historical reports, before Euro-American settlement some Jackson elk wintered in the southern portion of Jackson Hole (present location of the NER town of Jackson) and may have used areas outside Jackson Hole, including the Green River and Wind River basins to the south and east, respectively, and the Snake River basin to the southwest in what is now eastern Idaho (Allred 1950; Anderson 1958; Blair 1987; Barnes 1912; Sheldon 1927). Radio-collar studies have documented small numbers of Jackson elk wintering in each of these areas in recent times as well (*citations*). Over time, changes in land use and development in these areas, over hunting, and establishment of feedgrounds probably reduced the use of these areas by Jackson elk.

By the end of the 19th century the Jackson elk herd was believed to be largely confined to Jackson Hole and the immediately surrounding area, where wintering conditions are often harsh. Compounded by the loss of available winter range in Jackson Hole due to new ranching operations and a growing town, significant numbers of elk died during several severe winters in the late 1800s and early 1900s. This prompted local citizens and organizations, as well as state

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and federal officials in Jackson Hole, to begin feeding elk in the winter of 1910–11. Congress heeded the appeals for assistance and on August 10, 1912, appropriated $45,000 for the purchase of lands and maintenance of a "winter game (elk) reserve" (37 Stat. 293). The first winter census in the area was conducted in 1912 and showed about 20,000 elk residing in Jackson Hole and the Hoback River drainage.

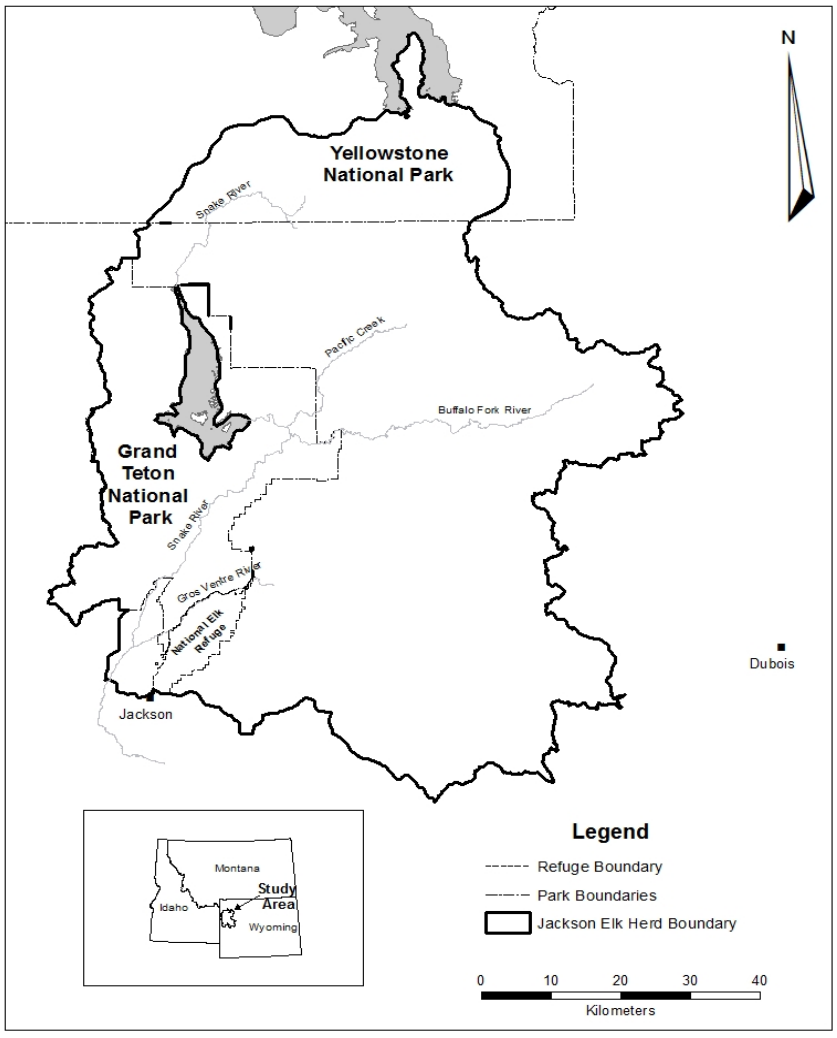

Figure 1. Jackson elk and bison herd ranges, including the National Elk Refuge, Grand Teton and Yellowstone National Parks, and Bridger-Teton National Forest. [include bison range, labels for continental divide and Bridger-Teton National Forest, and in Legend Jackson elk herd unit].

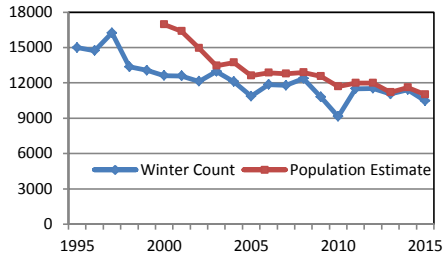

Figure 2. Winter counts and population estimates for the Jackson elk herd, 1995-2015.

Today, the need for the refuge's winter elk feeding program is a direct result of reduced access to significant parts of elk native winter range, loss of historic migration patterns, behavioral conditioning of elk to winter feeding, and the desire to maintain a population objective established in the context of supplemental feeding. Its population in recent times has fluctuated both above and below its herd objective of 11,000 adopted by the WGFD (Fig. 2)

An iconic symbol of the American West, bison are also popular with visitors and residents. Because so few opportunities remain to see bison in the wild, viewing and photographing them in Grand Teton National Park with the Teton Range in the background is a treasured opportunity for many of the valley's visitors. Similar to elk, there is also a high level of interest in bison hunting. Bison are of particular interest to nearby American Indian tribes and tribes in other parts of the United States because the animals are central to their culture and tradition.

Bison are native to Jackson Hole, as evidenced by the presence of prehistoric bison remains throughout the valley, but were extirpated outside Yellowstone National Park by the mid-1880s. In 1948, 20 bison from Yellowstone National Park (YNP) were reintroduced to the 1,500-acre Jackson Hole Wildlife Park near Moran. The Jackson Hole Wildlife Park was a private, non-profit organization sponsored by the New York Zoological Society, the Jackson Hole Preserve, Inc., and the Wyoming Game and Fish Department (WGFD). A population of 15–30 bison was maintained in a large enclosure there until 1963, when brucellosis was discovered in the herd (likely transferred with the original 20 animals from YNP). At that time, all the adult animals were destroyed, but four vaccinated yearlings and five vaccinated calves were retained. In 1964 twelve certified brucellosis free bison from Theodore Roosevelt National Park were added to the herd. In 1968 the herd (down to 11 animals) escaped the confines of the wildlife park, and a year later the decision was made to allow them to range freely. The expansion of GTNP in 1950 had enveloped the Wildlife Park, and allowing the bison to free range was and remains consistent with National Park Service wildlife management policy. The herd remained small and wintered mostly in the Snake River bottoms in GTNP until 1975, when it followed the winter environmental gradient to the NER and began wintering there. The use of standing forage by bison on the NER was viewed as natural behavior thus acceptable to managers. In 1980, however, bison discovered and utilized supplemental feed provided for elk, and they have continued to do so every winter since.

The discovery of supplemental feed by bison has had several consequences, including a significant increase in the population's growth rate (Fig 3). Bison on the elk feedlines have at times disrupted feeding operations and displaced and injured elk. To minimize conflicts between bison and elk, managers have provided separate feedlines for bison since 1984. As the population has grown, separating elk and bison on feedlines has become increasingly difficult, and a variety of feeding strategies are employed to help reduce displacement of elk.

As the herd has grown it has maintained fairly stable movement patterns, wintering almost entirely on the NER and summering within GTNP and adjacent lands on the BTNF (Fig. 1).

Planning History

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Jackson's bison and elk populations have been the subject of previous planning efforts. Elk management and research has been guided by the Jackson Hole Cooperative Elk Studies Group since it was established in 1953 [verify date]. The group consists of biologists and agency administrators from the National Elk Refuge, Grand Teton and Yellowstone National Parks, the Bridger-Teton National Forest, and Wyoming Game and Fish Department, who meet at least annually to coordinate management of the population and its habitat. Coordination of bison management began soon after they started frequenting the NER in 1976 and using supplemental feed provided to elk in 1980 (Fig. 3). Release of an "Interim" plan that called for maintaining a herd of 90-110 bison while data were gathered for a long term plan occurred in 1988. It was followed by implementation of a sport hunt administered by WGFD. This plan was halted after litigation in which the plan's violation of NEPA was successfully argued by plaintiffs.

In 1996, after considerable herd growth, a new long term management plan and environmental assessment for the Jackson bison herd was released (Fig 3). This plan had strong support and called for maintaining a herd size of 350-400 bison, but it was shelved a year later when plaintiffs from the earlier litigation successfully argued that, because the plan failed to consider the effects of feeding elk on bison management, it also violated NEPA and was not sufficient. This led to development of the draft bison and elk management plan and environmental impact statement from 2000-2006 and release of the final plan in 2007 (Fig 3).

The 2007 Bison and Elk Management Plan (BEMP; USFWS 2007) considered six alternatives for

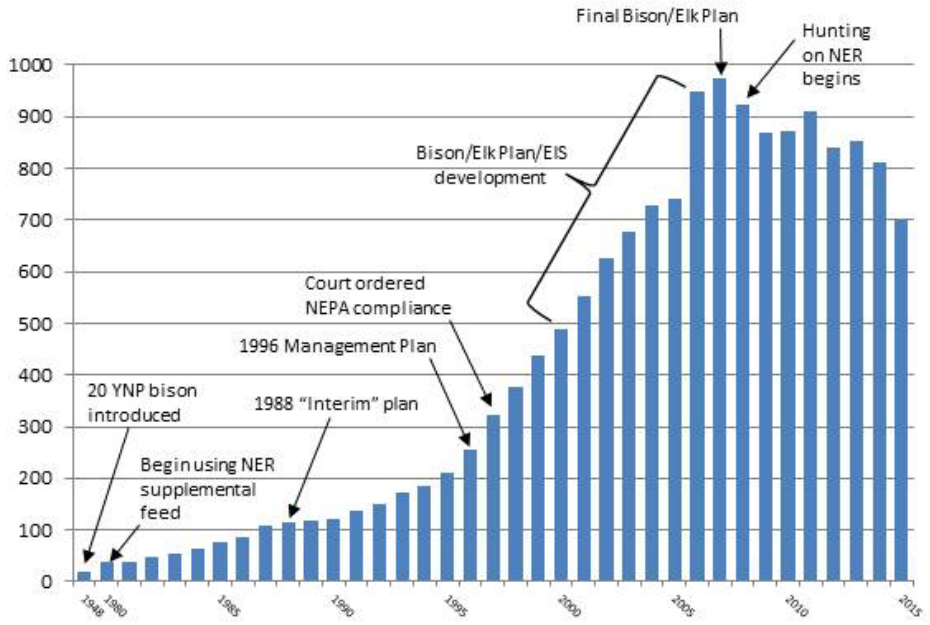

Figure 3. Population growth and planning history for the Jackson bison herd, 1948-2015.

bison and elk management focused on four broad goals related to: 1) habitat conservation; 2) sustainable populations; 3) numbers of elk and bison; and 4) disease management. The primary management scenarios presented in the alternatives included the status quo, terminating elk and bison hunting on the NER and the elk reduction program in GTNP, brucellosis vaccination options, restoring habitat, improving forage, and decreasing or phasing out supplemental winter feeding.

The final BEMP (USFWS 2007; www.fws.gov/bisonandelkplan) which set management direction for 15 years or until a subsequent plan is developed, proposed to maintain the state's elk herd objective of 11,000, establish a bison population objective of 500, restore habitat on the NER and in GTNP, continue hunting bison and elk on the NER, continue the elk reduction program in GTNP, when necessary, in concert with the parks enabling legislation (citation), continue to vaccinate elk for and effective vaccine becomes available, and develop a dynamic framework and adaptive management plan for decreasing the need for supplemental feeding on the NER. ***This Bison and Elk Management Stepdown Plan was developed to address the latter and specifically addresses the criteria for a structured framework listed on page 5 of the Record of Decision*** **(Fig. 4).** It does not address other on-going bison and elk management actions already prescribed by the BEMP.

The BEMP scheduled the completion of an Adaptive Management Plan for 2008. However, litigation challenging the BEMP in 2008 led to the decision to postpone its development until litigation was resolved. As of March 2015, two court rulings have upheld the 2007 BEMP and ROD. In a lawsuit against the BEMP and its author agencies (Defenders of Wildlife et al. v. the U.S. Department of Interior and State of Wyoming 2010), plaintiffs argued that the BEMP violated the National Wildlife Refuge System Improvement Act (National Wildlife Refuge System Improvement Act 1997) by disrupting the biological integrity of the Refuge, and that the plan and the accompanying EIS violated NEPA because they were insufficiently detailed to allow a reasonably complete discussion of mitigation. The crux of the plaintiff's argument was that the plan did not set a specific date for the cessation of supplemental feeding. In response, the agencies argued that the plan constituted a valid exercise of discretion and that it and the EIS were sufficiently detailed to satisfy the requirements of NEPA. In March 2010 the United States 4th District Court sided in favor of the agencies in this case. In 2011 the plaintiffs appealed this ruling to the United States 4th Circuit Court. The Circuit Court affirmed the District Court ruling (Defenders of Wildlife et al. v. the U.S. Department of Interior and State of Wyoming 2011).

National Environmental Protection Act Compliance

The 2007 BEMP/EIS and Final Record of Decision (ROD) satisfied NEPA requirements for current bison and elk management through a detailed analysis of alternative management actions and their likely effect on the environment, and substantial involvement of the public in the process. This adaptive management plan is does not duplicate or add to this process. It is designed to carefully tier off of the BEMP as a dynamic implementation guide to one part of the preferred alternative outlined in the BEMP ROD. As such, references to NEPA covered in the BEMP will be included where necessary in this document, and the discussion of any action that would require additional NEPA compliance will be explicitly stated as such in that context.

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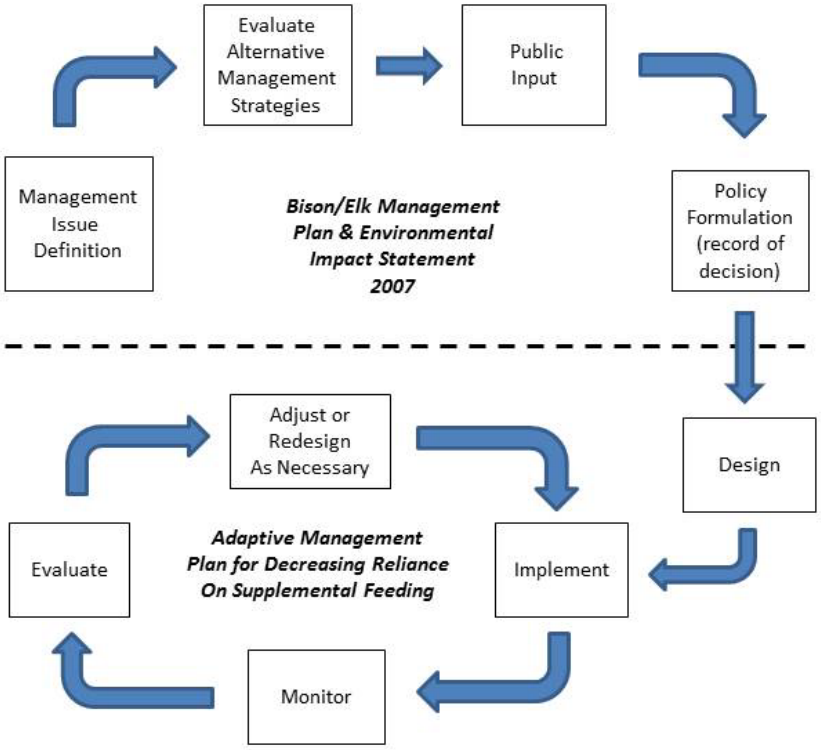

Figure 4. Adaptive management planning for supplemental feeding on the National Elk Refuge and its relationship to the 2007 Bison/Elk Management Plan and Environmental Assessment.

Adaptive Management Planning

Adaptive management plans have gained popularity in natural resource management planning because, by definition, they allow modifications of strategy based on monitoring results and outcomes toward reaching specific goals or objectives. There are four essential elements to an adaptive management approach: 1) well defined and mutually agreed upon objectives, 2 knowledge (including descriptive models) of the dynamics of the system being managed, 3) clearly articulated management actions and strategies, and 4) a monitoring program to evaluate responses of the system to management actions (Walters 1986).

This step-down plan utilizes adaptive management planning principles but is not intended to meet all of the adaptive management planning elements outlined in the Department of Interior Adaptive Management Technical Guide (2007). This Step-Down Plan is more accurately described as a "structured framework of adaptive management actions that progressively transitions from supplemental winter feeding to greater reliance on free-standing forage (BEMP ROD p.5).

OBJECTIVES

The management direction and desired conditions stated in the BEMP called for the NER and GTNP staffs to work with others (agencies, partners, etc) to "adaptively manage elk and bison in a manner that contributes to the State's herd objectives yet allows for the biotic integrity and environmental health of the resources to be sustained," so that the public can enjoy a variety of compatible wildlife-dependent recreational opportunities. Under the BEMP's 4 primary goals, 20 associated objectives were addressed (Table 1). This adaptive management plan addresses four objectives under the goal of sustainable populations (Fig. 5).

In Phase 1 of the second objective, the aim is to reduce the average number of elk on feed to 5,000 (while maintaining WGFD's 11,000 elk herd objective), and reduce the winter population of bison to the BEMP-adopted objective of 500. In Phase 2, the overall objective is to reduce the reliance of bison and elk on supplemental feed (USFWS and USNPS 2007a). Desired conditions include animals relying predominantly on native habitat and cultivated forage. Important consideration criteria for implementing Phase 2 will include: 1) the level of forage production and availability on the National Elk Refuge and adjacent winter ranges, 2) maintenance of desired herd sizes and age/sex ratios, 3) the ability to effectively mitigate bison and elk livestock conflicts, such as co-mingling on on private lands during high risk disease transmission periods, 4) maintaining desirable winter distribution patterns of elk and bison, 5) the prevalence of brucellosis, chronic wasting disease, and other wildlife diseases, and 6) public support. In short, the overall objective of this plan is to provide a path for progressively transitioning from winter feeding of elk and bison on the NER to greater reliance on free-standing forage, while maintaining population and herd ratio objectives.

Table 1. 2007 Bison/Elk Management Plan Goals and Objectives (Adaptive Management Plan objectives shaded)

Goal: Habitat Conservation

Objectives:

- Conserve important private lands.
- Increase forage production.
- Minimize non-native plants.
- Protect sagebrush grasslands.
- Restore willow, aspen, and cottonwood.
- Perpetuate natural mosaic of plant communities.

Goal: Sustainable Populations

Objectives:

- Develop adaptive management plan for reducing NER supplemental feeding.
- Phase reduction of animals on feed: 1) to 5,000 elk and 500 bison, and 2) elk and bison rely predominantly on native habitat.
- Maintain natural bull-to-cow ratios in park summer herd.
- Ensure a genetically viable bison herd with close to an even sex ratio.
- Enhance public outreach/education.

Goal: Elk and Bison Numbers

Objectives:

- Maintain state elk herd objective of 11,000.
- Maintain a genetically viable bison population of about 500 animals.

Goal: Disease Management

Objectives:

- Manage brucellosis transmission risk from elk and bison to livestock.
- Manage feeding to reduce brucellosis transmission among bison and elk.
- Educate hunters about wildlife disease human health hazards.

This Plan focuses on management actions to initially achieve Phase 1 objectives. However, if

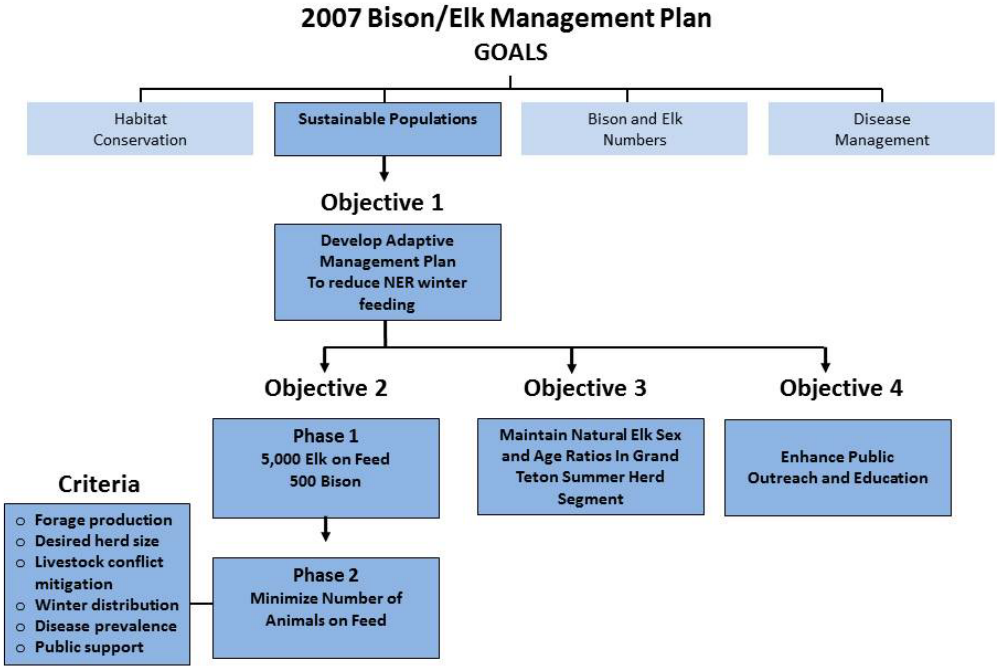

Figure 5. Relationship of Adaptive Management Plan to the 2007 Bison/Elk Management plan goals, phasing of objectives, and consideration criteria for reducing the reliance of elk and bison on supplemental feed during phase 2.

successful, these actions will continue to be used to achieve the Phase 2 objective of reducing reliance on supplemental feeding while considering the six criteria listed above.

MANAGEMENT ACTIONS AND STRATEGIES

Background

Elk have been fed for some period during nearly every winter on the National Elk Refuge since 1912, and bison have been fed there since 1980. The attraction of highly nutritious, easily accessible food during a time of year when natural forage is typically most limited is powerful to both species, and their knowledge of its existence has been passed down through generations. As a result, elk and bison have been strongly conditioned to seek supplemental food on the NER, even when natural forage is available and even abundant during some years. Because it is largely unprecedented, the concept of modifying this behavior on such a large scale is daunting and fraught with questions for which there is no answer. In some cases, the likelihood a specific management strategy's success will only be able to be roughly estimated, and unanticipated results are likely. The management stepdown approach will necessarily be one of investigation, constant evaluation, modifications to approach when indicated, and repeated trials (Fig 4). As such the approach will also be experimental, guided by rigorous analysis

and design, based on abundant empirical information, and monitored at an intensity commensurate with necessary decision making.

Since this plan is centrally tied to supplemental winter feeding on the NER, its focus will be on lands under NER authority. However, some strategies will also incorporate activities in GTNP, and on non-federal lands in collaboration with land owners and WGFD. Primary management practices that can be altered to achieve reduced reliance of bison and elk on supplemental feed fall into the 3 broad categories of 1) timing and intensity of winter feeding, 2) timing and intensity of hunting, and 3) herd segment specific and overall harvest levels.

Important Changes Since 2007

The BEMP was developed based on data collected and knowledge that existed up until its Record of Decision in 2007. Since then, important changes have taken place, some of which are advantageous to this effort, some of which are not.

A primary change that will facilitate meeting objectives under this plan is the reduction of the bison population from nearly 1,200 animals in 2007 to about 700 during winter 2014-2015 (Fig. 3) through hunting programs administered by WGFD. Licensing changes were enacted in 2014 to help increase harvest of female bison. These included a reduction in the bison cow/calf license fee (from $416 to $263 for residents and $2522 to $1022 for non-residents) and eliminating the once-in-a-lifetime restriction on a successful bison hunter to only those that successfully harvested a bull. Continued progress toward the 500 animal herd objective will require sustained harvest success.

During the same period, the Jackson elk herd has declined from nearly 13,000 to its objective of 11,000, but because the proportion of the Jackson Elk Herd that winters on NER has increased dramatically (Fig. 6), this will make achieving the Phase I objective of 5,000 elk on feed and any future elk population reductions more difficult. Preliminary modeling suggests that the increasing proportion of the Jackson Elk Herd wintering on NER has been associated with 1) changes in elk winter distribution associated with wolves and 2)high numbers of elk that summer immediately adjacent to NER (Cole and Foley et al. 2015).

Refuge-wide herbaceous forage production averaged 14,387 (SD = 4125) tons during 1998–2013. In recent years irrigation of approximately 3,600 acres has increased refuge-wide forage production by approximately 10% compared to what would have been produced with precipitation alone, and by 15% in the southern portion of NER which receives the greatest use by elk and bison.

Since 2007, the general awareness of climate change among the public has greatly increased. A strong, credible body of scientific evidence shows that climate change is occurring, is caused largely by human activities, and poses significant risks for a broad range of human and natural systems (National Academy of Science 2010). Ecological systems in the GYE are likely to be affected and associated changes will have implications for elk and bison management.

Current Management

Ongoing primary management actions on the NER include winter feeding, harvest, irrigation, and hazing. In GTNP, harvest of elk during the Elk Reduction Program takes place, when necessary, in collaboration with WGFD, and restoration of previously cultivated and irrigated sagebrush-grasslands is ongoing. Fundamental components of each of these will be briefly described below to provide a basis for comparison to adaptive management strategies that will follow.

Chronic Wasting Disease

Supplemental feeding has occurred in all but 9 winters on NER since 1912, and although this strategy minimizes winter elk mortality from starvation and contributes to Wyoming state elk

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herd objectives, elk occur at numbers and densities well in excess of carrying capacity (Smith et al. 2004, Lubow and Smith 2004). Considerable evidence suggests that Chronic Wasting Disease (CWD) transmission and prevalence are density dependent (Peters et al. 2000, Williams et al. 2002). Monello et al. (2014) found that elk densities of 15-110 per square km in Rocky Mountain National Park were associated with 13% CWD prevalence, and they predicted elk population declines when CWD prevalence exceeded 13%. NER elk densities commonly exceed 160 per square km (NER unpublished data), which suggests that the introduction of CWD to NER elk would have significant negative population effects over time.

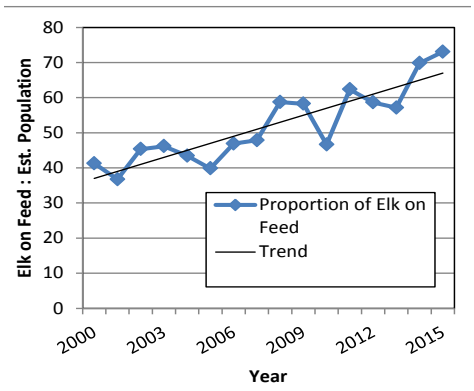

Figure 6. Increasing trend of National Elk Refuge elk on feed as a proportion of the Jackson Elk Herd estimated population size.

Winter Feeding

Initiation of feeding has the primary objectives of 1) minimizing elk winter mortality, focusing on calves since they are the most susceptible age class, and 2) minimizing comingling of elk with cattle on nearby adjacent private lands. Winter feeding begins when available forage reaches approximately 300 lbs/ac. Historic radio telemetry data and observations of elk movements indicate that when available forage delclines below 300 lbs/ac., some elk leave NER for surrounding private lands. Therefore, the purpose of this feeding trigger is to keep elk on the NER and prevent them from searching off-refuge for forage which increases the potential of comingling. This trigger is not a warning that a significant nutritional deficit threshold has been reached. Available winter forage for elk and bison on the NER is largely determined by biomass of forage produced during the previous growing season, rate of forage consumption during fall and winter, and how snow conditions affect forage availability.

Forage biomass estimates are calculated annually based on sampling at index sites. Index sites are selected subjectively each year based on presence of vegetation highly palatable to elk.

During 1995–2013, on average, initiation of NER winter feeding occurred on 28 January (range 30 December - 28 February), and feeding was terminated on 3 April (range 20 March - 20 April). Variation in feeding initiation and termination dates has been based on winter conditions and elk-cattle comingling problems on nearby private

Table 2. Annual distribution of wintering elk from the Jackson Elk Herd during February classification counts, 2011–2015, relative to the current objective.

	OBJECTIVE	2011	2012	2013	2014	2015	mean
NER	5,000	7,746	7,360	6,285	8,296	8,390	7,615
Gros Ventre	3,500	2,775	3,265	2,982	2,326	1,162	2,502
Native Range[1]	2,500	982	894	1,784	801	913	1,075
Total	11,000	11,503	11,519	11,051	11,423	10,465	11,192

[1]Excludes objectives for native range adjacent to Gros Ventre feedgrounds.

lands. Coordination of winter feeding dates on the NER and WGFD-operated Gros Ventre drainage feedgrounds (Alkali, Patrol Cabin) occurs annually to help minimize movement of elk between these areas. This coordination will continue regardless of the management strategy employed. The relationship of recent elk numbers and objectives for NER and WGFD-operated feedgrounds and native range is shown in Table 2.

Bison are fed as necessary to help minimize disruption to elk feeding operations. Bison will readily displace elk from feedlines, so since bison started using feedlines in 1980 refuge staff have developed a strategy of keeping most bison at the northernmost feedground (McBride) by feeding them there prior to feeding elk. Bison are provided a ration consistent with encouraging them to stay in this area away from elk feeding areas. This has also reduced conflicts associated with bison moving into Jackson or to the Nowlin area of the NER where commercial sleigh rides occur.

Harvest

Total harvest of the JEH was gradually reduced over the last decade as the population neared objective (Fig. 7). Elk hunting on the NER (Hunt Area 77) typically begins in mid-October and ends in mid-December, with peak harvest in recent years occurring in late November to early December. From 2005 to 2011 an average of 393 (SD = 56, range 329-457) hunters harvested 161 (SD = 38, range 126-225) elk per year during the NER hunt.

The 1950 legislation that created Grand Teton National Park provided for a controlled reduction of elk, when necessary, in specific portions of the park, primarily east of the Snake River. Elk reduction programs have taken place in the park each year since 1950 except two (1959, 1960), when GTNP and WGFD officials agreed a reduction was not necessary (Figure 8). Season dates have varied over the years but recently have run from mid-October to early-December. The GTNP harvest accounts for about 25% of the JEH overall harvest, thus has been an important factor in regulating the population. Increased natural regulation, likely a result of increases in grizzly bears and wolves over the last 20 years, has decreased the need for large harvests in the park.

Bison hunting begins on August 15 and ends in early to mid-January. Most harvest occurs on the NER, with some additional harvest on private and BTNF lands. Since resuming the bison hunt in 2007, mean harvest has been 210 (SD = 45.5, range 139-301) bison per year. This level of harvest has been sufficient to arrest the exponential growth of the population, reducing bison numbers from the peak in 2007 to about 700 animals in winter 2015 (Fig 3). Tribal bison harvest of up to 5 animals for ceremonial purposes was authorized in the BEMP. Translocation of wild bison to lands outside of Teton County is not currently permitted due to brucellosis concerns.

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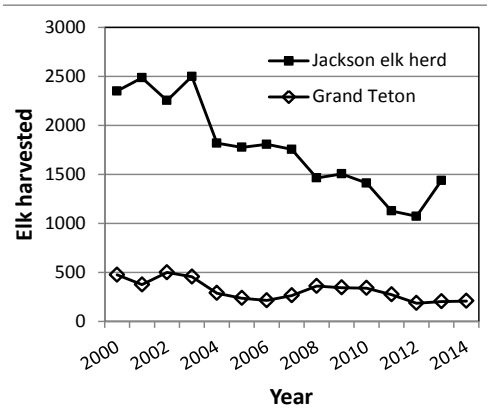

Figure 7. Estimated elk harvests for Grand Teton National Park and the Jackson elk herd (including the park) 2000–2014.

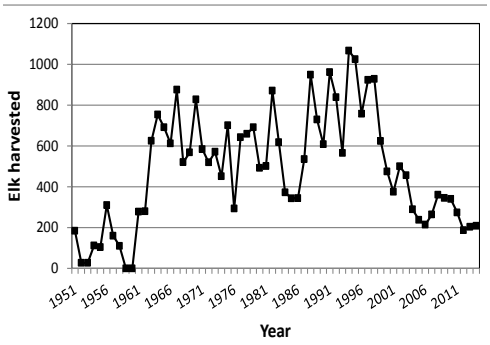

Figure 8. Elk harvest in Grand Teton National Park, 1950-2015.

Bison hunting is not allowed in GTNP because of long standing National Park Service policy that prohibits most hunting in national parks. Bison quickly learned to take advantage of the parks safety, which has made obtaining hunter harvest goals difficult. Many bison stay in the park during the hunting season, with only occasional short term movements to the NER, until severe winter conditions occur. In response, NER and WGFD managers attempt to balance extending the hunt as late in January as practicable without conflicting with winter feeding. The unpredictable nature of winter conditions that time of year makes this a risky proposition, and can result in the use of emergency season extensions or reductions.

Hazing

Elk and bison are hazed in spring to encourage movement off of NER winter ranges. Methods used have included ATVs, on foot, and on horseback, but recently ATV use has been found most effective. It's possible that some elk and bison might remain on the NER year around without hazing. If animals fail to leave the NER following the termination of feeding and adequate green-up has occurred, they are typically hazed to the north in late April to early May. Elk will stay off the NER until fall migration, and bison will generally remain in GTNP until mid-July. From July to early August bison often make forays back to the NER and are hazed back to GTNP to protect winter forage. Hazing efforts in August cease several days to weeks before the bison hunting season in an effort to increase hunter harvest.

Vegetation Restoration and Protection

The BEMP identified approximately 4,000 acreas of previously irrigated and cultivated grasslands in GTNP in need of restoration to native sagebrush grasslands community. Substantial progress in this endeavor has been made since 2007, including: [GTNP folks please add short description of methodological research and implementation, followed by what remains to be accomplished]

Private Lands Mitigation

Fencing of hay stacks and livestock feedlines has been historically used to mitigate particularly difficult conflicts on private lands. Targeted fencing of golf course greens and sand traps fall through spring has also been successful in some situations for mitigating elk and bison presence and associated damage in these areas. It is important to note that the county has a 'wildlife-friendly' fence policy and does not support extensive fencing that is impermeable to wildlife.

Methods, Assumptions, and Constraints Common to All Strategies

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Measuring the success of strategies toward objectives will require knowledge of several bison and elk herd attributes, particularly population sizes. Measurements of the Jackson bison herd will be based on the annual mid-winter census and sex and age classification survey performed by NER, GTNP, and WGDF biologists. This survey occurs one day in early February and includes ground counts of animals on feed at the NER and aerial counts of outlying bison across their winter ranges on the refuge, park, and Bridger-Teton National Forest.

Elk population estimates will also be based on mid-winter aerial and ground counts. However, the mid-winter counts are undertaken during a single survey period and do not necessarily represent either peak or cumulative abundance of elk on feed. Rather than basing progress toward the number of elk on feed for the entire season on those present during the day of the survey only, we will use a more meaningful measurement. Since we are more interested in the intensity of elk feeding throughout the entire feeding period, which includes both the number of animals on feed and the duration of feeding, we will use a measurement of elk-fed-days (EFD; the total number of elk fed per day per season) as a gauge of feeding intensity (see monitoring section). For example, if 5,000 were elk fed for 100 days during the winter, feeding intensity for that winter would equal 5,000 elk X 100 days = 50,000 EFD, whereas if 5,000 elk were fed for 50 days, EFD would equal 25,000.

We determined feeding intensity benchmarks for bison and elk-fed based on an actual average of 64 days of feeding from 1995-2007. Based on the Phase I objectives of 500 bison and 5,000 elk, fed-days benchmarks would be 64 x 500 = 32,000 for bison and 64 x 5,000 = 320,000 for elk. These values will assist in determining efficacy of strategies toward reducing reliance of both species on supplemental winter feeding.

Implementation of the AMP will have successfully attained the objective of "transitioning from intensive supplemental winter feeding to greater reliance on free-standing forage" when supplemental feeding was not used for more than 50% of the years in a 5 year period.

Comment [S3]: SK's draft.

Initial success of AMP implementation will be a consistent decline in the 3-year running average of elk and bison fed days from the established baseline. While the BEMP did provide specific measurement criteria for the definition of "transitioning from intensive supplemental winter feeding to greater reliance on free-standing forage" we will consider this objective met when the 3-year running average of elk and bison fed days is <50% of baseline for 5 years in a row.

Comment [S4]: SC's alterative in this paragraph, recognizing that the 50% number is the crux and a glaring target.

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Table 3. Summary of potential Adaptive Management Plan constraints.

Policy

- ESA[1] Lynx – limits on habitat impacts
- Greater Sage Grouse – core area protection
- 2007 BEMP/EIS (federal actions/lands)
  - No fertility control
  - No test and slaughter
  - Limited tribal harvest
- Bison/elk hunt end date (Feb. 1st)
  - WGFD, brucelosis safety
- Carcass disposal (Feb. 15th)
  - WGFD, brucellosis safety
- Forest Service winter closure (Dec. 1st – April 30th)
- Easement limitation (NER boundary)

Winter Feeding

- Only during non-hunting periods

Harvest

- State regulations

Vegetation Restoration/Protection

- Bison/elk distribution
- Exotic plant species management

Private Lands

- Owner agreements

Social

- Hunter density (safety; hunt quality)
- Elk/bison winter mortality levels
- Public safety (ungulate/vehicle collisions)
- Disease
- Land-use conflicts (agricultural and residential)

Biological

- Disease (bison/elk/cattle commingling)
- Sage grouse habitat conflicts
- Fencing/wildlife conflicts
- Elk herd distribution
  - summer segment distribution goals

Funding

- Easement purchase
- Plan implementation

[1]Endangered Species Act

Several management constraints are common to the strategies discussed below (Table 3). Many law and policy constraints are applicable but we include here only those most pertinent. Endangered Species Act (16 USC 1531 et seq.) requirements for wolves, grizzly bears, lynx, and others apply. Lynx requirements for maintaining certain habitat types could limit methods used and areas considered for habitat improvements in GTNP. Similarly, compliance with the Wyoming greater sage-grouse core area protection executive order (2011-5) could restrict habitat manipulations. NEPA compliance conducted as part of the BEMP/EIS constrains what federal actions can be taken as a part of this plan. State regulations constrain late (winter) hunt and carcass disposal timing to protect against brucellosis contamination, since February-April represent the period bison and elk are most likely to transmit the disease. Restrictions on hunting timing also result from BTNF winter range closures, immediately east of the NER and elsewhere, December 1 to April 30. Additional details about these and other constraints will be included in discussions about specific strategies that follow.

Strategies

This section will describe the management action this AMP proposes to implement. As such, it unveils the heart of management changes necessary to begin the process of transitioning to more reliance of bison and elk on native forage during winter. Fundamentally, the strategies discussed in this plan represent an experiment designed to achieve Phase I objectives of 5,000 elk and 500 bison on NER and are a first step towards reducing reliance on supplemental feeding while meeting the sustainable population goals identified in the AMP.

Initial strategies for achieving sustainable population goals identified in the BEMP (Table 1) are presented by objective below. The primary management actions available to the agencies to achieve phase I objectives are modifications to winter feeding and hunting seasons. To a lesser

extent, vegetation protection and restoration can be important, particularly for improving long-term ecological balance and enhancing natural production of native forage. Private lands are also an integral component as changes in elk and bison distribution occur and new challenges develop. The likely consequences of implementing these strategies were evaluated in the BEMP. The most relevant of these are summarized in Appendix 1.

Objective: *[Implement] a phased reduction of animals on feed: 1) to 5,000 elk and 500 bison, and 2) [to an extent where] elk and bison rely predominantly on native habitat* (Table 1).

This objective is what the need for an adaptive management plan – **this document** – is central to. As previously mentioned, the concept of reducing winter feeding after more than 100 years of the practice, and the associated behavioral conditioning of elk and bison to its presence, represents a formidable challenge that must be approached cautiously and systematically. The strategies discussed below have been developed in this context, with appropriate feedback mechanisms through rigorous monitoring and frequent evaluation. Inability to meet this objective under the strategies presented here would trigger a thorough evaluation and development of more aggressive strategies.

Chronic Wasting Disease

In 2014 WGFD began the revision process for the Wyoming CWD Management Plan (2006). WGFD has cooperated with federal agencies and other stakeholders to revise the plan, and NER and USFWS Region 6 Wildlife Health Office staff participated in several meetings associated with this effort. One goal of the CWD Management Plan update is to develop specific management responses should CWD be detected on or adjacent to State or NER elk feedgrounds. Early detection of CWD in the JEH is essential to ensure an effective management response.

Since 1997 NER has cooperated with Wyoming Game and Fish Department (WGFD) to conduct surveillance for CWD in the JEH unit. Although this effort indicates that CWD is not currently found in the JEH, continued surveillance at sample sizes sufficient to detect 1% prevalence with 95% confidence annually will be critical to ensure a timely management response and limit the long-term population effects of the disease (USFWS and NPS 2007). Given that CWD has been detected within 40 miles of the JEH in moose, within 70 miles in deer, and within 175 miles in elk, this level of surveillance is warranted.

Winter Feeding

Winter feeding actions that could be modified include starting date, ending date, and daily ration. To modify elk and bison behavior in the long run, delaying initiation of feeding is likely to have the greatest impact by gradually conditioning them to expect feed later on average, with the desired outcome of building a cohort of animals that rely primarily on native winter range and are not food conditioned. To reduce supplemental feeding overall, ending feeding early would also help decrease the amount of feed provided per animal per year. Both would help decrease the total elk/bison fed days, the parameter we will use to measure progress toward reducing supplemental feeding.

Initially, supplemental feeding will be delayed by approximately 2 weeks, depending on several variables (Table 4, Fig. 9). Time of season could influence this interval, most likely shortening it as the feeding initiation date gets later. During the last 20 years, feeding initiation dates, which have been based on forage availability, have varied from December 30 to February 28. Delaying feeding by two weeks in January, for example, is likely to be more successful than doing so in February, when food stress and tendency for animals to move to private lands is greater. Forage availability could also have an influence, particularly if a freeze thaw event resulted in an acute and large reduction in available forage.

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Both time of season and forage availability considerations would be affected by the numbers of elk and bison on the NER. And finally, the distribution of animals, particularly on private, livestock producing lands, would be considered.

A primary concern of manipulating feeding is elk winter mortality, particularly among calves. As food becomes limited in winter, calves are usually the first to suffer because of being displaced by more dominant animals. Monitoring programs will include measures of calf mortality and it will be an influencing parameter in feedback mechanisms. The BEMP anticipated that elk mortality could increase from 1-2% overall to 1-5% (Appendix 1).

Initially, the termination of feeding, which is now based on a snow cover index and subjective evaluation of available forage, will occur about a week earlier. The combination of a 2 week delay in feed initiation and 1 week advance in termination would shorten the feeding season by 3 weeks on average, or 32% based on an average feeding season length of 9.3 weeks from 1995-2015.

The AMP winter feeding strategy would include the establishment of additional key forage index sites and on-going measurements at those sites throughout the winter.

Harvest

Currently the Jackson elk herd is at the Wyoming Game and Fish Commission established objective of 11,000 animals, which means there is less flexibility in manipulation of harvest regimes than there would be if the herd was above objective. Initially there would be little change in elk harvest programs on the NER, with the exception of allowing a limited number of any elk permits throughout the season, considering allowing bow hunting near developed areas (roads and buildings) and shifting the season about a week later (Table 4). Allowing a limited number of any elk permits would be consistent with providing sport hunting recreation on National Wildlife Refuges (citation, NWR system act) and the NER (citation, CMP?), and possibly encourage more hunters to participate in antlerless elk hunts. Monitoring programs and consideration of bull ratios in the GTNP summer segment (since most park bulls migrate to the NER) would help inform levels of take proposed. Bow hunting in areas currently closed to firearms will likely increase harvest by eliminating “no-hunt” areas which can become sanctuaries for large numbers of elk. Shifting the hunt one week later is consistent with later migrations and will improve harvest effectiveness.

General elk harvest patterns in GTNP would continue to be based on need for harvest, summer segment population estimates, and mitigation for impacts on other resources and visitor activities.

Elk herd population objectives are reviewed every five years by the Wyoming Game and Fish Commission and adjusted as necessary. Serious consideration should be given to reducing the Jackson Elk Herd population objective. Lowering the population would help compensate for reduced use of traditional native winter range and increased growth of short-distance migrants which has lead to significant increases of winter elk concentrations on the NER.

The annual fall/winter arrival of elk to the NER during the past several decades has been occurring progressively later. This trend may necessitate extending the elk hunting season later into the year to achieve harvest objectives.

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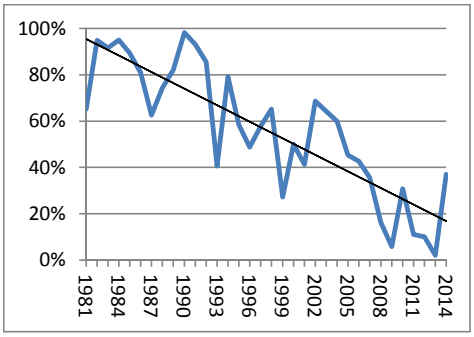

Figure ?. The annual fall/winter arrival of elk to the NER during the past several decades has been occurring progressively later. This trend may necessitate extending the elk hunting season later into the year to achieve harvest objectives.

Bison hunts on the NER (bison hunting is prohibited in GTNP) would see little initial change (Table 4). Consideration would be given to later hunt end dates commensurate with delayed feeding, and possible escorted hunting in the South Unit to help with distribution or discouraging bison from attempting to leave the NER via the south boundary into the town of Jackson. If progress toward reaching the herd objective of 500 animals continues and the objective is reached in the near future, State quotas will likely be reduced and management flexibility will increase.

A cattle guard will be installed on the Refuge Road near the east end of Broadway Avenue to help prevent bison and elk herds from entering the Town of Jackson. This will reduce the potential for dangerous human/wildlife interactions.

Serious consideration should be given to reducing the bison herd population objective in the future. This would lower winter forage consumption on the NER and help reduce elk and bison winter concentrations.

The current bison herd objective is ". . . maintain and ensure a genetically viable population of approximately 500 animals (five-year average), with as close to an even sex ratio as possible to maximize maintenance of genetic variation over time. . ." (BEMP p. 136).

The Jackson bison herd is not considered part of the U.S. Fish and Wildlife Service's meta-population approach to bison conservation because of its high prevalence of brucellosis. This disease prevents the export of Jackson bison to other DOI conservation herds.

The 500 bison population objective was set primarily to preserve existing genetic diversity assuming extremely limited natural genetic transfer with the Yellowstone or other DOI bison conservation herds. Genetic diversity can be maintained for a Jackson bison herd less than 500 if bison with desirable genetic diversity are periodically imported from other DOI bison conservation herds.

Currently, the effectiveness of NER late-season harvest regimes is affected by December 1st winter closures immediately east of the refuge on BTNF lands. Extensive elk telemetry data suggest that delaying the winter closures could aid elk management objectives. NER officials will work with BTNF and WGFD officials to explore the possibility of allowing hunting in limited areas after December 1st in the future.

Annual herd-wide population estimates, elk summer herd segment estimates, temporal and spatial harvest patterns, and animal-fed-days would be monitored, and the resulting information would be used to inform ongoing evaluation of adaptive elk and bison management harvest programs (Figs. 9 and 10).

Hazing

No change in hazing practices is anticipated initially under this adaptive management framework.

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Private Lands Mitigation

Delaying the onset of NER feeding is likely to result in changes in bison and elk distribution (Appendix 1). Some elk or bison may move to private lands in search of forage. Of greatest concern is the potential for elk or bison to commingle with cattle of cow/calf operations, where brucellosis transmission could have considerable consequences, in the worst case requiring depopulation of the cattle herd.

Several strategies would be employed to mitigate potential problems (Table 4), including providing incentives for non-breeding cattle operations (because brucellosis transmission to slaughter-bound cattle is not economically important), increased fencing in some limited areas to separate elk/bison from livestock feed lines, haze elk/bison away from livestock feed lines and purchase private lands easements to prevent co-mingling. A vital component in implementing these mitigation measures is to establish three seasonal Wildlife Conflict Technician positions which are supervised by the WGFD. These Technicians are also critical to the success of an expanded monitoring program vital to the AMP (see Monitoring section below).

A database will be established to track non-agricultural conflicts on private lands to determine trends which will help evaluate the effectiveness of AMP mitigation efforts.

Preventing elk and especially bison from entering the Town of Jackson is essential in minimizing safety and private property conflicts. Currently, bison are hazed northward when they drift south of Miller Butte. A double cattle guard will be installed on the Refuge Road just north of Broadway Avenue. This barrier is designed to prevent elk/bison from entering the Town of Jackson.

Vegetation Restoration/Protection

[NER and GTNP staff to draft material]

Objective: *Maintain natural bull-to-cow ratios in park summer herd* (Table 1).

National Park Service management policy (NPS 2006) provides guidance for maintaining naturally regulated wildlife populations, free from the impacts of humans, to the greatest extent possible. The final BEMP identified a goal of maintaining park elk bull:cow ratios (a common way of expressing sex and age ratios in wild ungulate populations) near 35 adult bulls per 100 adult cows, based on estimates of what this ratio would be in a herd free from the effects of human harvest. The sex and age ratios of most North American elk populations are affected by sport hunting and herd managers generally maintain lower bull ratios.

Harvest

Based on bull ratios in the park summer herd that were chronically below 35 bulls:100 cows, permit types for the park's elk reduction program (ERP) went to antlerless only in 2012. ERP permit structures in the park will remain antlerless only unless the bull ratios consistently exceed 35:100 cows. Park and refuge officials will work together to support this goal, recognizing that bulls harvested on the NER are most likely from the park summer herd segment.

A private lands Hunting Coordinator Position would be established and supervised by the WGFD to promote and coordinate hunting activity focused on Southern Herd Segment harvest in and around private lands in the Spring Gulch Area north to Moose, WY (Hunt Area 78).

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Table 4 [incomplete]. Comparison of current and adaptive primary management components and parameters.

Action	Current Management	Adaptive Management	Comments
Winter Feeding:			
Feed	Pelleted alfalfa	Pelleted alfalfa	No change
Ration	8 lbs/day/elk 20 lbs/day/bison	8 lbs/day/elk 20 lbs/day/bison	No change, to minimize calf mortality
Start criteria:			
Available standing forage	300 lbs/acre, as measured at traditional key index sites	Generally 2 weeks later; index sites to be increased in number and distribution	Influencing factors: - time of season - forage availability - numbers of elk/bison on NER - elk/bison distribution
End criteria:			
Available forage	Based on a snow cover index and subjective estimate of when residual or new forage is adequate	Generally 1 week earlier	Development of more objective criteria for future implemen-tation ongoing
Monitoring:			
Animals on feed	Mid-winter census	Elk/bison fed days[1]	
Proportion of JEH on NER feed	Mid-winter census	Mid-winter census	
Calf mortality threshold		<= 10%	
Elk/bison distribution - visual			
Elk/bison distribution – collars			
Winter mortality			
Elk summer range proportions			
Harvest, National Elk Refuge elk:			
Frequency	Annual	Annual	
Begin Date	2nd week October	3rd week October	Modified as necessary
End Date	2nd week December	3rd week December	Modified as necessary
Structure	- 1 week initial drawing - 1 week left over 1st served - partial week alternate	- 1 week initial drawing - 1 week left over 1st served - partial week alternate - daily 1st served alternates	

[1]Number elk and bison on feed per day, totaled by feeding season.

Table 4, continued. Comparison of current and adaptive primary management components and parameters.

Action	Current Management	Adaptive Management	Comments
Harvest, National Elk Refuge elk:			
Refuge permit types	- 1st week any elk - Antlerless only remainder of season	- Primarily antlerless only - limited any elk permits throughout season	
Access	Restrict access to specific locations	Restrict access to specific locations	
Hunt area boundaries		Consider expanding to allow bow hunting near developed areas	
Harvest, National Elk Refuge bison:			
Frequency	Annual	Annual	
Begin date	August 15th	August 15th	Modified as necessary
End date	2nd or 3rd week January	Consider later dates as appropriate	Modified as necessary
structure	As per WGFD	As per WGFD	
Refuge permit types	Any bison or cow/calf per state license	Any bison or cow/calf per state license	
access	Restrict access to specific locations	Restrict access to specific locations	
Hunt area boundaries	Limited to north of Nowlin Creek area	Consider escorted hunting in South Unit as needed	Guided hunts in South Unit when authorized
Harvest, Grand Teton NP elk:			
Frequency	As needed	As needed	
Begin Date	3rd week October	3rd week October	Modified as necessary
End Date	2nd week December	2nd week December	Modified as necessary
License types	Antlerless only	Antlerless only[1]	
Special regulations:	Cartridge limits	Cartridge limits	
	Bear spray required	Bear spray required	
	Hunter safety card required	Hunter safety card required	
Harvest, Bridger-Teton NF, Elk Hunt Area 80:			
Begin Date			
End Date		December 15	Would require change in winter closure dates

[1]Any elk licenses could be offered if bull ratios in the park consistently exceed BEMP criteria.

Table 4, continued. Comparison of current and adaptive primary management components and parameters.

Action	Current Management	Adaptive Management	Comments
Harvest, Elk Hunt Area 78			
Structure			Changes at discretion of WGFD
License types			
Private Lands Mitigation:			
Cattle commingling		Incentives for non-breeding operation	
Hay depredation		Increased fencing	
Landscape damage			
Easement acquisition			
Vegetation Restoration/ Protection: Elk Refuge			
Vegetation Restoration/ Protection: Grand Teton			

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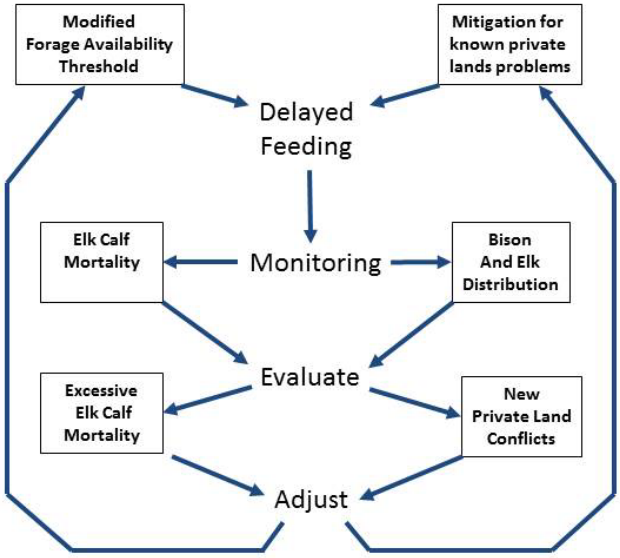

Figure 9. [example] Framework for delayed feeding strategy and adaptive management.

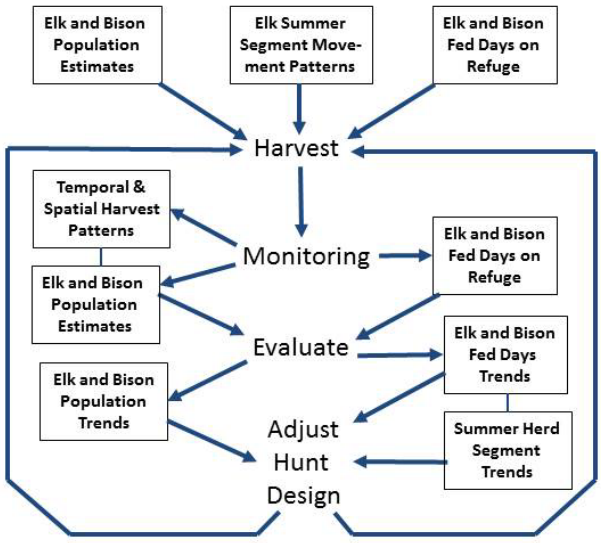

Figure 10. [example] Framework for harvest strategy and adaptive management.

Strategies Considered But Rejected

The BEMP considered several additional strategies for elk and bison management that, for a variety of reasons, were not selected for implementation in the preferred alternative and Record of Decision. The agencies reconsidered a subset of these during the development of this AMP (Table 5). Since they were not part of the ROD, additional NEPA compliance would be necessary to incorporate any of them into this adaptive management plan, and thus they are not being considered at this time.

Table 5. Strategies considered but rejected.

Strategy Considered	Reason Rejected
Fertility control in elk	Judged not reasonable or feasible in BEMP, primarily due to major technical, social, and financial hurdles[1]. For AMP discussed primarily with regard to the difficult to harvest herd segment in Hunt Area 78 on private lands, where federal agencies have no jurisdiction.
Fertility control in bison	Impacts discussed at length in BEMP[2]. Not considered for AMP because current hunting programs appear effective at slowly moving the herd toward the 500 animal herd objective.
Agency reduction of bison or elk	Not considered necessary or desirable on federal lands because current hunting programs that utilize sport hunters are effective at meeting herd objectives.
Altering rations of supplemental feed	Rejected as a strategy because reducing daily feed ration below 8 lbs/elk would be enough feed to encourage elk to remain on NER but would result in unacceptably high elk calf mortality rates.

MODELS OF SYSTEM DYNAMICS

Models provide a simplified representation of the biological system being managed. Adaptive management uses models of the managed system to link the objective response (e.g., elk winter distribution) to changes in the system resulting from management actions (e.g., altered initiation and cessation of winter feeding). Fig. 11 describes possible factors that affect winter elk distribution (the proportion of elk on NER feedgrounds versus native winter range). Models will be used to identify the relative influence of our principal management strategy (a reduction in feed season length) and other factors on winter elk distribution (Appendix 3). Over time this will allow us to assess whether changes in elk distribution were the result of our management actions or due to factors outside of our control.

An increase in calf elk winter mortality is a potential result of reduced feed season length. Fig. 12 portrays factors that influence winter calf elk survival on NER.

Models will be used to assess the effects of available forage on winter calf elk survival (Appendix 4). Over time this will allow us to assess the effects of our principal management strategy (reducing feed season length) relative to other factors on elk calf survival and potentially adjust our management actions based on model results.

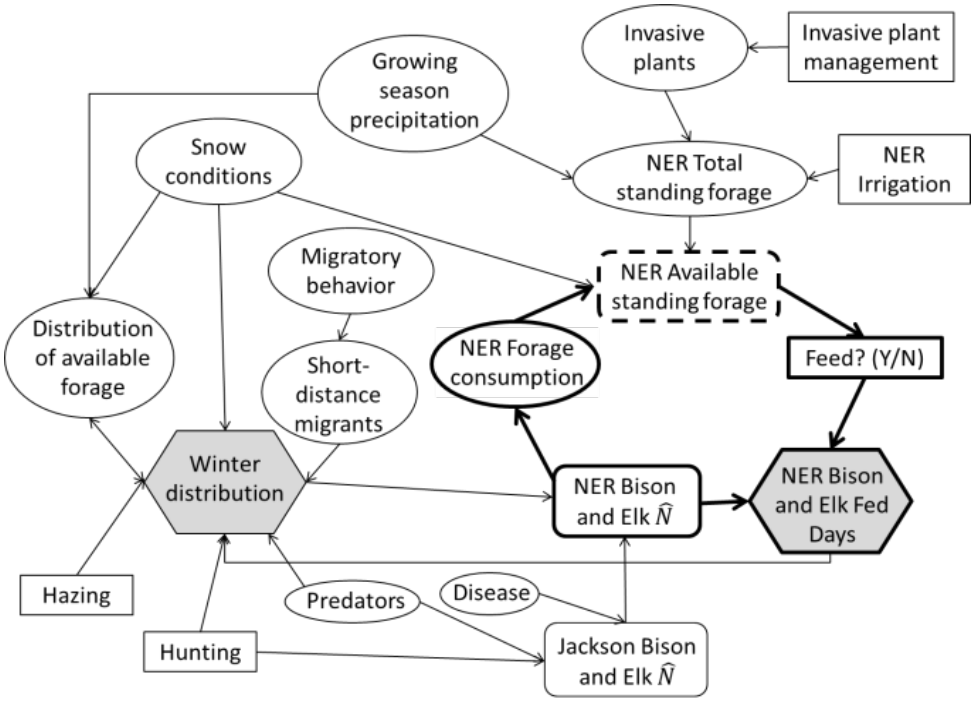

Figure 11. Influence diagram depicting factors (including management actions) influencing outcomes identified in the Bison and Elk Management Plan (BEMP; USFWS 2007a). Gray hexagons represent outcomes, rectangles represent management actions, rounded rectangles represent factors with numerical objectives, and ovals represent factors outside of management control. Bolded polygons and arrows represent outcomes and factors limited to the National Elk Refuge (NER). Available standing forage on the NER (dashed rectangle) is the BEMP criteria with a defined threshold to trigger initiation of supplemental winter feeding.

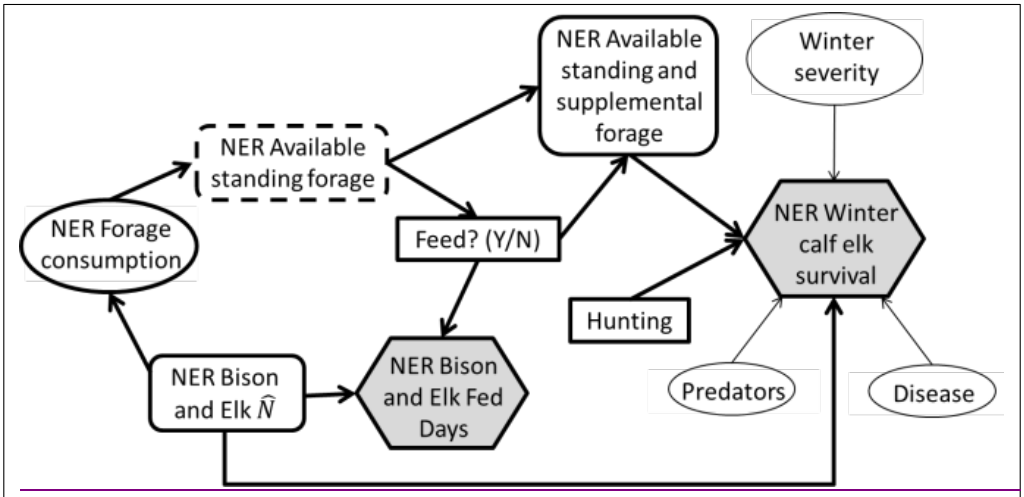

Figure 12. Influence diagram depicting factors (including management actions) influencing bison and elk fed days on the National Elk Refuge (see text for description) and winter calf elk survival. Gray hexagons represent outcomes, rectangles represent management actions, rounded rectangles represent factors with numerical objectives, and ovals represent factors outside of management control. Bolded polygons and arrows represent outcomes and factors limited to the National Elk Refuge (NER). Available standing forage on the NER (dashed rectangle) is the BEMP criteria with a defined threshold to trigger initiation of supplemental winter feeding.

MONITORING

Feeding Initiation Monitoring

NER uses weekly field estimates of the amount of forage available to elk to determine feeding initiation date. Currently measurements are taken at key index sites representing areas preferred by elk on NER (see supplemental materials at end of this section). These methods will be enhanced by 1) increasing the number of sampled sites to better represent the total amount of forage available to elk on the southern half of NER; 2) increasing the precision of estimates at each site by increasing the number of observers; and 3) extending the monitoring period later in the winter to assess the relationship between available forage and elk and bison distribution.

To better represent the total amount of forage available on the southern half of NER, a subsample of current key index sites will be retained to facilitate comparison with historic data, but additional random sample sites stratified by elk habitat preference will be added. Historic elk distribution mapping and elk GPS collar data (NER unpublished data) suggest that the areas most preferred by elk on southern NER are associated with moderate to high forage production and green vegetation. Because the distribution of forage production and greenness characteristics vary annually based on irrigation and precipitation patterns, we will annually map areas preferred and not preferred by elk and sample sites will be randomly selected within each of these mapped categories. At least 3 historic key index sites, 3 random sites in areas preferred by elk, and 3 sites in areas not preferred by elk will be sampled each week from late December through the initiation of supplemental feeding.

Currently the NER biologist is the only person trained in the techniques used to estimate available forage (see supplemental materials). At least 2 additional personnel will be trained in these techniques. This will provide a backup in the event of future personnel changes and will facilitate error estimates of the available forage measurements at each site.

Currently NER and WYGFD biologists monitor available forage conditions at least weekly from late December until average available forage at key index sites nears the threshold level of 300 lbs. per acre and feeding is initiated. The principal AMP strategy is to delay the initiation of supplemental feeding by 2 weeks after average forage production reaches the 300 lbs. per acre level at key index sites. Therefore the monitoring period will be extended to include the intervening 2 weeks.

Proportion of Elk Wintering on NER

A principal AMP goal is to reduce the number of elk wintering on NER. Our strategy will be to effect redistribution of elk to native winter range from NER over time via shortening the duration of the feed season, and thus slowly conditioning elk to seek food elsewhere. As feeding periods are shortened, the probability of younger elk age classes discovering NER feedgrounds will be reduced, and, hypothetically, that proportion of the JEH that utilizes NER feedgrounds will decline over time. We will measure this effect by examining changes in the winter distribution of the JEH. WGFD annual trend/classification count data provide a multi-year baseline data set to measure changes in the winter distribution of the JEH and categorizes observations by location. In each year, we will calculate the proportion of total classified elk in the JEH that are classified on NER feedgrounds. We will compare the 3-year running average post AMP implementation to the pre-implementation baseline. The pretreatment baseline will be comprised of data from 2008-2016, a time period that represents BEMP implementation prior to AMP actions (Figure 13).

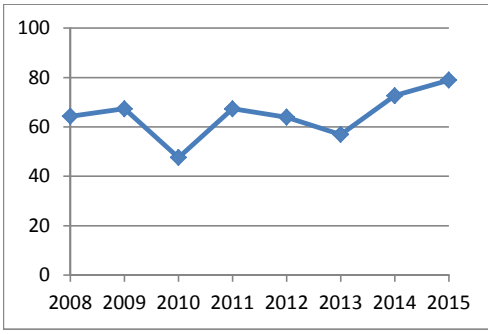

Figure13. Proportion of the Jackson Elk Herd that was classified on NER feedgrounds in the period following implementation of the Bison and Elk Management Plan and prior to the implementation of the Adaptive Management Plan (2008-2015). These values represent the pretreatment baseline which will be compared to the 3 year running average post AMP implementation.

Elk Fed Days and Bison Fed Days

The BEMP and AMP implicitly assume that the transmission rate and prevalence of elk and bison diseases are density dependent and positively correlated with the number of elk and bison utilizing feedgrounds and the number of days they are fed. We further assume the variables elk-fed-eays (EFD) and bison-fed-days (BFD) are a proxy for these conditions. EFD and BFD will be calculated annually for each species based on the following formulas:

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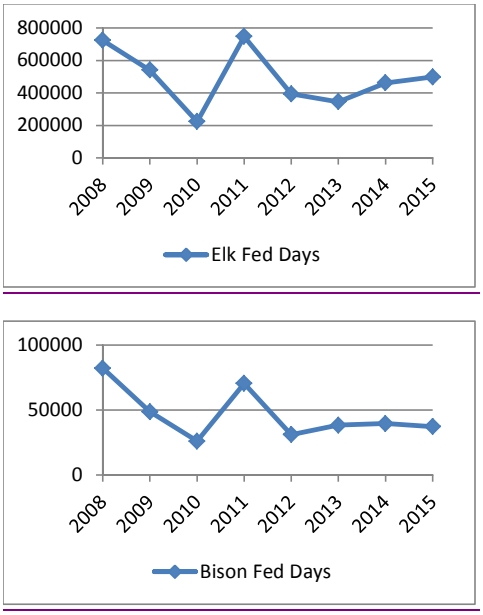

Figure14. Elk Fed Days (EFD) and Bison Fed Days (BFD) in the period following implementation of the Bison and Elk Management Plan and prior to the implementation of the Adaptive Management Plan (2008-2015). These values represent the pretreatment baseline which will be compared to the 3 year running average EFD and BFD post AMP implementation.

EFD= ∑ Total elk counted on feed during daily feedground counts for duration of feed season

BFD= ∑ Total bison counted on feed during daily feedground counts for duration of feed season

Because EFD and BFD are influenced by feed season length and the number of animals on feed, the AMP strategy of delaying the initiation of supplemental feeding will inherently reduce the number of EFD and BFD through a reduction in average feed season length. We believe that EFD will be further reduced by encouraging a greater proportion of the Jackson Elk Herd to winter on native winter range, thereby reducing the number of elk occupying NER feedgrounds. We will evaluate changes in EFD and BFD by comparing the 3-year running average post AMP implementation compared to mean EFD and BFD from 2008-2015. The running average is an appropriate comparison because it will help account for wide annual variation in EFD and BFD associated with winter severity (Fig. 14)

Elk Winter Mortality Monitoring

NER has used consistent methods to monitor winter elk mortality since 1982. Each winter NER biologists and other refuge staff conduct a survey of all non-hunting related winter elk mortalities that occur on NER from November through April. Mortalities are tallied by age/sex class and percent mortality is calculated using the corresponding number of elk classified on NER feedgrounds as the denominator. We will continue to monitor elk winter mortality using the same methods post AMP implementation, which will allow trend comparisons to the pre AMP baseline (Figure 15). Under the AMP framework, we believe the 3 year running averages for total and calf winter elk mortality will be within the range of variation exhibited by the pre AMP baseline. Historic monitoring suggests that calf and total mortality are sensitive to winter severity and disease outbreaks, and that winter mortality occasionally exceeds >3% total mortality and >10% calf mortality. Post AMP mortality in excess of these levels may warrant shortening the 2-week feeding initiation delay in subsequent years.

Elk Collaring

One of the AMP's principal strategies is to shorten the length of the feed season to encourage elk use of native winter range, but we anticipate that this strategy will also result in an increase in elk conflicts on surrounding private land in the town of Jackson and the Spring Gulch areas. To quantify this effect and provide real time information to WGFD and NER managers to facilitate a response, we propose maintaining a sample of 50 GPS collars on elk that winter on NER throughout the AMP implementation period.

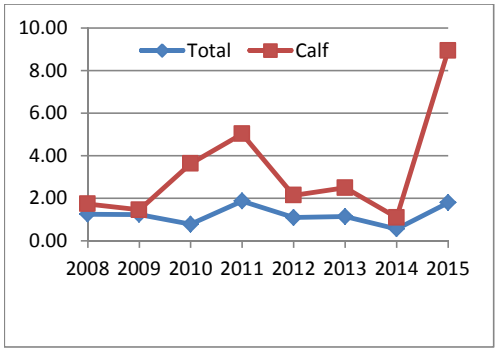

Figure15. Total and calf elk winter mortality (%) on NER in the period following implementation of the Bison and Elk Management Plan and prior to the implementation of the Adaptive Management Plan (2008-2015). These values represent the pretreatment baseline which will be compared to the 3 year running average post AMP implementation.

Forty -five elk represents approximately 0.5% (1 in 200) of the NER winter elk population. This sample size will not be sufficient to detect all elk movements from NER to surrounding private lands, particularly movements by small groups of mature bull elk, but it will be sufficient to detect and quantify significant movements of cow/calf/yearling elk groups compared to pre-AMP baseline data.

NER has elk GPS collar data available from the 2008-2013, which represents the post BMP, pre AMP baseline period. We hypothesize that elk movements from NER to surrounding private lands will increase during the AMP implementation period compared to the pre-treatment baseline. This will be tested by comparing the number of incidents that elk left NER for surrounding private lands (per elk/per year), and the proportion of elk GPS fixes on NER versus private lands during time periods of interest. The principal time period of interest is late December-March because this represents the period after the NER elk hunting season, and prior to and during NER feeding operations. This is the season when changes to the NER feeding program would be most likely to result in elk distribution changes.

Fifty adult cow elk will be captured on NER feedgrounds during February-March 2016 and Telonics Iridium GPS collars will be deployed with a 90 minute fix collection interval. Given 83% annual survival for adult cow elk in the Jackson Elk Herd (Cole and Foley et al. 2015) and 3 year collar life, approximately 10 additional elk will need to be collared each year in winter 2017 and 2018 to maintain the 50 elk desired sample size.

Ancillary data that will be collected and analyzed during the elk capture and collar data analysis process includes brucellosis seroprevalence, pregnancy rate, and elk summer range determination for comparison to the findings of Cole and Foley et al. (2015).

Disease

The primary purpose of limiting reliance on supplemental feeding is to reduce the prevalence of endemic elk and bison diseases and mitigate transmission risk associated with the introduction of novel diseases. We hypothesize that brucellosis seroprevalence will decline post AMP implementation. There are no recent brucellosis seroprevalence data for elk on the National Elk Refuge, but >50 elk will be captured during elk collaring operations in winter 2016, and each elk will be tested for Brucellosis exposure. The 2016 Brucellosis seroprevalence rate will be the pre-treatment baseline to evaluate post AMP change.

Chronic wasting disease (CWD) has been monitored in the JEH since 1997, and since 2008 it has been monitored with sufficient sample size to detect 1% prevalence with 95% confidence. No CWD positive cases have been detected in the JEH, which given the long term persistence of the disease, provides overwhelming evidence that CWD is not currently endemic to the JEH. However, most evidence suggests that the distribution of CWD is increasing and that its introduction to the JEH is inevitable. Early detection is critical to ensure an adequate

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management response, and therefore ongoing monitoring at sample sizes sufficient to detect 1% CWD prevalence with 95% confidence is necessary. CWD is sampled by testing tissues collected primarily from hunter harvested elk, and past experience suggests that 2 full time technicians working from September-December are necessary to ensure minimum sample size. Typical costs associated with 2 technicians are $32,000 per year.

EVALUATION/FUTURE MANAGEMENT

Modifying elk and bison behavior while reducing supplemental feeding will require a long-term, sustained commitment. Change is unlikely to happen fast, and interpreting effects of adaptive management actions will be complicated by varying environmental conditions from year to year. Consequently, we anticipate that the strategies outlined in this plan will be in place for a minimum of 5 years. Actions completed each year, the results of monitoring programs, and any proposed changes in course will be presented in an annual adaptive management update/report, completed by NER staff by the end of March for the previous year.

Investigating the potential effects of climate change on elk and bison management will be important in the long-term. During implementation of this plan, we will collect a variety of data that can be drawn upon for this purpose.

PUBLIC OUTREACH AND EDUCATION

The practice of winter feeding is inexorably woven into the historic fabric of Jackson Hole. Elk are identified with the rich and unique legacy for which Jackson Hole is known around the world. De-emphasizing the supplemental feeding program will be a major paradigm shift for the residents of Jackson Hole, Teton County, and the State of Wyoming.

An effective Public Outreach and Education program is essential for effective AMP implementation. The practice of feeding elk evokes passionate responses from those that oppose and those that support this practice. The general public and especially key stakeholder groups must understand the biological needs for and strategies of the AMP in order to gain general consent to modify longstanding elk/bison herd management methods.

A detail communication plan to guide outreach and education efforts can be found in Appendix 3.

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SCHEDULE

Table 6. Adaptive Management Plan proposed schedule.

Action	Date
GPS Collar 30-40 elk prior to strategy implementation (Iridium platform)	February 2016
Public outreach and education	March 2016
Initiate private lands conflicts mitigation contacts/actions	March 1, 2016
Implement enhanced forage monitoring	March 1, 2016
Initiate changes in supplemental feeding protocol	January 2017
Monitoring/Evaluation/Annual Report	June 2017

Table 7. Anticipated schedule of annual Adaptive Management Plan activities.

Activity	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
Elk and bison classification		x										
Irrigation						x	x	x	x			
Forage estimates	x	x	x	x								x
Etc…..												

[This table just for example. We could do the same with longer term schedule using years instead of months at the top if desired/necessary.]

BUDGET

Table 8. [incomplete]. Estimated Adaptive Management Plan budget above current expenditures, years 1-5.

Agency / Activity	Year 1	2	3	4	5
National Elk Refuge:					
Monitoring:					
Seasonal Biological Technician (0.5 FTE, GS-7)	24,000	25,000	26,000	27,000	28,000
Bison/elk fed days					
Mid-winter census					
Elk summer herd segment distribution[1]					
Expanded standing forage estimates[1]					
Chronic Wasting Disease, 2 seasonal biot-techs	32,000	32,000	32,000	32,000	32,000
Winter bison/elk distribution					
Irrigation					
50 Elk radio telemetry collars; Iridium Platform	$115,000	$25,000	$25,000	$25,000	$25,000
Bison barrier at NER south entrance	$80,000	$1,000	$1,000	$1,000	$1,000
Adaptive Management Plan annual reporting	$2,000	$2,000	$2,000	$2,000	$2,000
Private lands:					
Easements / Acquisition					
Damage reimbursements (Wyoming)					
Conflict mitigation coordination (Wyoming)	$91,000	$91,000	$91,000	$91,000	$91,000
Vegetation restoration/protection[1]					
Public Outreach and Education	$11,000	$1,000	$1,000	$1,000	$1,000
Subtotal					
Grand Teton National Park:					
Monitoring:					
Summer elk classification/distribution					
Hunter harvest					
Harvest age distribution					
Transition range forage production/utilization					
Vegetation Restoration/Protection					
Temporary bison fencing					
Hayfields restoration					
Exotic plant mitigation					
monitoring					
Elk Reduction Program					
Subtotal					
Wyoming Game and Fish Department:[2]					
Private lands:					
elk harvest coordination					
Easements / Acquisition					
Damage reimbursements					
Conflict mitigation coordination					
Add additional lines and categories as needed					
Subtotal					
Grand Total					

[1] See detail in Appendix

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APPENDIX 1. Summary of primary potential impacts associated with reduced supplemental feeding, as identified in alternative 4 environmental consequences section of the Final Bison and Elk Management Plan/Environmental Impact Statement (USFWS and USNPS 2007).

Populations

- Jackson elk herd objective of 11,000 would be maintained.
- New Jackson bison herd objective of 500 established.

Winter Feeding

- Supplemental feeding could be delayed or could occur earlier compared to current practices.
- Changes [to feeding program could] include alterations in the timing of feeding and providing supplemental feed in fewer years.
- Ration or pellet composition might need to be changed.
- Supplemental feeding would be initiated according to established criteria, including pre-winter forage production, assessments of forage utilization (done jointly by WGFD and NER personnel), elk condition and movements, and potentially on the January 1 index of winter severity calculations for elk (Farnes, Heydon, and Hansen 1999).
- Mechanical means could be used to increase forage access for elk after snow crusting events.
- Changes in the refuge supplemental feeding program could begin to affect elk nutrition (negligible adverse effect on NER elk from lower nutrition).
- Displacement of elk by bison during competition for standing forage would decrease as the bison herd is reduced.
- Aggressive social interactions involving competition for food among elk and bison would increase overall as feeding periods are reduced.

Winter Distribution

- Elk densities on the NER would decline due to more reliance on standing forage and wider distribution.
- Elk use of lands surrounding the NER would increase, including:
    - USFS lands east of the NER
    - Gros Ventre feedgrounds possibly
    - Southern GTNP
    - State feedgrounds south of the NER
- Most of winter distribution shift would involve elk in the Yellowstone, Teton Wilderness, and Gros Ventre segments.
- As ungulate numbers decreased and supplemental feeding was reduced, competition and aggressive social interactions on the refuge would also be reduced.
- Elk and bison distribution would increase as the animals relied more on native winter range.
- Fewer animals would be present on the refuge.

Mortality

- As supplemental feeding is reduced, natural factors such as climate and native forage availability would have a greater influence on numbers, movements, distribution, and mortality.
- More elk would be subject to natural factors affecting mortality, including loss of body condition, predation, and starvation.
- Increased mortality on and off the refuge would mainly affect older elk and calves, and some prime bulls entering the winter energetically stressed due to rut activities.

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- Late winter calf ratios could decrease as a result of higher winter calf mortality
- Average winter mortality on the refuge would increase from 1%–2% annually to an estimated 1%–5%.
- Overall, a higher total winter mortality rate of approximately 5% could be expected.

Disease

- Reductions in supplemental feeding or elk numbers would reduce the potential for impacts due to tuberculosis, septicemic pasturelosis, and CWD.
- The health and sustainability of the Jackson elk herd would be increased gradually as supplemental feeding was reduced and there was greater reliance on standing forage and wider ungulate distribution.
- Health and sustainability of the Jackson elk herd would be enhanced in the long term.
- Wider distribution of elk would result in moderate reductions in both the prevalence and potential transmission of brucellosis, as well as potential for spread of diseases not yet in the population.

Private Lands

- The agencies would work closely with the WGFD and landowners, including livestock producers, to coordinate actions that would prevent conflicts due to elk dispersal and to defray costs of managing potential conflicts. Preventing access to food/hay rewards on private lands would be vital for effective management.
- Private land conservation easements within NER boundaries would promote wider distribution.

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APPENDIX 2. Monitoring Supplemental Materials: Feeding Initiation Methods

At each sample site, 10 subplots will be measured at every 5 steps along the random bearing determined for each site. At each subplot a 13.27" diameter metal sampling ring will be placed on the ground. The amount of forage available to elk within the sampling ring (dry weight in grams) will be visually estimated. The 13.27" diameter subplot allows easy conversion from grams to lbs. per acre (each gram is equivalent to 100 lbs. per acre). During annual forage production sampling, refuge biologist Eric Cole has made approximately 1,000 of these visual estimates per year for 17 years, and 33% of Cole's estimates have been verified by clipping and weighing. Therefore, Cole will be the principal estimator, but additional personnel will be trained in these techniques to provide redundancy in the event of personnel changes, and to increase the number of observers to facilitate estimation of error.

Estimating available forage within the sample ring at each subplot is relatively straightforward when snow cover is limited, but estimating how much of the forage is accessible to elk when snow is dense, deep and crusted can be subjective. To decrease the subjectivity of the estimation process, if the area under the sample ring is covered with snow, only forage that can be exposed with a gloved hand will be included in the estimate of available forage. Forage that is fouled with manure and/or flush with the ground due to trampling and/or encrusted in ice will not be included in the estimate of available forage.

At each subplot the estimate of available forage (dry weight g) will be converted to an equivalent lbs./acre value (1 gram=100 lbs./acre). The arithmetic mean of available forage (lbs./acre) for the 10 subplots provides an estimate of available forage for each index site. There are 3 sample site categories: 1) Historic Key Index Sites that have been used since 2007, 2) New randomly selected sites within areas preferred by elk, and 3) New randomly selected sites in areas not preferred by elk. Historic key index sites were not randomly selected, but were instead selected to represent areas most preferred by elk on the south end of NER. These were the sites used to determine when supplemental feeding would be initiated from 2007 until the implementation of the AMP. To facilitate comparison with pre-AMP data, we will continue to use mean lbs. per acre across historic key index sites to determine the 300 lbs. per acre threshold. However, post AMP implementation we will delay feeding initiation by 2 weeks once the 300 lbs./acre level has been reached. We will concurrently sample at randomly selected sites stratified on an annual basis between areas highly preferred and not highly preferred by elk. This will enable us to quantify the relationship between mean forage availability at historic key index sites and random sites over time.

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APPENDIX 3. Communication Plan

Communication Goals

Prior to the Adaptive Management Plan's Implementation

- Utilize a variety of outreach methods to inform the public on the goals and timing of the Adaptive Management Plan's implementation and possible effects on wintering herds.
- Utilize a variety of outreach methods to inform the public on public comment opportunities.
- Identify and coordinate key messages and outreach with USFWS regional and national offices, State and federal agency partners, non-profits, elected officials, and other identified audiences.

During the Adaptive Management Plan's Implementation

- Continue to utilize a variety of outreach methods to describe current management actions as well as measurable and noticeable changes on the landscape, in animal behavior, or in animal health.
- Provide a comprehensive overview of the Adaptive Management Plan by providing links and references to previous outreach and background information.

Communication Objectives

- Work with current media contacts to promote news of the Adaptive Management Plan via print, radio, Web, and social media platforms.
- Utilize new media and social media tools to provide information on why the Adaptive Management Plan was developed, what public comment opportunities exist, and how the plan is being implemented.
- Plan, coordinate, and execute public meetings to allow for public comment and questions on the plan.
- Develop and provide methods for the public to submit written comments on the Adaptive Management Plan.
- Monitor print media on Refuge elk and bison management to see how Adaptive Management Plan objectives and reactions are being portrayed to the public.

Current Outreach Resources

- National Elk Refuge web site
- National Elk Refuge news release list
- (approximately 300 contacts)
- National Elk Refuge Twitter site (1,039 followers)
- Bison and Elk Management Plan web site (http://www.fws.gov/bisonandelkplan/)
- Space for an 11" x 17" poster in the Visitor Center on Refuge management topics
- Display panels in the Visitor Center theater for temporary displays

Available Supporting Outreach Resources

- USFWS Mountain–Prairie External Affairs staff
- USFWS Mountain–Prairie web site, including the
- "Top Stories" feature

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- USFWS Mountain–Prairie Twitter site USFWS Mountain-Prairie Region Facebook page
- USFWS National Wildlife Refuge System
- Facebook page
- USFWS Facebook page

Previous Outreach Efforts

- NER routinely writes and disseminates news releases on Refuge management activities, including the Comprehensive Conservation Plan, supplemental feeding, herd health monitoring, and forage production.
- Post the above news stories as Content.
- Management System (CMS) articles.
- Post CMS news story promos so they prominently appear on the home page, linking readers to the articles.
- Send out Twitter messages linking viewers back to the news stories.
- Prepare, upload and provide links to Adobe PDF versions of news stories with addtional photos where additonal images are available and/or help understand or visualize the content.
- Utilized the Conservation link on the web Content
- Management System to post information about the Bison and Elk Management Plan and the draft Comprehensive Conservation Plan.
- Retained and provided a link to the original Bison and Elk Management web page (http://www.fws.gov/bisonandelkplan/) that was developed during the planning process. The web site includes links to the Final Plan/EIS, Record of Decision, Federal Register Notice of Availability for both the Record of Decision and Final Plan/EIS, associated news releases, public meeting highlights, and other related documents. Note: the National Elk Refuge does not manage the site.

Additional Outreach Opportunities

- Public meetings in Jackson and other identified locations.
- Service produced video; video could be posted to the National Elk Refuge's multimedia web page, or USFWS Mountain–Prairie home page "Top Video" feature.
- Live radio interview on KHOL (Jackson, WY radio)
- Wyoming Public Radio interview with Refuge management staff
- Interviews with local print media sources
- Updates at community leader meetings such as Rotary Club, Jackson Hole Chamber of Commerce board meetings, and interagency breakfast meetings (with Federal agencies and local elected officials).

Target Audiences

Internal

- Regional and National USFWS Leadership
- Refuge permanent staff
- Refuge seasonal staff
- Refuge volunteers

External

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- Congressional representatives
- State of Wyoming leadership
- Federal agency partners, particulary Grand Teton National Park and the Bridger–Teton National Forest
- Wyoming Game & Fish Department
- Other NER partners, including county and town agencies and local nonprofit organizations
- Local elected officials
- Private landowners in proximity to the National
- Elk Refuge or neighboring Federal lands
- Tribes
- Local and state media
- Local public

Key Outreach Topics

- Overview of BEMP objectives
- Strategy to change elk/bison behavior
- Threat of disease
- Natural mortality rates
- Anticipated winter distribution changes for bison/elk
- Mitigate negative effects on private lands
- Change elk behavior and distribution while avoiding increased mortality.
- Explain the historic reasons a supplemental feeding program began and why it was continued.
- Explain the NER's limited large ungulate carrying capacity and the disproportionate impact of bison on available forage; 3 elk = 1 bison.

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APPENDIX 4. Models

Elk winter distribution model

The proportion of the JEH that winter on the NER will be linked to factors hypothesized to influence elk winter distribution (Fig. 2) using a generalized linear mixed effects model (GLMM). A GLMM can account for a proportional response variable (i.e., constrained to the interval 0–1) using a log link and binomially-distributed errors. A GLMM also includes fixed and random effects, with the latter capturing residual model variance otherwise not explained by fixed effects. Year will be including as a random effect, providing several benefits. First, we don't assume years are independent and comprise all of the factor levels of interest. Instead, the effect of year is treated as a random variable, with individual year effects realizations of that distribution. This allows inference to non-sampled factor levels, i.e. years, by estimating a latent population-level proportion of elk expected to winter on the NER regardless of fixed effect influences. Thus, the random year effect can be considered a latent variable describing elk behavior manifested as observed winter distribution. Second, because year effects are not treated as independent, estimated effects of year on the proportion of JEH elk wintering on the NER are dependent on all factor levels, leading to greater precision when estimating individual year effects (Kéry 2010).

The full GLMM incorporating fixed effects for each factor identified as influencing elk winter distribution (Fig. 2) is:

$$P_t = \beta_{0(t)} + \beta_1 * AFI_t + \beta_2 * SDM_t + \beta_3 * WP_t + \beta_4 * GSP_t + \beta_5 * SWE_t + \varepsilon_t$$

where the random intercept and residual model variance are

$B_{0(t)} \sim N(\mu_{\beta_0}, \sigma^2_{\beta_0})$, and

$\varepsilon_t \sim N(0, \sigma^2)$, respectively.

Fixed effects include 1) per capita available forage at initiation of winter feeding (*AFI*) , 2) proportion of the JEH that are short-distance migrants (*SDM*), 3) number of wolf packs present on JEH native winter range (*WP*), 4) growing season (May–August) precipitation for the Wyoming Snake Drainage climate division (*GSP*; a proxy for available forage on native winter range), and 5) snow water equivalent on 1 January at Thumb Divide (*SWE*; a proxy for early winter severity).

Elk calf winter survival and forage deficits

The Forage Accounting Model of Hobbs et al. (2003) has as an output weekly available forage biomass for the NER (sum of predictions for 30 × 30 m cells). These predictions account for snow conditions using a proxy of SWE and decrement total available biomass by 35% to account for unpalatable plants within the total estimate.

While calf survival is a function of multiple factors (Fig. 3), the primary management action influencing calf survival is supplemental winter feeding. Current winter feeding initiation criteria lead to calf survival generally higher than in unfed populations. Proposed feeding initiation criteria will result in later

Comment [WJ5]: I'm not comfortable with this interpretation yet and need to think about it some more.

Comment [WJ6]: This doesn't currently have a term for hunting, although our conceptual model above does. Need to decide if we want to include or exclude here.

Comment [WJ7]: Will need a more formal explanation of these variables and how they will be collected. May fit best in the monitoring section.

Comment [WJ8]: If we use Hobbs' model for predicting available forage these may be redundant.

Comment [WJ9]: Put in winter feeding initiation paragraph above? Then note where more samples are necessary to improve the precision of the estimates. Need to run this model from 2007 forward to see where, on average, feeding was initiated so we can make treatment adjustments as necessary. This would also allow us to look at the relationship between key index sites estimates and Hobbs' predictions. Need to consider validating Hobbs' model with field sampling Eric is currently designing to see if we can use the Hobbs model moving forward. This would take some time with stripping the Hobbs model down to our needs, identifying data sources, and developing a workflow process so weekly estimates of available forage can be calculated. Would only be able to use snow data from SNOTEL sites that have data available online, which shouldn't be too much of a problem.

Comment [KD10]: Need a citation here.

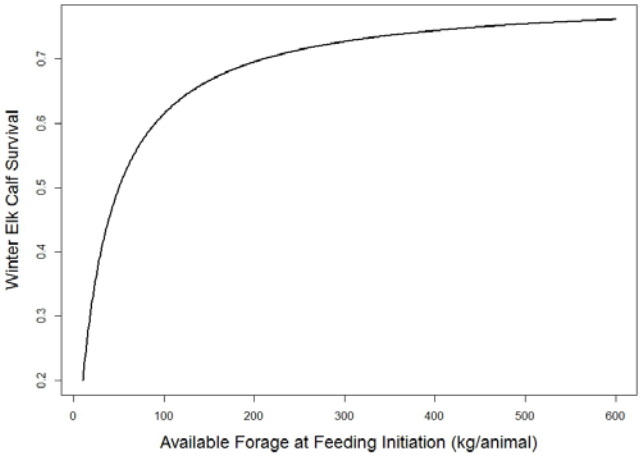
DRAFT

initiation of supplemental feed, which will be most influential to calf survival. There is currently little understanding regarding the relationship between initiation of winter feeding and calf survival, except that current feeding initiation criteria result in high calf survival. We believe a threshold level of available forage at initiation of winter feeding exists such that winter calf survival reaches an asymptote. Below this threshold, calf survival is hypothesized to decline quickly with reductions in available forage at winter feeding initiation. Available forage at the initiation of winter feeding will be related to on elk calf winter survival using a saturating function (i.e., Holling type-II functional response; Fig. 6) by

$$S_t = \frac{aAFI_t}{b + AFI_t}.$$

The parameters *a* and *b* determine how calf survival is related to available forage. Maximum calf survival is *a*, and *b* represents the value of available forage to an individual when survival is 50% of *a* (Hilborn and Mangel 1997).

Although this approach doesn't capture forage deficits *per se*, it does provide a potentially sensitive proxy for this concept. It is assumed that a forage deficit for calves would occur at a point on the curve of the relationship between calf survival and available forage at initiation of supplemental feeding. Modeling the response of winter calf elk survival to changes in feeding initiation criteria facilitates our ability to maximize the influence of feeding initiation criteria on winter distribution while minimizing the likelihood of a large mortality event.



Hypothesized relationship between winter survival of elk calves and per capita available forage at initiation of winter feeding on the National Elk Refuge.

From: Doug Brimeyer
To: Steve Kallin
Subject: Re: Draft Adaptive Management Plan Review for August 3, 2015 Team Meeting at 12:30 PM
Date: Friday, July 24, 2015 4:07:41 PM

Brad and I could not open the file. Not sure if anyone else has had a problem but you may try re-sending.

On Fri, Jul 24, 2015 at 3:46 PM, Steve Kallin <steve_kallin@fws.gov> wrote:

> Hi AMP Team:
>
> Attached is the latest draft of the AMP for your review prior to the August 3 meeting.
>
> There are several sections that are incomplete in this document. I would like to invite the WGFD and GTNP to populate the budget table (using track changes) for your anticipated expenses and add additional expenses that may not be identified in the table. You should estimate how much you believe these specific activities will cost, not how much you believe you can obtain from your agency. The source of the funding will be determined at a later time.
>
> Also, I believe GTNP would like to add information about vegetation restoration. Please add that info using "track changes" on pages 11 and 17.
>
> A number of you will be unable to make the August 3 meeting. Incorporating your feedback and suggested changes into the August 3 discussion would be extremely valuable. Please send your feedback/changes to this document, using track changes, to me prior to the meeting.
>
> Thank you again for all of your assistance. Look forward to seeing you on August 3!
>
> Steve Kallin
>
> Project Leader
>
> National Elk Refuge
>
> PO Box 510
>
> 675 East Broadway

Jackson, WY 83001

Phone: (307) 201-5409

Fax: (307) 733-9729

steve_kallin@fws.gov

--

Doug Brimeyer
Jackson/Pinedale Wildlife Management Coordinator
Wyoming Game and Fish Department
doug.brimeyer@wyo.gov
307-733-2321 ext. 230

E-Mail to and from me, in connection with the transaction of public business, is subject to the Wyoming Public Records Act and may be disclosed to third parties.

From: Brad Hovinga
To: Steve Kallin
Cc: Doug Brimeyer
Subject: Re: Additional AMP Versions
Date: Friday, July 24, 2015 4:41:45 PM

Steve - the .doc and .pdf file opened fine.

Thanks,
Brad

On Fri, Jul 24, 2015 at 4:35 PM, Steve Kallin <steve_kallin@fws.gov> wrote:

> Brad/Doug:
>
> Give these a try and let me know if these work.
>
> Read a bit in Word about documents from a questionable source (of course the Feds would qualify), which may need to be opened in "Protected View." With all the security stuff on our FWS servers, it may be triggering an alert. Hopefully the .docx will work this time.
>
> Sorry for the inconvenience. Have a great weekend!
>
> Steve Kallin
>
> Project Leader
>
> National Elk Refuge
>
> PO Box 510
>
> 675 East Broadway
>
> Jackson, WY 83001
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> Phone: (307) 201-5409
>
> Fax: (307) 733-9729
>
> steve_kallin@fws.gov

E-Mail to and from me, in connection with the transaction of public business, is subject to the Wyoming Public Records Act and may be disclosed to third parties.

From: Steve Kallin
To: Brad Hovinga
Cc: Doug Brimeyer
Subject: RE: Additional AMP Versions
Date: Friday, July 24, 2015 4:44:59 PM

Great! Please make any suggested changes or comments in the .doc. Again, I apologize for the inconvenience and thank you for your help.

Have fun this weekend,

Steve Kallin
Project Leader
National Elk Refuge
PO Box 510
675 East Broadway
Jackson, WY 83001
Phone: (307) 201-5409
Fax: (307) 733-9729
steve_kallin@fws.gov

From: Brad Hovinga [mailto:brad.hovinga@wyo.gov]
Sent: Friday, July 24, 2015 4:41 PM
To: Steve Kallin
Cc: Doug Brimeyer
Subject: Re: Additional AMP Versions

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Brad

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E-Mail to and from me, in connection with the transaction of public business, is subject to the Wyoming Public Records Act and may be disclosed to third parties.

From:	Murphy, Kerry M -FS
To:	Steve Kallin
Cc:	Deiter, Dale A -FS
Subject:	RE: Draft Adaptive Management Plan Review for August 3, 2015 Team Meeting at 12:30 PM
Date:	Saturday, July 25, 2015 9:56:43 AM

Steve: sorry, I will not be able to comment this round. I am addressing a couple of critical deadlines before I go…

From: Steve Kallin [mailto:steve_kallin@fws.gov]
Sent: Friday, July 24, 2015 3:47 PM
To: Brad Hovinga; Doug Brimeyer; Susan (Sue) Consolo-Murphy; Sarah Dewey; Deiter, Dale A -FS; Murphy, Kerry M -FS; Jeffrey Warren; Cris Dippel; Eric_Cole@fws.gov; Steve Cain
Subject: Draft Adaptive Management Plan Review for August 3, 2015 Team Meeting at 12:30 PM

Hi AMP Team:

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Also, I believe GTNP would like to add information about vegetation restoration. Please add that info using "track changes" on pages 11 and 17.

A number of you will be unable to make the August 3 meeting. Incorporating your feedback and suggested changes into the August 3 discussion would be extremely valuable. Please send your feedback/changes to this document, using track changes, to me prior to the meeting.

Thank you again for all of your assistance. Look forward to seeing you on August 3!

Steve Kallin
Project Leader
National Elk Refuge
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675 East Broadway
Jackson, WY 83001
Phone: (307) 201-5409
Fax: (307) 733-9729
steve_kallin@fws.gov

United States Court of Appeals

FOR THE DISTRICT OF COLUMBIA CIRCUIT

Argued May 12, 2011 Decided August 3, 2011

No. 10-5144

DEFENDERS OF WILDLIFE, ET AL.,
APPELLANTS

v.

KENNETH LEE SALAZAR, IN HIS OFFICIAL CAPACITY AS SECRETARY OF THE INTERIOR, ET AL.,
APPELLEES

Appeal from the United States District Court
for the District of Columbia
(No. 1:08-cv-00945)

Timothy J. Preso argued the cause for appellants. With him on the briefs were *Douglas L. Honnold* and *Sean M. Helle. Sierra B. Weaver* entered an appearance.

Mark R. Haag, Attorney, U.S. Department of Justice, argued the cause for federal appellees. With him on the brief was *Robert H. Oakley*, Attorney.

James Kaste, Senior Assistant Attorney General, Office of the Attorney General for the State of Wyoming, was on the brief for intervenor State of Wyoming in support of federal

appellees. *R. Craig Lawrence*, Assistant U.S. Attorney, entered an appearance.

Before: ROGERS, TATEL, and GRIFFITH, *Circuit Judges*.

Opinion for the Court filed by *Circuit Judge* GRIFFITH.

GRIFFITH, *Circuit Judge*: As required by the National Wildlife Refuge System Improvement Act, the U.S. Fish and Wildlife Service and the National Park Service devised a plan to manage the elk and bison populations in the National Elk Refuge and Grand Teton National Park. Part of this plan includes ending the longstanding agency practice of feeding these animals during the winter. The Defenders of Wildlife challenge the plan because it fails to include a time certain for ending the practice. The district court rejected the challenge, and, for the reasons set forth below, we affirm its judgment.

I

The National Wildlife Refuge System includes over 550 refuges and 150 million acres of protected land. The Department of the Interior, acting through the U.S. Fish and Wildlife Service, manages these properties pursuant to the National Wildlife Refuge Administration Act, Pub. L. No. 89-669, 80 Stat. 926 (1966), as amended by the National Wildlife Refuge System Improvement Act ("Improvement Act"), Pub L. No. 105-57, 111 Stat. 1252 (1997) (codified at 16 U.S.C. §§ 668dd-668ee).

The National Elk Refuge is part of that system. Located just north of Jackson, Wyoming, and adjacent to Grand Teton National Park, the Refuge was established in 1912 when Congress designated 2000 acres in Jackson Hole as a "winter game (elk) reserve." Act of Aug. 10, 1912, Pub. L. No. 62-261, 37 Stat. 293 (codified as amended at 16 U.S.C. § 673). The Refuge is now a 24,700-acre expanse that the Secretary

holds "for the grazing of, and as a refuge for, American elk and other big game animals." 16 U.S.C. § 673a. Its landscape consists of meadows, marshes, streams, ponds, and open fields across a valley floor that includes sagebrush and rock outcroppings, all set against the majestic backdrop of the Teton and Gros Ventre mountain ranges. Lucky wayfarers may spot wolves, grizzly bears, trumpeter swans, and any number of the area's magnificent ungulates, including bison, bighorn sheep, pronghorn, mule deer, and, of course, elk. The National Elk Refuge's eponymous herd comprises one of the largest concentrations of elk in North America. It goes without saying that these elk are of considerable ecological, economic, and cultural value.

Around the turn of the last century, a series of severe winters in Wyoming strained the elk populations and spurred the good people of Jackson to save the elk by feeding them. When Congress created the Refuge in 1912, the federal government continued this practice, which the parties refer to as supplemental feeding. For roughly seventy days each winter, approximately 7000 elk and 1000 bison are drawn daily to the federal trough.

In recent years, it has become apparent that this practice, though born of benevolence, causes significant problems. According to the Department of the Interior, supplemental feeding leads to a seasonal concentration of elk and bison that is "an unnatural situation that has contributed to . . . an increased risk of potentially major outbreaks of exotic diseases . . . [and] damage to and loss of habitat." Final Bison and Elk Management Plan and Environmental Impact Statement for the National Elk Refuge / Grand Teton National Park / John D. Rockefeller, Jr., Memorial Parkway 9 (Feb. 1, 2007) [hereinafter February 2007 Management Plan and EIS]. This risk poses an existential threat to the elk and bison and puts the very purpose of the Refuge at jeopardy. *See id.*

(noting that the risk of diseases posed by increased concentrations of the animals has "the greatest potential to hinder . . . [the] purposes . . . [of] the National Elk Refuge").

One major problem is brucellosis—also known as "Bangs disease, undulant fever, and contagious abortion," *id.* at 564—which causes an infected female to abort her first calf, leaving behind contaminated fetal tissue on the ground capable of transmitting the disease to other animals, *id.* at 129. Brucellosis rates within normal Wyoming elk herds are approximately two percent, but rates among elk that frequent the Refuge feeding lines have averaged around seventeen percent in recent years. *Id.* at 130. Another major problem, chronic wasting disease (CWD), is the elk version of mad cow disease: Like its bovine counterpart, CWD assaults the central nervous system, causing brain lesions, behavioral changes, a loss of body condition, and ultimately death. CWD is caused by abnormal, non-living proteins known as prions that persist in the soil where infected animals graze, even after intensive efforts to remove them. *Id.* at 136-40. Statistical sampling suggests that in open, elk-hunt areas in Wyoming, the prevalence of CWD in elk averages around four percent. *Id.* at 137. But in confined areas—like those created by the feed lines—the prevalence can exceed ninety percent. *Id.* CWD is not yet prevalent in the Refuge, but if that changes, "environmental contamination will become a major concern due to the disease's ability to persist in the environment for a long period of time." *Id.*

All agree that supplemental feeding increases the risk of such diseases. Without supplemental feeding, the elk would gather in smaller groups, meaning that one sick elk would infect only the handful of others around it. But because the feeding lines bring so many together, the disease of one can quickly become that of many, if not all.

Spurred by a district court order requiring reassessment of the winter feeding operation, *see Fund for Animals v. Clark*, 27 F. Supp. 2d 8, 12-15 (D.D.C. 1998), the Fish and Wildlife Service teamed with the National Park Service,[*] also part of the Department of the Interior, to prepare a management plan for the elk and bison populations. The agencies analyzed six alternatives for managing the herds over the next fifteen years. These plans ran the gamut from maintaining the status quo to ending the practice of supplemental feeding within five years.

In April 2007, the agencies settled on an approach that would, over time, create conditions that would allow the elk and bison to survive the winter without supplemental feeding and, in the meantime, manage the risk of contagion until the practice ended. In essence, their plan seeks to restore natural forage that will allow the animals to sustain themselves during wintertime without the help of supplemental feeding. Bison and Elk Management Plan: National Elk Refuge and Grand Teton National Park 129-34 (Apr. 2007) [hereinafter April 2007 Management Plan]. For example, it provides for substantial reductions in the numbers of elk and bison, primarily through short-term increases in hunting, so that their populations will be closer to levels that would have existed had there never been a practice of supplemental feeding. *Id.* at 134-37. The plan also seeks to reduce disease transmission by rotating feed sites, spreading feed in long lines, separating elk and bison from neighboring livestock, providing increased CWD monitoring, and allowing Wyoming to vaccinate the herds. *Id.* at 138-39. Ultimately, over a fifteen-year period, "[a]s habitat and population objectives are achieved, [the agencies will aim to] decrease reliance on intensive

[*] Because the plan in this case also addresses management of elk and bison populations in nearby Grand Teton National Park, the National Park Service, which manages the park, joined in the effort.

supplemental winter feeding, including complete transition to free-standing forage if and when several established criteria are met, including support from the Wyoming Game and Fish Department and the public." *Id.* at 137.

Before adopting this approach, the agencies considered and rejected the petitioners' preferred alternative, which would have committed the Secretary to ending supplemental feeding within five years. As described in their brief, the agencies recognized that this alternative "would provide some advantages in terms of habitat benefits, a lower prevalence of brucellosis over the long term, and a lower risk for the spread of chronic wasting disease." Appellees' Br. 19 (citing Record of Decision, Final Bison and Elk Management Plan and Environmental Impact Statement: National Elk Refuge and Grand Teton National Park 10 (Apr. 2007) [hereinafter Record of Decision]). But they also found that "[this alternative] would likely result in an increase in elk mortality from starvation, predation, and disease related to poor body condition, particularly in severe winters." *Id.* (citing Record of Decision 10). This in turn would lead to a "long-term decrease in elk hunting and viewing opportunities in the Refuge, with attendant impacts on the area economy, and could cause elk herd numbers to fall below [the Wyoming Game and Fish Department's] statewide objective in some years." *Id.* at 19-20 (citing Record of Decision 10).

The agencies concluded that their preferred plan "[is more] consistent with regional herd management objectives, better balances divergent stakeholder interests, builds upon success on the ground, and enables managers to adapt to new information and changing conditions," all while preparing the animals for the eventual cessation of supplemental feeding and providing most of the benefits offered by the petitioners' preferred alternative. *Id.* at 20 (citing Record of Decision 14). On the issue of when to end supplemental feeding, the

agencies stressed that although they are committed to abandoning the practice, they would "not preclude the use of supplemental feeding or other management tools as [they] work to resolve the bison and elk management issues . . . . [N]or [would they] make predictions about how fast [they could] implement the phased approach for improving forage, reducing the [elk and bison populations], and reducing the need for supplemental feed . . . . When the biological, social, and political conditions enable [them] to consider a phase-out of feeding, [the plan's] adaptive framework provides [the agencies] with that flexibility." Record of Decision 13. In essence, the agencies determined that a deadline for ceasing supplemental feeding would be unduly restrictive in light of the many variables and concerns that need to be accounted for in managing the Refuge.

The Defenders of Wildlife, the Jackson Hole Conservation Alliance, the National Wildlife Refuge Association, the Greater Yellowstone Coalition, and the Wyoming Outdoor Council (collectively, the Defenders) filed suit in the district court, challenging the Secretary's plan under the Administrative Procedure Act. They argue the plan's failure to commit to a deadline for ending supplemental feeding was arbitrary and capricious given the Secretary's duty under the Improvement Act to "provide for the conservation of . . . wildlife" and "ensure that the biological integrity, diversity, and environmental health of the [wildlife refuge system] are maintained." 16 U.S.C. § 668dd(a)(4)(A)-(B). The district court granted summary judgment for the agencies, reasoning that the plan accounted for and managed the dangers of supplemental feeding and also created a program for phasing out the practice over a fifteen-year period. *Defenders of Wildlife v. Salazar*, 698 F. Supp. 2d 141, 147-48 (D.D.C. 2010). The Defenders of Wildlife filed a timely appeal, and we take jurisdiction pursuant to 28 U.S.C. § 1291.

We review the district court's grant of summary judgment de novo. *Castlewood Prods., LLC v. Norton*, 365 F.3d 1076, 1082 (D.C. Cir. 2004). Under the Administrative Procedure Act, we set aside agency action that is "arbitrary, capricious, an abuse of discretion, or otherwise not in accordance with law." 5 U.S.C. § 706(2)(A). Our review focuses on whether the agency examined the relevant data, articulated a satisfactory explanation for its action, based its decision on the relevant factors, and committed no clear error of judgment. *Bluewater Network v. EPA*, 370 F.3d 1, 11 (D.C. Cir. 2004).

II

The parties agree that supplemental feeding poses serious risks for the elk and bison in the Refuge. The only question this case presents is whether it was arbitrary and capricious for the Secretary to transition away from supplemental feeding without committing himself to ending the practice on a particular date.

The Defenders argue it was, inasmuch as the very purpose of the National Wildlife Refuge System, as set out in the Improvement Act, "is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans." 16 U.S.C. § 668dd(a)(2). To that end, the Defenders point out, the Act mandates that the Secretary manage refuges to "provide for the *conservation* of fish, wildlife, and plants, and their habitats within the System" and to "ensure that the *biological integrity, diversity, and environmental health* of the System are maintained for the benefit of present and future generations of Americans." *Id.* § 668dd(a)(4)(A), (B) (emphases added). The Act also instructs the Secretary to

"sustain and, where appropriate, restore and enhance, healthy populations of fish, wildlife, and plants utilizing . . . methods and procedures associated with modern scientific resource programs." *Id.* § 668ee(4). The Defenders argue that the Secretary's plan is unlawful because it does not fix a definite time for ending supplemental feeding, even though the agencies have acknowledged that the dangers posed by this practice imperil explicit statutory objectives. *See* February 2007 Management Plan and EIS 9. Underlying this statutory argument is some common sense: the whole point of a National Elk *Refuge* is to provide a sanctuary in which populations of healthy, reproducing elk can be sustained. *See* 16 U.S.C. § 673a (creating a "refuge" for the elk). The Refuge can hardly provide such a sanctuary if, every winter, elk and bison are drawn by the siren song of human-provided food to what becomes, through the act of gathering, a miasmic zone of life-threatening diseases.

The Defenders acknowledge that the Improvement Act also requires the Secretary to consider other factors such as the importance of recreation on refuge lands and cooperation with state officials in pursuing the objectives of the Act. *See id.* § 668dd(4)(I), (M). They argue, however, that such considerations may be pursued only when "compatible" or "consistent with" the conservation mission of the System and the purposes of each refuge. *See id.* § 668dd(a)(3)(B), (e)(3). Reading the several provisions of the Act that emphasize the importance of wildlife conservation together with the general purpose of the National Wildlife Refuge System, the Defenders contend that the agencies' top priority in managing the Refuge must be conservation, and other considerations must not hinder that objective.

For their part, the Secretary and Wyoming (intervening as a defendant-appellee in this case) argue that the Improvement Act confers upon the Secretary broad managerial discretion in

how to pursue the Act's objectives. They concede that conservation is the overarching objective, but argue that it cannot be the sole consideration. After all, the Act lists fourteen factors that the Secretary "shall" consider in administering the System, including, among others, "ensur[ing] effective coordination, interaction, and cooperation" with adjoining landowners and State fish and wildlife agencies in pursuit of the objectives of the Act. *Id.* § 668dd(a)(4)(E).

Given the discretion afforded him, the Secretary argues that the agencies reasonably determined that the plan is consistent with the objectives of the Act and the purposes of the Refuge. The plan addresses the risk of diseases by (1) increasing natural forage and decreasing the herd sizes, which will work in tandem to create conditions under which supplemental feeding can be stopped without unduly increasing the risk of starvation, (2) monitoring and managing the diseases that accompany gathering at the feed lines, and (3) progressively reducing reliance on supplemental feeding when certain criteria have been met.

There is no doubt that unmitigated continuation of supplemental feeding would undermine the conservation purpose of the National Wildlife Refuge System. But we cannot conclude that the agencies acted unlawfully by adopting a plan that contained no deadline for ending the practice, and that is the only issue before us. The record amply demonstrates that the agencies collected the relevant data, identified the dangers posed by supplemental feeding, and adopted a plan to mitigate those dangers. That they also determined that the many objectives of the Act, including conservation, could best be met without implementation of a fixed deadline for stopping supplemental feeding was not arbitrary or capricious.

The district court was right that the plan "might well have been unreasonable had the agencies categorically refused to phase out the winter feeding program in spite of all the evidence in the record about the dangers of supplemental feeding." *Defenders of Wildlife*, 698 F. Supp. 2d at 148. But they did no such thing. Instead, they selected an approach that is geared toward ending the practice over time while maintaining the flexibility needed to respond to facts on the ground. The Defenders are understandably concerned that this flexibility could be used to continue the practice indefinitely. But the agencies must proceed in a manner that is consistent with the science and accounts for the risks posed by supplemental feeding. There is nothing the agencies have said or done that causes us to doubt that they will. It is highly significant and indeed dispositive to us, as it was to the district court, that the agencies are committed to ending supplemental feeding. We do not know precisely how they will proceed, and that makes it impossible, at this stage, to declare that their plan is arbitrary and capricious simply because it does not specify a particular date by which the practice will cease. Should the agencies act unreasonably in establishing criteria for the transition or in otherwise carrying out the plan, that will be a different issue for another panel.

III

The Defenders also argue that the plan unlawfully gives the Wyoming Fish and Game Department a veto over whether supplemental feeding will end. They point to language in the plan stating that the agencies will seek to "decrease reliance on intensive supplemental winter feeding, including complete transition to free-standing forage *if and when several established criteria are met, including support from the Wyoming Game and Fish Department* and the public." April 2007 Management Plan 137 (emphasis added).

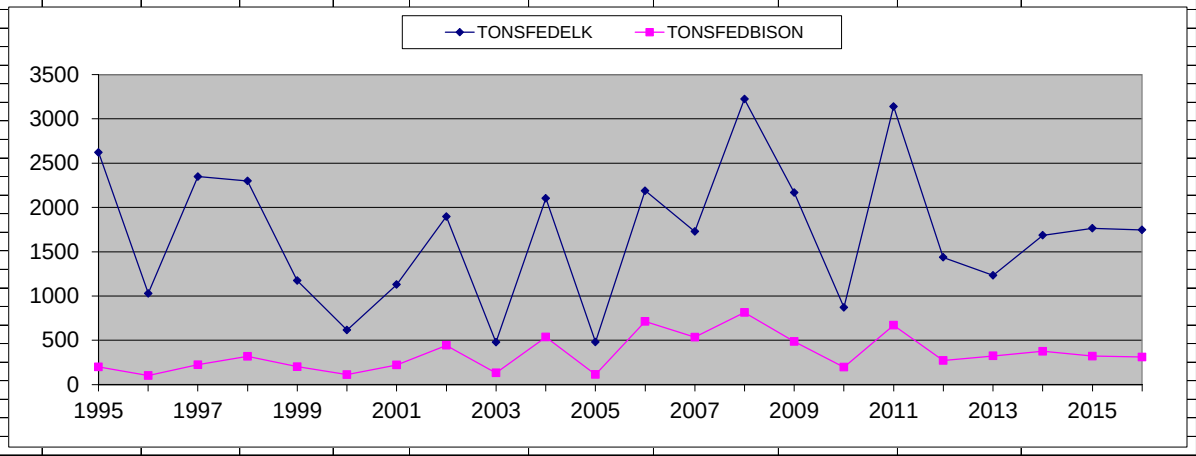
Regardless of how we might have read this language in the first instance, the Secretary has assured us in his briefs and at oral argument that the language confers no veto. *See* Appellees' Br. 34 (characterizing the disputed provision as "aspirational" rather than a grant of any power to Wyoming); Wyoming's Br. 28 n.6 (also agreeing that Wyoming does not have a veto); *cf. Wyoming v. United States*, 279 F.3d 1214, 1234 (10th Cir. 2002) ("[F]ederal management and regulation of federal wildlife refuges preempts state management and regulation of such refuges . . . where state management and regulation stand as an obstacle to the accomplishment of the full purposes and objectives of the Federal Government."). We take the Secretary at his word that Wyoming has no veto over the Secretary's duty to end a practice that is concededly at odds with the long-term health of the elk and bison in the Refuge.

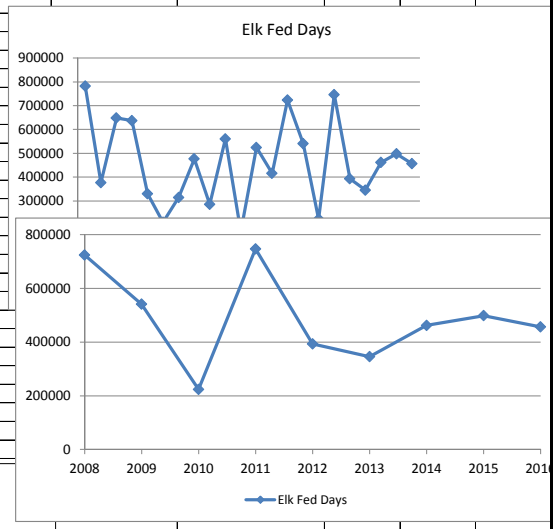
IV

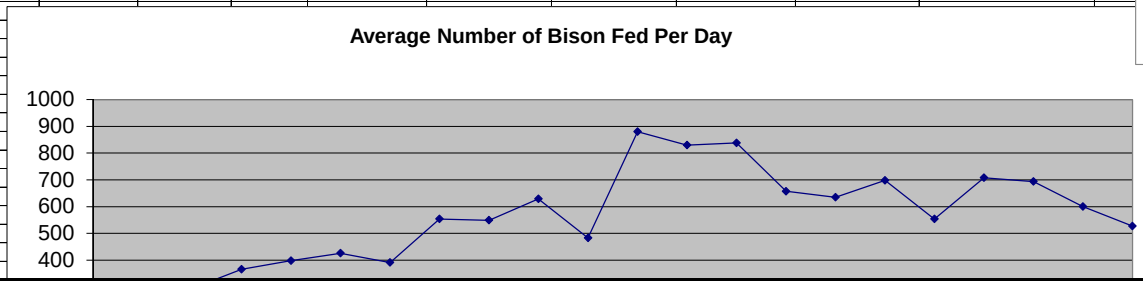
For the foregoing reasons, the district court's judgment is

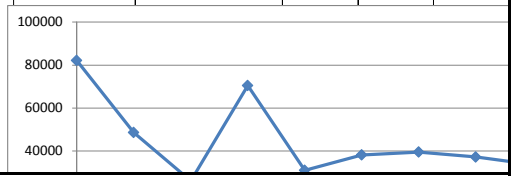
Affirmed.

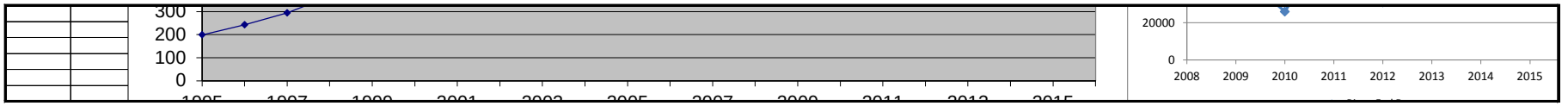
WINTER	START	STARTDAYOF	END	ENDDAYO	TONSFEDELK	TONSFEDBISON	TOTAL TONS FE	DAYSFEDELK	DAYSFEDBISON	AVE#ELKFEDPERDAY	AVE#BISO	AVElbsperelkperda	avelbsperbisonperday	YEAR	Elk Fed Da	Bison Fed
1994-1995	1/6/1995	6	4/6/1995	96	2622	199	2821	91	91	8604	199	6.7	22.0	1995	782964	18109
1995-1996	2/27/1996	58	4/4/1996	95	1029	102	1131	39	39	9653	243	5.5	21.5	1996	376467	9477
1996-1997	1/28/1997	28	4/6/1997	96	2348	224	2572	69	69	9403	294	7.2	22.1	1997	648807	20286
1997-1998	1/16/1998	16	4/4/1998	94	2299	319	2618	79	79	8070	366	7.2	22.1	1998	637530	28914
1998-1999	2/16/1999	47	4/4/1999	94	1175	202	1377	48	48	6875	398	7.1	21.2	1999	330000	19104
1999-2000	2/25/2000	56	3/30/2000	90	616	113	729	36	36	5849	426	5.9	14.8	2000	210564	15336
2000-2001	1/25/2001	25	3/24/2001	83	1129	221	1350	60	59	5242	391	7.2	19.2	2001	314520	23069
2001-2002	1/10/2002	10	3/29/2002	88	1897	443	2340	79	77	6036	554	7.5	19.5	2002	476844	42658
2002-2003	2/17/2003	48	4/3/2003	93	478	132	610	46	46	6213	549	5.5	17.2	2003	285798	25254
2003-2004	12/30/2003	-1	4/1/2004	92	2104	537	2641	94	93	5963	629	8.2	20.1	2004	560522	58497
2004-2005	2/28/2005	59	4/3/2005	93	480	114	594	34	31	5021	483	5.6	15.3	2005	170714	14973
2005-2006	1/16/2006	16	4/12/2006	102	2189	714	2903	87	86	6027	880	8.4	18.9	2006	524349	75680
2006-2007	1/13/2007	13	3/20/2007	80	1729	534	2263	68	64	6115	830	8.3	20.1	2007	415820	53120
2007-2008	1/14/2008	14	4/20/2008	111	3223	815	4038	98	98	7390	838	8.7	19.6	2008	724220	82124
2008-2009	1/27/2009	27	4/10/2009	100	2167	486	2653	74	74	7310	657	8.0	20.0	2009	540940	48618
2009-2010	2/12/2010	43	3/24/2010	83	871	197	1067	41	41	5454	635	7.8	15.2	2010	223614	26035
2010-2011	1/5/2011	5	4/15/2011	105	3139	670	3809	100	101	7468	698	8.4	19.0	2011	746800	70498
2011-2012	2/2/2012	33	3/28/2012	88	1437	271	1708	56	56	7024	554	7.3	17.5	2012	393344	31024
2012-2013	1/31/2013	31	3/25/2013	84	1234	324	1558	54	54	6397	708	7.2	17.0	2013	345438	38232
2013-2014	2/4/2014	35	4/1/2014	91	1686	376	2062	57	57	8100	694	7.3	19.0	2014	461700	39558
2014-2015	1/19/2015	19	3/21/2015	80	1765	321	2086	62	62	8035	600	7.2	17.3	2015	498170	37200
2015-2016	1/30/2016	30	4/2/2016	93	1747	311	2058	64	64	7130	527	7.7	21.9	2016	456320	33728
		28	MEAN	92	1698	347	2045	65	65	6972	552	7.3	19.1		460247.5	36886.09










300
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2008
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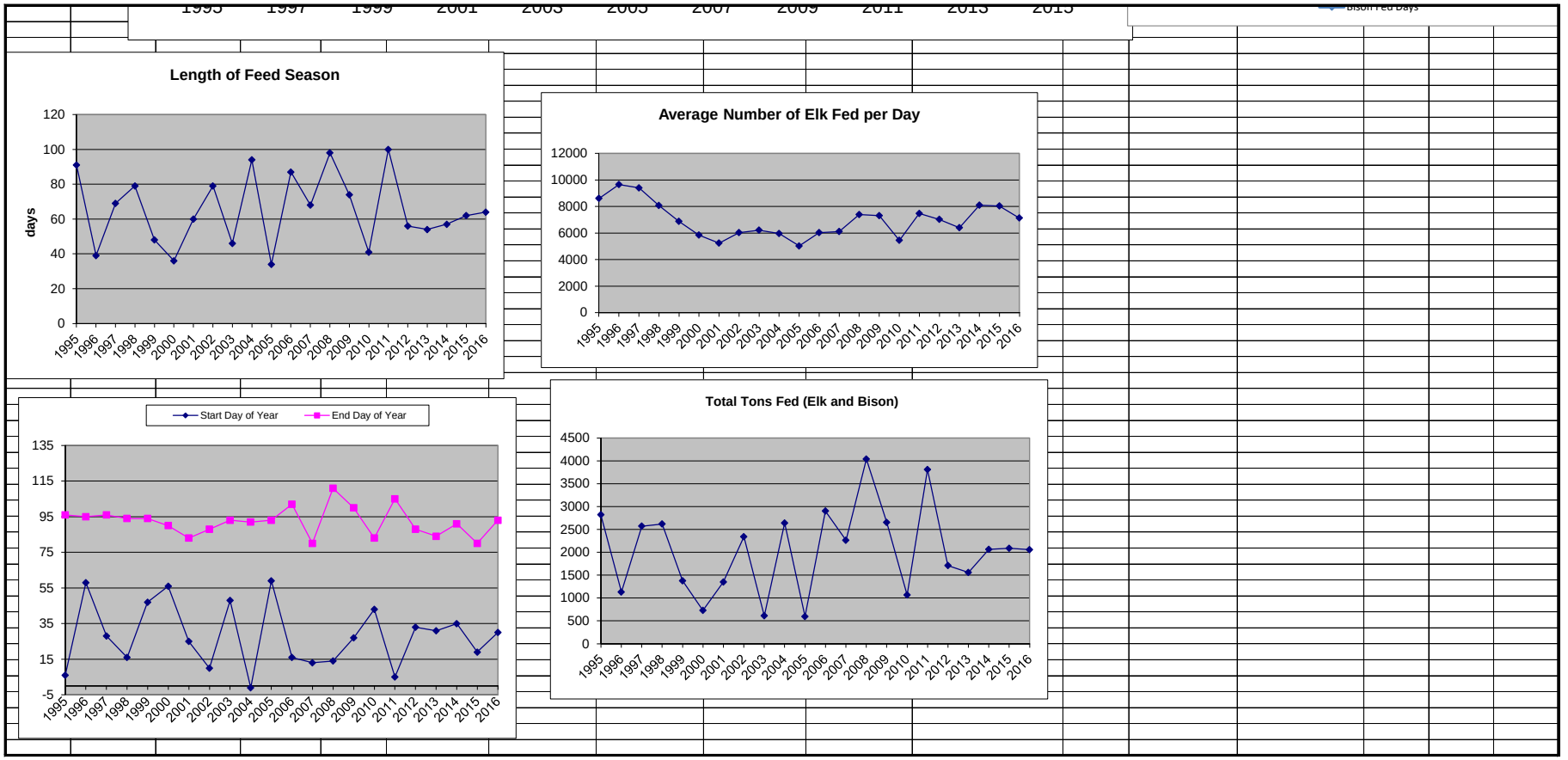
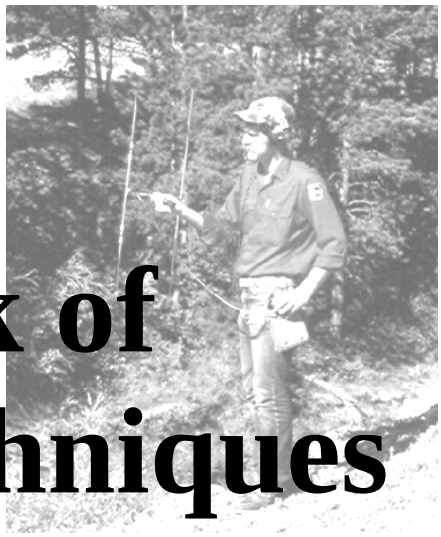

1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
Bison Fed Days
Length of Feed Season
days
120
100
80
60
40
20
0
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Average Number of Elk Fed per Day
12000
10000
8000
6000
4000
2000
0
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Start Day of Year
End Day of Year
135
115
95
75
55
35
15
-5
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Total Tons Fed (Elk and Bison)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016

COMMENT							
Although bison class count was 760, daily bison attendance on feedgrounds was sporadic							
95-2016 mean							

2016								



Handbook of Biological Techniques

Third Edition

Wyoming Game and Fish Department
Cheyenne, WY

Handbook of Biological Techniques

Third Edition

Edited by:
Stephen A. Tessmann

August, 2007

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Cheyenne, Wyoming

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Chapter 1

Pronghorn Antelope (*Antilocapra americana*)

Pronghorn Working Group of the Wyoming Game and Fish Department:
John Emmerich, Rich Guenzel, Lynn Jahnke, Bart Kroger, Joe Nemick, Bill Rudd, Tim Woolley

I. INTRODUCTION – Rangelands throughout Wyoming sustain more than half the pronghorn in the world. The species inhabits most non-forested habitats within the State (Fig. 1) and is even found in some alpine locations. The Wyoming Game and Fish Department manages 50 distinct pronghorn herds encompassing more than 100 hunt areas (Fig. 2). Herds are defined based on natural (geographic) or man-made barriers that restrict interchange to less than 10% annually. Hunt areas are established within herd units to achieve harvest objectives and to distribute hunting pressure.

Management and research techniques described in this chapter are commonly applied in Wyoming. Appropriate timeframes for surveys and management activities are depicted in Table 1. For more comprehensive discussions about life history and management of pronghorn, consult Big Game of North America: Ecology and Management (Schmidt and Gilbert 1978).

Table 1. Annual schedule of pronghorn survey and management activities.

	Page No.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May
Age Composition of Harvest	**15**			**XXXX**	**XXXX**	**XXXX**	**XXXX**	**XXX**					
Distribution Surveys	**21**						**XXXX**	**XXXX**	**XXXX**	**XXXX**	**XX**		
Cementum Annuli Analysis	**17**						**X**	**XXXX**	**XXXX**	**XXXX**	**XX**		
Fawn Trapping	**27**	**XX**											**XX**
Harvest Field Checks	**17**			**xxxX**	**XXXX**	**XXXX**	**xxxx**	**xxx**					
Harvest Questionnaire	**18**					**XX**	**XXXX**	**XXXX**	**XXXX**	**XX**			
Herd Trapping	**22**					**XX**	**XXXX**	**XXXX**	**XXXX**	**XXX**			
Incidental Observations	**22**	**xxxx**	**xxxx**	**xxxx**	**xxxx**	**xxXX**	**XXXX**	**XXXX**	**XXXX**	**XXxx**	**xxxx**	**xxxx**	**xxxx**
JCR'S	**38**	**XXXX**								**XX**	**XXXX**	**XXXX**	**XXXX**
Line-transect/Trend Counts	**14 / 6**	**XXX**											**XXXX**
Mortality	**17**	**xxxx**	**xxxx**	**xxxx**	**xxxx**	**xxxx**	**xxxx**	**xxxx**	**xxxx**	**xxxx**	**xXXX**	**XXXX**	**XXXX**
Pre-season Classifications	**3**			**XXXX**	**XX**								
Season Setting									**X**	**XXXX**	**XXXX**	**XX**	

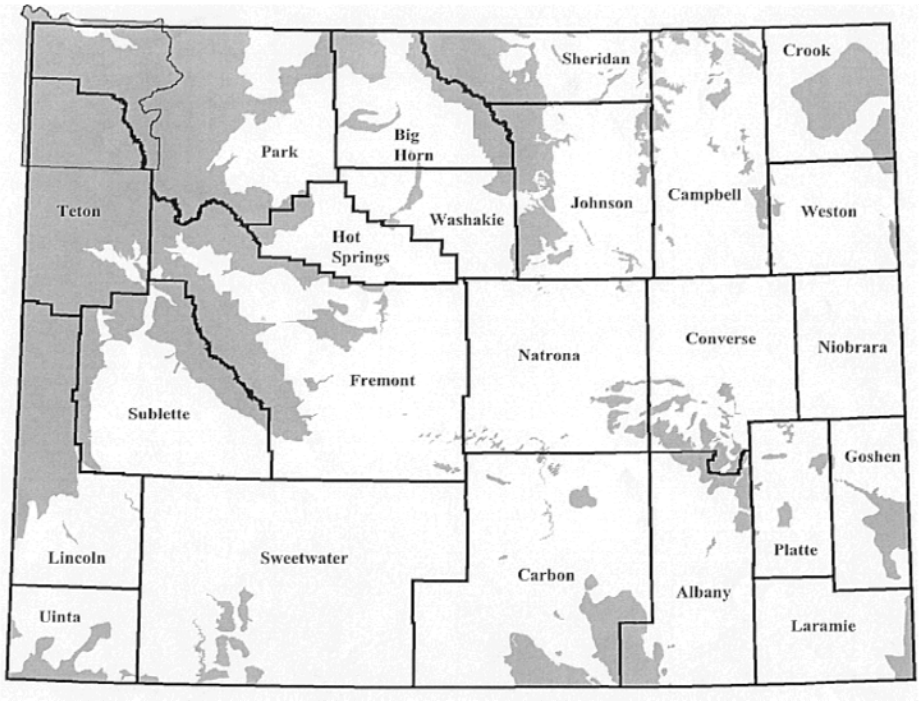


Fig. 1. Distribution of pronghorn in Wyoming (unoccupied habitats are shaded gray).

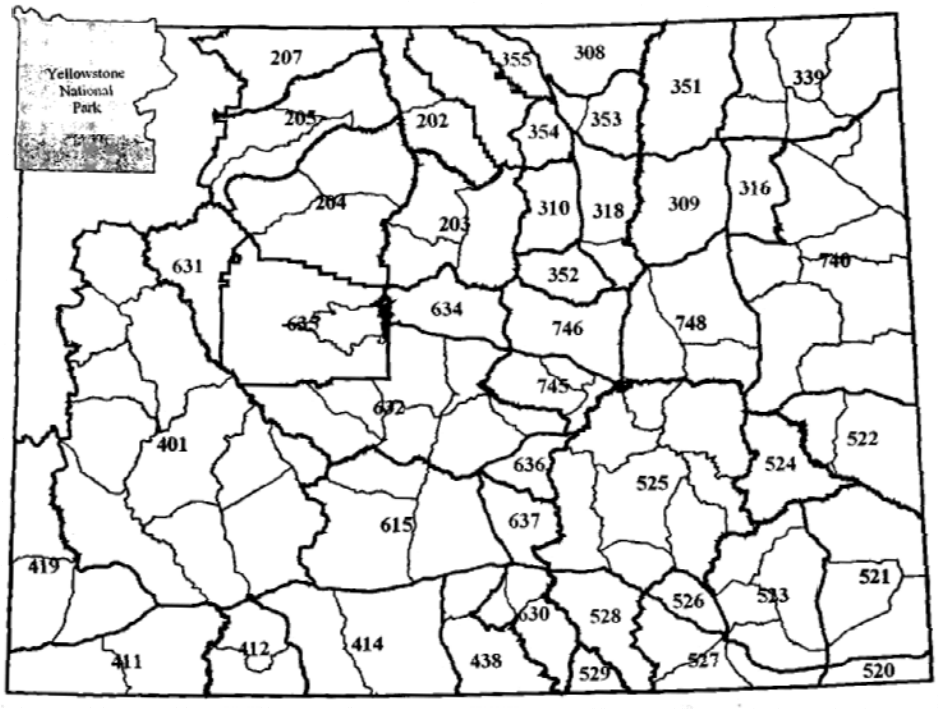


Fig. 2. Boundaries of pronghorn herd units and hunt areas in Wyoming.

II. CENSUS – The following techniques are commonly used in Wyoming to estimate sex and age composition, and size of pronghorn populations.

A. Pre-season Classifications – Pronghorn are classified from fixed wing aircraft and from vehicles on the ground. To assure consistent results, the same observer should conduct classifications each year, using the same method. If aerial and ground surveys are conducted in alternate years, biases associated with each method should be considered when data are interpreted (Woolley and Lindzey 1997). Minimum sample sizes are estimated according to the method described by Czaplewski et al. (1983 – Appendix XII) and achieved for each herd unit. However, it is more important to attain representative coverage of the entire herd unit, than to suspend sampling when the minimum sample size is achieved. If the minimum sample size is consistently exceeded, it may be possible to reduce sampling effort (e.g., by increasing transect spacing) while maintaining representative coverage of the herd unit.

1. Aerial Classifications

a. Rationale – Aerial surveys are more efficient than ground surveys and meet sampling assumptions better because the probability of encountering and classifying each pronghorn in the herd unit is approximately the same. Adequate, representative coverage can be achieved by flying successive transects spaced at regular (1-5 mile) intervals, beginning with a randomly selected transect. Precision of aerial surveys is comparable to that of ground surveys, however, lower fawn:doe and buck:doe ratios may be detected (Woolley and Lindzey 1997).

b. Application – Classifications should be done in late summer (O'Gara and Yoakum 1992), usually 1-31 August. Classifications conducted outside this period can generate biased fawn ratios (O'Gara and Yoakum 1992). Schedule flights the first two to three hours after daylight and the last two or three hours before dark. Bedded animals, especially bucks, are less visible during midday (O'Gara and Yoakum 1992). Aircraft should be designed to fly safely at slower speeds. Suitable aircraft include Piper Supercub, Bellanca Scout, Citabria Explorer, and Maule M-5. Helicopters are also suitable, but cost more to operate and may not improve accuracy of classifications (Woolley 1995). Advise the pilot to avoid stressing animals or running them into fences and other barriers. Dictate data into a small tape recorder. A mechanical counter and a data summary sheet also work well, however these are less efficient when large groups or high densities of pronghorn are encountered. Note essential details such as hunt area, herd unit, time, date, pilot and weather. If locations of pronghorn groups are needed, obtain the coordinates with a GPS receiver. Transcribe pronghorn locations onto Wildlife Observation System (WOS) data forms (Appendix I) after each flight.

c. Analysis of Data – Convert pre-season herd classifications into ratios of fawns, yearling bucks, and adult bucks per 100 does. These data are used to estimate productivity (Gilbert 1978), survival of fawns through summer, and pre-season buck:doe ratios. Ratios of yearling bucks can be highly variable and should be interpreted with caution (Woolley and Lindzey 1997). Ratios derived from aerial classifications are considered accurate provided a statistically valid sampling plan was followed (i.e., the probability of classifying each animal in the population is similar) and provided each animal is classified independently and correctly. However, distinguishing age classes accurately, especially yearling and adult bucks, can be difficult from the air.

The adequate sample size is based on the number of pronghorn in a population and the anticipated proportions of bucks and fawns (Czaplewski et al. 1983). The goal is to attain a 90% confidence interval (C.I.) of $\pm$ 5 animals per 100 does. The resulting buck:doe ratio may be overly precise because sample size is based on the larger ratio in the population, typically the fawn:doe ratio, and this results in a sample larger than necessary to achieve the target C.I. for the buck:doe ratio. Sex and age ratios are useful to monitor general population trends, however, these data should be interpreted in conjunction with other population data to assess population dynamics.

d. Disposition of Data – Record results of aerial classifications on Wildlife Observation Forms. At the end of the classification period, forward data to the biologist responsible for the herd. The biologist will summarize sex and age ratios observed within each herd, then incorporate the information into the Job Completion Reports (JCR) for the applicable herd units.

2. Ground Classifications

a. Rationale – Ground surveys often fail to meet sampling assumptions due in part, to the non-random distribution of road systems and topographic variation. However, reliable composition data can be obtained from ground surveys in areas with adequate vehicular access (Bowden et al. 1984, Woolley and Lindzey 1997). Ground classifications require about 4 times longer than surveys conducted from fixed-wing aircraft, but cost less (Woolley and Lindzey 1997).

b. Application – Plan ground survey routes to intersect all occupied habitats within a herd unit. Sample the entire herd unit. It is not sufficient to sample only high-density locations such as agricultural fields and areas surrounding water sources. Timing is the same as for aerial surveys – the month of August. Mark survey routes on BLM 1:100,000 maps and strictly follow the same routes each year. The same observer should conduct the classifications when possible. Drive at a moderate speed (<25 mph) and stop at regular intervals to observe using binoculars and spotting scopes. Classify every animal in each group of pronghorn encountered. However, classify only from distances at which all age

and sex classes can be reliably determined, normally less than 0.5 mile. Bucks are identified more easily at long distances, and this can lead to biased results. Use a GPS receiver or map to determine locations of pronghorn groups. Plot location data using GIS software to compare distributions among years.

c. Analysis of Data – Refer to Section II.A.1.c (Aerial Classifications).

d. Disposition of Data – Refer to Section II.A.1.d (Aerial Classifications).

B. Post-season Classifications – We do not attempt to classify pronghorn after hunting seasons in Wyoming. At that time of year, pronghorn congregate into much larger groups, which are much more difficult to classify. Fawns are also larger and more difficult to distinguish from adults, and bucks may have dropped horn sheaths, making distinction of sex more difficult.

C. Aerial Trend Counts – Trend counts were historically conducted from fixed-wing aircraft to estimate pronghorn abundance throughout Wyoming (Wyoming Game & Fish Department 1982). These counts were generally done between 1 May and 10 June when pronghorn are most visible against green vegetation. Pronghorn populations are currently estimated based on line-transect sampling (Section II.D). The Department no longer recommends trend counts, although they are still conducted within some smaller herds and interstate populations. We do not advocate trend counts during winter because patchy background conditions can substantially reduce observers' abilities to detect animals. In addition, large groups that congregate in winter are difficult to count.

1. Rationale – Aerial trend counts can provide indices to monitor changes in populations, provided the counts are conducted under similar conditions and similar proportions of animals are encountered in each survey. To accomplish this, consistent procedures must be followed. Aerial trend counts have also been used to align modeled simulations of population trends.

2. Application – Conduct aerial trend counts only in spring (mid-April through mid-June) when vegetation is green. The following procedures are used:
   - Consult records to determine if specific survey instructions, including dates and coverage areas, have been established.
   - If count blocks were defined previously, these should be retained for continuity of data. Count blocks are herd sub regions delimited with clearly identifiable boundaries, such as roads or power lines. Locations where pronghorn congregate, streams for example, are generally not good boundaries unless they are barriers to movement. Each count block should be less than 100 mi^2 so it can be surveyed in one flight. Essentially no animal movement into adjacent count blocks should take place during the survey. Count blocks are designated by Roman numerals.

- The survey crew is usually the pilot and one observer. The observer normally counts only on the side of the plane away from the sun. If 2 observers attempt to count, one is usually facing into the sun, resulting in less reliable counts.
- The pilot must fly the aircraft safely along straight transects at prescribed heights and intervals. The pilot should have previous experience flying low-level wildlife surveys near rugged terrain. Only the observer should count pronghorn. However, the pilot may note pronghorn the observer might not detect directly beneath the plane.
- Aircraft used for trend counts must be light, maneuverable high-winged planes that can be flown safely at low airspeeds ($\leq$ 80 mph = 70 knots). Helicopters are not recommended because they tend to displace pronghorn and rental costs are high. Suitable aircraft include the Bellanca Scout, American Explorer, Piper Supercub, Maule M7, and Cessna 180 and 185. Ideally, a GPS (Global Positioning System) should be on board, enabling the crew to precisely navigate transects. Radar altimeters are desirable to maintain prescribed heights above ground level (AGL).
- The airplane should be flown along parallel transects approximately 1/2 mile apart throughout each count block.
- The observer gauges the outer boundary of the survey strip by sighting across colored marks or streamers fixed to the wing struts. The inner boundary of the survey strip is the flight line vertically beneath the plane. An imaginary triangle is formed by the vertical line between the plane and ground, a horizontal line representing the survey strip width, and the observer's sight line to the outer boundary of the survey strip (Fig. 4). Calibrate the position of wing markers by projecting an identically shaped triangle while the plane is on the ground. Determining where the sight line (hypotenuse) of the miniature triangle crosses the wing strut. Use the following procedure: On the ground or hanger floor, prop up the tail of the plane to its normal flying attitude. Seat the observer in a position and posture normally used for counting pronghorn. Measure the vertical distance from the observer's eye level to the pavement. Calibrate the horizontal distance by multiplying the vertical distance by the ratio of the prescribed survey strip width (e.g., 2,643 ft) to the prescribed height above ground (e.g., 300-400f ft). Measure the horizontal distance from the point on the pavement directly beneath the observer's eye position, perpendicularly to the plane's direction. Using a white chalk or tapeline, mark the pavement at the measured distance, parallel to the plane's direction. While the observer sights across the strut to the line on the pavement, an assistant determines the proper placement of the strut marker. Repeat this procedure for the opposite side of the plane, so surveys can be conducted from either side. This procedure is very sensitive to measurement errors. For the wing strut calibration to accurately delineate transect width, the plane must be flown at the proper height AGL and the observer's eye must be consistently in the same position. Historically, strut markers were not routinely used to define the survey strips during trend counts.
- Count all pronghorn adjacent to the plane and within the outer strut mark. If struts have not been marked, the observer must estimate the outer boundary of

the strip. Surveys are generally flown along north/south transects and the observer counts from the side of the plane facing away from the sun. In some circumstances, an east-west orientation may be necessary, but this can affect accuracy. Fly each transect sequentially farther from the sun to provide the best visibility.

- Carry a map or written coordinates of transects on board. In many cases, transects can be defined by longitudinal headings.
- Conduct trend counts on clear days with unlimited visibility. Complete counts while the sun is between 20° and 60° above the horizon. Begin morning surveys about 30 minutes after sunrise and complete afternoon counts at least 30 minutes before sunset. Plan each flight to provide at least two hours of survey time during suitable light and weather. In rougher terrain, morning shadows can conceal pronghorn so surveys should begin somewhat later.
- Brief the pilot about the survey layout, the pilot's responsibilities, and potential problem areas (e.g., restricted airspace, bomber training areas) or hazards (e.g., power lines, radio towers, areas prone to downdrafts).
- The observer and pilot should be familiar with the Department's flight following procedures (WY. Game and Fish Aircraft Operation Procedures and Safety Policy, 4/27/99).
- Record the following information at the start of each trend count: (1) date, (2) hunt area, (3) herd name, (4) count block number, (5) observer's name, (6) pilot's name, (7) aircraft type, (8) take-off time, and (9) time the survey begins. Also, note weather and habitat conditions (e.g. green vegetation, drought) for comparison with conditions under which previous surveys were flown.
- Record all data on micro-cassette tapes. Tapes are a valuable aid for recording data, but take precautions to minimize equipment failures. Use fresh tapes and batteries and carry extras. Know how to proficiently operate the recorder. While flying out to the count block, check to make sure the recorder is working properly and the tape is understandable. If a recorder and back-up fail, manually record data on a paper form. However, we discourage writing or plotting data by hand, because this distracts the observer from counting.
- Over relatively flat terrain, fly surveys at an average height of 300 ft. AGL. In rougher terrain, increase survey heights (e.g., $\geq$ 400 ft.) for safety and to see over topography. When survey heights are changed, the survey strip-width must be recalculated.
- Fly surveys at a ground speed of not more than 100 mph (90 knots). If strong tailwinds prevent the aircraft from flying at a sufficiently slow speed, suspend the survey. Also suspend the survey when strong crosswinds cause the plane to crab (twist sideways) as it flies along the transect.
- Morning flights are preferable because temperatures are usually comfortable, winds are lighter, and clouds and storms are less prevalent. Late afternoon flights are acceptable when temperatures are less than 85°F, winds are light and little cloud cover has developed.
- Record each transect number, direction of travel, and start and end times.

- Count each cluster (group) of pronghorn within the survey strip. If distribution information is being collected, record the location using a GPS. Record each GPS waypoint with corresponding count data.
- Have the pilot circle larger clusters until an accurate count is obtained.
- When clusters of more than 50 pronghorn are encountered, it can be helpful to photograph them and count animals from prints or slides. Surveys in which photographic methods are used may not be comparable to other surveys done without the aid of photography.
- Record the time you complete each count block (or suspend a survey). Also record the time you land so ferry time can be estimated. These records enable managers to plan and budget future surveys.

3. Analysis of data – Transcribe data from the tape as soon as practical. All observations should be recorded on the Department's Wildlife Observation Forms. Talley the number of pronghorn observed within each count block. Carefully review notes about survey conditions and consult them when interpreting data. Limitations of trend counts include: (1) The proportion of the population not counted is unknown, (2) a measure of reliability is not available, and (3) detection rates may be inconsistent despite attention given to standardizing conditions and procedures.
   - The following procedure is used to estimate population size from trend count data:
     (a) If quantifiable biases can be identified, measure these as time and resources permit, and adjust the final estimate accordingly.
     (b) Estimate each observer's efficiency (usually between 0.4 and 0.8) at detecting pronghorn within each count block. Unfortunately, this is highly subjective.
     (c) Divide the number of pronghorn counted by the efficiency coefficient assumed for each count block.
     (d) Sum the adjusted count block totals to obtain a population estimate. In the past, when trend counts were the primary method used to survey pronghorn, most populations were underestimated because coverage was incomplete or observer efficiency was overestimated.
   - Comparisons of population trends among years are valid only if counts were done during the same seasons and under similar conditions.
   - Always evaluate trend counts in conjunction with other corroborating information such as hunter success and effort, weather and habitat data, and survey conditions.

4. Disposition of data – In cases where trend data are collected, the information is used to update population simulation models and to monitor abundance trends as a basis for regulating harvest. Results should be summarized, distributed to appropriate field personnel, and entered into the Department's Job Completion Report database. Trend data are also interpreted and discussed in Big Game Herd Unit Annual Reports. Distribution information from trend surveys can be plotted on maps,

entered into the Wildlife Observation System, or stored in a GIS database for subsequent analysis.

D. Line-transect Surveys – The principal technique used by the Department to estimate pronghorn populations is density sampling along aerial transects. Called "line-transect sampling," this adaptation of "distance sampling" (Buckland et al. 1993) was developed in Wyoming to estimate pronghorn populations (Johnson and Lindzey 1990; Johnson et al. 1991; Guenzel 1986, 1997). Line-transect sampling has several features in common with aerial trend counts, however it also differs in some fundamental ways (i.e., it's based on a sampling approach and corrects visibility biases). Persons conducting line-transect surveys must obtain specific training prior to implementing the surveys**.** Such training is beyond the scope of this handbook. Consult Appendix II, "Estimating Pronghorn Abundance Using Aerial Line-transect Sampling" (Guenzel 1997). Buckland et al. (1993) provide additional background regarding line-transect sampling.

1. Rationale – Less than 100% of animals are detected during aerial surveys. Two main factors affect detection rates: 1) distance from the observer; and 2) size of groups (clusters). Pronghorn nearer the observer and those in larger groups are easier to detect. Other factors such as light conditions and terrain may further compound visibility bias. Line-transect sampling offers several advantages compared to traditional aerial surveys for estimating pronghorn populations (Guenzel 1994):
   - Visibility adjustments are calculated to account for undetected animals in outer survey bands.
   - confidence intervals are calculated to indicate precision of population. This information is considered when apparent population changes are evaluated.
   - Line-transects are generally less costly and time consuming because the technique is based on sampling rather than total coverage. The approach enables managers to monitor herds more frequently to detect responses to harvest strategies and climatic events such as droughts or severe winter.

   Requirements and limitations of the technique include:
   - Aircraft must be specially equipped. Currently 1 air charter company, Sky Aviation in Worland, WY has flown line-transect surveys with the Department's new system. However, the Department will provide the necessary equipment and training to other air charter services on the Department's contract list.
   - Quality control procedures must be rigorously followed to effectively apply the technique. If sample sizes are low, surveys are poorly designed, or personnel deviate from survey protocols, resulting estimates may be unreliable.
   - Line-transect surveys may not work in all situations.
   - Sampling assumptions for conducting line-transect surveys must be rigorously met. Consult Buckland et al. (1993) for recommendations to deal with problem situations.

2. Application – Biologists should thoroughly review Guenzel (1997) before attempting to design or conduct an aerial line-transect survey. (Refer to Appendix II).

   A fundamental assumption of line-transect sampling is that all animals within the closest strip or band adjoining the flight path are seen. A computer program adjusts counts in outlying strips to correct decreasing rates of detection. Observers are required to carefully watch the line and region near the plane, count pronghorn accurately, and assign locations of observations within correct distance bands. Basic assumptions are: 1) All pronghorn on the line are seen; 2) Pronghorn do not move before they are detected; and 3) Pronghorn locations are placed in the correct distance band. Johnson et al. (1991) demonstrated these assumptions can be reasonably met during aerial line-transect surveys of pronghorn.

   The survey must be designed to maximize the probability all animals within the closest distance band along the transect line are seen. The area directly beneath the plane and approximately 65 m either side of the flight line is the "blind area." Accordingly, the transect line is offset from directly beneath the plane. The airplane is flown at a nominal height of 300 ft. (91.4 m) above ground level (AGL). This elevation is low enough to afford good detection rates, yet is sufficiently high for safety and to avoid displacing animals. Animals that move tend to run parallel to the flight line (Johnson et al. 1991). Transects should be sufficiently spaced to avoid displacing animals into an adjoining transect corridor. Observers record distance intervals or bands (e.g. 25-50 m) in which pronghorn are located rather than estimate actual distances from the line. Visually gauging specific distances or angles from an airplane usually produces inaccurate estimates.

   Pronghorn locations are assigned to parallel distance bands when the plane is perpendicular to the location where the pronghorn were initially seen. The observer projects distance bands onto the ground by sighting across calibrated marks on wing struts or windows of suitable, high-winged aircraft. At the prescribed height AGL, markers define the transect line and perpendicular distance bands to which observed animals are assigned. The placement of strut markers (using dowels) is calculated based on the plane's strut configuration and a fixed eye position. Two strips of tape are placed on the window to assure eye alignment is consistently correct. Before each observation is assigned to a distance interval, the observer must align the window marks with strut markers defining the inner (first) distance band. By design, distance bands are unequal – bands near the transect line beneath the plane are narrower and bands farther out are wider. The number of distance bands is limited so observers do not attempt to survey too much area, thereby missing animals in the closest band. Having fewer bands is also less confusing for observers attempting to assign animals to the correct band. A digital radar altimeter is essential to maintain flight altitude at the prescribed height AGL. In all surveys, circumstances will require some deviation from the planned height AGL. An onboard computer is linked to a GPS to instantaneously record starting and ending

points of each transect, locations of observations, and in some cases, flight paths. At the location each observation is recorded, the radar altimeter reading is stored in the computer to later correct observed distances based on the actual height AGL. The stored beginning and end points are used to estimate the actual linear distances surveyed. Transect lines must be laid out randomly with respect to the distribution of pronghorn and should not be manipulated to coincide with any natural pattern of clusters.

Both pilots and observers must be trained to conduct line-transect surveys and must practice beforehand. Outfitting aircraft for line-transect surveys is a complex, technical undertaking that must be done by experienced personnel. Only approved, properly equipped flight services that have the requisite training should be contracted to do line-transect surveys.

3. Analysis of data – A sophisticated software package, "Distance," is available to analyze line-transect data. Analysis procedures are described in Guenzel (1997). This publication references an MS-DOS version of "Distance," however most users will find the Windows-based programs easier to use. We recommend the Windows 95 release 3.5 or later version for analyzing line-transect data. An overview of steps in the analysis follows:
   - Review the flight reports and summary data. Survey data are generally provided in a Microsoft Excel worksheet or tabular format. Check the flight report for obvious errors or problems such as data that appear out of bounds, unusually large cluster sizes, or survey heights that deviate substantially from 300 feet AGL. Also consider comments or notes recorded during the survey, and conditions that may affect the data.
   - With some manipulation, the Excel worksheet can be reformatted, saved as a tab-delineated text file, and imported into "Distance" 3.5. Adjust cluster distances (distance band midpoints) from the flight line based upon actual height AGL recorded for each observation. Calculate average band distances based upon the recorded survey heights AGL.
   - Import the data file into the "Distance" program and run the analyses.
   - Select optimal analysis from the "Distance" program.
   - Consider survey conditions and data quality when interpreting results.

4. Disposition of data
   - Line-transect surveys are generally flown in late spring; therefore, population estimates derived from these surveys represent end-of-biological-year populations. Results are incorporated into the annual Job Completion Report for the applicable herd unit.
   - Population estimates derived from line-transect surveys are used to align population simulation models.

E. Quadrat Sampling – Quadrat sampling is another aerial survey technique available to estimate pronghorn abundance. As of the 2007 revision to the Handbook of Biological

Techniques, quadrat sampling was not widely used in Wyoming due largely to cost. Helicopters generally are used for quadrat sampling. We do not recommend fixed-wing aircraft for these types of surveys.

Quadrats are sample units distributed within the herd unit, based upon a stratified sampling design. Each quadrat is censused to estimate density. Depending on sampling design, the average densities of pronghorn within sampling strata are extrapolated to develop a population estimate. Quadrat surveys have been used in Colorado and tested in Wyoming (Pojar et al., 1995, Pojar and Guenzel, 1999) to estimate pronghorn abundance. Pojar et al. (1995) concluded quadrat surveys were the least biased technique among those they tested. Another advantage is, pronghorn can be classified as well as counted from a helicopter, and herd composition can be estimated from classifications. However, quadrat surveys cost substantially more than line-transect surveys to achieve the same precision (Pojar and Guenzel, 1999). Ferry time between sample units is generally greater for quadrat surveys than for line-transect surveys and rental costs of helicopters are higher than costs of fixed-wing aircraft.

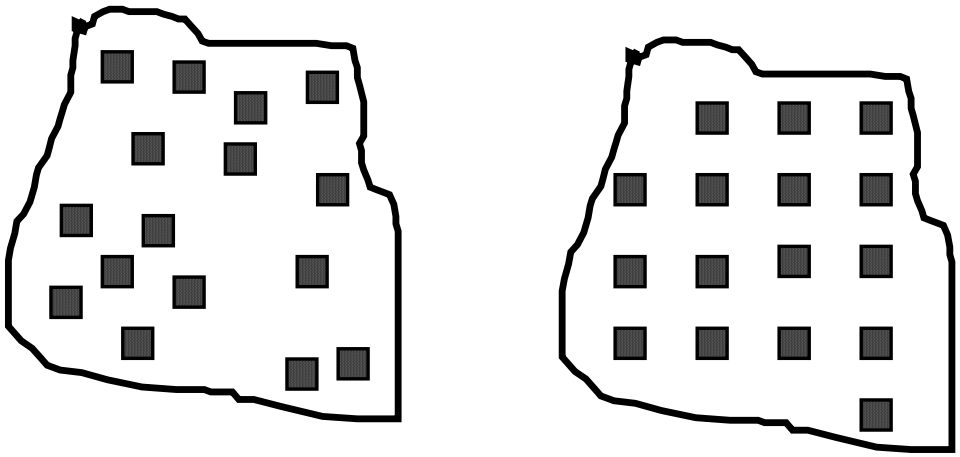
1. Rationale – The fundamental concept underlying quadrat surveys is, all pronghorn can be observed and counted within comparatively small sample units that are searched intensively by helicopter. Because helicopter rental costs are high and availability is limited in Wyoming, quadrat surveys may be most useful for estimating correction factors to improve line-transect estimates (Pojar and Guenzel, 1999). Quadrat surveys may be appropriate in areas that are less suitable for line-transect sampling and when a need for more accurate population estimates justifies the additional expense.

2. Application – Pojar et al. (1995) describe procedures generally followed in designing and conducting quadrat surveys. These procedures have been used in short grass prairie and sagebrush steppe habitats. However quadrat surveys are not a standard census technique in Wyoming.

    a. Planning the Survey
        - In general, sample units are symmetric squares. Other shapes, including rectangular plots, increase sample error (Thompson et al., 1998). Most quadrats are one square mile (Pojar et al., 1995, Pojar and Guenzel, 1999), but smaller units (e.g. 1 km^2) might also be suitable. Quadrats should not exceed an area that can be thoroughly covered. Otherwise, pronghorn may be undercounted. Avoid double-counting animals that flush into other portions of the quadrat. It becomes more difficult to scan longer distances adequately in variable terrain.
        - Estimate an adequate sample size (number of quadrats) and determine if a stratified survey is needed. References cited in the preceding paragraph contain guidance for determining sample size and design. See Cochran (1977) or Zar (1984) for additional background on sampling theory. If a

quadrat survey is used to correct a line-transect estimate, both surveys should have the same basic design (i.e., stratified or non-stratified).

- Select a quadrat configuration (Fig. 3). Random quadrats are most common (e.g., Pojar et al. 1995, Pojar and Guenzel 1999).



A. Random **B. Systematic**

Fig. 3 Alternative Sampling designs for quadrat surveys.

- Determine the UTM coordinates of quadrat corners. Store quadrat coordinates as GPS waypoints prior to the survey. Also carry a written list of coordinates and a topographic map with quadrats plotted.
- Quadrat surveys are normally conducted between late spring (mid-May) and late summer (early September). If quadrat estimates will be used to adjust line-transect estimates, the two surveys must be flown about the same time. However, quadrat surveys during which pronghorn are classified must be flown in late summer to estimate pre-season herd composition.

b. Conducting the Survey

- Normally the survey crew includes the pilot, an observer, and a navigator. Depending on the type of helicopter, two observers may be used in addition to the navigator.
- The observer's sole responsibility is to count pronghorn within each quadrat. Record observations on a cassette tape so pronghorn can be counted continuously.
- The navigator's responsibility is to guide the pilot to the first corner of each quadrat and assure the aircraft remains within quadrat boundaries as the

count is conducted. The navigator must have a proficient skill level using a GPS receiver.

- The pilot should concentrate on flying at the prescribed height and headings given by the navigator. It is best if the pilot does not divert his attention to search for pronghorn.
- Most quadrat surveys are flown between 50 and 100 feet above the ground.
- Survey the ground at a speed of 40-50 mph. Observers must fly slowly enough to navigate within the quadrat, detect pronghorn, and keep tract of pronghorn that are flushed.
- To minimize duplicate counting, note sizes, composition and locations of clusters as they are encountered within the quadrat**.**
- Begin at the first corner of each quadrat, fly the perimeter, then make one or more passes through the interior. To effectively search larger quadrats or rougher terrain, it may be helpful to fly concentric "orbits" inward (Fig. 4).

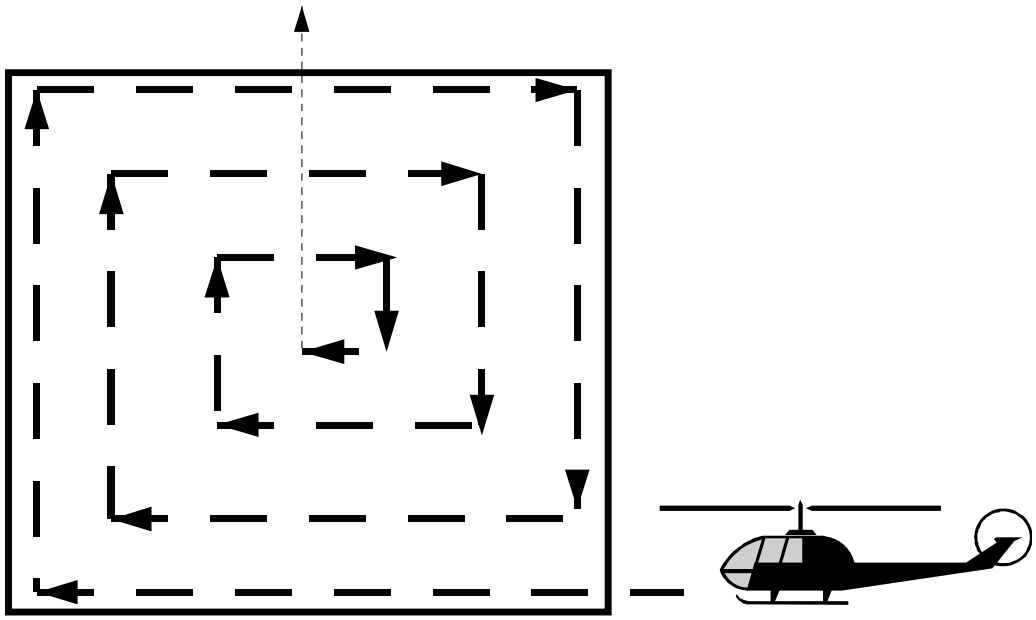


Fig. 4. Concentric search pattern used for quadrat surveys.

3. Analysis of data – Density estimation is straightforward when surveys are not stratified and quadrats are the same size and shape. The density estimate is simply the number of animals counted divided by the total area surveyed. Sample variances, standard errors, and confidence intervals can also be calculated. Version 3.5 of the "Distance" program can correct line-transect estimates by entering calibrating data from other squares, such as quadrat surveys. Distance then adjusts line-transect estimates, based upon this

information. Generally, some double sampling can be useful to routinely improve line-transect estimates.

4. Disposition of data – Data obtained from quadrat surveys are used for the same purposes as data from line-transect surveys. Results should be incorporated and discussed in Annual Big Game Herd Unit Reports. Estimates derived from quadrat surveys can be used to align population simulation models, in addition to calibrating line-transect estimates.

III. HARVEST DATA

A. Harvest Survey

1. Rationale – Managers require estimates of pronghorn harvests to evaluate results of harvest strategies and to adjust license quotas needed to obtain desired harvests. Harvest statistics are incorporated into population models and are also of some limited use for tracking population trends.

2. Application – Pronghorn harvest data are acquired from an annual survey mailed to a stratified sample of license holders. The following parameters are estimated: total harvest, age (adult/fawn) and sex composition of the harvest, hunter success, effort (avg. days expended per animal harvested), and total days of recreation. Harvest parameters are estimated and summarized with respect to each license type, hunt area, herd unit, and statewide. Refer to Appendix III for additional discussion of the Department's harvest survey procedures.

3. Analysis of Data – Harvest data are reviewed each year during the Department's annual season setting process, and are comprehensively evaluated in the JCRs compiled by each region. Changes in hunter statistics such as effort and success are also considered to detect and confirm population trends.

4. Disposition of Data – Statewide estimates of harvest and hunter activity are summarized in the Annual Report of Big Game Harvest published by the Wyoming Game & Fish Department. More detailed summaries of data from hunt areas and herd units are maintained in the annual Job Completion Reports. Herd unit files and databases housed at the headquarters office in Cheyenne serve as repositories for all herd unit information.

B. Age Determination

– Information about age structure and age-specific harvest rates can help managers understand the status of a population and predict how it may respond to specific management actions. Detailed age data are obtained from harvested animals. When substantial harvest of females takes place, the age structure of harvested females is presumed to represent the age structure of the female population segment that is older than fawns. However, ages of harvested bucks do not represent the age structure of the male segment because hunters tend to select older bucks.

1. Tooth Replacement

   a. Rationale – Examination of tooth replacement is a quick and easy field technique to determine the following ages of harvested pronghorn: 0.3 (fawns), 1.3, 2.3, 3.3 years, and older.

   b. Application – Hoover et al. (1959) and Dow and Wright (1962) described aging techniques based upon tooth eruption. Pronghorn have 3 sets of incisors and 1 set of incisor-like (incisiform) canines on the lower jaw. In juveniles (age 4-6 months), all incisors and incisiforms are deciduous; they are much narrower and smaller than permanent, adult incisors. Generally, one set of deciduous incisors is replaced annually, beginning with the central set (called the first incisors). Aging is accomplished by counting the number of larger, permanent incisors and incisiforms present on one side (one-half) of the lower jaw. Juveniles are readily identified by their smaller body size and short rostrum (muzzle). In yearling (16-18 months) pronghorn, the central set of permanent incisors is usually present. These are much larger and broader than adjoining, deciduous teeth. If the permanent incisors have not erupted, the central set of deciduous incisors will appear worn, widely spaced, and may be quite loose. The second set of permanent incisors is present in 2-year old (28-30 months) pronghorn, the third set in 3-year old (40-42 months) pronghorn, and the incisiform canines (fourth set) are generally replaced in 4-year old (52+ months) pronghorn. In some instances, incisiform canines can begin erupting in a 3-year old animal. Because of this, some managers only age pronghorn to 3.3 years. Always test the innermost deciduous teeth for looseness. A loose or missing deciduous tooth indicates the permanent tooth is erupting and the animal should be aged as though the permanent tooth is in place.

      Characteristics of molars and premolars can also be used to age pronghorn. Yearling and older pronghorn have 6 “cheek teeth” visible in the lower jaw. These include 3 pre-molars numbered 2-4 and 3 molars numbered 1-3 front (distal) to back (proximal). The fourth premolar of yearling pronghorn is deciduous and has 3 cusps. The third molar (at the rear of the gum) may still be erupting. In 2-year old pronghorn, the fourth premolar is permanent and has 2 cusps. Cusps on the first molar are sharp. Infundibula (conical recesses) are distinct on all molars, but are becoming worn on the first molar. In 3-year old pronghorn, infundibula are visible on all molars, but only form small pits on the first molar. Infundibula are no longer visible on the first molar of pronghorn when they reach 4 years and older.

   c. Analysis of Data. Information about the age structure of harvested animals is used for the following purposes:
      i. align the age structure of harvests simulated by population models
      ii. assess the effects of various harvest strategies
      iii. estimate age-specific, natural mortality rates within the female segment

iv. assess hunter selectivity for specific age classes, and
v. assess the availability of specific age classes for harvest

d. Disposition of Data – All age data are summarized in the annual JCR for each herd.

2. Tooth Cross-sectioning – Ages of big game animals can be accurately determined based on the number of annular cementum deposits in tooth cross-sections. However, this laboratory technique is expensive and time consuming.

a. Rationale – Tooth cross-sectioning is recommended when detailed age data are required to determine population age structure and numbers of age classes for modeling purposes.

b. Application - The first (central) incisors are extracted with roots intact. These are placed inside a tooth envelope on which the following information is recorded: species, sex, date of harvest, hunt area, drainage, and hunter's name and address. Tooth envelopes are forwarded to the Department's lab in Laramie. Aging is accomplished by staining and counting cementum annuli in a cross-section of the tooth root. Refer to Appendix V for a complete description of this technique.

c. Analysis of Data – Refer to Section III.B.1.c. (tooth replacement)

d. Disposition of Data – Refer to Section III.B.1.d. (tooth replacement)

C. Field Checks and Check Stations

1. Rationale – Large numbers of harvested animals can be examined efficiently at check stations situated on major roads. Various management data are obtained from hunters and harvested animals.

2. Application – Check stations must be manned, signed, and identified by lighting specified in Wyoming Statute 23-3-308, Chapter 2, Section 9 of the Wyoming Game and Fish Commission Regulations, and the Wildlife Division's "Guidelines for Establishment and Operation of Wildlife Check Stations" (Attachment 1). Always record the following information when each harvested animal is checked: species, sex, age, and hunt area. Depending management needs, additional information such as fat deposition indices, carcass weights, general condition, tissue samples for disease monitoring, and surveys of hunter opinions may be collected. Large samples of sex and age data can also be collected at commercial facilities that process wild game meat.

3. Analysis of Data – Refer to Sections III.A.3 and III.B.1.c. (harvest survey; tooth replacement).

4. Disposition of Data – Refer to Section III.B.1.d. (tooth replacement).

IV. MORTALITY ESTIMATION (non-hunting) – Records of non-hunting mortality are useful documentation to identify sources of significant mortality and to develop corrective actions. Mortality records are also used to assess impacts of development and adjust population models. Non-hunting mortality can result from severe weather, vehicle or train collisions, predation, illegal kills, crippling, starvation, disease, fence entrapment, entanglement, lightning, and poisoning. Severe weather patterns, such as the winters of 1978-79, 1983-84 and 1992-93 and droughts of 1988 and 1994 often lead to significant population declines. Other causes of mortality such as vehicle collisions, disease outbreaks and predation tend to have more localized effects. Several methods are used to document and evaluate non-hunting mortality in Wyoming.

A. Incidental Observations

1. Rationale – Various data, including age and sex composition, are obtained by examining dead pronghorn during and immediately following mortality events. A database of mortality records, maintained over a period of years, can help isolate and document problems such as lethal fences or highway segments. Observations of mortalities can be recorded throughout the year, but are usually more insightful during seasonal migrations. Locations of frequent and recurring mortalities should be depicted on a map that is retained in a permanent file. Such observations should also be reported in the annual JCR. If mortality is chronic, significant and localized, the biologist should investigate causes and corrective measures.

2. Application – When dead pronghorn are encountered, record age, sex, location, and cause of death. If the cause of death is not apparent, arrange to transport the carcass (provided it is in good condition) to the Wildlife Veterinary Laboratory in Laramie for post-mortem examination. Notify the laboratory by telephone so personnel can prepare. Complete a Field History and Necropsy Form to accompany the carcass when it is delivered.

3. Analysis of Data – Mortality records can be sorted and tabulated based on geographic location, season, age, sex, and cause. This information is useful to document and analyze impacts of developments and land uses. It can also assist in identifying and correcting sources of significant wildlife mortality.

4. Disposition of Data – All mortality data, including dates the animals were found, should be recorded on Wildlife Observation Forms. Each biologist is responsible for accuracy of the information collected in his district. The Wildlife Management Coordinator assures the data are entered into the Wildlife Observation System. Non-hunting mortalities should also be summarized and evaluated in the Job Completion Reports.

B. Mortality Transects

1. Rationale – Mortality transects are a systematic survey method used to estimate mortality resulting from severe winters, droughts, disease outbreaks and other causes.

2. Application – Using a 1:24,000 topographic map or aerial photographs, delineate the area in which mortalities have taken place or are suspected. Randomly superimpose a grid of transects onto the map. Transect density depends on sampling intensity and size of the area. Establish enough transects to achieve the desired confidence in the results. If sub-sampling is needed, randomly select transect segments for this purpose. Assign numbers to identify the beginning and end points of permanent transects. Use a GPS unit to locate transects and to navigate along them. Coordinates of transect endpoints should also be listed in the JCR. Transects can be followed on foot or horseback. The observer should record his name, the transect identification number(s), light conditions and ground cover. Determine coordinates of all dead pronghorn encountered within a specified distance from transects (100-500 ft. depending on topography) and record these on a Wildlife Observation Form. Also record the age and sex of each pronghorn. To estimate over-winter mortality, conduct mortality sampling soon after the ground is snow-free, but late enough in the season to assure the possibility of additional winter losses is minimal. Snow should also be melted from draws and other locations where carcasses could be buried under drifts. Conduct sampling on days with good light conditions – clear skies or high, thin clouds. Observers will require the following equipment and materials: map or aerial photo of transects, binoculars, Wildlife Observation Forms, a GPS unit, and a compass (optional). Information from winter mortality transects is recorded on the data form in Attachment 2.

3. Analysis of Data – The density of dead pronghorn is estimated based on the area sampled. If the sample is representative, estimates can be extrapolated to a larger area. Some pronghorn also die during egress from winter ranges. Therefore, to estimate total mortality, it would be necessary to sample spring/fall ranges as well. However, pronghorn dispersal patterns in most cases preclude effective sampling of spring transition habitats.

4. Disposition of Data – The regional biologist compiles results of mortality transect surveys and maintains this information in his files. Findings are also summarized in the annual Job Completion Reports.

C. Weather Severity Indices

1. Rationale – Severe weather patterns can lead to significant mortality and suppressed reproduction and recruitment in populations of pronghorn and other big game (Bartmann 1984, Martinka 1967, Oakley and Riddle 1974, Reeve and Lindsay 1991). The severity of this impact depends on several factors including season,

frequency and duration of weather events, temperature, wind speed, precipitation, and general condition of the animals. By evaluating weather severity data, herd composition (fawn:doe and yearling buck:doe ratios), and condition of animals, managers can, with some consistency, detect and predict elevated mortality rates. This information is used to adjust population estimates and recommend more effective management actions.

2. Application – Climatologic measurements (e.g., temperature, wind speed, precipitation) are recorded at weather stations throughout Wyoming and compiled by the National Weather Service and the Water Resources Center (WRC) at the University of Wyoming. Biologists have developed various criteria and indices to monitor departures from normal weather patterns that can impact big game populations. This information is used to adjust mortality estimates.

2. Analysis of Data – Weather indices are based on data from 4 chronological periods: early summer (SI_1, April-June), late summer (SI_2, July-September), early winter (WI_2, October-December) and late winter (WI_1, January-March). Severity indices are calculated by dividing the current weather index by the long-term (30 year) average weather index for each period, at each station. The following formula is used to calculate winter severity indices during the 2 winter periods:

$$WI = (TPPT/TMAX) \times 100$$

Where TPPT is total precipitation, and TMAX is the mean maximum daily temperature. Summer indices are based on the following formula:

$$SI = TMIN/TPPT$$

Where TMIN is the mean minimum daily temperature.

Reeve and Lindzey (1991), demonstrated fawn:doe ratios of mule deer were inversely correlated with the winter severity indices in south-central Wyoming. Christiansen (1991) modified the winter index based on how much the early summer (SI_1) index deviated from the long-term (30 year) average. His analysis resulted in the following mortality severity index (MSI) adjustments used in the POP-II model:

If the multi-station average SI_1 was 50-99% above the 30 year average,

$$MSI = \frac{WI1 + WI2}{2} + 0.1$$

If the multi-station average SI_1 was $\geq$100% above the 30 year average,

$$MSI = \frac{WI1 + WI2}{2} + 0.2$$

If the multi-station average SI_1 was $\geq$50% below the 30 year average,

$$MSI = \frac{WI1 + WI2}{2} - 0.1$$

4. Disposition of Data – Weather severity data should be compiled and interpreted annually in Job Completion Reports. Each year, the population model should be updated by incorporating the current MSI value to account for realized losses over the winter period.

V. DISTRIBUTION AND MOVEMENT – Pronghorn distribution and movement data are used to identify seasonal ranges, migration corridors, crucial habitats, and herd unit boundaries. Seasonal habitats and boundaries are delineated on herd unit maps maintained in the Cheyenne Headquarters Office. This documentation is essential to support credible analyses of impacts anticipated from development projects and to justify mitigation recommendations. The information is also provided to other resource agencies for use in planning. In addition, the Department may consider animal distributions when setting hunting seasons. Herd unit maps should be reviewed every five years and updated as new information warrants. Refer to Appendix VI for procedures used to update seasonal range maps, keys to range classifications and standard definitions. Distribution and movement data are obtained from observations of marked animals, aerial surveys, and incidental observations.

A. Marked Animals

1. Rational – Detailed information about pronghorn distribution and movements can be obtained from field studies in which animals are fitted with visible markers, radio telemetry, or satellite telemetry transmitters.

2. Application – Depending on objectives of the study, locations of marked animals are recorded during systematic surveys, or incidentally during other field activities. The information is accumulated in geographic databases.

3. Analysis of Data – Data are compiled and interpreted to improve knowledge about distribution, seasonal movements, and herd interchange. The data are interpreted considering time of year, and the influence of geographic features and weather patterns such as snow cover and storm events.

4. Disposition of Data – Observation records and other relevant information are compiled in a regional database and entered in the Wildlife Observation System. Conclusions are discussed in applicable JCRs. Interim and final project reports should be appended to the JCRs.

B. Aerial Surveys

1. Rational – Pronghorn distribution can be documented efficiently over large areas by flying systematic surveys. Flights can be scheduled to determine seasonal distributions or responses to extraordinary events such as severe snowstorms.

2. Application – Plan aerial surveys to make effective use of manpower, funds, and favorable weather conditions. Conduct flights in the early morning or late afternoon on clear days. Record UTM coordinates of all pronghorn observed and enter this data in the Wildlife Observation System.

3. Analysis of Data – Compare distributions of pronghorn observed to seasonal habitats delineated on existing seasonal range maps. Update maps when seasonal distribution data obtained during normal or severe weather patterns indicate refinements are needed. Refer to Appendix VI for a discussion of procedures to update seasonal distribution maps.

4. Disposition of Data – Results of distribution surveys should be evaluated and discussed the annual JCR for the applicable herd unit. Enter location data into the Wildlife Observation System.

C. Incidental Observations

1. Rationale – Knowledge of pronghorn distribution is continually improved as additional data are gathered. Incidental observations are a non-structured source of data for documenting distribution in areas not previously surveyed, and may alert managers to shifts that have taken place in response to development or changing land management practices.

2. Application – Biologists should record incidental observations of pronghorn when the location, time of year or other circumstances contribute further insight about pronghorn distribution patterns. Give particular attention to areas in which changes in land uses are proposed or underway, and to previously unoccupied habitat.

3. Analysis of Data – Refer to Section V.B.3. (Aerial Surveys).

4. Disposition of Data – Records of incidental observations are entered in the Wildlife Observation System. Herd unit maps are revised when distribution data indicate adjustments of boundaries or range delineations are warranted. Discuss all revisions in the applicable JCRs.

VI. CAPTURE METHODS

A. Live Capture – Pronghorn are most often captured for marking, collection of biological samples, or relocation. Capture methods include netting, trapping, chemical

immobilization, or hand capture of young fawns. Appropriate capture methods are selected depending on several considerations, for example: number, age, and sex of animals required; density of animals in the trapping area; terrain and proximity to roads; degree of acclimation to fences; wariness of animals; the possibility and acceptability of capture mortalities; and the cost in time and expense per animal captured or marked (Armstrup et al. 1980). The two methods used most commonly in Wyoming are corral traps and hand capture of fawns.

Lee, et. al. (1998) provided an excellent discussion of capture methods. Corral traps are the most efficient devices for capturing large numbers of pronghorn. The surround-net works well to capture small numbers of animals at waterholes. Net gunning from helicopters is also effective for capturing small numbers of animals, especially in remote locations and areas of low pronghorn densities. Chemical immobilization is effective in limited circumstances.

1. Corral Traps

   a. Rationale –The most efficient means of capturing relatively large groups (50 animals) of pronghorn is to drive them into corral traps.

   b. Application – The trap is an oval-shaped corral with two long (0.5km) lead fences or wings that converge at the entrance. The wings of the corral trap form a "v" funneling into the trap entrance. In Wyoming, the distance between these wings is narrowest at the trap, and gradually increases to 1,000-1,300 ft (300-400 m) at the outer end (Fig. 5) (Moody et al. 1982). Wings are constructed of woven wire supported by steel fence posts. Pliable cargo netting is used for the 100-m segment of each wing closest to the trap entrance, to reduce injuries during the final push into the trap. The trap can be set up to incorporate an existing fence as one of the wings. Existing fences are familiar to the animals and their movements around such features are more predictable.

      The corral wall is usually 2-inch, nylon mesh stretched between a cable anchored on the ground and another cable suspended 8 ft above ground by steel support posts. The mesh is covered with a burlap or canvas screen to discourage escape attempts. Before animals are driven into the trap, the screen is rolled to the top of the corral and secured with a quick-release string and cotter pin assembly (Fig. 6). A capture pen is formed by suspending a sliding, canvas curtain across the back of the corral, in front of the exit door. The 8-ft high curtain slides on rings attached to cables stretched tautly across the top and bottom of the corral. Detailed instructions for setting up the trap are provided in Attachment 3.

      A crew of at least 20 personnel is required to conduct this type of trapping operation. One person should supervise the entire operation. Individuals are assigned specific responsibilities that include handling animals, recording data,

operating the curtain, etc. The person in charge outlines trapping and handling procedures to ensure the overall operation runs smoothly. The corral and wings should be set up behind a topographic rise to conceal the corral trap from view until pronghorn are well within the wings. The open end must also be oriented downwind so the helicopter flies into the wind as pronghorn are driven between the wings. Other considerations can include taking advantage of known travel lanes of pronghorn, and avoiding steep terrain, tall vegetation, flight hazards, and other manmade or natural barriers.

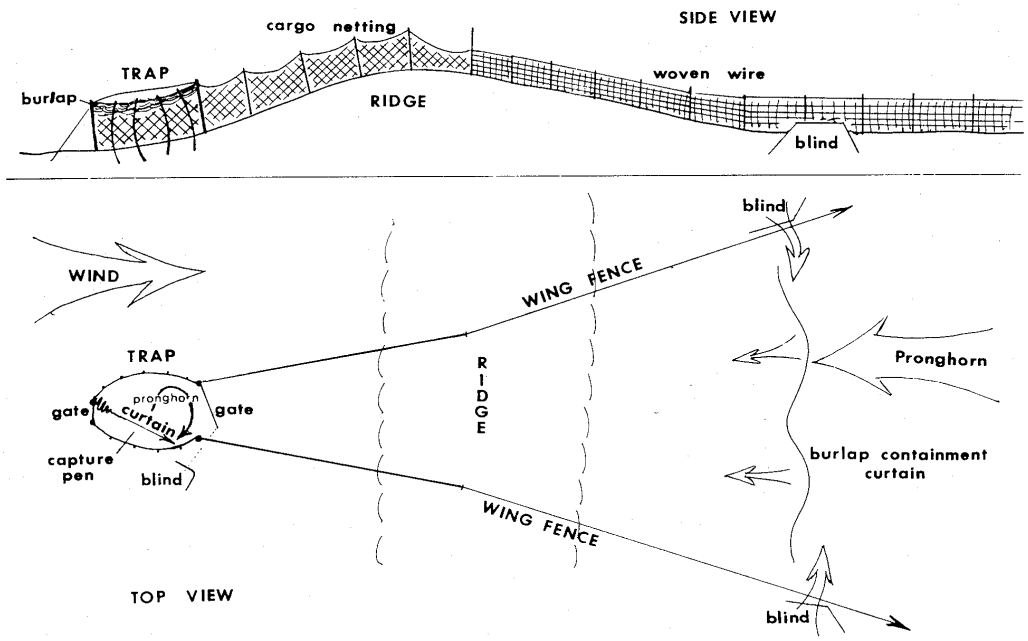


Fig. 5. Basic corral trap design

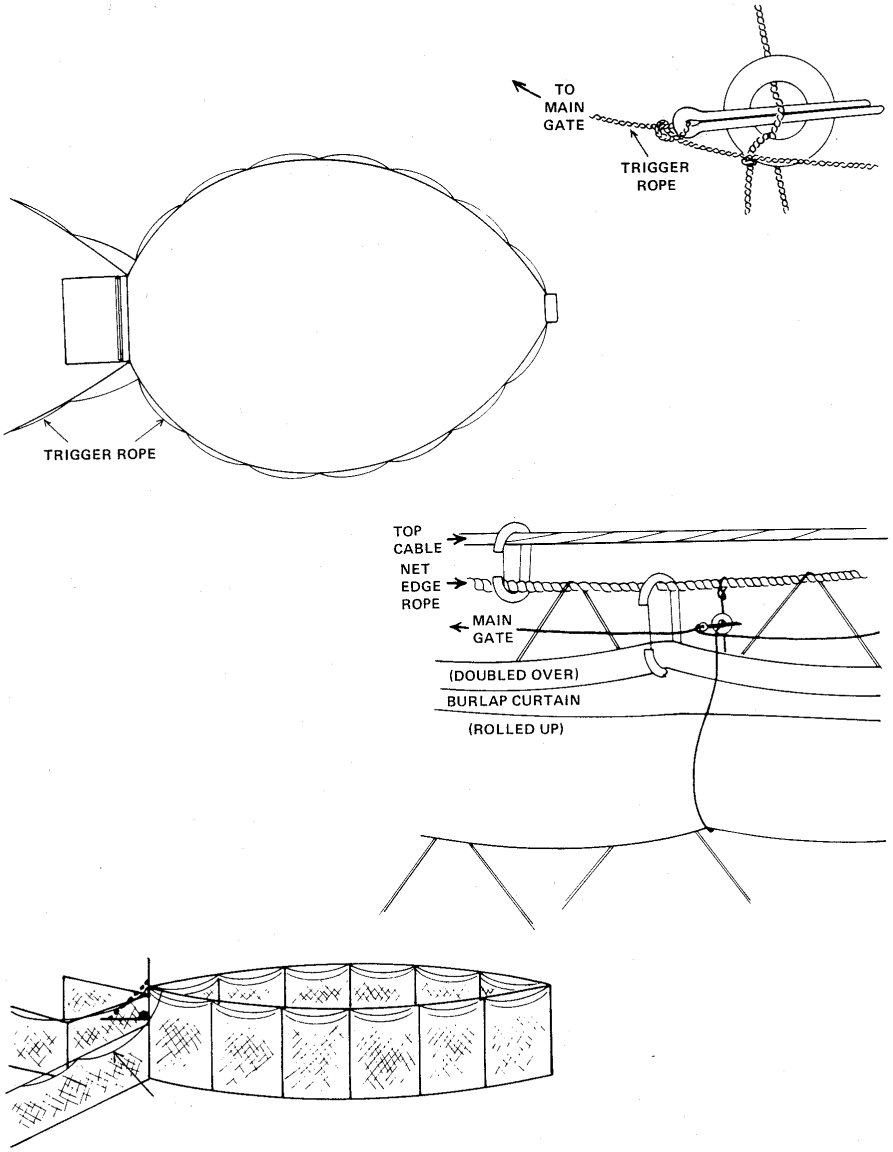


Fig. 6. Curtain (visual screen) and cotter pin assembly.

A helicopter must be used to locate and drive small groups of pronghorn into the trap wings. To minimize stress, do not pursue animals longer than 20 minutes. After a group has been driven well within the lead fence to a point where the wings are approximately 50 m apart, personnel move quickly from blinds located just outside the wings to form a containment line. A burlap curtain is often held along the human line to increase its effectiveness at moving pronghorn toward the trap. Personnel advance toward the corral when the pronghorn move in that direction and stop when the pronghorn stop. The line asserts gentle, but constant pressure until the animals enter the corral and the gate is closed. The curtain suspended above the trap walls is then released to form a visual screen which helps calm the animals. Noise is also kept to a minimum.

To reduce stress and injuries, confine no more than 50 pronghorn in the corral at any time. If a larger number is trapped, release the excess. The Department has had excellent success by marking and releasing animals as quickly as possible (Moody pers. comm.). Subjecting animals to the least possible stress is imperative to reduce mortalities from injuries and capture-induced myopathy.

To begin processing, one person draws the sliding canvas curtain across the corral to form the capture pen in front of the trap exit. Handlers enter the capture pen and stand with backs against the curtain. The end of the curtain is drawn open slightly, allowing 2-6 pronghorn into the capture pen area. Handlers quickly restrain the animals and carry them outside. Depending on the purpose of the capture operation, personnel may collect biological data and samples, and attach visible markers or radio transmitters. Animals are then released or loaded for transport to another release site. In most cases 2 handlers should restrain and move each pronghorn. If pronghorn are being transported but not marked, up to 10 handlers can enter the capture pen each cycle to expedite processing and removal.

Trapping is most effective when pronghorn are concentrated, either on winter range (December-March) or near water in late summer (August-October). Trapping and handling should not take place if air temperature is expected to exceed 70° F. Preferably temperatures should not exceed 50° F.

c. Analysis of Data – Refer to Appendix VII for additional details about analysis of data obtained from marking studies.

d. Disposition of Data – As applicable, compile the following information in a report to the Supervisor of Biological Services: date and location of the trapping/marking operation, identification numbers of ear tags, descriptions of neck bands, radio-collar frequencies, sex and age of all pronghorn captured, trapping related mortalities, release locations, and an evaluation of the trapping

operation. Summarize trapping and marking operation and analyze observations of marked pronghorn or tag returns in applicable JCRs.

2. Fawn Capture

   a. Rationale – Fawns are normally caught and marked when managers need specific information about movements between spring and summer ranges or to determine rates and causes of mortality. Handling and marking procedures can, however, affect mortality rates. This should be considered when data obtained from marked fawns are interpreted.

   b. Application – Fawns can be captured by hand when they are very young and relatively insensitive to human disturbance, usually during the last week of May or first week of June. Personnel locate fawns by using a spotting scope to observe does until a fawn is detected nearby. One member of a two-person team acts as a spotter and, using a 2-way radio, directs the other team member to the fawn. When the trapper locates the fawn, he quickly drops a long-handled landing net over it, taking care not to injure the animal. Well-trained dogs, both Labrador Retrievers and German Shepherds, have also been used successfully to locate fawns. After 10 June, fawns are mobile and become difficult to capture by hand.

      Select observation points that afford an unobstructed view for locating fawns. Preferably, conduct operations during mild, dry weather.

   c. Analysis of Data – Refer to Section VI.A.1.c. (Corral Traps).

   d. Disposition of Data – Refer to Section VI.A.1.d. (Corral Traps).

3. Chemical Immobilization

   a. Rationale – Specific animals can be targeted for capture by chemical immobilization, which is the chief advantage of this method (Copeland et al. 1978, O'Gara and Yoakum 1992). However, pronghorn are generally too wary to approach within effective darting range ($\leq$ 50m). Chemical immobilization may be feasible in places where pronghorn are acclimated to humans or vehicles, for example urban settings or golf courses.

   b. Application – Refer to Appendix VIII for detailed information about immobilization techniques. Drugs used to immobilize pronghorn include: succinylcholine (Beale and Smith 1967, Amstrup and Segerstrom 1981), Etorphine (Copeland et. at. 1978, Autenrieth et. al. 1981), and carfentanil (O"Gara 1987). A new opioid anesthetic, A-3080, has been used in trials to immobilize pronghorn at the Sybille Wildlife Research Unit, and was field-tested twice in 2000. In both trials A-3080 was superior to carfentanil with or

without xylezine. A-3080 is not currently available for field use, but should be accepted as the preferred anesthetic to immobilize pronghorn in the future.

Until A-3080 is available, the Department recommends a combination of carfentanil and xylazine to immobilize pronghorn. No other drug combination has been proven as safe or effective. The following dosages and equipment are recommended:

Bucks:	2.5 mg carfentanil plus 50 mg xylazine
Does:	2.0 mg carfentanil plus 40 mg xylazine
Fawns:	1.5 mg carfentanil plus 30 mg xylazine
Antagonists:	100 mg naltrexone per mg carfentanil given plus 0.15 mg yohimbine per kg body weight To avoid renarcotization with Carfentanil, give a double dose of antagonist including one dose intravenous and one intramuscular. After administration of the antagonist, expect up to 30 min. of excitation symptoms (rapid pacing, extended tongue, etc.). Do not use xylazine if antagonists will not be administered
.	
Darts:	13-mm (0.50 cal.) Pneu-darts equipped with 25-mm, barbed needles, having 1 or 2 ml capacity.
Dart Rifles:	Preferably, use adjustable CO2 powered. (Adjustable 0.22-cal. blank-powered can also be used).

c. Analysis of Data – Refer to Section VI.A.1.c. (Corral Traps).

d. Disposition of Data – Refer to Section VI.A.1.d. (Corral Traps):

B. Relocation

1. Rationale – Pronghorn are captured and relocated for several purposes including: reintroduction to vacant habitat, removal of animals causing damage, and acquisition of subjects for research.

2. Application – A full-size pick-up truck is satisfactory to transport pronghorn. A solid box enclosure with a thick canvas cover is mounted on the bed for this purpose. A horse trailer also works well if it is modified by suspending a canvas sub-roof inside to prevent injury caused by pronghorn jumping and hitting the roof. The vehicle used for hauling should be easy to load and unload, well ventilated, dark, and compartmentalized to segregate animals bearing horns. Approximately 3.2 ft^2 of space are required for each pronghorn. A canvas drape should hang inside the tailgate or trailer door while pronghorn are loaded. This helps prevent

pronghorn inside from bolting toward light and escaping when the tailgate or trailer door is opened to load new pronghorn. A rubber mat on the floor of the pickup or trailer, covered with dirt or wood shavings, will reduce the unnatural feel of the metal floor, provide footing, and aid in keeping the animals calm.

Two people should handle each captured pronghorn when it is moved. One controls the head and chest, the other the hindquarters. Struggling is minimized by lifting the pronghorn off the ground in an upright position with the head well above the level of rumen to prevent aspiration or regurgitation of rumen contents.

3. Analysis of Data – Each relocation project should be evaluated and improvements recommended, as necessary.

4. Disposition of Data – Refer to Section VI.A.1.d. (Corral Traps).

C. Transplant Protocol

1. Rationale – Translocation projects have restored pronghorn to many historic ranges in North America. In some cases, pronghorn are removed from the wild for placement in research facilities or in zoos for education and exhibition. Special handling procedures are needed because of the pronghorn's high-strung nature and susceptibility to injury. Adult animals should not be captured for placement in captive facilities. If captive pronghorn are needed for a legitimate purpose, the project proponents should plan on capturing and hand-rearing newborn fawns.

The purpose of these guidelines is to provide wildlife managers assistance with planning translocation projects. The four main focuses are: 1) identification of circumstances when relocation of wild pronghorn is justifiable; 2) determination of suitable donor populations; 3) evaluation of potential release sites; and 4) placement of animals in captivity for research or education purposes. Specific techniques for capturing and relocating pronghorn are discussed Section VI.A and B of this chapter. Additional considerations are discussed in the 1998 Pronghorn Management Guides (Lee et al. 1998).

2. Application – The Wyoming Game and Fish Commission has established a policy, "Terrestrial Wildlife Furnished to Others" (July 21, 1998), specifying procedures and conditions under which game animals may be captured and furnished to other agencies or institutions. Pronghorn translocations should be consistent with this policy.

Pronghorn occupy nearly all areas of suitable habitats in Wyoming. Currently, there is little need to restock or relocate pronghorn within the state, although pronghorn were restored on the Wind River Indian Reservation as recently as 1990. Many interests regard Wyoming as a source for translocations because pronghorn are abundant here compared to other states and provinces. In 2000, newborn pronghorn

fawns were captured near Cheyenne and flown to Mexico for use in research to aid recovery of endangered peninsular pronghorn.

a. General Considerations – Proponents of a translocation should evaluate: 1) the objectives of the project; 2) the likelihood of success; 3) the impact of the project on the donor population; and 4) the possible impact of the project on resources in the release area. Before a translocation operation is proposed, proponents should always consider whether another method could achieve the same objectives. Invariably, some mortality will take place when pronghorn are captured, confined, transported, and released into unfamiliar environments. Reasonable precautions are necessary to minimize injuries and mortalities, and to avoid adverse impacts.

   All translocation projects in Wyoming must be conducted according to the following standards:

   - Pronghorn translocations should be considered only when the objectives of the project are consistent with policies of the Wyoming Game and Fish Commission. Commission policy clearly states ownership of wildlife will not be transferred to private individuals. Chapter 10 of the Commission's regulations authorizes the Department to relocate animals for management purposes. Educational and research institutions can also obtain native big game animals for legitimate purposes.
   - Legitimate justifications include:
     - restoration of free-ranging populations;
     - public educational displays; and
     - research to promote conservation and improve knowledge about pronghorn biology.
   - Pronghorn should not be translocated principally to alleviate depredation. Relocating animals causing damage could become a very undesirable precedent for dealing with situations in which a landowner does not allow hunting. However, in certain cases nuisance animals can be acceptable candidates provided their removal serves a legitimate objective such as population restoration.

   Logistics of the capture and translocation project will depend on several practical considerations including:

   - The ultimate goals of the project (establish a free-ranging population, augment an existing herd, establish a captive herd for research, provide animals to other institutions for educational purposes, etc.)
   - Number of animals to be captured and anticipated mortality rates.
   - Desired sex and age composition of the captured cohort.
   - Genetic considerations – should animals be captured from different areas or populations?

b. Selecting Donor Herds – In Wyoming, removing comparatively small numbers of animals has no effect at the population level. A more important consideration is the suitability of animals from the donor herd to meet the objectives of the project. The following considerations will assist in determining where to capture pronghorn for specific translocation projects:

Suitability of the donor population:

- Suitable habitat: Obtain animals from habitats that are similar to the release area if possible. Animals with a history of crop depredation may not be the most desirable to release in certain areas.
- Genetics: Determine if animals are genetically suitable. Is there potential for introgressive hybridization or other undesired effects?
- Animal Health: Determine whether diseases or parasites in the donor population pose a risk to animals in the release area. What is the potential for introducing new pathogens? Will released animals commingle with existing wild populations? Are animals generally in good physical condition? Will translocated animals be exposed to new pathogens within the release area, which may impact their establishment there? It is essential to thoroughly understand pronghorn biology and management.
- Impact on source population: Assess whether the proportion removed could impact the donor population. Will the removal affect availability of adult males for harvest?
- Availability: Determine whether the number and composition of animals desired for the translocation are available and accessible in the donor area. Will additional translocations be required in the future?

Logistical considerations:

- Type of Capture: The capture technique should be suited to the objectives and purpose of the project. Select a technique that can be efficiently implemented within the capture area.
- Availability: Be sure the desired number and composition of animals are readily accessible in the capture area.
- Access: Assure personnel responsible for capture and transport can get to the area where pronghorn will be caught. Obtain the landowners' permission before conducting operations on private lands.
- Time-of-year: Select an appropriate time of year to assure the greatest success (i.e, not too late in the winter to capture adults, not too late in spring to capture fawns).
- Manpower: Secure an adequate number of experienced personnel for all phases of the translocation project.
- Conditions: Monitor weather to be reasonably sure conditions will not pose problems (e.g., too hot, cold or windy; snow too deep; roads closed).
- Health Considerations: Personnel from the Department's Veterinary Services Branch should supervise the care of animals during capture and

transportation. Determine what health certificates, treatments, or conditions will be required to translocate animals, especially across state lines or international boundaries. Will health inspections or quarantines be required prior to reaching the final destination?

- Transportation and Handling Facilities: Arrange to have suitable transportation equipment available for moving animals to the new location as quickly as possible.
- Adequate follow-up: Prepare a written account of the translocation and follow up with progress reports describing procedures, conditions encountered, adjustments made, and results. These reports provide a valuable record of experience gained from each translocation project.

c. Release Sites – A thorough knowledge of pronghorn ecology is essential to effectively plan translocations (Yoakum 1980). Areas pronghorn did not historically inhabit are not generally good candidates for release locations. Such sites typically lack one or more essential components of pronghorn habitat or may not have a suitable climate.

Each potential release site should meet the following conditions:

- Records or other evidence should indicate pronghorn historically occupied the area selected as a release site. Habitat at the release site should be similar to pronghorn habitat in Wyoming. The form developed by Hoover et al. (1959) is recommended to evaluate suitability of grassland release sites. Yoakum (1980) adapted the form for shrub-steppe ecosystems (Table 2). Managers should complete the relevant form before any transplants take place.
- The transplant should serve some legitimate public purpose. Trapping and translocation operations are labor-intensive and costly. Accordingly, they should be done only for justifiable reasons and when there are public benefits. Possible reactions to the transplant should be considered, particularly among private landowners and public land managers. Release sites on public lands receive priority consideration in areas where people will have the opportunity to hunt and observe pronghorn after they become established. Transplants to private lands where the public does not have access are discouraged.
- Obtain written concurrence from affected surface management agencies and private landowners in the release area.
- The major goal of a translocation should be the establishment of a viable herd. Franklin (1980) considered a population viable if it contained at least 50 breeding adults. Franklin also suggested 500 randomly mating individuals is the minimum population size that sustains sufficient genetic variation for adaptation to changes in the environment. Hoover et al. (1959) recommended translocations should contain at least 50 to 100 animals. As a rule, each animal requires at least 1 square mile of native sagebrush/ grassland habitat.

Table 2. Form used to evaluate potential sites for pronghorn transplants.
[adapted from Hoover et al. (1959) and Yoakum (1980) for sagebrush-grasslands]

1. LOCATION:
   A. County_____ Nearest town _____
   Nearest ranch _____ Accessibility by road _____
   Township _____ Range_____

2. SIZE (number of square miles of estimated habitat): _____

3. TOPOGRAPHY: _____
   A. Physical Barriers:_____
   B. Constructed Barriers:
   Fences (Location) (Construction Specifications)
   _____ _____
   _____ _____
   _____ _____
   Major highways
   _____
   Other
   _____

4. CLIMATE:_____
   A. Elevation_____ Annual Precipitation_____
   B. Mean depth of snow _____

5. WATER:

	Springs	Reservoirs	Lakes	Streams	Wells	Catchments
A. Number	_____	_____			_____	_____
Acres			_____			
Miles				_____		
B. Production:						
Surface Ac.		_____				
Gal./min.	_____			_____		
Gal/storage						_____

   C. Mean distribution of water sources _____
   D. Year-round water?_____

6. VEGETATION:

Major Types	No. Acres	Mean Ht.	Estimated Percent Grass	Forbs	Shrubs
A. _____	_____	_____	_____	_____	_____
B. _____	_____	_____	_____	_____	_____
C. _____	_____	_____	_____	_____	_____

7. LAND OWNERSHIP (number of acres)
   A. Private _____
   B. Public _____
   C. Other _____

8. LAND USE:
   A. Class of livestock_____

B. Stocking rate
_____

C. Grazing system_____

D. Cultivated crops_____

E. Other
_____

9. PREDATION:
   A. Natural - coyotes_____ eagles_____ bobcat_____
   B. Human
   _____

10. TRANSPLANT CONSIDERATIONS:
   A. Is the site historic pronghorn range?_____
   B. Attitude of ranchers
   _____
   Attitude of local Department personnel_____
   Attitude of local sportsmen's clubs_____
   _____
   Attitude of government agencies_____
   C. Is (are) land manager(s) agreeable to management objectives of State Wildlife Agency?
   _____
   D. Suggested number of pronghorn for transplant_____
   E. Route of trucks carrying pronghorn and release point_____
   _____
   F. Has a "habitat management plan" been developed?_____
   _____
   G. Are cooperative agreements completed?
   Private land owners_____
   Public land agencies_____
   H. Other_____
   _____

Most wild pronghorn appear healthy and comparatively free of debilitating diseases and parasites. However, Cowen (1951) observed, "There are in wild game mammals all shades of departure from the state of perfect health." Disease is always a potential factor that may require examination or observation by a qualified person. Therefore we encourage project managers to have a veterinarian present during capture operations. In addition, drugs are occasionally administered to immobilize animals or for euthanasia. Pronghorn can be transported in full-size pick-up trucks. Refer to Section VI.B. (Relocation) regarding suitable transport equipment. Pronghorn should be monitored a minimum of 3 years following the translocation, and results summarized annually in a report submitted to the Wyoming Game and Fish Department. Monitoring is important to document success and maintain accountability.

d. Placement in Captive Facility – Pronghorn are difficult to maintain in captivity. Therefore, projects involving captive pronghorn should be justified with a legitimate need and purpose for confinement. Such projects should be planned well in advance of the study or educational exhibit. Only persons with prior experience should care for captive pronghorn. Some procedures for maintaining pronghorn in captivity are described by Blunt and Myles (1998). The Department adheres to the following standards when providing pronghorn for retention in captivity:
   - Wild-caught adults are not provided for confinement: In general, projects requiring confined pronghorn should be planned sufficiently in advance to capture and hand-raise neonatal fawns. Attempts to confine wild-caught adults have been extremely unsuccessful in the past.
   - Legitimate public purpose: The project should serve a legitimate public purpose (research, education, conservation). The separation of fawns from does can become controversial, so the action should be justified.
   - Ultimate disposition: All animals and progeny will remain in the public domain. Animals will not be provided for private ownership nor may surplus animals be disposed to game farms or other private interests.
   - Transportation: Special provisions should be made to transport fawns as rapidly as possible to the confinement facility. Caretakers should accompany the fawns to the new location. See Blunt and Myles (1998) for additional considerations.
   - Adequate facilities: Facilities must provide adequate space, comfort, and isolation. Avoid direct contact with or contamination from other species.
   - Follow-up: Recipient agencies and institutions should provide the Department regular reports on the status of pronghorn taken from Wyoming.

3. Analysis of Data – Maintain records of the sex, age and condition of each animal captured and released. Also note method of capture, ambient temperature, duration of transport, types of veterinary inspections, and measures taken to reduce morbidity and mortality. Monitor health, survival and animal response following relocation.

4. Disposition of Data – Capture records, release information and an evaluation of the project will be included in a report to the Supervisor of Biological Services. A Summary of the capture, transport and release information is also included in the appropriate JCR.

VII. DEPREDATION – Consult Buhler et al. (1999).

VIII. MODELING – The Wyoming Game & Fish Department uses a population model (POP-II by Fossil Creek Software) to simulate pronghorn population trends. Refer to Appendix IX for additional details about the modeling process. Herd models are periodically aligned with population estimates derived from line-transect surveys, or with population trends derived from aerial trend counts. Table 2 identifies acceptable ranges and values of parameters used to model pronghorn populations in Wyoming.

Table 2. Parameters used to model pronghorn herds in Wyoming.

Parameter	Recommended range of values
Age Classes:	**12-15** – recommend **12** unless older age classes are documented in the population based on data from tooth cross-sections.
Sex Ratio at Birth:	**50:50**
Fecundity:	For does 2 yrs old and older, reported fecundity rates include 153:100 Beale and Smith 1969), 183:100 (Creek 1967), 185:100 (WGFD Pronghorn Working Group 2000). A standard fecundity rate of **180:100** has been adopted for does $\geq$ 2 years of age, for use in POP-II models in Wyoming. The fecundity rate of adult (2+) females and the pre-season mortality rate of fawns are fixed (standardized) values in the POP-II models. Accordingly, the pre-season mortality severity indices are adjusted to simulate the fawn:doe ratios observed prior to the hunting season.
Pre-season Mortality:	Juveniles: **50%**; based on known fecundity rates and pre-season fawn:doe ratios. Yearlings and adults: **2%**. Based on sex ratios of fawns in harvest data (52.57% females, 47.57% males, n=15,104) and November trapping data (55.77% females, 44.3% males, n=1,405) we have concluded pre-season mortality of male fawns is higher than that of females. A differential mortality rate of up to 1.2x the female ratio may be appropriate for male fawns.

Post-season Mortality:	Juveniles: **30-55%**. Yearling and adults: 3-10% for age classes 2-5 with mortality rates increasing in age class 6 up to 100% in the oldest age class used. Higher mortality rates can be used for males in age class 6 and older.
Wounding Loss:	**10%.**
MSI:	A "1.0" represents average pre-season and post-season mortality rates. Modify the pre-season MSI values as needed to align observed fawn:doe ratios each year. Modify the post-season MSI values using the methodology described by Lutz, et. al. (1996), based on winter (WSI) and summer (SSI) weather severity indices derived from data obtained from weather stations in vicinity of herd unit being modeled.

IX. SUPPLEMENTAL FEEDING – Free-ranging pronghorn are not fed in Wyoming. Because pronghorn are widely distributed and mobile, logistically, it would be very difficult to transport supplemental feed to a stressed population. In addition, no known feed has been found effective for preventing significant mortality of pronghorn during severe winter conditions.

To assure healthy populations are carried through winter, the most effective management includes maintaining winter ranges in good condition, removing barriers to pronghorn movements, and keeping pronghorn numbers within the carrying capacity of the habitat.

X. JOB COMPLETION REPORTS – Pronghorn management information is summarized annually in Big Game Job Completion Reports (JCRs). Each region prepares JCRs for the herds within its jurisdictional boundaries. JCRs include results of line-transect surveys, harvest data, classification data, mortality data, disease assessments, winter severity assessments, population models, management evaluations, applicable research reports, seasonal habitat maps, hunting seasons and justifications, and other pertinent information. Copies of JCRs are available at each regional office and the Cheyenne headquarters.

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ATTACHMENT 1

Revised 5-1-03

GUIDELINES FOR ESTABLISHMENT AND OPERATION

OF

WILDLIFE CHECK STATIONS

PURPOSE: To provide Department personnel with guidance on the establishment and operation of wildlife check stations authorized in W. S. §23-3-308.

OBJECTIVE: The objectives of Wildlife Check Stations are to gather biological data on harvested wildlife while assuring and measuring compliance of laws and regulations; to inform the public of Department operations and objectives; and, to create a deterrent to would be violators.

REGULATORY REQUIREMENTS: Check stations shall be signed and established at a point on a highway or public road clearly visible to the motoring public at a distance of not less than two-hundred (200) yards in either direction from the check station. Check stations shall be at a point where flashing warning lights shall be visible to on-coming traffic for a distance of not less than two-hundred (200) yards in either direction from the check station. Except at permanent check stations, the emergency warning lights on a marked Department law enforcement vehicle or a yellow flashing light on a marked Department non-enforcement vehicle shall be in operation. Except at permanent check stations, at least one (1) person working the check station shall be in Department uniform and at least one (1) vehicle at the check station shall be a marked Department vehicle. At permanent check stations that are specified in Commission Regulations, Chapter 2, General Hunting Regulation, all Department persons working the check station shall be in Department uniform.

A. MAJOR CHECK STATIONS

Major check stations are established on major routes of high motor vehicle traffic, including interstate highways and some State highways. The Regional Wildlife Supervisor shall be responsible for determining if a check station established on a State highway shall be treated as a major check station or a routine check station. Major check stations require the pre-approval of the Wildlife Administration before they are established and operated. These check stations require detailed pre-planning by Department personnel responsible for the establishment and operation of the check station. Department personnel shall adhere to the following guidelines:

1. Before any major check station is recommended to the Wildlife Division Administration, the Regional Wildlife Supervisor and assigned Department employees should review the objective of these guidelines to assure that a need exists to warrant the establishment of a check station. Having identified the need, the Regional Wildlife Supervisor shall submit to the Chief Game Warden or his designee a complete and detailed proposal for the operation of the check station and the expected benefits to the Department. Prior to the approval of the plan by the Chief Game Warden's or his designee, the plan will be submitted to the Assistant Attorney General assigned to the Department for review. The Chief Game Warden or his designee shall select the Department person who shall be in charge of the establishment and operation of the check station. Any non-Department personnel, excluding Peace Officers and Department volunteers, to be utilized to conduct the check station shall require a letter of authorization from the individual's appropriate agency administrator.

2. Public and personal safety is paramount and shall not be compromised under any circumstances. Written pre-approval shall be obtained from the Wyoming Department of Transportation (WYDOT) for any check stations to be operated on interstate highways. The Regional Wildlife Supervisor shall be responsible for deeming if pre-approval from the Department of Transportation is necessary for a check station to be operated on a State highway.

3. All Department persons working the check station shall be in Department uniform.

4. As sportsmen arrive at the check station, a Department person assigned the duty shall identify himself/herself and explain the purpose of the check station. Permission shall be requested from the owner/operator of motor vehicles and trailers to conduct motor vehicle and trailer searches. If permission is not granted, officers may search without a warrant if probable cause exists. Searches shall not be conducted in the absence of sufficient probable cause, without prior consent of the owner/operator. During the search, Department personnel may request assistance from the owner/operator of the motor vehicle and trailer.

5. Ground cloths, plastic sheeting, or some type of ground protection shall be used to assure protection for animal carcasses and items, such as meat, fish, etc., that may be removed from motor vehicles and trailers. Consideration shall be given to the weather, terrain, length expected for the inspection, and motor vehicle and human traffic in the area. Safety of the public and Department personnel shall be the highest priority. Department personnel should assist in returning or re-packing possessions following the completion of the inspection.

6. The use of law enforcement search dogs and handlers shall be in accordance with accepted training standards and such operation procedures as established by the agency that furnished the dog(s) and dog handler(s).

7 Overlapping check stations that could potentially occur on the route of travel by the public shall be minimized to avoid duplication and to prevent inconvenience to the public

8. At check stations where multiple personnel are handling multiple motor vehicles, personnel shall remain at their assigned duty area unless requested to assist at another position.

9. At the conclusion of each inspection, the sportsmen should be thanked for their cooperation and contribution to managing the wildlife resource. Department personnel should, if reasonable, take time to answer questions and address concerns.

B. ROUTINE CHECK STATIONS

These check stations are routinely established by Department personnel along exit routes from specific hunting or fishing areas. Personnel should follow the same guidelines established for major check stations, except prior approval from the Chief Game Warden and Regional Wildlife Supervisor is not required.

ATTACHMENT 2

DATA FORM FOR WINTER MORTALITY TRANSECTS

WINTER MORTALITY TRANSECT FORM

Date: _____ General Area: _____ Transect No. _____
Starting Point (Describe) T____ R _____ ¼ _____ ¼ _____ Sec._____ Course of Transect Line: _____
Length of Transect: _____ Habitat Type(s): _____
Exposure: _____ Elevation: _____ Observers: _____
Snow Cover? _____ Yes _____ No If "Yes" _____ %
Live Animals Seen in Area. Number: _____ Species:_____

	Spc.	Sex	Age	Dist. From Base Line (ft.)	Right (R) Left (L)	Dist. From Last Carcass		Spc.	Sex	Age	Dist. From Base Line (ft.)	Right (R) Left (L)	Dist. From Last Carcass
N_1							N_{31}						
N_2							N_{32}						
N_3							N_{33}						
N_4							N_{34}						
N_5							N_{35}						
N_6							N_{36}						
N_7							N_{37}						
N_8							N_{38}						
N_9							N_{39}						
N_{10}							N_{40}						
N_{11}							N_{41}						
N_{12}							N_{42}						
N_{13}							N_{43}						
N_{14}							N_{44}						
N_{15}							N_{45}						
N_{16}							N_{46}						
N_{17}							N_{47}						
N_{18}							N_{48}						
N_{19}							N_{49}						
N_{20}							N_{50}						
N_{21}							N_{51}						
N_{22}							N_{52}						
N_{23}							N_{53}						
N_{24}							N_{54}						
N_{25}							N_{55}						
N_{26}							N_{56}						
N_{27}							N_{57}						
N_{28}							N_{58}						
N_{29}							N_{59}						
N_{30}							N_{60}						

ATTACHMENT 3

PRONGHORN

TRAP

INSTRUCTIONS

Begin by unloading pipes and joints and arrange them in a circle (picture #1). The main gate should be located where the trailer is in this picture. The joints are numbered 1-8 with numbers welded on each bottom joint (picture #2). Joints painted brown go at point #1 and at the hinge for the front gate. Brown pipes are the uprights and black pipes are the laterals.

Spray joints with WD-40 before assembly (picture #3). Pipes should fit into each joint up to the welded bead (picture #4). Do not beat pipes and joints with steel hammers; use soft mallets. Build the two sides flat on the ground rather than in position (picture #5).

3

4

With one person at each joint, raise one side at a time (picture #6). Align so that the front gate is directly centered across from the main gate. Place the main gate first, the front gate second, and the two wing gates last. Hang the net from the top pipes first, then with people standing on the netting to stretch it, attach the nets to the bottom pipes. You may have to use a pry bar to raise the bottom pipes enough to slide the snap hooks through (picture #7).

Stake the trap down once the netting is all in place (picture #8). Pin wing panels to the wing gate and then to each other (picture #9). When laying out the wing panel, be sure they are all facing the same direction otherwise you will have to move them again.

8

Stake and pin wing panel supports as you go (picture #10). **Safety Point: Do not put up or take down the wing panels without supports in place or it may fall over and hurt someone.** The main gate is pinned to a support bar, which is then pinned to the first two wing panels (Picture #11).

10

11

Side curtains are hung by snap hooks, rolled up, and pinned (pictures #12 and #13).

13

The inside curtain is attached to a cable running from the front gate to joint #1 and staked outside the trap (picture #14). The cable is held by a come-a-long.

TOOLS/SUPPLIES TO BE KEPT WITH ANTELOPE TRAP

	ITEM	**USE**	**QUANTITY**
1.	WD-40	LUBE FITTINGS	2 CANS
2.	HAMMERS, MALLETS	FITTING PIPES	3 EACH
3.	SLEDGE HAMMERS	STAKES	2 EACH
4.	COME-ALONGS	INSIDE CURTAIN	2 (1 SPARE)
5.	LADDERS	NETTTING, CURTAINS	3 EACH
6.	END WRENCHES	CLAMPS, BOLTS	1 SET
7.	PRY BARS	NETTING	2 EACH
8.	PARACHUTE CORD	REPAIRS	1 SPOOL
9.	POST PULLER	WING FENCE	1 EACH
10.	HANDYMAN JACK W/CHAIN	PULLING STAKES	1 EACH
11.	SOFT WIRE	REPAIRS	1 SPOOL
12.	FENCING PLIERS	WING FENCES	2 PAIR
13.	HYDRAULIC JACK	CHANGE TRAILER TIRES	1 EACH
14.	4 WAY WRENCH	CHANGE TRAILER TIRES	1 EACH

ALL OF THE ABOVE ITEMS WILL BE SUPPLIED WITH TRAP AND TRAILER FROM THE CASPER REGION INVENTORY. ALL ITEMS WILL REMAIN WITH TRAP AND TRAILER OR WILL BE REPLACED WHEN RETURNED TO CASPER AT THE EXPENSE OF DISTRICT USING TRAP.

Chapter 2

Mule Deer (*Odocoileus hemionus*)

Dan Thiele

I. INTRODUCTION – The Rocky Mountain mule deer (*Odocoileus hemionus hemionus*) occupies nearly all habitats throughout Wyoming, including sagebrush, grasslands, riparian corridors, mountain shrublands and forests, subalpine forests, croplands, and urban interface.

A. History in Wyoming – Historical accounts suggest mule deer were not abundant during the 19th century (Julander and Low 1976, Connolly 1981). The population increased after the turn of the century, reaching its maximum densities in the 1950's and early 1960's. The population declined in the late 1960's and has fluctuated since. In more recent years, comparatively higher abundance was documented in the early 1980's and 1990's. However, the population apices are believed to be lower with each subsequent cycle. Possible factors include declining habitat quality and quantity, competition with elk, drought, and predation.

B. Current Status – Mule deer are segregated into 39 herd units in Wyoming, each consisting of one or more hunt areas. A herd unit represents a distinct population of deer that interchanges minimally with adjacent populations. Each herd is managed to maintain numbers within 10% of a postseason population objective. The objective represents a compromise between the biological carrying capacity and competing social desires. The statewide population objective is about 565,000 mule deer. In 2003, the estimated population was 487,000 deer or 14% below this objective (Schilowsky 2004).

C. Natural History Information –

1. Range of Productivity – Statewide, the average productivity has ranged from 55 fawns:100 does (1993 data) to 82 fawns:100 does (1987 data) based on postseason classifications (Ayres 1999). Productivity generally declined from 1978-98, but has varied substantially amoung herd units. Productivity of individual herds ranged from just 47 fawns:100 does in the Chain Lakes Herd Unit (1987-98 data) to 84 fawns:100 does in the Lance Creek Herd Unit (1987-98 data).

   From research in Utah, Colorado, California, Washington, and Arizona, managers have estimated 86 percent of does more than one year of age become pregnant. The average fetal rate is 1.50 fawns per doe, based on examination of reproductive tracts (Robinette 1956). The potential increase from the post-winter population to late summer (prior to hunting season) is 50 percent annually. However, under favorable habitat conditions an increase of 20–30% is more realistic (Zwank 1976).

2. Range of Natural Mortality – Natural mortality rates used to model deer populations in Wyoming are:
   – fawns (age class 1): pre-season, 30-50%; post-season, 30-55%;
   – yearlings (age class 2) and prime adults (age class 3 - 5): pre-season, 2-5%; post-season, 5-10%.

   Mortality rates increase incrementally after age class 5, based on a step-up process. In these older age classes, differentially higher mortality rages are applied to males than to females. Models should support 12-15 age classes.

   Unsworth, et. al. (1999) examined survival rates of mule deer radio-collared in Colorado, Idaho, and Montana. Overwinter fawn survival rates did not differ among states, but varied between years. The mean overwinter survival rate for fawns was 44% (56% mortality). The mean annual survival rate for adult females was 85% (15% mortality). Assuming survival of radio-collared deer is a valid approximation of natural survival rates, researchers predicted a December fawn:doe ratio of 66:100 is needed to maintain population levels**.** However, Mackie (1976) documented population increases associated with ratios of 55-66 fawns per 100 does and declines with ratios below 40 fawns per 100 does.

II. CENSUS – Accurate, cost-effective techniques are not available to census mule deer at the herd unit level. Techniques such as pellet group transects may be useful for small areas, but are impractical for estimating populations.

A computer-based model (POP-II) has been used to estimate mule deer populations in Wyoming since the early 1980's. The following field data are required to model populations: post-season age and sex classifications, harvest composition from field checks, mortality estimates, and total harvest estimates. Information from field studies and the literature are also used to establish model parameters for number of age classes in the population, harvest effort values, mortality estimators, wounding loss, and sex ratio at birth.

A. Preseason Herd Classification – This type of survey is not done in Wyoming. Herd classifications should not be attempted prior to the hunting season because mule deer are dispersed and difficult to observe in early fall.

B. Postseason Herd Classification –

1. Rationale – Herd classification ratios approximate the proportions of fawns, does, and bucks in the population . Age and sex ratios can be determined more accurately from postseason classifications because all segments of the population become more visible at that time of year. Bucks accompany does and fawns during the breeding season, and deer are beginning to concentrate on winter ranges. The data are used to analyze population dynamics. Annual fawn:doe ratios from successive years can indicate trends in reproductive success and survival of fawns to early

winter. They can also be compared against historic data to document population-level effects of habitat succession and land use changes. However, these data sets are used primarily to align population model simulations.

Classifications in inaccessible areas are conducted from helicopters. Elsewhere, they are done by ground surveys conducted from vehicles.

2. Application – The optimum time to conduct postseason classifications is 10 November through 10 January. In areas lacking distinct migrations to traditional winter ranges, classifications can be begin on 1 November. In areas with distinct winter ranges, classifications are most effectively accomplished when deer concentrate on winter ranges. Classifications within any herd unit should be completed within a two-week period.

   Design classification surveys to achieve a classification sample that is representative of the population being surveyed. The Job Completion Report (JCR) program is used to calculate an adequate sample size based upon the postseason population estimate and the anticipated buck:doe and fawn:doe ratios. Sample sizes are based on an 80% confidence interval (C.I.) of $\pm$ 5 animals per 100 does. Refer to Appendix XII (Classification Sample Sizes) for a detailed discussion of adequate sample sizes. Survey routes should cover all occupied deer habitats throughout the herd unit. The number of deer classified in any given area should be somewhat proportional to number of deer thought to be in the area.

   Fawns are distinguished from adults based upon the short rostrum, fuzzy head characteristics, and smaller body size. Yearling bucks typically have unbranched spikes or small antlers with a single fork. Buck:doe ratios derived from post-season classifications are somewhat conservative. Even though bucks associate with does and fawns during this period, many bucks tend to select denser cover, subordinate bucks may be displaced from territories occupied by dominant bucks, and some bucks wander as individuals. In addition, yearling bucks can be misclassified as does because their small antlers are more difficult to see.

   a. Aerial Surveys – Helicopters are used to conduct aerial classifications of deer. Survey operations must follow protocol outlined in the Aircraft Operation Procedures and Safety Policy of the Wyoming Game and Fish Department (WGFD) Policy Manual (WGFD 1999).

      Fly aerial classifications during favorable weather and good light conditions. Snow cover is preferred, but not essential. Surveys can be flown any time of day, because the helicopter will disturb and move bedded deer so they can be seen. Use a Global Positioning System (GPS) to record locations of all deer encountered. Identify and classify adult bucks, yearling bucks, does and fawns. Deer should be observed from distances that enable the observer to distinguish fawns and yearling bucks from adult does. It can be helpful to view animals in

profile, by maneuvering the helicopter as necessary . A second observer can assist with identifying yearling bucks and other deer standing away from the main group. Record classificatons by hand or with a tape recorder.

Fly surveys along creeks, draws, and other occupied habitats. Accurately record the type of helicopter used and the number of hours flown, including ferry time and fuel truck mileage. Coordinate surveys with adjacent biologists to limit ferry time since helicopter rental costs are high.

b. Ground Surveys – Deer are most often classified from the ground. Observations are made from a vehicle driven methodically through areas where deer concentrate. Conduct classifications during the early morning and late afternoon hours. In cold weather, deer often feed earlier in the afternoon, and this provides more time to classify. Select days with good light conditions. Use binoculars and a spotting scope to classify deer as adult bucks, yearling bucks, does, or fawns. .Record observations only when age and sex are positively identified. Also use a GPS receiver to determine locations of all deer encountered. Record classification data by hand or with a tape recorder. A siren or deer or predator call can be used to raise bedded deer or make feeding deer lift their heads.

   Travel slowly and deliberately along routes to obtain an adequate sample. If routes have not been established, plan classifications in a sequence that avoids duplication. If an area is classified a second time, only one set of data can be retained. Never combine the results of both classifications.

   When deer cannot be classified accurately due to exessive distances or poor light conditions, record the group sizes and specify "unclassified." It is important to identify all animals in the group to assure the classification is accurate

3. Analysis of Data – Data from post-season herd classifications are used to estimate herd composition including total bucks, yearling bucks, and fawns per 100 does. Herd ratios are useful to evaluate herd productivity, fawn survival to early winter, and fawn recruitment to the second year, as well as postseason buck ratios. Herd ratios are considered accurate when an adequate sample of classification data is obtained based on a statistically valid sampling plan. However, yearling bucks may be underrepresented because their smaller antlers can be difficult to detect.

4. Disposition of Data – Refer to Chapter 1, Section II.A.1.d (Pronghorn – Aerial Classifications).

C. Spring Herd Classification –

1. Rationale – The objective of classificatons done in March and April is to estimate overwinter survival of fawns. However, correctly classifying larger fawns can be difficult at this time of year.

   Spring classifications are done in some regions of Wyoming. However, post-season classifications are considered sufficient for management in areas where fawn survival through winter is not extremely variable.

2. Application – Spring classifications utilize the same procedures as post-season, ground classifications, except the sex of adults is not identified because bucks have shed their antlers.

   Spring classifications are done between 1 March and 30 April, before deer leave the winter range but after most winter mortality has occurred. Surveys are conducted the first three hours after daylight and the last two hours before dark, and are completed within a two-week period.

   To apply this technique, managers must assume: 1) the samples are randomly distributed throughout the known, occupied habitat; 2) biases associated with the post-season (pre-winter) and post-winter classifications are the same (ideally, the composition ratios are considered unbiased estimates of the true herd composition); 3) Overwinter mortality of adults is minimal; 4) fawns can be accurately classified in the spring; and 5) the probability of observing bucks is the same during both sampling periods (composition data are expressed as fawns:100 adults, including bucks and does).

3. Analysis of Data – Overwinter mortality of fawns can be estimated based on the difference between fawn/adult ratios observed during post-season and spring classifications. However, bucks may be more visible on winter ranges and fawns can be misclassified as adults during spring classifications. These biases would tend to depress the spring ratio of fawns:adults, resulting in an inflated estimate of overwinter fawn mortality. On the other hand, if adult mortality is significant, the spring ratio of fawns:adults would underrepresent fawn mortality, producing the opposite effect to some degree. These potential biases should be taken into account when spring classificaiton data are analyzed. Managers must also recognize deer distribution does change following the rut

4. Disposition of Data – Refer to Chapter 1, Section II.A.1.d (Pronghorn – Aerial Classifications).

III. HARVEST DATA – Harvest data are obtained from hunter field checks, game check stations, and an annual harvest survey conducted by mail each year.

A. Harvest Survey – The harvest survey is done annually by a consultant, under contract with the WGFD. Harvests of each sex and age (adult/juvenile) class are estimated for each license type, hunt area and herd unit. Licenses sold, number of active hunters, hunter success, and harvest effort values are also reported.

Refer to Chapter 1, Section III.A. (Pronghorn – Harvest Survey) and Appendix III (Harvest Survey) for detailed discussions of the harvest survey.

B. Age Determination –

1. Field Aging Techniques –

a. Rationale – The age structure of the harvest, especially the female segment, can indicate the age structure of the population when sample sizes are adequate. However, data obtained from harvested animals should be interpreted cautiously. Hunters tend to select larger bucks, but mature bucks are more difficult to locate and harvest. The degree to which this selectivity may bias the harvest sample is uncertain. Nontheless, the proportions of yearling and adult bucks in the harvest can provide important insights regarding year class recruitment. Age structures derived from harvested deer and from documented, nonhunting mortalities are commonly used to align deer population models.

b. Application – Field techniques for aging mule deer are described in the Wildlife Forensic Field Manual (Adrian 1992). Dentition patterns based on deciduous and permenent incisors and moliform teeth are used to distinguish fawns, yearlings (1.3 years), and adults 2.3 years or older. Deer older than 2.3 years can be aged based on tooth wear patterns, however the technique is not as accurate.

Fawns have a fully erupted set of deciduous teeth and a partially erupted fourth molariform tooth. The deciduous third molariform is 3-cusped and all teeth are new looking with little wear or staining. At 1.3 years of age, yearling deer typically have two or more pairs of permanent incisors and the deciduous, third molariform (3 cusps) is retained, but shows some wear. The permanent, fourth and fifth molariform teeth are in place, and the anterior cusp of the sixth molariform tooth may be erupting. Adult deer at 2.3 years of age have a full set of teeth with little wear or staining. The permanent third molariform tooth is 2-cusped with no wear or staining. At 3.3 years of age, all permanent teeth are in place with some staining and visible wear.

When specific ages of older deer are required, aging should be based on laboratory analysis of cementum annuli. Refer to Appendix V (Aging Techniques) and Section III.B.2 of this chapter.

c. Analysis of Data – Refer to Chapter 1, Section III.B.1.c (Pronghorn – Tooth Replacement).

d. Disposition of Data – Forward summaries of hunter field checks, including age information, to the Wildlife Management Coordinator (WMC) after the hunting season. The WMC's is responsible for distributing harvest data summaries to appropriate field personnel. These data should also be summarized annually in the applicable Job Completion Reports (JCRs).

2. Tooth Cross-sectioning

a. Rationale – Tooth Cross-sectioning (the cementum annuli technique) is the most accurate method of aging harvested animals. When an adequate sample can be obtained, the age structure of harvested adult females (>1.3 year old) is commonly assumed to represent the structure and number of age classes within the adult female segment of the population. However, hunters select older males with larger antlers, so managers generally presume the age structure of harvested adult males is biased. Tooth cross-sectioning is an expensive, laboratory technique that should only be used when the composition of ages greater than 2 years must be accurately determined for management purposes.

b. Application – Prior to the hunting season, Biological Services will coordinate with the regions to determine the number of teeth that will be processed, and then notify the laboratory. Field supplies needed for tooth collection include big game field check forms, knife, pliers, and tooth envelopes. To extract teeth, first split the gum deeply on both sides of the central pair of incisors. Use the pliers to twist, pry, and pull these teeth until they are loosened and can be removed with roots intact. Record the follwing information on a tooth envelope: species, sex, hunt area, date of harvest, collector's name, and WGFD Region of harvest. Do not collect teeth from fawns or yearlings, because these age classes can be reliably determined in the field. Use hunter field check forms to record information from fawns and yearlings.

Another method for obtaining large samples of teeth is to issue hunters tooth envelopes and instructions at the time licenses for specific hunt areas are mailed or issued over the counter. Hunters extract the teeth and return them in postage-prepaid boxes.

For a more thorough discussion of this technique, refer to Appendix V (Aging Techniques).

c. Analysis of Data – Refer to Chapter 1, Section III.B.1.c (Pronghorn – Tooth Replacement).

d. Disposition of Data – Refer to Section III.B.1.d. (Field Aging Techniques) of this Chapter.

C. Field Checks and Check Stations – Sex and age data be collected from harvested animals during hunter contacts in the field, and at check stations, game processing plants, hunter camps, and motels. Hunter contacts also enable biologists to get the hunters perspective on game populations, herd quality, access, and other issues. For a detailed discussion of field checks and check stations refer to Chapter 1, Section III.C. (Pronghorn – Field Checks and Check Stations). The Department's Guidelines for Establishment and Operation of Wildlife Check Stations are provided in Chapter 1, Attachment 2.

IV. MORTALITY ESTIMATION (non-hunting) – Significant mortality events should be taken into account when population models are updated and when hunting seasons are set. Localized mortiality events should also be documented to identify and correct human-created problems. Major sources of non-hunting mortality can include highway and railroad accidents, fence entanglements, starvation, disease, and predation. Other causes include illegal take and take authorized by kill permits. Significant die-offs can also result from severe winters, drought, or the combined effects of both. The following methods are used to document non-hunting mortality and to estimate the extent of mortality following weather extremes.

A. Incidental Observations – Refer to Chapter 1, Section IV.A. (Pronghorn – Incidental Observations).

B. Body Condition Evaluation –

1. Rationale – The ability of deer to survive winter conditions is determined in part by their physiological condition entering the winter period. Managers can assess the potential level of winter mortality by evaluating a body condition index in conjunction with winter severity indices. Body condition is also an indication of the general quality of spring/summer/fall habitats.

2. Application – The body condition index is a composite score based upon musculature and fat deposition in a sample of harvested animals (Lutz et al. 1997). Body condition scores are obtained from harvested animals examined during field checks, at check stations, or at locker plants.

Body condition scores are calculated in 5-point increments, ranging from 0 to 20. The portion of the score based on musculature is 5 points if the body has a full appearance and good overall mass, or 0 points if the body appears boney. Fat deposition patterns comprise up to 15 additional points. In deer, fat depostion takes

place along the back beginning in the posterior region and progressiong to the anterior region. Body fat measurements are taken at three points along the spine: 1) base of tail; 2) anterior to the hind quarters, and 3) above the shoulder (immediately posterior from the point of the shoulder). A knife blade is inserted through the hide, into the tissue at the base of tail. If fat is present, the blade is inserted at the second point, then at the foremost point. Scores are assigned as follow: 0 if no fat is present; 5 if fat is present at the first point only; 10 if fat is present at the first and second points; and 15 if fat is present at all 3 points.

The body condition score is the sum of the musculature score and the fat deposit score. The score is interpreted in the following manner: 0 or 5 points = poor condition; 10 points = fair condition; 15 points = good condition; and 20 points = excellent condition. Record the body condition score and the following additional information on field check forms: hunt area, sex, and age class. The following numerical codes can be used to indicate sex and age clas: 1 = yearling doe; 2 = yearling buck; 3 = adult doe; and 4 = adult buck. Fawns need not be checked. When determinable, note lactation by adult does as this will influence fat deposition and thus fat scores.

It's worthwhile for inexperienced personnel to visit a game processing plant and view skinned carcasses to observe how deer deposit fat. Connective tissue also has a white appearance that can be incorrectly identified as fat.

3. Analysis of Data – Calculate average condition scores of each sex and age class (yearling/adult) within each hunt area and herd unit. This information can be analyzed in conjunction with winter severity indices and habitat conditions, to estimate winter mortality rates. Lower body condition scores predispose animals to winter mortality, even in mild winters.

4. Disposition of Data – Body condition data are forwareded to the responsible biologist, and evaluated in the annual JCR for the applicable herd units. The data can be used to estimate postseason mortality severity indices (MSIs) for use in population models. However, post-season MSIs may also be adjusted to align other data points, such as ratios of yearling bucks to does, which reflect composit mortality for the herd. The body condition and weather severity indices become corroborating data in these cases.

C. Winter Mortality Transects – Mortality surveys have been used to estimate winter mortality in the Baggs area (Reeve and Lindzey 1991) and the Wyoming Range (Fralick 1995). Mortality transects are suitable for winter ranges with high deer densities when high mortality is suspected. Refer to Chapter 1, Section IV.B. (Pronghorn – Mortality Transects).

D. Weather Severity Indices – Weather severity indices, based on temperature and precipitation data, are used to evaluate climatic effects on deer populations. Weather

Severity Indicies provide a means to estimate mortality severity indices used in population models. Refer to Chapter 1, Section IV.C. (Pronghorn – Weather Severity Indices).

E. Diseases and Parasites – Mule deer in Wyoming are susceptible to several endemic diseases described by Thorne et al. (1982).

1. Potential Diseases – Two similar diseases, bluetongue and epizootic hemorrhagic disease (EHD), commonly afflict mule deer. The viral agents responsible for these diseases are carried by biting gnats called no-see-ums. Outbreaks occur when gnat populations are highest in late summer and early fall, and end with the onset of freezing temperatures.

   Chronic Wasting Disease (CWD) has been documented in free-ranging mule deer and white-tailed deer in the Bighorn Basin and the eastern half of Wyoming. In some hunt areas, over 25% of the deer are infected. The disease has also been documented among elk herds in southeast Wyoming. CWD is present in free-ranging and/or captive deer and elk populations in most bordering states, including Montana, South Dakota, Nebraska, Colorado and Utah. The disease slowly atrophies the brain stem of infected animals, producing the following symptoms: excessive salivation, lethargy, emaciation, and eventual death.

2. Management/Public Safety – When disease outbreaks are detected, regardless whether one or many animals are involved, it is important to document the event including location, number of mortalities, cause, and other relevant circumstances. Obtaining an accurate diagnosis of the cause usually requires submission of the entire animal or samples to the Wyoming State Veterinary Lab. When significant mortality is documented, managers may consider adjusting the herd population estimate and subsequent hunting seasons.

   The Department routinely advises hunters to avoid harvesting an animal that is behaving abnormally, because this could indicate the animal is sick. Humans are not succeptible to bluetongue or EHD, and outbreaks generally end before the firearm hunting season begins. No cases of CWD being transmitted to a human have been documented. As a precaution, hunters are advised to wear gloves while field dressing animals within CWD-endemic areas, and to avoid handling the brain or spinal cord.

   The Department's Chronic Wasting Disease Plan provides a flexible and adaptive framework for managing the disease in Wyoming. Distribution and prevalence of the disease are monitored through targeted surveillance of animals exhibiting symptoms, and by testing samples collected from harvested animals at check stations, locker plants, and during field checks throughout the state. In areas of high CWD prevalence, managers should take disease-related mortality into account when estimating populations and recommending hunting season frameworks. Field

personnel should familiarize themselves with Commission regulations governing carcass transport from the endemic area to control the potential spread of the disease.

3. Identification – It is possible to diagnose several diseases in the field, based on visible symptoms and knowledge of the disease history of the area. However, to support a definitive diagnosis, animals displaying symptoms must be necropsied and the vector isolated at the Wyoming State Veterinary Laboratory.

4. Collecting and Handling – Specimens submitted for necropsy should be in good condition. Suitable specimens include animals that recently died and have not begun to decompose, or symptomatic animlas that were collected by euthanasia. Ideally, the entire animal should be sent to the State Veterinary Lab. If it is not feasible to transport the whole carcass, preserve samples of the major organs and blood, and ship them by overnight delivery service to the lab. Shipping procedures are described in the Wildlife Forensic Field Manual (Adrian 1992). CWD testing requires collection of the retropharyngeal lymph node. The location where the animal was killed and information about the animal's condition must also be recorded. Instruction on CWD sampling is provided at annual training sessions held prior to hunting seasons.

V. DISTRIBUTION AND MOVEMENT –

A. Incidental Observations –

1. Rationale – The Department has delineated boundaries of mule deer populations generally throughout Wyoming. Acknowledged populations are managed as "herd units." Important seasonal habitats such as migration routes, parturition areas, and crucial winter ranges have also been identified within most herd units. Seasonal habitat delineations are continually refined and updated as additional distribution data are collected. In some cases, herd unit boundaries have been adjusted based on new information. Distribution data can provide essential documentation to support management recommendations and comments regarding impacts of proposed development or land use activities.

2. Application – The distribution data of greatest use to managers are mule deer observations during severe winters, migration periods, and fawning seasons, and observations within areas of proposed subdivisions and energy developments. Always use Wildlife Observation Forms to record mule deer observations (refer to Appendix I). If detailed location data are needed to document migration routes, seasonal habitat use, or potential herd interchange, studies involving radio-collared or marked animals may be justifiable. Seasonal range definitions and guidelines for mapping deer distribution are provided in Appendix VI (Wildlife Distribution and Seasonal Habitat Mapping).

Submit Wildlife Observation Forms containing deer observations to the responsible biologist. After proofing, these forms are forwarded to the applicable regional office for entry into the Wildlife Observation System database. Biologists can sort applicable observations from this database to develop and update seasonal distribution maps.

3. Analysis of Data – Refer to Chapter 1, Section V.B.3. (Pronghorn – Aerial Surveys).

4. Disposition of Data – Refer to Chapter 1, Section V.C.4. (Pronghorn – Incidental Observations).

B. Aerial Surveys –

1. Rationale – Aerial surveys can be an effective method of documenting the distribution of deer over large or remote areas. However the effectiveness of aerial surveys depends on type of aircraft, terrain, and time of year.

2. Application – Helicopters are the most effective aircraft for conducting surveys to document distribution of mule deer. However, the cost is prohibitive except when the distribution surveys are done in conjunction with post-season herd classifications on winter ranges. Fixed-wing aircraft are less expensive, but also effective because observers' abilities to detect deer are reduced. This is due to the greater height above ground level and faster airspeeds at which they must fly. Distribution surveys are more effective if conducted during adequate snow cover or with contrasting green vegetation during the spring green-up period. Plan flight patterns to adequately cover the areas or habitat types in which distribution data are sought. Use a GPS to determine deer locations. Record the locations with a tape recorder or note pad. Typically, it is sufficient to record the total numbers of deer observed in each location. Classifications are not necessary to map distribution, and are not considered reliable if attempted from a fixed-wing aircraft.

3. Analysis of Data – Refer to Chapter 1, Section V.B.3. (Pronghorn – Aerial Surveys).

4. Disposition of Data – Refer to Chapter 1, Section V.B. 4. (Pronghorn – Aerial Surveys).

C. Marked Animals – Refer to Chapter 1, Section V.A. (Pronghorn – Marked Animals).

D. Pellet Group Transects –

1. Rationale – The relative use of specific locations or habitats by mule deer can be estimated based on pellet group transects. The technique has limited application in Wyoming. However, pellet group counts have been employed to evaluate crop

depredation within agricultural regions and, in conjunction with habitat surveys, to estimate seasonal use of winter ranges. The technique is most useful within discrete areas such as crucial winter ranges, or locations where depredation is being investigated.

2. Application – Pellet group transects consist of ten or more 0.01-acre, circular plots (11 ft, 9 in radius) established at 66-foot centers along a straight line. Materials necessary to set up pots include a chain or rope, 11 ft, 9 in long, metal stakes 12 to 16 inches long for plot centers, and a compass. Place the circular plot stakes along a straight line following a compass reading from the starting point. Establish 1 transect per vegetation type.

   Identify and count all pellet groups less than 1 year old within each plot. Plots are delineated by walking the 11 ft, 9 in chain once around each center stake. Mark the start and end points with an object such as a rock, stick, hat, or notebook. Count pellet groups bisected by the plot boundary when more than one-half the group is inside the plot. Count every other group that is evenly bisected (alternatively, count each group as one-half group). If pellets were not cleared from the plot after they were counted the prior year, determine the age of pellet groups to be counted based on fresh versus weathered appearance and herbaceous plant growth around the group. If plots are to be read again, clear all pellet groups or spray them with yellow highway paint. Tally the pellet groups counted in all sample plots and extrapolate the total to estimate the number of pellet groups per acre. The expansion factor is generally 10 (the total area sampled is 0.1 acre). To estimate deer use (expressed as "deer-days" per acre), divide the number of pellet groups per acre by 13, the average, daily defecation rate per deer (Neff 1968).

3. Analysis of Data – Changes in use can be detected by contrasting results from pellet transects among years. However, apparent changes may not be related to a change in population size. Duration of use can also vary among years.

4. Disposition of Data – Results of pellet group surveys should be summarized and discussed in the appropriate annual JCR. There is no standard form for reporting these data.

VI. SEASONAL RANGE CLASSIFICATIONS – Refer to Appendix VI (Wildlife Distributioin and Seasonal Habitat Mapping) for a detailed discussion of seasonal range mapping.

A. Rationale – To support sound management decisions, it is extremely important to identify key seasonal habitats including crucial winter ranges, parturition habitats, and migration cooridors. Seasonal habitats are classified and mapped according to definitions developed by the Wyoming Chapter of the Wildlife Society (1990). The maps are kept on file to assist with planning habitat projects and to provide

documentation for commenting on proposed developments and land management actions.

B. Application – Seasonal ranges are identified based upon relevant distribution data obtained from field observations. The data are sorted depending upon the criteria used to define a specific type of seasonal range (e.g., time of year; prevailing weather conditions), and retrieved from the Department's Wildlife Observation System database. Seasonal habitats are mapped using Geographic Information System (GIS) technology, or they are hand-plotted on overlays fitting BLM 1:100,000 scale base maps.

C. Analysis of Data – Overlays of seasonal habitats are essential documentation for analysing the impacts of developments and land management decisions. In addition, this information is often requested by consultants, companies, and other federal, state, and local agencies.

D. Disposition of Data – Each regional biologist keeps copies of seasonal range overlays covering the herd units in his district. The Department's Biological Services Section also maintains a statewide set of overlays at the Cheyenne headquarters office.

VII. TRAPPING, MARKING AND TRANSPLANTING

A. Trapping Adults –

1. Rationale – The most common reasons for trapping mule deer are to conduct studies in which animals must be marked to document distribution and movement, habitat selection, or mortality. In very rare circumstances, mule deer may be captured for transplanting to vacant habitats, however this is seldom justified.

2. Application –

   a. Aerial Net-gunning – Net-gunning from a helicopter has become the preferred method to capture mule deer in recent years (Barrett et al. 1982, van Reenen 1982). Net-gunning is an efficient, cost effective, and highly mobile means of capture. The Department contracts private companies that specialize in use of net-gun equipment to capture big game. The net-gun is either hand-held or mounted on helicopter skids. "Muggers" restrain captured animals as they are processed and marked.

   b. Clover Trap – The Clover trap (Clover 1956) is also commonly used to capture mule deer. Deer are lured with bait, into the trap. Alfalfa from second cuttings has been used successfully for this purpose. Two men can normally handle deer inside a Clover trap. A modification to the trap (Rickens 1967) enables one man to handle the trapping, but this is not recommended. The trapping period is normally from mid December to March. Trapping operations are most

successful during periods of snow cover. A modified "Clover Trap" constructed of metal pipe and nylon mesh panels is commercially available.

c. Helicopter/Drive Net – Both mule deer and pronghorn have been captured in Wyoming by using a helicopter to drive them into nets (Easterly et al. 1991). Beasom (1980) describes this technique in detail.

d. Box Trap – The "Stephenson" box trap (Day, et al. 1980) and variations are also effective for trapping deer. Box traps designed to trap deer are constructed of wood or metal with the following dimensions: 1.2 m high, 1.2 m wide, and 3.7 m long. The trap is set with both ends open, so deer can see through it. Bait is used to lure deer inside. Gates at each end are released simultaneously by a tripping device.

e. Cannon-net Trap – Cannon nets have been used to trap white-tailed deer (Hawkins et al. 1968) and can be adapted for trapping mule deer.

f. Drop-net Trap – The drop-net trap has been used successfully in Wyoming to capture bighorn sheep and white-tailed deer. The method should also work well for capturing mule deer. Trapping should be done during periods of total snow cover, between 1 December and 15 February, when deer respond well to bait. However, trapping may be accomplished with lesser degrees of success when conditions are not ideal.

3. Analysis of Data – Refer to Chapter 1, Section VI.A.1.c. (Pronghorn -- Corral Traps).

4. Disposition of Data – Refer to Chapter 1, Section VI.A.1.d. (Pronghorn -- Corral Traps).

B. Trapping Juveniles –

1. Rationale – Juveniles are sometimes trapped and marked for specific research purposes such as documenting mortality. However, mortality data from such studies should be interpreted cautiously, because capture, handling and marking can increase stress and susceptibility to predation. Some researchers have attempted to control potential biases, for example, by not including marked animals in the sample unless they survive for a period of time after the initial capture operation. Nevertheless, the presence of a radio transmitter or other visible marker undoubtedly has some influence that should be considered. A potential control is to compare the proportion of marked fawns that survive to fall with the overall fawn:doe ratio in the herd or study area. The surviving proportion of marked fawns is essentially the ratio of fawns to does that gave birth. The overal fawn:doe ratio should be somewhat lower because it includes yearling does and adult does that were not pregnant or did not carry fetuses to term. If the proportion of marked

fawns that survives is similar to, or lower than the overall fawn:doe rato, this may indicate a bias exists. Several of the methods used to trap adults are effective for capturing fawns.

2. Application –

   a. Aerial Net-gunning – Net-guns fired from helicopters were used to capture both fawns and adult mule deer in Colorado (Unsworth et al. 1999) and Idaho (Idaho Dept. Fish & Game 1999). Refer to the technique described in this chapter for trapping adult deer (Section VIII.A.2.a.).

   b. Helicopter drive net – This technique (Beasom et al. 1980) was used to capture fawn mule deer in Idaho (Idaho Dept. of Fish & Game 1999) and Colorado (Unsworth, et. al. 1999).

   c. Vaginal implant transmitters – Vaginal implant transmitters have been used to locate parturition sites and newborn fawns of white-tailed deer (Bowman and Jacobson 1998). The technique should work equally well with mule deer. Pregnant does must be captured and fitted with vaginal implant transmitters prior to parturition

3. Analysis of Data – Refer to Chapter 1, Section VI.A.1.c. (Pronghorn – Corral Traps).

4. Disposition of Data – Refer to Chapter 1, Section VI.A.1.d. (Pronghorn – Corral Traps).

C. Chemical Immobilization –

1. Rationale – Chemical immobilization is an effective method to capture small numbers of mule deer in specific locations. The technique is commonly used to deal with injured or problem animals in urban settings.

2. Application – Various drugs and dosage rates are discussed in Appendix VIII (Immobilization). Additional information is available in the *Handbook of Wildlife Chemical Immobilization* (Kreeger 1997).

3. Analyisis of Data – When a mule deer is immobilized, the event should be documented by recording pertinent data on a Wildlife Observation Form and a Department Immobilization Data Form.

4. Disposition of Data – Submit the Wildlife Observation Form for entry into the Wildlife Observation System database and forward the Immobilization Data Form to the Veterinary Services Section.

D. Marking Protocol – Refer to Appendix VII (Marking Techniques).

VIII. MODELING – The Wyoming Game and Fish Department uses a simulation model (POP-II, Windows Version 1.2.5 by Fossil Creek Software) to estimate mule deer populations. Each year, the model is updated and aligned based on annual classifications, harvest estimates, and mortality severity indices. Body condition indices and weather severity indices are also considered in determining appropriate mortality severity indices. Consult Appendix IX (Population Modeling) for additional detail about the modeling process.

IX. DEPREDATION – Methods for evaluating and managing wildlife depredation are comprehensively described in the *The Handbook of Wildlife Depredation Techniques* (Buhler et al. 1999) and *Prevention and Control of Wlidlife Damage* (Hygnstrom et al. 1994). In addition, the Internet Center for Wildlife Damage Managment (http://wildlifedamage.unl.edu) provides various resources to assist persons dealing with wildlife damage management, as well as symposia proceedings and links to other related websites. The site is maintained by the University of Nebraska-Lincoln, School of Natural Resource Science.

A. Depredation Issues – At times, mule deer damage stored or growing hay, ornamental trees and shrubs, shelterbelts, and gardens. Damage can include forage consumed, waste excretion on stored crops, and physical damage to trees and shrubs.

B. Depredation Management – Widespread depredation is ordinarily addressed by controlling deer populations through liberal hunting seasons and increased doe/fawn harvest. In areas of localized damage, depredation seasons, kill permits, or damage compensation may be necessary. The Department generally supplies exclusion fence to stop or prevent damage to stored crops. When deer damage gardens, ornamental trees and shrubs, the homeowner or landowner is responsible for fencing or otherwise protecting his property.

X. SUPPLEMENTAL FEEDING – The Department does not support the practice of feeding deer. Elk feedgrounds are maintained to deal with otherwise irreconcilable circumstances in which access to native winter ranges has been lost or when depredation to private lands is excessive. However, supplementally feeding deer is generally ineffective and can lead to more serious, disease transmission problems. In addition, any inference that feeding deer could be a viable solution for loss of habitat will undermine the case for maintaining native winter ranges intact. Developers have recommended feeding to justify further loss of habitat. State-supported feeding would also contradict the Department's educational messages regarding the importance of habitat to sustain populations of wildlife.

During severe winters, when deer begin to show signs of malnutrition, the public may pressure the Department to feed. One of the problems is anticipating when to start feeding and how long severe weather will continue. Once deer have reached a state of diminished health, feeding often leads to death because the microflora in the deer's rumen cannot adjust to the change in diet. Deer that were fed have often been found dead with full

rumens. Therefore, by the time the public becomes concerned, it is often too late to begin a feeding operation.

If feeding is unavoidable, alfalfa is the best supplement because it is readily available and can be spread on the snow. During winter, deer consume approximately two pounds of browse per 100 pounds of body weight daily (Dean 1975). Therefore, fawns would require approximately 2 lbs of forage per day, yearlings about 3 lbs and adults about 4 lbs per day.

Alfalfa hay should be spread in a long line so all deer can access the supplemental feed. Otherwise, fawns and weaker adults will be driven from the hay by larger, stronger deer. The feed line can be moved incrementally to entice deer into exposed natural food and sheltered locations.

XI. JOB COMPLETION REPORTS – Refer to Chapter 1, Section X (Pronghorn – Job Completion Reports).

XII. LITERATURE CITED –

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XIII. OTHER REFERENCES – Attachement 1 is a list of literature containing information relavent to managing mule deer populations and habitat in Wyoming. These reference materials are available at the WGFD Mule Deer Working Group library in the Casper Regional Office.

ATTACHMENT 1

Mule Deer Working Group Library – Casper, Wyoming (July 2004)

AUTHOR	DATE	TITLE	PUBLICATION NUMBER
THOMAS E. KUCERA	1999	A SPORTSMAN'S GUIDE TO IMPROVING DEER HABITAT IN CALIFORNIA	1
RICHARD MACKIE, DAVID PAC, KENNETH HAMLIN, GARY DUSEK	1998	ECOLOGY AND MANAGEMENT OF MULE DEER AND WHITE-TAILED DEER IN MONTANA	2
LARRY E. BENNETT	1999	CURRENT SHRUB MANAGEMENT ISSUES IN WYOMING	3
HALL SAWYER, FRED LINDZEY	1999	SUBLETTE MULE DEER STUDY	4
THOMAS EASTERLY, ALAN WOOD, THOMAS LITCHFIELD		RESPONSES OF PRONGHORN AND MULE DEER TO PETROLEUM DEVELOPMENT ON CRUCIAL WINTER RANGE IN THE RATTLESNAKE HILLS	5
ARCHIE F. REEVE, FRED G. LINDZEY	1991	EVALUATION OF MULE DEER WINTER MORTALITY IN SOUTH-CENTRAL WYOMING	6
	1998	MANAGEMENT OF INDIGENOUS NORTH AMERICAN DEER AT THE END OF THE 20TH CENTURY IN RELATION TO LARGE PREDATORS AND PRIMARY PRODUCTION	7
STEVE TESSMANN	1999	LITERATURE RELEVANT TO THE CONDITION, TREND, AND ECOLOGY OF WYOMING SHRUBLANDS (2 BIBLIOGRAPHIES PERTAINING TO SUBJECT)	8

F.G. LINDZEY, W.G HEPWORTH, T.A. MATTSON, A.F. REESE	1999	POTENTIAL FOR COMPETITIVE INTERACTIONS BETWEEN MULE DEER AND ELK IN WESTERN US AND CANANDA	9
GAR W. WORKMAN, JESSOP B. LOW	1976	MULE DEER DECLINE IN THE WEST A SYMPOSIUM	10
STEVE TESSMANN	1999	LARRY BENNETT'S WHITE PAPER ON SHRUB MANAGEMENT ISSUES IN WYOMING	11
JAMES C. DEVOS, JR.	1997	PROCEEDINGS OF THE 1997 DEER/ELK WORKSHOP RIO RICO, ARIZONA	12
JAMES HEFFELFINGER, SAMUEL BEASOM, CHARLES DEYOUNG	1987-1989	THE EFFECTS OF INTESIVE COYOTE CONTROL ON POST-RUT MORALITY O FMALE WHITE-TAILED DEER	13
M. DUDA, K.YOUNG, S.JACOBS, A. LANIER, W. TESTERMAN, S. BISSELL	1998	DEER HUNTER SURVEY: LICENSED DEER HUNTERS' OPINIONS AND ATTITUDES TOWARD DEER MANAGEMENT IN WYOMING (RESPONSIVE MANAGEMENT)	14
LARRY BENNETT		(DRAFT) THE QUALITITY AND QUANTITATIVE ASPECTS OF WYOMINGS WILDLAND SHRUB COMMUNITIES AND RELATIONSHIP TO WILDLIFE POPULATIONS	15
CHARLES MEYERS (DENVER POST)	1998	OUTDOORS IN THE WEST: ENVIRONMENT EXACTING A DEER TOLL	16
BILLINGS GUZETTE	1999	SUPRISING THINGS ABOUT EASTERN MONTANA MULE DEER	17
CHARLIE D.CLEMENTS, JAMES A. YOUNG	1997	A VIEWPOINT: RANGELAND HEALTH AND MULE DEER HABITAT	18
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Chapter 3

White-tailed Deer (*Odocoileus virginianus*)

Greg Anderson

I. INTRODUCTION –

A. History in Wyoming – White-tailed deer are an endemic species within Wyoming. They were present throughout much of the state prior to the arrival of European settlers in the 1800's. Although particularly abundant in northeast Wyoming, white-tailed deer were also documented by trappers and explorers along the west boundary of the state in Yellowstone National Park (Anderson, 1949; Koch, 1941). Shortly after European settlement, white-tailed deer populations declined dramatically throughout Wyoming. The primary cause was unregulated hunting (Pauley and Lindzey, 1993). In the mid-1900's, the white-tailed deer population began to increase in the Black Hills region. As this population expanded between 1948 and 1953, deer were trapped and transplanted to other areas of Wyoming (Pauley and Lindzey, 1993). Since white-tailed deer thrive in agricultural environments, populations expanded rapidly throughout locations with irrigated cropland following releases.

B. Current status –

1. Distribution – White-tailed deer are currently distributed throughout Wyoming. Concentrations are greatest in the northeast and southeast corners of the state. Some concentrations are also present along the eastern edge of the Bighorn Mountains and in the Big Horn Basin. White-tailed deer are relatively uncommon within the western half of Wyoming, where they are typically confined to riparian corridors (Pauley and Lindzey, 1993). Three subspecies occupy the state. In general, O. *v. dacotensis* is found throughout much of the northeast, central and southeast portions of Wyoming. A small strip along the Nebraska border is occupied by O. *v. texanus*. The deer in western Wyoming are typically O. *v. ochrourus* (Smith and Rhodes, 1994).

2. Herd Units – The Department has delineated 6 herd units to manage white-tailed deer in Wyoming. These include: Black Hills, Central, Lance Creek, Powder River, Southeast Wyoming, and the Bighorn Basin. White-tailed deer are distributed throughout most of the Black Hills. Elsewhere, the species generally exists in isolated sup-populations along riparian corridors. The herd units, otherwise known as data analysis units (DAUs), were established primarily as a means to track harvest throughout designated regions. However herd unit boundaries do not have any intrinsic value for delimiting discrete populations of this species. Although population

objectives have been established for several of the herd units, the data collected within the DAUs is generally inadequate to support reliable population estimates. Most white-tailed deer herds are managed on the basis of recreation objectives and trend indicators such as harvest effort and success.

C. Natural History Information –

1. Range of productivity –

a. Fawn:doe Ratios – In Wyoming, annual classification samples are generally insufficient to reliably estimate fawn:doe ratios, except in the Black Hills unit. In some years, large enough samples have also been obtained in the Central and Powder River DAUs. Fawn:doe ratios from the Black Hills DAU of Wyoming and some areas within other states are listed in Table 1..

Table 1. Fawn:doe ratios within Wyoming and surrounding states.

Area	Time of Surveys	Typical fawn:doe Ratio	High fawn:doe Ratio	Low fawn:doe Ratio	Citation
Black Hills (WY)	mid-October	50:100	102:100	33:100	Anderson, 1999
Black Hills (SD)	Pre-parturition	163:100 *			Rice, 1984
North central MT	Dec./Jan.		122:100	16:100	Allen, 1968
Northeast MT	Pre-hunt, fall		112:100	64:100	Dusek et al., 1989
Northern ID	Postpartum	142:100			Will, 1973

* fetuses per 100 does, determined from road-killed deer.

Production can vary widely throughout geographic regions. Some of the variation is attributed to the age structure of the population. Dusek et al. (1989) noted fawns and yearlings contribute very little to the reproductive potential of white-tailed deer in northern latitudes. Thus, when the population contains a higher percent of yearling deer, the fawn:doe ratio will typically be lower. Their study also indicated reproduction by white-tailed deer is highly density dependent in Montana.

b. Range of Productivity – In some years, large enough classification samples were obtained from the Powder River and Central DAUs to permit comparisons. For example, 1,280 white-tailed deer were classified in the Central DAU in 1997. The data yielded a fawn:doe

ratio of 91:100. Based on the large number of deer classified, this was likely a representative ratio for that year. Similarly, larger samples of white-tailed deer were classified several years in the Powder River DAU. Fawn:doe ratios there have ranged from 70:100 to 88:100.

c. Effects of Weather – Weather and forage quality affect annual recruitment of white-tailed deer in northern latitudes. Fuller (1990) determined fawn mortality increases substantially as winter snow depths exceed 16 cm. Mundinger (1981) also documented an inverse relationship between winter severity and productivity. Heavy fawn mortality is revealed by a depressed ratio of yearling bucks to does during the subsequent biological year. Rice (1984) determined white-tailed deer in the Black Hills are nutritionally stressed compared to deer in other parts of South Dakota. The poor forage quality in the South Dakota portion of the Black Hills had resulted in low recruitment for over a decade.

2. Range of natural mortality

a. Annual Mortality – Mortality of white-tailed deer has not been studied extensively in Wyoming. However, a reasonable indication can be obtained from work done in South Dakota and Montana. Mortality estimates from neighboring states are summarized in Table 2. Mortality estimates from the central Black Hills (SD) and northeast Montana also include the fall harvest.

Table 2. Mortality rates of white-tailed deer in some adjoining states.

Area	Mortality Period	Fawn Mortality	Adult Mortality		Citation
Black Hills (SD)	Annual	65%			Rice, 1984
Northern Black Hills (SD)	Annual	60%			Benzon, 1996
Central Black Hills (SD)	Annual	66%			Benzon, 1998
Central Black Hills (SD)	Annual		37%-42%		DePerno, 1998
Northeast MT	Annual	50%	22% (female) 60% (male)		Dusek et al., 1989

b. Age and Sex Specific Variation – Mortality rates of male white-tailed deer are generally higher than those of female deer. Male fawn mortality was significantly higher than female fawn mortality during two studies in the Northern and Central Black Hills (Benzon 1996, 1998). The principal cause was higher predation of male fawns during summer months. Both DePerno (1998) and Dusek et al. (1989) found mortality

of adult males was also significantly higher than mortality of adult females. The higher male mortality was predominantly from harvest during fall hunting seasons.

c. Variation Around Wyoming – Mortality data other than harvest are not generally collected from the white-tailed deer herds in Wyoming. Mortality rates documented in surrounding states (Table 2) are probably representative of white-tailed deer mortality in Wyoming.

d. Effects of Weather – Weather patterns significantly affect mortality at northern latitudes. Fuller (1990) determined an inverse relationship between snow depths and fawn survival in Minnesota. Dusek (1987) also documented substantially higher white-tailed deer mortality during severe winters in Montana.

II. CENSUS

A. Pre-season Classifications

1. Aerial Surveys – Aircraft are not used to classify white-tailed deer prior to the hunting season in Wyoming.

2. Ground Surveys –

a. Rationale – Deer are classified to obtain information about recruitment as well as buck:doe ratios. Classifications of white-tailed deer are done prior to the hunting season in the Black Hills Herd Unit, but not elsewhere in Wyoming. Pre-season classifications do not appear to have any intrinsic benefit over post-season classifications. The primary reason this is done in the Black Hills relates to workloads. Personnel are required to classify mule deer after the hunting season. Therefore, due to time constraints, white-tailed deer are classified during the second half of October, just prior to the hunting season.

b. Application – White-tailed deer are typically secretive and often nocturnal. This behavior is particularly true of bucks prior to the rutting period. In order to assure bucks are adequately represented, pre-season classifications are conducted at night with the aid of spotlights. Counts begin a half hour before sunset and can continue through the night. It is helpful to have two observers with spotlights so deer can be observed from both sides of the vehicle. Spotlights should be at least 300,000 candlepower. Nighttime classifications can be conducted anytime throughout the summer (provided antler growth is sufficient to distinguish mature and yearling bucks), however surveys have typically been conducted mid-October in the Black Hills. Will (1973) indicated July was the best month for spotlight counts since antler growth was

adequate by then, and bucks were more active and commonly associated with other groups of deer. In subsequent months, bucks became progressively more secretive and difficult to survey. In contrast, Department personnel have found sampling prior to mid-October is less effective, because foliage on trees and shrubs make sighting and identification more difficult.

c. Analysis of Data – The following ratios are calculated from classification data: fawns:100 does; yearling bucks:100 does; mature bucks:100 does; and total bucks:100 does. These ratios are determined for each hunt area as well as the overall herd unit. Since specific routes are monitored annually in the Black Hills DAU, it can also be useful to calculate the ratios for each route.

d. Disposition of Data – Each biologist should maintain a spreadsheet of annual classification data. Classification results should also be entered in the Job Completion Report (JCR) database for the applicable herd unit.

B. Post-season Classifications –

1. Aerial Surveys –

a. Rational – White-tailed deer are often encountered when mule deer are classified after the hunting season. By recording incidental sightings of white-tailed deer during aerial counts, the ground classification sample of white-tailed deer can be augmented without substantially increasing flight budgets.

b. Application – Although mule deer and white-tailed deer typically occupy different habitats, both species often occupy riparian areas during winter. When riparian corridors are flown to classify mule deer, personnel should separately classify and record any white-tailed deer seen in these areas. However, if a flight budget is particularly tight, observers should not deviate from routes specifically to classify white-tailed deer.

c. Analysis of Data – Combine classification data recorded during aerial surveys with data from post-season ground classifications. Calculate the following ratios: fawns:100 does; yearling bucks:100 does; mature bucks:100 does; and total bucks:100 does.

d. Disposition of Data – Each biologist should maintain a spreadsheet of annual classification data. Classification results should also be entered in the JCR database for the applicable herd unit.

2. Ground Surveys –

   a. Rational – Ground surveys are the principal method used to classify white-tailed deer in Wyoming. Much of this data is collected incidentally during mule deer classifications. Personnel may periodically expend additional effort to obtain larger classification samples of white-tailed deer. However, surveys to classify white-tailed deer are of lower priority because the species is less abundant throughout the state than mule deer

   b. Application – Classifications are conducted by driving methodically through occupied habitats at dawn or dusk. Observers stop frequently to look with binoculars or a spotting scope. In some areas, white-tailed deer are classified more effectively after dark. During nighttime surveys, it is helpful to have two observers with spotlights so deer can be observed from both sides of the vehicle. Animals are classified as juveniles, yearling bucks, adult bucks, or adult females.

   c. Analysis of Data – Classification data recorded during aerial surveys are combined with data from post-season ground classifications. The following ratios are calculated: fawns per 100 does; yearling bucks per100 does; mature bucks per100 does; and total bucks per 100 does.

   d. Disposition of Data – Each biologist should maintain a spreadsheet of annual classification data. Classification results should also be entered in the JCR database for the applicable herd unit.

C. Spring Classifications –

   1. Rationale – Spring classifications are done primarily to estimate fawn survival, an indication of winter severity. Only juveniles and adults are classified. The post-winter ratio of juveniles per 100 adults is compared to a pre-winter ratio derived from classifications done either prior to, or immediately after the hunting season. Based on this comparison, managers can roughly estimate the mortality of fawns through the winter period.

   2. Application – Spring classifications are normally done in March. Classifications can be conducted at dawn, dusk, or at night. Juveniles are difficult to distinguish from yearlings at this time of year so observers should take extra time as needed, to observe and correctly classify the animals. In addition, observers should have experience classifying older fawns.

   3. Analysis of Data – The post-winter ratio of juveniles per 100 adults is compared to the pre-winter ratio. A significant decrease may indicate substantial mortality of fawns took place during the winter period. However, biologists should recognize possible biases are associated with

this method. Misclassification of larger fawns as adults can depress the spring ratio, resulting in an exaggerated mortality estimate. On the other hand, if pre-winter classifications were done before the hunting season, the spring ratio might not be directly comparable. Since the vast majority of deer harvested during the hunting season are adults, the actual pre-winter ratio of juveniles to adults is greater following the hunting season. In some cases, the post-winter ratio can remain larger than the ratio obtained prior to the hunting season. Such data are inconclusive, but do suggest fawn mortality would have been very low through the winter period.

4. Disposition of Data – Data from spring classifications should be stored in a spreadsheet. A summary of the data should be included in the yearly JCR for the appropriate herd unit.

D. Other Census Techniques – Currently, the Wyoming Game & Fish Department does not employ census techniques other than modeling to estimate white-tailed deer densities. A POP-II model has been developed to simulate the White-tailed deer population in the Black Hills herd, however the reliability of this model is uncertain because this population is not closed. Insufficient data are available to support reliable models for the remaining white-tailed deer herds in Wyoming. Other census techniques are costly and labor intensive. Most white-tailed deer in Wyoming occupy private lands where access is limited. The species tends to be very adaptable and resilient when conditions are favorable. Accordingly, a lesser priority is placed upon collecting population data for management. The cost and time required to census white-tailed deer are not justified in most areas of the State. Techniques used elsewhere to census white-tailed deer are listed below:
    1. Pellet counts; Fuller (1992), White (1992), Fuller (1991), Mooty (1980).
    2. Catch-effort models; Novak et al. (1991).
    3. Aerial surveys; DeYoung et al. (1989), Teer et al. (1985).
    4. Infrared-triggered cameras; Jacobson et al. (1997), Koerth et al. (1997).
    5. Spotlight counts; Wood (1985).

III. HARVEST DATA –

A. Harvest Survey –

1. Rationale – Data compiled from the annual harvest survey are used to estimate hunter participation rates, hunter success and effort, and the age/sex composition of the harvest in each herd unit and hunt area. Managers rely upon this information to recommend hunting seasons including license quotas, and to answer questions from the public. Harvest estimates are also a key parameter used to model big game populations. Finally, harvest information is incorporated in several annual reports, planning reports, and economic analyses prepared by the Department.

2. Application – Refer to Appendix III (Harvest Survey).

3. Analysis of Data – Refer to Appendix III (Harvest Survey).

4. Disposition of Data – Annual harvest data are summarized and analyzed in the JCR prepared for each herd unit. Harvest estimates are also recorded in the JCR database.

B. Age Determination –

1. Field Techniques – White-tailed deer can be aged in the field based on patterns of tooth eruption and replacement. Biologists who are accustomed to aging mule deer should note white-tailed deer typically replace deciduous teeth more rapidly. By 13 months, all permanent, incisiform teeth have erupted. Therefore, yearling white-tailed deer checked in the fall (at approximately 15-18 months of age) cannot be distinguished by looking for deciduous incisiforms. Instead, yearlings are identified based on characteristics of the pre-molars. Yearling white-tailed deer retain a deciduous pre-molar with three cusps until 20 months of age. At that time, a permanent pre-molar with two cusps replaces the deciduous pre-molar (Dusek 1994). It is also possible to determine specific ages of adult white-tailed deer based on dentition wear patterns, however the technique is imprecise and subject to errors. Investigators who require a harvest age structure more precise than juvenile, yearling, and adult should carry a sample board of known age, lower jaws for reference. Kroll (1994) describes how to age adult, white-tailed deer based on the percent of dentine and enamel exposed on molariform teeth.

2. Field Checks and Check Stations –

a. Rationale – The age structure and sex composition of the harvest are determined primarily based on data from the harvest survey. However field checks can provide useful data for detecting biases in the harvest survey (e.g., hunters underreport harvest of fawns or females). In addition, field checks provide a means of collecting more detailed age data as well as body condition data.

b. Application – Several types of biological data can be collected from harvested animals as personnel make routine hunter contacts in the field. Depending on the area, check stations can also be established along major ingress and egress routes to increase the sample of field-checked animals. Personnel should become familiar with the Department's protocol for establishing and operating check stations (Wyoming Statute 7-17-103; also refer to Chapter 1, Attachment 1). Ideally, at least 10% of the total harvest in a herd unit should be checked in the field to comprise a meaningful sample for comparison against the harvest survey data.

c. Analysis of Data – The age structure and sex composition of animals checked in the field are compared against estimates from the harvest survey. Biologists should particularly note the proportion of juveniles documented by field checks versus the proportion reported in the harvest survey. In the past, harvest of juveniles has been underreported in the harvest survey. If major discrepancies exist, assuming the sample of field-checked animals is adequate, the biologist may consider the age and sex proportions documented by field checks as more representative of the harvest than the proportions obtained from the harvest survey. In such cases, the proportions of field-checked animals can be extrapolated to adjust the composition of the total harvest estimated from the harvest survey. The extrapolated harvest composition can also be used in POP-II models in place of the composition derived from the harvest survey. However, biologists should also recognize field check data can possibly contain biases resulting from disproportionate sampling effort either geographically (e.g., harvests on public land versus private land) or temporally (e.g., opening weekend versus later in the season). Another potential method of detecting reporting biases is to "flag" animals that are checked in the field by entering the information, including the hunter's name, into a database. If the person responds to the harvest survey, the age/sex information he reports can be compared directly against the information that was recorded during the field check.

d. Disposition of Data – Data from all field checks, along with the appropriate mortality code, should be recorded in the Wildlife Observation System. After the hunting season, wildlife management coordinators from each region should summarize the field check data and distribute it to the appropriate biologists. Biologists should include an evaluation of field check data in the annual JCR for each big game herd. This data should also be entered in the JCR database.

3. Age Determination from Cementum Annuli –

a. Rationale – At times, managers require more accurate age data than can be obtained from field checks. In these cases, the animal's actual age is determined accurately from tooth cross-sections by analyzing stained, cementum annular rings. The technique is used to determine the proportions of harvested animals within each year class of age. This information can be used to estimate the age structure of the population (adult female segment only), and can be particularly helpful during modeling exercises.

b. Application – Refer to Appendix V (Aging Techniques). Also consult Gilbert (1966) for detailed information about aging white-tailed deer based on cementum annuli.

c. Analysis of Data – Biologists should recognize samples of harvested animals are biased proportionately toward older, adult males. For this reason, it is best to obtain data from adult females to establish the age structure of the female segment of the population. Bar charts can be quite useful representations of age distribution data. Reduced or lost age cohorts resulting from weather or disease events will be clearly evident in bar charts. Investigators can use a chi-square contingency table to determine if the age structure of a population has changed significantly through several years. It is desirable to have a minimum of five observations within each age class to accurately approximate a chi-square distribution. See Zar (1974) for a more detailed discussion of chi-square analysis.

d. Disposition of Data – Enter age structure data into the JCR database. Comparisons of age structure data from different years should be depicted using charts, and discussed in the JCR for the applicable herd unit.

IV. MORTALITY ESTIMATION –

A. Incidental Observations–

1. Rationale – Mortality records obtained from incidental observations are of little intrinsic value for evaluating winter severity or other impacts to a deer population. However, biologists can often identify problems associated with road and fence crossings, disease outbreaks or other hazards by noting and recording mortalities they observe during routine activities.

2. Application – As the terminology implies, incidental observations of mortalities are recorded as time and circumstances permit. A standardized methodology is not normally followed. When biologists encounter dead animals, they should attempt to make a field determination of the cause(s). If unusual numbers of dead animals are located and the cause is not readily apparent, a necropsy should be conducted and samples collected for laboratory analysis. Alternatively, transport an entire, fresh carcass to the Department's laboratory facilities. Refer to Section V.D. of this chapter (Collection of Tissue Samples).

3. Analysis of Data – Mortality records can be plotted in a GIS database to indicate locations with unusually frequent mortalities. After such locations are plotted, biologists should attempt to identify hazards or other causes. In some cases, for example when a disease outbreak or poisoning is suspected, a systematic, follow-up survey may be necessary to document the total mortality loss.

4. Disposition of Data – All mortality records should be entered in the Wildlife Observation System (WOS) database. Field personnel with access to GIS software may choose to maintain individual databases of mortality records for various reasons, including documentation of environmental review comments. However, these individual databases should not supplant the WOS, which is the principal, statewide database of observation records.

B. Body Condition Evaluation –

1. Rationale – The ability of deer to survive winter conditions is related in part to their physiological condition as they enter the winter period. Managers can assess the potential level of winter mortality by evaluating a body condition index, in conjunction with winter severity indices. However, comparatively few, white-tailed deer harvests are checked throughout most of Wyoming. Therefore, the Black Hills is the only White-tailed deer herd in which the technique is practically applicable.

2. Application – Refer to Chapter 2, Section IV.B.2 (Mule Deer – Body Condition Evaluation).

3. Analysis of Data – Refer to Chapter 2, Section IV.B.2 (Mule Deer – Body Condition Evaluation). Body condition scores are "nominal data." In other words, the numerical scores essentially identify morphological states based on fat deposition patterns and overall appearance. They do not necessarily represent an interval scale or mathematical gradient of actual condition. In addition, the measurements fail to meet assumption regarding normally distributed data, since mostly healthy adults are checked. Samples are typically skewed heavily toward scores of 15 and 20. Accordingly, one may question whether it is valid to construct a "mean" condition score for comparisons among years. However, on a gross scale, the scores do indicate "better" or "worse" body condition. Although comparatively small changes in the average score probably have little meaning, a substantial decline would indicate an overall decline in the condition of the herd.

   An alternative, perhaps more sensitive method of analyzing body condition scores is to set up a contingency table of score frequencies, then calculate a chi-square statistic to test the assumption that proportions of different scores have changed from year to year. The score categories of the contingency table are 0, 5, 10, 15, and 20. Any categories with fewer than 5 observations should be excluded from the analysis. A significant decrease in the proportion of animals given scores of 20 in a particular year would indicate animals were generally in worse condition that year.

4. Disposition of Data – Refer to Chapter 2, Section IV.B.2 (Mule Deer – Body Condition Evaluation). Biologists should maintain spreadsheets containing body condition data from the herds they manage. The age and sex of each

animal should be recorded along with the score. Body condition data should be summarized and analyzed each year in the applicable JCR.

C. Weather Severity Indices –

1. Rationale – Severe winters characterized by above average snow depths and cold temperatures can impact white-tailed deer populations (Fuller, 1990; Mundinger, 1981). In order to consistently and quantitatively evaluate weather severity, biologists have developed indices based upon temperature and precipitation. Refer to Chapter 1, Section IV.C.1 (Pronghorn – Weather Severity Indices). Biologists use these indices primarily to incorporate weather effects into population models. In addition, weather severity indices can assist in explaining to the public why a deer population may have been impacted by a severe winter.

2. Application – Consult Reeve and Lindzey (1991) for a discussion of the winter severity index currently used by the Wyoming Game & Fish Department. Also refer to Chapter 1, Section IV.C.2 (Pronghorn – Weather Severity Indices).

3. Analysis of Data – Consult Christiansen (1991) for an explanation of how the weather severity index can be used to adjust post-season mortality severity indices in POP-II models. Also refer to Chapter 1, Section IV.C.3 (Pronghorn – Weather Severity Indices).

4. Disposition of Data – Weather severity data should be summarized and analyzed in the annual JCR for each herd unit. Post-season MSI values used to align POP-II models can be adjusted based on weather severity information.

D. Documentation of Mortality Agents –

1. Rationale – An unusual number of deer mortalities may indicate problems such as highway or railroad hazards, lethal fence designs, movement barriers, disease outbreaks, or environmental toxins. If the source of mortality can be identified and documented, it may be possible to correct the problem, or at least account for the mortality in the population model and in decisions relating to herd management. Mortality records can also be useful documentation for commenting on specific development proposals involving features that may cause similar problems.

2. Application – Refer to Section IV.A.2 of this chapter (Mortality Estimates; Incidental Observations). If an unusual number of mortalities is detected, personnel should conduct systematic surveys to assess the severity of the situation, identify the cause, and assist with planning remedial actions.

3. Analysis of Data – Whenever a problem is suspected, the biologist should create and maintain a file of mortality records and associated information to facilitate the investigation and document the event. As information is collected, the biologist should attempt to identify the source of mortality and other contributing factors. If it is available, GIS software can also help analyze spatial data in order to isolate problems.

4. Disposition of Data – Enter records of all mortalities, including codes identifying the causes, into the WOS database. Biologists who collect mortality data as part of a specific project or investigation should maintain files of this information.

V. DISEASES AND PARASITES –

A. Potential Diseases – Consult Thorne et al. (1982) for information about diseases that affect white-tailed deer in Wyoming. White-tailed deer are especially susceptible to periodic outbreaks of epizootic hemorrhagic disease (EHD) and bluetongue. These diseases often lead to significant mortality events.

B. Management – When sick and dead animals are observed, it is important to collect specimens to document the disease. Although there is no way to control or manage most diseases of white-tailed deer, biologists should at least be aware of potential implications. Hemorrhagic disease is the major pathogen impacting white-tailed deer populations in Wyoming. Managers should be prepared to respond when populations decline following an outbreak. Adult animals are particularly susceptible. The number of mature bucks in a population can decline precipitously afterward. Accordingly, hunting seasons may require adjustments reduce the harvest of bucks. Because hunting seasons are established in the spring, such adjustments are generally not possible, except on an emergency basis, until the subsequent year.

C. Identification – Outbreaks of hemorrhagic disease usually take place in late summer and early fall. If large numbers of white-tailed deer begin to die at this time of year, managers should suspect hemorrhagic disease is the cause. The vector is a biting gnat so outbreaks usually end shortly after the first hard freeze. In general, deer with hemorrhagic disease exhibit a swollen neck and tongue. Infected animals may also have ulcers on their tongue, palate, and in the digestive tract.

D. Collection of Tissue Samples – Consult Adrian (1994) for instructions regarding proper collection and handling of biological samples. Personnel should keep updated lab sample forms on hand for submitting samples to the Veterinary Diagnostics Lab in Laramie. Questions regarding sample collection and submission procedures should be directed to the Veterinary Services Section. If hemorrhagic disease is suspected, collect a blood sample from an animal that

has been dead less than twelve hours. Place the blood sample in a test tube containing an anti-coagulant and keep it cool, but do not allow it to freeze.

VI. DISTRIBUTION AND MOVEMENT –

A. Incidental Observations –

1. Rationale – Records of incidental observations, accumulated through time, often help identify important seasonal habitats such as migration routes, winter ranges, and parturition habitats. This type of data can be collected in a cost-efficient manner, since personnel record incidental observations while carrying out other routine activities.

2. Application – In order to identify important seasonal habitats, personnel must diligently record observations throughout an extended period of time. Observations recorded sporadically may fail to detect important movements or shifts of habitat use that take place in response to changing weather patterns from year to year.

3. Analysis of Data – Incidental observations are unsuited for most types of statistical analysis because the data are not collected based on a systematic sampling approach. The best method of identifying patterns is to use GIS software to plot seasonally relevant observations. Well-defined movement routes and heavily used areas often become apparent when observations are displayed. However, it is important to consider biases that incidental observations can entail. Since personnel spend a lot of time in vehicles, many observations are recorded near roads. Such biases should be taken into account when recommendations are based on patterns derived from incidental sightings.

4. Disposition of Data – All records of incidental observations should be entered in the WOS database. A biologist who is attempting to delineate or refine seasonal ranges within his area of responsibility may want to maintain his own database as well. It is easier to retrieve and plot records with GIS software if they are maintained locally.

B. Other Techniques to Obtain Distribution Data –

1. Radio-telemetry – Radio-telemetry studies are done to acquire very detailed information about habitat selection and movement patterns. The technique may be justified when it is necessary to resolve important management questions such as the integrity of herd unit boundaries, locations of specific migration routes, or responses to disturbance. However, telemetry studies are expensive and time consuming. Accordingly, managers should assure the need for this type of data warrants the cost of obtaining it. A detailed

study plan and clear objectives must be developed prior to the start of any radio-telemetry study. White and Garrott (1990) provide excellent guidance regarding the design and implementation of telemetry studies.

2. Aerial Surveys – Aerial surveys can be an effective means to document distribution of white-tailed deer during winter. Flights should be scheduled during periods of deep snow when deer tend to concentrate. Important winter habitats are identified based on the locations deer use consistently when snow cover persists. In general, white-tailed deer tend to be associated with agricultural fields and riparian zones. These habitats are limited throughout much of Wyoming, so personnel may be able to record observations in such areas effectively from the ground, at a lower cost.

VII. SEASONAL RANGE CLASSIFICATIONS –

A. Rationale – Biologists often consult seasonal range maps to evaluate the potential impacts of resource development projects, land use plans, and other proposed activities. The seasonal range maps can help biologists determine conflicts potentially caused by developments within crucial habitats. The maps also provide essential documentation to support review comments and mitigation recommendations.

B. Application – Seasonal ranges are identified based upon distribution data from various sources such as telemetry studies, aerial surveys, ground surveys, and incidental observations. Observations are plotted to locate areas consistently occupied, on a seasonal basis, under normal to severe climatic conditions. Deer distributions recorded during winter flights can be particularly useful to identify important winter habitats. For the most part, white-tailed deer in Wyoming are non-migratory. Therefore, most occupied areas are classified as "yearlong" habitat. The major exception is the Black Hills, where white-tailed deer traditionally migrate between low and high elevation habitats each spring and fall.

C. Analysis of Data – Managers should always consult seasonal range maps when commenting on development proposals, land use plans, and other activities. The maps should also be reviewed before projects are planned to treat or otherwise modify deer habitats.

D. Disposition of Data – The GIS Section in Cheyenne maintains digitized, seasonal range maps, with statewide coverage, for all big game species. Biological Services can print Mylar overlays matched to BLM surface status maps (1:100,000 scale), for all herd units. Each biologist should maintain a set of seasonal range overlays covering the herd units in his district. Changes to seasonal range delineations should be made on overlays and sent with an accompanying justification to the Biological Services Section. After the changed is approved, Biological Services will make the appropriate revisions to

the GIS database. Biologists who have GIS software on their local computers may also wish to retain digital copies of seasonal range delineations. However, no changes should be made to a local GIS file until Biological Services has first updated the statewide database in Cheyenne.

VIII. TRAPPING, MARKING, AND TRANSPLANTING –

A. Trapping Adults –

1. Rationale – The most common reason for trapping white-tailed deer is to attach radio telemetry transmitters or other visible markers, in order to study movement patterns, habitat selection, or mortality factors. In rare circumstances, deer may be trapped for relocation, but this is seldom justified.

2. Application – Several methods are available to capture adult, white-tailed deer. The person in charge of the project should notify the Biological Services Section regarding essential details of the capture and marking operation before it is begun. Include the following details in a letter to the Supervisor of Biological Services: purpose and location of the operation; herd unit; proposed duration of the study; dates and method of capture; numbers, sex, and age of animals to be marked; and the sizes, numbers, colors and other identifying features of all markers, collars or tags to be used. Before ordering radio-telemetry transmitters, consult the frequency database maintained by the Biological Services Section to avoid signal overlaps with other studies in the same area. Some effective capture methods are described below:

    a. Clover Traps – Clover traps are effective within areas of high deer densities, particularly in the winter. Deer are baited into the trap. White-tailed deer respond well to alfalfa bait normally used for this purpose. Consult Clover (1956, 1954) for a description of the design and operation of Clover traps. The Department has several clover traps stored at regional offices throughout the state.

    b. Aerial Net-gunning – This method of capture can be quite expensive on an hourly basis, but the overall cost may be less when personnel time is taken into account. Net-gunning may be the most effective option during the spring, summer, or fall when deer are less responsive to bait. In remote locations, net-guns are often the only practical means to capture animals. Several companies provide net-gunning services. Contact the Biological Services Section for an updated list of companies approved for contract by the Department.

c. Cannon Nets – Cannon nets can also be effective in areas of high deer density, provided the locations are accessible and animals can be easily baited. Consult Hawkins et al. (1968) for a description of this method.

3. Analysis of Data – Data from marking studies are complex to interpret and analyze. Managers should prepare a detailed study plan including well-defined objectives and an analysis procedure prior to marking any animals. It is also advisable to seek a peer review by an experienced researcher before finalizing the plan. Consult Manly et al. (1993) for direction regarding analysis of habitat selection data, and White and Garrott (1990) for discussions about survival analysis, habitat utilization, and home range estimation.

4. Disposition of Data – Studies that involve capturing and marking deer are expensive and generally conducted to answer important management questions. Accordingly, data and final results should always be published in a special, Department report. In addition, the results should be summarized in the annual JCR for the herd unit(s) involved in the study.

B. Trapping Juveniles –

1. Rationale – Refer to Section VIII.A.1 of this chapter (Trapping, Marking, and Transplanting). Also refer to Chapter 2, Section VII.B. (Mule Deer – Trapping Juveniles) for a discussion of possible biases associated with marking juvenile animals.

2. Application – Managers studying fawn behavior and survival often rely upon radio transmitters or other markers attached soon after birth. Two common methods of capturing fawns are:

a. Hand Capture – Fawns can be captured by hand up to a few days after birth. During the parturition period (typically 1-10 June), project personnel monitor does intensively to identify animals that recently gave birth. The fawn can often be located by carefully searching the area. However, managers should consider biases potentially associated with this capture method. Typical parturition sites are in dense cover, where locating does and neonates can be especially difficult to observe. The does that are more visible may be animals that would normally have lower fawn survival rates by virtue of their habitat selection.

b. Vaginal Implant Transmitters – To reduce the potential for biased selection of study specimens, managers may consider using vaginal implant transmitters to locate birthing sites. Bowman and Jacobson (1998) describe this technique.

3. Analysis of Data – Refer to Section VIII.A.3 of this chapter (Trapping, Marking, and Transplanting).

4. Disposition of Data – Refer to Section VIII.A.4 of this chapter (Trapping, Marking, and Transplanting).

C. Chemical Immobilization –

1. Rationale – White-tailed deer in Wyoming tend to be non-migratory. They have comparatively small home ranges and are attracted to agricultural food sources. Because of these behaviors, small numbers of deer can be captured effectively with immobilization equipment. In some instances, the food source, such as grain bales or ear corn, can serve as an effective blind from which to dart animals.

2. Application – Refer to Appendix VIII (Immobilization).

3. Analysis of Data – Refer to Section VIII.A.3 of this chapter (Trapping, Marking, and Transplanting).

4. Disposition of Data – Refer to Section VIII.A.4 of this chapter (Trapping, Marking, and Transplanting). Results of studies involving marked animals should be published in a special Department report. In addition, Veterinary Services should be notified any time immobilizing agents are used.

D. Marking Protocol – Refer to Appendix VII (Marking Techniques).

IX. MODELING –

A. Rationale – Refer to Appendix IX (Big Game Population Modeling).

B. Application – In general, efforts to model white-tailed deer herds in Wyoming have been relatively unsuccessful. White-tailed deer are widely dispersed throughout the state. Existing herd boundaries do not delineate discrete or closed populations and this violates a fundamental assumption of the POP-II model. Instead, each herd consists of numerous sub-populations scattered over broader regions. Population attributes such as productivity, mortality, and harvest pressure can also vary substantially within a herd unit. Relatively little empirical data is collected in most white-tailed deer herds. Since white-tailed deer are typically classified on an incidental basis during mule deer surveys, sample sizes are usually quite small.

C. Analysis of Data – Refer to Appendix IX (Big Game Population Modeling).

D. Disposition of Data – Refer to Appendix IX (Big Game Population Modeling).

X. DEPREDATION MANAGEMENT –

A. Issues – White-tailed deer commonly inhabit riparian areas throughout Wyoming. They often forage on or near irrigated pastures and croplands. As a result, white-tailed deer are implicated in agricultural damage more often than mule deer.

B. Management Implications – Because white-tailed deer are frequently associated with agricultural damage, depredation management becomes a common basis for herd management decisions. In most cases, managers are unable to develop reliable population estimates. Therefore, management objectives must be based upon criteria other than population size. The most logical objective is to limit damage problems while maintaining adequate recreational opportunity.

XI. WHITE-TAILED DEER HABITAT –

A. Habitat Requirements – The following references contain detailed information about habitat use by white-tailed deer in the Black Hills of Wyoming and South Dakota: Griffin et al. (1999); DePerno (1998); Benzon (1996); Sieg and Severson (1996); Stefanich (1995); Griffin et al. (1994); and Olson (1992). Additional studies of habitat use within the surrounding region include Dusek et al. (1989) and Allen (1968).

B. Interactions with Mule Deer – Sawyer and Lindzey (2000), Wood et al. (1989), Swenson et al. (1983), and Martinka (1968) studied habitat selection and competitive interactions between white-tailed deer and mule deer. Managers in Wyoming may find this information useful.

XII. JOB COMPLETION REPORTS –

A. Purpose and Content – The major purpose of job completion reports (JCRs) is to consolidate the management information and data collected from within a herd unit during the preceding biological year, and to provide an analysis of this material. As applicable, JCRs contain classification and harvest data, trend counts, mortality information, population models, browse utilization readings, seasonal range maps, a summary of management issues and concerns, special studies, and other pertinent information. The format should follow guidelines established by regional wildlife management coordinators and the Biological Services Section.

B. Disposition – Each population biologist maintains copies of annual JCRs covering the herd units in his district. In addition, each regional office maintains copies of all JCRs from within the region. The Biological Services Section and the Science Library at the University of Wyoming maintain statewide sets of JCRs. The reports also serve as references containing

historical management data such as annual population estimates, age and sex ratios, harvest estimates, and other information.

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Chapter 4

Elk (Cervus elaphus)

Joe Nemick and Brandon Scurlock

I. INTRODUCTION –

Consult "North American Elk: ecology and management" (Toweill and Thomas 2002) for comprehensive details about elk life history and management. Elk are distributed throughout forested habitats in Wyoming. Several herds also inhabit desert environments. The Wyoming Game and Fish Department manages 35 distinct herds encompassing more than 125 hunt areas. Management and research techniques commonly used in Wyoming are described in this chapter. Appropriate timeframes for surveys and management activities are outlined in Table 1.

Table 1. Schedule of elk surveys and management activities.

	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May
Age Composition of Harvest				**XXXX**	**XXXX**	**XXXX**	**XXXX**	XXXX				
Distribution Surveys (aerial)	**XXXX**	**XXXX**	**XXXX**				**XXXX**	**XXXX**	**XXXX**	**XX**		
Aging (tooth cross-sectioning)						**X**	**XXXX**	**XXXX**	**XXXX**	**XX**		
Calf Trapping	**XX**											**XX**
Harvest Field Checks				**XXXX**	**XXXX**	**XXXX**	**XXXX**	XXXX				
Harvest Questionnaire					**XX**	**XXXX**	**XXXX**	**XXXX**				
Herd Trapping							**XXXX**	**XXXX**	**XXXX**			
JCR's	**XXXX**									**XX**	**XXXX**	**XXXX**
Trend Counts		**XXXX**	**XXXX**				**XXXX**	**XXXX**	**XXXX**	**XX**		
Mortality Monitoring	**xxxx**	**xxxx**	**xxxx**	**Xxxx**	**xxxx**	**xxxx**	**XXXX**	**XXXX**	**XXXX**	**XXXX**	**XXXX**	**Xxxx**
Post-Season Classifications							**XXXX**	**XXXX**	**XXXX**			
Season Setting								**X**	**XXXX**	**XXXX**	**XXX**	
Pre-Season Classifications		**XXXX**	**XXXX**									

II. CENSUS –

Elk are normally counted when they congregate on winter ranges each year. Generally, elk winter in the same traditional areas, though a variety of sites including steep-walled canyons, ridges with scattered timber, open benches, meadows and feedgrounds are used as winter range. Each circumstance presents differing challenges that may require survey adaptations to obtain accurate trend counts. Counts can be done from the ground or air.

Personnel must have a thorough knowledge of the areas in which elk winter to assure coverage is complete as possible.

A. Trend Counts – Trend counts enable managers to detect population changes over time. A trend count is typically treated as a minimum estimate under a given set of conditions. It is not a total population count. The efficiency of trend counts can vary. Therefore, it is important to conduct them under comparable conditions and during the same season each year. In particular, changing snow conditions can result in wide discrepancies. Unique properties of the herd should also be considered when trends are constructed from count data. For example, comparisons should be based on cow/calf counts if the distribution of large bulls is more variable year-to-year than the distribution of the rest of the herd. Though trend counts are not population estimates, they are useful for documenting population fluctuations and for refining population models.

1. Ground –

a. Rationale – Elk can be counted accurately from the ground when they congregate in locations where when they can be viewed clearly.

b. Application – During harsh weather, elk may remain in cover until wind or other conditions moderate. Generally, older bulls isolate themselves singularly or in small groups away from the rest of the herd, but often in the same locations year after year. When deeper snow accumulates, bulls typically winter in very secluded locations within heavy timber. In most cases, these areas are not visible from the ground.

Counts should be conducted after herds assemble on winter ranges, typically between 1 December and 15 March. The best background for locating and counting elk is complete snow cover. In many situations, elk move away from cover in late evening to feed. The observer can position himself at first light to count elk before they return to cover. In other situations, depending on light conditions and elk movements, counting can be more effective during the afternoon. Binoculars and a spotting scope are essential to count accurately. Dense groups exceeding 500 elk are difficult to completely classify from the ground due to a "stacking" effect as elk in the foreground shield elk behind them. Viewing elk from an elevated vantage can help in these situations. A hand-clicker can be useful to keep track of the count. The observer may recount the group several times until he is satisfied the highest count has been made. If several areas are surveyed, counts should be completed over the shortest possible interval and on the same day to minimize potential for double counting.

In Western Wyoming, elk are counted on feedgrounds attended by the majority of elk in each herd. Counts are usually made from a hay sled or feed truck. However, some feedgrounds are counted by methods similar to ground counts because elk avoid feedgrounds when humans are present.

c. Analysis of Data – Annual counts are compiled and compared to identify trends. However, the extent to which substantially differing weather may affect completeness of counts should be considered in these analyses.

d. Disposition of Data – Record counts on Wildlife Observation Forms (Appendix I). Data including hunt area, general location, number counted, date, time, weather, and observer should be forwarded to the appropriate biologist and entered in the Job Completion Report (JCR) database as soon as practical.

2. Aerial –

a. Rationale – Elk can be counted from aircraft when topography, snow conditions or time constraints make ground counts impractical. However, weather can affect aerial surveys and planes are occasionally grounded due to high winds or poor visibility.

b. Application – Aerial counts are most effective when elk are away from cover and easily seen. The following types of fixed-wing aircraft are suitable: Interstate Tern, Piper Supercub, or Cessna 180 or 185. All are high-wing aircraft and can fly safely at 80 to 100 mph in mountainous terrain. In addition, the following helicopters are suitable: piston-fired Hiller for low elevations, and the Hughes 500 or Jet Ranger for higher elevations. Helicopters are especially useful to count groups exceeding 1,000 individuals. They are particularly suited for circumstances when greater maneuverability is needed because of topography, cover and elk distribution. The paramount concern is always observer safety. The data are not as important as your life! Optimal conditions for aerial counts include:

- Elk concentrated on winter ranges, usually by deep snow at higher elevations.
- Fresh snowfall present to assure good background contrast.
- Clear skies.
- Little or no air turbulence.

To ensure all elk are located, fly parallel transects approximately 0.5-1.0 mile apart (depending on topography) throughout each wintering area. Altitude above ground level will depend on the type of aircraft, method of surveying, topography, visibility, and wind conditions. Use a hand-held GPS unit to record exact locations of elk or the pilot can enter them into the aircraft's GPS unit (if equipped) and they can be downloaded later.

Counting options include real-time counts and photographic interpretations from still images or video streams. Photographic interpretations enable observers to complete very accurate counts after the flight. However, herds of up to several hundred elk can be counted accurately without the aid of photographic methods. Elk often string out as they move toward cover. This behavior enables observers to count them easily from an aircraft. If the observer believes a real-time count

would not be accurate, he should photograph the elk. When elk are scattered, they can be herded together by making a few passes with the aircraft at a moderate altitude. Plan passes so elk do not reach cover before they can be photographed. Have the pilot orient the aircraft with the sun opposite the direction photographs are taken, and fly at a high enough angle such that elk are not "stacked" (i.e., hidden behind one another). If herds are too large to cover in one photo, a series can be taken provided identifiable landmarks are present. However it is better to film each bunch on a single frame to avoid the possibility of duplicate counting.

Discernable images of elk herds can be taken using a 35mm camera and color slide film with an ASA of 64 to 200. The camera should be equipped with a 70- to 250-mm variable lens so the observer can adjust the magnification to record the maximum image size that fills the frame. Slides are projected onto white paper and elk are counted by marking individuals with a "dot" or an "x." Digital imagery has several advantages compared to traditional film, including more analysis, handling, and storage options. Digital images also provide far superior zooming and resolution capabilities. Images can be permanently stored on a computer and easily retrieved. Any digital still camera having a resolution of at least 3 Megapixels will work well.

Digital video is useful to record groups exceeding 700 elk, and provides greater flexibility than regular VHS, Hi-8, or still imaging. Digital video also provides superior color, contrast and clarity than VHS or Hi-8. Groups of 1,500 and more elk in snow-covered, grassy, open terrain can be counted accurately using digital video recorded from a fixed-wing aircraft. However, the hovering capabilities of a helicopter greatly increase the observer's ability to video all elk in a group. Specific recommendations include:

- When photographing elk, fly in flat light. Suitable photos can be taken 1 hour after sunrise, 1 hour before sunset, or on overcast days. Bright sun creates distinct shadows that appear as additional elk and can hide other elk.
- Adjust shutter speed to record at 1/2000th of a second or faster. This produces a sharper image. Set camera functions on manual and maintain focus on infinity, otherwise the camera will tend to automatically focus on the aircraft window. Record video with both eyes open to track elk not seen in the viewfinder.
- When approaching a group, video an overview before the elk mass together. After elk begin moving, wait until they string out. Then zoom in and fill the frame as much as possible. Begin at one end and either fly down the line of elk or allow them to pass by. Avoid panning the camera back and forth. Take sequential shots in one direction to avoid duplication.
- Avoid flying so low the elk appear "stacked" against one another.
- Number each group in sequence and use a hand clicker to keep track of the number assigned to successive groups. As you video each group, hold the camera microphone close to your mouth and state the location and group

number. The observer may need to video the same group several times. Identify repeat images on the audiotape.

- Bring a TV set to the airport and review the tape immediately after each flight to determine if the count was effective or if another flight is needed. About 15 minutes are required to review 1 minute of video frame-by-frame.

c. Analysis of Data – Data from aerial classifications are analyzed in essentially the same manner as data collected by ground counts (refer to Section II.A.1.c). However, differing biases are associated with each method. Accordingly, aerial and ground counts cannot be used interchangeably to evaluate population trends.

d. Disposition of Data – Record counts on Wildlife Observation Forms. Data including type of aircraft, hunt area, general locations, number counted, date, time, weather conditions and observer should be promptly forwarded to the responsible biologist and entered in the JCR database.

3. Classifications –

a. Rationale – Elk are classified to assess reproduction, calf survival and herd composition. These data are incorporated into population models (POP-II) used to estimate population size. Elk are difficult to locate and classify prior to the hunting season. It is also generally infeasible to obtain an adequate sample of mature bulls on summer ranges. Post-season classifications are much more effective. However, mature bulls are underrepresented because they tend to winter away from cow/calf groups.

b. Application – Post-season classifications are generally conducted between December and mid-March, during periods of complete snow cover, when elk are concentrated on winter ranges ad visible. Classifications should be completed in as short a timeframe as possible to avoid duplication. Good light conditions are essential. Conduct classifications during the morning and late afternoon as elk feed in open terrain.

When classifying from the ground, the observer should station himself on vantage points that enable him to clearly see elk moving into open areas. Binoculars and spotting scopes are essential. Record tallies of cows, calves, yearling bulls, and adult bulls. A hand-held clicker with at least 4 independent number fields is very useful to keep track of the tallies.

Elk are classified on feedgrounds as they are counted each winter. Several observers tally bulls (adult and yearling), calves and total elk. Results are averaged to obtain an approximate estimate of each category. The number of cows is determined by subtracting the numbers of bulls and calves from the total. Classification ratios are approximate because some elk are missed or incorrectly classified. The composition of elk on a feedground may not accurately represent the composition of the herd because bulls and calves are more likely to avoid

feedgrounds than are cows. Elk wintering on native ranges should also be classified and the data combined with feedground classifications to determine the herd composition. Counts must be done concurrently on feedgrounds and native winter ranges to avoid duplication as elk move on and off feedgrounds.

Elk can also be classified effectively from a helicopter (suitable helicopters are described in Section II.A. – Trend Counts). Fly at low elevation (150-200 feet AGL) along side each group of elk as they string out, for best visibility to accurate classifications. A tape recorder is useful, especially when flying. However, transcribing data from tapes is tedious, and malfunctions often are not detected until the flight is over.

Regardless whether classifications are done on the ground or from an aircraft, the survey must cover major winter ranges thoroughly. Attempt to classify entire groups, especially when an aircraft is used. As elk escape toward cover, calves and bulls often bunch up at the rear so partial classifications can be biased.

c. Analysis of Data – Refer to Chapter 1, Section II.A.1.c. (Pronghorn – Aerial Classifications).

d. Disposition of Data – Data recorded during classifications include hunt area, date, time, observer, geographic location, number of cows, calves, spikes and bulls, and weather conditions. The information should be forwarded to the biologist responsible for the particular herd, and entered in the JCR database as soon as practical.

III. HARVEST DATA –

Elk harvest data are derived from 3 sources: (A) the Big Game Harvest Survey; (B) check stations; and (C) hunter field checks.

A. Harvest Survey –

1. Rationale – Managers rely on harvest estimates to determine license quotas needed to attain harvest objectives. Harvest information is incorporated into population models and can also be of some use (e.g., success, effort data) for tracking population trends among years.

2. Application – Harvest data are acquired through an annual survey mailed to a stratified sample of licenses holders. Statistics estimated from the harvest survey include total harvest, age (adult/calf) and sex composition of the harvest, hunter success, effort (avg. days expended per animal harvested), and total days of recreation. These parameters are estimated and summarized for each license type, hunt area, herd unit and statewide. A detailed summary of the Big Game Harvest Survey is provided in Appendix III.

3. Analysis of Data – Harvest data are evaluated each year during the Department's annual season setting process, and in JCRs compiled by each region. Changes in hunter statistics (effort, success) are reviewed to detect and confirm population trends.

4. Disposition of Data – Statewide harvest results are compiled in the Annual Report of Big Game Harvest published by the Wyoming Game and Fish Department. More detailed summaries of harvest data from each hunt are and herd unit are provided in the regional Job Completion Reports. Herd unit files and databases housed at the headquarters office in Cheyenne are repositories for current and historic information.

B. Check Stations –

1. Rationale – Check stations have traditionally been used to obtain some types of harvest information and to enforce conservation laws such as licensing and tagging requirements. The Department has operated check stations on both a permanent and temporary basis for many decades. Data obtained at check stations can include sex and age of harvested animals, location of kill, date of harvest and number of days spent in the field. However, data reported by a hunter may not represent his activities for the entire hunting season. Check station data can be summarized in daily, weekly or monthly increments and compared with data from prior years to assess ongoing harvest trends in a specific hunt area. Another use of check station data is to detect or verify reporting biases in the harvest survey (e.g., calves reported as adults, cows or calves reported as bulls).

2. Application – Strategically placed check stations, staffed full time or randomly, are a useful means to contact hunters, determine success rates and estimate sex and age composition of the harvest (Mohler and Toweill, 1982). Check stations also provide an opportunity to obtain specific information from hunters and to collect biological samples and other materials from game. For example, blood and tissue samples, teeth, jaws, ear-tags and neckbands can be collected.

3. Analysis of Data – Refer to Chapter 1, Sections III.A.3. and III.B.1.c. (Pronghorn – Harvest Survey, Tooth Replacement).

4. Disposition of Data – Harvest data are recorded on standard check station cards and ledgers. The Coordinator or Biologist in charge of a check station is responsible for assuring check station attendants accurately record data. All records must be summarized on the Check Station Report Forms soon as possible after the station is closed. The report should be distributed to appropriate field personnel and the Supervisor of Biological Services. At temporary check stations, harvest data are recorded on Wildlife Observation Forms or harvest data sheets. Afterward, the data are submitted to the biologist responsible for the particular herd, and are entered in the JCR database as soon as practical.

C. Hunter Field Checks –

1. Rationale – In many locations, field checks are the only practical means to contact a large sample of hunters. The types of data recorded are similar to those obtained at check stations. However, field checks are not a random sampling process, so data tend to be biased. The resulting information is often difficult to interpret because it is incomplete and the type, degree and direction of inherent biases are usually unknown and vary among sub-samples (Mohler and Toweill 1982). Despite these problems, hunter field checks are widely used not only for enforcement purposes, but to assess big game harvests.

2. Application – Hunter field checks are most useful in areas lacking well-traveled ingress/egress routes on which a check station might be operated effectively. As harvested animals are encountered in the field, record the animal's sex and age and the hunt area in which it was taken, on standard forms.

3. Analysis of Data – Refer to Chapter 1, Sections III.A.3. and III.B.1.c. (Pronghorn – Harvest Survey, Tooth Replacement).

4. Disposition of Data – Data from hunter field checks should be forwarded to the appropriate district biologist at the end of the hunting season. The data from each hunt area and herd unit are summarized in the Job Completion Report.

IV. AGE DETERMINATION –

Elk are long-lived and some females can live up to 20 years or more. On the other hand, few bulls live past 10 years. Knowledge about age structure of the population (particularly the female segment) and age-specific exploitation rates can often be derived from the age structure of harvested elk. Age structure data are important to anticipate near-term trends and to model populations. In Wyoming, elk are born primarily from late May to late June. When the majority of elk are harvested in September and October, they are about 4 months older than the birth date. However, by convention elk are aged in half-year intervals: [i.e., 0.5 (calves), 1.5, 2.5, 3.5, etc.]. The pattern of elk dentition is common to all Cervids, except upper canines are present. Age classification data are most useful when samples are representative of the herd age structure or at least the female age structure.

Field Aging, Tooth Eruption and Wear – Elk more than 2.5 years old can rarely be aged accurately based on tooth eruption and wear patterns. Teeth of bulls generally wear more rapidly than those of cows. The following table indicates approximate ages of elk based on tooth eruption and wear.

Chapter 4 ELK AGE DETERMINATION*										
AGE	INCISORS			CANINE	PREMOLARS			MOLARS		
	1	2	3	1	2	3	4	1	2	3
CALF	D	D	D	D	D	D	D	P		
1½ YEARS	P	D	D	D	D	D	D	P	P	
2½ YEARS	P	P	P	P	P[a]	P	P	P	P	(P)[b]
3½ YEARS	P	P	P	P	P[c]	P	P	P	P	P[d]
4½-7½ YEARS	P	P	P	P	P[c]	P	P	P	P	P[e]
8½+ YEARS	all teeth P, no infundibula on M1									

[a] straw colored no wear
[b] 3rd cusp not up
[c] stained purple-black
[d] 3rd cusp up no wear
[e] 3rd cusp shows wear, buccal crest even or below lingual crest
* D = deciduous, P = permanent

Laboratory Aging (Cementum Annuli) – The most accurate method to age elk is based on analysis of cementum annular rings. However, the technique can be expensive and time consuming. It is appropriate when detailed age composition data are needed, for example, to determine the age structure of a population or the oldest age class for modeling purposes. The central 2 incisors are used for this purpose because they are the first permanent teeth to erupt and are the most easily removed. Tooth samples obtained from harvested adult female elk are assumed to provide an unbiased age representation of the adult female segment. However, tooth samples collected from males are biased toward older age classes because of hunter selectivity. Adequate tooth samples from either sex can be used to establish the oldest age classes in the population. For a detailed description of this technique, refer to Appendix V.

Upper Canine Tooth – Deciduous upper canine teeth appear in elk calves a month after birth and are retained about a year. They are replaced when crowns of permanent canines erupt in June or July. Nearly a year is required for approximately half the crown to become exposed. Root extremities develop last and the tooth is completely formed between the second and third years. Wear becomes noticeable within a year after the permanent canine erupts through the gums, and continues throughout the life of the animal. The complete crown is exposed by age 7 in nearly all elk. The tooth has often worn to the root component in animals over 15 years. The formation, development and wear of canine teeth advance somewhat more rapidly in females than in males of the same age (Greer and Yeager, 1967).

A. Rationale – The age structure of the harvest can provide insights about hunter selectivity and availability of specific age classes for harvest. Age data are also used to align the harvest age structure simulated in population models. In addition, age structure data can be used to evaluate the effectiveness of various harvest strategies and to estimate age

structure and age-specific natural mortality rates, particularly in the female segment of the population.

B. Application – Large numbers of animals can be examined at check stations, locker plants, and during hunter field checks to determine ages based on tooth eruption and wear patterns. If more refined age information is needed, tooth samples can be collected during these hunter contacts. Tooth envelopes or boxes with instructions can also be mailed to hunters prior to the hunting season when a larger sample is needed. The middle incisors are easily loosened by cutting the gum on either side, and around the base of the teeth. The 2 teeth can then be pried forward and removed.

C. Analysis of Data – Before requesting tooth samples for laboratory analysis, the biologist should be confident an adequate sample will be available to make reasonable inferences about the harvest age structure. Otherwise, tooth samples should not be collected. Typically, teeth should be obtained from about 25% of the harvest. In areas with smaller harvest quotas of under 100 animals, tooth samples should be obtained from larger proportions of the harvest, up to 100%. Age data should be tallied according to age classes discernable by the particular methodology (tooth eruption and wear or tooth cross-sectioning). The harvest age structure may be used to estimate the population age structure, reproductive success, and/or age-specific harvest rates. The data may also provide insights about current and future population trends.

D. Disposition of Data – Refer to Chapter 1, Section III.B.1.d. (Pronghorn – tooth replacement).

V. MORTALITY – Principal sources of elk mortality include hunting, predation, diseases, parasites, malnutrition, exposure, harassment and accidents (Tabor et al. 1982). Little is known about the comparative importance of these factors, and they undoubtedly vary from location to location. Certain analytical means, modeling for example, are available to indirectly estimate mortality. Although it is seldom practical to estimate mortality by direct methods, mortality records can provide useful management information.

A. Incidental Observations –

1. Rationale – If they are diligently recorded, elk mortalities detected through incidental observations can help managers identify problem areas or significant mortality events such as disease outbreaks and poisonings.

2. Application – The biologist should establish a record of each dead elk encountered by completing a Wildlife Observation Form. The following information should be entered: date of observation, location, sex, age and cause of death. If the cause of death is unknown or associated with unusual circumstances, and the carcass has not seriously decomposed, a necropsy should be done. Either tissue samples or the entire carcass should be delivered to the veterinary laboratory in Laramie for this purpose. Procedures for collecting and shipping tissue samples are described in Adrian (1992).

3. Analysis of Data – Refer to Chapter 1, Section IV.A.3. (Pronghorn – Mortality Estimation).

4. Disposition of Data – Forward completed wildlife observation forms to the appropriate, regional wildlife management coordinator at the end of each month. All non-hunting mortalities and necropsy results should be discussed in the Job Completion Report for the applicable herd unit.

B. Winter Mortality Transects – It is seldom practical to establish winter mortality transects in typical elk habitat. Refer to Chapter 1, Section IV.B. (Pronghorn – Mortality Transects) for a detailed description of the procedure.

VI. DISTRIBUTION AND MOVEMENT –

A. Direct Observation –

1. Rationale – The distribution, movements and seasonal habitats of elk have been generally described and mapped in Wyoming. However, specific knowledge about some crucial winter ranges, migration routes and parturition habitats remains incomplete. As energy development and other activities continue to expand throughout Wyoming, more specific distribution data are increasingly needed to support land use decisions.

2. Application – Whenever elk are observed outside currently documented ranges, the location and activity of animals should be recorded on a Wildlife Observation Form. Distribution information should be collected within existing herd units when needed to better define seasonal ranges and migratory movements. The district biologist should identify the season(s) for which additional distribution data would be beneficial.

3. Analysis of Data – Guidelines for mapping wildlife distribution are provided in Appendix VI. Also refer to Chapter 1, Section V.B.3. (Pronghorn – Distribution and Movement, Aerial Surveys).

4. Distribution of Data – Forward Wildlife Observation Forms with distribution data to the appropriate, Regional Wildlife Management Coordinator at the end of each month. The information is entered into the Wildlife Observation System database. Distribution records provide documentation for updating seasonal range maps, and they are also accessed and compiled for other purposes such as commenting on proposed projects.

VII. CAPTURE, MARKING, AND TRANSPLANTING –

A. TRAPPING –

1. Corral Traps –

a. Rationale – Corral traps have been used successfully for many years to capture elk in Wyoming. Both permanent and temporary trap setups are employed. Although the initial cost of a permanent trap is greater, long-term costs may be lowered by reduced annual setup time and maintenance. Conversely, temporary corral traps are cheaper to build, but may cost more to transport, set up, and maintain each year. Permanent traps should be considered for long-term trapping programs in winter concentration areas, such as feedgrounds or Department Wildlife Habitat Management Areas. Portable traps may be more suitable for short-term operations or when elk are sampled from several different herd segments. Either trap is very effective for capturing and processing large numbers of elk, at relatively low cost. Three experienced personnel can operate a portable trap efficiently, but 4-7 may be needed to run a permanent corral trap, depending on its size.

b. Application – Permanent corral traps designed for elk are illustrated in Taber and Cowen (1969), Straley (1970), and Mace (1971). Plans for portable corral traps constructed of pipe frame panels and nylon impregnated canvas are available from the Jackson/Pinedale Region.

Corral traps should be erected in areas where elk normally concentrate in winter. The handling chute should be positioned to provide an unobstructed escape route when animals are released. Sites for permanent and portable corral traps should be as level as possible, but must drain to prevent ice buildup in corrals and chutes.

Various baits, including alfalfa hay, grass hay, apple pulp, or salt are used to lure animals into these traps. However, baits such as alfalfa or apple pulp attract deer and can disrupt the elk trapping operation. If deer are present, use native grass hay to attract elk.

Check corral traps just after sunrise each day. Elk can be held several hours following capture. However, animals should be moved into chutes, marked, and either released or loaded onto transport vehicles as soon as practical to reduce stress and injuries. Animals caught in large, permanent traps should be moved into the smaller holding pen to minimize chances for injury. Elk left unattended in a large corral can become exhausted from continuous running, or can be seriously injured if they attempt to jump out.

Corral traps are generally used to capture elk during winter. Portable traps baited with salt or water can be deployed on other seasonal ranges.

c. Analysis of Data – Refer to Section VII.B.1.c. (Marking).

d. Disposition of Data – Refer to Section VII.B.1.d. (Marking).

2. Clover Traps –

a. Rationale – Clover traps are suitable for capturing small numbers of elk during short duration trapping operations, especially when a mobile trap design is required. Generally, elk are caught one at a time a large sample is difficult to obtain. However, Clover traps are much easier than portable corral traps to transport and utilize in remote sites. Clover traps can often be moved into desired locations during winter when vehicular access is limited.

b. Application – Designs of Clover traps are illustrated in Clover (1956). Traps are set up in areas of fresh elk sign and baited with alfalfa hay or apple pulp. Always place Clover traps on level ground that is adequately drained to prevent ice build-up under the trap. Captured, elk are handled in several ways including: 1) chemically immobilize the animal; 2) cover the trap with canvas to restrict elk movements; or 3) collapse the trap to restrain the animal. Check traps each morning to prevent elk from being injured by fighting the netting. Crews of 2 persons are required to check traps and process captured animals.

c. Analysis of Data – Refer to Section VII.B.1.c. (Marking).

d. Disposition of Data – Refer to Section VII.B.1.d. (Marking).

3. Netguns –

a. Rationale – Trained professionals using netguns can capture elk very efficiently from helicopters. Several companies now specialize in this technique. Depending on terrain and elk densities, an experienced crew can capture, mark, and release up to 30-50 elk in a day. Biological samples can be collected as well. With proper instruction, a good crew has the ability to place collars on animals well distributed throughout a seasonal range, in a short amount of time.

b. Application – Show pilots and crews where to capture elk on detailed topographic maps. It may also be acceptable orient the crew during a reconnaissance flight prior to capture operations. However, for safety, Department personnel should not participate as a crewmember once the capture operation begins. Depending on the company's equipment inventory, the Department may need to supply ear tagging pliers or other capture equipment.

Animals captured in most netgun operations are marked and released on site. However, crews can also transport animals to a central staging area for processing or relocation. During these types of operations, animals may be tranquilized to reduce the stress of capture and aerial transportation. Trailers

used to transport elk should be equipped as described in Section VII.C.1 (Transport).

c. Analysis of Data – Refer to Section VII.B.1.c. (Marking).

d. Disposition of Data – Refer to Section VII.B.1.d. (Marking).

4. Immobilization –

a. Rationale – Tranquilizing drugs can be used to immobilize and capture small numbers of elk in specific locations. Elk in traps are often immobilized to assist with handling.

b. Application – Refer to Appendix VIII for a discussion of various immobilizing agents, their properties and dosages. Drugs can be administered by a variety of devices including dart rifles, pistols, blowguns, and jab sticks. Darting from helicopters is the preferred method to capture elk on all seasonal ranges. However, aerial darting is usually more effective after animals have congregated on winter habitats. Elk can also be darted from the ground when personnel are able to get close enough. At certain times of year, calls are effective to attract animals within darting range – specifically: 1) a calf call is used to attract females and young bulls during calving season (June 15-July 7); and 2) a bugle is used to attract adult bulls during the rut (September). In addition, elk can be darted from hay wagons or other equipment that is familiar to them on winter feedgrounds. After elk are captured in corral or Clover traps, they are sometimes immobilized to facilitate handling or transport.

c. Analysis of Data – Record a detailed account of each immobilization. Note the drug type, dosage, and the age, sex, and approximate weight of the animal. Document induction times and length of anesthesia for future reference and to help refine dosage rates.

d. Disposition of Data – Summarize immobilization records and forward them to Veterinary Research Services. Report results of any operation involving immobilization in the Job Completion Report for the applicable herd unit.

B. Marking Studies –

1. Neckbands and Ear Tags –

a. Rationale – Important geographic data are obtained from observations and recoveries of marked elk. This information enables managers to delineate and refine seasonal ranges and migration patterns of sub-populations. Harvest strategies can be developed to target specific herd segments. In some applications, elk are marked to evaluate the integrity of existing, herd unit

boundaries, or to refine estimates of harvest rates, natural mortality rates or longevity.

b. Application – If elk are to be trapped and marked at several sites in a herd unit, a differently colored neckband should be assigned to each site. Symbols or codes imprinted on neckbands must be sufficiently large to be read easily. Unique symbol patterns should be used at each trap site to eliminate duplication. Individual elk can also be marked with cattle ear tags that are colored and numbered. Colors of ear tags should correspond to specific trap sites as well.

   When elk are fitted with neckbands, attach numbered aluminum ear tags with return instructions to both the animal's ears. Elk sometimes lose collars, but seldom shed both ear tags.

   Newborn elk calves can also be uniquely marked with ear tags. Long-handled nets are an effective means of capturing calves shortly after parturition. However, this method is very labor-intensive and typically returns minimal data. It is appropriate for unique circumstances in which a large sample of calves can be marked.

c. Analysis of Data – Each trapping and marking project should include a provision for extensive monitoring to document subsequent locations of marked animals. Record Universal Transverse Mercator (UTM) coordinates of elk locations and enter these into a Microsoft Access database. Geo-referenced databases are used to construct distribution layers in a Geographic Information System. These layers help biologists delineate seasonal ranges, migration routes, and interchange among herd units. They also provide documentation to support impact analyses and mitigation recommendations.

d. Disposition of Data – Immediately after a marking operation is concluded, collate and forward records to the Supervisor of Biological Services for entry into the Department's Marked Animal Database. At a minimum, this information should include the dates elk were marked, ear tag numbers, ages of the elk, locations of trap sites (UTM coordinates), and locations of release sites if different from capture sites. Summarize trapping data, marked animal locations, and mortality returns in Job Completion Reports for applicable herd units.

2. Radio Telemetry –

   a. Rationale – Radio transmitters cost substantially more than traditional neckbands, however the quantity and quality of data acquired are much greater. Radio telemetry can be used to identify migration routes, refine seasonal range delineations, estimate home range size (an indication of habitat quality), and assist in analyzing habitat selection patterns. Recent advances in Global Positioning Satellite (GPS) technology enable modern telemetry systems to track, record, and store thousands of individual animal locations. From such

high-density data, biologists can monitor fine-scale movements, enabling them to identify daily activity patterns, habitat selection, exact migration routes, and many other attributes without disturbing the animal after it is collared.

b. Application – Elk must be captured and restrained or immobilized to attach telemetry transmitters. Appropriate trapping techniques depend on goals of the marking operation (refer to previous subsections). To facilitate observation of telemetry-marked elk, a neckband sheath of 4-inch wide, rubber-impregnated material can be affixed with pop rivets to the standard transmitter collar. These sheaths are available in a variety of colors and can be numbered for individual identification.

c. Analysis of Data – Several software packages are available to plot locations obtained from telemetry data, and to calculate home range sizes. Each has strengths and weaknesses depending on the number of relocations of each marked individual. Since software is constantly evolving, biologists should consult the Cooperative Fish and Wildlife Research Unit at the University of Wyoming, for advice about current technologies and their suitability for specific study objectives.

d. Disposition of Data – Immediately after the marking operation is concluded, collate and forward records to the Supervisor of Biological Services for entry into the Department's Marked Animal Database. At a minimum, this information should include: the date the elk was marked, ear tag numbers, radio collar colors and numbers, transmitter frequencies, sex and ages of the elk, locations of trap sites (UTM coordinates), and locations of release sites if different from capture sites. Summarize trapping data, marked animal locations/home ranges, and mortality returns in Job Completion Reports for each, applicable herd unit.

C. Transplant and Relocations –

1. Transport – Historically, elk were transplanted from capture sites in northwest Wyoming via horse drawn wagons to railheads in eastern Idaho. There, they were loaded onto railroad stock cars and transported to various release sites for reintroduction or augmentation across Wyoming. As technology improved during the 1900s, the Department began using vehicles to relocate elk. Due to the prevalence of CWD and brucellosis, any elk transplanted from within Wyoming would need to be tested, making it unlikely elk from Wyoming would be used in future transplants.

a. Rationale – Elk currently occupy most suitable habitats in Wyoming. In fact, elk are beginning to disperse into open rangelands and agricultural regions where the Department does not wish to establish new populations. Accordingly, there is no biological reason to relocate elk for reintroduction or augmentation within

Wyoming. Occasionally, we may provide elk to other states or provinces for reintroduction. Sometimes, problem animals are relocated.

b. Application – Several precautions are necessary to minimize stress and injury when elk are transported. Currently, 4-horse or larger stock trailers are preferred. Most openings on trailers should be covered with panels of plywood or other materials to minimize noise and other stressful stimuli. Fit panels such that they allow adequate ventilation when the trailer is stopped, and provide shelter and thermal insulation during transport. Separate adult elk from calves by installing dividers in the trailer, or by hauling them in different trailers. Similarly, separate bulls from cows. Trailers used to transport elk should have low beds for easier loading. Spread wood chips, sawdust, or clean hay throughout the trailer to provide traction and bedding. Trailers set up to transport wildlife are maintained within most Department Regions.

c. Analysis of Data – Refer to Section VII.B.1.c. (Marking).

d. Disposition of Data – Refer to Section VII.B.1.d. (Marking).

2. Release –

a. Rational –.

b. Application – Additional precautions are necessary to release elk with a minimum of stress and injury, without jeopardizing safety of personnel or spectators. Select release areas that afford open escape lanes. Assign personnel to assure the area is clear of obstructing objects and to control spectators. Keep news media and other spectators out of escape lanes. Back transport trailers into position and release elk from all trailers simultaneously if possible. Minimize noise and encourage spectators to leave the area as soon as possible so animals can adjust to the unfamiliar environment.

c. Analysis of Data – Refer to Section VII.B.1.c. (Marking.)

d. Disposition of Data – Refer to Section VII.B.1.d. (Marking).

VIII. DISEASE MANAGEMENT – A range of infectious diseases and parasites have been documented in elk populations. Thorne (1982) identified these and described their distribution, transmission, pathogenesis, diagnosis, and control. More recently, Williams and Barker (2001) published a comprehensive treatise on wildlife diseases resulting from viral, prion, bacterial, and mycotic infections. Among the diseases that affect elk in Wyoming, brucellosis probably receives the greatest attention and its management accounts for the expenditure of resources.

A. BRUCELLOSIS MANAGEMENT –

1. Surveillance –

   a. Rationale – Brucellosis is potentially transmitted between elk and cattle that commingle during the late winter/spring period and poses risks to the State's livestock industry. A major objective of elk management in western Wyoming is to reduce the distribution and seroprevalence of brucellosis.

   b. Application – Elk are bled and tested for the presence of antibodies for the bacterium *Brucella*. Blood samples are collected from live-captured animals (corral traps, chemical immobilization, net-gunning, etc.) via jugular venipuncture. Samples are also collected from hunter-harvested animals typically by mailing blood kits to licensed hunters in a specific area targeted for surveillance.

   c. Analysis of Data – Testing is conducted by WGFD at the Wildlife Disease Laboratory in Laramie. Data from each herd are compiled and reported in annual Job Completion Reports.

2. Vaccination –

   a. Rationale – Research has demonstrated vaccinating elk with the Strain 19 (S19) inoculum reduces Brucella-induced abortions (thought to be primary mode of transmission).

   b. Application – Elk are ballistically vaccinated with lyophilized S19 vaccine loaded into hydroxycellulose "biobullets." Vaccinations are typically conducted from a feedsled on feedgrounds during winter.

   c. Analysis of Data – Elk have been vaccinated on the Grey's River feedground since 1985, but were never vaccinated on the Dell Creek feedground. Efficacy of the S19 vaccination program has been evaluated by comparing seroprevalence estimates collected from these treatment and control sites. Efficacy is also interpreted based on trends in brucellosis seroprevalence of elk over time (pre vs. post-vaccination) at Grey's River.

3. Habitat Enhancement –

   a. Rationale – Healthy, intact and available winter range for elk spatially separated from potential livestock conflict areas can reduce elk dependence on supplemental feed (i.e., feedgrounds) and concurrently reduce potential for intraspecific transmission events. Strong correlations exist between artificial feeding season length (and end feeding date) and exposure rates of brucellosis in elk on feedgrounds. Reducing feeding season length and/or stopping feeding seasons early may result in reduced brucellosis seroprevalence in elk.

b. Application – WGFD has limited relatively limited land ownership. Most large-scale habitat enhancement projects must be coordinated with federal landowner agencies. Funding needed for projects is sometimes immense, and grants should be submitted to as many funding agencies as possible.

c. Analysis of Data – Treated/control vegetation monitoring transects can be erected to determine effects of treatment. Browse and fecal transects or animal marking can be employed to determine use.

4. Prevention of elk-cattle commingling –

a. Rationale – Transmission of brucellosis from elk to cattle, or vice-versa, is not possible if contact between the two species is prevented.

b. Application – Livestock producers typically report commingling events to local wardens and elk are hazed away from the situation by various means

c. Analysis of Data – Warden report?

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Chapter 5

Moose (*Alces Alces shirasi*)

Doug Brimeyer

I. INTRODUCTION – George Shiras III described a race of moose inhabiting mountainous regions of the western U.S. during his explorations from 1908-1910 in Yellowstone National Park. In honor of Shiras, Nelson (1914) named the Yellowstone moose *Alces alces shiras.*

A. History in Wyoming – Moose are believed to have entered Wyoming from Montana and Idaho within the past 150 years. Moose became established along the Teton Mountain Range and in Jackson Hole during the late 1800s. Numbers declined following early settlement. Hunting seasons were closed from 1903-1911. The 1908 Annual Report of the State Game Warden indicated moose were distributed along the Teton Mountains, the upper Yellowstone River and at the head of the Green River. Moose hunting seasons were reopened in 1912. Blunt (1950) estimated 500 moose inhabited Wyoming in 1912, principally in the in northwest region.

Moose began to occupy portions of the Wind River Range during the 1930s, and became quite numerous by the 1960s. Afterward, the population began to decline. From 1935 through 1948 the legal harvest totaled 1515 moose. In addition, moose were often mistaken for elk and accidentally killed. Managers estimated the statewide population was 3,210 in 1940.

Historically, moose were relocated to establish new populations in Wyoming and elsewhere. Twenty-nine moose were captured in the Jackson area and released in the Bighorns in 1948, 1950, 1974 and 1987. Twelve moose were relocated from Jackson to North Park, Colorado in 1979. Another 12 moose were transplanted to the Upper Laramie River in Colorado in 1987. Moose dispersed from the Colorado population into southeast Wyoming and by 2000, a huntable population had become established in the Snowy Range.

B. Current Status – Moose currently occupy habitats in western, north central and southeastern Wyoming. The statewide population objective is 12,370. Managers estimated the statewide population was approximately 14,028 in 1998. Hunting seasons have been conservative in Wyoming and hunter success has generally remained in the 80-90% range. In 1998, regulations were changed to prohibit hunters from taking a cow moose accompanied by a calf. This action was taken to improve recruitment by increasing survival of dependent calves.

C. Natural History Information –

1. Range of Productivity – Productivity of moose varies considerably among occupied habitats within Wyoming, and among years. At the low end, 24 and 26 calves per 100 cows were classified in the Jackson and Dubois herd units, respectively, in 1996. At the high end, 63 and 58 calves per 100 cows were classified in the Lander Herd Unit in 1995 and 1998, respectively. Generally, statistically adequate classifications of moose are difficult to obtain except in the Sublette and Jackson herds. The average calf:cow ratio was 46 calves per 100 cows in this herd during the 1994-1998 period. Statewide, the calf:cow ratio was 48.7 calves per 100 cows following the hunting season in 1998, based on 3,843 moose classified in 7 herd units

   The age at which cow moose reproduce varies from 1.4 to 2.4 years (Schwartz 1992) and can be delayed to 3.4 years in poor quality range (Albright and Keith 1987). Pregnancy and twinning rates also vary depending on habitat quality and population density. Pregnancy rates ranging from 60-100% have been reported in various moose populations (Schwartz, 1998). Berger (2003) reported an average pregnancy rate of 75% from 1995-1998 in the Jackson Hole area. Twins were not observed during Berger's study. However, 1-2% of cows were observed with twins in the Jackson and Targhee herd units during the 1999 post-hunt period. Houston (1968) reported a 4% twinning rate in the Jackson area. Schladweiler and Stevens (1973) reported a 16% twinning rate in Montana.

2. Range of Natural Mortality – Calf mortality rates of 40% prior to the hunting season, and 15-25% afterward (over-winter) are used in population simulation models for Wyoming moose herds. As large predators become established in Wyoming, we expect mortality rates will increase. Van Ballenberghe (1987) reported an annual survival rate of just 10% for calves in areas where predators were abundant. Conversely, survival rates as high as 67% have been reported for calves in non-hunted populations where predators were absent (Mytton and Keith, 1981). In 1999, Berger (2003) documented calf survival rates of 73% (10 of 14) during the first two months of life and 50% (7 of 14) through the winter period in the Jackson area. Survival of radio-collared, adult cow moose was 80% during 1999 and 2000, 91% in 2001 and 62% in 2002. Annual survival of adult moose transplanted to southwestern Colorado was 94 and 83 percent for males and females respectively (Olterman and Kenvin 1998).

II. CENSUS – Moose are the least social ungulate in Wyoming, often observed alone or in small groups. Department personnel documented an average group size of 2.2 moose (range 1-15, n = 358 groups) during sightability flights in the Jackson area in 1998 and 1999. Moose also tend to segregate according to sex and age, making some classes of animals more difficult to observe than others (Peek et. al., 1974). These behaviors pose unique challenges for managers attempting to census moose. Because of small group sizes and distribution in diverse vegetation cover, it is impossible to obtain a total count of moose. Even attempting to count most of the moose in a population is difficult and expensive. Moose populations are currently estimated based on population models, population indices, and in some cases, sampling approaches such as sightability models.

Data required to model populations include: age and sex classifications, harvest composition and mortality rates (refer to Appendix IX – Big Game Population Modeling). Managers should consult literature and field studies to derive appropriate values for modeling parameters.

A. Preseason Classifications –

1. Aerial Classifications –

a. Rationale – Prior to the hunting season, it is difficult to observe and classify an adequate sample of moose. However, moose in some herds are more visible at that time than after the hunting season when they move into dense, conifer habitats. Preseason classifications are used to estimate recruitment of calves in the fall, as well as bull:cow ratios. The data are applied to align population simulation models.

b. Application – In areas where pre-season classifications are advantageous, they can be done most effectively from a helicopter (WGFD 1998). Conduct preseason classifications over a weeklong period in July or August. A shorter timeframe reduces the likelihood of duplicate observations. Use consistent survey techniques each year so results can be validly compared among years. Schedule flights in early morning and limited them to 2-3 hours. Always follow protocol outlined in the Aircraft Operation Procedures and Safety Policy of the Wyoming Game and Fish Commission's Policy Manual (WY Game and Fish Commission 2005).

c. Analysis of Data – Express ratios as calves per 100 cows and bulls per100 cows.

d. Disposition of Data – Data from moose classifications are processed and distributed as described in Chapter 1, Section II.A.1.d. (Pronghorn – Pre-season Classifications). Use a hand-held GPS to determine locations of observations, and then download the coordinates based on the NAD (North American Datum) 1983 geographic reference. UTM Coordinates are downloaded into a Microsoft Excel spreadsheet or transcribed by hand to a Wildlife Observation Form. The spreadsheet should contain fields for each location (waypoint) and separate fields

to record the numbers of moose classified as cows, calves, bulls and unclassified adults. Records can also be saved as a Microsoft Access data file and imported directly into ArcView for mapping applications. Records of observations help managers identify important habitats and their proximity to potentially conflicting land uses such as subdivisions, roads, energy developments, recreational areas, and timber sales.

2. Ground Classifications –

   a. Rationale – Pre-season classifications are done from the ground in some herd units with low moose densities and where aerial surveys are not feasible due to budget constraints.

   b. Application – Refer to Section II. A. 1.b. of this chapter, and related discussions in Chapter 1, Section II.A.2.b. (Pronghorn – Ground Classifications). Select routes that afford reasonably complete coverage of occupied habitats. The same routes should be followed in successive years. Conduct surveys 2-3 hours in the early morning. Look for moose while driving at slow to moderate speeds, and stop periodically to glass from vantage points. Classify and record all moose observed.

   c. Analysis of Data – Refer to Section II. A. 1.c of this chapter and related discussions in Chapter 1, Section II.A.2.c. (Pronghorn – Ground Classifications). Sample sizes obtained from ground classifications of moose are typically small. In addition, survey routes generally do not provide random or systematic coverage of occupied habitats. These limitations can result in imprecise or biased classifications, which should be considered when data are analyzed.

   d. Disposition of Data – Refer to Section II. A. 1.d, of this chapter and related discussions in Chapter 1, Section II.A.2.d. (Pronghorn – Ground Classifications).

B. Postseason Classifications –

   1. Aerial Classifications –

      a. Rationale – Accurate age and sex ratios are required to analyze herd dynamics and reliably estimate moose populations. Aerial surveys are the most practical means of classifying moose over large areas and diverse cover types. Aerial surveys enable managers to meet sampling assumptions better than ground surveys, and generally yield more observations per unit effort.

      b. Application – Post-season classifications are conducted from a helicopter during the December-February period. Schedule flights during periods of complete snow cover, preferably within a few days of fresh snowfall. Ideally flights should last 2 –3 hours to reduce observer fatigue and should be scheduled to coincide with peak moose activity. During severe weather, moose may forage throughout the day. Always follow protocol outlined in the Aircraft Operation Procedures and Safety Policy of the Wyoming Game and Commission's Policy Manual (WY Game and Fish Commission 2005).

         Surveys should cover representative areas of riparian, deciduous and conifer habitats occupied by moose. Partial or incomplete surveys of an area may result in a biased composition estimate. In Alaska, Gasaway et al. (1986) determined

classifications that were conducted during surveys designed for population estimation purposes provided higher, more representative calf:cow ratios than did less intensive, composition surveys.

Assign each moose encountered to one of the following classes: bull, cow, calf, or unclassified adult. Also tally cows with calves and note those accompanied by twins. Body size tends to be the most useful criterion for identifying calves. Use head features to avoid misclassifying large calves as yearlings. Calf moose have relatively small ears and a short, pointed nose by comparison with the larger, bulbous nose of an adult moose. Calves also tend to remain close to the cow (30-40 yards) and will follow close behind her when disturbed (Timmerman and Buss, 1997). We recommend observers use at least 2 primary or secondary criteria to determine the sex of adult moose. Timmerman and Buss (1997) summarized criteria used to identify sex and age groups. The primary criteria are antler or pedicel scars, vulva patch, behavior, and bell shape and size. Secondary criteria include: group composition, facial coloration, body conformation, pelage coloration, head position when the moose is moving, and position of the legs when the moose rises from its bed. Not all females have the characteristic vulva patch and some males have a small light brown area that can be mistaken for a vulva patch.

c. Analysis of Data – Postseason composition ratios should be expressed as calves and bulls per 100 cows and bulls per 100 cows.

d. Disposition of Data – Refer to Section II.A.1.d in this chapter and related discussions in Chapter 1, Section II.A.2.d. (Pronghorn – Ground Classifications).

2. Ground Classifications –

a. Rationale – Ground surveys may be warranted to classify herd units with low densities of moose, and where aerial surveys are not feasible due to budget constraints. Ground classifications of moose are done in a manner similar to that described for mule deer (Chapter 2, Section II.B.2).

b. Application – Refer to Section II. A.1.b. of this chapter and related discussions in Chapter 2, Section II.B.2.b. (Mule Deer – Ground Surveys).

c. Analysis of Data – Report classification results as calves per 100 cows and bulls per 100 cows.

d. Disposition of Data – Refer to section II. A.1.d. of this chapter and related discussions in Chapter 1, Section II.A.2.d. (Pronghorn – Ground Classifications).

3. Wyoming Moose Sightability Model –

   a. Rationale – Observers detect only a portion of a moose population during aerial surveys. However, correction factors can be developed to compensate for visibility biases associated with vegetation cover, terrain, group size, observer skill, etc. Based on procedures described by Unsworth et. al. (1991), Anderson (1995) developed a sightablity model for moose in Wyoming. Sightability surveys are based on a stratified sampling approach to improve accuracy and precision of population estimates, and to reduce costs.

   b. Application – Occupied habitat is divided into 2 or 3 survey strata within the herd unit based on expected moose densities (low, medium or high). The strata are then subdivided into sample units, each large enough to be surveyed from a helicopter in one hour. The sample units are typically 3-6 sq. mi. Stratification reduces sample variance and improves precision of population estimates. The survey is applied to a randomly selected subset of sample units within each stratum. Counts are corrected for visibility bias, and then extrapolated based on the proportionate area sampled, to estimate the number of moose within each stratum. The strata estimates are then summed to estimate the population within the herd unit. The optimum time to survey is early winter (December and January) when moose still occupy comparatively open habitats. Personnel are directed to follow procedures outlined in the Aerial Survey User's Manual (Unsworth et al. 1994) for observing and recording moose, and for evaluating vegetation cover. Classify moose and record the locations as described in Section II.B.2.b. of this chapter. Always follow protocol outlined in the Wyoming Game and Fish Commission's Aircraft Operation Procedures and Safety Policy (WY Game and Fish Commission 2005).

   c. Analysis of Data – Transcribe and enter data based on the format described by Anderson (1995). Aerial Survey Software developed by Unsworth et al. (1994) is used to evaluate Moose sightability data.

   d. Disposition of Data – See related discussions in Chapter 1 (Pronghorn), Sections II.C.4. (Aerial Trend Counts), II.D.4. (Line-transect Surveys), and II.E.4. (Quadrat Sampling).

III. HARVEST DATA –

A. Harvest Survey – All moose permit holders are surveyed after each hunting season to obtain harvest data. Typically, 75-80 percent of moose hunters respond to the first mailing. Persons who fail to respond are mailed a second questionnaire. Data from survey responses are used to estimate total harvest and harvest composition, and to develop other statistics including hunter success, effort (days per moose harvested), and total recreation days. Appendix III provides a detailed discussion of the WGFD harvest survey.

B. Age Determination –

1. Field Aging Techniques –

a. Rationale – Younger animals are commonly underreported in the harvest survey because hunters are less likely to submit incisors from these animals for aging, and often inaccurately report them as adult cows on the harvest questionnaire. Field checks are a comparatively unbiased means of detecting of calves and yearlings in the harvest. Age data can be collected from harvested moose and non-hunting mortalities that are encountered in the field. Managers can also collect teeth for aging and can measure antlers during field checks. The most accurate means of aging moose is laboratory analysis of cementum annular rings. Although considerable material has been published regarding tooth eruption and wear patterns for aging ungulates, comparatively little technical guidance is available to age moose based on such criteria. In the field, moose can be coarsely separated into calves, yearlings or adults based on gross morphological characteristics.

b. Application – Calf moose are identified based on body size. Yearlings are larger, but often have lightly stained lower premolars (2 and 3) and may still have deciduous upper premolars. Tooth cross-sectioning is the only reliable method for determining specific ages of adult moose. This laboratory technique requires staining and counting cementum annular rings (discussed in next section).

c. Analysis of Data – See related discussions in Chapter 1, Section III.B.1.c. (Pronghorn – Age Determination).

d. Disposition of Data – See related discussions in Chapter 1, Section III.B.1.d. (Pronghorn – Age Determination).

2. Tooth Cross-sectioning –

a Rationale – Tooth sectioning is the only accurate means to determine specific ages of harvested moose (Sergeant and Pimlott 1959). Age is determined by counting cementum annular deposits that become discernable when tooth cross-sections are stained and examined under a microscope. Precise age information has several management applications. Antlerless moose taken by hunters are considered an unbiased sample of adult (yearling and older) females in the population. Accordingly, managers can estimate the age structure of the female segment based on harvested, antlerless moose. On the other hand, hunters tend to select older age classes of bulls so ages of harvested bulls are not a valid representation of the age structure of the male segment. However, the age distribution of harvested bulls is useful to assess harvest trends in relation to objectives. A persistent shift in the age composition of harvested males can indicate a need to adjust license numbers, or may provide evidence of changing

moose numbers or sex ratios. Age-specific harvests data are also used to update population simulation models each year. Longer-term data sets are used to establish the initial female age structure and oldest age class for developing a population model.

b. Application – Collect both incisors from each adult moose checked in the field or at a check station. Using a sharp knife, slice deeply into the gum on each side of the teeth. The incisors can be forced forward and down with a heavy knife or pliers until the teeth separate from the gum line. Remove the teeth from the soft tissue lining along the jaw, taking care to not break off the root. The entire root is needed for cross-sectioning. Place teeth in a Department tooth envelope labeled with the species, hunt area, date of harvest, and the hunter's name and address. Submit all tooth envelopes to the Wildlife Management Coordinator.

c. Analysis of Data – See related discussions in Chapter 1, Section III.B.2.c. (Pronghorn – Aging).

d. Disposition of Data – See related discussions in Chapter 1, Section III.B.2.d. (Pronghorn – Aging).

3. Check Stations –

a. Rationale – Check stations enable managers to examine larger samples of harvested animals along egress routes from popular hunting areas. In addition, field personnel are afforded the opportunity to contact sportsmen, monitor compliance with hunting regulations, and respond to questions from the public regarding access, hunting opportunities, management issues and Department operations.

b. Application – Check stations should conform with the Wildlife Division's "Guidelines for Establishment and Operation of Wildlife Check Stations." Refer to Attachment 1 in Chapter 1 (Pronghorn).

c. Analysis of Data – See related discussions in Chapter 1, Section III.C.3. (Pronghorn – Field Checks and Check Stations).

d. Disposition of Data – See related discussions in Chapter 1, Section III.C.4. (Pronghorn – Field Checks and Check Stations).

IV. MORTALITY ESTIMATION (NON-HUNTING) –

A. Incidental Observations –

1. Rationale – Moose die naturally from many causes including: accidental falls, drowning, fight-related injuries, breaking through ice, parasitic infections, diseases,

predation, exposure, and starvation. Non-natural mortalities most commonly result from accidents such as vehicle collisions, fence entanglements, or entrapment in pits. Other sources of non-natural mortalities (excluding legal harvests) can include poaching, unintentional capture in leg snares, or poisoning, for example, at a contaminated water source. The magnitude of losses can be significant but difficult to estimate. Natural and accidental mortalities can equal or exceed the legal harvest (Child, 1997). It is important to document and record mortalities to identify potential problems and to assist agencies with making sound decisions regarding land uses and development proposals. For example, 11 moose were killed in 1997 along a five-mile stretch of Wyoming Highway 390. As a result, additional signing was posted and a recommendation was forwarded to modify the design of right-of-way fences.

2. Application – See related discussions in Chapter 1, Section IV.A.2 (Pronghorn – Mortality Estimation).

3. Analysis of Data – See related discussions in Chapter 1, Section IV.A.3 (Pronghorn – Mortality Estimation).

4. Disposition of Data – See related discussions in Chapter 1, Section IV.A.4 (Pronghorn – Mortality Estimation).

B. Weather Severity Indices – See related discussions in Chapter 1, Section IV.C. (Pronghorn – Weather Severity Indices).

C. Winter Mortality Transects – See related discussions in Chapter 1, Section IV.B (Pronghorn – Mortality Transects).

D. Documentation of Mortality Agents – See related discussions in Chapter 1, Section IV (Pronghorn – Mortality Estimation).

V. DISEASES AND PARASITES – Moose are susceptible many parasites and diseases. A detailed account of diseases and their implications is available in *Diseases of Wildlife in Wyoming* (Thorne et al. 1982) and in the *Pests, parasites and diseases* (Lankester and Samuel 1997).

A. Potential Diseases – Moose co-evolved with many disease and parasitic organisms. Under most circumstances, infections remain sub clinical and do not affect the overall population. Only a few diseases and parasites have the potential to impact moose at a population level. These include winter tick (*Dermacentor albipictus*), the arterial worm (*Elaeophora schneideri*), and in eastern North America, the meningeal worm (*Parelaphostrongylus tenuis*).

B. Management /Public Safety – Hunters often question the edibility of game meat after they have observed a parasite or abnormal condition. The public should be informed virtually all wild animals have parasites (including viruses and bacteria). Most parasites

coevolved with host organisms and generally serve to strengthen the population by reducing the survival of weaker individuals. Very few infectious organisms are transmissible from moose to humans. Transmission of Brucellosis and Toxoplasma is possible but unlikely. The tapeworm Echinococcus granulosus, can infect humans after the final association with a canid host. The larval stage of Echinococcus occurs in the lungs of moose and can infect coyotes, wolves and dogs. Tapeworm eggs shed in the canids' feces are infectious to humans.

C. Identification – Hunters commonly report internal and external parasites to Department personnel who may offer a general diagnosis. However, a necropsy and analysis are required for definitive diagnosis. The Wyoming State Veterinary Lab in Laramie performs these services.

D. Collection and Handling of Tissue Samples – If managers suspect a moose is infected with a parasite or disease the moose should be collected and transported to the Wyoming State Veterinary Lab. If euthanasia is necessary, the animal should be dispatch with a single shot behind the ear near the base of the skull. A rifle or shotgun and slug are suitable. The entire animal should be sent to the lab if transportation is feasible within several hours of the animal's death. Due to the size of moose and distance to the lab, the carcass often spoils before tissue samples can be collected. Biological samples can be collected and shipped in accordance with procedures outlined in the Wildlife Forensic Field Manual (Adrian, 1992).

VI. DISTRIBUTION AND MOVEMENT –

A. Incidental Observations –

1. Rationale – Moose distribution and movement patterns have been documented and mapped to varying degrees throughout Wyoming. More detailed, current information is needed on most herds to help managers deal with increasing development, winter recreation, and habitat modifications.

2. Application – During aerial and ground surveys, moose locations can be recorded as waypoints on a hand held GPS unit, then downloaded a Microsoft Excel Spreadsheet, or transcribed to Wildlife Observation Forms (Appendix I). Guidelines for mapping animal distribution are outlined in Appendix VI. Also see related discussions in the Antelope Techniques Chapter.

3. Analysis of Data – See related discussions in Chapter 1, Section V.C.3. (Pronghorn – Distribution and Movement, Incidental Observations).

4. Disposition of Data – See related discussions in Chapter 1, Section V.C.4. (Pronghorn – Distribution and Movement, Incidental Observations).

B. Other Sources of Distribution Data – Moose distribution and movement patterns should be documented during aerial surveys and telemetry studies. Aerial surveys are the best method to observe moose in remote areas and dense vegetation. As locations from

various times of the year are accumulated, a database should be constructed to help managers identify important seasonal habitats. Biologists should record and manage data as described in Section II.A. (Preseason Moose Classifications).

Franzmann et al. (1976) analyzed habitat preferences of Alaskan moose based on pellet group counts. In Wyoming, pellet groups have been recorded to determine the presence or absence of moose in areas where projects or land use developments are proposed.

VII. SEASONAL RANGE IDENTIFICATION –

A. Rationale – Seasonal ranges are mapped within each moose herd in Wyoming. Maps are maintained at Regional Offices and the Cheyenne Headquarters. Biologists and others use distribution maps for planning purposes and to assess potential impacts of proposed land uses.

B. Application – See related discussions in Chapter 1, Section V (Pronghorn – distribution and movement).

C. Analysis of Data – See related discussions in Chapter 1, Section V (Pronghorn – distribution and movement).

D. Disposition of Data – See related discussions in Chapter 1, Section V (Pronghorn – distribution and movement).

VIII. TRAPPING, MARKING AND TRANSPLANTING –

A. Trapping Adults –

1. Rationale – Adult moose are trapped chiefly for the following purposes: collect biological information; affix marking devices or transmitters; and relocate individuals for depredation/nuisance control or reintroduction. Managers mark moose to evaluate their distribution and movements. Before the advent of chemical immobilization and an efficient delivery system, physical restraint was the only method available to capture moose (Pimlott and Carberry 1958).

2. Application –

a) Corral Traps – Very stout corral traps are required to physically restrain moose. Consequently, this method has had limited utility in the past. Corral traps and trip mechanisms are described by Franzmann and Schwartz (1997). Corral traps are costly and labor intensive to construct. Operation of these traps requires a substantial personnel commitment for the number of moose trapped, and animals captured experience high mortality rates. From 1934 to 1953, 230 moose were captured in corral traps in Michigan, Wyoming, Newfoundland and Alberta. Of those, 133 were relocated, 35 escaped and 62 (27%) died (Pimlott and Carberry 1958).

b) Aerial Net-gunning – Net guns have been deployed from helicopters to capture moose (Carpenter and Innes 1995). This method is more efficient, economical, and better adapted to sample animals across a broad area. From 1993-1995, net-guns were used to capture a total of 392 moose were captured in North America, by a firm called Helicopter Wildlife Management. Overall, mortality at the time of capture was less than one percent.

c) Analysis of Data – See related discussions in Chapter 1, Section VI.A.1.c. (Pronghorn – Corral Traps).

d) Disposition of Data – See related discussions in Chapter 1, Section VI.A.1.d. (Pronghorn – Corral Traps).

B. Trapping Juveniles –

1. Rationale – Telemetry methods are commonly used to study movements and mortality of calf moose (Franzmann et al. 1980). Telemetry offers many advantages over conventional marking and observation methods. In particular, telemetry gives managers the capability to follow and relocate calves, and to detect mortalities soon after they happen. However, managers should consider potential biases when interpreting telemetry data. Capture and handling stress may directly increase mortality. Human scent and activity at the capture site can attract predators' attention. In addition, transmitters and marking devices can alter behavior and increase visibility of moose calves, making them susceptible targets for predation. Methods to control these biases include using appropriate telemetry equipment and not including moose calves in the sample until several days after they are captured and marked.

2. Application – A helicopter provides the most efficient means of capturing neonatal moose. After a cow and calf are located, the helicopter is maneuvered to chase the cow away from the calf. The helicopter is then landed and the capture crew exits to restrain and collar the calf. While the calf is being processed, the helicopter returns to the air and is maneuvered to keep the cow at bay. The cow will generally return to the calf after the capture operation is completed. If not, the helicopter can be used to herd her back to the calf (Ballard et al. 1979). Calves have also been captured with a helicopter net-gun during the winter period in Wyoming and Colorado (Olterman et al. 1994).

3. Analysis of Data – See related discussions in Chapter 1, Section VI.1.c. (Pronghorn – Corral Traps) and Section VI.2 (Pronghorn – Fawn Capture).

4. Disposition of Data – See related discussions in Chapter 1, Section VI.1.d. (Pronghorn – Corral Traps) and Section VI.2 (Pronghorn – Fawn Capture).

C. Chemical Immobilization –

1. Rationale – Moose are difficult to restrain unless they are chemically sedated. Modern procedures enable mangers to quickly and efficiently immobilize moose for safe handling.

2. Application – We currently recommend the synthetic drug, carfentanil, to immobilize moose in Wyoming. Various other drugs used in the past had significant drawbacks. Two early drugs were nicotine salicylate and succinylcholine. Both are paralytic drugs with very narrow ranges of effectiveness. In addition nicotine salicylate often had unpredictable effects. Houston (1968) used Succinylcholine chloride to immobilize Shiras moose. The Department used this drug during the 1970s and 1980s, to remove problem moose from urban settings in the Jackson area. Approximately 25% of moose immobilized with succinylcholine chloride died from respiratory failure during capture (Crawford pers. comm.). Capture-All, is a concentrated powder form of ketamine hydrochloride and xylazine. Capture-All hydrated with xylazine hydrochloride was also used to immobilize moose in urban settings, but this drug was not effective unless administered in very large doses. It required a lengthy 3-5 hour recovery period. Telazol hydrated with xylazine was used with limited success. However, moose that were agitated at the time of administration often escaped or had to be roped and physically restrained. Lengthy recovery periods were also required.

   Carfentanil is administered at a dosage of 0.006 mg per lb of estimated body weight. If the capture site is close to noise and activity, such as urban settings, the muscle relaxant xylazine can be mixed with carfentanil to calm the animal. The effect of Carfentanil is rapid and completely reversible by administration of an antagonist. Carfentanil is a highly regulated, narcotic drug that is potentially hazardous to humans. Consult Appendix VIII for detailed information on dosage calculations and handling protocol.

   After a moose has been immobilized, hobble its legs and place a cover over its eyes and ears. If ectoparasites are present administer an injection of 1ml "Ivomec" per 110 pounds of estimated body weight. If the moose is to be relocated, it can be loaded in an enclosed horse trailer. Once the animal is immobilized it should be moved onto a heavy tarp and then pulled onto the trailer bed. After the moose is confined inside the trailer, administer the antagonist naltrexone hydrochloride at a rate of 100 times the dosage of carfentanil. Transport the moose to the release site and free it.

IX. POPULATION MODELING –

A. Rationale – Simulation models are a useful tool for estimating populations and evaluating harvest strategies. Adequate data must be collected annually to assess population age structure, harvest rates, and environmental factors in order to update and refine simulations. Refer to Appendix IX for a detailed discussion about population modeling.

B. Application – Appropriate or standardized ranges of model parameters are discussed in Section I.C. and Appendix IX. For additional information about population modeling, consult Timmerman and Buss (1997), Kovach et al. (1998), Bubenik and Pond (1992), Boer and Keppie (1988), Ballard et al. (1991) and Peterson (1977).

C. Analysis of Data – See related discussions in Chapter 1, Section II (Pronghorn – Census) and Chapter I, Section VII (Pronghorn – Modeling).

D. Disposition of Data – See related discussions in Chapter 1, Section II (Pronghorn – Census) and Chapter I, Section VII (Pronghorn – Modeling).

X. SETTING SEASONS – **[Reserved]**.

XI. DEPREDATION – Depredation management is discussed in the Handbook of Wildlife Depredation Techniques (Demaree et al. 1991) and in Prevention and Control of Wildlife Damage (Hygnstrom et al. 1994).

A. Depredation Concerns – Moose can damage stored crops and disrupt livestock feeding operations. In urban settings, moose occasionally damage ornamental shrubs, landscaping, and vehicles. Public safety is also a concern when moose enter subdivisions.

B. Management Implications – In some locations, liberal hunting seasons have been set to reduce moose densities on private land. Moose are generally solitary so instances of damage are often isolated. Aversive conditioning has been used to displace moose from agricultural fields. However, the effect is often only temporary. Fencing is the best option to protect private property. The Department may relocate moose when human safety becomes an issue.

XII. SUPPLEMENTAL FEEDING – The Wyoming Game & Fish Dept. discourages feeding of moose. Moose require large quantities of browse and will decimate woody vegetation adjacent to feed sites. Schwartz et al. (1980) did not believe moose could extract sufficient nutrients from diets high in fibrous material, like hay, to survive. An adequate feed ration was developed in Alaska by combining aspen sawdust with other ingredients. Moose were historically fed in western Wyoming (Johnson et al. 1985). Feeding areas were established to draw moose away from stored hay and livestock feed lines on private lands. The Wyoming Game & Fish Department is legally obligated to compensate landowners for damage caused by big and trophy game including moose. During the 1970s, the Department supplied ranchers with alfalfa (*Medicago sativa*) to feed moose that were damaging stored hay. By the early 1980s, the Wyoming Game and Fish Commission had approved five moose feeding areas and several unofficial moose feedgrounds also existed. Moose were given 1 kg of forage each day during the early winter, and up to 7 kg/day in February. Feeding generally began in January and ended by mid-March. It is likely the feeding operations only supplemented normal moose diets of browse. Most feeding sites were phased out by the early 1990s.

Damage claims decreased in the drainages where moose were fed, but it is likely population reductions and moose proof stack yards were more important factors contributing to the decrease in damage claims. Permanent stack yards are a more cost effective solution that avoids the damage feeding causes to adjoining habitat.

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Chapter 6

Bighorn Sheep (*Ovis canadensis*)

Tom Ryder, Kevin Hurley, and Doug McWhirter

I. INTRODUCTION - Historically, bighorn sheep occupied suitable habitats throughout much of Wyoming (Honess and Frost 1942, Buechner 1960). Early taxonomists classified 2 subspecies: "Audubon's" and "Rocky Mountain" bighorn sheep (Cowan 1940). Audubon's sheep inhabited mountain ranges, badlands, and rimrock breaks in eastern Wyoming. They tended to be non-migratory, fulfilling seasonal habitat needs within comparatively limited yearlong ranges. This subspecies was extirpated from Wyoming by 1907 (Cowan 1940, Honess and Frost 1942, Morris 1979).

Rocky Mountain sheep occupied the western mountain ranges of Wyoming. They were characteristically migratory, generally wintering in low elevation foothills and summering in alpine habitats above 10,000 feet. As the state was settled in the mid 1800s, Rocky Mountain bighorns declined precipitously throughout traditional low elevation ranges. Buechner (1960) listed several causes including excessive market hunting, disease (primarily scabies), competition with livestock, and encroachment by settlers into available winter range. Despite these factors, Rocky Mountain bighorns apparently flourished in remote high mountain habitats until domestic sheep were brought to montane pastures during the 1880s. Smith (1982) concluded bighorns were greatly reduced by disease and competition for forage after huge flocks of domestic sheep were brought from Oregon to the southeastern Wind River Mountains in approximately 1880. Similarly, Hornaday (1908) and Honess and Frost (1942) described die-offs from scabies presumably contracted from domestic sheep.

Sixteen herd units are currently defined to manage bighorn sheep in Wyoming. The Department's Bighorn Sheep Working Group considers 8 of these "Core Native Herds" that should receive highest management priority. Core herds include the Clarks Fork, Francs Peak, Jackson, Targhee, Trout Peak, Wapiti Ridge, Whiskey Mountain, and Yount's Peak populations. The other 8 herds were established in historic sheep range by transplanting sheep from the Whiskey Basin Herd. In most cases, herds that started as transplants have remained relatively stagnant or even declined after an initial rapid expansion. Since these herds are performing beneath expectations, the Bighorn Sheep Working Group recommends management emphasis should be directed primarily to core native herds.

II. CENSUS

A. Herd Classifications/Trend Counts

1. Rationale – Managers use data from herd classifications to estimate lamb survival, yearling recruitment, and sex composition. These data are also incorporated into

POP-II computer models to estimate population size and predict effects of future harvest strategies.

2. Application – Ground or aerial surveys are conducted to classify bighorn sheep, as circumstances warrant. Ground classifications should be done in late-November through mid-December, after hunting seasons, when bighorn sheep are concentrated on winter ranges and rams are rutting. Sheep can be observed for longer periods from the ground, so observers should attempt to classify all sheep according to specific age and sex categories. Record the total numbers of rams, ewes, yearlings, and lambs observed. Male and female yearling sheep can be difficult to distinguish, however, personnel should attempt to do so. Geist (1971) also defined 4 age classes of adult rams (Fig. 1). When possible, classify all adult rams observed during ground surveys according to these 4 categories.

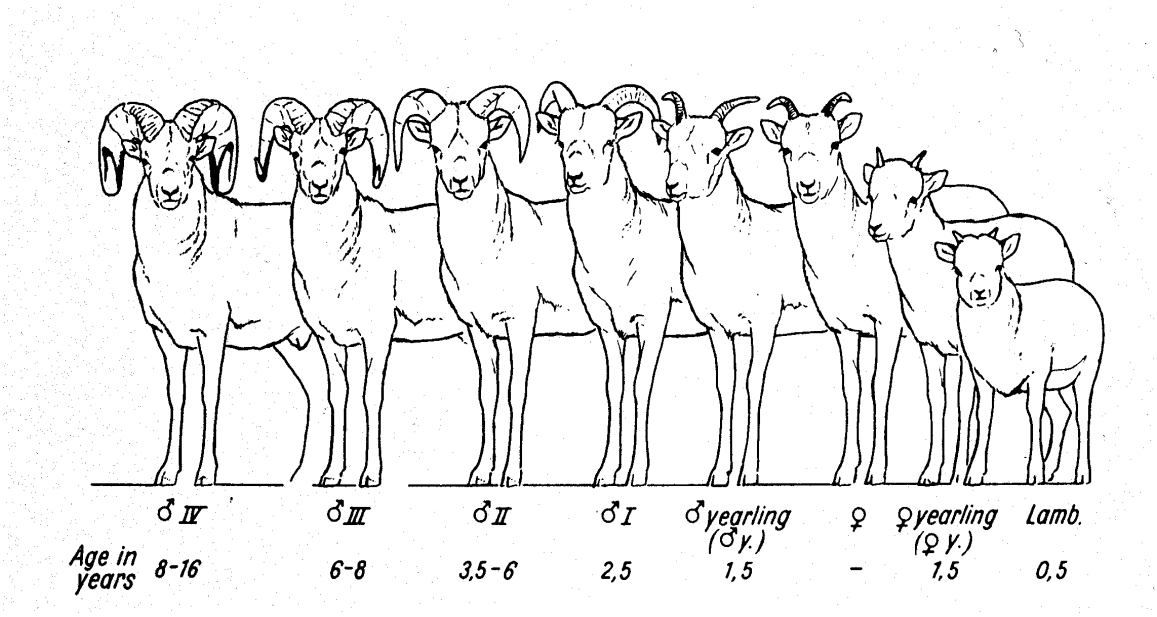


Fig. 1. Bighorn sheep age and sex characteristics. Note that animals form a cline in body and horn size, and the adult female is very similar in external appearance to the yearling ram. The above drawing is taken from Geist 1968.

Sheep can be classified from aircraft between mid-December and mid-March, depending on snow conditions and distribution of animals. Although fixed-wing aircraft have been used in the past, helicopters provide a much stabler and safer platform from which to classify sheep in Wyoming. Hughes 500 or Bell Jet Ranger helicopters are recommended for higher elevations. Piston-fired Hiller 12E or turbo-charged Bell 47 helicopters can be used at lower elevations to reduce the cost of surveys. During aerial surveys, personnel should record the total numbers of adult rams, ewes, and lambs observed. If it is possible to distinguish yearling rams, they should be recorded as a separate category.

In some herd units, sheep are classified most effectively by a combination of aerial and ground surveys. The Whiskey Mountain and Yount's Peak Herd Units are especially suited for concurrent surveys. Observers have excellent vehicle access to large concentrations of sheep wintering at low elevations in these herds. However, large numbers of sheep also winter at scattered high-elevation sites that are accessible only by air. In such circumstances, ground surveys and flights should be scheduled as concurrently as possible to avoid duplicate counts of groups that may move between high and low elevation winter habitats. Data from both surveys are combined to estimate sex and age ratios for the herd unit.

Sheep population trends can be tracked through time based on classification surveys if a consistent protocol is followed. Specifically, the surveys must take place at the same time of year, under similar conditions, and must cover the same winter ranges. A trend count represents the number of animals observed under a given set of conditions. It is not a total count. Climatic conditions and observer biases (detection rates) change from year to year so varying proportions of animals are missed. Therefore, trend analyses should be based on data from years in which environmental conditions (i.e., snow cover, cloud cover, temperature, wind speeds, etc.) are reasonably comparable. Trend counts provide corroborating data to verify and refine population models.

3. Analysis of Data – Estimate the ratios of rams and lambs per 100 ewes based on classification data. If rams were classified as yearlings and adults, distinguish these age groups in the ram:ewe ratios. Herd composition data are incorporated into POP-II models.

4. Disposition of Data – Enter classification data in applicable Job Completion Report databases. These data and the population simulation model are analyzed and discussed in the Annual Job Completion Report.

III. HARVEST MONITORING AND AGE DETERMINATION

A. Harvest Survey - Refer to Appendix III.

B. Mandatory Head Registration

1. Rationale – A mandatory registration system was instituted to discourage illegal possession and trafficking of bighorn sheep heads. The system retains permanent records of harvested and found heads so they can be traced and identified as legal, if necessary. Since sheep heads must be physically presented for registration, managers are able to determine the actual ages, sexes, and horn measurements of sheep taken by hunters each year. Other harvest related data such as location, effort (days expended per animal harvested), number of other sheep seen, date, and type of harvest (legal, illegal, firearm, archery) are recorded as well.

2. Application – The heads of all sheep that are legally harvested, and the skulls and horns of sheep that are found dead (i.e., "pick-up" heads), must be presented at a Department Regional Office or Headquarters for tagging and measurement within 15 days of the date the sheep was possessed. Persons who acquire an unmarked sheep head that was taken prior to the Department's registration program are also required to present the head for registration within 15 days. Pertinent data are recorded on a Kill Record and Registration Form (Fig. 2). Each set of horns is assigned a unique identification number imprinted on an aluminum plug. The plug is inset with glue in a countersunk hole drilled in the back of one horn. The hunter is given the option of selecting which horn (right or left) he wants plugged. This will often depend on the position the head will be mounted. Harvested heads are marked with a silver plug stamped in the following sequence: WYO-(3-digit number)-(year of harvest). Pick-up heads are marked with a red plug stamped in the following sequence: (3-digit number)-WYO-P (for pick-up head). Heads acquired prior to the Department's registration program are similarly marked with a silver plug stamped with the following sequence: WYO-(3-digit number)-PRE. Standard metal game tags issued by the Department are attached to ewe and lamb skulls. After the head is registered, record the following information on a Wildlife Observation Form: date, age and sex, hunt area, cause of mortality (if known), and location.

Wyoming Game and Fish Department Rocky Mountain Bighorn Sheep Kill Record & Registration (Revised 7/98)

Date of Harvest or Possession:_____ Region of Harvest:_____ Hunt Area:_____ Horn ID No.____-____ (year)

Harvest Type: Legal_____ Illegal_____ Pickup Head_____ Other_____

Location and/or Drainage:_____

Section____ Township_____ Range_____ UTM East_____ UTM North_____ UTM Zone_____

Sex:_____ Estimated Age:_____.35 years No. Days Hunted:_____

(midpoint of hunting season is approximately 0.35 years into the biological year. This does not necessarily apply to pickup heads and illegal harvest)

Name_____Phone_____ Resident _____ Non Resident ____

Address_____

City_____ State_____ Zip_____ Date Entered on WOS:_____

Was Guide or Outfitter Used (Y/N)_____ Name_____

	Left	Right
Number of Annual Rings	_____	_____
Total Horn Length	_____mm	_____mm
Length from lamb to yearling horn ring	_____mm	_____mm
Length from yearling to 2+ horn ring	_____mm	_____mm
Length from 2+ to 3+ horn ring	_____mm	_____mm
Horn Basal Circumference	_____mm	_____mm

Tip Spread:_____mm Maximum Spread:_____mm

Other Identifying Marks (note location on horn):_____

I,_____ of _____

being duly sworn, depose and say that I am the holder of Wyoming Bighorn Sheep License Number _____

and lawfully took the above sheep on_____, in Hunt Area No._____. Inspected in _____Region

_____ _____ _____

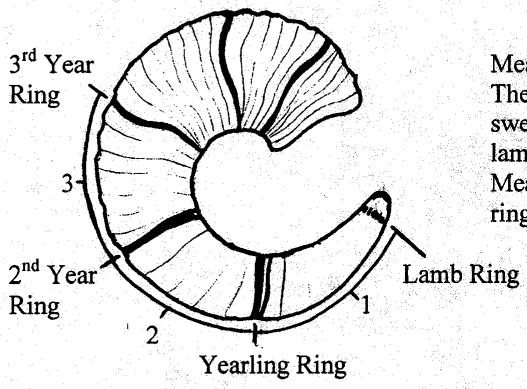
Inspected by Date: Hunter or Owner Signature

Fig. 2. Bighorn sheep mandatory horn registration form.

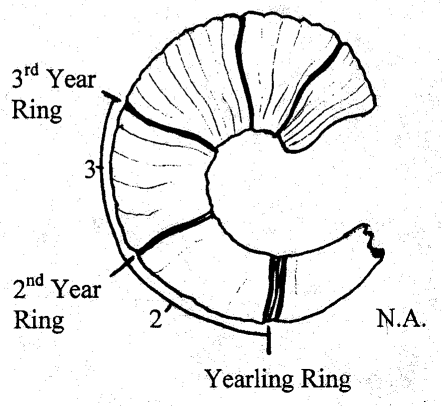
Ages of rams are determined by counting the number of annular rings on each horn. Beginning at horn tip, the lamb's horn is segment 1. The lamb segment is often missing from broomed horns of older rams, so the first visible ring may indicate the end of the second segment (Fig. 3). Occasionally, "false rings" complicate the determination of a ram's true age. These depressions encircling the horn are uncommon on segments grown before 7 years of age, but are often prominent on segments grown by rams older than 9 years. Geist (1966) concluded the true age ring is a distinct break between adjoining horn segments often present at the terminus of each segment. The correct way to measure age from the lamb ring to the third-year ring is illustrated in Fig. 3. After horns are measured and tagged, photograph the left side of the head. Print the registration number and hunter's name on the photo and attach it to the registration form.

BIGHORN SHEEP
ANNUAL RING MEASUREMENTS

Starting in 1998 three new measurements were started on bighorn sheep horns in addition to the standard horn basal circumference and total horn length measurements. These three new measurements are simply the length of the horn between the lamb ring and the yearling ring (measurement 1), the yearling ring and the 2-year ring (measurement 2) and the 2-year ring and the 3-year ring (measurement 3). ALL OF THESE MEASUREMENTS ARE TAKEN ON THE OUTSIDE PERIMETER OF THE HORN (same place as the total horn length measurement).



Measurements for horn with a lamb tip. The lamb ring is usually only a small swell of the horn and not a true ring. The lamb tip is usually < 1" long. Measurement 1 is made from the lamb ring (small swell) to the yearling ring.



Measurements for a horn with the lamb tip broomed off. Only the second and third measurements are taken. Record N.A. for first measurement on card.

Fig. 3. Bighorn sheep horn characteristics and measuring techniques.

3. Analysis of Data – Managers can evaluate results of harvest strategies by comparing the average ages and age distributions of rams harvested over periods of years. Rates of horn growth between years 1 and year 3, which are affected by weather and habitat conditions, may be useful to identify periods of stress or potential habitat issues. Kill

locations are also useful to delineate or refine bighorn distribution late summer and fall provided they are reported accurately.

4. Disposition of Data – Each regional office at which sheep are presented for registration, retains a copy of registration form. A second copy is sent to the regional office responsible for managing the herd from which the animal was taken. A third copy is forwarded to the Supervisor of Biological Services in Cheyenne. The responsible District Biologist compiles registration data annually after hunting seasons end, and then enters the data for each herd into applicable Job Completion Report databases. The data are also analyzed and discussed in the Annual Job Completion Reports.

C. Tooth Eruption and Wear – Specific ages of female bighorn sheep must be determined for some management applications, for example, when ewes are harvested or captured or when mortalities are encountered. Aging can be based on tooth eruption and wear patterns. Dimmick and Pelton (1996) described tooth eruption patterns in the lower jaw of bighorn sheep up to 4 years old (Table 1). Note the first incisor of bighorns is replaced at Year 1, but the second incisor is not replaced until Year 3.

Table 1. Bighorn sheep tooth eruption and replacement patterns. D = Deciduous tooth, P = Permanent tooth, ( ) = tooth is being replaced.

Age	Age in	Incisors			Canine	Premolars			Molars		
in years	months	1	2	3	1	2	3	4	1	2	3
Birth	0	D	D	D	D	D	D	(D)			
	1	D	D	D	D	D	D	D			
	6	D	D	D	D	D	D	D	(P)		
1	12	(P)	D	D	D	D	D	D	P	(P)	
	16	P	D	D	D	D	D	D	P	P	
2	24	P	D	D	D	D	D	D	P	P	
	30	P	D	D	D	(P)	(P)	D	P	P	(P)
3	36	P	(P)	D	D	(P)	(P)	(P)	P	P	(P)
	42	P	P	D	D	P	P	P	P	P	P
4	48	P	P	P	P	P	P	P	P	P	P

D. Tooth Cementum Annuli – Although managers generally rely on horn annuli and tooth replacement patterns to age sheep, adults of both sexes can be aged very accurately based on laboratory analysis of annular cementum layers (Turner 1977). The first (middle) incisors are selected for cross sectioning because they are the first permanent teeth to erupt. The technique is expensive and time consuming, and should be considered only

when detailed age data are required to address unique management or research needs. Refer to Appendix V for a detailed description of the cross-sectioning technique.

E. Check Stations and Hunter Field Checks

1. Rationale – Check stations and hunter field checks are useful sources of harvest data, including relatively unbiased data on age and sex composition, for many game species. However, data collected from bighorn sheep at check stations is of lesser importance, because the mandatory registration requirement enables managers to collect more detailed information when sheep are presented at regional offices. Hunter contacts during field checks and at check stations are valuable means of enhancing public relations and helping to assure sheep hunters comply with game laws.

2. Application – When checking harvested sheep in the field or at a check station, record the animal's age and sex and the date, hunt area, and location of harvest. Inspect the hunter's license to verify it was filled out properly.

3. Analysis of Data – Personnel should forward all data from checked sheep to the responsible District Biologist after the hunting seasons ends. The District Biologist compiles this information. The age composition of harvested sheep should be reported for each Hunt Area and Herd Unit.

4. Disposition of Data – Information obtained from field checks of harvested sheep should be entered into the responsible Biologist's Job Completion Report database and reported/discussed in the Annual Job Completion Report.

IV. NON-HUNTING MORTALITY

A. Rationale – Non-hunting mortality is not generally an important concern with respect to population management. However, large losses of bighorn sheep occasionally take place in localized situations. Disease outbreaks (especially pneumonia epizootics) or severe winter losses can impact individual populations. Other causes of mortality such as predation, vehicle accidents, and parasites don't normally have population-level impacts. Nevertheless, a herd management evaluation should include an assessment of the relative importance of various mortality agents.

B. Application – When a bighorn sheep is found dead or must be euthanized for management purposes, perform a thorough necropsy if the carcass is fresh enough. Preferably, transport the entire carcass to the Wyoming State Veterinary Laboratory (WSVL) in Laramie for this work. When it is not possible to deliver an intact carcass, personnel should attempt to perform a field necropsy. Suitable instruments are not always available in the field so some of the recommended procedures may not be possible. At a minimum collect and preserve a lung tissue sample and send a specimen to the Wyoming State Veterinary Lab (WSVL) as soon as practical if the suspected cause of death is a disease.

Ideally, conduct a full field necropsy. The following procedures will provide field personnel with the most complete data regarding the animal's condition. Record relevant information on a field necropsy form (Figure 4). Thoroughly examine the animal's pelage and collect any external parasites in a container filled with ethyl alcohol. Subjectively rate body muscle condition based on a scale of 0-5 (0 = very poor; 5 = excellent). To determine the body fat score, make 3 incisions along the animal's back: 1) at base of tail, 2) between the shoulder and hindquarter, and 3) at the shoulder. Score body fat according to the following criteria: 0 = no fat at any location; 5 = fat at location 1 only; 10 = fat at locations 1 and 2; and 15 = fat at all 3 locations. If the age cannot be determined based on tooth replacement patterns or horn rings, extract the lower middle incisors with roots intact, and submit them to the Department's Veterinary Services Laboratory in Laramie for cross-sectioning.

Collect samples to examine for microscopic mites by swabbing deeply inside both ears with long Q-tip swabs. Store Q-tips in a leak-proof Whirl-pak® bag. In addition, remove a piece of ear and store it in a tube filled with formalin. Use Culturettes (available from Veterinary Services) to deeply swab the animal's nasal passage. After swabbing, return the culturette to its housing and crush the bottom to release preservative. Tonsils of dead sheep should also be sampled. Collect samples by swabbing the tonsil with a sterile culture swab, then place the swab in a Port-A-Cul™ media tube (available from Veterinary Services).

After examining the sheep's body condition and collecting samples collected, open the animal and follow standard necropsy protocol. Measure the amount of fat (mm) on the heart, kidney, omentum, and xyphoid. Crack one femur, examine the bone marrow for color and texture, and collect a sample for histological examination. To determine parasite loads, collect fecal samples by removing 5-6 in of the terminal rectum containing at least 20 pellets and place it in a Whirl-pak bag.

If possible, collect at least 2 fresh lung samples from dead bighorn sheep for virus isolation and microbial cultures. Use sterile or very clean instrument to sample fresh tissues. Clean instruments are effectively sterilized by dipping them into 70-90% ethyl alcohol then burning the alcohol off. Use sterile forceps to place tissues in Whirl-pak bags. Do not add preservatives or other materials to the bags. Expel air by collapsing the bag and concurrently spinning it around the tabs at least 4 times.

Bighorn Sheep Necropsy Form

Herd name/location: _____ Animal ID (if any): _____
Location: Township _____ Range _____ Section _____ or UTM _____
WSVL accession #: _____ Date of necropsy: _____
History/signs of disease prior to death:
_____
_____
_____
_____
Estimated age: _____ Sex: _____ Weight (if available): _____
Hair coat quality: Excellent_____ Good_____ Fair_____ Poor_____ Very Poor_____
Species and number of external parasites: Collected? _____
_____
_____
Body muscle (0-5): _____ Back fat score: 0 5 10 15
mm fat on: Heart_____ Kidneys_____ Omentum_____ Xyphoid_____
Bone marrow color: _____ Texture:_____ Subjective body condition:_____
Internal exam notes:
_____
_____
_____
_____
Species and number of internal parasites: Collected? _____
_____
_____
Fetuses: _____ Weight: #1:_____ #2: _____ Sex: #1:_____ #2:_____
Crown-rump: #1:_____ #2:_____ Crown-nose: #1:_____ #2:_____

Tissues fixed:
Heart_____
Liver_____
Spleen_____
Lung_____
Tongue_____
Muscle_____
Kidneys_____
Rumen_____
Reticulum_____
Omasum_____
Abomasum_____
Ileum_____
Gonads_____
Brain_____
Pancreas_____
Ileocecal LN_____
Bladder_____
Bone Marrow_____
Retropharyngeal LN_____
Ear Notch_____
Tonsil_____
Placenta_____

Tissues taken for lab evaluation:
Fecal (parasitology)_____
Blood (red tops) X2_____
Blood (green top)_____
Blood (purple top)_____
Teeth (both Ils) for aging_____
Lungs_____
Tonsil swab in Port-A-Cul_____
Liver_____
Kidneys_____
Brain_____
Rumen contents_____
Feces_____
Fat_____
Nasal Swabs_____
Ear Swabs_____

Fetal Tissues Fixed:
Liver_____
Spleen_____
Kidney_____
Lung_____
Brain_____

Others (list):
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Fetal Tissues Fresh:
Kidney_____
Eyeball_____
Abomasum_____
Spleen_____
Liver_____
Lung_____
Placenta_____

Fig. 4. Bighorn sheep field necropsy form.

Draw blood samples directly from the heart or jugular vein for complete blood counts (CBCs), serum chemistry, trace mineral analysis, and/or serologic testing. Place blood in 1 purple-topped tube (for CBC and blood chemistry), 2 red-topped tubes (1 for serology; 1 for trace mineral analysis), and 1 green-topped tube (for selenium).

Open and thoroughly examine the animal's entire gastrointestinal tract. Record the number and type of macroscopic parasites. Preserve internal parasites in formalin for later identification by the WSVL personnel. Open and examine the uteruses of ewes to determine the presence of fetuses. Record the number, sex, and weight of each fetus, as well as the crown-rump and crown-nose lengths. If reproductive problems have been documented in the herd, collect fetal tissues for histological examination. Refrigerate all tissue samples until they are transferred to the WSVL, but do not allow them to freeze.

C. Analysis of Data – Ship tissues samples to the WSVL as soon as practical after the necropsy is completed. Preferably, hand-deliver them. Most common carriers (e.g., U. S. Postal Service, United Parcel Service, or Federal Express) will not ship samples unless they are bagged and the shipping carton is insulated and protected by an outer fiberboard box. Fill extra space in the box with wadded newspapers or paper towels. Add frozen ice packs to keep samples cool and place accompanying paperwork in a separate plastic bag on top of the insulated container lid.

D. Disposition of Data – Personnel at the WSVL will perform relevant tests on bighorn tissue samples and report results to the responsible District Biologist. The biologist should summarize data from all necropsies in applicable Annual Job Completion Reports.

V. DISTRIBUTION AND MOVEMENTS

A. Rationale – Biologists require detailed information about distribution, migration patterns, and habitat use of bighorn sheep to effectively manage populations. The Department began compiling seasonal distribution data in the early-1970s. However, distribution and habitat use can change through time, in response to weather trends, succession, and land uses. Accordingly, managers should periodically update seasonal range delineations when shifts in bighorn sheep use areas are documented.

B. Application – Sheep locations are obtained from aerial classifications, ground observations, harvest records, and studies involving marked animals. As data are accumulated, record locations on Wildlife Observation Forms using Universal Transverse Mercator (UTM) Coordinates. Approximately every 5 years, District Biologists should update seasonal range overlays for bighorn sheep herds.

C. Analysis of Data – Applicable location records can be retrieved from the Wildlife Observation System, and incorporated into a Geographic Information System (GIS) database. Specific data used to define or update seasonal ranges are sorted based on relevant observation dates and in some cases, based on years of normal to severe climatic conditions. The Department generally maps seasonal ranges on 1:100,000 scale,

transparent overlays. However, seasonal range maps are also being digitized for GIS applications. Seasonal range terminologies are described in Appendix VI.

D. Disposition of Data – After seasonal range overlays are updated, the responsible District Biologist should distribute copies to the Supervisor of Biological Services and to local jurisdictions of federal resource agencies. The District Biologist also retains copies for his own reference and use.

VI. CAPTURE, MARKING, AND TRANSPLANTING

A. Capture

1. Trapping

a. Rationale – In Wyoming, bighorn sheep are captured for the following purposes: marking, collection of biological samples for testing, and to obtain stock for reintroductions. Capture methods usually involve luring or driving sheep into traps. The most successful type of trap has been the drop net. For over 20 years drop nets have been successfully used to capture sheep at the Whiskey Mountain Wildlife Habitat Management Area near Dubois. Nearly 2,000 bighorn sheep have been captured, marked, and transplanted (Hurley 1996). The Department currently owns 2 complete drop net traps, both stored and maintained by the Lander Region.

Bighorn sheep can also be captured effectively with portable drive nets and either permanent or portable corral traps depending on topography and goals of the capture operation. These types of traps have been used successfully in other western states (Coggins 1999). Consult Kock et al. (1987) for information regarding how various capture techniques and operations affect bighorn sheep physiologically.

b. Application – Trap sites should be readily accessible and situated so personnel will be screened from approaching animals. Erect drop nets and corral traps on relatively flat slopes to assure the equipment functions properly. Place corral traps on drained areas to prevent ice buildup. Sheep are baited onto the trap site. Second cutting alfalfa hay and apple pulp are extremely effective. Trapping is generally most successful between December 15 and March 1. At that time, bighorns are usually concentrated on lower elevation winter ranges.

The drop net used at Whiskey Mountain is a 70 X 70 ft canopy comprised of four, 35 X 35 ft nets clipped together. The perimeter of the net is fitted with 3/8 in nylon rope to provide support. A steel ring is fastened to the junction of the 4 smaller nets. The center pole is a 20-ft section of heavy steel pipe. The 4 corner posts are 12 ft sections of heavy steel pipe. Two steel guy cables support each corner post and a guy cable extends from the top of each corner pole to the top of the center pole. The posts and guy lines form a rigid superstructure that supports

the net. The completed trap is stable in high winds often encountered at Whiskey Basin during winter. Refer to Emmerich et al. (1982) for a description of the electronic triggering system for this trap.

c. Analysis of Data – Refer to Section VI. B. 1. c. (Marking).

d. Disposition of Data – Refer to Section VI. B. 1. c. (Marking).

2. Netgunning

a. Rationale – Several companies now specialize in wildlife capture with netguns fired from helicopters. When conducted by trained professionals, aerial netgunning is a rapid, very efficient way to capture bighorn sheep. Depending on terrain and sheep densities, an experienced crew can capture, mark, and release 30-50 animals in a day. Netgun crews can also collect biological samples. Given adequate instruction, a good crew can distribute collars throughout an entire seasonal range within a herd unit in little time.

b. Application – After contracting services of a wildlife capture firm, provide the pilots and capture crews maps on which targeted capture locations are marked. It may be acceptable to ride in the helicopter before the capture operation begins, to orient the crew and identify capture sites. However, for safety reasons, Department personnel should not be involved as crewmembers once the operation is underway. Depending on the company's inventory, the Department may need to supply ear tagging pliers and other capture equipment.

Most netgun operations involve marking, and releasing animals at the capture site. However, captured animals can also be transported to a central location for processing or relocation. When animals are transported, they can be tranquilized to reduce stress. Trailers or other equipment used to relocate bighorn sheep should be equipped as described in Section VI. C. (Transport) of this chapter.

c. Analysis of Data – Refer to Section VI. B. 1. c (Marking).

d. Disposition of Data – Refer to Section VI. B. 1. c (Marking).

3. Immobilization

a. Rationale – Immobilizing drugs can be used to capture small numbers of bighorn sheep in specific locations. Drugs can also be used to sedate sheep while they are in traps and while they are being transported to release sites.

b. Application – Refer to Kreeger (1996) and Appendix VIII for a discussion of various immobilizing agents, their effects on bighorns, and dosage rates. A variety of delivery instruments including rifles, pistols, blowguns, and jab sticks are used to administer drugs. By darting animals from a helicopter, managers can

capture greater numbers of sheep throughout all seasonal ranges. However, aerial darting is usually more effective when animals congregate on winter habitats. If sheep are darted from the ground, they can be baited into a more limited area to reduce costs and save time. Alfalfa hay from 2nd or 3rd cuttings and apple pulp are highly effective baits.

c. Analysis of Data – Maintain detailed records of each immobilization event. Record the type of drug used; dosage; the animal's age, sex, and approximate weight. Document induction times to help refine dosages in the future. Similarly, document the length of time an animal remains immobilized.

d. Disposition of Data – Provide Department Veterinary Staff records from each bighorn sheep. Summarize results of each operation in applicable Job Completion Reports.

B. Marking

1. Neckbands and Ear Tags

a. Rationale – Seasonal observations of marked sheep provide essential data to delineate spring, summer, and/or fall ranges of sub-populations that were trapped on specific winter habitats. Managers can develop harvest strategies targeting specific herd segments based on these data. Sheep are also marked to detect interchange across herd unit boundaries and to estimate harvest rates, natural mortality rates, or longevity.

b. Application – When marking sheep for individual identification, use neckbands and symbols that can be readily seen and read. Each animal should be marked with unique symbol patterns to prevent duplication. In addition, use different colored neckbands at each site. For some applications, numbered, cattle ear tags are suitable to identify individual animals. Colors of ear tags should also correspond to specific trap sites.

Numbered aluminum ear tags should be fitted to both ears of sheep that are marked with neckbands. Tags should also have return instructions imprinted. Sheep sometimes shed neckbands and other types of collars, but seldom lose both ear tags.

c. Analysis of Data – Following each trapping and marking operation, personnel should conduct an extensive monitoring/survey effort to observe marked animals. Enter UTM coordinates of each observation into a Microsoft Access database. Construct GIS layers depicting animal distribution to identify and refine seasonal ranges, migration routes, and herd unit interchange.

d. Disposition of Data – Immediately after each marking operation, forward records to the Supervisor of Biological Services for inclusion in the Department's Marked

Animal Database. Records should at a minimum include: dates animals were captured and marked; species, condition, ages and sexes of marked animals; description of markers including types, colors, numbers, and symbols; and locations of trap sites (UTM coordinates) and release sites if different. Summarize the following information in applicable Job Completion Reports: trapping records, marked animal observations, harvest returns, and other reported mortalities of marked animals.

2. Radio Telemetry

   a. Rationale – Collars with telemetry transmitters cost more than traditional neckbands, however they yield data of substantially greater quantity and quality. Modern telemetry systems are capable of recording and storing thousands of individual locations. This high-density, geographic data enables Biologists to accurately chart daily activity patterns, habitat selection, seasonal distribution, migration corridors, and many other parameters without disturbing the animal once it has been collared.

   b. Application – Transmitter collars are fitted on bighorns during capture operations. To improve visibility, a rubber-impregnated neckband material can be attached with pop-rivets to the standard transmitter collar. These 4-inch wide sheaths are available in various colors and can be numbered to identify individual animals.

   c. Analysis of Data – Several computer programs have been developed to plot telemetry locations and calculate home range sizes. Each program has strengths and weaknesses depending on how many observations of marked individuals are in the data set. Software technology is also continually evolving. Biologists should consult the Cooperative Fishery and Wildlife Research Unit in Laramie, Wyoming for advice regarding the most relevant versions.

   d. Disposition of Data – Immediately after each marking operation, forward records to the Supervisor of Biological Services for inclusion in the Department's Marked Animal Database. Records should include: dates animals were captured and marked; species, condition, ages and sexes of marked animals, description marking devices including types, colors, numbers and symbols; and locations of traps (UTM coordinates) and release sites if different. Summarize the following information in applicable Job Completion Reports: trapping records, marked animal observations, harvest returns and other reported mortalities of marked animals.

C. Transplanting

1. Guidelines for Transplanting Bighorn Sheep within Wyoming – For many years, the Department routinely transplanted bighorn sheep into suitable habitats within Wyoming. Transplants were done either to re-establish populations in vacant, historically occupied habitats or to augment poorly performing herds. In recent years,

increasingly complex issues, such as land use changes, landowner concerns, and habitat suitability, have affected the Department's consideration of sheep transplants. In 2001, the Department and the Domestic Sheep/Bighorn Sheep Interaction Working Group devised guidelines to assist planning and coordination of bighorn sheep transplants.

The following steps were identified to enhance success of future bighorn sheep transplants within Wyoming. First, select a potential transplant area based on presence of essential habitat attributes. Identify Federal agency personnel, non-governmental organizations, and other public interests that should be involved. Next, have regional population and habitat biologists, the Bighorn Sheep Working Group, and Veterinary Services Section assess the feasibility, suitability, and habitat characteristics of the proposed site. Identify funding options and potential source populations of bighorn sheep. Review health histories of source stock to identify potential concerns about disease transmission. Map all seasonal and year-round habitats bighorn sheep are expected to occupy after they become established. The areas mapped should not include areas bighorn sheep are unlikely to use. Next, identify any domestic sheep use within bighorn sheep habitats and evaluate the risk of contact between the 2 species. Finally, determine a post-season population objective for the new bighorn herd.

If district personnel conclude a transplant is feasible and desirable, the responsible Region should forward Wildlife Division Administration a recommendation to proceed. After reviewing the proposal, Division Administration should forward the Director's Office a recommendation to approve the plan and regional personnel should notify the appropriate Game and Fish Commissioner. If the Commissioner supports the proposal, begin the public notification and review process by contacting potentially affected interests.

If the release site or surrounding habitats are public lands, begin contacts with Federal agency personnel and affected livestock permittees. All parties should be given a clear explanation of: 1) whether or not "buffer zones" between domestic and bighorn sheep will be sought; 2) whether or not the livestock operator will be indemnified should co-mingling between domestic and bighorn sheep lead to a disease outbreak; and 3) whether or not the livestock permittees' Federal grazing privileges could be affected by the presence of bighorn sheep. These contacts and discussions should be recorded in the official record.

If the release site or surrounding habitats include private lands, contact potentially affected landowners to discuss the issues outlined in the preceding sections. Summarize results in the official record.

After individual contacts are completed, schedule a meeting of all public land managers and private landowners/lessees who have an interest. Also invite members of the Domestic Sheep/Bighorn Sheep Interaction Working Group. If attendees support the transplant, proceed to the next step in the review process by contacting

sportsmen and conservation organizations. You should also plan media releases at this stage.

If concerns are expressed regarding the transplant, open houses or additional meetings can be scheduled to provide opportunities for additional public involvement. Locate meetings in the town nearest the transplant site and a larger, central location like Casper. Record all written and verbal comments in the public record. Forward copies of comments to Wildlife Division Administration, the Director's Office, and the Game and Fish Commission. If circumstances warrant, regional personnel involved with the transplant proposal can meet with Department Staff and/or the Commission to discuss the proposal further.

If the Commission approves the transplant, personnel should secure funding, establish a schedule, identify a source herd and acquire sheep, then complete the transplant operation. Encourage media coverage of release(s). Attach radio collars to as many released animals as feasible. Closely monitor the newly established herd post-release and lethally remove any bighorn sheep that comes in contact with domestic sheep, to prevent disease transmission.

2. Transport

   a. Rationale – Bighorn sheep transplants are expensive, labor-intensive operations to plan and carry out. Given the costs involved, it is prudent to enhance prospects for success by ensuring the sheep are transported with a minimum of stress and injury.

   b. Application – Four-horse or larger stock trailers are generally the most suitable equipment to transport bighorn sheep within Wyoming. However, a variety of other methods are also employed. Helicopters are sometimes used to transport sheep, especially from capture sites to staging areas and to inaccessible release areas. Depending on terrain at the release site, sheep can also be transported in boxes or crates mounted on pick-up trucks or flatbed railroad cars. Cover larger openings on trailers with plywood or other materials to minimize noise and other environmental stimuli. Attach panels in a manner that allows adequate ventilation when the trailer is stopped, but also affords shelter from wind, heat and extreme cold during transport. Separate ewe/lamb groups from rams either by installing dividers within a trailer, or by hauling these groups in different trailers. Trailers used to transport sheep should be low clearance to facilitate loading and unloading. Dispense wood chips, sawdust, or clean hay throughout the interior to provide traction and bed sites. Stock trailers maintained by most Department regions can be adapted to transport wildlife. Lander Region maintains a trailer (named the "Ewe Haul") that is specifically adapted to transport sheep.

   c. Analysis of Data – Refer to subsection VI. B. 1. c. (Marking).

   d. Disposition of Data – Refer to subsection VI. B. 1. d. (Marking).

3. Release

a. Rationale – When sheep are released into the wild or placed in a research facility, a paramount objective is to assure all animals safely leave the trailers, acclimate to their new environments, and experience the least possible stress and injury.

b. Application – Do not hold sheep any longer than is necessary. Upon arrival at the release site, assign personnel to assure the area is free of obstructing objects. Clear news media and other spectators from potential escape lanes. Move trailers or other transport equipment into position and release bighorns from confinement. If possible minimize noise and encourage spectators to leave the area as soon as possible so animals can adjust to their new environment. Always release animals during daylight hours.

c. Analysis of Data – Refer to subsection VI. B. 1. c. (Marking).

d. Disposition of Data – Refer to subsection VI. B. 1. c. (Marking).

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Chapter 7

Mountain Goat (*Oreamnos americanus*)

Doug McWhirter and Larry Roop

I. INTRODUCTION –

A. History in Wyoming – The mountain goats currently found in Wyoming are not generally considered native to the State, but originated from transplants in Montana and Idaho. In the conterminous U.S., the species' distribution was historically limited to northern Idaho, northwestern Montana and Washington. Archaeological evidence has confirmed mountain goats were present in western, central, and southeastern Wyoming during the late Pleistocene approximately 10,000 to 15,000 years ago (Laundre' 1990, Guenzel 1978, Guilday et al. 1967, Anderson 1974). Although evidence of more recent habitation is generally lacking, some historical accounts contain reports of isolated observations. A U.S. Army hunting party in the southern Teton Range of Wyoming reportedly killed a mountain goat in the late 1940s (Cooke 1947-1948), and a map produced by Hornaday (1914) entitled "Distribution of the White Mountain Goat," depicts an "actual occurrence" in the Teton Range near Jackson, Wyoming. The assertion mountain goats were present in Colorado prior to 1900 is given credence by some historical documents (Irby and Chappell 1994), which increases the likelihood they may also have been present in Wyoming.

However, additional investigations have yielded no substantive evidence that goats were present in Wyoming before the existing populations became established. Although some early trappers and explorers mentioned "goats" in their journals, biologists believe these reports referred to bighorn sheep as the terms were used interchangeably and light colored, wild sheep were occasionally confused with goats (Walpole 1997). An earlier investigation whether mountain goats were historically present in Wyoming concluded they were not (Skinner (1926). More recent investigations have reached the same conclusion (Laundre' 1990, Varley and Varley 1996, Schullery and Whittlesey 2001).

B. Current Status – The Department currently recognizes 2 distinct herds of mountain goats in Wyoming. The Beartooth Herd became established after the Montana Department of Fish, Wildlife and Parks transplanted 14 goats into the Rock Creek drainage near the Wyoming-Montana border in 1942 (Cooney 1946). The Palisades Herd originated from 5 goats the Idaho Department of Fish and Game transplanted into the Palisades Creek drainage near the Wyoming-Idaho border in 1969 (Hayden 1989). Current population objectives for the Beartooth and Palisades Herds are 200 and 50 goats, respectively. Both populations are interstate herds, which can complicate management and requires coordination between state wildlife agencies. McWhirter (2004) provides a detailed account of these transplants and their subsequent expansion into Wyoming.

C. Natural History –

1. Productivity – Mountain goats breed between early November and mid-December (Geist 1964). Characteristically, males move among groups of females, tending estrous nannies for 2-3 days (DeBock 1970, Chadwick 1983). In some populations, nannies reach sexual maturity at age 2 and produce their first kid at age 3 (Peck 1972, Stevens 1980, Bailey 1991). In other populations, breeding is delayed until age 3 (Festa-Bianchet et al. 1994). This delay in sexual maturity dramatically reduces the potential for rapid growth in a mountain goat population (Lentfer 1955, Hayden 1990). Twinning rates are generally low, but can be higher in expanding populations on high quality ranges (Holroyd 1967, Hibbs et al. 1969, Hayden 1989, Foster and Rahs 1985, Houston and Stevens 1988). Nannies rarely bear triplets (Hayden 1989, Hanna 1989, Lentfer 1955, Hoefs and Nowlan 1998).

   Mountain goat kids are precocious and begin to consume forage and ruminate within days after birth (Brandborg 1955, Chadwick 1983). Nannies with new kids spend the first 2 weeks in seclusion, and then congregate in nursery groups along with other nannies and kids. Nursery groups often include yearlings. However, 2 year-old billies generally leave the nursery herd and become solitary or form small bachelor groups. Kids remain with their mothers through their first winter. The presence of the mother is thought to increase survival of kids, although orphaned kids are known to survive (Foster and Rahs 1982). From the time goats reach sexual maturity, reproductive success generally increases until age 8, after which it declines (Stevens 1980, C.A. Smith 1984, Bailey 1991).

   Productivity is often described by one of the following ratios: kids per100 adults; kids per 100 non-kids (older goats); or kids per 100 females. Managers should interpret such data cautiously, as ratios of kids per 100 adults are frequently reported from classifications in which yearlings are not distinguished from adults, meaning the ratio is actually kids per 100 “older goats.” Productivity varies markedly among locations and among years (Table 1). Bailey and Johnson (1977) determined productivity of introduced herds ranged from 36-100 kids:100 non-kids (average = 59:100). In native herds, kid:non-kid ratios ranged from 9-52:100 (average = 28:100). Population density also influenced goat reproduction (density dependence). For example, Adams and Bailey (1982) documented kid production declined as populations increased in Colorado.

   When goats are classified as kids and non-kids, sex composition is not determined. Therefore, kid:non-kid ratios can be imprecise measures of productivity due to unknown and variable composition of males. In one example, non-hunted and heavily hunted herds of mountain goats had kid:non-kid ratios of 32:100 and 31:100, respectively (Hebert and Turnbull 1977). However, the unhunted/lightly hunted herd had a kid:female ratio of 82:100, while the heavily hunted herd had a kid:female ratio of 52:100. When it is possible to obtain more detailed classification information, kid:female and yearling:female ratios provide additional information that is useful to monitor populations.

Table 1. Productivity (kids:100 non-kids) of mountain goats from locations throughout the species' range.

Location	kids:100 non-kids	Source
Kenai Peninsula, Alaska	20-44	Del Frate and Spraker (1994)
Southeast Alaska	15-47 (avg.=28.6)	Porter (2002)
Southeast Alaska	2-36 (avg.=22.9)	Barten (2002)
British Columbia (various locations)	7.7 – 27.5 (avg.=18.2)	Hebert and Turnbull (1977)
Similkameen Mountains, British Columbia	8-60 (avg.=25.8)	Bone (1978)
Eagles Nest Wilderness, Colorado	48	Thompson and Guenzel (1978)
Selway River, Idaho	28	Brandborg (1955)
Absaroka Mountains, Montana	29-60 (avg.=38.4)	Swenson (1985)
Absaroka Mountains, Montana	25-47 (avg.=34.6)	Varley (1996)
Absaroka Mountains, Montana	17-39	Lemke (2004)
Gallatin Mountains, Montana	13-48	Lemke (2004)
Square Butte, Montana	29-70 (avg.=47.8)	Williams (1999)
Glacier National Park, Montana	42	Petrides (1948)
Yellowstone National Park, Montana/Wyoming	36	White (2003)
Wallawa Mountains, Oregon	0-61 (avg.=28.7)	Coggins and Matthews (2002)
Washington (various locations)	27-58 (avg.=35.0)	Michalovic (1984) from Johnson (1983)

Kid:female ratios reported from British Columbia ranged from 15-73:100 and averaged 40:100 (Hebert and Turnbull 1977). In Idaho, Brandborg (1955) documented kid:female ratios ranging from 22-79:100, while Anderson (1940) reported 73 kids:100 females in Washington. Kid:female ratios in the Sawtooth Range of Montana ranged from 46-78:100 (M.J. Thompson 1981) and 49-67:100 in the Absaroka Range (Varley 1996). Yearling:female ratios in British Columbia were 3-41:100 and averaged 16:100 (Hebert and Turnbull 1977). Brandborg (1955) documented yearling:female ratios of 10-39:100 along the Salmon and Selway Rivers in Idaho. Varley (1996) reported yearling:female ratios that ranged from 17-47:100 in the Absaroka Mountains of Montana.

2. Natural mortality – Mountain goats have adapted to harsh environments through a strategy that focuses more on the survival of individual goats than on production of offspring (Hayden 1990). Many researchers hypothesize severe winters and their impact on forage availability and energy expenditures are the principal factors leading to mortality among mountain goats (Dailey and Hobbs 1989). Adams and

Bailey (1982) demonstrated a negative correlation between snow depth and kid:adult ratios. On the other hand, a positive relationship was detected between reproductive rates and total winter precipitation 1.5 years prior to birth (Stevens 1983). In Alaska, severe winters were associated with poor reproduction the following spring (Hjeljord 1973).

Annual mortality rates in Alaska were 29% for yearlings, 0-9% for prime age classes 2-8, and 32% for goats older than 8 years (C.A. Smith 1986). Goats older than 8 died primarily from predation or other natural factors, while hunting was the major source of mortality among prime-age goats. Annual mortality in Alberta was 28% for yearling males and 16% for yearling females (Festa-Bianchet and Cote' 2002). Mortality of 4-7 year old males was 5%, but increased dramatically after 8 years. Between ages 2 and 7, mortality of females was 6%. After mortality and emigration, only 39% of yearling males remained in the population as 4 year olds. In a rapidly growing population in Idaho, kid mortality was only 12% and yearling mortality only 5% (Hayden 1989). However, mortality of marked kids in the Black Hills of South Dakota was 40%; annual mortality of yearling and older goats was estimated to be 14% (Benzon and Rice 1988).

Mortality of young goats can be high during their first winter. Kid and yearling mortality during a severe winter was 73% and 59%, respectfully, compared to only 27% and 2% during a mild winter (Rideout 1974a). During a series of severe winters in Colorado, kid mortality reached 56% and kid:adult ratios dropped from 48:100 to 14:100 (R.W. Thompson 1981). Populations declined 82-92% following severe winters in coastal British Columbia (Hebert and Langin 1982).

Grizzly bears (Festa-Bianchet et al. 1994, Jorgenson and Quinlan 1996, Cote' and Beaudoin 1997), wolves (Fox and Streveler 1986, C.A. Smith 1986, Jorgenson and Quinlan 1996, Cote' et al. 1997), mountain lions (Brandborg 1955, Rideout and Hoffman 1975, Johnson 1983), coyotes (Brandborg 1955), golden eagles (Brandborg 1955, B.L. Smith 1976), and wolverines (Guiguet 1951) are predators of mountain goats. In west-central Alberta, annual mortality of juveniles was 42% (Smith et al. 1992). Most of the mortality took place before November. Grizzly bears were the most significant predator of young mountain goats (Festa-Bianchet et al. 1994). Collectively, wolves, grizzly bears, and mountain lions accounted for 88% of the mortality. In Alaska, goat remains were found in 62% of wolf scats (Fox and Streveler 1986). On the other hand, only 2% of wolf scats from Banff National Park, Alberta, contained goat remains (Huggard 1993). In Yellowstone National Park, only 2 of approximately 3,000 prey animals killed by wolves (confirmed) were mountain goats (D.W. Smith, National Park Service, pers. comm.).

Because of the precarious habitats goats frequent, accidental deaths from falls, avalanches or rockslides, and being struck by lightning are relatively common events (Brandborg 1955, Hayden 1990, Roop 1996, Hanna 1989). The oldest goats recorded in the literature were 14-15 year old males and 16-18 year old females (Cowan and McCrory 1970, Festa-Bianchet and Cote' 2002).

Internal parasites include lungworms (Block 1970, Samuel et al. 1977, Cooley 1976), stomach worms (Boddicker et al. 1971, Johnson 1983), muscle worms (Johnson 1983, K.G. Smith 1982), cestodes (Samuel et al. 1977), and protozoans (Brandborg 1955, Shah and Levine 1964, Todd and O'Gara 1968, Johnson 1983, Mahrt and Colwell 1980). Ticks and lice have also been documented on mountain goats (Brandborg 1955, Kerr and Holmes 1966, Boddicker et al. 1971). Diseases include pasteurellosis (Brandborg 1955), contagious ecthyma (Samuel et al. 1975, Hebert et al. 1977), and capture myopathy (Hebert and Cowan 1971a, Jorgenson and Quinlan 1996). These afflictions are not generally a significant source of mortality.

3. Habitat Use – Mountain goats occupy well-defined seasonal habitats including wintering areas, yearlong habitats, spring-summer-fall areas, and parturition or "kidding" areas. They also migrate between seasonal ranges, although such movements tend not to follow distinct routes. Some seasonal migrations are merely shifts in elevation. A few longer movements of up to 24 km have been documented (Holroyd 1967, Johnson 1983). Daily movements are very limited, especially in winter. As a result winter home ranges are often quite small (Brandborg 1955, B.L. Smith 1976). Nocturnal movements are not common, but have been recorded (Rideout 1974a).

   Home ranges vary considerably. As a rule, males occupy the largest home ranges. In the Sawtooth Range of Montana, Thompson (1981) documented home ranges of 18-22 km^2 for adult males and 2-14 km^2 for adult females. In the Sapphire Mountains of Montana, Rideout (1977) documented average home ranges of adult males and females were 21.5 km^2 and 24 km^2, respectively. Joslin (1986) reported home ranges varying from 23-182 km^2 for adult males and 16-64 km^2 for adult females. In the Black Hills of South Dakota, Benzon and Rice (1988) determined adult males and females had average home ranges of 29 km^2 and 5 km^2, respectively.

   At times, goats disperse considerable distances outside traditional ranges. This type of movement (relatively common at high population densities) is typically made by young billies, and may be a precursor to range expansion. Dispersal movements of 16-93 km were documented within a high-density (14 goats/km^2) population on the Olympic Peninsula (Stevens 1980). In Wyoming, McWhirter (2004) documented bobcats moved up to 90-130 km from transplant sites in Montana and Idaho.

   Goats are found in two general habitat types, the coastal mountains of British Columbia and Alaska (Herbert and Turnbull 1977) and interior, or continental mountains of the Rocky Mountains. Goats favor alpine meadows or plateaus in close proximity to inaccessible cliffs and steep ridges (Haynes 1991, Von Elsner-Schack 1986). Goats, especially nursery groups, rarely venture more than 400 m from the security of cliffs (Haynes 1991, Stevens 1979, K.G. Smith 1982). Coniferous forests are found within most goat ranges and provide shelter from rain, snow, and solar radiation. Conifers are also consumed as forage.

Goats are dietary generalists (Casebeer 1950, Brandborg 1955, Hibb 1967, Johnson et al. 1978, Adams and Bailey 1983). Depending upon the area, they make use of grasses, forbs, shrubs, and conifers. Johnson (1983) surmised goats select habitats that are topographically secure, and then eat what is available. Goats also make substantial use of mineral licks (Brandborg 1955, Hebert and Cowan 1971b, DeBock 1970, Stevens 1979), especially in spring. In some populations, this craving prompts goats to travel long distances (Hopkins et al. 1992), swim rivers (Singer 1978), and traverse heavily forested areas far from escape terrain (Turney and Blume 2004a.

4. Response to Harvest – Mountain goat herds are acutely susceptible to being overharvested. Although compensatory reproduction has been documented in some herds (Swenson 1985, Williams 1999), several investigators have concluded harvest mortality has had an additive effect (Hebert and Turnbull 1977, Kuck 1977, Smith 1986, Smith 1988). Cote' et al. (2001) urged cautious interpretation of population data that suggest reproduction may be compensatory. By and large, the sustainable harvest is limited due to the species' delayed sexual maturation, low productivity, and potential for high natural mortality. Reproduction is often greatly depressed in herds that are overexploited or subjected to extreme weather events. Low productivity and declining populations often continue years after hunting seasons are closed (Kuck 1977, K.G. Smith 1988). Goat herds can also respond differently to hunting pressure depending on their status within the ungulate irruption sequence of initial growth, stabilization, decline, post decline (Caughley 1970). In addition, goat populations that inhabit shrub-dominated ranges may not respond in a compensatory manner if habitats have been damaged (Swenson 1985).

   Although the impacts of harvest tend to vary among herds, many investigators have recommended appropriate harvest rates for mountain goats. In west-central Alberta, goat populations increased for a period when a constant harvest rate of 4.5-9.0% was applied, but then dramatically declined (K.G. Smith 1988). The harvest rate in an introduced population in central Montana averaged 20% with no decline in total counts (Williams 1999). Harvest rates that ranged from 5.7-23.1% and averaged 15.7% produced similar results in another introduced population in Montana (Swenson 1985). A much more conservative harvest rate of 1% has been recommended based on studies in Alberta (Festa-Bianchet and Cote' 2002). Harvest rates in British Columbia ranged from 0.36-9.0%, but purportedly could have been increased if harvest was uniformly distributed (Hebert and Smith 1986). Managers generally prescribe overall harvest rates of 3-7% in most states and provinces, but encourage minimal female harvest. Some jurisdictions have set female harvest thresholds at $\leq$30-50% of the total harvest.

   Data from annual trend counts and productivity surveys are essential to establish harvest quotas and manage goat herds toward population objectives. Mandatory checks of harvested goats are also essential to accurately monitor harvest including the sex ratio of harvested animals, and to determine hunter success. Although productivity is comparatively low, goats are polygamous. Therefore, harvest of male goats is emphasized to allow greater sustainable harvest. To encourage the harvest of

billies, most wildlife agencies provide literature to mountain goat hunters informing them about how to identify sex and where to find billies.

II. CENSUS

A. Herd Classifications/Trend Counts

1. Rationale – Aerial classifications and trend surveys are the most cost effective and practical means of obtaining data to assess population status. Productivity is determined from classifications and aerial counts are used to monitor population trends. These surveys are normally conducted prior to the hunting season (pre-season). Ground surveys enable managers to obtain more detailed sex and age data, which can be used to estimate productivity and recruitment of yearlings.

2. Application – Throughout most of the year, goats remain widely scattered in rugged, partially timbered terrain, typically in groups of 5 or fewer (Hebert and Wood 1984, Varley 1996, Poole et al. 2000). This behavior makes it difficult to obtain adequate classification samples. However, goats congregate in larger groups during late spring to early summer as they stage on windswept, grassy plateaus before moving to summer ranges at higher elevations. In Wyoming, larger groups of goats can usually be found and classified in early to mid July. Weather significantly influences activity patterns, habitat use, and visibility of mountain goats. Activity peaks usually occur during clear weather at sunrise and sunset when goats use more gentle topography farther from secure terrain (Fox 1978). Avoid mornings after severe storms and lightning as goats avoid these events by moving off higher elevations. Similarly, avoid conditions under which goats seek thermal cover in timber.

   Sex cannot be reliably distinguished until mountain goats reach $\geq$ 1 year of age. Horn characteristics that distinguish sex are not apparent until age 2. Methods used to classify sex of goats in the field are: 1) observation of genitals – the male's scrotum can be seen in summer (it is obscured by long pelage in winter) and a black vulva patch is visible on females $\geq$ 1 year when the tail is raised; 2) urination posture – male goats "stretch" when urinating whereas females "squat"; 3) horn morphology – horns of the male are generally more robust than those of the female and curve gently backward throughout their length; horns of females are thinner and straighter with a backward "crook" approximately 5-7 cm from the tip.

   Adult males are generally 10-30% larger than adult females (Brandborg 1955, Houston et al. 1989) and appear stockier or heavier in the chest and shoulder. Beards of males are also heavier and broader than beards of females. During the breeding season, males urinate on themselves and paw dirt onto their body, creating a dirty appearance. Adult males ($\geq$ 2 years) are normally solitary or consort with small groups of other males. Generally, solitary adult animals seen away from herds of nannies, kids, and yearlings, are adult males, though this criterion isn't entirely reliable (B.L. Smith 1988, Hibbs 1965). In some cases, the stage of hair molt can indicate sex and reproductive status (Brandborg 1955, Chadwick 1983). Adult males

are the first to shed their winter coat, usually beginning in May. Nannies with kids are the last and often do not shed until August. Both males and females possess glands at the base of their horns. These are thought to have some function in mating behaviors (Geist 1964). The glands of males are more prominent when examined at close range.

Aerial surveys of mountain goats are conducted from slow moving, fixed-wing airplanes or helicopters. However, helicopters can disturb and displace goats, and have even caused accidental mortalities (Cote' 1996). Aerial surveys should be scheduled when fidelity to spring/summer range is at a maximum, and movements are at a minimum. These surveys should be done only when weather conditions are suitable for low level flying in alpine areas. Goats are generally classified as the number of kids and non-kids, because age and sex are difficult to distinguish accurately from an aircraft. Yearlings are included in the adult or "non-kid" segment. The observer may need to count larger groups 2 or 3 times because kids tend to hide under the nannies when the group is disturbed or agitated by a low-flying aircraft. Adult males are harder to locate, because they are usually solitary or associate in small bachelor groups during the spring/summer period. Only subadult males are commonly found within herds of nannies and kids.

Yearlings are difficult to classify from an aircraft. Only 50% of known yearlings were correctly classified during aerial surveys in Alberta – many were mistakenly classified as kids (Gonzalez-Voyer et al. 2001). Kids remain with the nanny until they are over one year old. By the second summer, kids born the prior season (yearlings) are about half adult size and 1.5 times larger than kids born in the current year. Any goat followed by a kid is a female at least 3 years old.

Aerial trend counts are done periodically to monitor status of mountain goat populations. Detection rates between 46% and 70% have been documented for aerial surveys (Smith and Bovee 1984, Cichowski et al. 1994, Poole et al. 2000, Gonzalez-Voyer et al. 2001). Therefore, trend counts represent minimum or sub-minimum estimates of the population. During the years trend counts are scheduled, they can be combined with aerial classifications. However, trend counts require expanded coverage of goat habitats beyond the areas typically sampled during aerial classifications.

Estimates of kid survival and yearling recruitment are based on ratios of kids and yearlings to females, and this type of information may improve managers' confidence in population assessments and trend analyses. When more precise sex and age ratios are desired for population management, classifications must be done from the ground at close range. Typically, biologists are able to obtain larger classification samples during late spring or summer when goats congregate on traditional ranges and are more accessible. In addition, sex and age can be distinguished more easily after goats have shed their long winter pelage. Ground counts targeting specific areas may also be useful to classify scattered groups missed during aerial counts.

3. Analysis of Data – Kid: adult ratios estimated from aerial classification data provide coarse information about herd productivity. Ratios of yearlings, lambs, and adult males to adult females are obtained from ground classifications and provide more refined data on productivity, recruitment, and herd dynamics. Productivity and recruitment information can be compared to series of data from prior years to detect population trends and responses to harvest, climate, changing habitat conditions, and other environmental factors. Results of trend counts are analyzed in conjunction with classification data to estimate the minimum population size and to evaluate performance (e.g., productivity) of the population.

4. Disposition of Data – Data from classifications and trend counts are recorded on Wildlife Observation Forms and entered in the appropriate JCR database. The responsible biologist summarizes herd composition data and trend counts in the annual JCRs for the applicable herd unit.

III. HARVEST SURVEY AND AGE DETERMINATION

A. Harvest Survey – Consult Appendix III (Harvest Surveys), Section II.D (In-house Surveys).

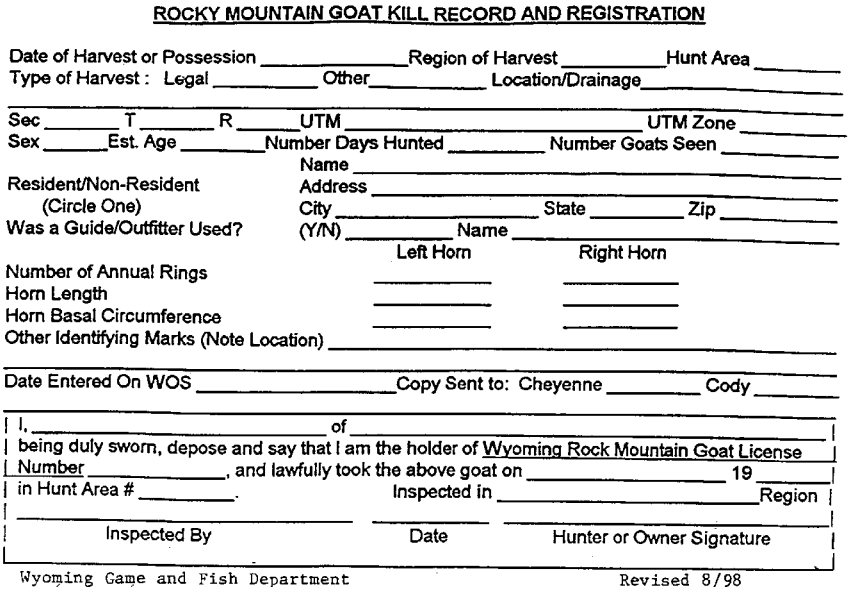
B. Mandatory Registration of Mountain Goat Heads/Horns

1. Rationale – Accurate harvest statistics are vital to properly manage populations of mountain goats. Prior to 1998 all goat hunters were surveyed by mail to obtain harvest information. However, responses were inconsistent and some non-respondents and persons who returned incomplete or illegible surveys could not be reached to conduct a follow-up survey. To obtain more complete harvest information, in 1998 the Department implemented a regulation requiring mandatory registration of mountain goat heads.

2. Application – Persons who legally harvest a mountain goat are required to register the skull or horns attached to skull plate at a Department Regional Office within 15 days of possession. Department personnel record the following data on a Kill Record and Registration Form (Fig. 1): hunter's identification and contact information, sex and age of the mountain goat, horn measurements (length and basal circumference), location where the goat was harvested, days of hunting, and number of other mountain goats seen. Although numbered plugs are affixed to bighorn sheep horns at the time they are registered, mountain goat horns are not plugged, nor are photographs taken.

   Each harvested goat is aged based on visible horn annuli (Stevens and Houston 1989). Mountain goats do not form a distinct ring the first year, so the actual age is the number of horn rings plus one (Fig. 2). For example, a goat harvested in the fall is 5 years old if 4 rings are visible. When inspection of horn annuli is not possible (e.g. broken horns), age can also be determined from tooth eruption and wear patterns (Table 2).

Mountain goats can also be aged precisely based on laboratory analysis of annular cementum layers. The first (middle) incisors are selected for cross sectioning because they are the first permanent teeth to erupt, and they are relatively easy to extract. This technique is expensive and should be considered only when detailed age data are required and inspection of horn annuli is not possible. Consult Appendix V (Aging) Section III (Laboratory Techniques Based on Cementum Annuli).



ROCKY MOUNTAIN GOAT KILL RECORD AND REGISTRATION

Date of Harvest or Possession _____ Region of Harvest _____ Hunt Area _____
Type of Harvest : Legal _____ Other _____ Location/Drainage _____
Sec _____ T _____ R _____ UTM _____ UTM Zone _____
Sex _____ Est. Age _____ Number Days Hunted _____ Number Goats Seen _____
Name _____
Resident/Non-Resident (Circle One) Address _____
City _____ State _____ Zip _____
Was a Guide/Outfitter Used? (Y/N) _____ Name _____

	Left Horn	Right Horn
Number of Annual Rings		
Horn Length		
Horn Basal Circumference		

Other Identifying Marks (Note Location) _____
Date Entered On WOS _____ Copy Sent to: Cheyenne _____ Cody _____
I, _____ of _____
being duly sworn, depose and say that I am the holder of Wyoming Rock Mountain Goat License Number _____, and lawfully took the above goat on _____ 19 _____ in Hunt Area # _____. Inspected in _____ Region
Inspected By Date Hunter or Owner Signature
Wyoming Game and Fish Department Revised 8/98

Fig. 1. Wyoming Rocky Mountain Goat Kill Record and Registration Form.

3. Analysis of Data – Information from registration cards is used to calculate several statistics including: overall hunter success, resident and non-resident hunter success, effort (days per animal harvested), age and sex composition of the harvest, and total recreation days (total days collectively expended by all hunters).

4. Disposition of Data –The Regional Office where each mountain goat is registered retains one copy of the registration form. A second copy is sent to the Regional Office (Wildlife Management Coordinator) that manages the herd from which the goat was harvested. A third copy is sent to the Supervisor of Biological Services at the Cheyenne Headquarters. The responsible wildlife biologist compiles registration data annually after each hunting season. Data are summarized and entered into the appropriate JCR database. Data from goat registrations are also analyzed and discussed in the annual JCRs.

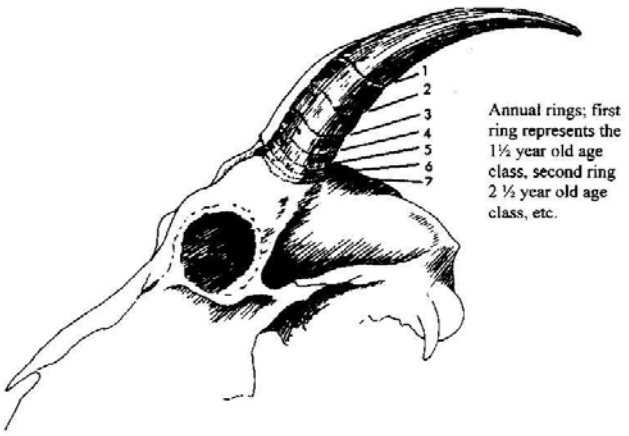


Fig. 2. Aging mountain goats based on horn ring annuli.

Table 2. Tooth eruption and replacement patterns in mountain goats (Brandborg 1955).

	Incisors			Canine	Premolars			Molars		
Age	1	2	3	1	2	3	4	1	2	3
1 Week	(D)	(D)	(D)		(D)	(D)	(D)			
6 Months	D	D	D	D	D	D	D	(P)		
10 Months	D	D	D	D	D	D	D	(P)	(P)	
15-16 Months	(P) P	D	D	D	D	D	D	P	(P)	(P)
23 Months	P	D	D	D	D	(P)	(P)	P	P	(P)
26-29 Months	P	(P)	D	D	(P)	(P)	(P)	P	P	(P)
38-40 Months	P	P	(P)	D	P	P	P	P	P	P
48 Months	P	P	P	(P)	P	P	P	P	P	P

D – Deciduous tooth
P – Permanent tooth
( ) – Parentheses indicate tooth is being replaced

C. Check Stations and Hunter Field Checks

1. Rationale – Check stations and hunter field checks are traditionally employed to enforce game laws, and to collect biological data including sex, age, and condition of harvested animals, antler/horn measurements, geographic distribution of the harvest, and biological samples for laboratory analysis. Sometimes, data from field checked animals are compared against harvest survey results to detect bias. However, data from harvested mountain goats are obtained through the mandatory registration requirement. Check stations and field checks are impractical to monitor mountain goat harvest because few licenses are issued, most hunting is done in remote locations, and seasons are comparatively long. However, periodic field checks are valuable to assure compliance with game regulations and to enhance public relations with sportsmen.

2. Application – When checking harvested mountain goats in the field or at a check station, record the hunter's identification and license number, hunt area, date and location of harvest, and the sex and age of the harvested animal. Inspect the license to verify proper tagging procedures were followed. Advise or remind the hunter that he needs to present the head and horns for registration at a Department regional office within 15 days of the date of harvest.

3. Analysis of Data – Data from field checks should be compared against the information on the Kill Record and Registration Form to ensure accurate reporting and to identify potential enforcement violations.

4. Disposition of Data – The harvest data reported in the Annual JCRs are taken from the mandatory registrations, not field checks. If inconsistencies are found between field checks and Kill Record and Registration Forms, these should be reconciled. However, any inconsistencies that may indicate a violation should be reported to the appropriate game warden.

IV. NON-HUNTING MORTALITY

A. Rationale – Natural mortality is often quite substantial in mountain goat populations. For instance, significant losses may take place during severe winters. Accidental deaths from avalanches, falls, and lightning strikes are also common, but typically do not have population level effects. On the other hand, deaths from parasites, disease and starvation may indicate an overpopulated environment or other conditions producing physiological stress. If a goat population begins to deplete the limited resources in alpine habitats, deaths from pathogenic organisms and other secondary causes may become increasingly prevalent, and are often the first indication of population or habitat problems.

   Accidental or stress-related deaths may also increase in response to human activities or disturbances such as helicopter flights, causing potential problems for the herd (Cote' 1996, Haynes 1991). It is important to maintain records of all goat mortalities and determine causes where possible.

B. Application – When a dead mountain goat is reported or encountered in the field, personnel should attempt to document the cause of death. If the carcass is in satisfactory condition, perform a thorough field necropsy. If possible, transfer the entire carcass to the Wyoming State Veterinary Laboratory (WSVL) in Laramie. Consult Chapter 6 (Bighorn Sheep), Section IV.B. (non-hunting mortality) for a detailed discussion of field necropsy techniques. Record all mortalities in the Wildlife Observation System, report and summarize them in each annual JCR, and maintain files of lab reports and lab test or necropsy results.

C. Analysis of Data – Forward all samples collected during field necropsies to the WSVL as soon as practical. Consult Chapter 6 (Bighorn Sheep), Section IV.C. (non-hunting mortality) for procedures to follow when delivering samples to the WSVL.

D. Disposition of Data – Test results from the WSVL will be sent to the responsible wildlife biologist. Summarize and discuss mortality events and necropsy results in the applicable Annual JCRs.

V. DISTRIBUTION AND MOVEMENT

A. Rationale – To effectively manage a population of mountain goats, biologists must identify herd boundaries, seasonal ranges, crucial habitats, and migration corridors. However, the species' distribution and movement patterns are difficult to study due to the rugged, remote terrain goats typically inhabit. Herd unit and seasonal range maps (overlays) are maintained in the Cheyenne Headquarters. These maps are used extensively by Department personnel to evaluate potential impacts of land use decisions and other resource agencies frequently consult them as well.. Refer to Appendix VI (Wildlife Distribution and Seasonal Habitat Mapping) for procedures to update season range overlays, and for standard definitions and keys to seasonal range types.

B. Application – Several sources of information are used to delineate seasonal ranges and movements, including marking studies, aerial and ground surveys, and incidental observations. Mountain goats congregate seasonally in large bands or nursery groups, however, most of the year they are scattered widely in rugged, inaccessible terrain. For this reason, distribution and movements are often studied with the aid of telemetry and marked animals. Standard telemetry methods are used, but rock cliffs and canyons can create signal bounces that produce inaccurate readings. Recent advances in Global Positioning System (GPS) technology have been an invaluable aid to mountain goat research (Taylor 2002, Poole and Heard 1998, Keim 2004a, Turney 2004b). Individual animals have also been marked with colored paint-balls to monitor movements, calculate sightability, and develop mark-recapture population estimates (Hanna 1989, Cichowski et al. 1994, Toweill 2003).

   Systematic aerial surveys, done on a consistent basis, are the best source of information for documenting mountain goat distribution. However, incidental observations can provide useful information during times of year flights are not normally conducted. Mountain goat surveys are generally flown in mid-late summer, so there is often a gap in distribution data for the remainder of the year. Record all observations of mountain goats on Wildlife Observation Forms. Locations should preferably be described using Universal Transverse Mercator (UTM) Coordinates.

C. Analysis of Data – Applicable records are sorted and retrieved from the Wildlife Observation System, and incorporated into a Geographic Information System (GIS) to map the seasonal distribution of mountain goats. Maps representing observations collected under varying climatic conditions can be compared among years to identify seasonal ranges and to update seasonal range overlays.

D. Disposition of Data – All mountain goat observations should be entered in the Wildlife Observation System. Digital maps of seasonal habitats and migration corridors are

maintained at the Cheyenne Headquarters and by the responsible biologist. Discuss significant distribution shifts in Annual JCRs. When appropriate, include distribution maps in the applicable JCR.

VI. CAPTURE, MARKING, and TRANSPLANTING

A. Capture

1. Rationale – There are several potential reasons to capture mountain goats, including: 1) affix markers such as ear tags, neckbands, or telemetry transmitters; 2) collect biological samples; 3) obtain animals for research; or 4) translocate animals to establish populations in vacant habitats or to augment existing populations. As of this writing, only one prior research project had involved capturing mountain goats in Wyoming. A future effort to capture and mark goats could improve managers' capabilities to assess population status and trends, evaluate distribution and movements, and refine herd boundaries.

2. Application – Managers have trapped mountain goats successfully with Clover traps (Clover 1956, Rideout 1974b, K.G. Smith et al. 1992), box traps (K.G. Smith et al. 1992), corral traps (Hebert et al. 1980), rope snares (R.W. Thompson 1981, Johnson and Moorhead 1982), drop nets (Rideout 1974b, Johnson and Moorhead 1982), portable cannon nets (Thompson and McCarthy 1980), and woven wire pen traps (Cooney 1946, Rideout 1974b). Salt is often used to lure goats into traps. In some instances portable traps have been constructed near artificial mineral licks, several years prior to a trapping operation (Adams et al. 1982). Please consult these publications for details regarding each technique.

   Immobilizing drugs have also been used successfully to capture mountain goats. Consult Kreeger (1997) and Appendix VIII (Immobilization) for information about various immobilizing agents and dosage rates. In some circumstances, biologists can approach goats closely enough to dart them from the ground (Haynes 1991), however this method is usually inefficient. Goats can be darted efficiently and safely from a helicopter (Nichols 1982). In one Alaska study, each goat captured required 0.64 hours of flight time. Researchers were able to place darts on target in 68% of attempts and 88% of the goats hit were successfully immobilized (Schoen 1979).

   Specific precautions are necessary when mountain goats are immobilized. Goats habitually flee to precipices or other extreme terrain when they feel threatened. Any attempt to capture them in such locations can be hazardous to both the animal and researcher. Conditions that can lead to capture-related mortalities include slow induction time, poorly placed darts or partial dosage delivery, and terrain that is unsuitable for capture operations. In addition, some drugs can produce long lasting, deleterious effects. For example, Cote' et al. (1998) documented reproduction and survival were subsequently suppressed among adult females that were immobilized with xylazine prior to the rut.

Avoid the rear flank when attempting to dart goats. This portion of a goat's anatomy is covered by a tough, thickened skin called a dermal shield that evolved to minimize puncture wounds from combat with other goats (Geist 1967). Goats are also known to "play possum" or "faint" by appearing limp and dead while they are handled, and then immediately jump up and run away when released (Cooney 1946, Thompson 1981). During one episode in a Wyoming study, a goat did not appear to recover after the drug "antagonist" was administered, but became immediately mobile when the blindfold was removed (Haynes 1991). Goats held in captivity for more than two days, for example during relocations, tend to succumb at an abnormally high rate. Such deaths are caused by white muscle disease or capture myopathy (Thorne, et. al. 1982, Foster 1982). Before managers attempt to capture and relocate goats, they should become thoroughly familiar with relevant literature and should consult an experienced veterinarian to obtain direction regarding immobilization and handling precautions.

In recent years, netguns fired from helicopters have become the preferred means of capturing most large ungulates. This method considerably shortens the length of time required to intercept, restrain and process animals, and does not require use of drugs. As a result, overall stress to the animal is less. However, netguns should only be used in terrain that is accessible to a helicopter crew and away from potential hazards. Some researchers have successfully maneuvered goats into suitable capture locations by "slowly pushing" them for short periods (< 1 minute) prior to capture (Poole and Heard 1998). With netguns, managers can limit pursuits to less than 5 minutes and the time required to capture and release an animal to less than 20 minutes (Poole and Heard 1998). In an Alberta study, only 1 animal was lost from 78 goats captured by helicopter netgunning techniques (Jorgenson and Quinlan 1996). Netgunning also gives managers added flexibility to select target animals (e.g. avoid nanny/kid groups) and to assure individuals are marked in a distribution that is consistent with study objectives.

3. Analysis of Data – Researchers should plan extensive field surveys following each capture and marking operation, to search for marked animals. Record UTM coordinates of each observation, and enter the information into a geo-referenced data set that can be plotted and analyzed using GIS software. Seasonal distributions of marked animals provide documentation to identify seasonal ranges, migration routes, and population boundaries.

4. Disposition of Data – After each capture operation, forward records of all marked animals to the Supervisor of Biological Services at the Cheyenne Headquarters, who will have the data entered to update the Marked Animal Database. Each record should identify the species, sex, and age of the marked animal, capture date, description of marker (neckband, eartags, radio collars), frequency of radio collar (if applicable), location of capture site, and location of release site (if different). Summarize capture records, observations of marked animals, harvest returns, and known mortalities in each applicable JCR. If the marking effort is associated with an

independent research project, include progress and final reports of the research the annual JCRs.

B. Marking

1. Rationale – Animals are most commonly marked in a population to study habitat use, seasonal distribution and movements. Marking is a particularly valuable tool for species like mountain goats, which are often dispersed in distinct subpopulations throughout occupied habitats. In some cases, mountain goats have been marked to estimate population size based on the proportion of marked animals observed in a survey sample (mark-recapture type analysis), or to develop sightability models used to adjust survey results (Cichowski et al. 1994, Smith and Bovee 1984, Poole et al. 2000, Gonzalez-Voyer et al. 2001).

2. Application – Goats have been successfully marked with various materials and devices including sheep branding paint, paintball guns, colored eartags and plastic neckbands (Rideout 1974b, Hanna 1989). Because each captured goat represents a substantial investment of cost and effort, managers often elect to fit most animals with radio-collars as the quality of data obtained is much greater. Markers such as neckbands and eartags must be visually observed to establish data points, so fewer locations are obtained. Conventional Very High Frequency (VHF) radio-collars are suitable to monitor general movement patterns and habitat use. When continuously recorded data are necessary to accurately describe habitat use, movements, survival, and response to human activities, Global Positioning System (GPS) collars are used (Poole and Heard 1998, Taylor 2002, Keim 2004b).

3. Analysis of Data – Consult Section VI.A. (Capture)

4. Disposition of Data – Consult Section VI.A. (Capture)

C. Transplanting – Although goat populations in Wyoming are the result of prior transplants by adjoining states, no effort has been made to transplant goats within Wyoming (Hurley 1996). Since there is negligible evidence mountain goats historically inhabited Wyoming, it is unlikely future transplants will be considered in Wyoming, especially on federal lands.

VII. MODELING – Models are not currently used to simulate mountain goat populations in Wyoming because sex and age composition data needed to support a credible model are very difficult to obtain. This would require a substantial commitment of personnel and funding over several years. For management purposes, population status is monitored based on periodic trend counts and annual productivity surveys. Goats display a strong affinity to certain habitats. Nursery bands in particular are easily monitored from year to year. Consult Appendix IX (Big Game Population Modeling) to review a general discussion of population modeling.

VIII. JOB COMPLETION REPORTS – All data collected and analyzed to manage mountain goat herds, in addition to season descriptions and harvest results, are summarized in the annual JCRs prepared by the responsible regions. The format for reporting productivity data is somewhat different from that used for other species. Because adult males and females are difficult to distinguish during classification surveys, productivity is reported as juveniles per 100 adults rather than juveniles per 100 females. This format requires some modification of the graphs and tables in the standard JCR format.

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Chapter 8

Black Bear *(Ursus americanus)*

Ron Grogan, Dan Bjornlie, Mark Ternent, and Dave Moody

I. INTRODUCTION –

A. Management – Numerous changes have taken place throughout the history of black bear management in Wyoming. Black bears were considered a predator prior to 1911, and then classified as big game (1911-1977), and ultimately as trophy game (1978-present). Hunt areas were established in 1981, the annual bag limit was reduced from 2 to 1 in 1988, and the bear tag was removed from the resident elk license 1988.

A black bear management plan was written in 1994 (Wyoming Game and Fish Department 1994) and revised in 2007 Wyoming Game and Fish Department 2007). Management scale was expanded from the hunt area level, to broader Bear Management Units (BMUs) (Fig. 1). Harvest is regulated through a mortality quota applied to the female segment of the population. Presently, separate female harvest quotas are applied to the spring and fall hunting seasons in each BMU. Seasons close when quotas are reached. The spring hunting season is typically from 1 May to 15 June. The fall season is typically 1 September to 31 October. Dogs cannot not be used to hunt bears in Wyoming, but baiting is allowed. Baits must be registered and the number and density are subject to standards set forth by regulation. Hunters are responsible for inquiring about the status of harvest quotas prior to hunting. A toll free, 24-hour "hotline" is operated for this purpose. Bears must be checked at a Game and Fish Office within 3 days of harvest. Sale of edible bear parts is prohibited, but skulls, hides, claws, and gall bladders may be sold.

Approximately 200 black bears are harvested annually in Wyoming. Sixty percent are harvested in the spring season. Eighty percent of spring-harvested bears are killed over bait. Only 24% of bears harvested during fall seasons are taken over bait. Hunter success is also higher in spring.

Under Wyoming statute, a landowner or lessee, or the employee of a landowner can kill any black bear causing damage to private property. Depredations are most common in high elevation areas where domestic livestock, particularly sheep, graze seasonally. The Department reimburses livestock owners for losses that are confirmed depredations by bears. Owners of beehives are also reimbursed for damage caused by bears. In some parts of the state, bear damage can be a problem in residential areas and campgrounds as well. Statewide, an average of 9.5 black bears are removed annually to resolve conflicts. The Department does not limit the number of bears that can be removed to alleviate damage problems, nor are those mortalities applied against annual hunting quotas.

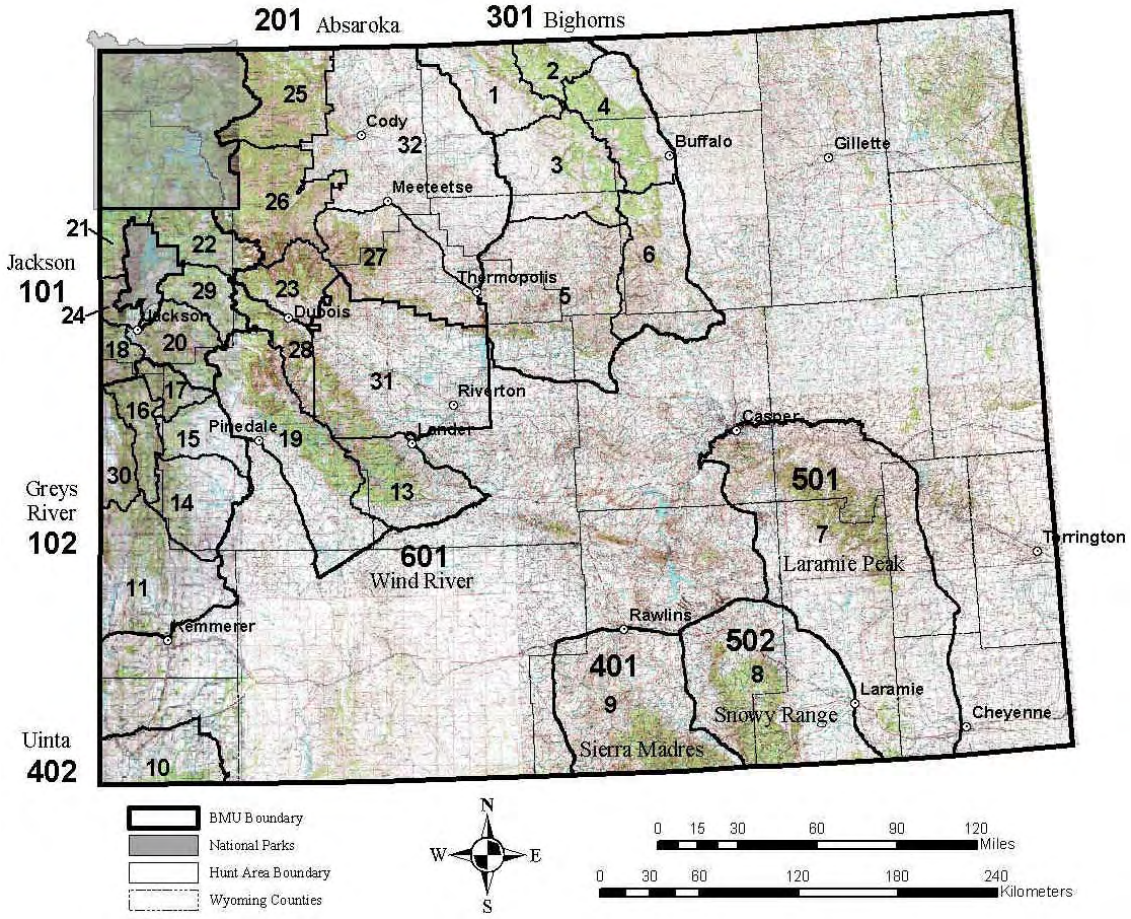

Fig. 1. Black bear hunt areas and Bear Management Units. Boundaries were delineated in 1994 to correspond with known black bear distributions and population centers.

II. LIFE HISTORY –

Black bears inhabit forested areas of all major mountain ranges in Wyoming. Populations are presumed highest in northwestern Wyoming, where higher seasonal moisture creates more abundant forage. The Bighorn Mountains in northern Wyoming also contain a robust black bear population. Lower densities of black bears inhabit the Snowy, Sierra Madre, Laramie Peak, and Uinta mountain ranges of southern.

Black bears vary from blond to black in Wyoming. Light brown, chocolate brown and cinnamon are common. Combinations of color phases, such as light brown body with darker brown legs, are also present. Weights of 57 adult males captured during Department research and damage operations between 1988 and 2005 ranged from 120 to 440 pounds (average 248 pounds). Weights of 39 adult females captured during the same period ranged from 85 to 250 pounds (average 160).

Black bears can be aged, and the reproductive efforts of females assessed from cementum annular rings deposited on roots of teeth (McLaughlin et al. 1990, Coy and Garshelis

1992, Harshyne et al. 1998, Costello et al. 2004). Based on samples from 384 female black bears harvested in Wyoming from 1988 – 2005, the average age of first reproduction is 5.2 (Table 1). These data indicate 70% of female black bears have produced a litter by their 5th summer. The average birth interval was 2.2 years (n=632). Although female black bears may have up to 5 cubs per litter in more productive habitats, typical liters in Wyoming are between 1 and 3 cubs. Mean litter size of 16 female black bears handled in winter dens from 1995 – 2005 was 1.9 cubs. The young remain with the female until spring/summer of their second year when they disperse and the female will again breed.

Female black bears usually enter dens in October. Males enter dens later, and all but a few adult males are denned by late November. Adult males are first to leave dens in spring, usually in late March to early April. Females with newborn cubs are last to leave, usually in late April or early May (Beecham and Rohlman 1994, Grogan 1997, Costello et al. 2001).

Food habits of black bears vary widely depending on season and location. In the Rocky Mountain West, black bears emerging from dens consume new growing grasses and forbs. As temperatures rise, they follow snowmelt to higher elevations focusing on the newly greening vegetation (Beecham and Rohlman 1994). When more nutritious mast crops (berries and nuts) ripen in late summer and fall, black bears focus intently on these foods (Beecham and Rohlman 1994, Costello et al. 2001). Ants, bees, and insect larvae comprise the majority the black bear's diet other than vegetation (Beecham and Rohlman 1994). However, during early summer, newborn ungulates such as elk calves can become a key food source in the West (Smith and Anderson 1996, Zager et al. 2005, Zager and Beecham 2006). Irwin and Hammond (1985) determined 83–94% of the volume of black bear diets in the Grey's River area of western Wyoming was vegetable matter, depending on annual and seasonal variation. The bulk of remaining animal matter consisted of carrion in spring and insects in summer and fall.

Black bear populations are very susceptible to changing environmental conditions. Significant declines in reproductive success have been documented after preferred black bear food crops failed (Beecham and Rohlman 1994). Costello et al. (2001) also documented the number of bears and proportion of females harvested by hunters were higher in years when oak mast crops failed in New Mexico. In Wyoming, the numbers of black bear incidents and black bears killed during the hunting season increase during very dry years and when production of critical bear foods, especially fall mast crops, is poor. During such years, bears move greater distances in search of food, making them more vulnerable to harvest and more likely to be involved in conflicts. Sometimes, they enter areas inhabited by humans.

We have few reliable estimates of bear densities in Wyoming, but based on harvest indices all populations are believed stable or increasing. The total area of suitable habitat in Wyoming is approximately 74,000 ha.

III. DESCRIPTION OF TECHNIQUES –

A. Census –

1. Mark-Recapture –

a. Rationale – Mark-recapture studies are done to estimate the actual population of bears. Procedures involve marking a random sample of animals and resampling to estimate the proportion of marked animals in the population. The total number of animals originally marked is extrapolated based on the proportion of marked animals in the sample to estimate the population size. Although mark-recapture procedures are widely used and generally considered the most accurate method to estimate bear populations, some problems can be encountered. Two key assumptions are difficult to rigidly meet. These include, equal probability of capture, and no ingress or egress of animals in the study area (geographic closure). In addition, mark-recapture studies tend to be costly and labor intensive, which limits their practicality to small geographic areas. Total population estimates are geographically extrapolated from representative areas. Despite these problems, 16 of 27 states (59%) report using some form of mark-recapture technique to help assess their black bear populations (Garshelis 1990).

b. Application – A mark-recapture study must be designed properly to be successful. Catch rates are balanced through trap spacing (to ensure all animals have access to traps), timing and duration of trapping (to account for seasonal movements), and trap types, sets and baits (to enhance capture of trap-wise animals). Radio-transmitters may be used to detect movements across study area boundaries. The study areas should be large enough to represent a population, and its attributes (habitat, hunting pressure, harvest structure) should be representative of other areas to which the estimate may be applied.

Several mark-recapture or resight methods are currently used to estimate bear abundance. The most common approach is to capture, mark, and release bears, then recapture a random sample of bears from within the population. Trapping and handling techniques are described in Erickson (1957), Johnson and Pelton (1980), and Jonkel (1993). Ear-tags and radio-collars can serve as marks. Sampling to obtain recapture/resight data can be accomplished with trapping (Lindzey and Meslow 1977, LeCount 1982, Beecham 1980), aerial observations (Miller et.al. 1997), photographs (Mace et al. 1994, Beck 1997, Grogan and Lindzey 1999), or by tallying marks in the harvest (Garshelis 1990). Methods that do not involve handling bears include distributing baits laced with chemical markers that are detectable in scats (radio-isotopes; Eager 1977, Pelton and Marcum 1977) or bones/teeth of harvested bears (tetracycline; Garshelis 1990), or typing (profiling) DNA from hair collected at bait sites (Paetkau and Strobeck 1994, Proctor 1995, Grogan and Lindzey 1999).

c. Analysis of data – Various population ecology textbooks (i.e., Begon 1979, Krebs 1989) describe methods used to analyze mark-recapture data. Analytical methods have also been devised to address unique issues, such as unequal catch rates or lack of demographic closure (see Otis et al. 1978, Pollock 1982, White et al. 1982, White 1996). If radio-location data are available, the estimate can be improved by calculating the number of marked animals present during recapture efforts (Miller et al. 1987, Miller et al. 1997) or by weighting the marked proportion based upon the time each animal spends in the trapping area (Garshelis 1992). In general, lack of demographic closure (caused by births, deaths, immigration, emigration) can be addressed with the proper analysis (i.e., Jolly-Seber), however, populations will tend to be overestimated unless the assumptions of equal susceptibility to capture and geographic closure are met or accounted for in the analysis.

d. Disposition of data – The results of any mark-recapture study should be reported and distributed to Regional Wildlife Coordinators and the Trophy Game Section. This information is useful for evaluating hunting season frameworks and harvest quotas.

2. Bait-station Surveys –

a. Rationale – Bait-station surveys can provide an index to assess local abundance of bears. Baits are placed along predetermined routes. Bears attracted to the baits leave signs such as claw marks on a tree, tracks in sifted dirt or sand, hair on trees or shrubs, or tooth punctures in sardine cans. Bait-station surveys are easy to conduct (i.e., bear sign is easy to identify and capture/handling of bears is not needed) and relatively inexpensive. However, there are three potential drawbacks. First, bears visiting more than one bait may inflate abundance estimates. The likelihood of this occurring is relatively high since baits are typically placed close together (0.5 mi intervals). Second, baits are typically distributed along roads, therefore visitation rates may indicate use of these routes by bears rather than the number of bears living in the vicinity. If bears avoid the selected road, abundance would be underestimated, as documented by LeCount (1982). Conversely, selecting a route used as a major travel lane by bears would lead to an overestimate. Third, bait visitation rates can be affected by availability of natural foods. Visitation decreases during periods of high natural food abundance. This effect can occur between years, or more importantly, between sampling periods within the same year. Surveys should be scheduled to provide consistent results.

b. Application – Numerous studies describe how to conduct bait-station surveys (Carlock 1986, Fendley et al. 1989, Johnson 1989, Clark 1991). Surveys typically involve multiple routes of 50 baits each. Baits are separated by 0.5 miles and placed on alternate sides of the road. Ideally, several routes should be established in each major habitat type. The area surveyed should be representative of other areas to which the results will be extrapolated. Baits should be set out the same

timeframe and for the same duration each year. Weather conditions, natural food abundance, and plant phenology should be noted to help explain fluctuations in visitation rates. Baits are generally checked after 2 to 3 weeks, and evidence of bear visitation is recorded. Missing baits may be replaced. Baits may or may not be moved between consecutive surveys.

c. Analysis of data – The percent of baits visited is an index of bear abundance that can be compared among years, provided sources of bias are recognized. Visitation rates may also be compared among areas if all other factors (i.e., natural food abundance, age/sex structure of the population) are similar. Bait-station surveys are, for the most part, used only as supporting information and not as the primary means of assessing bear populations (Garshelis 1990). At present, Wyoming does not use bait-station surveys.

d. Disposition of data – The results of bait-station surveys should be reported and distributed to Regional Wildlife Coordinators and the Trophy Game Section. This information can be useful for evaluating hunting season frameworks and harvest quotas.

3. Incidental Observations –

a. Rationale – Black bears are secretive, nocturnal, and live in forested habitats. Consequently, incidental sightings are rare and thus a poor index of bear abundance. However, bear sign can corroborate presence. Some states, including Wyoming, record numbers of bear sightings reported by hunters, but these data should be viewed cautiously. For example, persons hunting over bait may report several observations of the same animal.

b. Application – Department personnel should record bear sign they encounter and submit records for inclusion in the Wildlife Observation System (WOS). The number of bears observed by successful hunters should be recorded on the Black Bear Mortality Form when harvested bears are checked.

c. Analysis of data – Records of incidental observations can be consulted to corroborate other trend indicators, but should not constitute a primary measure of abundance. Incidental observations can be tallied for each hunt area or BMU. Data can be graphically displayed by Geographic Information System (GIS) software. Observations may also be useful for reviewing environmental effects of proposed projects, particularly if the presence of bears must be documented.

d. Disposition of data – Wildlife Observation records should be forwarded monthly to regional Wildlife Coordinators. Biological Services performs data searches upon request. The system has recently been reprogrammed enabling field personnel to search and sort records from remote personal computer stations. Black Bear Mortality Forms should be forwarded to Regional Wildlife Coordinators, and then to the Trophy Game Section where they are entered into a

statewide Black Bear database. Bear sightings by hunters are not tallied in the Annual Black Bear Mortality Summary, but they can be requested from the Trophy Game Section if needed.

B. Harvest Data –

1. Harvest Survey –

a. Rationale – A harvest survey is mailed annually to each licensed black bear hunter in Wyoming. The survey is designed to measure hunter effort and success. The total harvest is not estimated because it can be more accurately determined from mandatory inspection data. In Wyoming, hunter surveys are done by a contracted service, and results are published in the Department's Annual Report and the Report of Big Game Harvest. The harvest survey is discussed in Appendix III.

2. Bait Registration

a. Rationale – In Wyoming, the density of bear baits cannot exceed 1 per section of federal land. Hunters are required to register locations of baits prior to placing them in the field. This prevents crowding of baits (and hunters), improves hunter satisfaction, and enables the Department to evaluate baiting.

b. Application – Each regional office maintains a database of bait registration records. As hunters register bait locations, the information is entered in the database and plotted on a map. Office managers typically do this. Copies of the regional databases are forwarded to the Trophy Game Section at the end of each hunting season (i.e., each spring and fall), and the information is compiled into a statewide database.

c. Analysis of data – Bait locations can be tallied several ways. For example, bait densities (i.e., baits/mi^2) can be calculated within a drainages or hunt area. Success of hunters using baits can also be contrasted against success of hunters who do not.

d. Disposition of data – Copies of regional bait registration databases should be forwarded to the Trophy Game Section at the end of each spring and fall hunting season.

3. Sex/Age Determination –

a. Rationale – Many states, including Wyoming, use sex and age composition of harvested bears as a primary tool to evaluate and recommend management actions (Garshelis, 1990). In Wyoming, the desired harvest of female bears for a stable population is 30 – 40% of the total harvest in each BMU. Further information

regarding sex and age criteria is provided in the Wyoming Black Bear Management Plan (Wyoming Game & Fish Department 2007).

b. Application – The skull and pelt from each harvested bear must be presented to a Department employee for inspection within 3 days after harvest. Harvested bears are the only source of data presently used to monitor black bear populations in Wyoming. The mandatory reporting system has been in place since 1975. Two teeth are extracted from each bear skull and used for aging. Department personnel also record location of kill, sex, number of days hunted, and method of take. Skulls must be presented in an unfrozen condition to allow successful removal of teeth. Teeth are sent to the Veterinary Lab at the University of Wyoming. Aging is based on the cementum annuli technique (Willey 1974, Stoneberg and Jonkel 1966). Proof of sex must remain naturally attached to the pelt for accurate identification. A survey conducted in 1992 indicated 96% of licensed bear hunters comply with these regulations (University of Wyoming, 1992).

   Game and Fish personnel identify the sex of each bear by examining genitalia. Teats of female bears are inspected to determine if the bear has previously lactated. If a bear has not previously lactated, its teats are pinkish in color and lack pigmentation. A bear that has lactated will have darker, pigmented teats. Teats are generally swollen and milk is present if the bear is currently lactating.

   Although age is most accurately determined based on the cementum annuli technique, each bear's age is also estimated at the time it is checked. Tooth eruption and wear patterns are examined for this purpose. Juveniles can usually be identified by body size. Estimating age in this manner is very subjective and tooth wear patterns vary depending on diet. Consequently, bear ages are assigned to the following, broader categories: Juvenile ($\leq$ 1), subadult (2-4), adult (5 and over). Juvenile teeth show little wear and no staining. Cubs-of-the-year have milk teeth and usually weigh < 40 lbs. Yearlings retain some milk teeth, however permanent incisors and canines have erupted, yearlings usually weigh < 80 lbs. Body weights can be highly variable and should only be considered along with other factors when estimating age. Bears acquire a full set of permanent teeth by age 2. Subadult bears (2-4 yrs) typically have little to no tooth wear and some staining. Canines are usually sharp and incisors are slightly worn. Adult bears between 5 and 10 years of age generally have considerable wear on incisors, canines are rounded with slight wear patterns where lower and upper canines contact, and staining is prominent. Bears > 10 years old almost always have considerable wear on incisors, and as age progresses, incisors become worn even with gum line. Canines are usually very rounded, chipped or broken, and wear patterns are pronounced where upper and lower canines contact. Staining is extensive, and older bears have commonly lost one or more abscessed molars.

c. Analysis of data – Sex and age data are used to evaluate harvest in each BMU. Desired harvest composition is 30 – 40% females. Adult females should

comprise 45 – 55% of the female harvest (Wyoming Game & Fish Department 2007).

d. Disposition of data – Tooth samples and copies of Black Bear Mortality forms are sent to Regional Wildlife Coordinators. Coordinators forward these to the Trophy Game Section. The information from each form is entered into a statewide database. Tooth samples are sent to the Game and Fish Laboratory for age determination. Harvest composition (sex and age) is reported in the Annual Black Bear Mortality Summary prepared by the Trophy Game Section.

4. Body Condition –

a. Rationale – Body condition is an indication of health and fitness, and can be useful in assessing habitat quality and general condition of the population (Bailey 1984, Smith 1990). The Department does not use a quantitative method to evaluate body condition. The condition of each harvested bear is qualitatively assessed when it is inspected through the mandatory check process. The conditions of all captured bears are also noted.

b. Application – Presence and quantity of fat are the basis for assessing excellent, good, fair, or poor condition when each bear is checked or captured. The condition is recorded on each mortality form or capture form.

c. Analysis of data – The Department does not currently analyze body condition data. However, biologists may refer to this data when evaluating environmental conditions or population status in specific areas.

d. Disposition of data – Information about body condition is recorded on Black Bear Mortality and Capture forms. Copies of the forms are sent to Regional Wildlife Coordinators. After proofing, Coordinators forward them to the Trophy Game Section. The information from each form is entered in a statewide database.

5. Laboratory Aging by Tooth Cross-Sectioning –

a. Rationale – The most reliable method of aging bears is based on counting annular layers of cementum in tooth cross-sections (Marks and Erickson 1966, Stoneberg and Jonkel 1966, Willey 1974, Kolensky and Strathearn 1987). A layer of cementum is deposited each year around the dental roots of mammals. These layers indicate age in years (Dimmick and Pelton 1994). Older bears can be difficult to accurately age because outer annuli are deposited in thinner layers (Willey 1974). False and double annuli are also present in some bears (Morris et al. 1978). However, estimates derived from tooth annuli provide the most accurate age information for managing bear populations.

b. Application – The cementum annuli technique involves both field and laboratory procedures. A tooth must first be extracted from captured or harvested bears. To

ensure consistency, we recommend using the first premolar (pm1) to age black bears (Dimmick and Pelton 1994). This tooth is located directly behind the upper or lower canine.

Teeth can be removed with various dental elevators or tooth extraction devices available through veterinary supply companies. Waddell (1975) describes the technique and tools used to remove black bear teeth. Exercise care to maintain the integrity of the tooth. In most cases, it is imperative to keep the root of the collected tooth intact (Dimmick and Pelton 1994). If the root is broken, remove another tooth (there are generally 4 vestigial premolars). In addition, you should take into consideration the well being of live animals and preservation of trophy skulls. However, these teeth are very small, sometimes barely breaking the gum line. Removing more than one should not impair the appearance of trophy skulls, nor should it affect the function of live bears. After teeth are removed, they should be kept clean and placed in a small, properly labeled envelope.

Reproductive histories of female black bears can also be reconstructed from cementum annuli (Coy and Garshelis 1992). It is possible to obtain such information as age at first reproduction, interval between reproductive efforts, and number of reproductive efforts. These reproductive histories can help biologists estimate reproductive rates, construct population age structures, and set harvest quotas.

c. Analysis of data – The Game and Fish Laboratory determines ages and reproductive histories. The lab returns this data to the Trophy Game Section where it is assessed based on criteria in the Wyoming Black Bear Management Plan (Wyoming Game & Fish Department 2007).

d. Disposition of data – Bear teeth and accompanying data forms are sent to Regional Wildlife Coordinators. After proofing forms, Coordinators forward these to the Trophy Game Section where they are cataloged and forwarded to the lab. Data are summarized in an annual report of black bear mortality. These reports are available through the Trophy Game Section.

C. Capture and Handling –

1. Trapping and Marking –

a. Rationale – Bears are captured and marked for various reasons including research to estimate sex and age structure of a population, population size and density, home ranges, and habitat use patterns (Lindzey and Meslow 1977, Beecham 1983, Garshelis 1992, Beck 1997, and Grogan 1997). Trapping may also be necessary to manage nuisance bears (Wyoming Game & Fish Dept. 1994). Personnel should be thoroughly familiar with capture and handling techniques to assure safety and proper care of the bear.

b. Application – Several effective techniques are available to trap bears. The Department generally uses trailer-mounted culvert traps or foot snares, depending on accessibility of the site and public safety concerns. Culvert traps are used near areas of concentrated human activity such as housing developments or campgrounds. Foot snares are used when many traps are needed during research efforts, or when accessibility by motorized vehicle is limited. Trapping techniques are discussed by Jonkel (1993). Baits such as commercial scent lures, animal parts or other food items are used to attract bears into trap sites.

Once captured, bears are immobilized with Telazol (a combination of tiletimine hydrochloride (HCL) and zolazepam HCL). Dosage is 7 mg/kg (Kreeger 1996). Bears can tolerate imprecise dosages of Telazol. It is rapid acting and allows a gradual recovery in bears (Gibeau and Paquet 1991). Telazol is generally delivered by a CO_2-powered pistol, dart rifle, or jab stick. Bears >1 year of age are sometimes fitted with a radio transmitter collar. Cotton spacers are used in the collars to increase the likelihood the collar will be shed after 2-3 years (Jonkel 1993).

Each bear is fitted with ear-tags and marked with an identification tattoo when possible. Round, hog-button style ear tags are used. Each tag has a unique number on one side and the letters WGFD on the other signifying the bear was captured by the Wyoming Game & Fish Department. Tattoo pliers are used to place a tattoo on the inside upper lip. The tattooed number generally corresponds with the ear tag number.

Several morphometric measurements are recorded during capture, including weight, total length, contour length, girth, height, neck circumference, head length and width, and pad length and width. Mammary nipple length, width and pigmentation, and vulva condition are recorded to assess reproductive status of females (Jonkel and Cowen 1971, LeCount 1986, Beck 1991). Depending on the purpose of trapping, bears are either released on site or relocated.

c. Analysis of data – The Department does not formally analyze bear capture data. However, the Trophy Game Section maintains a statewide database of capture information, and data are available upon request.

d. Disposition of data – Any time a bear is anesthetized, a Large Predator Capture Form must be completed. When bears are not anesthetized (only trapped and moved), the sections of the capture form pertaining to date and location of capture, date and location of release, and a physical description of the bear must be completed. Capture forms are sent to Regional Wildlife Coordinators. After Coordinators have proofed the forms, they are forwarded to the Trophy Game Section and the information is entered in a statewide database.

2. Relocation –

a. Rationale – Relocation of offending animals is often necessary to resolve conflicts between bears and humans. In each case, the decision to move a bear is made by regional enforcement personnel. Bears are usually moved to prevent further conflicts such as garbage raiding, livestock depredations, or property damage. Relocation gives the bear an opportunity to stay out of trouble. Once relocated, young bears often remain in the general vicinity of the release site, however older bears frequently return to the location where the conflict happened, especially when a food reward has been obtained. In most cases, the preferred management action is to move a nuisance bear at least once before lethal measures are considered.

b. Application – The safest way to transport bears is in a culvert-type trap mounted on a trailer. Bears should be fully conscious when being transported. If the bear has been anesthetized, it should be allowed to recover before transporting commences. Keep the trap/trailer out of direct sunlight when it is parked. If the bear will be moved a long distance, keep the animal hydrated. To do this, run water from a common garden hose into the trap. Bears will drink heavily when ambient temperatures are high.

c. Analysis of data – The Department does not currently analyze data collected during relocation actions. However, the data can be acquired from the statewide database maintained by the Trophy Game Section.

d. Disposition of data – If the bear is anesthetized, a Large Predator Capture Form must be completed. When bears are not anesthetized, the sections of the capture form pertaining to date and location of capture, date and location of release, and a physical description of the bear must be completed. Capture forms are sent to Regional Wildlife Coordinators. After proofing the forms, Coordinators forward them to the Trophy Game Section, and the information is entered in a statewide database.

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Chapter 9

Grizzly Bear *(Ursus arctos horribilis)*

Dave Moody, Ron Grogan, Dan Bjornlie, Mike Hooker and Scott Becker

I. INTRODUCTION –

A. Distribution and Status – Historically, grizzly bears (*Ursus arctos horribilis*) occupied most of the western United States and Canada (Rausch 1963). Currently, the species is restricted to small populations in northwest Montana, northern Idaho and Washington, and the Greater Yellowstone Area of Wyoming, Montana, and Idaho. The current range of the grizzly bear in Wyoming is not known precisely, but a general distribution has been constructed from locations of radio-collared bears over the past 25 years (Fig. 1). This distribution includes all of Yellowstone and Grand Teton National Parks, the National Elk Refuge, and portions of adjacent lands administered by the Forest Service south and east of Yellowstone extending to the east border of the Shoshone National Forest, south to the Green River Lakes area in the Wind River mountains, and southwest to the Greys River drainage in the Wyoming Range.

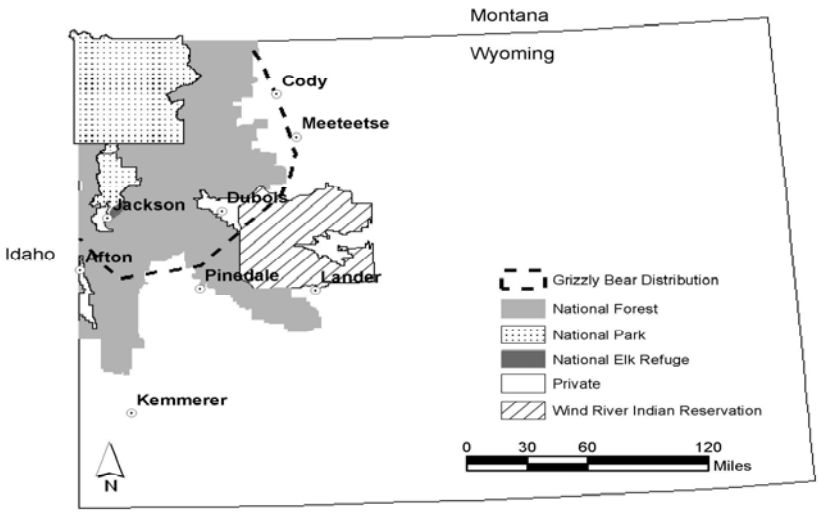

Fig. 1. Present distribution of grizzly bears in Wyoming based on minimum convex polygon analysis of grizzly bear locations since 1975. The Primary Conservation Area (PCA) is also shown.

In 1975, grizzly bears in the lower 48 states were listed as 'Threatened' under the Endangered Species Act (ESA). Prior to that time, grizzly bears in Wyoming were managed under the jurisdiction of the Wyoming Game & Fish Department (Department). Grizzlies were classified as "game animals" on most national forests, meaning they could not be trapped or hunted without approval by the Chief or local game warden. On private lands, grizzlies were considered predators and could be killed at any time and by most methods. Until 1967, no permits were required to take grizzly bears during hunting seasons. In 1968 and 1969, grizzly bear hunting was suspended because of concerns about low bear populations. In 1970, a limited permit system was instated and hunting grizzlies continued until 1975 when the bear was federally listed.

In 2002, a plan was developed to manage grizzly bears after the species is eventually removed from federal protection under the ESA and management authority reverts to the states (Moody et.al. 2002). The plan identifies the areas of the State grizzly bears will occupy, and the types and amounts of monitoring and management to be done by the Department and other agencies.

B. Management –

The United States Fish and Wildlife Service (USFWS) currently has management jurisdiction over grizzly bears in Wyoming. The Department assists with trapping, data collection, and management of nuisance bears as part of the Interagency Grizzly Bear Study Team (IGBST)(Schwartz and Moody 2000). The IGBST monitors grizzly bears within the Primary Conservation Area (PCA) (Fig. 1). The PCA is the core, or recovery area delineated in the Draft Conservation Strategy for the Grizzly Bear in the Yellowstone Area (IGBC 2000).

The minimum population of grizzly bears in the Greater Yellowstone Ecosystem is estimated based upon the number of unduplicated females with cubs-of-the-year observed during the non-denning season (June-October). This estimate ranged from 344 to 361 during 1999-2001 (IGBST 2001). The estimate is conservative because not all females with cubs are seen. A current estimate of the grizzly bear population within Wyoming is not available. The trend in unduplicated females with cubs, and thus the population, has increased 3-4% per year since grizzlies were federally listed in 1975 (Haroldson 2000).

C. Key Food Sources –

The IGBST monitors 4 key food sources of grizzly bears within the PCA. These food sources include winterkilled ungulate carcasses, spawning cutthroat trout (*Oncorhynchus clarki*), army cutworm moth (*Euxoa auxiliaris*) aggregation sites, and whitebark pine (*Pinus albicaulus*) production (USFWS 1993). Only moth aggregation sites are currently being monitored outside the PCA in Wyoming. However, whitebark pine production will also be monitored outside the PCA when jurisdiction of the grizzly bear is returned to the states (Moody et.al. 2002).

D. Human/Grizzly Conflicts and Damage –

In Wyoming, the Department handles human/grizzly bear conflicts and livestock depredation incidents inside and outside the PCA. However, final approval of management actions rests with the USFWS. Under the current system, bears receive greater consideration when bear/human conflicts occur within the PCA. Outside the PCA, human uses receive greater consideration (IGBC 2000). Criteria for managing nuisance grizzly bears are outlined in the "Draft Conservation Strategy (IGBC 2000) and the Interagency Grizzly Bear Guidelines. Once the Yellowstone grizzly bear population is removed from federal protection, the Department will manage conflicts based on criteria in the state management plan (Moody et.al. 2002). Currently, the Department reimburses landowners for confirmed livestock losses, and apiary damage caused by grizzly bears. The compensation rate for livestock losses is based on research done by Anderson et.al. (1997). For further information on grizzly bear depredation, refer to the Department's depredation techniques handbook (WGFD 1999).

II. CENSUS –

A. Population Monitoring –

A protocol is not currently in place to monitor the grizzly bear population in Wyoming outside the PCA. However, monitoring provisions of the State management plan will be implemented when the grizzly bear is no longer protected under the ESA. The State plan includes several protocols currently used by the IGBST inside the PCA (USFWS 1993, IGBC 2000). Managers can track population trends and occupancy by consistently monitoring several population parameters such as unduplicated females with cubs, bear distribution, and mortality.

1. Unduplicated sightings of females with cubs –

a. Rationale – An annual estimate of the minimum population size is calculated from observations of unduplicated females with cubs-of-the-year (FWCs). This method also enables managers to assess reproduction and determine whether the population is large enough to sustain the numbers of documented mortalities. When the Wyoming state management plan and the Yellowstone Grizzly Bear Conservation Strategy are implemented, a new methodology will be used to estimate the total population size based on FWCs (Keating et al. 2002).

b. Application – Sightings of FWCs are obtained from several sources including tracking of females with radio-collars, aerial surveys and ground observations, and capture efforts. Record the following information: date, location, number of cubs observed, and detailed physical descriptions including size, pelage color, and distinct markings.

c. Analysis of data – The Trophy Game Section screens reports of FWCs to determine credibility and eliminate duplicate sightings. Duplications are identified based on criteria developed by Knight et al. (1995). A minimum population estimate is calculated based on the principal that the sum of the most current 3 years of unduplicated FWCs represents a proportion of the females in a population (Knight et al. 1988). A 6-year running average of FWCs is also calculated. The 6-year period encompasses 2 breeding cycles, based on an average breeding interval of 3 years.

d. Disposition of data – FWC observations should be forwarded to the Trophy Game (Management) Coordinator. Data will be included in the annual Grizzly Bear Summary prepared by the Trophy Game Section.

2. Distribution –

a. Rationale – By monitoring locations and movements of grizzly bears, managers can document geographic distribution and occupancy of habitats. Monitoring efforts are focused on females with cubs to assess distribution of the reproductive cohort. Successful reproduction is also used as an indication of suitable habitat conditions. While the focus of monitoring is on the reproductive cohort of females, other bears are monitored as well. A healthy grizzly bear population should be well distributed throughout its occupied range.

b. Application – Distribution is monitored in several ways including radio telemetry, observation flights, capture efforts, and incidental observations. Emphasis is placed on documenting distribution of females with young (cubs-of-the-year, yearlings, or 2-yr olds). Subadult females usually establish home ranges adjacent to their mother's home range. Accordingly, monitoring this cohort may give an indication of future occupancy (Holm 1998). Capture operations are conducted to radio collars on a specific number of females.

c. Analysis of data – The Trophy Game Section will use home range and GIS software to analyze distribution data. The purpose of these analyses is to determine, home range size, core use areas and type of habitats used.

d. Disposition of data – Data collected on grizzly bear distribution should be forwarded to the Trophy Game (Management) Coordinator. Distribution, home range, and habitat use information will be published in the annual Grizzly Bear Summary, and can be requested through the Trophy Game Section.

3. Incidental Observations –

a. Rationale – Grizzly bears are secretive, nocturnal, and inhabit forested habitats, therefore, incidental sightings are rare and thus a poor index of bear abundance. However, observations of bear sign can corroborate presence or absence.

b. Application – Sightings of grizzly bears or grizzly bear sign should be recorded and entered in the Wildlife Observation System (WOS).

c. Analysis of data – Bear observations can provide additional corroboration of population trends, in conjunction with other indicators, but should not be used as a primary measure of abundance. Managers can tally observation records within each BMU and generate graphic displays using GIS software. Records of observations can be useful for reviewing impacts of proposed agency actions, particularly if documentation of bear presence is needed.

d. Disposition of data – Observation records are forwarded monthly for proofing by regional Wildlife Management Coordinators before they are entered in the WOS database. At one time, requests for data queries and downloads were submitted to the Biological Services Section in Cheyenne. However, the system has been reprogrammed enabling remote users to query, sort, and retrieve WOS data from personal computer stations in the field.

4. Mortality Thresholds –

a. Rationale – Harris (1985) suggested a 6 % rate of human-caused mortality is sustainable within grizzly bear populations, provided mortality of females does not exceed 30 % of the 6 %. Managers have established a lower mortality threshold (currently 4%) for the Yellowstone Population to allow population growth, and to compensate for unknown/unreported mortalities (estimated to be 50% of known mortalities). The application of this mortality rate based on a minimum estimate of the population assures additional conservatism. Mortalities of grizzly bears must be monitored closely to assure the total mortality level is within sustainable levels.

b. Application – Department personnel investigate all detected mortalities of grizzly bears. These investigations are done by a Bear Management Officer, Trophy Game Biologist, or regional Game Warden. The cause of death is determined when possible, or otherwise classified as unknown. Sex and age are also determined when possible. Investigators shall record: identity of investigator, date, reporting party, location (UTM), drainage, physical description of the bear, identity of landowner or public land status, and details of the incident.

c. Analysis of data – Mortalities are analyzed and tabulated by the Trophy Game Section, and then compared to allowable mortality levels based on the minimum population estimate. Allowable mortality levels will be based on the total population estimate when the new methodology to estimate total population is in place.

d. Disposition of data – All information from investigations of grizzly bear mortalities is forwarded to the Trophy Game Section (Nuisance) Coordinator. The information is added to a grizzly bear mortality database. Mortality data are

reported in the annual Grizzly Bear Summary. Mortality data can be requested through the Trophy Game Section.

5. Mark-Recapture –

   a. Rationale – Mark-recapture studies are done to estimate the actual population of bears. Procedures involve marking a random sample of animals and resampling to estimate the proportion of marked animals in the population. The total number of animals originally marked is extrapolated based on the proportion of marked animals in the population to estimate the total population size. Although mark-recapture procedures are widely used and generally considered the most accurate method to estimate bear populations, some problems can be encountered. Two key assumptions are difficult to rigidly meet. These include, even probability of capture, and no ingress or egress of animals in the study area (geographic closure). In addition, mark-recapture studies tend to be costly and labor intensive, which limits their practicality to small geographic areas. Total population estimates are geographically extrapolated from representative areas.

   b. Application – A valid sampling design is critical to successfully conduct a mark-recapture study. The potential for unequal catch rates is lessened through trap spacing (to ensure all animals have access to traps), timing and duration of trapping (to account for seasonal movements), and trap types, sets and baits (to enhance capture of trap-wise animals). Investigators should also consider marking animals with radio-transmitters to assess movements across study area boundaries. Study areas should be large enough to encompass a population and should be representative of other areas to which the estimate may be applied.

      Several mark-recapture or resight methods are used to estimate bear abundance and density. Most commonly, bears are captured, marked, released, and then recaptured or resighted. Trapping and handling techniques are described by Erickson (1957), Johnson and Pelton (1980), and Jonkel (1993). Ear-tags, radio-collars, or both can serve as marking devices. Recapture or resighting can be done through trapping (Martinka 1974, Craighead 1976), aerial observations (Miller et.al. 1997), or photographs (Mace et al. 1994). Other mark-recapture techniques do not require bears to be handled. They include distributing baits laced with chemical markers that are detectable in scats (radio-isotopes; Eager 1977, Pelton and Marcum 1977) or bones/teeth of harvested bears (tetracycline; Garshelis 1990). Individual bears can also be identified through genetic fingerprinting from hair collected at bait sites (Paetkau and Strobeck 1994, Woods et al. 1996, 1999, Grogan and Lindzey 1999, Mowat and Strobeck 2000).

      In 1998, the IGBST began a 3-year mark-resight study to estimate the bear population throughout the PCA, and to determine the precision of that estimate. The design was based upon the capture-mark-resight technique described by Miller et al. (1997). Radio-collared bears constituted the marked segment. A pilot and an observer searched each BMU from a fixed-wing aircraft. Each bear

sighted was identified as marked or unmarked. Each area was flown twice during the non-denning season (June-August) to estimate the proportions of marked and unmarked individuals. Results of this technique in the Yellowstone area were inconclusive due to the low number of grizzly bears seen during the study.

c. Analysis of data – Methods for analyzing mark-recapture data are described in numerous population ecology textbooks (i.e., Begon 1979, Krebs 1989). Other references address unique issues, such as unequal catch rates or lack of demographic closure (see Otis et al. 1978, Pollock 1982, White et al. 1982, White 1996). When telemetry data are available, estimates can be improved by calculating the number of marked animals present during recapture efforts (Miller et al. 1987, Miller et al. 1997) or by weighting the marked:unmarked ratio based on how much time each animal spends in the trapping area (Garshelis 1992). Abundance estimates derived from mark-recapture studies tend to be inflated unless the assumptions of equal catchability and geographic closure are met or taken into account by the analysis.

d. Disposition of data – A final report summarizing the results of any mark-recapture or resight studies, including population estimates, should be prepared and distributed to the Trophy Game Section and applicable Regional Wildlife Coordinators.

III. TRAPPING AND MARKING –

A. Capture and Handling –

1. Rationale – Grizzly bears are captured and marked for many reasons, including to determine the sex and age structure of a population, to estimate population density or size, and to document home ranges and habitat use patterns (Craighead 1976, Knight and Eberhardt 1985, Miller et al. 1997). Trapping is also done to manage nuisance bears (U.S. Fish and Wildlife Service 1993). Personnel must possess a thorough knowledge of capture and handling techniques to assure the operation is conducted safely and to properly care for the bear.

2. Application – Several effective techniques are available to trap bears, however the Department generally uses trailer-mounted culvert traps or foot snares, depending on access to the site and public safety concerns. Culvert traps are employed in areas of concentrated human activity, such as housing developments or campgrounds. Foot snares are used when many traps are needed, such as during research efforts or when access by motorized vehicle is limited. Trapping techniques are discussed by Jonkel (1993). Bait such as commercial scent lures, animal parts or other food items are generally used to attract bears into traps.

   Captured grizzly bears are immobilized with a combination of tiletimine hydrochloride (HCL) and zolazepam HCL (Telazol), administered at a dose of 8 mg/kg (Kreeger 1996). Telazol acts rapidly, but allows a gradual recovery in bears

(Gibeau and Paquet 1991). Telazol is generally delivered by a CO_2-powered pistol, dart rifle, or jab stick. When a bear is anesthetized, its vital signs including pulse, heart rate and temperature should be monitored and recorded every 15-20 minutes. Most captured bears > 1 year of age are fitted with a radio-transmitter collar. Cotton spacers are used to increase the probability the collar will be shed after 2-3 years (Jonkel 1993).

Each bear captured is fitted with an ear-tag and marked with an identification tattoo when possible. Ear tags are round with a unique number on one side and the letters WGFD on the other. These are attached to each ear. Tattoos are placed on the inside of an upper lip using tattoo pliers. The tattooed number generally corresponds with the ear tag number. A "W" preceding the tattoo number signifies the bear was captured in Wyoming.

Biological samples such as hair, tooth and blood are collected from each captured bear. Samples are labeled with the following information: type of sample, bear ID number, sex, estimated age, date, location, investigators' names, and the Department region. Several morphometric measurements are recorded including weight, total length, contour length, girth, height, neck circumference, head length and width, and pad length and width (front and rear). Reproductive status of females is assessed from mammary nipple length, width and pigmentation, as well as vulva condition (Jonkel and Cowen 1971, LeCount 1986, Beck 1991). Depending on the reason for trapping, bears are either released at the site of capture, or relocated.

3. Analysis of data – The Trophy Game section maintains a statewide database of information from captured bears, which is available upon request.

4. Disposition of data – Whenever a bear is anesthetized, a Trophy Game Capture Form is completed. When bears are not anesthetized (only trapped and moved), the following sections of the capture form should be completed: date and location of capture, date and location of release, and physical description of the bear. Capture forms are sent to the applicable Regional Wildlife Coordinators, and then forwarded to the Trophy Game Section. The Trophy Game Section enters information from the forms into a statewide capture database for grizzly bears.

IV. SEX / AGE DETERMINATION –

A. Field Techniques –

1. Rationale – Many states, including Wyoming, base management recommendations on criteria relating to the sex and age composition of harvested bears (Garshelis 1990). Grizzly bears cannot be harvested legally due to their current "Threatened" status under the ESA. Therefore, sex and age data must be collected from grizzly bears captured for research or management purposes, from dead bears that are discovered, and when possible, by observing free ranging bears in the field.

2. Application – A bear's sex can easily be identified by examining the external genitalia when the bear is handled (Jonkel 1987). Determining the sex of free ranging bears is more difficult and subjective. Optical equipment can sometimes be used to distinguish characteristics such as male genital hair (Jonkel 1982). Grizzly bears exhibit sexual dimorphism – adult males can grow to twice the size of adult females (Pearson 1975). However, the size of males of one age class can considerably overlap the size of females in an older age class (Pearson 1975, Craighead and Mitchell 1982). Therefore, identifying sex based on body size can be impercise. Lastly, sex may be apparent when bears are observed in groups (i.e., females with offspring or adult bears during courtship).

   Determining age is also best accomplished by handling the bear. Patterns of tooth eruption and wear can be used to distinguish age classes and occasionally, specific age groups (Lecount 1986). Jonkel (1987) indicated permanent dentition is acquired during a bear's second year. The presence of milk teeth or newly erupted, permanent teeth indicates the bear is a juvenile. In addition, body size can help distinguish juveniles from older, larger bears. Bears older than two years can be grouped into age classes based on dental wear patterns. Jonkel (1993) has provided descriptions and diagrams of tooth replacement and dental wear patterns for grizzly bears. However, factors such as genetics, diet, and tooth damage can also influence dental wear patterns (Jonkel 1993).

   Additional characteristics useful for estimating age can include: testicular descension, vulva enlargement, and condition of mammary nipples. These gender-specific, physical characteristics should be inspected whenever a bear is handled. Males with testes that have not descended testes are most likely juveniles or subadults. Vulva enlargement in females may indicate preparation for breeding and therefore adulthood. The vulva can enlarge to twice its normal size during the breeding season (Craighead and Mitchell 1982). To determine if lactation has occurred, first attempt to hand express milk from the nipple. If no milk is expressed, examine nipple color. Nipples of bears that have never lactated are small and pinkish without dark pigmentation. If the bear is lactating or has previously lactated, the nipples will be larger and brown or gray (Jonkel 1993).

3. Analysis of data – The use of field criteria to estimate ages of bears is very subjective, and not suitable for obtaining age-specific data. Bears handled in the field are simply assigned to age classes (i.e., cub-of-the-year, juvenile, subadult, young adult, old adult). Specific ages are determined based on laboratory analysis of tooth cross-sections (refer to Laboratory Analysis of Cementum Annuli).

4. Disposition of data – Record the sex and estimate of age on a standard bear capture form. Forward all capture forms to the Trophy Game Section. Data are entered into the grizzly bear capture/mortality database.

B. Laboratory Analysis of Cementum Annuli –

1. Rationale – The most accurate means of aging bears is based on laboratory analysis of cementum annular layers from tooth cross-sections (Marks and Erickson 1966, Stoneberg and Jonkel 1966, Willey 1974, Kolenosky and Strathearn 1987, Harshyne et al. 1998). Cementum is deposited annually in layers around the dental roots of mammals. These layers, when counted, indicate age in years (Dimmick and Pelton 1994). Refer to Appendix III (Aging Techniques), Section III (Laboratory Techniques Based on Cementum Annuli) for a detailed discussion of this technique. In addition, patterns of cementum layers can indicate the reproductive histories of female black bears (Coy and Garshelis 1992). This technique, however, has not yet been perfected for female grizzly bears.

   In some cases, age determination is complicated by false or double annuli (Morris et al. 1978), or by close spacing of annuli in older bears (Willey 1974). Regardless, when teeth are handled properly, the cementum annuli technique is sufficiently accurate for management purposes (Harshyne et al. 1998).

2. Application – Both field and laboratory procedures are required to collect teeth and prepare them for aging. One of the premolars is collected from all bears of unknown age. Normally, the first upper premolar (upm1) is extracted. This vestigial premolar is directly behind the canine tooth and can be removed from live bears without causing them harm (Kolenosky and Strathearn 1987).

   A variety of dental elevators or tooth extraction devices are suitable for removing teeth from their sockets. These devices are available through most veterinary supply companies. Waddell (1975) describes the tools and techniques used to remove black bear teeth. Personnel should exercise care to avoid breaking the tooth. In most cases, the root must remain intact (Dimmick and Pelton 1994).

   After teeth are removed, they should be kept clean and placed in a paper sample envelope labeled with the following information: date, bear or tag number, species, sex, estimated age, identity of collector, and geographic location. The effect long-term storage has on teeth is unknown (Dimmick and Pelton 1994). Therefore, teeth and accompanying data forms should be forwarded to the Trophy Game Section as soon as possible. The Trophy Game Section will catalog tooth samples, and then send them to the laboratory for further processing.

3. Analysis of data – The Wyoming Game and Fish Department does not currently analyze age data obtained from grizzly bears. Due to the bear's "threatened" status under the ESA, analysis of age data is done by the IGBST.

4. Disposition of data – The Wyoming Game and Fish Laboratory processes tooth samples to determine the age of bears, and then returns the results the Trophy Game Section. Age data are entered into a database and forward to the IGBST.

C. Evaluation of Body Condition –

1. Rationale – The overall health and fitness of a bear, and the quality of its habitat, are generally reflected in the bear's body condition (Bailey 1984, Smith 1990). The Deptartment does not quantitatively measure body condition, however a qualitative assessment is recorded at the time each grizzly bear is captured or inspected during mortality investigations.

2. Application – The qualitative assessment is based on presence of fat. A score of 1-5 is recorded on each capture or mortality form, 1 being poor condition and 5 being excellent.

3. Analysis of data – Qualitative data characterizing body condition are not formally analyzed. However, biologists may use this data to monitor the general condition of bears captured in specific areas, or during specific years.

4. Disposition of data – Body condition scores are recorded on Grizzly Bear Mortality or Capture forms. These forms are sent to the applicable Regional Wildlife Coordinator. The Coordinator then forwards the mortality/capture forms to the Trophy Game Section, and the information is entered into the statewide grizzly bear database.

C. Translocation

1. Rationale – In Wyoming, the decision to relocate bears is made on a case-by-case basis by the Trophy Game (Nuisance) Section and the USFWS, in cooperation with land management agencies. Bears are usually moved in an attempt to prevent or abate conflicts such as foraging in garbage, depredating livestock, or damaging property. Relocation away from the original conflict affords bears an opportunity to avoid further human conflict.

2. Application – The safest way to transport bears is in a trailer-mounted, culvert-type trap. When bears are transported they should be fully conscious. If the bear has been anesthetized, it should be allowed to recover before it is transported. Never park the trap in direct sunlight. If the bear is to be moved a long distance, keep the animal hydrated by running water from a common garden hose into the trap. Bears will drink a lot when ambient temperatures are high. Although relocating a younger bear will often keep it out of trouble, older bears frequently return to the conflict site, especially if a food reward was obtained. Generally, a nuisance bear is moved at least once to avoid further conflicts before lethal alternatives are considered.

3. Analysis of data – Managers may evaluate relocation data to determine the success of translocating specific cohorts of bears for example, based on age and distance moved. All relocation data are available from the statewide database maintained by the Trophy Game Section.

4. Disposition of data – If the bear is anesthetized, a Large Predator Capture Form must be completed. When bears are not anesthetized, the sections of the capture form pertaining to date and location of capture, date and location of release, and a physical description of the bear must be completed. Capture forms are sent to Regional Wildlife Coordinators. After proofing the forms, Coordinators forward them to the Trophy Game Section, and the information is entered in a statewide database for grizzly bears.

V. SEASON SETTING –

A. Procedures –

1. Rationale – Wyoming has no established hunting seasons for grizzly bears because, as of this writing, they remain classified as "Threatened" under ESA. When the grizzly bear is delisted, the procedure for setting seasons will be similar to that used for mountain lions and black bears, except mortality thresholds will be closely monitored to assure population criteria established by the Conservation Strategy and State management plan are met. Specific protocols for hunting seasons have not been finalized at this point.

VI. ANNUAL REPORTS –

A. Completion Reports – The Department traditionally prepares annual completion reports to summarize population status and harvest results for big and trophy game, however a completion report is not done for grizzly bears. Currently the IGBST is responsible for producing an annual report that summarizes all data for the Yellowstone population. The Department collects population and mortality data within its jurisdictional boundaries and analyzes specific indices for the report. The grizzly bear annual report can be viewed at http://nrmsc.usgs.gov/research/igbst-home.htm.

B. Annual Status Reports – The USFWS also requires that Wyoming prepare annual status reports as specified under section 6 of the ESA. These reports summarize data collected in Wyoming and their primary purpose is to assure that Wyoming does not exceed the limitations set forth in USFWS permits. The reports are also used to justify financial requests from the Department to the Service.

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Chapter 10

Mountain Lion (*Puma concolor*)

Dave Moody, Dan Bjornlie, Mike Hooker, and Scott Becker

I. INTRODUCTION –

A. Management – Efforts to manage mountain lions have changed markedly since the nineteenth century. In 1882, the Wyoming Territorial government enacted legislation awarding a bounty to persons who killed mountain lions and other predators (Wyoming Game & Fish Department 1997). Lions were hunted throughout the year and no bag limits were enforced. In 1973, mountain lions were reclassified as a trophy game animal. Since then, hunting seasons have been established, management units and hunt areas delineated, and quotas applied to regulate the number and sex of lions harvested.

A draft mountain lion management plan was written in 1997, revised in 2006, and is the current basis for managing lions in Wyoming (Wyoming Game and Fish Department 2006). The State is divided into 5 Mountain Lion Management Units (MLMUs) and further divided into 29 lion hunt areas (Fig. 1). Harvest is regulated through annual mortality quotas. A total quota is prescribed for each hunt area and a female sub-quota is also prescribed for some areas. If either quota is reached, the hunting season closes. The bag limit is 1 lion per hunter per calendar year except in area 27, where 1 additional lion may be taken each calendar year. Hunters are responsible for checking the status of the harvest quota prior to hunting. Status reports are continually updated on a recorded message that is accessed via a 1-800 statewide hotline. Within 3 days of harvest, the hunter must present the pelt and skull from each harvested lion for inspection by a Game and Fish official. The hunting season is 1 September to 31 March within all hunt areas except 15, 22, and 27, where the season is yearlong. Approximately 150-200 mountain lions are harvested annually in Wyoming. Most lions are harvested with the aid of dogs. From 1993 through 2006, dogs were used to take 91% of the lions legally harvested in the state.

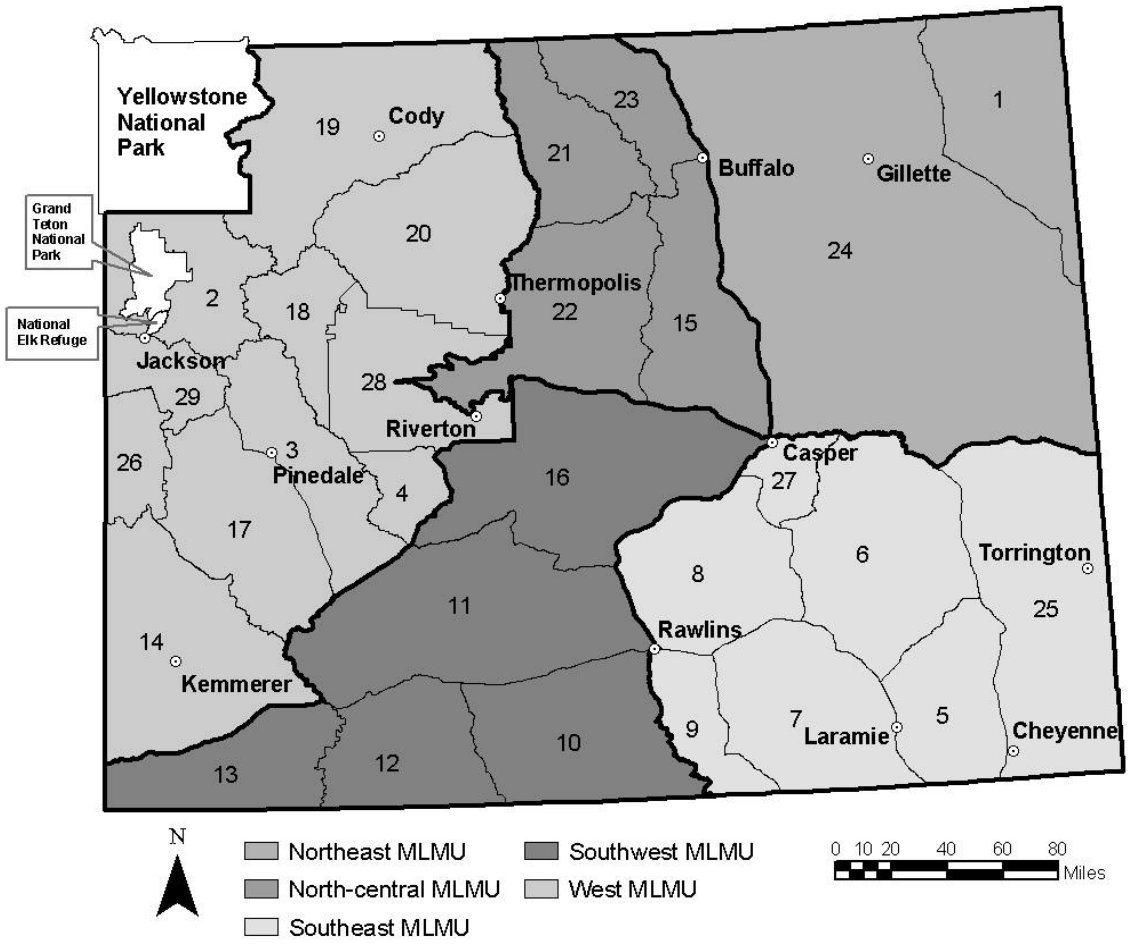

Fig. 1. Mountain lion hunt areas and management units in Wyoming.

Wyoming statutes provide that any mountain lion damaging private property can be killed by the owner or lessee of the property, or by an employee of the owner or lessee. Depredations by mountain lions are most common in locations where domestic livestock are moved seasonally to graze. Lions are capable of killing most species and age classes of livestock, however cattle less than 1 year of age and sheep of all age classes are most susceptible (Shaw 1979). Cattle depredations are a greater problem in the southwestern U.S. because calves are generally born in mountain lion habitat (Shaw 1979). In the northern Rocky Mountains, calves are born at lower elevations where lions are not as prevalent (Chuck Anderson, personal communication). Sheep are depredated whenever they are grazed in areas occupied by lions (Lindzey 1987), but most frequently during the summer months (Shaw 1979). In Wyoming from 1996-1999, 88% of depredations by lions involved sheep, 5% involved cattle, 3.3% involved horses, and 1.6% involved unknown livestock. Under State statutes, owners of livestock killed by lions receive compensation when the cause can be confirmed.

In the Western U.S., the continuing expansion of human populations into lion habitats has been accompanied by an increase in lion/human interactions (Beier 1991). From 1990-

2003, the Department removed an average of 2.9 nuisance lions annually as a result of such interactions. The Department does not limit the number of nuisance lions that can be destroyed, but all other forms of human caused mortality are deducted from the annual mortality quotas.

II. LIFE HISTORY –

A. The historic range of the mountain lion was the largest of any terrestrial mammal in the western Hemisphere, other than humans (Logan and Sweanor 2001). The mountain lion still ranges from the southern tip of South America to northern British Columbia (Logan and Sweanor 2001), but was apparently extirpated from the eastern U.S. (except southern Florida) and eastern Canada by the late 1800s to early 1900s. Between the mid 1960s and the early 1990s, mountain lion populations increased in many western states and they expanded their distribution into some of the mid-western states including Nebraska, South Dakota, and North Dakota. This expansion largely took place after mountain lions were reclassified from unregulated status to game animals in most states, and after the use of poisons was restricted beginning in the early 1970s. Similarly, mountain lions in Wyoming have increased in abundance and distribution and currently occupy most regions with timber or tall-shrub cover statewide. In the early part of the 20th century, efforts to remove mountain lions from many areas of Wyoming caused local extirpations. However, robust populations are currently found in the Black Hills of northeastern Wyoming, the pinyon-juniper country of southwestern Wyoming, and all major mountain ranges throughout the state. The recovery of mountain lions throughout Wyoming (and likely much of the species' former range) is likely due to favorable shifts in management practices and policies, and habitat conditions favoring increases of some prey (e.g., elk, *Cervus elaphus*, white-tailed deer, *Odocoileus virginianus*).

Dispersal patterns and genetic evidence suggest mountain lion populations are well connected throughout most of the western U.S. (Culver et al. 2000, Sinclair et al. 2001, Anderson et al. 2004). Males have been known to move distances in excess of 1,000 km (Thompson and Jenks 2005). These long-range movements provide a very effective means of genetic transfer helping to maintain lion populations in distant regions. In addition, much of the habitat occupied by mountain lions in Wyoming consists of mountain ranges that extend into surrounding states. This provides excellent connectivity to other habitats and lion populations. Overall, gene flow throughout the Central Rocky Mountains would indicate the region sustains one large mountain lion population with rapid genetic exchange among suitable habitat patches (Anderson et al. 2004).

B. Habitat Use

The mountain lion's broad distribution in North America attests to its adaptability and its ability to persist virtually any place with adequate prey and cover [Cougar Management Guidelines Working Group (CMGWG) 2005]. Mountain lions may be found in climates ranging from arid desert environments to temperate rainforests of the Pacific Coast. Previous studies in the western U.S. suggest mountain lions select conifer, deciduous timber, riparian, and tall shrub habitat types at mid-high elevations in steep or rugged

terrain (Logan and Irwin 1985, Laing 1988, Koehler and Hornocker 1991, Williams et al. 1995, Dickson and Beier 2002). Tall vegetation or rugged terrain provides the necessary hiding and stalking cover for securing prey and raising young (CMGWG 2005). Besides lack of prey, the only other conditions limiting lion distribution are vast, open areas with little hiding cover and severely cold winter temperatures of northern climates (Pierce and Bleich 2003).

Despite the mountain lion's broad geographic distribution and adaptability, development and habitat fragmentation can negatively impact lion populations (Beier 1993). New road construction and homes in mountain lion habitat not only reduce the amount and quality of habitat available to mountain lions and their prey [e.g., deer (*Odocoileus* spp.) and elk (*Cervus* spp.)], but also increase human presence in these areas. Increased human activity ultimately leads to more frequent conflicts and ultimately higher mortality rates of mountain lions in these areas (CMGWG 2005). Even in sparsely populated states such as Wyoming, where most lion range is still relatively intact, subdivisions, new road construction, and oil and gas development may negatively habitats occupied by mountain lions.

C. Mountain Lion Social Structure and Reproduction

The social behavior of mountain lions likely evolved to maximize individual survival and reproductive success (Logan and Sweanor 2001). Mountain lions are solitary carnivores exhibiting a polygynous breeding strategy wherein dominant males typically breed with females that reside within their home ranges (Murphy 1998). Resident males aggressively defend their territories against male intruders, whereas females allow more overlap, but express mutual avoidance (Lindzey et al. 1989, Ross and Jalkotzy 1992, Logan and Sweanor 2001). Home ranges of females tend to be large enough to provide sufficient prey for themselves and their young (~50-100 km^2, 20-40 mi^2). On the other hand, home ranges of males tend to be larger (~150-300 km^2, 60-120 mi^2), overlapping the home ranges of several females apparently to maximize reproductive success (Murphy 1998). Young females commonly express philopatric behavior (remain in their natal range) upon independence, but males typically disperse from their natal range (Anderson et al. 1992, Ross and Jalkotzy 1992, Lindzey et al. 1994, Logan and Sweanor 2001). Mountain lion densities are low by comparison to other large mammals. They range from about 10 independent (>1 year old and self sufficient) mountain lions/1,000 km^2 (386 mi^2) in arid climates such as southern Utah (Lindzey et al. 1989) to about 35 independent mountain lions/1,000 km^2 in moister regimes such as the Diablo Range, California (Hopkins 1989) and southwest Alberta (Ross and Jalkotzy 1992).

Female mountain lions typically produce their first litter when they are 2-3 years old (Anderson 1983, Ashman et al. 1983, Logan and Sweanor 2001). Although mountain lions can breed at any time of year, they exhibit seasonal birth pulses. Data from 7 studies in western North America indicate May through October is the peak period for mountain lion parturition (CMGWG 2005). Gestation lasts 82-96 days and litter size is typically 2 to 4 young. The average size of 53 nursling litters documented in New Mexico was 3.0, with 13 (26%) 2-kitten litters, 26 (49%) 3-kitten litters, and 14 (26%) 4-

kitten litters (Logan and Sweanor 2001). Other studies reported average litters of kittens <6 months old ranged from 2.2 in Alberta (Ross and Jalkotzy 1992) to 2.9 in Wyoming (Logan et al. 1986). Kittens are usually weaned at 2–3 months and typically remain with the female 12–18 months until they become independent (Pierce and Bleich 2003).

D. Food Habits and Prey Relationships

Mountain lions consume primarily large vertebrate prey. In much of North America, deer comprise the majority of mountain lion diets (Pierce and Bleich 2003), but other large ungulates such as elk, bighorn sheep (*Ovis canadensis*), moose (*Alces alces*), and pronghorn (*Antilocapra americana*) may also be consumed (Ross and Jalkotzy 1996, Ross et al. 1997, Murphy 1998, Anderson and Lindzey 2003). Although mountain lions primarily subsist on large ungulates, small mammals including porcupines (*Erethizon dorsatum*), lagomorphs (hares and rabbits), ground squirrels (*Spermophilus* spp.), and beavers (*Castor canadensis*) may also supplement mountain lion diets. Mountain lions occasionally prey on domestic livestock and pets as well. Sheep and goats are the most common domestic livestock taken by lions, but they also kill cattle, horses, and pets including dogs, and cats (CMGWG 2005).

Mountain lions can affect the trajectory of some ungulate populations. Lions were an important source of predation on a bighorn sheep population in Alberta (Ross et al. 1997) and were implicated in the decline of another bighorn population that began to avoid areas of high quality forage where it was exposed to predation (Wehausan 1996). Logan and Sweanor (2001) reported mountain lion predation was the most important, proximate factor limiting a New Mexico mule deer (*O. hemionus*) population. In this case, lion predation slowed the rate of growth during an increasing population phase, and hastened the decline when drought impacted forage quantity and condition. Mountain lions annually removed an estimated 15-20% of a mule deer population on the Kaibab Plateau, Arizona (Shaw 1980), 8-12% of a mule deer population on the Uncompahgre Plateau, Colorado (Anderson et al. 1992), and 2-3% of elk and 3-5% of mule deer in the northern Yellowstone Ecosystem (Murphy 1998). Predation by mountain lions, however, does not necessarily suppress or regulate a prey population. Suppression is more likely in systems with multiple prey and multiple predator species. In these situations, predators that would normally decrease as their prey becomes less abundant are supported by other, more numerous prey species (Pierce and Bleich 2003).

The potential effect of lion predation depends largely on the condition of the prey and its habitat. In areas where habitat is in good condition, most individuals in the prey population are likely to survive in the absence of predation. Where prey is in poor condition due to diminished forage quality, individuals are more likely to die regardless of predation. Mountain lion predation is more likely to be *additive* to other causes of mortality when ungulates are in good physical condition. Conversely, mountain lion predation is more likely to be *compensatory* when ungulates are in diminished physical condition (Logan and Sweanor 2001). Healthy prey populations typically have higher reproductive rates and offset predatory regulation by producing more young than are consumed by predators. Ungulate populations that are limited by predation (Table 1)

may benefit from increased mountain lion harvest. Populations limited mainly by habitat conditions will not likely benefit from increased harvest of mountain lions, except during the initial phases of habitat recovery. In this circumstance, reducing predation may allow the prey population to respond more rapidly to improved forage conditions. Where alternate prey is unavailable, mountain lions will decline naturally following a decrease in the primary prey (ungulate) population, regardless how liberal or conservative mountain lion harvests are (CMGWG 2005).

Table 1. Characteristics of ungulate prey populations regulated by predation and by forage conditions (from the Cougar Management Guidelines 2005, page 15).

Prey species characteristic	Population size mainly affected by predation[b]	Population size mainly affected by forage conditions
Physical condition of adult females	better	poorer
Pregnancy rate of adult females	higher	lower
Pause in annual production by adult females	less likely	more likely
Yearlings pregnant[a]	usually	seldom
Corpora lutea counts of adult females[a]	higher	lower
Litter size[a]	higher	lower
Age at first reproduction for females	younger	older
Weight of neonates	heavier	lighter
Mortality of young	additive	compensatory
Age at extensive tooth wear	older	younger
Diet quality	higher	lower

[a] Some species of ungulates may exhibit limited variability in these characteristics.
[b] These traits will be evident in *any* population that is far below carrying capacity, even if it experiences *no* predation. The manager should have evidence that predation is a limiting factor before concluding that reducing predation would increase ungulate recruitment.

III. POPULATION ESTIMATION TECHNIQUES – Population parameters such as size, density, and age and sex composition are difficult to estimate because lions are secretive and primarily nocturnal, and they exist at naturally low densities within typically rugged terrain (Wyoming Game & Fish Department 2006). The most reliable demographic information about mountain lions is obtained from radio telemetry and mark/recapture or re-sight studies (Logan et al. 1986, Lindzey et al. 1994). Population indices have also been derived from

track surveys (Van Dyke et al. 1986, Van Sickle and Lindzey 1991, Smallwood and Fitzhugh 1995, Beier and Cunningham 1996, Becker et al. 1998), and new DNA marking techniques (Ernest et al. 2000).

A. Mark-Recapture –

1. Rationale – Mark-recapture procedures involve marking a random sample of animals and then resampling to estimate the proportion of marked animals in the population. The proportion of marked animals in the sample is extrapolated based on the sample size and total number marked, to provide a population estimate. Although mark-recapture procedures are widely used to census mountain lion populations and are generally considered the most accurate method, it is often difficult to fulfill the assumptions of the method. All animals in the population must be equally susceptible to capture and no immigration or emigration can take place during the sampling period. Mark-recapture studies tend to be costly and labor intensive, limiting their application to smaller geographic areas. Managers should exercise caution when applying density estimates to other similar habitats and populations, as varying harvest intensity and other factors can influence lion demography (Lindzey 1987).

2. Application – A mark-recapture study must be designed properly to be successful. Catch rates are balanced through trap spacing (to ensure all animals have access to traps), timing and duration of trapping (to account for seasonal movements), and trap types, sets and baits (to enhance capture of trap-wise animals). Radio-transmitters may be used to detect movements across study area boundaries. Study areas should be large enough to represent a population and attributes (habitat, hunting pressure, harvest structure) should be representative of other areas to which density estimates may be applied.

   Several mark-recapture or resight methods are currently employed to estimate abundance of mountain lions. The most common approach is to capture, mark, release, and recapture lions. Trapping and handling techniques are described in Hemker et al. (1984) and Lindzey (1987). Ear-tags and radio-collars can serve as marks. Sampling to obtain recapture or resight data can be accomplished by recapture (Logan et al. 1986), aerial observations (Van Sickle 1990, Lindzey et al. 1994), or harvest monitoring (Garshelis 1990).

3. Analysis of data – Methods used to analyze mark-recapture data are described in various population ecology textbooks (e.g., Begon 1979, Krebs 1989). Analytical methods have also been devised to address unique issues, such as unequal catch rates or lack of demographic closure (Otis et al. 1978, Pollock 1982, White et al. 1982, White 1996). If radio-location data are available, the estimate can be improved by calculating the number of marked animals present during recapture efforts (Miller et al. 1987, Miller et al. 1997) or by weighting the marked proportion based upon the time each animal spends in the trapping area (Garshelis 1992). Analytical tools (e.g., Jolly-Seber) are available to address lack of demographic closure caused by births, deaths, immigration, emigration, etc. However, populations tend to be overestimated

unless the assumptions of even catch rates and geographic closure are met, or the disparities are corrected.

4. Disposition of data – The results of any mark-recapture study should be summarized in a report distributed to Regional Wildlife Coordinators and the Trophy Game Section. This information can be useful to evaluate or adjust hunting season frameworks and harvest quotas.

B. Track Surveys –

1. Rationale – Track surveys can provide an index to the abundance of mountain lions (Van Dyke et al. 1986, Lindzey 1987, Van Sickle and Lindzey 1991). Tracks in the snow are located by walking ground transects (Van Dyke et al. 1986, Van Sickle 1990, Smallwood and Fitzhugh 1995, Beier and Cunningham 1996) or by aerial observations (Van Sickle and Lindzey 1991, Becker et al. 1998). The number of unique track sets is determined to estimate the abundance of lions in a specific area.

2. Application – Observers survey a defined area either on the ground or from the air to locate all mountain lion tracks (Lindzey 1987). Tracks of individual lions are identified based on measurements or distinguishing characteristics such as missing toes (Van Dyke et al. 1986, Van Sickle 1990). The number of unique track sets is an estimate of lion density within the area surveyed. If a representative area is surveyed, the estimate can be extrapolated to calculate a regional population estimate (Smallwood and Fitzhugh 1991). Van Dyke et al. (1986) examined the probability of detecting lion tracks under various conditions.

   Tracks observed from the air cannot be assigned to individual, unmarked lions, however such observations can be used in probability sampling to estimate the density of lions within a particular area. One technique is to fly transects across the study area, perpendicular to a baseline (e.g., drainages or ridges, Van Sickle 1990, Becker et al. 1998). Each track set observed is backtracked to a point where tracks are no longer fresh, then foretracked until the animals are located (Becker et al. 1998). Becker et al. (1998) developed equations to estimate the population based on the track length in relation to the length of the baseline of the area searched (Van Sickle 1990). Using this technique, Van Sickle and Lindzey (1991) accurately estimated the number of lions in a known population. A population can also be estimated by dividing the sum of the number of individual tracks observed per survey unit by the probability of observing those tracks (Becker et al. 1998). Another method involves marking a random sample of lions with radio collars. The average distance traveled by lions parallel to the baseline is determined from the radio-collared animals. Based upon these parameters and the number of tracks detected by observers, the population can be estimated (Van Sickle 1990). Studies were done in Idaho, Utah, and Wyoming to evaluate the use of probability sampling to estimate lion populations. Results from Idaho and Utah were summarized in the proceedings of the 6th Mountain Lion Workshop published in December 2002. Anderson et al. (2003) investigated this method further using computer simulations of mountain lion

GPS data (≤6 locations/night) to simulate mountain lion tracks and reported that changes of 15-30% could be detected (90% probability) for medium-high density mountain lion populations (23-35 independent mountain lions/1,000 km^2 or 386 mi^2) depending on sampling effort (transects spaced 2 to 3 km apart). An area of about 2,000 km^2 (771 mi^2) could be surveyed in 2 helicopter days for about $8,000-$10,000. Thus, the technique would be limited to relatively small areas and likely only affordable to management agencies every few to several years.

3. Analysis of Data – Selective harvest by hunters in accessible areas can impact age and sex composition data obtained from roadside and aerial track surveys. This source of potential bias should be considered when these types of data are used to estimate lion densities. The precision of aerial track surveys is also affected by the density of lions in the area (Van Sickle and Lindzey 1991). Precision increases at higher densities.

4. Disposition of Data – Results of track surveys should be summarized in a report and distributed to Regional Wildlife Coordinators and the Trophy Game Section for use evaluating hunting season frameworks and annual mortality quotas.

C. Minimum Population Estimation from DNA Sampling –

1. Rationale – Using recent developments in DNA analysis, managers can now collect samples of hair, feces, or other tissues in the field and analyze them to establish genetic profiles of individual animals. Ernest et al. (2000) identified individual mountain lions in California by analyzing microsatellite DNA from feces collected in Yosemite National Park. Mountain lion DNA was successfully isolated from prey DNA in the feces, and was also distinguishable from DNA of other carnivore species (Ernest et al. 2000). A minimum population of mountain lions (number of unique individuals) was estimated based on his technique. The population included both resident individuals and lions traveling through the study area.

2. Application – Mountain lion scats are collected from the survey area and sent to a lab where DNA analysis is performed. By cataloging the individual genetic sequences identified from scats, a minimum population of lions can be determined, provided sufficient effort is expended to collect scats.

3. Analysis of Data – Currently, the technique involves simply tallying the numbers of individual lions represented in genetic samples collected from within an area. However, mountain lion scats can be quite difficult to locate. Intensive searches are needed to locate feces from a large number of individuals and this may make the technique impractical for most management applications.

4. Disposition of Data – The results of DNA studies should be summarized in a report and distributed to Regional Wildlife Coordinators and the Trophy Game Section for use in evaluating hunting season frameworks and annual mortality quotas.

D. Incidental Observations –

1. Rationale – Mountain lions are secretive, nocturnal, and live in rugged terrain. Consequently, incidental sightings are rare and thus a poor index of lion abundance. However, lion sign can corroborate presence or absence. Some states, including Wyoming, record numbers of lions observed and reported by hunters, but these data should be interpreted cautiously because of the potential for repeat sightings of individual lions.

2. Application – Observations of lions by Department personnel should be recorded on Wildlife Observation Forms and entered in the Wildlife Observation System (WOS) database. When each harvested lion is registered, the hunter is asked to report the number of lions he observed while hunting. This information is entered on the Mountain Lion Mortality Form (Attachment 1).

3. Analysis of data – Compilations of lion observations may be used in conjunction with other trend indicators, but not as a primary measure of abundance. Observations can be tallied on the basis of hunt areas or MLMUs, or they can be graphically displayed using GIS software. Records of lion observations can be useful when Department personnel comment on project proposals, particularly if documentation of presence or absence is needed.

4. Disposition of data – Forward records of lion observations monthly for regional Wildlife Coordinators to proof before they are entered in the Wildlife Observation System. In the past, requests for data queries and downloads were directed to Biological Services. However, the WOS has recently been reprogrammed enabling field personnel to query, sort, and download records from remote P.C. stations. Lion Mortality Forms should be forwarded to the Trophy Game Section where they are entered into the statewide Mountain Lion Database. Tallies of lions sighted by hunters are not published in the annual Mountain Lion Mortality Summary, but they can be requested from the Trophy Game Section if needed.

IV. HARVEST DATA –

A. Houndsman Survey –

1. Rationale – A survey designed to measure hunter effort and success was mailed to approximately 150 mountain lion houndsman and hunters each year through 2000. Houndsmen were requested to report the numbers and locations of lions harvested or released, the ages and sexes of lions harvested or released, the number of days they hunted in each hunt area, numbers of lion tracks passed up, and opinions regarding lion population trends. The survey was not used to estimate the total harvest, which can be determined more accurately from mandatory registration data. The survey was discontinued after 2000 due to poor response from hound handlers.

2. Application – Responses to the houndsman surveys were compiled and published in a report that was distributed to all survey respondents and others who requested the data. The results are available through the Trophy Game Section.

B. Sex/Age Determination –

1. Rationale – Information about age and sex structure is essential to successfully manage a mountain lion population. In Wyoming, criteria used to manage lions are based upon the sex and age composition of harvested lions.

2. Application – Since 1974, all successful mountain lion hunters have been required to present the skull and pelt of harvested lions to a Wyoming Game and Fish Department employee within 3 days of harvest. Data from each harvested lion are recorded on Mountain Lion Mortality Forms (Attachment 1). The following information is collected: location of kill, sex, number of days hunted, total number of lions observed while hunting, and method of take. Two premolar teeth are extracted for cross-sectioning to determine age. Generally, the second upper premolars are extracted. Exercise care to avoid breaking the roots as broken teeth are useless for aging. Hair and tissue samples are also collected for DNA analysis. Clip a small (approximately 1 cm^2) hair and tissue sample from the edge of the pelt. Place tooth and hair/tissue samples in separate small paper envelopes. Samples must be stored in a manner that allows desiccation, as moisture retention promotes spoilage. Label the envelopes with type of sample, sex and estimated age of lion, name of hunter, location, hunt area, and date. Envelopes are attached to a Mountain Lion Mortality form and mailed to the Trophy Game Section. Skulls must be presented in an unfrozen condition so teeth can be removed, and evidence of sex must remain naturally attached to the pelt for accurate identification. The vulva or penis spot can also be used to determine sex of lions. The penis spot is 4-5" anterior from the anus on males and the vulva spot is about 1" anterior from the anus on females. Information collected from harvested lions is the primary source of data used to monitor mountain lion populations in Wyoming.

3. Analysis of data – Harvest data are compiled in an annual Mountain Lion Mortality Report prepared by the Trophy Game Section after each hunting season. Reports include the harvests in each MLMU and statewide, as well as the sex composition of the harvest.

4. Disposition of data – Mountain Lion Mortality Forms are forwarded to the Trophy Game Section upon their completion. The information is then entered into the statewide mountain lion database. Annual mortality reports can be requested from the Trophy Game Section.

C. Aging Techniques – The techniques currently available to age mountain lions are approximate and sometimes subjective. However, coarsely defining age classes as young non-breeding individuals and older, probable breeders is considered sufficient to support management decisions (Lindsey 1987). Techniques currently used by the Wyoming

Game and Fish Department to age captured or harvested mountain lions are described in the following sections. No single technique is entirely reliable. A combination of techniques will provide the most dependable results.

1. Laboratory Aging Based on Tooth Cross-Sectioning –

    a. Rationale – Cementum is deposited annually in layers around the roots of mammal teeth. The cementum layers can indicate age in years (Dimmick and Pelton 1994). However, early attempts to count the cementum annuli in cross-sections of mountain lion teeth proved unreliable (Lindzey 1987). The dependability of this technique improved with advancements in lab technology and development of aging criteria specifically for mountain lions. Moody (1997) reported reasonable agreement between ages determined from cementum annuli and tooth wear in 80% of 93 cases.

    b. Technique – The cementum annuli technique involves both field and laboratory procedures. A tooth must first be extracted from captured or harvested lions. To ensure consistency, we recommend using the second upper premolar (upm2) to age mountain lions (Dimmick and Pelton 1994). This tooth is located directly behind the upper canine.

        Teeth can be removed with various dental elevators or tooth extraction devices available through veterinary supply companies. Exercise care to maintain the integrity of the tooth. In most cases, it is imperative to keep the root of the collected tooth intact (Dimmick and Pelton 1994). In addition, you should take into consideration the well being of live animals and preservation of trophy skulls. After the tooth is removed from the jawbone, keep it clean and place it in a small paper envelope that has been labeled. Send collected teeth and accompanying data forms to the Trophy Game Section where they will be cataloged and forwarded to the lab. Once at the lab, teeth will be processed and examined to determine age.

    c. Analysis and Disposition of Data – Age data are compiled by the Trophy Game Section and analyzed in the annual Mountain Lion Mortality Summary. These reports can be requested from the Trophy Game Section.

2. Field Techniques for Aging – Ages of mountain lions can also be determined from tooth wear, presence or absence of a canine ridge, and pelage characteristics. Lions can be reliably categorized into distinct age classes based on these methods. Anderson and Lindzey (2000) published a detailed photographic guide for estimating lion ages based on canine ridge, previous or current lactation, tooth wear and staining, and pelage characteristics. This guide is available through Biological Services or the Wyoming Cooperative Fish & Wildlife Research Unit. Also refer to Appendix V (Aging Techniques), Section II.E. (Mountain Lions). Anderson and Lindzey (2000) provided the following descriptions:

a. Tooth Wear, Staining, and Eruption – Note the degree of wear on the outer incisors in relation to the other incisors and note wear on the canines. The degree of tooth staining can also indicate age. The progression of tooth eruption is useful to age lions up to 16 months of age.

b. Pelage Characteristics – Spots on the tan portion of the pelage become difficult to discern by about 1 year of age and are typically gone by 2 years of age. Spots on the white underfur become difficult to detect after 2 years of age, but may be present up to 3 years of age. Bars on the inside front legs are last to disappear and may be present on 3 year old lions.

c. Canine Ridge – The canine ridge is a junction along the top of the canine tooth where the cylindrical upper portion of the tooth meets the tapered lower portion. This ridge becomes detectable at about 2-3 years of age and is the best means of differentiating between breeding age and non-breeding age males.

d. Evidence of Previous Lactation in Females – The nipples of females that have previously lactated are typically flattened or enlarged and black in color. Females that have not lactated typically have white or light colored nipples. Female mountain lions generally give birth by 24-30 months of age. The external appearance of nipples is the best means of differentiating between breeding age and non-breeding age females.

V. NON-HUNTING MORTALITY –

A. Incidental Observations –

1. Rationale – Records of non-hunting mortalities are useful to document lion presence, and to detect potential problems such as disease or hazards.

2. Application – Record all non-hunting mortalities of mountain lions, either human-caused or natural, on Mountain Lion Mortality Forms (Attachment 1). These forms should be completed to document all mortalities discovered by, or reported to the Wyoming Game & Fish Department.

3. Analysis and Disposition of Data – Records of non-hunting mortalities will be summarized in the annual Mountain Lion Mortality Summary at the conclusion of the hunting season. Natural mortalities are not counted against hunting season quotas. Human-caused mortalities are not counted if they are non-hunting (e.g., vehicle collisions). However, lions taken illegally are counted against the quotas.

VI. LION-HUMAN INTERACTIONS – A statewide protocol was adopted to manage interactions between trophy game and humans in Wyoming (Wyoming Game & Fish Department 1999). The protocol outlines specific policies and procedures the Department follows in dealing with individual lions identified as dangerous or a nuisance. To determine

an appropriate response, the Department classifies mountain lion/human interactions in one of the following categories:

- Recurring Sighting – Repeated sightings of a particular lion or group of lions close to developed areas.

- Encounter – An unexpected direct meeting, without incident, between a human and a mountain lion near developed areas.

- Aggressive Encounter – An incident during which a lion displays aggressive behavior toward a human, but the aggressive encounter doesn't result in physical injury.

- Attack – A human is physically injured or killed as a result of contact with a mountain lion.

The Statewide Protocol for Managing Trophy Game/Human Interactions outlines responses recommended for the above categories of encounters. Depending on the circumstance, appropriate responses can include no action, deterrence measures, aversive conditioning, trapping and relocation, or destruction of the animal.

When a lion/human encounter is reported, personnel are required to fill out a Trophy Game Incident Report and a Trophy Game/Human Interaction Form (Attachment 2). If the incident is a sighting, depredation, property damage, etc. that does not directly involve a human encounter, only a Trophy Game Incident Report needs to be filled out. Data from these forms are used to improve damage prevention strategies and public instruction regarding effective responses in confrontations with lions.

A pamphlet entitled, "Living in Lion Country" was published by the Wyoming Game and Fish Department in 1996. The pamphlet describes specific responses to deal with an aggressive lion and steps to minimize conflicts around developed areas. Similar information is provided in educational workshops presented by Department personnel each spring.

VII. CAPTURE AND IMMOBILIZATION – Although lions can be captured in traps or foot snares, they are most commonly treed with the use of trained dogs and then immobilized with a dart propelled by a CO_2 or .22-caliber charge (Lindzey 1987). This method of immobilization can be dangerous to both the animal and the handler and should not be attempted except with personnel present who are trained in chemical immobilization and emergency care (Pond and O'Gara 1994). For general discussions of immobilization procedures, consult Seal and Kreeger (1987) and Pond and O'Gara (1994). Recommended dosages of Telazol, Xylazine, and Yohimbine (a reversal drug for Xylazine) are listed in Attachment 3. In over 80 lion captures, only 1 lion was lost due to drug-related causes (Chuck Anderson pers. comm.). Always find appropriate sites to release captured lions, as lions recovering from immobilizing drugs are at risk if released near water, cliffs, etc. A Trophy Game Capture Form is also included in Attachment 4.

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ATTACHMENT 1

MOUNTAIN LION MORTALITY FORM

Hunt Area _____ Region _____

Date of kill: _____ TYPE: Legal_____; Illegal_____; Damage Control_____; Other_____; Unknown_____

If "Other" or "Unknown", probable cause of mortality _____

PERSON WHO HARVESTED LION: Name: _____

Address: _____ City: _____

State: _____ Zip: _____ Phone: _____ Resident: _____ Nonresident: _____

METHODS/EFFORT: Days hunted: _____ Were dogs used? (Y/N) _____ If not, how was lion harvested? _____

Was a guide/outfitter used? (Y/N): _____ Name: _____ Dog owner: _____

Number of lions observed: _____ Were you selective while hunting? (Y/N): _____ Number of lions treed and released: _____

Number of lions that were marked: _____ (Ear tag / tattoo / radio collar frequency : _____)

Number of fresh tracks not pursued: _____ (How many were single adults?: _____ How many were adults with kittens?: _____)

LOCATION/DRAINAGE: Where was lion harvested? _____

Sec: _____ Twnshp: _____ Rng: _____ UTM Zone: _____ UTM Easting: _____ UTM Northing: _____

SEX AND AGE: Sex: _____ Est. Age: _____

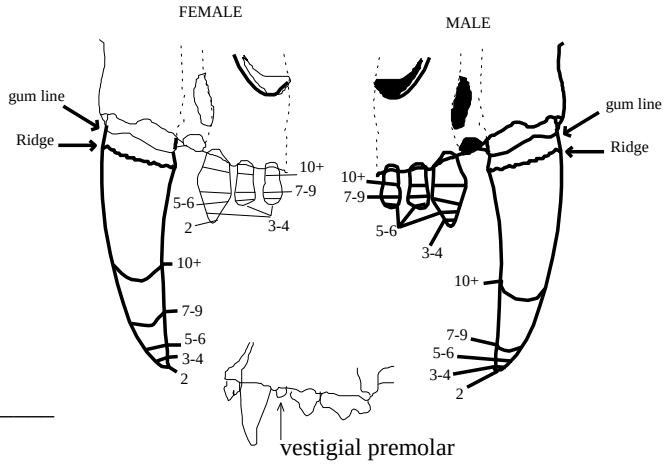
If female, presently lactating? (Y[≥2] / N) _____

Appear to have lactated in past? (Y / N) _____

Canine ridge below gumline? (Y[≥2.5] / N) _____

Any visible spotting on rear legs? (Y[≤3] / N / ?) _____

Visible bars on inside of front legs? (Y[<4] / N / ?) _____



REQUIRED SAMPLES:

Number of teeth collected: 0 1 2 Pictures of teeth (Y/N): _____

Hair/Hide sample (1/2" X 1/2") taken (Y/N): _____

Remarks: _____

_____

_____

Date record was WOFed: _____ Date Biological Services Called: _____

I, _____ of _____

being duly sworn, depose and say that I am the holder of Wyoming Mountain Lion license # _____,

and lawfully took the above lion on _____ - _____, 20_____ in Hunt Area # _____.

_____ _____ _____

Inspected by Date Hunter's Signature

Any person who makes a false statement on the registration form regarding the date the mountain lion was taken or the hunt area in which it was taken shall be in violation of this regulation and, such violation shall be punishable as provided by Title 23, Wyoming statutes for violation of Commission regulations.

ATTACHMENT 2

TROPHY GAME INCIDENT REPORT

Trophy Game Section

SPECIES: GRIZZLY BEAR BLACK BEAR MOUNTAIN LION WOLF	Record ID # Entered By: Date:
MORTALITY # CAPTURE #	ANIMAL ID# LAB AGE
TROPHY GAME SECTION	

DATE:_____ INVESTIGATORS:_____ AGENCY: _____

INCIDENT/CAPTURE SITE INFORMATION

SECTION_____ TOWNSHIP_____ RANGE_____

UTM COORDINATES:_____(east)_____(north) ZONE:_____ WGFD REGION: _____

MANAGEMENT UNIT:_____ HUNT AREA:_____ LANDOWNER:_____

LOCATION (Drainage etc.):_____ HABITAT:_____

AFFECTED PERSON:

NAME: _____

ADDRESS: _____

CITY:_____ STATE: _____

REPORTING DATE:_____ ZIP: _____

PHONE: _____

TYPE OF NUISANCE / DAMAGE

GARBAGE ..... _____

LIVESTOCK..... _____

VEHICLE ..... _____

CAMP ..... _____

DEVELOPED SITE / STRUCTURAL ..... _____

PET ..... _____

HUMAN INTERACTION * ..... _____

AGE CLASS (# and sex of each)	FEMALE	MALE	UNK	OTHER
ADULT	____	____	____	
SUBADULT	____	____	____	
YEARLING	____	____	____	
YOUNG OF YR.....	____	____	____	
UNKNOWN	____	____		

**** Refer to Trophy Game/Human Interaction Form***

_____ESTIMATED DAMAGE COST: $ _____

DID ANIMAL RECEIVE HUMAN FOOD REWARD?

_____ YES NO

ID MARKS:

TYPE:_____ COLOR:_____ NUMBER:_____ LOCATION: _____

ACTION TAKEN:

REPORT ONLY:_____ SITE INVESTIGATION:_____ AVERSIVE CONDITION:(type)

CAPTURE ATTEMPTED:(days) _____ ANIMAL CAPTURED:** _____ TRANSLOCATED: _____

EUTHANIZED: _____ PHOTOS:(y/n) _____ ENTERED IN WOS: _____

***** Complete a Trophy Game Capture form if an animal is captured.***

RELEASE INFORMATION: SECTION_____ TOWNSHIP_____ RANGE_____

UTM COORDINATES:_____(east)_____(north) ZONE:_____ WGFD REGION: _____

MANAGEMENT UNIT:_____ HUNT AREA:_____ LANDOWNER:_____

LOCATION (Drainage etc.):_____

DETAILS: (animal descriptions, site description, circumstances, etc.) _____

_____

(cont. on back)

WILDLIFE/HUMAN INTERACTION FORM

This form is to accompany a completed Trophy Game Incident Report form.

Complete this form only in the event of: recurring sightings or encounters near human development, or an aggressive encounter or attack

LARGE CARNIVORE: Mt. Lion; Black Bear; Grizzly Bear; Other: _____

RECORD TYPE: Mark the correct choice after reading definitions:

Recurring Sighting: repeated sightings of a particular animal or group of animals in close proximity to human developed areas (e.g., homes and campgrounds).

Encounter: an unexpected direct meeting between a human and a large carnivore without incident near human developed areas.

Aggressive Encounter: an incident where a large carnivore displays aggressive behavior toward a human, but does not cause physical injury.

Attack: When a human is physically injured or killed from contact with a large carnivore.

Recurring Sighting:_____ Encounter:_____ Aggressive Encounter:_____ Attack:_____

Age Class: Enter # and Sex of: Adults:_____ Subadults:_____ Yrlg:_____ Young:_____

If attack: Victims Name: _____ Age: _____ Fatal? Yes No

Interview Section

Call received by: _____ Date: _____ Time (military): _____

A. Activity of involved party prior to incident:

1. Hiking _____ 2. Fishing _____ 3. Hunting _____ 4. Retrieving game _____ Other: _____

B. What action did the person involved exhibit? (check all applicable)

1. Waved arms _____ 2. Backed away _____ 3. Ran _____ 4. Talked _____ 5. Shouted _____

5. Threw objects _____ 6. Fired warning shot _____ 7. Fought _____ Other: _____

C. What action did the animal exhibit? (check all applicable)

1. Watched person _____ 2. Pop jaws _____ 3. Show teeth _____ 4. Growled _____ 5. Fled _____

6. Crouched _____ 7. Bluff charged _____ 8. Attacked _____ Other: _____

D. Which of following best describe the incident? (check all applicable)

1. Surprise encounter _____ 2. Food guarding _____ 3. Defense of young _____

4. Inquisitive/habituated _____ 5. Human predation _____ Other: _____

I&E Brochure(s) Mailed: Yes No List Title(s): _____

_____

Follow-up: Public Meeting _____ Other: _____

(Narrative Report On Back)

Send original with completed Large Carnivore Incident Report to Regional Office. Regional Office will forward to Trophy Game Section.

5/15/97

WILDLIFE/HUMAN INTERACTION FORM (PAGE 2)
NARRATIVE REPORT

Required for recurring sightings and encounters near human development for trophy game species and all aggressive encounters and attacks for all species.

Date: _____ Investigators: _____

Reporting Party:_____ Address: _____

Phone: _____ **Incident/Capture Site Information:** Section:_____ Rng:_____ Tn:_____

UTM Coordinates:_____(East)_____(North) Zone:_____ WGFD Region: _____

Management Unit (DAR):_____ Hunt Area:_____ Landowner:_____

Location (drainage, etc.):_____ Habitat Type:_____

ID Marks: Type:_____ Color:_____ Number:_____ Location:_____

Action Taken: _____

Release Information: UTM: _____East _____North Zone:_____ WGFD Region:_____

Management Unit (DAR):_____ Hunt Area:_____ Location:_____

Comments:

ATTACHMENT 3

Mountain Lion Drug Dosages Using Telazol, Xylazine, and Yohimbine

Recommended dosage: Telazol – 2.2mg/lb, Xylazine – 0.45mg/lb, Yohimbine – 0.057mg/lb
***Hydrate Telazol with 2ml of sterile water/vial (500mg vial), total volume will be 2.6ml**

Body Weight (lbs)	Total Drug Dosage (mg)		Drug Volume (ml or cc)		Reversal (Yohimbine)	
	Telazol	Xylazine	Telazol	Xylazine	Dose (mg)	Volume (ml)
20	44	9	0.23	0.09	1.14	0.23
30	66	13.5	0.34	0.14	1.70	0.34
40	88	18	0.46	0.18	2.28	0.46
50	110	23	0.57	0.23	2.85	0.57
60	132	27	0.67	0.27	3.42	0.68
70	154	32	0.80	0.32	3.99	0.80
80	176	36	0.92	0.36	4.56	0.91
90	198	41	1.03	0.41	5.13	1.03
100	220	45	1.14	0.45	5.70	1.14
110	242	50	1.26	0.50	6.27	1.25
120	264	54	1.37	0.54	6.84	1.37
130	286	59	1.49	0.59	7.41	1.48
140	308	63	1.60	0.63	7.98	1.60
150	330	58	1.72	0.68	8.55	1.71
160	352	72	1.83	0.72	9.12	1.82
170	374	77	1.94	0.77	9.69	1.94
180	396	81	2.06	0.81	10.26	2.05
190	418	86	2.17	0.86	10.83	2.17
200	440	90	2.29	0.90	11.40	2.28

ATTACHMENT 4

Trophy Game Capture Form

Res. or Mngt. Date:_____ Bait:_____ Species:_____
Trap Method:_____ Agency:_____ ID # _____
Location:_____
UTM's_____E _____N Zone:_____ Mngt. Unit:_____ Hunt Area:_____
Trappers:_____

Immobilization Procedures

Drug strength(mg÷ cc)= mg/cc Dosage(total mg÷ lb)= mg/lb

Time	Drug	Dosage(cc)	Injection Site	Method	Reaction

Time animal immobile: Time Recovery Started: Time Recovery Complete:

PHYSIOLOGICAL MONITORING

Time	Respiration	Heart Beat	Temp. (F)

TAGS, WEIGHT, & AGE

Est. Weight:_____ Scale:_____
Sex:_____ Est. Age:_____ Lab Age:_____
Old Markers:_____
Tattoo:_____ Where:_____

	Number	Color	Shape
Ear Tags: **R:**			
L:			

Reproductive Status:_____

RADIO TRANSMITTER

TYPE	FREQUENCY	TRANS. #	COLOR	ATTACHED WITH:	PULSE RATE

BODY CONDITION (1-5) AND DESCRIPTION:_____
_____
_____
_____
_____

REMARKS:_____
_____
_____
_____
_____

Note: FARAD withdrawal time (time before human consumption of animal is safe) is 15 days for Telazol, 3 days for Ketamine, and 30 days for Xylazine.

RELEASE SITE:_____

Release UTM's_____E _____N Zone:_____ Mngt Unit:_____ Hunt Area:_____ Region:____

WGFD LOT #'s_____

Bear Measurements

Body Measurements (cm)

A. Total Length	
A-1. Contour Length	
B. Girth	
C. Height	
D. Neck Circ.	
E. Head Length	
F. Head Width	
F-1.Head Circ.	
F-2 Tail Length	

Foot Measurements (mm)

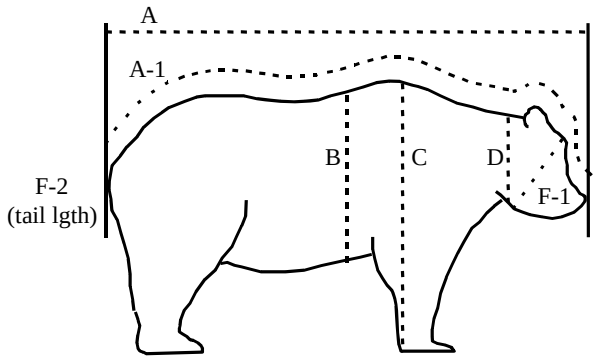
G	H	I	J	K	L	M	N

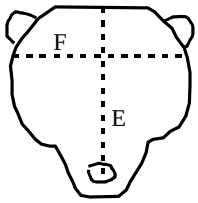
Samples Taken

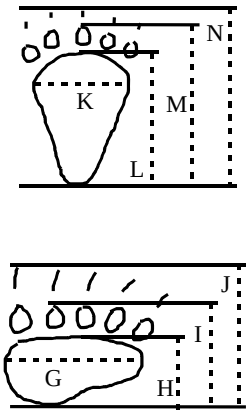
Tooth	Blood	Hair	Tissue

BIA Measurements

Reactance	Resistance	% Body Fat







Lion Measurements

Body Measurements (cm)

A. Total Length	
A-1. Contour Length	
B. Girth	
C. Height	
D. Neck Circ.	
E. Head Length	
F. Head Width	
F-1.Head Circ.	
F-2 Tail Length	

Foot Measurements (mm)

G	H	I	J	K	L	M	N

Samples Taken

Tooth	Blood	Hair	Tissue

Wolf Measurements

Body Measurements (cm)

A. Total Length	
A-1. Contour Length	
B. Girth	
C. Height	
D. Neck Circ.	
E. Head Length	
F. Head Width	
F-1.Head Circ.	
F-2 Tail Length	

Foot Measurements (mm)

G	H	I	J	K	L	M	N

Samples Taken

Tooth	Blood	Hair	Tissue

Revised 4/04

Chapter 11

Small Game Mammals
(cottontail rabbit, snowshoe hare, red, gray and fox squirrel)

Olin Oedekoven, Mark Zornes (Introduction by editor)

I. INTRODUCTION – Cottontail rabbits, snowshoe hares, and red, gray and fox squirrels are designated small game in Wyoming [W.S. 23-1-101(a)(xi)]. Several states, especially in the eastern U.S., conduct surveys to monitor small game populations. However, the information has limited value for harvest management because hunting mortality has little or no impact on carryover of small game to the subsequent breeding season. The major reasons to collect population data are to provide status information to the public, forecast game abundance for fall hunting seasons, or conduct special studies. However, there is little biological justification for adjusting small game hunting seasons on the basis of population data.

This chapter provides life history information and traditional monitoring techniques for reference purposes. Several techniques may have utility for research, monitoring effects of development, evaluating habitat treatments including reclamation success, or to document trends for hunting forecasts. The Department has no plans to conduct small game surveys at a statewide level.

II. BACKGROUND, STATUS, AND NATURAL HISTORY –

A. History in Wyoming – The cottontail rabbit was designated a game species in 1966 and hunting seasons were established thereafter. The first hunting seasons for snowshoe hares and tree squirrels were established in 1974.

B. Current Status –

1. Distribution –

a. Cottontail Rabbits – The eastern cottontail is confined to the southeast corner of Wyoming. Desert and Nuttall's cottontails are distributed throughout the state, however Nuttall's range probably does not coincide with the eastern cottontail, and the desert cottontail is not found along the Idaho-Wyoming border (Long 1965).

b. Snowshoe Hare – Snowshoe hares occupy higher-elevation, coniferous forests throughout mountain ranges of Western Wyoming, the Snowy Mountains and Big Horn Mountains (Long 1965).

c. Red and Fox Squirrel – Red squirrels inhabit mountain spruce-fir and pine forests throughout the state (Long 1965). In recent history the range of the fox squirrel has expanded (through releases and dispersal) to include most deciduous riparian, agricultural, and urban habitats east of the Continental Divide in Wyoming (Long 1965, Wyoming Game and Fish Department 1999). An isolated population of gray squirrels inhabits the Sheridan areas. The species possibly exists in some other locations along the eastern edge of the state, but has not been documented in the Department's observation records.

C. Natural History Information –

1. Range of productivity –

a. Cottontail Rabbit – Cottontails begin breeding at 3-6 months of age (Wyoming Game and Fish Department 1992). They typically produce about 3 litters per year, but can have up to 5. Each litter consists of 3-7 young (average 4).

b. Snowshoe Hare – Snowshoe hares also begin breeding at 3-6 months of age. They produce 2-4 litters per year, averaging 2 liters and 3 young per litter (Wyoming Game and Fish Department 1992).

c. Red and Fox Squirrel – Red and fox squirrels are able to breed at 6-9 months of age. Both species have 1 litter per year and 2-7 young per liter (Wyoming Game and Fish Department 1992).

2. Range of natural mortality –

a. Cottontail Rabbit – Natural mortality of cottontails is very high (Eberhardt et al. 1978). Annual survival rates can be as low as 20%. Average life span is approximately 2 years. Mortality is highest during the juvenile age class, post-weaning.

b. Snowshoe Hare – Natural mortality of snowshoe hares is also high, but varies markedly depending on environmental conditions and population cycles. Juveniles in their first year sustain highest mortality, ranging from 50% during periods of increasing populations to 90% during periods of decreasing populations (Dolbeer and Clark 1975, Meslow and Keith 1968). Annual mortality of adults ranges from 25-60% during increasing and decreasing population cycles, respectively.

c. Red and Fox Squirrel – The literature contains relatively little information about natural mortality of squirrels. However, squirrel populations are known to sustain themselves under heavy hunting pressure. This capability is typical of species with high rates of recruitment and natural mortality. In winter, mortality probably varies depending on weather conditions. Since squirrels are arboreal and store

food caches, it is likely they are more susceptible to long cold spells than to heavy snow cover.

3. Food Habits – Consult Adams (1959), DeCalesta (1971), Hansen and Flinders (1969), Martin et al. (1951), Turkowski (1975), Yeager (1959), Zimmer (2004) and others). Diets of most small game are comparatively broad, enabling them to utilize a variety of food sources depending on season and availability. Common methods for conducting food habits studies include field observation and fecal analysis (Adams et al. 1962, Schemnitz 1980).

III. CENSUS – Although the Wyoming Game and Fish Department does not currently monitor small game populations, population trends can be assessed using data from the small and upland game harvest surveys (e.g. hunter harvest, success, and effort). Methods discussed in this chapter are not widely used by the Department, but potentially have some application for research, special projects and prey base monitoring.

A. Trend Counts – Various trend counts have been used to monitor small game, especially in the eastern United States (Boufford and Hein 1978, Flyger 1959, Kline 1965, Lord 1961, and Newman 1959). Trend counts have also been applied within some areas of Wyoming, however the Department has no plans to develop a statewide trend count.

1. Rationale – The purpose of trend counts is to detect changes in abundance that take place over time, or differences that exist between locations. Generally, population sizes are not estimated from trend data except in limited circumstances, provided a conversion ratio has been developed. Surface management agencies can incorporate trend data into land management plans to evaluate impacts of various surface management activities, and results of habitat manipulations. The Department may use trend data for some species management. For example, trend counts can indicate prey abundance for various avian and mammalian carnivores.

2. Application –

a. Cottontail Rabbits – Spotlight trend counts are conducted along driving transects of at least 20 miles, typically in August and March. All observations of rabbits and the corresponding mileage readings are recorded on a data form. In Wyoming, personnel traditionally drive transects at 40 mph or less, beginning each 0.5 hour after sunset. However, researchers in other states recommend driving the routes at 20 mph. Kline (1965) determined cottontails were most active in late February and late July. Peaks of daily activity occur one hour before sunrise in February and one hour after sunset in July. Bearing this in mind, morning surveys could be evaluated in Wyoming. The width of coverage along transects should be standardized (e.g., the road and an equal distance on either side).

b. Snowshoe Hare – An accepted method has not been developed to monitor population trends of snowshoe hares.

c. Red and Fox Squirrels – Several techniques have been used to census squirrels (Boufford and Hein 1978, Fitzwater 1941, Flyger 1959, Kufeld 1964). The time-area count appears to be the most efficient (Kufeld, R. C. 1964).

3. Analysis of Data – Summarize the number of observations per unit of survey effort, e.g., the number of rabbits seen per mile, or the number of squirrels heard per station.

4. Disposition of Data – Send copies of census forms to the area biologist. This information should be entered in the Wildlife Observation System database. Also, summarize results in small game completion reports.

B. Mark-recapture – Mark-recapture techniques could be used to estimate local populations of small game mammals in Wyoming (Dolbeer and Clark 1975, Edwards and Eberhardt 1967, Friley 1955, Keith et al. 1968, Nixon et al. 1967, Schemnitz 1980, Skalski et al. 1983). Also refer to Chapter 20 (Nongame Mammals) and Appendix VII (Marking Techniques).

C. Road-kill Surveys – The Illinois Department of Natural Resources (IDNR) conducts road-kill surveys to monitor population trends of cottontails (Hubert 1988). Although road-kill surveys have not been implemented in Wyoming, they could potentially have some utility.

1. Rationale – Lineal frequencies of road-killed rabbits are generally correlated with population densities. Therefore, road-kill surveys can provide an index to cottontail population trends.

2. Application – Road-kill surveys should be conducted in June or July. The IDNR found results of June and July surveys were directly correlated with fall harvest of cottontails.

3. Analysis of Data – Talley the number of road-killed animals seen per thousand driving miles.

4. Disposition of Data – Summarize results of road-kill surveys in small game completion reports.

IV. HARVEST DATA –

A. Harvest Survey – Small game harvest statistics are estimated annually from a hunter mail survey (Appendix III). Data from field check stations can also provide some useful harvest information.

1. Rationale – When more costly, labor-intensive field surveys are impractical, harvest data are an excellent indication of small game population trends. Harvest data are

analyzed in the Department's program (job) completion reports and are also used to develop economic data for the Department's annual report.

2. Application –

   a. harvest survey – Refer to Appendix III (Wildlife Harvest Survey). A harvest questionnaire is mailed to a sample of small and upland game license holders. Results are extrapolated to develop harvest estimates statewide and for small and upland game management areas (Attachment 1).

   b. harvest field checks – Results from check stations and field checks can provide certain management information such as hunter success and participation, which may be useful at the regional level . Check station results can also be included in annual completion reports for small and upland game.

3. Analysis of Data – Summarize hunter numbers, total days of hunting, effort (days/animal harvested), success (animals/hunter), and total harvest of each species within each management area and statewide.

4. Disposition of Data – Biological Services compiles and distributes small game harvest reports by 1 June of each year.

B. Age and Sex Determination – Annual reproductive success and recruitment can be estimated from age ratios of harvested animals. However, given the short life span of most small game and high reproductive potential under favorable conditions, information about age and sex composition is probably unnecessary for population management.

1. Field Aging and Sexing Techniques – Reliable field techniques for determining ages of small game mammals are not currently available. Sex can often be determined by examining external genetalia. Body size, weight, and (in the case of squirrels) tail pelage can be used to distinguish adults, juveniles, and sometimes yearlings (Keith et al. 1968, Kemp and Keith 1970, Petrides 1951).

2. Field Checks and Check Stations – Small game harvest information should be collected as opportunity permits at big game check stations. The Department does not operate check stations specifically for monitoring small game harvest.

3. Laboratory Aging Techniques – Several laboratory techniques are available to distinguish age and sex of lagomorphs and squirrels (Beale 1962, Bothma et al. 1972, Carson 1961, Edwards 1962, Fogl and Mosby 1978, Hale 1949, Kemp and Keith 1970, Petrides 1951, Rongstad 1966, Schemnitz 1980, and others). Accurately determining age requires examination of eye lens weight, cementum annuli, or epiphyseal closure of the humerus, radius, or ulna. Sullins et al. (1976) determined periosteal layers in mandibles of eastern and Nuttall's cottontails are present in adults and absent in young-of-the-year.

V. DISEASES AND PARASITES – Refer to Thorne et al. (1982) – Diseases of Wildlife in Wyoming.

VI. DISTRIBUTION AND MOVEMENT –

A. Incidental Observations –

1. Rationale – The general distribution of most small game has been well documented, however ranges of some species continue to expand in Wyoming. Specific habitat use and population densities have not been thoroughly investigated in some areas. The observation database does not include any documentation of gray squirrels.

2. Application – Record all observations of species outside currently recognized distributions, on Wildlife Observation forms (Appendix I). In addition, record unusual observations of behavior, habitat use or mortalities.

3. Analysis of Data – Plot distribution of small game onto Mylar overlays of 0.5 inch to 1.0 mile topographic base maps. Identify high, medium, and low-density areas of occupied habitat. GIS layers can also be developed from distribution data. Update small game range maps regularly.

4. Disposition of Data – Enter wildlife observation records in the Wildlife Observation System database. Summarize distribution information in small game completion reports.

VII. TRAPPING, MARKING, AND TRANSPLANTING –

A. Trapping – Night-lighting techniques can be used to capture cottontails (Labisky 1959). Lagomorphs and squirrels are also readily captured in live traps.

B. Marking –

1. Ear Tags – Numbered fish fin tags are suitable for marking ears of squirrels, rabbits, and hares. Adams (1959) used numbered tags of his own manufacture to mark snowshoe hares. O'Farrell (1965) and Rose (1977) attached No. 1005 Size 3 Monel metal "Jiffy" wing bands (National Band and Tag Co., Newport, KY) to the lower posterior edge of snowshoe hare ears. Some marking materials have drawbacks. Loose-fitting ear tags can tear out by snagging on shrubs or other vegetation. Metal tags can cause frostbite where they are attached.

2. Tattooing – Tattooing ears is one of the easiest and most permanent methods of marking rabbits (Keith et al. 1968). Even very young rabbits can be safely tattooed without possibility of losing the marking or causing further injury to the animal. Tattoos are weightless and inconspicuous to predators, but cannot be read unless the animal is in hand (Brady and Pelton 1976). Tattooing the inside of the ear is a

standard marking procedure for lagomorph field studies (Brady and Pelton 1976, Keith et al. 1968).

3. Toe Clipping – Toe clipping is one of the most permanent methods of marking small mammals for positive identification. Toes can be clipped off at the first joint with sharp scissors, in a sequence described by Layne (1954) (Fig. 1). Front toes are numbered 1 to 8. Hind toes are numbered in tens, from 10 to 100. Based on this numbering scheme, 143 individuals can be marked without removing more than 3 toes or more than one toe from any foot. The method is suitable for either squirrels and lagomorphs, and can supplement other forms of marking. Toe clipping is relatively painless to the animal and the wound heals quickly. Tracks of marked animals can often be distinguished in snow or dirt. Schemnitz (1980) provides an alternative method.

4. Fur Clipping – Layne (1954) described a method for marking squirrels by clipping patches of fur. The method also has some potential for marking lagomorphs. Outer (guard) hairs are removed to expose patches of darker, inner fur in specific patterns (Fig. 2). By clipping various combinations of up to two patches, animals can be labeled consecutively from 1 to 49. Up to 38 more individuals can be marked with additional combinations. This technique enables researchers to identify marked animals from a distance, however the animal's back must be fully visible to see all the clipped spots. The markings persist until the fur is molted.

VIII. SETTING SEASONS – The Department maintains liberal hunting seasons and bag limits for small game because hunting has little or no effect on populations. Population data are not needed to set hunting seasons. Harvest is regulated by the "law of diminishing returns." During periods of lower populations, harvest success declines and hunters lose interest. The result is lower harvest rates, which protect the breeding stock during unfavorable environmental conditions. In addition, small game species have extremely high reproductive potentials, enabling them to recover rapidly from even very low densities when favorable conditions return. In some intensely hunted locations (generally urbanized states), lower limits are sometimes prescribed to distribute harvest opportunity more equitably among hunters. However, small game animals are not hunted intensively enough in Wyoming to warrant limit reductions for this purpose.

IX. DEPREDATION – Refer to The Handbook of Wildlife Depredation Techniques (Buhler et al. 1999); The Prevention and Control of Wildlife Damage (Hygnstrom et al. 1994); and Homeowner's Guide for Resolving Wildlife Conflicts – Habitat Extension Bulletin No. 45 (Wyoming Game and Fish Dept. undated).

A. Depredation Problems – Cottontail rabbits periodically cause localized damage to standing crops, rangeland, ornamental plants, or stored foods. During severe food shortages, lagomorphs can damage or kill tree plantings by clipping stems and de-

barking trunks. In towns, the nesting or gnawing habits of squirrels can become intolerable to property owners. Both red and fox squirrels can damage tree branches, sometimes extensively, by eating buds or cutting branches to obtain cones, nuts or other seeds. In some instances, the animals must be removed by trapping, relocation or shooting to resolve these problems,. Chemical repellants, baiting, electric or other fencing, and squirrel-proof barriers (on tree trunks) are additional options for dealing with nuisance animals. Under Wyoming Statute (W.S. 23-3-115) the landowner can take and kill any gray, red and fox squirrel causing damage to private property. However, no similar provision allows a landowner to take cottontail rabbits.

X. JOB COMPLETION REports – Job completion reports were compiled for small game from 1986-1992. Biological Services retains copies of these reports on file. The Department may or may not resume compilation of small game completion reports in the future. Annual harvest reports of small and upland game are still compiled.

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Fig. 1. Numbering scheme used to permanently mark small mammals by toe clipping. From Wildlife Management Techniques, 3rd Edition, The Wildlife Society (Giles 1971).

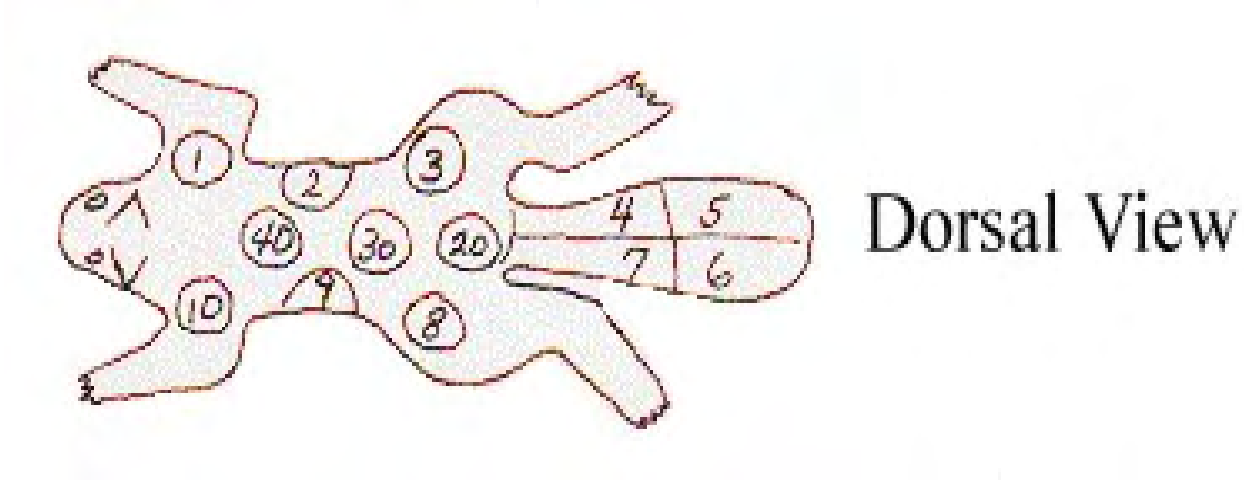
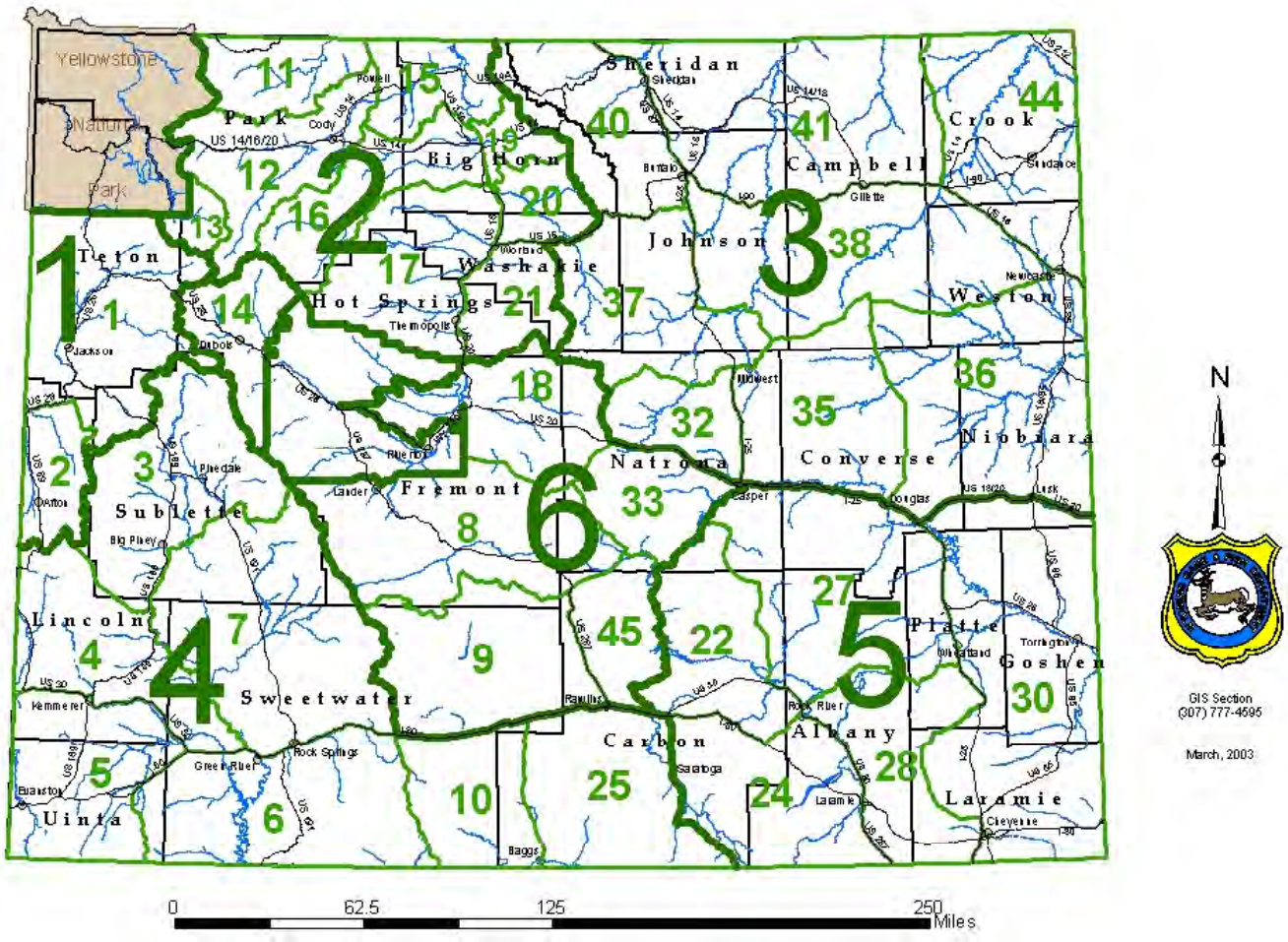


Fig. 2. Numbering scheme used to mark animals by fur clipping (Layne 1954).

Attachment 1

Small and Upland Game Management Areas



Chapter 12

SAGE-GROUSE (*Centrocercus urophasianus*)

Tom Christiansen

ACKNOWLEDGMENT – The techniques described in this chapter are based largely on "Monitoring of Greater Sage-grouse Habitats and Populations" by J.W. Connelly, K.P. Reese, and M.A. Schroeder (2003). We gratefully acknowledge these authors' contribution to sage-grouse management in Wyoming and across the West.

I. INTRODUCTION – Characteristics of greater sage-grouse (*Centrocercus urophasianus*) populations and habitats have been described in numerous studies throughout the species' range (Gregg et al. 1994, Fischer et al. 1996a, Schroeder 1997, Apa 1998, Sveum et al. 1998, Commons et al. 1999, Lyon 2000, Nelle et al. 2000, Smith 2003, and others). Connelly et al. (2000b) developed guidelines for managing sage-grouse populations and habitats, and stressed monitoring is a critical element of any effective management program.

Most studies of sage-grouse ecology have relied on previously published techniques for assessing rangeland vegetation, and for monitoring and trapping sage-grouse (Canfield 1941, Daubenmire 1959, Floyd and Anderson 1982, Giesen et al. 1982, Emmons and Braun 1984, Wakkinen et al. 1992, Burkepile et al. 2002, Connelly et al. 2000a, and others). However, vegetation assessment methods were not developed specifically for sage-grouse habitats. In addition, some techniques for monitoring populations were not described in detail while others were based on work done in a limited geographic area, or done over a relatively short time.

In recent decades, sage-grouse populations have declined (Connelly and Braun 1997, Braun 1998, Connelly et al. 2004) and numerous factors continue to threaten the species and its habitats (Connelly and Braun 1997, Wambolt et al. 2002, Connelly et al. 2004). Standard techniques for monitoring populations and habitats will provide consistent data sets that permit comparisons among areas and years. Connelly et al. (2003) compiled and attempted to standardize all the major techniques useful for monitoring sage-grouse habitats and populations. The following information is largely taken from their document. Some important additions (e.g., lek definitions) and minor edits/deletions have been made.

II. POPULATION MONITORING AND ASSESSMENT – The foundation of an effective conservation strategy for sage-grouse is a standardized monitoring program that assures meaningful population status and trend information are collected. The monitoring program must generate regular reports that can be used to analyze factors affecting sage-grouse populations on a local scale, in order to implement local conservation plans. As well, the data should be suitable for statewide analysis and comparisons with similar data sets from other states. A Wyoming Sage-grouse Database was recently developed to fulfill these needs. The database houses results of lek surveys and counts, and harvest data including age and sex composition derived from wing barrel

collections. As the database comes into use, it should provide a basis for local, regional and statewide analyses of sage-grouse status and trends.

A. Breeding Populations – Sage-grouse gather on traditional display areas called leks each spring. This behavior enables biologists to collect data used to track breeding populations. Survey methods include lek censuses (annually counting the number of male sage-grouse attending leks in a given area), lek complex routes (annually counting the number of male sage-grouse within a group (complex) of leks that are relatively close and represent part or all of a single breeding population), and lek surveys (annually counting the number of leks that are active in a given area). All lek monitoring is done early morning (1/2 hour before to 1 hour after sunrise), under reasonably good conditions (calm to light wind, partly cloudy to clear), from early March to early May. Appropriate ranges of survey dates depend on the elevations at which leks are found and the persistence of winter conditions. In milder climates at lower elevations, sage-grouse begin displaying during late February. Grouse may also begin displaying at this time in response to mild winter weather. At higher elevations, lek attendance persists through early or mid-May.

The following definitions have been adopted for the purposes of collecting and reporting lek data:

- Lek. A traditional courtship display area attended by male sage-grouse in or adjacent to sagebrush dominated habitat. A lek is designated based on observation of two or more male sage-grouse engaged in courtship displays. New leks must be confirmed by a survey conducted during the appropriate time of day, during the strutting season. Sign of strutting activity (tracks, droppings, feathers) can also be used to confirm a suspected lek.

- Lek Complex. A group of leks in close proximity between which male sage-grouse may interchange from one day to the next. A specific distance criterion does not yet exist.

- Lek Count. A census technique that documents the actual number of male sage-grouse observed attending a particular lek or lek complex.

- Lek Survey. A monitoring technique designed primarily to determine whether leks are active or inactive. Obtaining accurate counts of males attending is secondary.

- Annual status – Lek status is assessed annually based on the following definitions:

    - active – Any lek that has been attended by male sage-grouse during the strutting season. Acceptable documentation of grouse presence includes observation of birds using the site or signs of strutting activity.

    - inactive –Any lek where sufficient data suggests there was no strutting activity throughout a strutting season. Absence of strutting grouse during a single visit is insufficient documentation to establish that a lek is inactive. This designation requires documentation of either an absence of birds on the lek during multiple (3+) ground visits under ideal conditions (4/1-5/7, no precipitation, light or no wind, ½ hour before to 1 hour after sunrise) **or** a ground check of the exact known lek site late in the strutting

season (after 4/15) that fails to find any sign (droppings/feathers) of strutting activity. Data collected by aerial surveys may not be used to designate inactive status.

- o unknown – Leks for which status as active or inactive has not been documented during the course of a strutting season.

Based on its annual status, a lek may be assigned to one of the following categories for management purposes:

- o occupied lek – A lek that has been active during at least one strutting season within the prior ten years. Occupied leks are protected through prescribed management actions during surface disturbing activities.

- o unoccupied lek – (Formerly "historical lek".) There are two types of unoccupied leks, "destroyed" and "abandoned." Unoccupied leks are not protected during surface disturbing activities.

- o destroyed lek – A formerly active lek site and surrounding sagebrush habitat that has been destroyed and is no longer suitable for sage grouse breeding. A lek site that has been strip-mined, paved, converted to cropland or undergone other long-term habitat type conversion is considered destroyed. Destroyed leks are not monitored unless the site has been reclaimed to suitable sage-grouse habitat.

- o abandoned lek – A lek in otherwise suitable habitat that has not been active during a period of 10 consecutive years. To be designated abandoned, a lek must be "inactive" (see above criteria) in at least four non-consecutive strutting seasons spanning the ten years. The site of an "abandoned" lek should be surveyed at least once every ten years to determine whether it has been reoccupied by sage-grouse.

- o undetermined lek – Any lek that has not been documented active in the last ten years, but survey information is insufficient to designate the lek as unoccupied. Undetermined leks will be protected through prescribed management actions during surface disturbing activities until sufficient documentation is obtained to confirm the lek is unoccupied.

1. Locating Leks –

   a. Rationale – Managers must locate and document leks before designing a program to monitor sage-grouse breeding populations. Leks can be detected by searching from the ground or air in early March to early May.

   b. Application –

      i. aerial searches – Lek searches can be done effectively from either helicopters or fixed-wing aircraft. Strutting cocks are highly visible during early morning hours when the sun shines on their white chests. Fly north-south transects approximately 1 km (0.6 mi) apart throughout suitable breeding habitats. Observations made during

aerial searches are biased toward larger leks; small leks (<15 birds) are more difficult to detect. Conduct aerial searches only on calm, clear mornings. Cancel the flight if winds exceed 15 mph or if more than scattered cloud cover is expected. Cocks can be seen from more than 1.0 km (.6 mi) in early morning sun, but cloud cover greatly reduces illumination and contrast at this distance. In marginal light, fly narrower transects. High winds not only make traveling a straight transect difficult, but also affect strutting behavior. Under such conditions, fewer cocks strut continuously, and they tend to flush at greater distances.

Fly transects about 100-150 meters (300-450 ft) above ground level. Whenever possible, transport 2 observers in addition to the pilot so 1 observer always looks away from the sun regardless of the flight direction. Begin north/south search patterns at the east edge of the survey area and progress westward to avoid flying over leks before they are seen. Pay particular attention to old lakebeds, stock-watering areas, and other relatively open sites largely surrounded by sagebrush with 15 to 25% canopy cover. Conduct aerial searches from ½ hour before sunrise to 1 hour after. Searches can be extended to 1½ hours after sunrise during the portion of the breeding season when male attendance peaks.

Cocks respond to approaching aircraft in various ways that can affect search results. In some cases, they may continue to strut as the plane approaches and flies past or overhead. In other cases, grouse will "squat" as they do when an avian predator approaches. Sage-grouse virtually disappear when they squat, therefore observers should scan well ahead and laterally to the next transect line to detect cocks before the aircraft approaches closely or flies overhead. Based on past research, up to a third fewer birds are detected by aerial counts compared to ground counts. Therefore aerial counts are not generally considered adequate to monitor trends in lek attendance. However, researchers in Nevada have attempted to develop a dependable method for counting grouse from helicopters.

Search intervals can be increased to 1.5 km (about 1.0 mile) in poor habitat and areas with no recent history of use by sage-grouse. On the other hand, narrower search intervals are advised in areas where habitat alteration or human development is anticipated, to assure the area is thoroughly searched.

ii. ground searches – In areas with relatively good access, observers can locate leks by driving along roads in suitable breeding habitat and stopping every half mile to listen for sounds of displaying grouse. During calm mornings, displaying sage-grouse may be heard from a distance of 1.5 km (about 1 mi). Ground searches can begin an hour before sunrise. In less accessible areas, searches can be done from a mountain bike, trail motorcycle, 4-wheel all-terrain vehicle, on horseback or afoot. Use binoculars or a spotting scope to look for displaying birds within openings and areas of less dense sagebrush.

Leks can also be located by looking for evidence after fresh snowfall the prior night or early morning. Lek activity is minimal during stormy weather and the birds may

flush at the first sign of an intruder. However some male sage-grouse will attend leks on virtually every morning throughout the spring period, regardless of weather. Search locations of suspected leks immediately following a snowfall. If grouse use the area, they will leave tracks in the snow. The number of tracks may give some indication of the relative size of the lek. In addition, leks are occasionally discovered when concentrated tracks, droppings, and feathers are encountered during other field activities (e.g., big game winter mortality transects). Always have field personnel record locations where this type of sign is observed. To confirm the site is a lek, it must be visited during early morning strutting hours to document attendance by male sage-grouse.

iv. lek identification – Not every site where sage-grouse are seen strutting is a lek. Grouse that have been flushed from a lek often resume strutting at a different location for the remainder of the morning, and then return to the actual lek the following night. Juvenile cocks sometimes pursue hens as they leave a lek. Groups of strutting juvenile males been observed up to 0.8 km (½ mi) from the lek as they follow the females. Therefore, additional confirmation is necessary to verify a site where males are seen strutting is actually a lek. Strutting activity should be documented at a site on at least two mornings before it is designated as a lek. Ground survey of the site to search for sign of prolonged activity can also separate true leks from temporary strutting sites.

c. Analysis of Data – Numbers and distribution of occupied and abandoned leks are monitored through time to assess population trends, changing habitat conditions and impacts of disturbance. Lek locations are also incorporated into GIS layers for future reference by persons planning or commenting on development activities, and by persons who are preparing habitat management plans or mitigation projects.

d. Disposition of Data – Record the center point of all leks in UTM demarcations using NAD83 datum and store this information within the Wyoming Sage-grouse Database. It is also advisable to record/map the perimeters of all leks.

2. Breeding Surveys –

a. Rationale – Various types of breeding surveys are applied in research and management to monitor lek status, population trends, and responses to disturbances, habitat treatments, and land management practices. The data also provide documentation for commenting on land use plans, and proposed developments.

b. Application –

i. Lek Counts –

- Rationale – Lek counts are a common means of collecting data used to monitor sage-grouse populations. Methods accepted by researchers and managers are used to document the actual number of male sage-grouse observed on a particular

lek or lek complex (Jenni and Hartzler 1978, Emmons and Braun 1984). A lek complex is a group of leks in close proximity between which male sage-grouse are expected to interchange.

Although lek counts are widely employed to monitor sage-grouse populations, some researchers have questioned their usefulness (Beck and Braun 1980). However, data problems tend to arise more because the survey protocols are not rigorously followed than from any inherent flaw in the techniques themselves. For example, some leks have been counted at the wrong time of the year or during periods of wind or precipitation. All observers should receive adequate training before conducting lek counts. Proper methods for conducting lek surveys are described in this chapter. Video training guides (Power Point format) are also available.

- Application – Adhere to the following criteria to assure counts are done consistently and accurately, enabling valid comparisons to be made among data sets.

    - Conduct lek counts at 7-10 day intervals over a 3-4 week period after the peak of mating activity. Although mating typically peaks in early April in Wyoming, the number of males counted on a lek is usually greatest in late April or early May when attendance by yearling males increases.
    - Conduct lek counts only from the ground. Aerial counts are not accurate and are not comparable to ground counts.
    - Conduct counts between ½ hour before sunrise to 1 hour after.
    - Count attendance at each lek a minimum of three times annually during the breeding season.
    - Conduct counts only when wind speeds are less than 8 kph (5 mph) and no precipitation is falling.

    Subdominant males are often less active and visible than are dominant males occupying the center of the lek. Consequently, subdominant birds are easily missed during a single count. A lek can be counted effectively in the following manner:

    - Locate a spot that affords good visibility of the entire lek. If the lek is very large (100 or more birds) it may be necessary to select two or more vantage points. Be careful not to get so close that your presence disturbs the grouse.
    - Record the time the count begins.
    - Count the birds from left to right (or vice versa).
    - Wait one to two minutes and then count from right to left.
    - Wait one to two minutes and count from left to right again.
    - Record the highest counts of male and female grouse separately, and then move to the next lek.

Some sage-grouse will move among several leks throughout a breeding season (Dalke et al. 1960, 1963). Therefore, changes in attendance at a particular lek may actually represent birds shifting to nearby leks. Moreover, birds may cease using a lek because of disturbance or changes in vegetation. The disappearance of a lek may or may not mean the population is declining. To assess actual changes in a grouse population, all leks within a complex must be counted annually.

ii Lek Count Routes –

- Rationale – A lek count route is a survey method designed to census a group of leks (a lek complex) that are relatively close and represent all or part of a single breeding population. Leks should be counted along routes to facilitate replication by other observers, increase the likelihood of recording satellite leks, and account for shifts in breeding birds if they occur.

- Application – Select routes such that all leks within a complex can be counted within 1.5 hours. If weather conditions deteriorate after a lek count route has begun, the route should be run again. If no birds are observed on a lek that was occupied in prior weeks or years, the observer should exit the vehicle and, with the engine off, listen for sounds of displaying grouse. Birds will sometimes relocate to a new lek site when they are subjected to continuing disturbance. If a predator flushes grouse from a lek, and it is still reasonably early in the morning, the grouse may resume displaying nearby once the predator leaves the area.

  Before establishing lek routes in a given area, give some thought to the number of personnel available for conducting counts. It is much better to plan fewer counts yielding high quality data than to compromise data by scheduling more counts that personnel can reasonably handle. A responsible Department biologist or wildlife coordinator should assign lek counts and count routes. It is acceptable for persons from outside the agency to conduct counts, provided they are properly trained. Leks with the longest history of consistent data collection should be included in count routes, as these provide a basis for long-term trend assessment. At least one lek count route should be conducted in each management area occupied by sage-grouse.

iii. Lek Status Surveys –

- Rationale – Ideally, all sage-grouse leks would be counted annually. However, some breeding habitat is inaccessible during spring because of mud and snow, or the location of a lek is so remote it cannot be routinely counted. In other situations, topography or vegetation may prevent an accurate count from any vantage point. In addition, time and budget constraints often limit the number of leks that can be visited. Where lek counts are not feasible for any of these reasons, status surveys are the only reliable means to monitor population trends. Lek status surveys are designed principally to determine whether leks are active or inactive, requiring just a single visit to each lek. Obtaining accurate counts of

the numbers of males attending not essential. Status surveys involve substantially less effort and time than lek counts. They can also be done from a fixed-wing aircraft or helicopter. Because multiple visits are not required to determine peak attendance, leks that are not on count routes can be surveyed from the initiation of strutting in early March until early-mid May, depending on the site and spring weather.

This technique has a major drawback in that it is not very sensitive to population changes unless the sample of leks is very large. For example, 50 males may be observed within a group of 5 leks during one spring survey and 75 males two years later. What appears to be a 50% increase may not be the case for a variety of reasons. The only legitimate interpretation of these results is that all 5 leks were active each year they were surveyed. However, on a very gross scale, lek survey data have been consistent with lek count data and population trends (up, down, stable) within Wyoming.

- Application – To obtain the most useful insight regarding population trends, conduct lek status surveys in the same manner, during the same time period each year. In other words, surveys should not be conducted from a fixed-wing aircraft one year and a helicopter the next year, or in early March one year and May the next. Record the date and time each survey is conducted. Also record UTM coordinates of each lek encountered, and note any other information that might later be considered important. Although it is difficult to accurately count birds from an aircraft, it is usually possible to estimate the number present.

  If the exact location of a lek is known, its activity status can be checked any time of day and for a short period following the strutting season, based on presence of sign. Active strutting grounds characteristically have concentrations of scattered fecal pellets, feathers, tracks and trampled vegetation. In contrast, fecal deposits on winter ranges are typically discrete piles next to sagebrush. Strutting sites are also usually marked by large numbers of caecal droppings (miniature black "cow pies"). Caecal droppings are initially green, but cure to black quickly in the sun. Presence of green caecal droppings and fresh tracks indicate lek was active earlier in the morning. Fecal droppings can last for years, though they fade with time. On the other hand, caecal droppings usually decay within days or weeks, depending on precipitation, and this limits the time they are useful for documenting lek activity. Site visits also give observers an ideal opportunity to precisely map the lek location by waking to its exact center and recording the coordinates with either GPS technology or orthophoto quad maps.

  The ideal time for lek surveys is the same as for lek counts – about 1/2 hour before until 1 hour after sunrise. Under some conditions, sage-grouse will strut two hours or more after sunrise. Prolonged attendance usually coincides with: 1) presence of hens on the lek; 2) dim light conditions (overcast skies, fog, or light snowfall); or 3) the small, or "new" phases of the moon, when little strutting activity occurs at night. Males generally stop strutting early on mornings when

hens are absent (late in the strutting season) or near the full moon, when much of the strutting and breeding take place at night. During the full and nearly full moon, sage-grouse may strut all night and males will occasionally initiate strutting at sunset or shortly after. At these times, leks can occasionally be checked in the evening. Lek surveys can be conducted at night during the full moon, provided leks can be approached closely enough to either hear or spotlight displaying grouse. However, nighttime surveys are not suitable for counts of lek attendance.

The frequency surveys are conducted at known leks depends on personnel availability, budget, and the priority of data collection based on factors such as ongoing habitat alteration or proposed development. Leks in remote locations should be surveyed at least once every three years. Other leks should be surveyed more frequently, depending on potential threats. The public's interest in sage grouse management has increased in recent years, and which has afforded the opportunity to utilize volunteers to survey or count leks and thus increase data collection efforts. The Wyoming Wildlife Federation's "Adopt-a-Lek" program has shown to provide a pool of reliable volunteers. Volunteers should be properly trained in monitoring techniques to ensure quality data and not disrupt breeding activity.

c. Analysis of Data – Before compiling and analyzing data from lek counts or status surveys, review all raw data to assure the information was collected properly. Lek counts conducted during stormy weather, high winds or late in the morning (i.e., routes completed more than 1.5 hours after sunrise) should not be included in the analysis. In addition, status surveys done under any of the above conditions should not be considered conclusive if birds were not observed.

To assess breeding population trends, the minimum amount of information needed is a record of the number of active leks in a given area over a period of years. This information can be obtained from lek surveys and lek routes, but these data only represent gross changes in the population and can produce misleading results.

When collected properly, lek count data are more useful for assessing population trends than the number of active leks. The following types of data are derived from lek counts: number of active leks/route; average number of males/route or complex; maximum number of males/route or complex; average number males/lek; maximum number of males/lek; and possibly, males/area (all males counted on a group of lek routes). Sometimes the number of leks along a route changes because the route was altered, the habitat has changed or satellite leks have become established. If such circumstances arise, the most effective means of tracking populations and analyzing changes is to examine the number of males per lek. If the number of leks does not change over a period of years, then the number of males per route should constitute the basis for assessing the breeding population.

Although females are generally counted along lek routes, they are difficult to detect because of their secretive nature and cryptic appearance. The number of females observed may provide some indication when breeding peaks, however these data should not be used to assess population changes.

The Wyoming Sage-grouse Database and Job Completion Report have improved data storage, retrieval, analysis and reporting at both regional and statewide scales. All current and historical data should be entered into the database.

Estimates of breeding populations have been developed from lek attendance data in the Wyoming Sage-grouse database and Job Completion Report. However, the procedure is not widely accepted by other wildlife agencies. All leks representing a population are identified and the maximum attendance counts during a specific year are summed. The total is divided by 0.75 (to adjust for unseen males) and multiplying by 2 to estimate the number of females in the population (assuming a 2:1 sex ratio of females to males). In effect, the population estimate is 3 times the estimated number of males. This method has never been validated through experimental trials nor have researchers recommended it as an independent population estimator. Because of uncertainties associated with lek attendance patterns (Beck and Braun 1980, Emmons and Braun 1984, Walsh 2002), possible differences in sex ratios among years and areas (Swenson 1986), and some lack of uniformity in counting procedures, population estimates derived from lek counts are considered very crude, minimum estimates and are not generally useful for making comparisons among areas or years. However, Walsh (2002) identified a procedure based on Bowden's estimator (Bowden and Kufeld 1995) that may be useful for estimating sage-grouse populations in relatively small, discrete areas.

d. Disposition of Data – Enter all data from lek counts and status surveys into the Wyoming Sage-grouse Database. These data are annually summarized and analyzed in the Sage-grouse Job Completion Report.

B. Brood Production – Brood production is monitored for several purposes: 1) low production can indicate problems with habitat or effects of drought and other stressful weather patterns; 2) production is useful to forecast the availability of birds during the upcoming hunting season; 3) production can be an indicator of the success of habitat treatments; and 4) increasing or decreasing brood production can foretell the beginning of a population recovery or downward trend, respectively. Production is expressed as the proportion of hens with broods or the ratio of juveniles to adults, and can be assessed using one or more of the following techniques: brood observations, brood routes and wing surveys (Autenrieth et al. 1982).

1. Brood Observations –

a. Application – Brood observations, sometimes called random brood routes, are simply records of all sage-grouse broods observed incidentally by any field personnel working in an area. Once they are tallied, brood observations provide some indication of the juvenile to adult ratio and proportion of hens with broods.

b. Analysis of Data – Brood observations are somewhat better than anecdotal data, but are not easily replicated. It can also be difficult to interpret comparisons of data among years.

2. Brood Routes –

a. Application – Brood route surveys are usually scheduled during late June, July, and early August. Routes are generally established in areas of known sage-grouse concentrations, often in or adjacent to wet meadows, riparian zones, and agricultural areas. Routes are followed on foot or horseback, or in a vehicle driven at speeds <32 kph (20 mph) and are completed in the morning (sunrise to about 0900) and evening (1800 to sunset). Record each brood separately, indicating the size of the brood, its location, and whether a hen is present. Also tally groups of unsuccessful females and males as they are encountered. Chicks are quite secretive therefore it is usually necessary to flush the brood to obtain an accurate count. A trained bird dog can help the observer locate broods more efficiently. If a sufficient sample of grouse broods is observed, this technique can provide a reliable indication of production trends.

b. Analysis of Data. The following information is derived from brood route data: birds/km, broods/km, average brood size, and ratio of chicks to adult hens. Brood routes are the only economical means to assess production within non-hunted or lightly-hunted populations from which relatively few wings are collected. Productivity can also be assessed using hens marked with telemetry transmitters, however this is a much more intensive and costly method.

3. Wing Collections –

a. Rationale – Sage-grouse wings collected during hunting seasons are used to estimate the age and sex composition of harvested birds. Within hunted populations of sage-grouse, wing surveys are the most useful technique available to estimate production (chicks/hen). However, sample sizes should exceed 150 wings, and could be considerably greater depending on how large an area is sampled and the size of the population.

b. Application – Wings are normally collected in barrels (called, “wing barrels”) strategically placed along egress routes, or by Department personnel at hunter check stations. The Wyoming Game & Fish Department’s Sage-grouse Working Group published a “Sage-grouse Sex and Age Guide” (based on Clait Braun’s “A Key for Age/Sex Identification from Wings of Hunter-Harvested Sage-grouse,” Attachment 1). Use this guide to determine age and gender of harvested grouse from wing plumage characteristics. Wings are usually “read” at an annual “wing-bee” held in November each year. The wing-bee format allows participants to share their experience and expertise, which greatly enhances the learning process for those with less experience.

c. Analysis of Data – Data from wing collections are compiled to assess trends in production and to compare production among geographic areas. However, these data may not accurately represent population trends. For example, a range type conversion

could impact or eliminate a portion of the winter habitat used by a population while breeding habitat remains intact. Afterward, the overall population may decline because mortality has increased on winter range, yet this decline might not be evident from production statistics (the ratio of juveniles to adult hens), which could remain stable. Thus, it is best to view production information in conjunction with other data (e.g., lek counts) to make inferences about population trends.

d. Disposition of Data – Production data should be entered into the Wyoming Sage-grouse Database and summarized in the applicable Job Completion Reports.

C. Documentation of Winter Use Areas –

1. Rationale – Knowledge about winter use areas can be helpful to biologists as they review proposed development actions or land use plans, and is also an important consideration for planning habitat treatments. In addition, the information can help biologists identify seasonal movement patterns within migratory populations of grouse. However, no widely accepted methods are recognized to census grouse populations during winter. In part, this is because grouse distribution can vary markedly from one winter to another. Birds may be spread out over large areas during mild winters but concentrate in relatively small portions of their range in severe winters (Beck 1977).

2. Application – Winter use areas can be documented by searching for grouse or sign from a 4-wheel drive vehicle, snowmobile, or on foot. Winter habitats can also be located effectively from either a fixed-wing aircraft or helicopter by looking for grouse and tracks on the ground in snow cover. Aerial searches can often be done in conjunction with surveys for other wildlife (e.g. elk trend counts/classifications). Fly north-south transects about one minute of longitude apart. This transect interval is not intended to provide complete coverage for "census" purposes. Rather, it is designed to systematically survey a large area in order to efficiently determine relative distribution and habitat use patterns. Not every group of grouse will be seen. Record observations of grouse as well as tracks and sign. Under good conditions (bright sun and fresh, uncrusted snow) grouse tracks are quite easy to detect from 300 feet or lower elevation above ground. Tracks are usually seen in groups. Individual tracks tend to wander in a "snakelike" pattern rather than a straight line, and the bird's abdomens plow the snow.

   In Wyoming, the falconry season for sage grouse extends through March 1st. Falconers, who often hunt grouse in winter, can also be a good source of information to help identify wintering areas. Many have volunteered to record grouse observations.

2. Analysis of Data – At a minimum, record the approximate size and location of each flock you observe during winter. Additional descriptive information, particularly cover type (including species of sagebrush), topography, and snow depth, is also valuable. However, it may not be possible to collect this information from an aircraft. Data should be acquired over a series of years with varying snow conditions to obtain a more complete picture of grouse distribution.

4. Disposition of Data – Use the Sage-grouse Observation Form attached to this chapter (Appendix B) to record winter survey data. Observations should be entered on the Wildlife Observation System (WOS). Important winter habitats should be incorporated in the statewide GIS layer of sage-grouse habitats, and described in the applicable Job Completion Report.

III. TRAPPING AND MARKING –

A. Trapping –

1. Rationale – Sage-grouse are captured and handled predominantly for two purposes: 1) to mark individual birds; and 2) to collect biological samples for analysis. If samples are collected, this is generally done in conjunction with a marking study. Marking has been employed as a method to study sage-grouse populations for well over 50 years (Patterson 1952). Techniques have been refined and the quality of radio transmitters has improved considerably. The 2 periods sage-grouse can be captured most effectively are spring and late summer. Biologists in Colorado have also been successful trapping grouse during winter (A. D. Apa, pers. Comm.). The most suitable techniques depend on terrain, access, weather, and population size.

2. Application –

a. Night-lighting. During March and much of April, male and female sage-grouse often roost on or near leks at night. This behavior is especially common when attendance by hens is at its peak, usually the last week of March and first week of April. (In higher elevations, hen attendance may peak in mid-April). At these times, birds are fairly easy to capture by night-lighting (Giesen et al. 1982, Wakkinen et al. 1992). One difficulty posed by this technique is that males are much easier to see and hence, captured more often than females. Moreover, males tend to roost in the center of a lek while females are found near the edges, sometimes in rocky cover. The peripheral areas can be more difficult to traverse with a 4-wheel drive truck. To overcome these difficulties, researchers in Idaho have adapted the standard night-lighting technique by employing binoculars (to spot and sex birds from a distance) and by broadcasting rock and roll music (a form of "white noise") to conceal approaching footsteps.

Before each trapping session, the research leader should assign specific responsibilities and brief the crew about general trapping procedures. Ideally, the crew will consist of four people: a driver, spotter, primary netter and secondary netter. If possible, personnel should trade jobs during the night to avoid fatigue.

The trapping process begins after complete darkness. The crew drives slowly toward the lek area in a 4-wheel drive truck. As the vehicle approaches, the crew scans the ground with a 1-million candlepower spotlight and binoculars to locate roosting grouse (Wakkinen et al. 1992). (More powerful spotlights may also be available). The spotlight should be equipped with a shroud to help narrow its beam. An effective shroud can be made from a coffee can or plastic plant container. As the crew moves around the lek, the

driver should stop every 100-200 m (yds), or whenever the crew signals, allowing the spotter to scan the lek and nearby area. If possible, drive to higher ground near the lek to provide a better vantage for spotting birds roosting in heavier cover.

Sage-grouse eyes reflect light at night, and resemble sparkling green emeralds in the spotlight. Depending on terrain and vegetation, this eye reflection can be visible from over 200 m (yds). Normally, spotters are able to identify the white breast feathers of males when they are viewed from less than 100 m (yds). However, it may not be possible to distinguish sex at longer distances. The bird's location relative to the lek also provides a clue to the bird's gender. Males tend to roost alone in the comparatively open area of the lek, or sometimes on sparsely vegetated ridges adjacent to the lek. Females tend to be more secretive, roosting near sagebrush cover at the perimeter, and sometimes in small groups.

Once the crew has spotted a bird and decided to capture it, the rock and roll music is put to use. Trapping trucks are equipped with tape or compact disc (CD) players and loud, external speakers. A portable player with reasonably powerful speakers can also be used. As trappers approach the grouse, loud music is played which, together with the sound of the vehicle's idling engine, masks their footsteps and tends to disorient the roosting bird. Tape recordings of snowmobiles, generators, or other sources of "white noise" can serve the same purpose.

Two netters dressed in dark clothing walk along the driver's side of the truck. All netting should be done from the driver's side for safety (assuring the driver is aware of the netters' location) and to facilitate communication between the driver and netters. As the truck and netters approach, the spotter will eventually see the bird easily without binoculars. At this point, the spotter begins to shimmy the spotlight rapidly, keeping the light focused on the roosting grouse. This produces a strobe-like effect that serves to further confuse the grouse. Netters on the ground are not likely to see the bird at this point but when they notice the rapidly moving light, they move 5-10 m (yds) to the side of the truck, taking care to stay out of the spotlight. Even though the bird may not be visible, the netter must concentrate on the center of the light. Eventually, the bird will come into view. As the truck's front fender is about to pass the grouse, the trapper should place the net over the bird. The net should be moved relatively low and parallel to the ground rather than swung down from overhead like a butterfly net – to do so increases the risk of injuring the grouse. If the netters are somewhat slow, the driver should begin to circle the bird at a distance of about 5 m (yds) until the netters are able to position themselves for a capture attempt. Throughout this activity, the spotter continues to shimmy the spotlight directly on the bird's eyes to help keep it mesmerized.

Once the grouse is in the net, the netter should restrain it by holding the wings next to the bird's body and wait for help to remove it from the net. To reduce the chance of injury or escape, a grouse should not be allow to struggle loosely in the net. An experience netter can remove grouse from the net and safely handle them without additional help. As soon as the spotter observes the captured grouse is under control, he should search the immediate area (out to about 100 m/yds) to locate other grouse. If another bird is found,

the trapping crew can proceed after it. If the crew waits until the captured bird is processed, nearby birds will likely flush before another approach can be made. The second netter has two purposes. The first is to replace the primary netter should he stumble or fall while approaching the bird. The other is to assist with a rapid, second capture when the opportunity avails itself.

Most sage-grouse are caught within a few meters of the truck. The only time a capture should be attempted at longer distances (up to 20 yards) is when a grouse is roosting in a rock pile or muddy area where driving is unsafe. The same procedure should be followed, but the netter must move quite rapidly and take special care to stay out of the light. The loud music is especially helpful to conceal footsteps during such attempts.

In very muddy or rough terrain, the procedures for night-lighting from a truck can be employed from a 4-wheel ATV. Birds are more difficult to spot because the observer does not have the high vantage angle afforded by a truck. When an ATV is used, the trapping crew is normally just 2-3 individuals.

Night-lighting can also be done on foot. This technique can be especially useful when roosting locations are known and minimal search time is necessary. It has the advantage of only requiring two personnel, although three are optimum. The method is also suitable for terrain that is too rough for a vehicle. One person is equipped with a rechargeable power pack carried in a backpack, a portable spotlight, and a tape or CD player to broadcast loud rock music. The power pack is the type normally used to jump start engines, available at most auto supply and hardware stores. Binoculars are also useful to locate sage-grouse by glassing from high points. The other trapper carries a long-handled net and a backpack with marking supplies. When a grouse is located, the trappers should approach it swiftly, although running in the dark often results in falls, and the bird typically escapes when this happens. The netter should remain a few meters/yards abreast of the person with the spotlight. If the grouse begins to walk (usually a prelude to flushing), the netter may have to sprint ahead to capture it.

Personnel may consider carrying a portable power-pack while night-lighting from a truck in case grouse are found roosting in inaccessible areas. Night-lighting on foot is generally the best method to capture birds associated with a radio-marked bird (usually a hen and her brood), or to replace a radio. In such applications, the person with the spotlight carries an antenna and telemetry receiver connected to headphones. Unless headphones are used, the transmitter signal cannot be heard over the rock music.

Night-lighting is normally done in spring, summer, and early fall. The method may be less effective during winter when grouse often roost in large flocks. In addition, snow cover makes trappers visible at longer distances and deep or crusty snow can impede the netters' movements. However, researchers in Colorado have captured grouse effectively by night-lighting during winter (A. D. Apa, personal communication). During the 2001 winter, Colorado biologists captured 40 hens. The technique worked well until snow was shin deep or became very crusty.

Night lighting is not very effective on bright, moon-lit nights because birds can easily see approaching trappers well before spotlights and music have any effect. Avoid night-lighting within 3 days of a full moon unless the sky is heavily overcast.

b. Walk-in Traps – Various walk-in traps (Gill 1965, Schroeder and Braun 1991) are also effective for capturing sage-grouse on leks (Schroeder 1997, Leonard et al. 2000, Aldridge and Brigham 2002) and on summer foraging habitats (Connelly 1982). Walk-in traps can be round, square, or rectangular. They are typically about 50 cm (20 in) high, and 100 to 150 cm (40-60 in) deep (round traps are 100-150 cm (40-60 in) in diameter). Each trap has a funnel opening that provides unobstructed entrance but hinders the bird's escape. Normally, wings or leads connect several traps or "pods" together and direct walking grouse into the trap entrances. Leads are generally 25 to 75 meters/yards long, about 35 cm (14 in) high, and are set to intercept hens moving onto a lek or grouse moving onto a feeding area. Traps should be constructed of nylon or cotton netting. Never use poultry netting because it can inflict deep cuts into grouse when they struggle to escape. A latching door can be installed on the side or roof of each trap to provide access for removing birds. Personnel should constantly tend traps when they are set. Otherwise, a captured bird can injure itself while struggling in the trap, a predator may detect and kill it, or it can suffer from stress and overheating.

c. Mist nets – Mist nets can be used to capture sage-grouse on summer range (Connelly 1982, Browers and Connelly 1986). Researchers have also attempted to use mist nets on leks, but typically only 1 or 2 males are caught each morning. As soon as the grouse are become entangled, they must be removed to prevent injuries and this disrupts breeding activities for the remainder of the morning. However, mist nests can be an effective way to capture broods on summer foraging areas. They have also been used in conjunction with walk-in traps. By placing mist nets behind walk-in traps, birds that would otherwise flush at the trap entrance may be caught. Like walk-in traps, mist nets must be constantly tended to avoid injuring birds.

d. Drop Nets – Drop nets have been used to capture sage-grouse on leks (Leonard et al. 2000). However, they tend to disrupt lek activities and are not as efficient as other trapping methods.

e. Cannon and Rocket nets – For many years, cannon and rocket nets were widely used to capture grouse on leks. Researchers in Colorado recently used a relatively new type of cannon net (CODA Netlauncher) and to capture a number of hens on leks (Hausleitner 2003, A. D. Apa, personal communication). However, cannon and rocket nets also tend to disrupt lek activities and may not be as efficient as other trapping techniques.

f. Pointing dogs – Sage-grouse chicks up to about 4 weeks of age can be caught with the aid of a well-trained pointing dog. Connelly et al. (2003) used pointing dogs to capture the chicks of radio-marked hens by first locating and flushing the hen. The dog was allowed to search an area within a radius of 200 m/yd from where the hen flushed. The dog will normally point within 50 cm (20 in) of a chick's location. Once it is spotted, the chick

can then be picked up by hand. A long-handled net is useful to catch older chicks (> 2 weeks old). This technique requires the use of very steady, experienced dogs.

3. Analysis of Data – Analysis of marking data is discussed in Section B.3. below. Maintain records of all grouse that are captured or recaptured, including numbers, age and sex, location, time and date, weather conditions, and method of capture. Note any capture-related mortalities and the circumstances involved, so techniques can be modified if necessary.

4. Disposition of Data – Report results of all capture projects in research reports and applicable job completion report.

B. Marking –

1. Rationale – Sage-grouse are marked for a variety of research and management purposes such as movement and distribution studies, survival studies, home range delineation, nesting studies, assessment of impacts from development or other land uses, and monitoring response to habitat treatments. Marking methods and devices have included cataloging pigmentation patterns on tail feathers or clipping tail feathers (Wiley 1973), leg-bands (Patterson 1952, Dalke et al. 1963), wing markers (Connelly 1982), ponchos (Wallestad 1975), colored back-tags (Autenrieth 1981), and radio-transmitters (Wallestad 1975, Autenrieth 1981). Two researchers even resorted to shooting tips off the tail feathers of displaying males as a means to identify individual birds (Hartzler and Jenni 1988). Leg bands and radio-transmitters are the most common methods presently used to mark grouse. Patagial tags can also provide some movement and distribution data at a relatively low cost.

2. Application –

a. Banding – Virtually all captured sage-grouse are marked with serially numbered leg bands. Very young chicks (<10 weeks of age) are the only exception. In most cases, the bands are imprinted with unique numbers and an address to notify when bands are recovered. Letters denoting the species and other information [e.g., sgm (sage-grouse, male), sgf (sage-grouse, female)] can also be included. The letter prefix assures the species can be immediately ascertained when a band report is received, which is very useful if other game birds are being banded in the state or province. In some studies, grouse (especially males) have been marked with series of color-coded leg bands that identify individual birds in the field. This marking system works well if observations are made on leks or other reasonably open areas, but grouse stay in relatively dense cover much of the time so viewing leg markers is often difficult.

b. Wing-markers – Wing-markers or patagial tags have also been used to identify individual birds (Connelly 1982, Musil et al. 1993). These are often modified cattle ear tags inscribed with an identifying letter or number. Wallestad (1975) used numbered metal clips to mark wings of young chicks. Patagial tags are a relatively inexpensive means of obtaining information on local and seasonal movements. They tend to be more visible than colored leg bands and should therefore yield more data from re-sightings. However, birds marked in this manner may also be more vulnerable to predators. Therefore,

patagial tags should only be placed on males (considered expendable to the population) and should be used when other marking methods are ineffective.

b. Radio-telemetry – Radio transmitters are the most commonly used and most effective means of documenting seasonal habitat selection and movements by sage-grouse. Data from radio-telemetry studies can also be used to estimate daily, seasonal, and annual survival rates. Biologists have used radio-transmitters to study sage-grouse since at least 1965 (Autenrieth 1981). Unfortunately, early transmitters weighed >70 g (≥5% of an adult female's weight) and had relatively short battery lives. Because of the potential effects these larger, heavier transmitters had on grouse behavior and survival, and their brief span of operation, data and conclusions from early studies should be interpreted cautiously. By the mid- to late 1970s, transmitters weighed about 25 g (≤ 2% of an adult female's weight) and would generally last 6 months or more. Throughout the 1970s and early 1980s, researchers employed variations of a backpack harness (Brander 1968) to attach transmitters on sage-grouse. During the early 1980s, we learned backpack harnesses increase susceptibility to predation and thus switched to a poncho-mounted transmitter (Amstrup 1980).

   Poncho-mounted transmitters were placed on sage-grouse throughout much of the 1980s and early 1990s. Both battery and solar powered transmitters were used. Poncho openings were custom fit to individual birds. The poncho was attached by pulling the opening over the bird's head and arranging or "preening" feathers around the poncho material. The transmitter was fixed to the poncho so it would lie against the bird's crop. Although the method provided a quick, reliable way to place radio-transmitters on sage-grouse, solar transmitters mounted in this fashion occasionally malfunctioned. During summer, sage-grouse often feed on succulent forbs including dandelion (*Taraxacum officianale*), salsify (*Tragopogon dubius*), lettuce (*Lactuca* spp.) and hawksbeard (*Crepis acuminata*). A milky substance contained in these plants often runs down the bird's bill, onto the breast feathers. The substance can also collect and harden on transmitters and will cause solar transmitters to stop functioning as it accumulates on light panels.

   By the mid 1990s, most research biologists were using a necklace-type mounting system and battery-powered transmitters on sage-grouse. The necklace is generally made of plastic-coated cable. This type of radio-harness is somewhat lighter than a poncho, but attaches just as quickly to the bird's neck area. The transmitter itself can be attached more quickly to a necklace than to a poncho. The necklace cable must be loose enough to avoid impacting the crop and potentially harming the grouse. Normally, a finger's width of room is left between the bird's throat and cable. This enables the bird to forage normally, yet is sufficient to retain the transmitter.

   A tremendous amount of biological information has been acquired and published from studies of radio-marked sage-grouse. However, virtually all birds fitted with radio transmitters were more than 10 weeks old. Prior to 1998, few if any attempts had been made to place radios on grouse chicks younger than 10 weeks. The technique for chicks had to address several practical considerations. Foremost was the physical challenge of designing a radio and attachment device suitable for chicks as young as 1 day and

weighing just 30 grams. A transmitter life of at least 2 weeks was desired, but the device also needed to pose low risk to grouse chicks. A simple attachment system was developed for sage-grouse chicks. The procedure involves piercing the skin just in front and behind the transmitter with a 20-gauge hypodermic syringe. Sutures are threaded through the syringe and through holes in the transmitter, then tied off. Cyanoacrylic glue ("Superglue") is applied to the knots to enhance security of the attachment (Burkepile et al. 2002).

3. Analysis of Data – Several types of data are obtained from the different types of marking studies. Band return data provide information on harvest rates, survival, and seasonal movements (Zablan et al 2003). If a sufficient number of grouse are marked and subsequently recaptured, the population size can be estimated through a mark-recapture type of analysis. The sample of captures and recaptures necessary to estimate a population depends on the size of the population and the geographic area it occupies. Re-sight data from birds marked with patagial tags are used predominantly to determine local distributions and movements, and to identify migration patterns. Radio-telemetry studies are typically done to obtain detailed information on seasonal habitat use, response to disturbances, distribution and movement patterns, and survival rates. Methods applied to analyze telemetry data depend on the specific purpose(s) for which the study was designed and conducted.

4. Disposition of Data – Numbered leg bands are attached to all adult sage-grouse that are captured and marked by any method or device. Leg bands must be recorded in the Department's banding database. In addition, radio frequencies of birds fitted with telemetry transmitters must be entered in the Department's telemetry frequency database. Both databases are managed by Biological Services in Cheyenne.

   Results of studies involving marked birds are typically published in special reports prepared by the investigators. In addition, progress and final reports should be included in the applicable Job Completion Reports.

IV. HABITAT ASSESSMENT –

A. Rationale – Sagebrush (Artemisia spp.) habitats have changed markedly over the past 25 to 50 years. In many areas of the west, fire management and agricultural activities have had major influences (Knick and Rotenberry 1997, Connelly et al. 2000a, 2004, Wambolt et al. 2002). Energy development has substantially impacted sagebrush rangelands in other locations (Braun 1998, Lyon 2000, Holloran 2005). Connelly et al. (2000b) emphasize habitat management plans must rely on the best available data regarding the quality and quantity of seasonal habitats used by sage-grouse, which must be thoroughly investigated to assure appropriate management decisions are made. Habitats are assessed for 5 general purposes: 1) identify and characterize seasonal habitats used by a sage-grouse population; 2) document current condition and trend; 3) evaluate impacts of a land treatment; 4) assess the success of a habitat restoration program; and 5) evaluate the habitat's suitability for a reintroduction effort.

B. Application – In virtually all cases, managers should identify and characterize habitat based on the areas sage-grouse select and inhabit seasonally or yearlong (Johnson 1980). Habitat

assessments should initially reflect "first-order selection" or the geographic range of a sage-grouse population. Habitats constituting "second-order selection" are based on home ranges of individual birds or subpopulations (e.g., birds associated with a lek or lek complex). The condition of various habitat components within the home ranges constitutes third order selection and further refines the habitat assessment process (e.g., breeding habitat). Finally, assessments can be done at a fourth-order selection level, if necessary, to evaluate the quality and quantity of food or cover at particular sites used by sage-grouse.

Changes in vegetation characteristics can be monitored over time by establishing permanent transects and rereading them at regular intervals. This kind of data is often collected to assess the impacts of land uses, or the effectiveness of habitat treatments.

1. Landscapes-scale assessments – Many, if not most sage-grouse populations are migratory. They characteristically occupy large ranges on an annual basis, though they use differing habitats at different times of the year (Connelly et al. 1988, 2000b, 2004). Seasonal habitats can be highly interspersed within the ranges of non-migratory populations, but separated by considerable distances (up to several km) within the ranges of migratory grouse (Schroeder et al. 1999; Connelly et al. 1988, 2000b, 2004, Leonard et al. 2000). The seasonal movements and distribution of grouse must be well documented before managers or researchers can begin a meaningful assessment of habitat conditions on a landscape scale. Aerial photos, satellite imagery, and digitized maps are helpful to identify specific habitats and measure their sizes and juxtaposition (Homer et al. 1993). Remote sensing imagery is often the basis for inventorying, evaluating, and monitoring rangeland resources (Tueller 1989, Anderson and Gutzwiller 1994). Landscape assessments correspond to first-order habitat selection (Johnson 1980). Landscape characteristics that should be measured include patch size, habitat quality, connectivity (availability of corridors connecting patches), amount of edge and distance between habitat patches. Hamerstrom et al. (1957) provided an early example of landscape assessment for managing greater prairie chickens (*Tympanuchus cupido*).

   To be functional, seasonal habitats used by non-migratory populations should be well interspersed and free of major barriers to movements (e.g., reservoirs, urban areas). These areas (sagebrush uplands, mesic areas) can be identified from aerial photographs, satellite imagery, or by field inspections and mapping. Some past studies offer a general sense of the size or scale of various seasonal habitats used by grouse. Breeding complexes have been measured at 23 km^2 (Wallestad and Pyrah 1974) and specific areas used as summer habitats ranged from 0.4 to 0.9 km^2 in Montana (Wallestad 1971) to 28 km^2 in northeastern Colorado (Hausleitner 2003). Wallestad (1975) identified and mapped winter ranges that varied from 11 to 31 km^2.

   Populations of migratory grouse may range throughout areas as large as Rhode Island. These movements vary depending on factors such as annual precipitation (Connelly 1982, Fischer et al. 1996*a*). However, migratory grouse tend to use specific seasonal habitats on an annual basis. These habitats may be disjunct, but are typically interconnected by sagebrush dominated corridors. Seasonal ranges of migratory grouse also vary in size, but generally breeding habitats are 150 to >600 km^2 (Leonard et al. 2000, J. W. Connelly unpublished

data), summer range are 0.5 to 7 km^2 (Connelly and Markham 1983) and winter range can exceed 400 km^2 (Leonard et al. 2000).

Leonard et al. (2000) used remote sensing technology to analyze spatial components and juxtaposition of seasonal habitats within the range of a migratory sage-grouse population. On a landscape scale, this study contrasted seasonal habitats available to sage-grouse in the 1970s with those available in the 1990s. The analysis was based on LandSat imagery obtained from the U.S. Geological Survey's Earth Resources Observation Systems Data Center. Image processing software was used to classify habitats. Land ownership was documented with Arc View software (ESRI, Inc., 380 New York St., Redlands, CA 92373-8100). The research determined agricultural lands had increased more than 70% within sage-grouse habitat over a 17-year period in eastern Idaho. A relationship between cropland expansion and declining sage-grouse populations was also demonstrated (Leonard 1998, Leonard et al. 2000).

Landscape analysis is becoming a fairly common approach for assessing sage-grouse habitat. Oyler-McCance et al. (2001) used a landscape approach similar to that of Leonard et al. (2000) to assess changes in habitat occupied by Gunnison sage-grouse (*C. minimus*) in Colorado. Using a Geographic Information System and low-level aerial photographs, researchers documented changes in sagebrush-dominated habitats between the 1950s and 1990s (Oyler-McCance et al. 2001). Smith (2003) used a similar approach to investigate sage-grouse habitat in the Dakotas.

2. Vegetation Assessments – The methods used to sample vegetation and the amount of data collected usually depend on the objectives of the habitat assessment or research project, but may also be influenced by time, budget, and manpower constraints. Irrespective, habitat assessments should be done in as unbiased a manner as possible. This usually requires a stratified, random sampling design. The selection of sample strata depends on proportions of differing vegetative and topographic features, interspersion and clustering effects. Thus, involving a statistician early in the planning process is usually a good idea to assure results will withstand critical review.

   Long-term studies commonly exceed 3 years and can involve numerous personnel changes. Therefore, it is essential to standardize techniques used for all data collection. Field personnel should receive adequate training and the techniques generally should not be modified throughout the study. These considerations will help assure data are collected consistently among personnel and over periods of time.

   Most quantitative assessments of sage-grouse habitats are done using one or more of the following vegetation measurements: cover, height, density, frequency, and visual obstruction. "Density" is the number of individual plants per unit area (e.g., plants/m^2), often used to measure the availability of plants that are important to sage-grouse. "Frequency" is the percent of a series of sample plots, in which a species or genus of plant is found (Daubenmire 1968). Sample plots must be uniform size and shape. The relative abundance or distribution of specific plants is often expressed as their "frequency of occurrence." "Visual obstruction" is a method used to measure the relative density and height of vegetation. The term "cover"

is generally used in vegetation sampling to describe the percent of ground covered by plant material, litter, rocks, or bare soil at ground level, or the percent of ground covered by the canopy projection of plants. Canopy cover is the attribute most often used to characterize sage-grouse habitat.

Three general approaches are commonly applied to assess vegetation within shrub steppe habitats: line transects, quadrats, and ocular estimates (Table 1). Line transects are more suitable for estimating shrub cover while quadrats have advantages when estimating herbaceous cover. Several specific techniques have been developed based on each of the general approaches. Different techniques can often yield comparable results. Hanley (1978) reported similar estimates of sagebrush canopy cover were obtained from line intercept and Daubenmire plot sampling in northwestern Nevada. However, line intercepts are superior to Daubenmire frames when higher levels of precision are required (Hanley 1978). Common techniques used to estimate canopy cover in sagebrush-dominated rangelands are discussed in the paragraphs that follow.

Visual obstruction indicates the relative cover of all vegetation, alive and dead, at a sampling point. It is sensitive to both the density and height of vegetation, but is not specific to individual species or genera of plants. Methods for measuring visual obstruction (Table 2) have a wide range of field applications, but for sage-grouse, are most often used to assess nesting cover. However, visual obstruction alone may have limited value for identifying nesting habitats because readings can be similar in areas dominated by sagebrush, and in habitats dominated by other shrubs and grasses, which are not important to nesting sage-grouse.

Sometimes it is necessary to classify proportions of habitats based on dominant vegetation (e.g., the relative amount of sagebrush-dominated habitat within a rangeland). Marcum and Loftsgaarden (1980) described a simple, non-mapping technique for this purpose. A number of points are randomly selected and then located in the field (easily accomplished from the ground or air with a GPS unit). The dominant vegetation is classified at each point (e.g., sagebrush, annual grass, bare ground, etc.). The authors also provided an appropriate method for analyzing these data.

Rotenberry et al. (2002) described a model that predicts animal use based on a minimum combination of the species' requirements. The model functioned well for predicting habitat use by sage sparrows (*Amphispiza belli*) in an altered landscape. The model may be also adaptable for sage-grouse habitats.

Sather-Blair et al. (2000) devised another approach to assess sage-grouse habitats and identify management actions based on the assessments. They provided a qualitative method and 2 quantitative methods for gathering data. Although methods to assess habitat conditions may vary, all methods should be relatively objective and biologically defensible.

Table 1. Methods used to estimate canopy cover in shrub-steppe habitats. "Yes" or "no" entries indicate whether a technique is suitable to measure the specified parameter.

	Technique					
	Line Transect Methods		**Quadrat Methods**			**Ocular Estimates**
Parameter: Attribute	**Line Intercept**	**Point Intercept**	**Daubenmire Plot**	**Circular Plot**	**Point Intercept**	
Shrub Cover	Yes	Yes	Yes	Yes	Yes	
Time Required[a]	2	2	1	3	2	1
Precision[b]	3	2	1	2	2	1
Ease of Replication[c]	2	1	2	2	2	1
Other Data Recorded[d]	1,3,4	1,3,4	1,3,4	1,2,3,4		--
Herbaceous Cover	Yes	Yes	Yes	No	Yes	
Time Required[a]	2	2	1	NA[e]	1	1
Precision[b]	2	2	3	NA	3	1
Ease of Replication[c]	2	2	2	NA	2	1
Other Data Recorded[d]	1,3,4	1	1,2,3,4	NA	1,2,3,4	--
References	Canfield 1941	Evans and Love 1957	Daubenmire 1959	Connelly 1982	Floyd and Anderson 1982	Daubenmire 1968

[a] Approximate time needed to sample: 1 = < 10 minutes; 2 = 11-30 minutes; 3 = 31-60 minutes (20 m transect, standard Daubenmire plot, point intercept frame, and 1-m radius circular plot).

[b] 1 = low; 2 = medium; 3 = high.

[c] An indication of the relative bias when other observers repeat the process: 1 = not easily replicated, results may vary substantially among observers; 2 = easily replicated, results are comparable among observers.

[d] Other data that can be recorded while using this technique: 1 = height; 2 = density; 3 = frequency; 4 = species composition.

[e] NA = not applicable

Table 2. Methods used to estimate visual obstruction in shrub and grass dominated habitats.

Attribute	Technique			
	Robel Pole	**Cover Pole**	**Jones Cover Board**	**Profile Board**
Time Required[a]	1	1	1	1
Precision[b]	2	2	1	2
Ease of Replication[c]	2	2	1	2
Other Data Recorded[d]	1	1	1	1
References	Robel et al. 1970	Griffith and Youtie 1988	Jones 1968	Nudds 1977

[a] Approximate time needed to sample: 1 = < 10 minutes; 2 = 11-30 minutes; 3 = 31-60 minutes.
[b] Estimated for sagebrush dominated habitats only: 1 = low; 2 = medium; 3 = high.
[c] An indication of the relative bias when other observers repeat the process: 1 = not easily replicated, results may vary substantially among observers; 2 = easily replicated, results are comparable among observers.
[d] Other data that can be recorded while using this technique: 1 = height; 2 = density; 3 = frequency; 4 = species composition.

a. Shrub Characteristics – Field personnel assigned to measure shrub characteristics must first receive training to identify species of shrubs, and to differentiate among the subspecies of sagebrush. Several keys to the identification of sagebrush taxa have been published (e.g., Atwood 1970; Winward and Tisdale 1969, 1977; Shultz 1984).

i. Cover – Shrub overstory is a vital component of sage-grouse habitat. Normally, overstory is measured in terms of canopy cover, defined as the projection of the plant's crown or stems onto the ground (Higgins et al. 1994). Canopy cover is the measurement most commonly reported in studies of sage-grouse habitat. The suitability of an area for nesting, early brood-rearing, or winter habitat is frequently based on measures of live shrub canopy along with herbaceous vegetation. In virtually all cases, data are recorded separately for each species and subspecies of shrub. Accordingly, field personnel must be proficient at identifying shrubs.

It is also important to understand the difference between canopy cover and total cover. Total cover includes the cover contribution from all plant species, regardless their relation to the canopy. This distinction becomes important when evaluating vegetation response to treatments. For example, in a community dominated by sagebrush with a significant understory of rabbitbrush, canopy cover would accurately represent the sagebrush cover but would underestimate the rabbitbrush cover (i.e., some of the rabbitbrush lies within the canopy projection of the sagebrush). If this community were treated (fire, herbicide, rotobeating, mowing, etc.) and then inventoried several years later, canopy cover data would correctly show the expected decrease in sagebrush, but would it would also show an increase in rabbitbrush (a species that resprouts readily after fire). This apparent increase may not

be real because rabbitbrush cover was underestimated in the initial canopy cover measurements.

Specific cover measurement techniques follow:

- Line Intercept – Line intercept (Canfield 1941) is one of the commonest techniques used to estimate shrub canopy cover. A tape is stretched out (usually 15 to 50 m) and the lengths of tape intersected by live shrub canopy are recorded along an imaginary vertical plane. Line-intercept measurements are usually done at specified intervals along a baseline transect (e.g., laid out perpendicular to the transect), but may also be done at specific points such as sage-grouse nest sites. When taking measurements, exclude large gaps (e.g., $\geq$5cm) between live branches or foliage so only live shrub cover is counted (Baker 1968). The distances intercepted by shrubs along the line are tallied and then divided by the total length of the line (for example: 580 cm of sagebrush ÷ 2500 cm of total line = 23.2% canopy cover). Often, the Daubenmire technique (Daubenmire 1959 – see below) is applied to estimate herbaceous cover at the same time line-intercepts are run.

  Line intercepts may be somewhat more time consuming than other methods used to estimate cover, but are less subjective, generally more accurate and precise (Higgins et al. 1994), and the method is widely accepted. Data from line intercepts can often be compared among studies because this is a very common method used to measure sagebrush canopy (Wakkinen 1990, Connelly et al. 1991, Gregg et al. 1994, Fischer 1994, Holloran 1999, Lyon 2000).

- Point Intercept – The point intercept method (Evans and Love 1957, Hanson et al. 1988, Sather-Blair et al. 2000) is based on the proportion of random sample points that intercepts live shrub canopy. A pin or small-diameter rod is randomly dropped to the ground (a notch or point on the toe of a boot can also be used). A "hit" is recorded each time the pin strikes the canopy of a shrub. Canopy cover (percent) is estimated based on the following calculation: 100 times the number of hits divided by the total number of pin drops. The pin diameter and the manner in which the pin is dropped or lowered can affect accuracy (Higgins et al. 1994). A very large sample of points is needed to estimate canopy in sparse shrub cover. Consequently, the method can be very inefficient within these types of environments (Heady et al. 1959, Higgins et al. 1994). Hanson et al. (1988) evaluated three specific variations of the point intercept method for estimating cover: step-point, wheel-point, and point-frame. They reported data obtained from the step-point and wheel point methods differed from point-frame data. All methods were subject to operator bias as well. In most sagebrush stands, results of point intercept and line intercept methods are comparable. Point intercept sampling can often be faster (depending on the number of samples needed), but is also prone to greater observer bias.

- Quadrat Sampling – Quadrat sampling is another means of estimating shrub canopy (Connelly 1982, Alldredge 2000). A frame (usually metal) is laid on the ground at sampling locations, usually at set intervals along a baseline transect. The percent of the frame area covered by individual species or groups of species is estimated. Quadrats can vary in size and shape, but are generally square or rectangular. The Daubenmire frame (Daubenmire 1959) and its variations (Leonard 1998) are among the commonest types of quadrat sampling frames. Although some frames can be bulky and awkward [e.g. point intercept frame (Floyd and Anderson 1982)], many are easy to construct and highly portable in the field (Neal et al. 1988).

  Quadrat sampling is a relatively quick way to estimate shrub cover. Unfortunately, the definition of canopy cover used in some quadrat methods (e.g., Daubenmire frame) differs somewhat from the definition used in line intercept sampling. In quadrat sampling, canopy cover is often considered the surface area over which a plant has influence, thus root systems can be included. Plant canopies are also treated as polygons (i.e, the exterior points of the canopy shape form a polygon). Because of this, quadrat sampling can over-estimate nesting cover for sage-grouse.

- Circular Plot – The circular plot (Connelly 1982) is another variation of quadrat sampling, but is seldom used. It was originally developed to estimate cover on big game winter ranges (Lyon 1968, Peek et al. 1978) and subsequently adapted to measure shrub characteristics on sage-grouse winter habitat (Connelly 1982). Circular plots (often 1-m in radius) are placed at intervals along transects laid out within the area of interest. Lengths and widths of sagebrush plants within the plots are measured to estimate the crown area of each plant, and an average crown size is determined. The percent of the plot area covered by the sagebrush crowns is an estimate of canopy cover.

- Ocular Estimates – In some circumstances, shrub cover is estimated based on a strictly visual examination in the field (Leonard 1998). These "ocular" estimates are suitable mainly for reconnaissance type inventories that don't require a high degree of precision. Although the Daubenmire frame may be considered an ocular estimate as well (Higgins et al. 1994), precision is enhanced through the use of a sampling frame and cover classes, which also enable the different observers to replicate the method (Daubenmire 1959). True ocular estimates are simply characterizations of the canopy cover, sometimes by cover class, without the aid of sampling frames or other standardized techniques. This approach may be useful for broad categorizations (Leonard 1998), but is subject to a great deal of observer bias. Cover tends to be overestimated because shrubs screen more of the ground surface when viewed from an oblique compared to a more or less vertical aspect. Thus, ocular estimates should only be used to make very rough approximations of shrub cover in a stand.

ii. Density – Studies of sage-grouse habitats often report shrub densities. However, density alone may not be sufficient to characterize nesting or winter habitats. Canopy cover is a more essential consideration, but may not be closely tied to density. For example, the density of new seedlings can be very high after initial establishment, but young plants are short and often provide minimal canopy. Measures of density may be more useful for evaluating reestablishment of sagebrush from a seeding project or natural regeneration after a disturbance.

Density estimates are typically done using sample plots placed systematically or randomly within an area of interest. The number of shrubs inside the plots is counted and then divided by the total area of the sample plots. Plots are often placed at intervals along transects randomly established within a study area.

iii. Frequency – Frequency sampling is not normally used to assess the shrub component of sage-grouse habitats. However, sage-grouse are known to selectively forage on some sagebrush species, subspecies, or individual plants (Remington and Braun 1985,Welch et al. 1988, Welch et al. 1991). Thus, data on the frequency of preferred shrubs may have some utility as an indicator of habitat quality, especially within sage-grouse winter ranges. Methods used to collect this kind of data are also less subjective, which can minimize errors among different observers and help detect trends over time (R. Miller, personal communication). Frequency data can be obtained using quadrat-sampling procedures. Relatively large frames or plots are used to assure the proportion of plots in which each shrub species is detected is a consistent indication of the species' relative abundance. The plots must also be of uniform size so the probability of detection is even (Daubenmire 1968). Frequency can also be measured based on the point intercept method (Higgins et al. 1994). The point of a pin or small-diameter rod is dropped to the ground repeatedly (usually along a transect). The percent of drops that hit each species provides an estimate of the species' frequency of occurrence. If frequency information is needed, observers can collect the data most efficiently during sampling procedures to assess shrub density.

iv. Height – Most sage-grouse nest in locations with sagebrush that is 40-80 cm tall (Connelly et al. 2000b). During winter, sage-grouse feed on relatively short sagebrush or sagebrush that protrudes a short height above snow (Robertson 1991, Connelly et al. 2000b). Accordingly, shrub height has some intrinsic importance for characterizing these habitats. Shrub heights are normally recorded in conjunction with procedures for estimating canopy cover. The tallest live part of each shrub in the sample (along transects or within plots) is measured. Normally, the average height is reported. Height measurements can vary depending on time of year and whether seed heads were included. Therefore, observers should always record the date measurements were taken, and indicate whether seed heads were included in the measurements.

v. Age Class – Connelly et al. (2003) do not mention shrub age class among the attributes they recommend for monitoring sage-grouse habitats. However, the

Department's Habitat Biologists regard age composition as a primary indication of a shrub stand's health and vigor. A stand that is comprised largely of dead and decadent shrubs, lacking recruitment, is in a declining trend.

Age data can be collected by classifying shrubs within a three foot belt transect along one side of a line transect tape. Unfortunately, investigators have used inconsistent criteria to define shrub age classes. For example, some Department reports (Cundy, 1989, Clause 1999) defined "decadent" as a mature plant having a canopy that is more than 25% dead. USFS (1993) and Nelson et al. (1994) defined decadence as >50% dead wood in the crown. To assure data are consistently collected and the surveys can be replicated, the same age class definitions should always be applied. Investigators should record the definitions used for classifying shrub ages at the time data are collected. Those definitions should be retained with the archived data (e.g., data files) and included in any report or publication in which the data are summarized or analyzed.

b. Herbaceous Vegetation Characteristics

i. Cover – Herbaceous understory is a critical component of sage-grouse breeding, early brood rearing, and summer habitats. Canopy cover measurements are widely used to assess the quality and availability of these habitats (Fischer 1994, Gregg et al. 1994, Hanf et al. 1994, Apa 1998, Lyon 2000). This approach is based on the same techniques described previously for estimating canopy cover of shrubs. However, herbaceous canopy can generally be sampled faster by quadrat and point intercept methods opposed to line intercept. The Daubenmire technique is one of the commonest methods for estimating herbaceous cover (also litter and bare ground) in sagebrush steppe habitats (Daubenmire 1959). Regardless of method used, canopy cover of each grass and forb species should be recorded and these measurements should normally be taken in late May and early June to coincide with hatching.

Ocular estimates are not generally suitable for estimating herbaceous canopy because shrub overstory can screen much of the understory from view. Moreover, shrubs and grasses can obscure the forb component. In some cases, very general observations (e.g., sparse or dense herbaceous cover) are useful.

Herbaceous canopy cover is sensitive to annual climatic changes. For example, cover can increase significantly during favorable conditions and decreases in unfavorable periods such as drought. The annual effects of climate make it difficult to detect overall trends. Basal cover is less influenced by annual climatic changes and is therefore a better indicator of long-term trends. However, the utility of this measurement is limited mainly to bunch grasses.

ii. Density – The density of important forb species can be measured to assess quality of habitats used by pre-laying hens (Barnett and Crawford 1994) and young broods. Density is estimated by counting the number of individual plants in circular, square or rectangular quadrats. The size of quadrats should be sufficiently large to assure each

forb species of interest occurs in a majority of quadrats, yet small enough that individual plants can be counted efficiently.

iii. Frequency – Frequency measurements are another method used to quantitatively assess the availability of forbs for pre-laying hens and young broods (Barnett and Crawford 1994, Drut et al. 1994). Frequency of important forbs can be assessed using any of the quadrat sampling procedures used for density or cover sampling, provided the sample plots (frames) are of uniform size (Daubenmire 1968). Hyder et al. (1963) suggested a quadrat of 230 to 645 cm^2 was adequate to sample frequency of forb species within a sagebrush habitat in eastern Oregon. If frequency information is needed, observers can collect the data most efficiently during sampling procedures to assess herbaceous cover or density.

iv. Height – Herbaceous cover averaging more than 18 cm tall is an important characteristic of sage-grouse nest sites (Wakkinen 1990, Gregg et al. 1994, Delong et al. 1995). Heights of grasses and forbs (both residual and new growth) can be easily measured along transects or within quadrats established for estimating cover. When mature, most grasses and many forbs tend to bend or droop somewhat, often because of the weight of the seed head. Normally, observers should record the natural or "droop" height above ground rather than the plant's total length. This provides a better indication of the lateral cover afforded by the herbaceous vegetation. Height measurements are normally taken in late May and early June, and coincide with hatching. Windy conditions may affect the accuracy of height measurements and if wind is a problem, measurements should be deferred until winds decrease.

c. Visual Obstruction – Visual obstruction is another means used to assess the overall cover value provided by the combination of both shrub and herbaceous vegetation in sage-grouse habitats. The Robel pole (Robel et al. 1970), cover pole (Griffith and Youtie 1988) and Jones cover board (Jones 1968) can be used to assess visual obstruction in sagebrush-dominated rangelands (Wakkinen 1990, Fischer 1994, Gardner 1997). Nudds (1977) also described a cover board that may have similar applications. Some data that were collected using a Robel pole have been useful for analyzing nest sites. However the Jones cover board (3-sided or 4-sided) did not appear sensitive enough to detect differences among areas and may not be easily replicated by different observers (Wakkinen 1990, Fischer 1994). The Jones cover board is shorter than a Robel pole, so readings taken in some sagebrush habitats tend to be grouped near 100% (Wakkinen 1990). However, Fischer (1994) and Apa (1998) successfully used the Jones cover board to identify cover characteristics that differentiated sage-grouse nest sites from random sites.

The Robel pole was originally developed to help distinguish habitats used by greater prairie chickens in grassland ecosystems (Robel et al. 1970). The method is now in widespread use and appears suitable for assessing habitats of many other species, except where vegetation is very sparse (Higgins et al. 1994). The cover pole (Griffith and Youtie 1988) was developed to evaluate deer hiding cover in several habitats including sagebrush-dominated rangeland. It has not been widely used in studies of sage-grouse

habitats, but its application for this purpose should be investigated. Given the limited experience with cover poles and sensitivity issues of the Jones cover board, we generally recommend investigators use the Robel pole to measure visual obstruction in sage-grouse habitat.

3. Insects – Insects are an essential food source for young sage-grouse chicks (Patterson 1952, Klebenow and Gray 1968, Johnson and Boyce 1990). To thoroughly investigate quality of early brood-rearing habitat, investigators should consider an evaluation of insect abundance. Several methods including sweep nets, beating sheets, and pitfall traps are available to estimate insect numbers (Fischer 1994). Ants and beetles are often the most important groups of insects eaten by young sage-grouse chicks (Johnson and Boyce 1990, Fischer et al. 1996*b*). Abundance of ants and beetles can be easily gauged with pitfall traps. Although pitfall traps can vary in size, shape, and materials used, a common method used in sage-grouse habitat is to place test tubes in a grid arrangement, such that the top of each tube is flush with the ground (e.g., a 4x4 grid of 16 tubes placed 50 cm apart) (Nelle 1998). Tubes are filled with a 1:1 solution of water and ethylene glycol and then sealed with a cork or rubber stopper until the sampling period begins. Sampling for insects should coincide with the early brood-rearing period (late May to mid-June). We suggest sampling over at least one 24-hour period during this timeframe.

V. ENVIRONMENTAL COMMENTS AND RECOMMENDED MANAGEMENT PRACTICES –

Refer to Appendix X (Environmental Review Procedures). Utilize the following resources when conducting wildlife environmental reviews (WERs) of actions potentially impacting sage-grouse habitats, or when developing habitat management plans.

Bohne, J., T. Rinkes, and S. Kilpatrick. *in press.* Sage-grouse habitat guidelines to be used when managing sagebrush communities in Wyoming. Wyoming Game & Fish Dept.

Connelly, J.W., M.A. Schroeder, A.R. Sands and C.E. Braun. 2000. Guidelines to manage sage-grouse populations and their habitats. Wildlife Society Bulletin 28(4):967-985.

Paige, C., and S.A. Ritter. 1999. Birds in a sagebrush sea: managing sagebrush habitats for bird communities. Partners in Flight Western Working Group, Boise, ID. 47pp. (can also be found on the SAGEMAP website: http://sagemap.wr.usgs.gov).

Wyoming Interagency Vegetation Committee. 2002. Wyoming guidelines for managing sagebrush communities with emphasis on fire management. Wyoming Game & Fish Dept. and Wyoming BLM. Cheyenne, WY. 53pp.

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Current seasonal stipulation recommendations available from the WGFD Habitat Protection staff.

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ATTACHMENT 1

A KEY FOR AGE/SEX IDENTIFICATION FROM WINGS OF HUNTER-HARVESTED SAGE-GROUSE

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Key words: sage-grouse, Centrocercus urophasianus, age and sex identification

The Sage-grouse, (Centrocercus urophasianus) is an important game bird in the western United States and is presently hunted in 9 states. Most states collect wings from hunter-harvested sage-grouse to ascertain sex and age composition of the harvest. These data are used to monitor trends in productivity and overall reproductive health of populations by local area, region, and state (Autenrieth et al. 1982).

Separation of sex and age classes of sage-grouse has followed descriptions of Eng (1955) and Dalke et al, (1963), and a key developed by Crunden (1963). Beck at al. (1975) summarized the general knowledge useful in identification of sage-grouse sex and age from wings. Each of these sources is useful but each has limitations such as incorrect terminology and failure to report repeatable measurements. Some require that ”wing boards”, be constructed and retained, examination of intact birds or intact wings, or have reduced usefulness because feathers are damaged, missing, or discolored (because of water or blood). The objective of this paper is to present a dichotomous key to separate sex and age classes of sage-grouse from wings collected through mail surveys, volunteer wing collection stations (Hoffman and Braun (1975) and at hunter-check stations.

METHODS

Measurements of primaries from hunter-harvested sage-grouse were initially obtained from hunters at check stations in Jackson County, Colorado in 1973-74. This effort was expanded to all hunted populations in Colorado in 1975-79. Sex of bird from which wings were collected ($n \geq 1000$ individuals) was obtained from gonadal inspection of intact birds at check stations in Jackson and Moffat counties, Colorado from 1976 continuing into the late 1980's. Wings from gonadally inspected, hunter-harvested sage-grouse were used to initially develop and refine measurement criteria for males and females in each age class. Additionally, wings ($n \geq 500$) from hunter-harvested, spring-banded sage-grouse were obtained (and individually marked or stored) at check stations in Jackson and Moffat counties, Colorado from the mid-1970's continuing until the early 1990's.

USE OF THE KEY

The key (Table 1) can be used for frozen, dried, or fresh (unfrozen) wings but is easier to use if the wings have been allowed to thaw without becoming dry. The only tool necessary is a flexible millimeter ruler with a minimum length of 210 mm. Primary feathers (numbered 10 through 1. distal to proximal) are examined for appearance (pointed or rounded, Fig, 1) as is the 1st secondary (numbered I through 10, distal to proximal) (Fig. 2).

Measurements of fully replaced primaries are taken from the insertion point between the bases of primary feathers (skin) to the tip of the target primary. Thus, length of primary 10 is measured from the base of the feather between primaries 10 and 9 to the top of primary 10, 9 is measured by placing the ruler between primaries 9 and 8, etc., except that both primaries 1 and 2 are measured by placing the ruler between them. Care must be taken to identify primaries that are being molted but this is rarely a problem except for late hatching chicks (those molting/replacing juvenile primaries 5 and /or 6). Late-hatched chicks molting juvenile primaries 5 and/or 6 comprised 0% of the chicks examined in Nevada in 1986 (n = 51) and in Oregon in 1993 (n = 205), 6.3% in Utah in 1993 (n = 222) and 20.5% in Colorado in 1993 (n = 774).

Wings can be sorted (if sample sizes are large) by apparent size (females are markedly smaller than males in all age classes) and by age class by appearance of primaries 10 and 9 (Fig. 1) as compared to primaries 7 or 6 through 1 (except for a few late-hatching chicks). Separation of yearlings (birds 15-16 months of age) and chicks should be based on examination of the 1st secondary (rounded in yearlings, pointed if still retained in juveniles) (Fig. 2) or the presence or absence of juvenal tertials and covert feathers (Figs. 3,4). The first secondary of juvenile sage-grouse is normally replaced with an adult secondary when juvenile primary 8 has been replaced with an adult primary that is greater than 40-60 mm in length.

Once wings are sorted (for large samples) or examined, sex and age classes can be verified using the key. Sample sizes in each category should be recorded along with molt schedules, and length of the most recently molted growing adult primary for juveniles, etc. depending on data requirements. One person can easily process 500-600 wings per day. Two people can easily process in excess of 1000 wings per day including measurement of feathers in wings of chicks to aid in ascertaining hatching date and recording of molt schedules for all age classes.

DISCUSSION

Use of the appearance of outer primaries 10 and 9 to separate age classes of prairie grouse was first reported by Petrides (1942), Wright and Hiatt (1943) and Amman (1944) and specifically for sage-grouse by Patterson (1952) and Eng (1955). However, these authors made no attempt to separate the yearling age class from adults in areas in Nevada, Oregon, and Utah and in low elevation areas of Colorado since few yearlings can be identified in harvest samples after mid-September. This is because replacement of primary feathers follows completion of breading activities for males and nesting activities of females. Yearling males cease breeding activities prior to adults (Eng 1963) and initiate malt of primaries (starting with primary, 1) 7-14 days before adult males, Thus, in areas where breeding activities peak in March, few yearling males will be identifiable in the harvest after 7-10 September. Wings from these birds appear as having all primaries fully molted (replaced) and are indistinguishable from wings of adults.

Molt schedules of yearling females are identical to those of adult hens except that yearlings are markedly less successful than adult hens in nesting. Replacement of primary feathers is initiated by hens following termination of incubation. Because yearling hens are less successful in nesting than adults, many yearlings have advanced primary molt schedules when compared to adults harvested at the same time. Successfully nesting yearling hens have primary molt schedules similar to successfully-nesting adults. Depending upon timing of nesting activities (which is related to amount of snow cover,

elevation, etc.), hens retaining old primaries 9 through 6 (in combination 9 and 8; 9,8 and7; or 9,8,,7 and 6) can be considered as successfully hatching their clutch. Hens that have molted all primaries or are retaining only old primary 10 can be considered as unsuccessful in hatching their clutch (C.E. Braun, unpubl. data). Most wings with fully molted (replaced) primaries are likely from yearlings because of low nest success and early advent of molting.

Some difficulty may arise in separating yearlings from chicks (birds less than 3-4 months of age). These difficulties are minimal if the first secondary is retained (pointed in juveniles, rounded in yearlings) (Fig. 2), the tertial feathers are examined (narrow and worn in juveniles vs. rounded and usually new in appearance in adults)(Fig. 3), or the upper wing Coverts are examined (narrow with a white streak in the center for juveniles vs. broad and barred in adults and yearlings) (Fig. 4).

Identification of sex classes for chicks is only a problem for late hatching birds that have actively growing juvenile primaries 10 and 9 (sheathed at base). This problem is minor except in extremely late hatch years, which may be caused by late springs, heavy winter snowfall, etc. Measurement of primary 1 will normally result in correct classification of all chicks older than 4-5 weeks.

Substantial variation in size of sage-grouse occurs throughout the species' range with the smallest birds occurring in southwestern Colorado and southeastern Utah. (Now considered a separate species – Gunnison Sage-Grouse – ED.) Separate keys have been developed for use in southwestern Colorado, Oregon, and Washington along with the "standard" key presented in this paper. These keys vary only in length of primaries 10, 9, and -1. All differences between the populations of sage-grouse tested are less than 10 mm per key feather and less than 5 mm for primary 1.

SUMMARY

The key developed in Colorado and used since the late 1970's has been tested on sage-grouse populations in Nevada, Oregon, Utah, and Wyoming. It is reliable for an estimated 97% of the wings examined (40,000 + since development), it is useful for wings under most conditions (dried, disintegrating, frozen, stained, etc.), and is easily understood and applied by relatively inexperienced personnel. It needs further testing and refinement (adjustment of the length criteria) for populations in other states. Upon testing, it is logical that a modified key (In terms of length of primaries 10, 9, and 1) will be developed for individual populations in some states (such as has been done in Colorado, Oregon, and Utah).

Acknowledgements: I thank the many hunters who allowed examination and collection of data from sage-grouse they had harvested. Collection of wings was facilitated by Area and Regional personnel of the Colorado Division of Wildlife. I especially thank T.D.I. Beck for help in the developmental stages collection system in Colorado, and R.W. Hoffman for help throughout. Many different individuals assisted with operation of check stations, collection of wings, and data tabulation. I thank all who have been involved since 1973-74. This manuscript was improved by the reviews of T.D.I. Beck and J.R. Young. The cooperation of wildlife agencies in Nevada, Oregon, Utah, and Wyoming is appreciated. This is a contribution from Colorado Federal Aid in Wildlife Restoration projects W-37-R and W-167-R.

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KEY FOR SEPARATION OF AGE AND SEX CLASSES OF SAGE CROUSE FROM NORTHERN COLORADO

Clait E. Braun

1a. Primaries 10[a] and 9 rounded and similar in appearance to primaries 7 and 6 …..…….…….2

1b. Primaries 10 and/or 9 and/or 8 pointed when compared to primaries 7 and 6……...…….…….3

2a. All primaries rounded, primary 9 if present, longer than 200 mm. If primary 9 is not present primary 10 is longer than 165 mm. If neither primary 10 or 9 is not present, primary 1 longer than 140 mm…….…..……...….**Adult Male**

2b. All primaries rounded, primary 9 if present, less than 199 mm in length. if primary 9 is not present, primary 10 is less than 160 mm. If neither primary 10 or 9 is present, primary I is less than 140mm ….…….….**Adult Female**

3a. Primaries 10 and 9 pointed, worn, faded, secondary 1 broad and round...….....…….…….……...4

3b. Primaries 10 and 9, and possibly 8 and 7 pointed, new, not frayed and not rounded, secondary 1 full in and pointed[b]…….……..…….……...….5

4a. Primaries 10 and/or 9 pointed, worn, faded, secondary 1 broad and round. Primary 9 if present, more than 200 mm, if primary 9 missing, primary 10 is greater than 160mm..……**Yearling Male**

4b. Primaries 10 and or 9 pointed, worn faded; secondary 1 broad and round. Primary 9 if present less than 198 mm, if primary 9 missing, primary 10 is less than 160mm……**Yearling Female**

5a. Primaries 10 and 9 and possibly 8 and 7 pointed, new in appearance, secondary 1 pointed[b], primary 9 longer than 190 mm, primary 10 more than 160 mm in length if Juvenile primaries 8 and/or 7 present……..……..**Chick Male**

5b. Primaries 10 and 9 and possibly 8 and 7 pointed, new in appearance, secondary 1 pointed[b] primary 9 less than 190mm, primary 10 less than 158 mm if juvenile primaries 8 and 7 are present ……..……..……**Chick Female**

[a] Primaries are numbered 10 - 1 from distal (outer) to proximal (inner). Secondaries are numbered 1 - 10 from distal (outer, next to primary 1) to proximal (closest to body). Measurements are from the insertion to the tip (i.e., P 10 is measured from insertion between 10 and 9 to the tip of large P 10, etc.)

[b] Juvenile secondary 1 is replaced when adult primary 8 is E (empty) to 100 mm in length.

Table 2. Length (mm) of primary flight feathers* of sage-grouse useful for age and gender separation.

	Adult						Yearling/Juvenile					
	Male			Female			Male			Female		
Area	10	9	1	10	9	1	10	9	1	10	9	1
Gunnison	>157	>190	>140	<150	<190	<140	>157	>190	>140	<150	<190	<140
N. Color.	>160	>200	>140	<160	<200	<140	>160	>195	>140	<160	<195	<140
Oregon	>160	>195	>140	<160	<195	<140	>155	>195	>140	<155	<195	<140

*Numbered from inner (1) to outer (10)

Figure 1. Appearance of tips of primaries 10 and 9 for juvenile (left), yearling (center) and adult (right) sage-grouse.

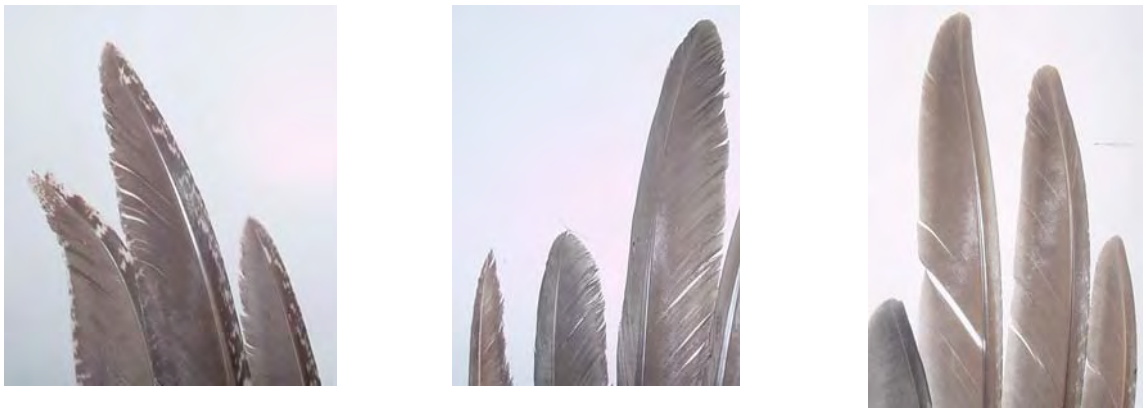

Figure. 2. Appearance of juvenile (left) and adult (right) first secondaries of sage-grouse.

Fig. 3. Appearance of juvenile (left) and adult (right) tertial feathers of sage-grouse.

Fig. 4. Appearance of juvenile (left) and adult (right) upper wing coverts of sage-grouse).

Appendix B: Forms

Annual Sage Grouse Lek Observation Form

Lek:_____ **Warden District:** _____

Complex: _____ **GPS Datum: NAD83** **Biologist District:** _____

QQ Q Sec Tw Rng Zone Northing Easting **WGFD Region:** _____

Prim. Location: __ __ __ __ ___ ___ _____ _____ **BLM Office**: _____

Alt. Location: __ __ __ __ ___ ___ _____ _____ **Land Status:** _____

Area:_____ **Year Discovered:** _____ **County:** _____

BLM Map:_____ **Topo Map**: _____

Comments: _____

1st Count/Survey

Date			Weather		# Grouse Observed			If no grouse observed, was sign (droppings/feathers)	
mm/dd/yy	Time	Observer	Wind<10mph?	PPT?	Male	Female	Unk	checked?	observed?
_____	_____	_____	_____	_____	_____	_____	_____	_____	_____

Comments and field notes, incl. new location coordinates if different from above:

_____

_____

2nd Count/Survey

Date			Weather		# Grouse Observed			If none observed, was sign (droppings/feathers)	
mm/dd/yy	Time	Observer	Wind<10mph?	PPT?	Male	Female	Unk	checked?	observed?
_____	_____	_____	_____	_____	_____	_____	_____	_____	_____

Comments and field notes, incl. new location coordinates if different from above:

_____

_____

3rd Count/Survey

Date			Weather		# Grouse Observed			If no grouse observed, was sign (droppings/feathers)	
mm/dd/yy	Time	Observer	Wind<10mph?	PPT?	Male	Female	Unk	checked?	observed?
_____	_____	_____	_____	_____	_____	_____	_____	_____	_____

Comments and field notes, incl. new location coordinates if different from above:

_____

_____

4th Count/Survey

Date			Weather		# Grouse Observed			If no grouse observed, was sign (droppings/feathers)	
mm/dd/yy	Time	Observer	Wind<10mph?	PPT?	Male	Female	Unk	checked?	observed?
_____	_____	_____	_____	_____	_____	_____	_____	_____	_____

Comments and field notes, incl. new location coordinates if different from above:

_____

_____

*Lek **Counts** should be conducted starting the second or third week of April through the first week of May. Visits to the lek should be made about one week apart from each other. Each lek should be visited and counted at least 3 times under good weather conditions (wind<10 mph, not raining/snowing). Lek **Surveys** can begin in mid-March and should be conducted until the lek status (active/inactive) is verified. One visit is enough to consider a lek "active" if birds are observed or signs of strutting are observed. Three ground visits, including a late season visit, are required to classify a lek as "inactive" if no birds are observed and a search for sign is not conducted.*

SAGE GROUSE OBSERVATION FORM

Observer: _____ UTM Zone: _____

Check One: Ground___ Fixed Wing___ Helicopter___ Transfer appropriate data to WOS.

Date	Live or Sign	# Grouse	UTM (NAD83) or lat/long location Easting	Northing	Habitat Type	Cover Est.(1)	Aspect (N/S/E/W)	Relative Elevation(2)	Slope(3)	Snow Depth	Other

(1) Low: ≤10% shrub cover, Med: 15-25% shrub cover, High: ≥30% shrub cover; (2) Low:draw, Med:mid-slope, High:ridge top; (3) Flat, Med, Steep

SAGE GROUSE MOLT DATA FORM

Management Area:_____ **Collection Date:**_____

Collection Location/Barrel Name:_____

Adult Males

Full Molt:_____
Old P10:_____
Old P9:_____
Old P8:_____

Yearling Males

Old P10:_____
Old P9:_____
Old P8:_____

Adult Females

Full Molt:_____
Old P10:_____
Old P9:_____
Old P8:_____
Old P7:_____
Old P6:_____

Yearling Females

Old P10:_____
Old P9:_____
Old P8:_____
Old P7:_____
Old P6:_____

Chick Males

Adult P8:_____
Adult P7:_____
Adult P6:_____
Adult P5:_____

Chick Females

Adult P8:_____
Adult P7:_____
Adult P6:_____
Adult P5:_____

Other Wings in this Collection

Gray Partridge Wings:_____

Sharp-tailed Grouse Wings:_____

Pheasant Wings:_____

Blue Grouse Wings:_____

Ruffed Grouse Wings:_____

Sage Grouse Wing Analysis Summary Form

Year: _____ **MANAGEMENT AREA:** _____

Adult Males: _____ Percent of All Wings: _____
Adult Females: _____ Percent of All Wings: _____
Adult Unknown: _____ Percent of All Wings: _____
Total Adults: _____

Yrling Males: _____ Percent of All Wings: _____
Yrling Females: _____ Percent of All Wings: _____
Yrling Unknown: _____ Percent of All Wings: _____
Total Yearlings: _____

Chick Males: _____ Percent of All Wings: _____
Chick Females: _____ Percent of All Wings: _____
Chick Unknown: _____ Percent of All Wings: _____
Total Chicks: _____

Unknown Sex/Age: _____ Percent of All Wings: _____

Grand Total for all Sex/Age Groups: _____

Chick Males: _____ Percent of All Chicks: _____
Yrling Males: _____ Percent of Adult + Yrling Males: _____
Adult Males: _____ Percent of Adult + Yrling Males: _____
Adult + Yrling Males: _____ Percent of Adults + Yrlings: _____
Total Males: _____ Percent of All Sex/Age Groups: _____

Chick Females: _____ Percent of All Chicks: _____
Yrling Females: _____ Percent of Adult + Yrling Females: _____
Adult Females: _____ Percent of Adult + Yrling Females: _____
Adult + Yrling Females: _____ Percent of Adults + Yearlings: _____
Total Females: _____ Percent of All Sex/Age Groups: _____

Chicks: _____ Percent of All Wings: _____
Yearlings: _____ Percent of All Wings: _____
Adults: _____ Percent of All Wings: _____

Chicks:Hen _____

Chapter 13

BLUE GROUSE AND RUFFED GROUSE (*Dendragapus obscurus and Bonasa umbellus*)

Harry Harju

I. CENSUS –

A. Production Surveys –

1. Rationale – Random brood counts are a survey method used to assess the reproductive success of blue or ruffed grouse. Unfortunately, these counts are done too late in the year to be considered in setting or adjusting hunting seasons. If the sample size is large enough, the counts can help identify important habitats used by broods and can provide insight to the potential quality of hunting in the fall.

2. Application – Random brood counts can be conducted on foot, from horseback or from a vehicle and should cover all portions of the brood-rearing area. A good pointing dog is invaluable to locate broods. If a flushing dog is used, it should be trained to walk very close to the observer. Each time a grouse is seen, record the species, location, age, sex and habitat on a wildlife observation form. If a count is incomplete, circle the number of birds recorded.

   The time frame for these surveys is July 15 to August 31. Warm, clear days are best for brood counts. The best results are obtained by searching for broods in the first two and last three hours of daylight. When a well-trained dog is used, counts can be conducted throughout the day.

3. Analysis of Data – Refer to chapter 12 (Sage-grouse), Section II.B (Brood Production).

4. Disposition of Data – All records of brood observations are forwarded to Regional Wildlife Management Coordinators for proofing, and then entered into the Wildlife Observation System Database.

B. Harvest Survey –

1. Rationale – Harvest data may be obtained in several ways, each suited for differing purposes and precision. The best methods are wing collections and the harvest survey questionnaire.

   Harvest data enable managers to monitor population trends, hunting pressure, chick survival to fall, annual changes in production, sex ratios of adults, hunter success and

the number of birds harvested. This information is used predominantly for answering questions from the public, industry and federal agencies.

2. Application – Refer to Chapter 12 (Sage-grouse), Section II.B.3 (Wing Collections) for additional information on wing barrels.

   Hunter Field Checks: Hunter field checks are inefficient and usually produce disappointingly small samples. Any major effort to contact hunters in the field should only be undertaken to fulfill data requirements for special studies.

   Wing Barrels: Wing barrels are 20 to 30 gallon metal barrels attached horizontally to a pipe which slides over a metal fence post. A guy wire attached to the back prevents the barrel from turning. A semi-circular opening is cut from the top half of one end of the barrel, enabling hunters to place the wings inside. A sign next to the barrel instructs, "Hunters, please deposit one wing from each grouse you harvested" (Hoffman and Braun 1975).

   Wing barrels are placed in locations passed by a large number of grouse hunters. Wing barrels work well in mountainous areas because there are few major ingress and egress routes. A small number of barrels can collect wings from relatively large areas.

   Wings should be removed from the barrels on Friday and Sunday evenings and immediately after holidays. Locations of barrels and dates of collections should be written on the collection sack or tags attached to the wings. Data from wings provide information on harvest trends, age and sex composition, and hunting pressure.

3. Analysis of Data – Changes in the proportion of young birds in the harvest can indicate an increase or decrease in survival of young. When young survival to fall is low, it is reasonable to expect a decrease in reproducing adults the following year. However, blue grouse are territorial and long-lived under current harvest pressures, therefore changes in survival of young probably don't affect the following year's production in most cases.

   Hunters do not select specific ages or sexes of blue and ruffed grouse. Therefore, we can presume harvest proportions represent the sex and age composition of the population. The sex ratio of adults, percentage of hens that nested successfully, and average size of broods can be determined from wings of harvested grouse.

   Yearly trends in the number of birds harvested per hunter and total harvest can indicate relative sizes of populations among years if weather was comparable. An increase in birds taken per hunter indicates more birds were available, hence an increase in the population. Conversely, a lower hunter success may indicate a decrease in available birds. Wing data that indicate a higher proportion of young in the harvest generally correspond to higher production and hunter success. Occasionally, factors such as weather cause the birds to move or change their habits,

making them more or less accessible to hunters. At such times hunter success may give a false reading of population changes.

C. Age and Sex Determination –

1. Rationale – The sex and age composition of the harvest represents the sex and age composition of grouse populations in the fall. This in turn indicates the population trend and the influence of adverse weather upon survival of young birds to the fall.

2. Application –

Aging Blue Grouse: (June 1967).

Physical Characteristics:

Lower Jaw (Patterson 1952). Support the entire weight of the dead bird by clasping the lower jaw (mandible) and shake it.

Juvenile: The lower mandible breaks.
Adult: The lower mandible does not break.

Flexibility of Breastbone (Patterson 1952). Push on the tip or end of the breastbone (sternum) with one finger.

Juvenile: The tip of the breastbone may be easily bent with one finger.
Adult: The tip of the breastbone is rigid and blunt.

Cranium (Westerskov 1956). Hold the bird's head is held between the index and middle finger and press the thumb on the forehead.

Juvenile: The cranium breaks.
Adult: It is not possible to press in the brain case.

Plumage Characteristics:

Outer primary Feather (Boag 1965)

Juvenile: The two outer primary feathers (#9 and #10) are pointed and new in appearance.
Yearling: The two outer primary feathers (#9 and #10) are pointed and old in appearance.
Adult: The two outer primary feathers (#9 and #10) are rounded.

Contour Feathers (Tabor 1963)

Juvenile: The contour feather shaft is streaked with dull white.

Adult: The contour feather shaft is streaked with dark.

Breast (Tabor 1963)

Juvenile: The breast is a pale buff or white.
Adult: The breast is a dark brown.

Outer Tail Feather (Petrides 1942). This measurement is taken one-half inch below the tip of the feather.

Juvenile: The outer tail feather is more rounded at the tip, shorter and narrower, 3/4 to 7/8 inch wide.
Adult: The outer tail feather is more square-tipped, longer and wider, 1¼ to 1½ inches wide.

Total Length of Plucked Outer Tail Feather (Bendell 1955)

Juvenile Male: The total length of the plucked outer tail feather is 132 to 152 mm.
Adult Mail: The total length of the plucked outer tail feather is 162 to 194 mm.
Juvenile Female: The total length of the plucked outer tail feather is 111 to 134 mm.
Adult Female: The total length of the plucked outer tail feather is 138 to 161 mm.

Tail feathers of blue grouse in southeastern Wyoming have grey bands at the tip, while those in northwestern Wyoming have only grey flecks on the tip.

Primary feather development and Auditory Region (Juvenile age in weeks) (Smith 1963). The primaries are numbered one to ten, from the inside to the outside of the wing. This follows the sequence in which they are molted. The outer primaries are shed and replaced last. Grouse molt only through primary #8 in their first fall. The latest-shed primary is indicated by a gap or a growing, replacement feather that is blue at the base. The number of the latest-shed primary is most reliably determined by counting backward from the outermost primary, since the division between primaries and secondaries is sometimes confusing.

A key for determining juvenile age in weeks by primary replacement follows:

Primary #8 not emerged:
Primary #1 with blood. . . . . 1 week old
Primary #2 bloodless. . . . . 2 weeks old
Primary #8 emerged:

Primary #1 dropped.	3 weeks old
Primary #2 dropped	3-4 weeks old
Juvenile feather emerging in capital tract	4 weeks old
Primary #3 dropped	4-5 weeks old
Primary #4 dropped	5-6 weeks old
Primary #5 dropped	5-7 weeks old
Secondary #8 dropped	5 weeks old
Total length of rectrices (tail feathers) 120 to 271 mm	6 weeks old
Total length of rectrices 272 to 485 mm	7 weeks old
Primary #6 dropped	7-8 weeks old
Total length of rectrices 486 to 720 mm	8 weeks old
Primary #7 dropped	9-10 weeks old
Secondary #2 dropped	9 weeks old
Total length of rectrices 721 to 921 mm	9 weeks old
Total length of rectrices 922 to 1082 mm	10 weeks old
Primary #8 dropped	11 weeks old
Total length of rectrices 1083 to 1190 mm	11 weeks old
Auditory region of males, well defined circles of post-juvenile feathers	12 weeks old
Auditory region of males, areas of post-juvenile feathers enlarging	13 weeks old
Auditory region of males, area of post-juvenile feathers enlarging and beginning to merge with those in capital tract	14 weeks old
Auditory region of males, post-juvenile feathers cover head and neck	15 weeks old

Adults	Rounded condition of primaries #9 and #10.
Yearlings	Pointed condition of primaries #9 and #10.

Primary Feather Development (Juvenile Age in Weeks) (Zwickel, 1966)

Classification for rating each primary follows:

E (empty) = an empty feather follicle.

P (pulp) = a new feather in which the vane has not yet broken from the quill. (From the time the vane breaks from the quill until the feather stops growing, the development is estimated in relation to a fully grown primary. For instance, a feather in which the vane has just broken from the quill represents 1/8 grown. The other categories used are 1/4, 1/3, 1/2, 2/3, 3/4, and 7/8 grown).

F (full) = a fully-grown feather, one in which all bluish color (the blood) is gone from the lower end of the quill.

A key for determining age of young blue grouse beyond 2 weeks old follows:

PRIMARY NUMBERS								
AGE WEEKS	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***
2	E	-	-	-	-	-	-	-
3	P	E	-	-	-	-	-	-
4	2/3	1/3	P	-	-	-	-	-
5	3/4	2/3	1/3	P	-	-	-	-
6	F	7/8	3/4	1/2	P	-	-	-
7	F	F	F	3/4	1/2	1/4	-	-
8	F	F	F	7/8	2/3	1/2	E	-
9	F	F	F	F	7/8	2/3	1/4	-
10	F	F	F	F	F	3/4	1/2	P
11	F	F	F	F	F	7/8	3/4	1/4
12	F	F	F	F	F	F	3/4	1/2
13	F	F	F	F	F	F	7/8	3/4
14	F	F	F	F	F	F	F	3/4
15	F	F	F	F	F	F	F	3/4
16	F	F	F	F	F	F	F	F

Average length (mm) of fully grown primaries:

PRIMARY NUMBERS								
SEX	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***
MALE	108	117	125	139	156	162	161	158
FEMALE	104	112	118	129	144	149	148	145

Plumage Characteristics:

Cervical Air Sac (Over 6 weeks of age) (Caswell 1954):

Male: The male cervical feathers have a white base and are tipped with bluish black

Female: The female cervical feathers lack the white base and are bluish brown in color.

Head, Nape and Interscapular Feathers (Ridgeway 1946):

Male: The male has no barred feathers.

Female: The female has some barred feathers.

Minor Primary Coverts (Mussehl 1963). The minor primary coverts (Tectrices) are immediately under the alula.

Male (Adult): The male coverts are gray with less pronounced or no mottling.
Female (Adult): The female coverts are blotched with brown mottling, particularly along the rachis or center.

Length of Primary Feathers (Mussehl 1963). Measure the lengths of primaries #1, #3 and #5, which are usually fully developed by September. The measurements are made from the point of insertion to the tip of the feather.

The primaries are numbered one to ten from inside to outside. This follows the sequence in which they are molted. The outer primaries are shed and replaced last. Grouse molt only through primary #8 in their first fall. The latest-shed primary is indicated by a gap or a growing, replacement feather which is blue at the base. The number of the latest-shed primary is most reliably determined by counting backward from the outermost primary, since the division between primaries and secondaries is sometimes confusing.

Male (Adult): The total value (Z) is greater than the general mean (Zm) of the #1, #3 and #5 primaries.
Female (Adult): The total value (Z) is less than the general mean (Zm) of the #1, #3 and #5 primaries.

Zm = General mean of the #1, #3 and #5 primaries (Zm = 0.440525).

Z = total value of the #1, #3 and #5 primaries.

Z1 = Total value of primary #1.

Z3 = Total value of primary #3.

Z5 = Total value of primary #5.

Z = Z5 + Z3 – Z1

Measure the first (Z1), third (Z3) and fifth (Z5) primaries. Convert their lengths to primary feather values, and then apply the above formula.

PRIMARY FEATHER VALUES

FIFTH FEATHER

Length (mm)	Total Value
140	0.111580
141	.11237
142	.113174
143	.113971
144	.114768
145	.115565
146	.116363
147	.117159
148	.117956
149	.118753
150	.119550
151	.120347
152	.121144
153	.121941
154	.122739
155	.123535
156	.124332
157	.125139
158	.125926
159	.126723
160	.127520
161	.128317
162	.129114
163	.129911
164	.130708
165	.131505
166	.132302
167	.133099
168	.133896
169	.134693
170	.135490
171	.136287
172	.137084
173	.137881
174	.138678
175	.139475
176	.140272
177	.141069

THIRD FEATHER

Length (mm)	Total Value
110	0.337370
111	.340437
112	.343504
113	.346571
114	.349638
115	.352705
116	.355772
117	.358839
118	.361906
119	.364973
120	.368040
121	.371107
122	.374174
123	.377241
124	.380308
125	.383375
126	.386442
127	.389509
128	.392576
129	.395643
130	.398710
131	.401777
132	.404844
133	.407911
134	.410978
135	.414045
136	.417112
137	.420179
138	.423426
139	.426313
140	.429380
141	.432447
142	.435514
143	.438581
144	.441648
145	.444715
146	.447782
147	.450849

FIRST FEATHER

Length (mm)	Total Value
90	0.080460
91	.081354
92	.082248
93	.083142
94	.084036
95	.084930
96	.085824
97	.086718
98	.087612
99	.088506
100	.089400
101	.090294
102	.091188
103	.092082
104	.092976
105	.093870
106	.094764
107	.095658
108	.096552
109	.097446
110	.098340
111	.099234
112	.100128
113	.101022
114	.101016
115	.102810
116	.103704
117	.104598
118	.105492
119	.106386
120	.107280
121	.108174
122	.109068
123	.109962
124	.110856
125	.111750
126	.112644
127	.113538

PRIMARY FEATHER VALUES (continued)

FIFTH FEATHER

Length (mm)	Total Value
178	.141866
179	.142663
180	.143460
181	.144257
182	.145054
183	.145851
184	.146648
185	.147445
186	.148242
187	.149039
188	.149836
189	.150633
190	.151430

THIRD FEATHER

Length (mm)	Total Value
148	.453916
149	.456983
150	.460050
151	.463117
152	.466184
153	.469251
154	.472318
155	.475385
156	.478452
157	.481519
158	.484586
159	.487653
160	.490720

FIRST FEATHER

Length (mm)	Total Value
128	.114432
129	.115326
130	.116220
131	.117114
132	.118008
133	.118902
134	.119796
135	.120690
136	.121584
137	.122478
138	.123372
139	.124266
140	.125160

Example:

The first (Z1), third (Z3) and fifth (Z5) primaries are found to be:

Z1 = 109mm. Z3 = 128mm. Z5 = 160mm.

These are converted to total values from the table:

Z1 = 0.097446 Z3 = 0.392576 Z5 = 0.127520

The values for Z5 and Z3 added together total 0.520096; subtracting Z1 from this sum gives a value of 0.422650. This value is less than the general mean (Zm = 0.440525), accordingly it is a female wing.

Aging Ruffed Grouse: (June 1967).

Physical Characteristics:

Lower Jaw (Patterson 1952). Support the entire weight of the dead bird by clasping the lower jaw (mandible) and shake it.

Juvenile: The lower mandible breaks.
Adult: The lower mandible does not break.

Flexibility of Breastbone (Patterson 1952). Push on the tip or end of the breastbone (sternum) with one finger.

Juvenile: The top of the breastbone may be easily bent with one finger.
Adult: The tip of the breastbone is rigid and blunt.

Cranium (Westerskov 1956). Hold the bird's head between the index and middle fingers and press the thumb on the forehead.

Juvenile: The cranium breaks.
Adult: It is not possible to press in the brain case.

Plumage Characteristics:

Outer Primary Feather (Tabor 1963)

Juvenile: Primaries #9 and #10 are pointed and the same color as other primaries; primary #8 is rounded, with sheathing at the base (Fig. 4).
Yearling: Primaries #9 and #10 are pointed and worn; primary #8 has sheathing at base (Fig. 4).
Adult: Primaries #8, #9 and #10 are rounded, with sheathing at their bases (Fig. 4).

Width of the Shaft of Primary #9 [Spring] (Dorney 1957). The width of the shaft of primary #9 is measured where the larger proximal barbs begin.

Yearling Male: The width of the shaft is 0.117 inch or less.
Adult Male: The width of the shaft is 0.117 inch or more.

Length of the Central Tail Feather [Spring] (Dorney 1957).

Yearling Male: The width of the shaft of the central tail feather is 0.087 inch or less.
Adult Male: The width of the shaft of the central tail feather is 0.092 inch or more.

Length of a Single Barb of the Central Tail Feather (Dorney 1966). See section under sexing.

Primary Feather Development – Juvenile Age in Weeks (Tabor 1963). The primaries are numbered one to ten, from inside to outside. This follows the sequence in which they are molted. The outer primaries are shed and replaced last. Grouse molt only through primary #8 in their first fall. The latest-shed primary is indicated by a gap or a growing, replacement feather that is blue at the base. The number of the latest shed primary is most reliably determined by counting backward from the outermost primary, since the division between primaries and secondaries is sometimes confusing.

A key for determining juvenile age in weeks by primary replacement follows:

PRIMARY FEATHERS

1		2		3		4		5		6		7		8	
A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
wk	wk	wk	wk	wk	wk	wk	wk	wk	wk	wk	wk	wk	wk	wk	wk
2	7	3	7	4	9	5	10	6	11	7	11	9	14	10	17

A= Primary begins growth. B=Primary is fully grown.

Plumage Characteristics:

Tail Length (Edminister 1947).

Male: The length of the tail is 159 mm or more.
Female: The length of the tail is 146 mm or less.

Color of the Bare Spot Over the Upper Eyelid (8-14 week old chicks and older) (Palmer 1959).

Male: Bare spot over the upper eyelid is subdued orange to bright red-orange.
Female: The bare spot over the upper eyelid has little or no color.

Tail Band (Bump et al. 1947).

Male: The black band on the tail is unbroken in the center.
Female: The black band on the tail is generally broken on the two central feathers, especially on the underside (Fig. 1).

Length of Central Plucked Tail Feathers (Hale 1954).

Male: The length of the plucked central tail feather is 150 mm or more.
Female: The plucked central tail feather is 149 mm or shorter.

II. DISTRIBUTION –

A. Field Observation –

1. Rationale – Distribution data are useful to define management units and to identify important habitats. These data provide basic information needed to carry out any grouse management program.

2. Application – Grouse can be observed any time of year, but most often from spring through fall. Any observation of a grouse should be recorded on a wildlife

observation form (Appendix I-E). The activity of the bird(s) at the time of observation should be recorded.

Both species of grouse are difficult to observe in large numbers. Indirect observations including tracks, droppings, feathers, nests, eggs or other signs should be recorded, including location, estimated season of use, and sex and activity if discernable.

Grouse are most readily observed on foot or horseback, and in some places from vehicles. Following light snows, blue and ruffed grouse are easy to locate by tracks.

Blue grouse are most readily observed during mild, clear weather in early morning or late afternoon. In fall and spring light snow is helpful especially when temperatures are freezing or above, since grouse leave the trees to feed. Blue and ruffed grouse may feed through the middle of the day during fall and winter.

III. TRAPPING, MARKING AND TRANSPLANTING –

A. Trapping – Capturing large numbers of grouse quickly is virtually impossible because both species are somewhat solitary or form small flocks of less than 15 birds. Capture with a cannon net is infeasible within their preferred habitats. Grouse have been captured in mist nets strung on the ground and from poles, but this is time-consuming and inefficient.

Noose Capture – Blue grouse have been captured with a noose on a long pole. (Zwickel and Bendell 1967). A noose has also been used to capture sage grouse hens lured within range by distress calls of young sage grouse. A fiberglass or light pole at least 16 feet long is used.

The pole bears a noose of plastic coated 80# test steel leader. The noose is placed around the grouse's neck and drawn tight as the bird tries to escape. The worker then places the bird in a fabric (e.g., cotton, burlap) bag and marks it. Chicks and hens have been captured in a landing net with an 8-10 foot handle. Both are attracted by distress or locator calls of young blue grouse.

B. Marking – Refer to Appendix VII (Marking Techniques)

IV. HABITAT MANAGEMENT – An effective habitat management program requires identification of seasonal habitat preferences and assessment of habitat conditions. Although seasonal ranges of blue grouse have been described within some portions of Wyoming, development of general guidelines for habitat management are impractical due to the vast diversity in topography and vegetative composition of grouse habitats. The literature indicates grouse vary widely in habitat selection and we know little about how habitat modifications such as burns, clear cuts, and herbicide treatments affect grouse.

V. FOOD HABITS – Food habits of forest grouse have been studied extensively in most habitat types. Further studies are of doubtful value except in conjunction with specific research projects. The Department's Laboratory should be involved with all phases of a food habits investigation other than initial collection of samples and gross analysis. Two standard techniques are suitable to determine food habits of blue and ruffed grouse:

1. Crop analysis
2. Fecal analysis

Various adaptations of these techniques are described in Litvaitis et al. (1994:266) and the references they cite. If an investigation of food habits is planned, the project should last at least three years and should employ both of the aforementioned techniques. Habitat cover types should be accurately mapped each year of the study. A seasonal voucher collection of available plant species is also necessary. Finally, an accurate map and record of sample locations should be maintained.

Fecal Analysis – Types of plants ingested by spruce grouse have been successfully identified from fecal samples (Gurchinoff 1969) and this method would probably work for blue or ruffed grouse. Fecal samples could yield data on seasonal food habits without the need to collect and sacrifice birds.

VI. DAMAGE CONTROL – Forest grouse are not known to cause damage.

VII. POPULATION MANAGEMENT – Current knowledge about management of blue and ruffed grouse populations is summarized in Chapter 17, Harvest Management, in Research and Management Techniques for Wildlife and Habitats (Strickland et al. 1994). Harvest management can be summarized fairly succinctly: All game birds produce surpluses of young. The primary factor affecting numbers of birds available for harvest is the number of young produced. Changes in the length of hunting seasons and the bag limit are unnecessary because participation by hunters declines when there are few grouse, thus reducing harvest. The converse is true when grouse are abundant.

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CHAPTER 14

SHARP-TAILED GROUSE (*Tympanuchus phasianellus*)

Olin Oedekoven and Mark Zornes

I. STATUS –

A. Plains Sharp-tailed Grouse (*Tympanuchus phasianellus jamesi* Ord) –

1. Distribution – Plains sharp-tailed grouse (PSTG) occupy most suitable habitats in eastern Wyoming. Their distribution extends from the eastern slopes of the Bighorn Mountains and Laramie Range to South Dakota and Nebraska. PSTG densities are highest in portions of Sheridan, Johnson, Campbell, Platte, Goshen, and Laramie counties. The distribution and density of PSTG have increased markedly in Wyoming since the Conservation Reserve Program (CRP) was begun in the early 1980s.

2. Principal Habitats – PSTG occupy habitats ranging from lower elevation agricultural lands to mixed mountain shrub communities at mid-elevations. In general, the species is most abundant within open, grass-dominated habitats often lacking shrub cover. In contrast, Columbian sharp-tailed grouse (*T. p. columbianus* Ord) are more abundant in shrub-dominated foothills. PSTG dancing grounds are also found in a variety of habitats ranging from large openings in mountain shrub stands to wheat stubble strips. Many leks in southeast Wyoming are on grazed rangelands near CRP tracts that provide nest and escape cover. Lek sites are typically locations with open visibility, but relatively close to escape cover, and are usually on slight rises.

   Residual herbaceous vegetation is essential cover for successful nesting. Hens tend to select dense cover for nest sites, often in shrub stands that provide overhead concealment. PSTG nests in southeast Wyoming have been found within sand sage (*Artemisia filifolia*) and true mountain mahogany (*Cercocarpus montanus*). Nest sites are also commonly located within dense herbaceous stands such as CRP fields, but may be found in dense alfalfa or tall wheat stubble. Brood rearing habitats are typically dense, herbaceous vegetation associated with little or no shrub cover. These habitats provide escape cover and sustain higher densities of insects, the principal food consumed by young grouse.

   In Wyoming, PSTG are not known to move long distances between seasonal habitats. PSTG tend to occupy similar habitats throughout the year, but may relocate short distances to areas with greater shrub and tree cover during inclement weather. PSTG tend to congregate as mixed flocks in late fall. During winter, PSTG often loaf on open, wind-blown hilltops, probably for visual security.

3. Recent Population Trends and Studies – PSTG have not been studied extensively in Wyoming. Wachob (1997) probably conducted the most thorough investigation of the subspecies' ecology, focusing on use of CRP and associated habitats. The Department does annual surveys to document lek status and attendance. We are not aware of other research that has been conducted in Wyoming. .

4. Historic Data, Reliability of Historic Estimates – Historic data are limited to records of dancing ground locations and harvest reports. Little or no sharp-tailed grouse harvest was recorded within southeastern Wyoming before the CRP was begun.

A. Columbian Sharp-tailed Grouse (*Tympanuchus phasianellus columbianus* Ord) –

1. Distribution – Columbian sharp-tailed grouse (CSTG) were historically reported near Pinedale (Fuller and Bole 1930) and more recently in Jackson Hole where the species has wintered on the National Elk Refuge (Igl 2003). Bohne (pers. comm.) also reports Columbian sharp-tailed grouse are occasionally observed in Jackson Hole and are present in the Salt River drainage in Idaho. However, the only breeding population currently known in Wyoming is found in the Baggs-Savery area (Carbon County) in the southcentral portion of the State. This is the northernmost distribution of a larger population inhabiting Northwest Colorado. CSTG are slightly smaller than PSTG and somewhat darker. Male CSTG weigh around 750 grams, females weigh slightly less.

2. Principal Habitats – CSTG occupy mixed shrub communities of mid-elevation foothills along the western slope of the Sierra Madre Mountain Range. The species prefers shrub-dominated habitats with diverse species and structural composition. Dancing grounds (leks) are typically located in mixed shrub stands, usually within small to moderate openings that afford greater visibility between the birds. However, some dancing grounds have been found within comparatively tall (0.5 – 1.5m), dense (30 – 80 percent) shrub cover. CSTG usually nest in dense shrub cover that is often associated with mountain snowberry (*Symphoricarpos oreophilus*). Brood rearing habitats characteristically have a higher composition of grasses and forbs and less total shrub cover than adjacent areas not used by broods.

   During fall, CSTG tend to congregate in larger flocks (coveys) and often occupy ridges, hilltops, and steeper slopes that blow free of snow. These habitats are usually open stands of (*Artemisia tridentata*) and antelope bitterbrush (*Purshia tridentata*), but vary in composition. During winter, CSTG often move into wooded, riparian habitats dominated by narrowleaf cottonwood (*Populus angustifolia*) and other deciduous trees and shrubs.

3. Recent Population Trends and Studies – Oedekoven (1985) studied distribution and seasonal habitat use of CSTG in Wyoming. Klott (1987) examined characteristics of sage grouse and CSTG nesting and brood rearing habitats. No other formal research has been done in Wyoming.

. Historic data and reliability of historic estimates – Historic information regarding the distribution and status of CSTG is limited to few isolated observations. No detailed surveys or studies were conducted prior to the 1980s.

II. CENSUS –

A. Dancing Ground (Lek) Surveys and Counts –

1. Rationale – Lek "surveys" are a less intensive form of monitoring done periodically to document status (active/inactive). Lek "counts" are conducted annually to determine peak attendance. Managers interpret both types of data to monitor population trends and assess responses to land use practices and other habitat modifications. Information about lek locations, status and attendance is also essential documentation to support environmental analyses and mitigation recommendations, for example, to assure land use plans adequately protect locations of dancing grounds. Trend data can be helpful to inform the public about population status.

2. Application –

a. Dancing Ground Locations – Plot locations of all permanent dancing grounds (leks) on either 1:24,000 or 1:100,000 USGS maps. Enter records of lek locations and annual count information in the Wildlife Observation System (WOS) database. Individual biologists may consider developing and maintaining an ACCESS database with additional fields to house their own records of dancing ground locations, survey data and other information. A statewide database similar to the one developed for sage grouse is not available specifically for sharp-tailed grouse. However, the Department's primary database is the WOS and all grouse records are to be entered into that system.

Regional databases should contain the following general fields: legal description accurate to quarter/quarter section, UTM location, year of discovery, warden and biologist districts, surface ownership, and a narrative description of the location, including a general description of the terrain, man-made features, and land management practices. The database should also contain fields for date, time of day, number of males and females observed, code for observation of sign only, indication whether ground or aerial observation, observation type (lek count, status survey, lek search, casual observation), observer name, and other comments or notes.

b. Aerial Surveys – Refer to Chapter 12 (Sage-grouse), Sections II.A.1.b.i (Aerial Searches) and II.A.2.b.iii. (Lek Status Surveys) for rationale, objectives and techniques. Plan flights within areas occupied by both sage grouse and sharp-tailed grouse to census leks of both species. Sharp-tailed grouse are more difficult to see from the air because they dance in unison, are smaller and lighter colored than sage grouse. Observers should become familiar with locations of STG leks to aid in their

detection from the air. The sight of grouse flushing can indicate a dancing ground is present within the area.

c. Ground Counts – A representative sample of leks within the range of a population should be counted 3-5 times annually during the breeding season. Data from these counts provide an indication of population size and trend. The remaining leks should be surveyed during the breeding season, at least once every 3 years to confirm location and status. These surveys also have some utility for monitoring general population trends.

STG begin displaying as early as mid-February, however counts and surveys should coincide with the peak of breeding activity between 1 April and 15 May. Begin counts 0.5-hour before sunrise and terminate them 0.5-half hour after sunrise. Some birds may remain on leks up to 2 hours after sunrise, however counts later than 0.5-hour after sunrise produce inconsistent results and may not capture the maximum attendance of that day. Each lek in the annual census should be counted 3-5 times. Allow 7-10 day intervals between counts. Tally numbers of males and females separately. Males have a yellow patch above the eye and pink to violet patches of bare neck skin. They are most easily distinguished as they dance or face off other males. Females typically walk onto leks and may assume a submissive posture on the ground before or during copulation. Establish systematic routes in areas where several leks are within short driving distances. To save time, routes can include both sage grouse and sharp-tailed grouse leks in areas occupied by both species.

Leks selected for the less intensive, status survey should be checked at least once every 3 years. The best time to conduct status surveys is the 7-10 day interval when maximum numbers of females are typically recorded during the annual attendance counts. Observers can also examined the location of a lek for sign of activity (droppings and feathers) anytime during the season to determine its status.

During surveys and counts of known leks, look for new or previously unrecorded leks. Search within suitable habitats by periodically stopping and listening for vocalizations (turn engine off), and by glassing for birds. New dancing grounds may also be discovered during aerial surveys that cover broader regions and more remote locations. If evidence of a lek is observed, record the location and number of birds. Return the following year to confirm the site is a lek before formally designating it such.

d. Lek Routes – Lek routes serve the following major purposes: 1) search for evidence of breeding activity and lek locations; and 2) count attendance at known and newly discovered leks along each route. Lek routes can be effective in locations where road networks provide satisfactory access throughout suitable habitats. However, the technique can require a substantial commitment of personnel depending on the size of the area surveyed and the number of routes. Lek routes have been established to monitor trends and distribution of STG populations in southeast

Wyoming. Indices that were correlated with fall harvest have been developed from lek route data and mid-summer brood surveys.

Attachment 1 is the protocol for lek routes in southeast Wyoming. Standard routes of 20 miles each were established along suitable road networks. The same routes are followed each year. The observer stops for timed observation periods of 2-3 minutes each at ½ mile intervals. All grouse observed or heard are recorded on data sheets (Attachment 2). Procedures are generally the same as described in Section II.A.2.c (Ground Counts). In southeast Wyoming, lek routes are run during the peak of dancing activity, typically the last two weeks of April. Optimum dates can vary with location and climate. If the time when attendance normally peaks is unknown, run lek routes on the dates listed in Section II.A.2.a, until sufficient information has been collected to adjust the dates based on local data. Begin each route at least 45 minutes before official sunrise to ensure the entire route can be completed before birds begin deserting leks. Conduct lek routes annually if trend data are desired.

Attendance is also counted at leks along each route. If a lek is not visible from a ½-mile observation point, the observer should drive to a vantage point from which an accurate count can be made, then resume driving along the established route (stopping at ½-mile intervals). To increase the chance peak attendance is recorded, it is necessary to conduct multiple counts at 7-10 day intervals, as described for regular lek counts (see Section II.A.2.c.). At a minimum, record the following data: 1) time; 2) lek location (indicate whether an ocular or auditory determination was made); 3) number male and female grouse on the lek; and 4) weather conditions (temperature, wind speed, cloud cover). If possible, drive lek routes on calm, clear days. Also indicate if incomplete counts, estimates, or unclassified grouse were recorded. If displaying grouse are heard, indicating a possible lek, estimate the location so the lek can be visually confirmed and counted during subsequent visits.

Maintain data in a permanent file. Permanent records of dancing ground locations are maintained in Biologist's files and the Wildlife Observation System (Refer to Sections II.A 2 and II.B).

3. Analysis of Data – For direction regarding calculation of local population densities, Refer to Chapter 12 (Sage-grouse), Section II.A.2.c (Breeding Surveys).

The sex ration of adults in spring is approximately 52 percent males and 48 percent females (Hillman and Jackson, 1973; Johnson and Henderson, 1965; Grange, 1948; Rokel et al., 1972; and Klett, 1953). Nesting success ranges from 10-80%, depending largely on the amount and quality of residual cover. Residual vegetation from the prior growing season provides concealment from nest predators including various birds and ground squirrels. Typical clutch size is 10-13 eggs. Brood sizes average 2 to 5 chicks in mid-summer, but also depends largely on the quality and quantity of brood rearing habitats (Hart et al. 1950).

4. Disposition of Data – Refer to Chapter 12 (Sage-grouse), Section II.A.2.c (Breeding Surveys).

B. Locating Unrecorded Dancing Grounds –

1. Rationale – Locations of all permanent dancing grounds should be recorded to provide a basis for assessing grouse distribution, local population densities, and responses to long-term habitat changes. These records are essential documentation for environmental impact reviews and for recommending protective measures and other mitigation.

2. Application – Observers can detect lek locations most effectively by listening for auditory cues. On still mornings, the "flutter-jumps" and "cooing" displays of sharp-tailed grouse can be heard up to a mile away. Grouse often dance both morning and evening during the breeding season. Leks can be located visually when birds are seen "flutter-jumping." or by following flying birds as they move toward lek locations in spring. Sharp-tailed grouse have also been observed dancing during a "false breeding cycle" in the fall, triggered by decreasing day length usually from mid-September through late October. Recheck these locations in spring to confirm they are dancing grounds.

3. Disposition of Data – Refer to Chapter 12 (Sage Grouse), Section II.A.1.d (Locating Leks).

C. Production Surveys –

1. Rationale – Managers often use data from brood counts to identify and document important habitats that warrant protection. Brood counts may also indicate the availability of birds during the upcoming hunting season, so the information can be used to develop hunting season forecasts for public distribution. However, the data are not useful for developing harvest management strategies because the harvest mortality of this and most other upland game species is compensatory to natural mortality. In other words, harvest has little or no impact on the number of grouse that survive to the next breeding season and reproduce successfully. Any sharp-tailed grouse observed during the late summer should be recorded and the information entered on the Wildlife Observation System. Grouse are often observed during preseason antelope classifications. If the data will be used to determine average brood size and production, all sharp-tailed grouse must be recorded, not just those with broods. Personnel making observations in late summer should distinguish male and female sharp-tailed grouse. A small area can be sampled adequately if it is searched intensively.

2. Application – Drive or walk slowly through brood rearing habitats to locate grouse. In many areas, sharp-tailed grouse are difficult to observe from roads. Binoculars are useful to spot grouse and identify hens. Once a brood is located, flush the birds to assure they are counted accurately. A well-controlled bird dog can be very helpful

because young birds tend to sit tight. If a dog is used, note this on the data sheet and in any report that summarizes or discusses the results.

3. Analysis of Data – Refer to Chapter 12 (Sage-grouse), Section II.B (Brood Production).

4. Disposition of Data – Refer to Chapter 12 (Sage-grouse), Section II.B (Brood Production).

D. Harvest Surveys –

1. Rationale – Harvest data provide a means to assess population trends, changes in hunting pressure, public interest, and survival of young to fall. The information is used to answer public questions and it can also provide additional documentation for analyzing impacts of proposed developments or land use plans. To some degree, harvest data may be consulted for hunting season recommendations, particularly when dealing with social perceptions and distribution of harvest opportunity. Harvest data are also used to compile economic data for various Department reports.

2. Application –

a. Harvest Mail Survey – This is the best method to obtain a consistently adequate sample of harvest information from large areas. Refer to Appendix III.

b. Field Checks and Check Stations – Field checks and check stations are generally not effective means of collecting harvest data from sharp-tailed grouse hunters. Hunter densities are usually much too sparse to obtain adequate samples. Check stations are also expensive to operate and yield little harvest data because of because of comparatively light hunting pressure and numerous egress roads in the areas where sharp-tailed grouse are hunted. Check stations could be justifiable if an area is being intensively studied. When check stations are operated for big game, pheasants or other species, personnel should record any harvest of sharp-tailed grouse they encounter.

E. Wing Barrels – Although wing barrels have been used extensively in Wyoming to collect blue grouse and sage grouse wings, barrels may not be as efficient for collecting sharp-tailed grouse wings. Considerably more barrels would be needed to adequately cover egress roads from agricultural areas in which most hunting is done. Personnel would also have to travel greater distances and expend more time retrieving wings. However, barrels have been used successfully to collect sharp-tailed grouse wings in northwest Colorado. In some regions, barrels may be placed to collect wings of both sage grouse and sharp-tailed grouse.

1. Application – If wing barrels are used to collect sharp-tailed grouse wings, areas of locally heavy harvest pressure should be targeted to obtain adequate samples. Data from wings can provide additional trend and age information. Place wing barrels at junctions of major egress routes and check them at least weekly.

2. Analysis of Data – On immature birds, appearance of the outer two primaries is rougher, worn and faded by comparison to primaries one through eight. The outer two primaries of adult birds will appear new, dark and rounded on the top.

F. Age and Sex Determinations –

1. Age Determination – Techniques are not as well described for determining ages of juvenile sharp-tailed grouse as they are for aging sage grouse. Ages are roughly classified as juvenile, immature (yearling) and adult based on the rate and pattern of primary molt. Sharp-tailed grouse chicks probably replace juvenile primaries beginning the first month of life and continue at a rate of roughly one feather every five days. The two outermost primaries (#9 and #10) are retained through first winter and replaced during the post-nuptial molt, by the second winter. In the fall, juveniles are separated from adults based on the appearance of the outer 2 primaries (narrower and more sharply pointed than adult primaries). These primaries will be severely faded and worn following the first winter, and this characteristic is used to distinguish yearling birds (Refer to Chapter 12 (Sage-grouse), Section II.B.3 (Wing Collections) and Chapter 12, Appendix A (Key fro Age/Sex Identificatio from Wings of Hunter-harvested Sage-grouse). The post-nuptial molt of juvenile sharp-tailed grouse is similar in rate and pattern to that of other grouse species (Johnsgard 1973). However, the post-nuptial molt is apparently associated with endocrine changes and may be somewhat earlier in males. Some yearling birds harvested in late fall may already have adult plumage.

2. Sex Determination – External characteristics of male and female sharp-tailed grouse differ only slightly. Sex can be distinguished with about 87 percent accuracy based on the appearance of the two central retrices (tail feathers). The markings on these feathers have a strongly transverse pattern in females. Markings of male grouse are nearly parallel to the rachis (feather shaft).

   Henderson, et al. (1967) also identified differences in crown feather patterns. Individual crown feathers of males are uniformly dark with a buff-colored edge. The crown feathers of females have crossbars with alternating light and dark bands.

   Crown feather markings of males may suggest a light crossbar, particularly at the tip, but in gross aspect, show a V-shaped dark area. Crowns of males are dark and relatively uniform in appearance. Crowns of females appear blotchy and barred. Novices should examine individual feathers on the crown rather than the gross crown patterns. Identification of ovaries and testes is the most reliable method of determining sex. Gonadal location and appearance is the same for all grouse.

G. Mortality Surveys –

1. Rationale – Environmental factors that limit populations of sharp-tailed grouse are undoubtedly the same factors limiting other species of upland game birds. Predominantly, they include quality of nesting habitat, post-hatch weather, and quality

of brood rearing habitat. Cycles in predator/prey populations may also have some bearing, however exposure to predation is largely determined by habitat quality. For example, predation on hens, eggs and young chicks is ever-present and related to the quality of nesting habitat.

Cold, wet weather after hatching is probably the most significant source of chick mortality in any given year. However, the capability of sharp-tailed grouse to survive harsh weather is also influenced by habitat quality. Accidents such as drowning in stock tanks, collisions with fence wires, and accidental harvest are a minor source of mortality, having little or no impact at the population level. The influence of illegal harvest is also believed to be minor, though it is largely unknown. Some hunters within Carbon County (where the season is closed) mistake Columbian sharp-tailed grouse for sage grouse or blue grouse, but it's unlikely this illegal harvest has any significant effect. Parasites of sharp-tailed grouse have been identified and studied, and some related mortality has been documented. However, other grouse species are known to tolerate rather high parasite loads, generally with little outward sign of problems. West Nile Virus has reportedly killed some prairie sharp-tailed grouse in South Dakota.

Annual mortality studies of upland game species are costly and generally do not provide information that is useful for management. Accordingly, the Department does not conduct such studies, except where intensive research involving radio-tagged birds is already underway. For example, West Nile Virus was detected in a sample of radio-tagged sage grouse found dead in northeast Wyoming (Naugle et al. 2006). Mortalities of sharp-tailed grouse should be documented when they are encountered during other activities in the field. If unusually large numbers of dead grouse or other unusual circumstances are observed, some of the birds should be collected, preserved and sent to the Department's Veterinary Lab for necropsy. Sometimes, events such as these are an indication of more serious environmental problems.

2. Application – Record information about grouse mortalities on Wildlife Observation Forms. Include the location, age, sex, apparent cause of death, number of dead and disposition of carcass(es). Photograph carcasses for which the cause of death cannot be readily determined, or appears to be unusual. If the carcass is fresh, deliver it immediately to the Department lab for post-mortem examination.

3. Analysis of Data – In the absence of a structured sampling design, natural mortality data have little value for population analysis. However, information about the relative importance of various mortality factors could help managers identify environmental problems and the need for additional research or special management practices.

4. Disposition of Data – Mortality observations and associated information are entered into the Wildlife Observation System Database. Any significant or unusual mortality should be discussed in the region's small and upland game job completion report (if one is produced), or in a special report. The report should recommend appropriate actions to address significant sources of mortality other than from natural causes.

III. DISTRIBUTION AND MOVEMENT –

A. Field Observations –

1. Rationale – Detailed information about a species' distribution and movements is essential to develop any management program. Grouse distribution and movement data are useful for defining management units and identifying important habitats.

2. Application – Record all observations of sharp-tailed grouse, including dead grouse (see Section II.G., Mortality), on wildlife observation forms. Records of dead grouse are useful distribution data. In addition, age and sex data and food habits information can be obtained from grouse carcasses. Also record observations of sign including tracks, feathers, breeding display sounds, etc. Note on the form these are indirect observations.

   The best times to observe sharp-tailed grouse are when environmental conditions such as drought or snow cover cause them to concentrate. Grouse also tend to concentrate following storms. The best conditions for making observation are clear, calm days with good visibility.

3. Analysis of Data – Refer to the corresponding sections of Chapter 12 (Sage-grouse), Sections II (Population Monitoring and Assessment) and III (Trapping and Marking).

4. Disposition of Data – Field personnel are responsible for reporting grouse observations. Wildlife Observation System forms (WOS forms) should be forwarded monthly to the area biologist. The area biologist is also responsible for maintaining a permanent file of sharp-tailed grouse observations, and annually reporting information about distribution and numbers of grouse observed.

IV. TRAPPING, MARKING AND TRANSPLANTING –

1. Trapping – The most common reason for trapping sharp-tailed grouse is to mark them for research purposes. Funnel traps and cannon-nets have been used successfully. In South Dakota, yellow ear corn and milo were effective bait to lure birds into traps or within range of cannon nets during winter. Although cannon nets are productive, associated mortality can be high. For this reason, they are not generally recommended. Drift fences and funnel traps can be set up to trap grouse on dancing grounds. Long-handled nets have been used to catch grouse in winter, when they burrow under the snow to roost at night. Net-guns have also been used to catch smaller numbers of grouse in some situations.

2. Marking – The following devices and methods have been used successfully to mark sharp-tailed grouse: Aluminum butt-end leg bands, colored plastic leg bands, poncho markers, and plumage dyes (refer to Appendix VII – Marking Techniques).

3. Transplanting – Prairie sharp-tailed grouse are currently distributed throughout suitable habitats in Wyoming. Populations are apparently at the carrying capacity of the available habitat. Columbian sharp-tailed grouse are also at the limit of their available range.

Accordingly, there is no reason to relocate prairie sharp-tailed grouse. Pending completion of adequate habitat inventories, it may be possible to identify some range expansion opportunities as a conservation measure for Columbian sharp-tailed grouse. However, this is a low priority.

V. HABITAT MANAGEMENT –

Sharp-tailed grouse habitat typically consists of healthy, native grasslands interspersed with brushy cover. However, the species has adapted well to moderate amounts of agricultural conversions, provided sufficient native or tame grass cover remains throughout the area. Optimum habitats include lightly grazed mid- and tall grass prairie interspersed with shrub-lined draws, water sources, and riparian margins in good condition. Since sharp-tailed grouse utilize a variety of food and cover sources, vegetation structure is probably more important that species composition. Although populations of sharp-tailed grouse are most commonly limited by the quantity and quality of suitable nesting habitat and brood rearing cover, other seasonal habitats can be important.

To manage sharp-tailed grouse habitats effectively, managers should first evaluate the quality and availability of seasonal habitats, and then prescribe specific treatments or land management practices that improve conditions thought to limit grouse populations. In general, the most important considerations are sound rangeland management and retention of sufficient permanent cover. Riparian margins of water sources are important sources of food, nesting and escape cover. These areas should be at least partially fenced to prevent excessive trampling and grazing by domestic stock. Food plots, shelterbelts, and agricultural fields can be important sources of food during late summer, fall and winter and are used to a greater extent by grouse if permanent cover is liberally interspersed nearby. Controlled burning and herbicide applications are useful treatments to improve grouse habitats impacted by advanced succession or excessive shrub cover. Shelterbelts and other habitats dominated by trees or tall shrubs can be exceptionally valuable sources of food and shelter during winter.

VI. FOOD HABITS –

Sharp-tailed grouse have a more diverse and adaptable diet than other grouse in Wyoming. This is especially true in winter. However, the composition of sharp-tailed grouse diets in Wyoming has been described only in general terms because of the species' wide distribution and the diversity of habitats it occupies. Because the species' diet is so adaptable, it's questionable whether information from a comprehensive study of food habits would have practical management applications. However, there may be some value in determining regional food preferences to more clearly understand habitat preferences. This information would enable managers to more accurately predict the influences of land use changes, and could improve technical documentation for habitat evaluations and treatment recommendations. Two standard techniques that can be applied to study food habits of sharp-tailed grouse are:

1. Crop analysis
2. Fecal analysis

Personnel from the Department's Laboratory should be involved with all phases of analysis after samples have been collected and grossly examined. Various adaptations of the laboratory techniques are described by Litvaitis et al. (1994:266) and in references cited by the authors. Whenever food habits are studied, the project should span at least three years and employ both techniques (crop and fecal analysis). Habitats, including agricultural crops and cover types, should be accurately mapped each year of the study. Voucher collections of seasonally available plant species are also necessary (a separate collection should be assembled representing plants available each season of the annual cycle). Finally, an accurate map and record of sample locations should be maintained.

Though untested on sharp-tailed grouse in Wyoming, the two standard techniques have been successfully applied to study food habits of grouse in other states:

VI. DEPREDATION CONTROL – Sharp-tailed grouse are not known to depredate crops or cause other damage in Wyoming. Therefore, depredation control is not necessary.

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ATTACHMENT 1

Sampling Protocol for Sharp-tailed Grouse Lek Surveys.

Thank you for volunteering to assist with the annual sharp-tailed grouse survey in eastern Wyoming. This survey gathers data to monitor sharp-tailed grouse abundance, trends, and distribution. The past surveys have been extremely successful, and have yielded much needed information regarding the effects of the CRP program on prairie dependent species.

Materials Necessary

- Vehicle (Department Vehicles)
- Binoculars (if you don't have these, see the Survey Coordinator)
- Data sheets and clipboard (sheets provided)
- Copy of your route map (provided)
- Dress appropriately (you will be standing outside your vehicle for 2 minute intervals).

Routes are approximately 20 miles and are set up to sample varying densities of CRP (Conservation Reserve Program) lands. Copies of route maps and sampling protocol will be distributed to all personnel conducting surveys.

Survey Period – Conduct all surveys between April 8th and April 26th. Monitor the weather and select "calm" mornings if possible to run survey routes. Our objective is to obtain at least one good run of each route. Lek attendance will be greatest on days of fair weather, and the observer's ability to detect leks will also be greater.

Survey Time – You should arrive at the starting point of your route no less than 45 minutes before sunrise. Sunrise tables will be provided. On average, the sun will rise at approximately 0610 during April in eastern Wyoming. This means you have to be on site, ready to begin *no later than 0525.* It is critical that you begin your route at this time. The grouse are active by then, and they disperse around 0730.

Methods – Stop the vehicle at ½ mile intervals, on topographic rises or "hill tops" if possible. Shut off the engine, get out, and scan the surrounding land 360° with your binoculars. Look for concentrations of dancing males. Leks are often found by listening for the birds. Listen for the distinctive sounds made by dancing male sharp-tails (the Survey Coordinator has a tape of these sounds). Remain at each stop no more than 2-3 minutes. *If you remain longer, you will not complete your route in the allotted time.*

Count the total number of grouse in attendance, and then attempt to classify and count each sex. Determination of sex can be difficult. Birds seen dancing are always males. The grouse that are not dancing may be females, or inactive males. Unless you can positively identify the sex of each bird, record these as unclassified. Mark the location of the lek on your map (be especially careful to do this as accurately as possible).

ATTACHMENT 2

DATA FORM

SHARP-TAILED GROUSE LEK SURVEYS Date 1: _____ Date 2: _____

Instructions: Record only sharp-tailed grouse observations. Enter each individual observation on a separate line. Record numbers and locations of all grouse observed, including those seen away from leks. Record all times using military (24-hour) notation. Example – First observation. Assign OBS # 1 (then 2, 3, and so on). Identify the location of each observation by marking dots and corresponding observation numbers on the route map. Fill in the necessary information (with the OBS #) on your data sheet. Make sure your map locations are correct. *All recorded observations must correspond (OBS #) to a MARKED location on your route map, or they are of no value*. This system eliminates the need to determine legal descriptions or UTMs in the field, thereby helping the observer stay on schedule.

OBS #	TIME	MALES	FEMALES	UNCLASS	HABITAT*	ANIMAL ACTIVITY	NOTES
1	0632	7		5	AGR	COURTSHIP	BIRDS FLUSHED BY NORTHERN HARRIER
2	0636			2	RNG	LOAFING	

Habitat Codes:

(CRP) – Conservation Reserve Program lands
(AGR) – Agricultural lands (wheat fields, etc.)
(RNG) – Rangelands (pastures)

CHAPTER 15

RING-NECKED PHEASANT (*Phasianus colchicus*)

Mark Zornes (introduction by the editor)

I. INTRODUCTION – Ring-necked pheasants were successfully introduced to the United States from a release in 1881 in the Willamette Valley, Oregon. Since that time, pheasants have been transplanted throughout the United States, but they reached their maximum densities in the upper Mid-west, central and northern plains states in the 1950s and 1960s. They remain the most popular upland game bird where they are still abundant.

Several state wildlife agencies continue to monitor pheasant populations within the species' primary range. The data obtained from these studies has limited practical value for setting hunting seasons, primarily because harvest has no impact on carryover of pheasants to the subsequent breeding season. For the most part, population monitoring is done to provide status information to the public. In some cases, annual information about distribution and abundance is useful to evaluate the effects of land management practices or habitat treatments. Since most pheasant habitat is private land where the dominant use is agriculture, the capability to influence land management practices is somewhat limited. Habitat assessments are potentially useful for recommending treatments and land management practices to improve pheasant habitat, for example, through extension services and habitat incentive programs.

This chapter discusses life history information and traditional monitoring techniques for reference purposes. Some techniques may have utility for research, development of localized habitat plans or to document trends for hunting forecasts. However, the Department has no plans to conduct pheasant population surveys for the purpose of setting hunting seasons.

II. STATUS –

A. Distribution – Wild populations of ring-necked pheasants are currently distributed throughout all suitable habitats in Wyoming. Pheasants were established in the State in 1937 using wild stock brought from Oregon. All suitable habitats were occupied within the state by the 1950s. Since then, pheasants have declined statewide, primarily due to changes in farming practices producing less optimal habitat conditions.

B. Principal Habitats – Ring-necked pheasants are predominantly associated with areas of small grain production. Waste grains are a principal component of a pheasant's diet. During winter, pheasants seek dense cover such as cattail patches for thermal protection. Close juxtaposition of winter cover, food sources, and nesting habitats is critical. Hens typically seek areas of dense cover, such as hay or alfalfa meadows for nesting, particularly in close proximity to winter cover. Water sources are also necessary for pheasant survival.

C. Recent, Statewide Population Trends and Studies – Pheasants have declined significantly in Wyoming since the 1950s and 60s. Populations appeared to rebound during a period of favorable moisture conditions in the 1980s to mid-1990s, but declined again during a protracted drought cycle that extended at least through 2004. The generally declining trend will likely continue unless large-scale efforts are made to improve quantity and quality of pheasant habitat.

D. Historic Data, Reliability of Historic Estimates – Local and statewide harvest statistics are the principal pheasant data we collect in Wyoming. This information is summarized each year in the Annual Report of Small and Upland Game Harvest. Population indices, including spring crow counts and brood surveys, have been collected locally in portions of the state since the 1960s. While these data are somewhat useful for predicting harvest success, they are of limited value in detecting changes in pheasant density. Crow counts and brood surveys are more useful when considered in conjunction with harvest trends.

III. CENSUS –

A. Winter/Spring Flock Surveys –

1. Rationale – Although Wooley et al. (1978) recommended winter/spring flock surveys as a means to predict pheasant harvest in the fall, the methodology provides little useful information about overall trends in abundance. Meaningful inferences are difficult to draw because the technique is sensitive to variations in weather conditions and is hard to standardize. In addition, correlations between winter and spring sex ratios are poor. Annual, site-specific density and sex ratio information may be obtained from the technique, but to be useful the information should be considered in combination with production data collected during the subsequent breeding season. Standardized protocol must be followed with regard to survey conditions, timing, and use of dogs to obtain useful results.

2. Application – Winter flock surveys should be conducted in a standardized manner throughout the survey area. Typically, the observer(s) drives no more than 15 mph along a specific survey route. Routes should be established to sample all potential wintering habitats. All pheasants observed along the route are counted and classified according to sex. Binoculars and spotting scopes are necessary to classify pheasants seen at a distance. Areas of dense cover along routes are systematically surveyed on foot with the aid of trained bird dogs. Observers position themselves to count and classify pheasants as they flush. Record all observations on Wildlife Observation forms (Appendix I - E) and submit these to the district wildlife biologist upon completion of the survey. Estimates and incomplete counts should be circled on the data sheets.

   Winter flock surveys are conducted between December 15 and March 1, during the first and last 2 hours of daylight. Surveys should be conducted immediately after a major snow event or when intense cold and snow have concentrated wintering pheasants.

3. Analysis of Data – Submit Wildlife Observation forms containing pheasant data to the district wildlife biologist before the data are entered in the Wildlife Observation System. This affords the biologist an opportunity to analyze the information and discuss it in annual Job Completion Reports. If the data are to be used to detect annual trends, report observations per unit of effort (e.g., birds/mile or birds/hour surveyed). It is also important to accurately describe conditions under which the survey was conducted, because variability can significantly impact data consistency. Data should be collected annually for at least 5 years to allow meaningful assessment of pheasant abundance and sex ratio trends. Also refer to Chapter 12 (Sage-grouse), Section II.C. (Documentation of Winter Use Areas).

4. Disposition of Data – Forward all data records to the appropriate district wildlife biologist so the information can be analyzed and discussed in Annual Upland Game Reports (JCR) and entered in the Wildlife Observation System.

B. Spring Crow Count Surveys –

1. Rationale – Spring crow counts provide additional information about annual and long-term trends in the density of breeding pheasants, and can also provide an index of winter survival. Wooley et al. (1978) determined crow counts were correlated with fall harvest ($r = .60$, $P = .01$), but a more significant correlation existed between harvest and brood counts. Neither winter flock surveys nor spring crow counts should be interpreted without supplemental data from an August brood survey.

2. Application – Traditional survey routes are established through representative areas of occupied pheasant habitat. Each route begins at an identifiable starting point. At least 10, but not more than 15 listening stations are located at one-mile intervals along each route. The peak of spring crowing varies geographically, but is generally between April 25 and May 15 (Gates 1966). Counts in Wyoming have typically been done in May, however crowing intensity declines dramatically the last two weeks of May.

   Survey conditions and timing are important considerations (Gates 1966). Avoid surveying during high winds or cloud cover. High winds reduce hearing distances (Kimball 1949) and crowing intensity is lower on cloudy days (Taber 1949). Accordingly, select calm, cloudless days to run crow count routes. Begin surveys 50 minutes prior to official sunrise. Stop at each station, turn off the vehicle's engine, and record the number of calls heard during a timed two-minute period. Record data on crow count forms (Attachment 1).

3. Analysis of Data – Submit crow count forms and a map of survey routes to the appropriate district wildlife biologist before the data are entered in the Wildlife Observation System. Also include a description of actual survey conditions, as they can significantly affect results. The biologist will provide an analysis and summary of crow count data for inclusion in annual Job Completion Reports (JCRs). The data summary should include: 1) total calls heard, 2) total calls per route, 3) average calls per station

(all stations on all routes), and 4) average calls per station, calculated for each route. Also include a summary of data collected over the preceding 5 years if it is available.

4. Disposition of Data – Crow count data are entered in the Wildlife Observation System database, and data summaries/analyses are printed in Annual Upland Game Reports. District biologists should maintain file copies of data sheets and JCRs.

C. Production Surveys –

1. Rationale – August brood counts provide additional information regarding pheasant population trends and more importantly, can serve as a valuable forecast of fall harvest. Brood count data can also be used to identify important habitats that should be maintained or enhanced. Although various methods of collecting brood data are useful for predicting fall harvest, the number of broods observed along a 30-mile survey route appears to have the strongest correlation. However, 30-mile routes are somewhat costly to survey. An adequate sample can be obtained from a smaller area if it is searched intensively.

2. Application – Traditional survey routes are established within representative areas of occupied pheasant habitat. Run survey routes on cool days, during the first 3 weeks of August. Prior to this time, chicks are more difficult to observe and more susceptible to stress-related mortality. After this time, chicks are more difficult to distinguish from adults.

   Drive along survey routes at 15-20 mph during the first and last 3 hours of daylight. Count all hens and broods observed, including hens without broods. A trained bird dog can greatly assist with detecting additional broods. Stop at each location a brood is observed and use the dog to search the area immediately surrounding. A dog will enable the observer to detect multiple broods and hens that may be concealed in dense cover. Binoculars are also useful to detect pheasants from longer distances. Once a brood is located, flush the birds to ensure an accurate count is made. A well-controlled dog is essential for this purpose because young birds tend to hold tight in cover. If brood data will be used to estimate average brood size and production, all hen pheasants observed must be recorded, not just those with broods.

   Record observations on Wildlife Observation forms (Appendix I). Note the location and numbers of all hens and chicks observed. Estimate and record the ages (reported as size, e.g. ¼ grown, ½ grown) of chicks in each brood. Also note weather conditions during the survey. Estimates or incomplete counts should be circled on the data forms.

3. Analysis of Data – Data should be submitted on Wildlife Observation forms to the district wildlife biologist prior to inclusion in the Wildlife Observation System. This provides the biologist with an opportunity for analysis and inclusion in annual Job Completion Reports. The following information should be summarized: 1) the number of hens observed, 2) number of chicks observed, 3) total number of broods observed, and

4) average chicks per hen. These data should be compared to data from the previous 5 years if it is available.

4. Disposition of Data – All data are forwarded to the district wildlife biologist for inclusion in Annual Upland Game Job Completion Reports (JCRs) and the Wildlife Observation System.

D. Harvest Surveys –

1. Rationale – Pheasant harvest data are used as an index to gauge population trends, hunting pressure changes, public interest, and survival of young to fall. This information is used to answer public questions, assess responses to potential habitat alteration projects, and to some degree in making hunting season recommendations.

2. Application –

a. Harvest Questionnaire Survey – Harvest surveys are the best method for obtaining comparable annual harvest information over large areas on a consistent basis. Refer to Appendix III-A.

b. Field Checks – Hunter field checks have traditionally used to obtain preliminary harvest information based largely on incomplete data. Field checks provide an opportunity for law enforcement and may yield limited biological information. However, most of the data that are obtained from field checks (with the exception of law enforcement) can be collected much more efficiently with questionnaires, wing barrels, and at established check stations. Field checks should be used to collect information that would otherwise be unattainable, for example hunter distribution, evaluation of crippling loss, access problems, property damage, and hunter attitudes and perceptions. While no standardized technique exists for field checks, they can be valuable from a standpoint of making hunter contacts, assessing attitudes, conveying educational information, and obtaining a general index of hunter success. All pheasant field checks should be recorded on Wildlife Observation Forms.

c. Check Stations – Check stations are set up at fixed locations that most hunters must pass, usually along major egress routes. Harvest data are recorded on check station sheets or Wildlife Observation Forms. Although it is generally possible to collect more data at check stations than during field checks, the data represent a very small portion of the total harvest. Check stations are most effectively deployed to collect data for special projects or to gauge hunter success on a localized basis. Data on the age composition of the harvest may also be collected, although sample sizes are usually small.

E. Age and Sex Determinations –

1. Aging – It is typically more difficult to determine age of pheasants, once they acquire their adult plumage, than many other upland game birds. The most accurate method of

aging pheasants (adult versus juvenile) is by measuring the bursa of fabricus. The bursa is a thin-walled, sac-like structure lying dorsal to and at the extreme posterior end of the large intestine. Age determination is accomplished by probing the bursa through its opening, which is located on the dorsal median surface of the cloaca. An eight-penny nail with a rounded tip works well as a probing instrument. A permanent mark should be made on the nail, eight mm from the rounded tip. When measured in November, a bursa eight mm or deeper indicates an immature pheasant, while one that is less than eight mm or absent indicates an adult. The bursa is absent in ***most*** pheasants that are a year or more of age.

Ages of juvenile pheasants can be determined based on stage and pattern of primary feather replacement (Table 1).

2. Sexing – Once pheasants reach 7-8 weeks of age, sex can be determined easily based on plumage dimorphism.

Table 1. Length criteria used to determine ages of juvenile pheasants based on certain primary feathers. [1]

	PRIMARY FEATHER					
AGE (weeks)	1	2	3	4	5	8
1				15-28 mm 100%		
2				29-47 mm 94%		
3				48-68 mm 93%		
4	6-25 mm 87%					
5	26-50 mm 87%					
6	51-73 mm 88%					Molt
7						33-81 mm 94%
8						82-117 mm 91%
9					Molt	118-144 mm 90%
10				Molt	31-76 mm 76%	
11					77-113 mm 67%	
12			Molt		114-142 mm 63%	
13			55-87 mm 62%			
14		Molt	88-121 mm 67%			

15			122-147 mm 55%			
16	Molt	77-107 mm 61%				
17		108-123 mm 55%				
18		124-150 mm 73%				
19	92-112 mm 50%					
20	113-129 mm 37%					
21	130-145 mm 41%					
22	146-159 mm 58%					

[1] Percent accuracy (%) based on pen-reared birds.

F. Mortality Surveys –

1. Rationale – Populations of pheasants are limited or impacted by many of the same factors as other upland species. The factors principally affecting pheasants in Wyoming include: 1) quality and juxtaposition of winter cover and nesting habitat; 2) weather events after broods have hatched; 3) farming practices (particularly the cutting of hay); and 4) availability and quality of brood rearing habitat. Predators, disease and accidents impact pheasants, as well. As with other ground-nesting species, predation on hens, eggs and young chicks can be substantial and is related to the quality of nesting habitat.

   In portions of Wyoming, hay harvest typically coincides with the peak pheasant hatching. Second cuttings of hay can also impact success of renesting attempts. This practice is probably the most significant cause of mortality to hens and young birds in Wyoming.

2. Application – When mortalities of pheasants are encountered in the field, they should be recorded on Wildlife Observation forms. Include the location, age, sex, apparent cause of death, number of birds found dead and disposition of carcass(es). If the cause of death cannot be determined or is unique, take a photograph to document the mortality. If the cause of death is inexplicable and the carcass is fresh enough, immediately deliver it to the Department laboratory for post-mortem examination.

3. Analysis of Data – Incidental observations of pheasant mortalities have little value for population analysis; however, analysis of the relative importance of various mortality factors may suggest areas where research of special management measures is needed.

4. Disposition of Data – It is the responsibility of field personnel to record pheasant mortalities on Wildlife Observation forms and to submit the forms for entry into the

Wildlife Observation System. If patterns of significant mortality are detected, field personnel should recommend measures to alleviate the cause.

IV. DISTRIBUTION AND MOVEMENT –

A. Field Observations –

1. Rationale – Data that describe pheasant distribution and movements can help managers identify critical habitats. Although pheasants typically do not move long distances between seasonal habitats, documentation of year-round use and movements to wintering areas is useful for developing management plans and recommendations.

2. Application – Record data pheasant observation data on Wildlife Observation forms (Appendix I). Observations of dead pheasants can also be useful sources of distribution data (refer to Section II.F, Mortality). In addition, pheasant mortalities provide opportunities to collect age and sex data and food habits information (through crop analysis). Tracks, feathers, crowing, and other sign can be recorded as "indirect observations" when such information is useful (e.g., fills in gaps in distribution records).

3. Analysis of Data – Seasonal observation data can be queried and loaded into GIS layers, which can then be superimposed onto cover types and other land use classifications to identify important habitats or to track changes in distribution over time. This type of analysis can be useful to identify factors impacting pheasant distribution, or to provide supporting documentation for management plans and recommendations.

4. Disposition of Data – Field personnel should forward records of pheasant observations monthly to the responsible wildlife biologist. The district biologist should maintain a permanent file of pheasant distribution records and should summarize and report the information annually.

V. TRAPPING, MARKING AND TRANSPLANTING –

A. Trapping – Pheasants have been captured using funnel traps, swinging wire traps, and at night, using hand nets (Day et al. 1980). Cannon nets have also been used, but the technique produces fairly high mortality of captured pheasants.

B. Marking – Pheasants are most commonly marked with aluminum butt-end or colored plastic leg bands (refer to Appendix VII, Marking Techniques). Some researchers have used patagial markers successfully on upland birds.

C. Transplanting – Varying densities of pheasants currently occupy the areas of Wyoming that are considered suitable pheasant habitat. The species has a high reproductive potential and populations respond rapidly when environmental conditions are favorable. No additional transplants of wild ring-necked pheasants are needed at this time. If suitable habitat, distant from wild pheasant populations, should be developed in the future, birds could potentially be transplanted into the vacant habitats.

D. Stocking for "Put-and-take" Hunting – Each year, the Wyoming Game and Fish Department releases over 20,000 pheasants for "put-and-take" hunting on Department-managed lands, some public lands, and walk-in areas enrolled in the Department's "Private Lands Public Wildlife" program. Pheasants for these releases are provided from 2 state-operated bird farms. The stocking program provides additional recreation for bird hunters within a state with limited opportunity to hunt wild pheasants. In some cases, the program also provides incentive to maintain additional habitat and cover on private lands. There is very limited carryover of stocked birds that survive until the subsequent breeding season. The primary objective is to produce birds to be harvested in an intensive "put-and-take" hunting program.

VI. HABITAT MANAGEMENT –

Characteristics of pheasant habitat have been well documented throughout the United States. The most thorough references available for managers in Wyoming include work by Koerner (1992) relative to pheasant habitat management and enhancement in Wyoming, and recommendations by Baxter (1974) regarding pheasant habitat management in Nebraska. Most literature describes seasonal habitats, but does not provide specific insight about the juxtaposition of those habitats to one another. Changes in farming practices have impacted habitat juxtaposition, causing declines in pheasants throughout their range in North America. In Wyoming, removal of brushy and weedy field edges and fences row habitats, burning of irrigation ditches, timing of hay harvest, crop selection, fall plowing, and increased use of corn stubble fields as livestock forage have drastically reduced pheasant carrying capacity.

Although limited in area, Department lands on which pheasant management is emphasized have increased local populations of the species. However, most pheasant habitat is on private land. The Department, through landowner contacts and extension services, encourages landowners to maintain and enhance pheasant habitats. A variety of federally funded conservation programs are available to assist with habitat restoration and improvement on private lands. Several programs associated with the Farm Bill are administered through local NRCS offices. Local chapters of Pheasants Forever have successfully implement many privately funded and cost-shared habitat improvements in cooperation with private landowners. The Conservation Reserve Program (CRP) has had tremendous benefits for pheasants in some regions of Wyoming, particularly areas with interspersed small grain production.

Pheasant habitats should be managed on a landscape scale. The most important factor limiting pheasant populations in Wyoming is availability of permanent nesting and winter cover associated with agricultural lands and water sources. Where appropriate, farmers should be encouraged to leave vegetative cover on unused corners near center pivots, and along fencerows and ditch banks. Mowing or haying along road ditches and at least in portions of hay fields should be delayed until July 1. Field mowing should be done in a pattern (e.g., progressive strips from edge to edge) that avoids "trapping" pheasants in remaining patches of cover just before they are mowed. Only the shoulder vegetation along roads should be removed. Water sources should be at least partially fenced to prevent grazing and trampling by domestic livestock and to enhance vegetation that provides nesting and escape cover, and sources of food. Livestock use should be excluded from all cattail habitat as well as corn stubble fields. Managers should encourage landowners to plant food plots, shelterbelts, and dense nesting

cover. Many of these plantings can be implemented through cost share agreements at little or no expense to the landowner.

VII. FOOD HABITS –

Food habits of wild pheasants have been well documented throughout the United States. Further studies are of doubtful value unless new crop varieties are introduced or mortality that appears linked to agricultural or industrial practices is documented. The Department's Laboratory should be involved with all phases of a food habits investigation other than sample collection and gross analysis. Two standard techniques are suitable to determine food habits of pheasants:

1. Crop analysis
2. Fecal analysis

Various adaptations of these techniques are described in Litvaitis et al. (1994:266) and the references they cite. If an investigation of food habits is planned, the project should last at least three years and should employ both of the aforementioned techniques. Habitats, including agricultural crop types, should be accurately mapped each year of the study. A seasonal voucher collection of available plant species is also necessary. Finally, an accurate map and record of sample locations should be maintained.

VIII. DEPREDATION CONTROL –

Although pheasants normally cause little agricultural damage, they can harm sprouting corn. Typically the damage involves plants less than 6 inches. Pheasants dig young corn sprouts from the ground and eat the kernel. Pheasant-caused damage is easily distinguished from cutworm damage wherein only the shoot (not the kernel) is removed. Pheasants actively feed during early morning and evening hours, consequently most damage happens at these times. Birds can be discouraged using Zon-guns, Ca-Ca rope with cherry bombs, bird bombs, and Avalarms until corn is past the vulnerable stage. Pheasants can also be lured away from growing crops by spreading whole kernel corn near cover.

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Chapter 16

CHUKAR (*Alectoris chukar*) and GRAY PARTRIDGE (*Perdix perdix*)

Tom Easterly

I. INTRODUCTION –

A. History in Wyoming – Chukar and gray (Hungarian) partridge were introduced to North America in the early 1900's. The history and movement of gray partridge in Wyoming is not well documented. We know private individuals and sportsmen's groups brought the first chukars to the Bighorn Basin in the early 1930's. The Wyoming Game & Fish Department raised both Indian and Turkish strains at its bird farm in Story from the late 1930's until 1977. The Department also periodically trapped chukars within areas of high concentrations and transplanted them to begin populations in other suitable habitats. Chukars from Nevada were released along Flaming Gorge Reservoir south of Green River in 1998.

In 1955, the first chukar hunting season in Wyoming was opened for 5 days in the Bighorn Basin. By 1999, hunting seasons for both species of partridge had been expanded to 105 days throughout the State. Annual harvests fluctuate greatly in response to partridge populations, while season length has little apparent impact on harvest. When partridge populations are low, interest by hunters and harvest decline; during periods of high populations, more hunters participate and on average, they harvest more partridge.

B. Current Status –

1. Distribution – Chukar and gray partridge are found in suitable habitats throughout the northern two thirds of Wyoming. The densest populations are in the Bighorn Basin and east of the Bighorn Mountains. Gray partridge also occupy portions of southwest Wyoming near Kemmerer. In recent years, Chukars from released stock have become established near Flaming Gorge Reservoir. A few scattered flocks are also found in Jackson Hole and Star Valley. During population irruptions, when weather and habitat conditions are optimal, gray partridge have been observed near Torrington, Wheatland, and Rawlins in southern and southeastern Wyoming.

2. Management Units – The Department has subdivided the state into 36 small and upland game management units. These units were established primarily for collecting and reporting harvest data and other management information. However, they do not represent discrete populations of partridge nor do they indicate natural breaks in their distribution.

C. Natural History Information –

1. Range of Productivity – Productivity of gray partridge has not been studied in Wyoming. Based on data collected from throughout the species' range, Johnsgard (1975) reported a mean clutch size of 15-17 eggs and an average brood size of 8 juveniles per mated pair. Rotella et al. (1996) determined density dependent factors had the greatest influence on annual recruitment of gray partridge.

   Chukar clutch sizes range from 9-15 eggs (Alcorn and Richardson 1951, Williams 1950, Mackie and Buechner 1963, Lindbloom et al. 1998). Johnsgard (1975) reported some chukar nests contain more than 20 eggs. Lindbloom et al. (1998) estimated nesting success (nests successfully hatched) was 41%. No data regarding clutch sizes or nest success are available from Wyoming, however Britt (1970) summarized brood surveys conducted in the Bighorn Basin between 1955-1959. The average brood size was 10.6 chicks. Brood data from Wyoming are comparable to data collected in other parts of the country: 13.5-14.5 chicks/brood in Washington (Galbreath and Moreland 1953), 3.5-13.3 in Nevada (Christensen 1970), 9 in California (Harper et al. 1958), and 12 in Idaho (Lindbloom et al. 1998).

   In Wyoming, surveys of chukar production were done from vehicles during the late summer period from 1957 to 1964. The average brood size was 699 young:100 adults, ranging 607 to 933:100 adults (Johnson 1957-1961, Coyner 1962-1964). Christensen (1970) reported young to adult ratios of 307:100 and 706:100 from brood counts done in 1968 and 1969, respectively.

   Both species of partridge commonly re-nest if the first attempt fails (Johnsgard 1973, Lindbloom et al. 1998). Lindbloom et al. (1998) documented third nest attempts following two unsuccessful nests. Re-nesting attempts generally produce smaller clutches and brood sizes.

2. Range of Natural Mortality –

   a. Causes of Mortality – Predators and weather are the dominant sources of mortality to partridge. Bohl (1957), Harper et al. (1958), and Christensen (1970) believed predation of adult chukars was minimal. Galbreath and Moreland (1953) had also reported comparatively little predation. However, Lindbloom et al. (1998) determined predators took 41% of radio-tagged chukars during spring and summer, avian predators accounted for 59% of that total. Predation was also a leading cause of mortality in a study of radio-tagged gray partridge (Bro et al. 1999). Raptors are the most important source of predation to gray partridge (Weigand 1980, Church 1984, Carroll 1990). Predation of chukar nests was studied and documented by Harper et al. (1958), Mackie and Buechner (1963), and Lindbloom (1998). A Study of predation on partridge has not been conducted specifically in Wyoming.
      Partridge populations have often declined markedly following severe winters. Melinchuk and Ryder (1984) concluded there was a relationship between weather

severity and overall mortality rates of gray partridge in Saskatchewan. Even a single, severe weather event can kill large numbers of partridge (Knapton 1980). Carroll (1990) believed weather and fat reserves influence susceptibility to predation. However, Rotella et al. (1996) were unable to explain variations in population growth rate or fall-winter mortality based on weather variables. In Wyoming, Chukar harvests have declined sharply following severe winters (e.g., 1961-62, 1969-70, 1978-79). Drought conditions in 2002-03 also led to a major decline in gray partridge populations throughout Wyoming. Poor production is thought to be the principal cause of the decline.

b. Mortality Rates – Partridge mortality has not specifically been investigated in Wyoming. Lindbloom et al. (1998) reported the annual mortality of chukars was 52% in Idaho and mortality increased steadily from March to August. Other reports of mortality rates include 66% during winter in North Dakota (Carroll 1990), 78% during winter-spring in Montana (Weigand 1980), 60-89% in New York (Church 1984), 39-49% during nesting and brood rearing in Wisconsin (Church 1980), 56% during early winter in South Dakota (Ratti et al. 1983), and 58% and 72% from fall to spring of 1983-84 and 1984-85, respectively, in Washington (Rotella and Ratti 1986). However, studies may not be comparable because techniques used to measure populations and mortality rates vary (Carroll 1990). In Addition, mortality estimates derived from radio-tagging studies can be influenced by handling and radio attachment (Carroll 1990, Lindbloom et al. 1998, Bro et al. 1999).

Carroll (1990) and Bro et al. (1999) determined body condition had a significant effect on mortality rates of gray partridge. Partridge that were heavier at the beginning of winter had a better chance of survival. Carroll (1990) also documented mortality was higher among males compared to females.

D. Incomplete Management Information – Very little research has been done in Wyoming to document habitat use, limiting factors, mortality, reproductive rates, or population characteristics of either partridge species.

II. POPULATION EVALUATION TECHNIQUES –

A. Population Surveys –

1. Breeding Call Routes – Breeding surveys of partridge tend to produce variable and unreliable results. Male partridge do not have a strong fidelity to specific breeding areas and are not strongly territorial. Chukars and gray partridge often move in response to varying habitat conditions, which can influence locations of breeding pairs from one year to the next. Breeding surveys have not been conducted for chukar or gray partridge in Wyoming. Rotella and Ratti (1986) estimated gray partridge densities in Washington based on call surveys, but did not restrict their surveys to the breeding season.

The breeding cycle begins with pairing in late February or early March (chukars) or late January (gray partridge). Egg production begins in early to mid-April for both species (Lindbloom et al. 1998). The appropriate timing for breeding call surveys, if they are done, is from the last part of winter until early spring.

2. Brood Surveys – Brood surveys have been conducted in Wyoming to determine reproductive success and population trends of chukars. Surveys should be conducted in July and August by driving and/or walking in representative chukar habitat and other areas where chukars are commonly seen. In the past, data were generally summarized in terms of age ratios (young per 100 adults) rather than young per brood and were compiled for large areas such as the Bighorn Basin. Broods of chukars band together at an early age, making individual broods difficult to distinguish (Johnson 1962). In Oregon, data are compiled on the basis of counties, and summarize as chicks per brood, chicks per adult, and birds per mile surveyed (VanDyke, pers. comm.).

   Brood surveys were conducted in Wyoming from 1955-1964. However, sample sizes were insufficient to reliably evaluate population trends. During wet years, birds can be widely dispersed and difficult to detect. In dry years, chukars are concentrated in large groups around water.

3. Aerial Surveys – In Nevada and Idaho, trend surveys of chukars are conducted from helicopters during the first half of August (Stiver pers. comm., Hemker pers. comm.). In Nevada, transects are flown across survey blocks, at 100 ft above ground level and an air speed of 30-50 knots. Birds are counted as they flush. Birds tend to flush downhill, so hillsides are flown from the bottom up. This avoids flushing birds ahead of the plane, into the area being surveyed. Individual birds in groups of less than 25 are comparatively easy to count. Adult birds without chicks tend to fly long distances, but adults with chicks fly shorter distances, tending to land in thick cover. Young birds, especially chicks from a late hatch, may not fly at all. The number of birds observed per square mile is reported. Mark-resight experiments in Nevada indicated up to 40% of the marked birds can be observed during aerial surveys (Stiver, pers. comm.). Although Idaho does not use trend data to modify hunting seasons, the information is useful for predicting harvest success (e.g., 150 birds/mi^2 represent about 7 covey flushes per hunter per day). In Nevada, aerial counts also correlate well with hunter success (r^2 approaching .80; Stiver, pers. comm.)

B. Age and Sex Determination –

1. Rationale – Age and sex composition data are often collected to assess the status of a game bird population or to help evaluate responses to habitat treatments. Age ratio data are most commonly used to estimate survival and reproductive success from the prior breeding season.

2. Application – Age and sex composition of partridge populations can be estimated efficiently by examining wing collections from harvested birds. Age and sex data can

also be collected during trapping operations. Several methods for aging and sexing partridge in the hand are described in the sections that follow:

a. Chukar – Siopes and Wilson (1973) determined the sex of newly hatched chukars by inspecting the cloaca. Females have a genital fold on the ventral rim whereas males have a genital protuberance in that location.

   Woodard et al. (1986) used shank length (distance from the foot pad to the top of the hock joint when legs are flexed 90 degrees between the tibia and tarsometatarsus) to determine sex of adults. Shank lengths of males were ≥ 61mm whereas those of females were ≤ 61mm. Christensen (1954) distinguished sexes based on body mass. Female chukars weigh between 462-550g and males between 536-729g. Cunningham (1959) attempted to identify sexes based on diameter of the tarsus and the middle toe length. However, these morphological characteristics provided no clear distinction because the ranges of measurements overlapped.

   Although molt patterns of primary feathers are useful for ageing several game birds, Cunningham (1959) felt this approach was too inconsistent to reliably age chukars due to effects of local and year-to-year environmental variation. Weaver and Haskell (1968) developed a key to age and sex chukars based on wing primary and primary covert characteristics (Table 1). In Idaho, chukars are considered juveniles if any white or tan specking remains on the tips of the outer coverts above primaries nine or ten; birds are adults if the coverts are solid gray (Hemker, pers. comm.). Christensen (1970) used the following size classifications to age juvenile chukars:

Size	Approximate age
downy to ¼ grown	0-4 weeks
¼ to ½ grown	4-8 weeks
½ to ¾ grown	8-12 weeks
¾ to adult size	12-16 weeks

b. Gray Partridge – Sexes can be distinguished based on color patterns of the scapulars and median wing coverts (McCabe and Hawkins 1946, Johnsgard 1973). Larson and Taber (1980) provided diagrams illustrating the center stripe on the male scapular feather and horizontal barring on the female feather. The feathers of the female bear a wide buff stripe down the shafts and two to four buff crossbars (Johnsgard 1973). The bases of the scapulars are blackish, and only the outer parts of the feather are vermiculated. The male's scapulars are usually yellowish-brown with fine black vermiculation across the feather and a chestnut-colored patch near the outside edge.

   The rectrices of juvenile gray partridge are tipped with buff, and have subterminal dark bars and spots and dusky barring across the central feathers (Ridgeway and Friedman 1946). The outer primaries are usually pointed and coverts of these

primaries are retained from juvenal plumage (Johnsgard 1973). The ninth covert is typically pointed and resembles an adult covert, but is rarely tipped with white. The feet of juveniles are yellow and change to blue-gray in adults (Ridgeway and Friedman 1946, Johnsgard 1973).

Table 1. Key for determining age and sex of chukar partridge based on primary feather characteristics (Weaver and Haskell 1968).

1a. Mottled secondaries absent…….…….	2
1b. Mottled secondaries present…….…….	Juvenile – 5
2a. Neither primary nine nor ten in stage of molt……	3
2b. Either primary nine or ten, or both, in stage of molt…….	Adult – 8
3a. Upper primary covert nine is less than 29mm……...	4
3b. Upper primary covert nine is 29mm long or more…….	Adult – 8
4a. Outer two primaries pointed at tips, only slightly faded, showing little wear …..……	Juvenile – 5
4b. Outer two primaries faded, showing wear……	Adult – 8
5a. Primary three is fully grown, is at least 4mm longer than primary two…	6
5b. Primary three is in stage of molt, not fully grown……	7
6a. Primary three is less than 135mm long……	Juvenile female
6b. Primary three is 135mm long or more……	Juvenile male
7a. Primary one is 119mm long or less…….…….	Juvenile female
7b. Primary one is longer than 119mm…..…..……	Juvenile male
8a. Primary three is 136mm long or less……	Adult female
8b. Primary three is longer than 136mm……	Adult male

3. Analysis of Data – Age and sex composition data can be useful for assessing responses to habitat conditions, planning habitat projects, and monitoring populations. Changes in age ratios can indicate adverse responses to weather events or changes in habitat conditions.

   Sex and age ratios should be compared against long-term averages or data from other areas. Christensen (1970) reported chukar sex ratios (males:females) of 119:100, 95:100, and 95:100 respectively, from data collected in New Zealand (N=302), Nevada (N=176), and California (N=96). Chukar sex ratios have not been estimated in Wyoming. Christiansen (1970) reported young:adult ratios of 307:100 and 706:100 in 1968 and 1969, respectively. The following young:adult ratios were

derived from brood counts conducted in Wyoming (Bighorn Basin): mean = 712:100; median = 645:100; range = 607-933:100 (Johnson 1957-1961, Coyner 1962-1964):

3. Disposition of Data – Data on age and sex composition of partridge populations should be reported to the biologist responsible for the area where the data were collected. These data should be included in annual completion reports, if applicable.

III. HARVEST DATA –

A. Harvest Survey –

1. Rationale – Harvest data (number of hunters, total birds harvested, success, and effort) are used to assess long-term population trends of game birds in Wyoming. Harvest levels can also be used to evaluate year-to-year changes in partridge distribution and relative abundance throughout the State.

2. Application – Refer to Appendix III (Harvest Survey) for a description of methodology.

3. Analysis of Data – When populations of partridge are high, more hunters participate and they spend more days hunting. When populations are low, fewer hunters go afield resulting in lower harvest. The philosophy in Wyoming has been to set hunting seasons that maximize recreational opportunity, irrespective of population levels, because harvest is primarily regulated by the density of chukar populations and the rugged topography they typically occupy (Johnson 1960, Britt 1970). Thus, harvest data have little or no utility for setting seasons. However, continuous data sets spanning several years do provide managers with insights about long-term population trends.

4. Disposition of Data – Biological Services compiles harvest statistics statewide and for each management area. These data summaries are distributed to district biologists and published in the Department's Annual Report of Upland Game and Furbearer Harvest.

IV. DISTRIBUTION AND MOVEMENT –

A. Field Observations –

1. Rationale – To effectively manage partridge populations, biologists must understand their seasonal distribution, movements, and habitat selection. Field observations recorded opportunistically can yield some general insights about production, mortality, habitat use, and distribution. This type of data can also be used to document colonization of new areas.

2. Application – All observations of partridge are recorded on Wildlife Observation (WOS) Forms (refer to Appendix I). Records should indicate the species, number seen, age (if possible), date, location, management (hunt) area, habitat type, and the birds' activity. Both species tend to be secretive therefore any distribution data can be valuable. Occasionally, partridge mortalities (e.g., road kills) are the first evidence of the species' presence in a new area. Observations of mortalities can provide important clues to detect new distributions.

   Partridge are observed most easily when they congregate as coveys. Coveys usually form in mid-summer near water sources. During winter, concentrations of birds and tracks are easily found after light snowfall. Both species frequently forage in grain fields. Hunters and landowners occasionally report seeing partridge in areas where they were not previously documented. Credible reports from such sources should be recorded.

3. Analysis of Data – Records from the Wildlife Observation System can be transferred onto base maps to provide documentation for environmental reviews and other projects. Overlays showing seasonal habitats, including breeding/nesting areas, should be completed and updated every five years. The WOS is a geographically delineated data set that can be loaded into GIS layers for a variety of applications in response to specific queries.

4. Disposition of Data – Field personnel are responsible for ensuring records of partridge observations are entered in the WOS database. Each biologist should also maintain a permanent file with paper copies of partridge distribution data. Distribution patterns of both species should be updated every five years. Current and recent distribution data should be summarized in the Annual Small and Upland Game Completion Reports.

V. TRAPPING, MARKING AND TRANSPLANTING –

A. Trapping –

1. Rationale – The most common reasons for trapping partridge are to mark individual birds and collect biological samples. Marking studies are typically done to obtain information about movements, productivity, habitat use, and mortality rates.

Partridge have also been trapped to secure wild stock for transplants into suitable vacant habitat.

2. Application – Schedule trapping at times when partridge concentrate in predictable locations such as near water sources in late summer or on wintering areas. Trapping is most effective during years of higher than average partridge populations.

   Chukars can be captured effectively in traps deployed over watering sites, but these are only successful if water is limited (Stiver, pers. comm.). Biologists have used traps baited with grain in Wyoming, but this method is generally less productive (Johnson 1960, Johnson 1961). Chukars have also been successfully captured in clover traps (Johnson 1961, Christensen 1970, Lindbloom et al. 1998). Christensen (1970) described a design for a portable funnel trap flexible enough to fit in confined areas. The trap site is enclosed with three foot tall wire fencing (one inch by two inch mesh). To form the trap entrance, the two fence ends are turned inward and brought together such that the ends open into the center of the enclosure and are tapered to about the width of the birds body for 1½-2 feet. The trap is covered with woven wire or one-inch mesh netting. The wire fence is secured with dirt or rocks placed around the outer edge, or with metal stakes driven into the ground.

   Gray partridge have been captured with both clover and funnel traps using small grain as bait (Gaither 1969, Carroll 1990). Gray partridge have also been captured at night using a strong light and handheld nets (Bro et al. 1999), but the technique was not effective for capturing chukar partridge (Lindbloom et al. 1998).

3. Analysis of Data – Trapping, marking, and transplanting operations should be thoroughly documented. Transplants should be monitored several years afterward to determine whether new populations become established. When birds are to be captured and marked, depending on the project objectives, an appropriate study design should be developed and followed to optimize data collection. Investigators should plan field surveys to record observations of marked animals and other data relevant to the study. Observations can be mapped to estimate home range sizes, and to document movements or migration patterns and seasonal habitat use. Recoveries of banded or marked birds can provide data on mortality and longevity (when birds of known age are marked), which can be useful in population analysis.

4. Disposition of Data – District or special project biologists are responsible for compiling, analyzing, and reporting results. The report should include a description of the project's purpose, number of birds trapped, their age and sex composition, types of markers applied including numbers, colors or patterns, and an assessment of any trap-related mortality. Results of surveys or monitoring should be reported annually throughout the duration of the project.

VI. EVALUATION OF HABITAT CONDITIONS AND SUITABILITY OF TRANSPLANT SITES –

A. Rationale – Projects that involve trapping and transplanting partridge can be expensive and time-consuming. Therefore, suitability of habitats at potential release sites should be investigated thoroughly before significant resources are invested. Characteristics of partridge habitats are described in the following references: Galbreath and Moreland 1953, Harper et al. 1958, Christensen 1970, Church and Porter 1990, Carroll et al. 1995, Lindbloom et al. 1998. In addition, the first step of any habitat development or improvement project is to complete an assessment of existing habitat conditions and limiting factors.

B. Application –

1. Limiting Habitats – The suitability of any area to support a population of partridge is determined by the habitat component(s) most limited in availability. Water sources can limit both chukars and gray partridge. Deep snow conditions also impact the suitability of an area to sustain partridge populations, however cold weather does not appear to harm birds if enough food is available. Nesting habitat typically is comprised of shrubs and residual herbaceous vegetation. Feeding sites contain seed-bearing plants, succulent forbs, and grasses.

   Gray partridge depend less on permanent water sources than do chukars, and are often able to obtain sufficient hydration from plants in mesic environments. Gray partridge commonly occupy areas of interspersed croplands, especially small grain fields (Church and Porter 1990, Carroll et al. 1995). They prefer rolling hills, but may seek steeper or rocky terrain for escape cover. During the late 1990's, a well-noted irruption of gray partridge populations took place throughout much of Wyoming. In several areas, the species had expanded its distribution many miles from croplands. Partridge occupying non-agricultural regions may feed on native grasses, forbs, and seeds. Comparatively little research has been done to characterize habitat use by partridge in the arid and semi-arid landscapes of Wyoming.

   Availability of water sources influences chukar distribution and habitat use (Galbreath and Moreland 1953, Harper et al. 1958, Christensen 1970). Lindbloom et al. (1998) determined chukars in Idaho predominantly used grass/forb cover types during spring, followed by rocky, shrub-dominated, and agricultural types. In summer, chukars shifted distribution to shrub habitats, followed by grass/forb, rocky, and agricultural areas. During both seasons, chukars selected rocky and shrub-dominated habitats more than expected and grass/forb and agricultural areas less than expected based on their availability. However, grass/forb habitats comprised 78% of the study areas, therefore use of that cover type would need to have been exceptionally heavy to represent its proportionate availability. Agricultural areas are not important habitat for chukars (Harper et al. 1958, Christensen 1970, Lindbloom et al. 1998).

   Habitats used by chukars have not been formally studied in Wyoming. From 1950-70, chukars appeared closely tied to agricultural lands. However, the species was initially stocked in agricultural regions because access was easy and managers

believed the birds would survive better in locations with additional food supplies. After the stocking program was discontinued in the late 1970's, chukars were found mainly in areas with permanent water, steep rocky terrain, and grasses.

2. Habitat evaluation techniques – Between 1940 and 1960, suitability of potential release sites was assessed based on the following criteria: 4,000-5,000 feet elevation, rugged topography, 30-60 degree slopes, ≥ 300 yards long with over-hanging ledges, presence of cheatgrass interspersed with sagebrush, few or no trees, permanent water supplies, south-facing slopes without snow through the winter, and 6-13 inches of annual precipitation. Farmland was not essential, but was thought to provide additional sources of food during winter.

3. Potential habitat improvements – Maintenance of naturally occurring water sources is important. When dependable water supplies are developed for livestock and farm use, these can also benefit partridge in arid locations. Water tanks should include ramps that provide the birds a means of accessing water and escaping from inside the tank. If water is piped from a developed springhead to other areas for livestock use, some water should be left on the ground at the original site for partridge. Water collecting devices (guzzlers) can also increase availability of water to game birds (Elderkin and Morris 1989, Bartlett 1992).

   Food plots and shrub plantings can potentially benefit partridge, but may not be practical in most arid regions of Wyoming. Carroll et al. (1995) and Church and Porter (1990) recommended planting cereal grains and sunflowers to provide additional food for gray partridge. Berry-producing shrubs are important sources of food and cover for chukars (Galbreath and Moreland 1953, Lindbloom et al. 1998). Private and federal land managers should adopt rangeland management practices that sustain shrubs as well as residual grasses and forbs that bear seed and provide nesting habitat. Lindbloom et al. (1998) discussed the importance of livestock management and its possible effects on chukar habitat.

   Prescribed burns have not been recommended to improve partridge habitat. Although cheatgrass (an invasive, exotic species) responds favorably to fire and is a food source for chukars (Galbreath and Moreland 1953), land managers generally discourage practices that increase cheatgrass cover. Both partridge species rely on a variety of shrubs for cover and food. Properly planned burns are occasionally used to rejuvenate decadent stands of shrubs. However, in many environments occupied by chukars, there is a significant risk that shrubs will be permanently eliminated due to competition with cheatgrass following a burn.

C. Analysis of Data – Historically, many of the chukar transplants in Wyoming were not successful. In most cases, it is likely the quantity or distribution of habitat was not adequate to sustain viable populations in release areas.

   Where practical, habitat treatments might benefit partridge populations. Such treatments can include development of food plots, establishment of berry-producing shrubs near

water sources, installation of water guzzlers, and changes in livestock grazing practices. Each location must be evaluated to identify limiting habitat components and appropriate treatments.

D. Disposition of Data – Habitat assessments should be included in a regional upland game bird and small game report (if one is compiled). Otherwise, the district wildlife biologist should retain file copies. Surplus birds may occasionally be available from within the state for transplant to other sites. If birds are imported from outside Wyoming, procedures in Chapter 10 (Importation of Live Wildlife) of the Wyoming Game & Fish Department Regulations must be followed. In some cases, stock adapted to specific ecological conditions may not be available from within Wyoming and it is preferable to import birds from other regions of the country that are more similar to the proposed release site.

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Chapter 17

Wild Turkey (*Meleagris gallopavo*)

Greg Anderson

I. INTRODUCTION –

A. History in Wyoming – The wild turkey was not historically found in Wyoming. Wild turkeys from New Mexico were released near Laramie Peak in 1935 (Hengel et al., 1999). The introduction program was expanded in the 1950's when birds were released in the following additional areas: Black Hills, base of the Big Horn Mountains, Big Horn Basin, and throughout Platte County. Since then, the species has thrived and now provides abundant opportunity for hunters in much of the eastern half of the state.

Taxonomists have identified 5 subspecies of wild turkey (Kennamer et al., 1992). Most introductions in Wyoming were the Merriam's (*M. g. merriami*) subspecies. In more recent years, the Rio Grande (*M. g. intermedia*) subspecies has also been introduced. Some eastern wild turkeys (*M. g. sylvestris*) were released near Laramie Peak in the 1960s. Both Merriam's and Rio Grande turkeys evolved in the west and are well adapted to the arid conditions and patchy cover found throughout Wyoming. Unauthorized releases (both intentional and unintentional) from game farm birds have also taken place. Typically, these involved the eastern subspecies and domestic turkeys including the bronze variety. Landowners wanting to increase wild turkeys on their properties were also responsible for several releases. As a result of hybridization, a number of turkeys throughout the state have morphological characteristics of more than one subspecies.

B. Current Status – Wild turkeys occupy most of the suitable habitats in the eastern half of Wyoming and the Big Horn Basin. It is likely wild turkeys were historically absent from Wyoming because natural foods were not dependably available during winter. Food availability in winter continues to be the limiting factor for turkey populations in the state. Throughout much of Wyoming, wild turkeys are closely associated with ranch compounds in the winter where they are either fed by landowners or have access to waste grain scattered by cattle feeding operations. In spring, the turkeys typically disperse into areas surrounding the ranch compounds, where they nest and rear broods.

Beginning in 1996, the Game & Fish Department began to release Rio Grande wild turkeys in areas where the Merriam's subspecies had not fared well. The Rio subspecies was primarily released along river bottoms that more closely resemble the habitats in which it evolved. In contrast, Merriam's turkeys evolved in pinyon pine/juniper and mountain foothills habitat.

C. Natural History Information –

1. Identification – There is no completely reliable method other than genetic analysis to distinguish the various subspecies of wild turkey. This is particularly true in Wyoming and other locations where subspecies have likely interbred. Some general guidelines are available to identify subspecies, but these are somewhat subjective and not entirely accurate. The following guidelines are based on tail and body feather coloration (Stangel et al., 1992):

   a. Merriam's wild turkey – Tips of tail feathers and tail coverts are nearly white. May range to off-white or cream. In general, body feathers are blacker than those of either the eastern or Rio Grande subspecies.

   b. Rio Grande wild turkey – Tips of tail feathers and tail coverts are tan or yellowish. Body feathers are typically more copper than the Merriam's.

   c. Eastern wild turkey – Tips of tail feathers and tail coverts range from tan to reddish brown (darker than either the Rio Grande or Merriam's).

2. Reproduction – The peak of breeding activity has not been well documented in Wyoming. Based on casual observations, it appears sexual activity can begin in male birds as early as February. Hens appear to become most receptive between late March and early May.

   To a degree, the dates hens breed can be inferred from nest initiation dates published by Rumble and Hodorff (1993). In the Black Hills, most hens initiated nests the last week and a half of April and the first week of May. Once a nest is initiated, hens typically lay one egg per day until all eggs are laid. Hengel and Anderson (1990) determined hens laid an average clutch of 12 eggs near Laramie Peak. Rumble and Hodorff (1993) determined the average clutch in the Black Hills was 9. Hens begin to incubate after the last egg is laid and typically sit on the nest 28 days. The median dates of hatching were May 27 in one year of Hengel's study and June 1 in the other year (Hengel and Anderson, 1990). Rumble and Hodorff (1993) observed a high proportion of yearling hens attempted to nest in the Black Hills. However, yearling hens were not as successful as adults. General breeding statistics are summarized below:

Breeding Activity:	Late March through Early May
Nest Initiation: (first nest attempts)	Mid-April through mid May (Rumble and Hodorff, 1993; Hengel and Anderson, 1990)
Nest Incubation:	Late April through late May (Rumble and Hodorff, 1993; Hengel and Anderson, 1990)
Average Clutch Size:	9 to 12 (Rumble and Hodorff, 1993; Hengel and Anderson, 1990)

3. Survival – Hengel and Anderson (1990) determined 36% of poults survived to 8 weeks of age. Survival estimates from other studies were similar, ranging from 38% to 46% by 4 weeks after hatching (Hubbard, 1997; Vangilder and Kursejeski, 1995). Annual survival of adult wild turkeys has also been studied widely (Hubbard, 1997; Lint et al. 1995, Godwin et al. 1995, Vangilder 1995, Vangilder 1992), except in Wyoming. Virtually every study concluded adult survival rates can vary substantially from year to year. On average, annual survival rates of adult hens and gobblers were 60% and 57%, respectively.

II. CENSUS –

A. Winter Counts –

1. Rationale – During spring, summer, and fall, wild turkeys typically scatter in small flocks along drainages and throughout forested lands. Attempting to survey populations at these times is inefficient because the potential for observing an adequate sample is low. In winter, turkeys tend to congregate in ranch compounds where they are fed or have access to waste grain. During that period, the birds are easy to observe and count because they spend lengthy amounts of time on feeding sites. Winter counts can provide a general index to detect trends and annual fluctuations in a turkey population. However, many factors influence the number of birds present at a particular count site, so winter counts should not be viewed as a census technique. For example, a larger proportion of turkeys may remain away from artificial feeding sites during mild winters, or birds may move to a different feeding site that is unknown to managers (Hoffman et al., 1993). Personnel must count turkeys at the same locations and approximate times each year to maintain a consistently valid index. Any location that is removed from or added to the counts should be noted in a completion report or the winter count report. Although birds may not use particular sites during the course of several years, it is important to visit all sites each year and note the absence of birds to assure the counts are done consistently.

2. Application – Hoffman et al. (1993) recommended counting turkeys during late February and early March. By that time, most of the winter mortality has taken place, but the birds are still concentrated. However, in the Black Hills sizes of winter flocks often decrease in late February as turkeys begin to leave feeding sites. During particularly open winters, turkeys may not have congregated on feeding sites by December and many birds begin to disperse in March. To assure wintering flocks are counted when they reach peak size, we recommend conducting winter counts in January or February. Counts should also be completed over a relatively short period (2 to 3 weeks) to reduce potential biases from double-counting or missing birds that move between feeding sites. Clusters of feeding sites with potential for daily interchange should all be counted on the same day. At sites where turkeys are fed, counts should be done when the landowner is feeding to assure nearly all the birds

are present. Landowners may be willing to count the turkeys on their property and this can save considerable time and effort. However, personnel should only use counts from landowners who express a genuine interest. Otherwise, the counts are likely to be estimates rather than an actual count.

3. Analysis of Data – Series of annual winter counts can be plotted to detect population trends or changes within comparatively limited areas such as drainages or particular ranches. However, inferences about trends throughout larger areas are less reliable because it is unlikely managers know all locations of winter feeding sites and often they cannot survey them within a particular counting period. During mild winters the problem is compounded because many birds may remain dispersed due to the availability of natural feed.

4. Disposition of Data – Annual winter counts from each count site should be recorded on a spreadsheet. Note any counting sites that were added or deleted in a particular year. Normally, data from winter counts should be summarized and analyzed in a job completion report (JCR) prepared each year. The data summaries should cover at least the most recent 5-year period. Names and locations of all count sites should be listed in the JCR. Any sites that were added or removed from the counts should be identified. If a JCR is not prepared, the biologist should retain file copies of data summaries and reports.

B. Winter Classifications –

1. Rationale – Turkeys are classified in winter to estimate sex ratios within a population. Age ratios, however, cannot be reliably determined because by winter, young of the year are too large to be accurately distinguished from adult hens. Although covert characteristics have been used successfully to age some subspecies, the technique is not proven for Merriam's turkeys (see Section VI, Aging and Sexing). In addition, the technique would be difficult to apply where large flocks congregate (Hoffman et al., 1993). For this reason winter classifications are not a good tool to estimate production. Winter classifications may also under represent the proportion of males, because they tend to be more mobile than hens at that time of year (Hoffman et al., 1993). However, classification bias is not likely a problem at artificial feeding sites since nearly all the birds in an area congregate at these locations.

   The literature does not provide consistent direction regarding an ideal tom:hen ratio in winter. Biologists believe a ratio of 1 tom to 3 hens is fairly healthy. If ratios of 1:1 or higher are documented during winter classifications, managers should act quickly to harvest more toms in the area. Several populations in southeast became extirpated after the tom:hen ratio reached or exceeded 1:1. If too many toms are present, they harass hens excessively during the breeding and nesting season, and displace them from food in the winter. Excessive tom:hen ratios tend to develop in areas where turkey harvest is heavily restricted or precluded. In such cases, it is important to advise landowners about the potential consequences.

2. Application – Turkeys should be classified at the time winter counts are done in January or February. Small groups can be easily classified by recording numbers and sexes on a tally sheet. If groups of 50 or more birds are encountered, it is helpful to use a tape recorder or have an assistant record data. An observer can classify very large groups of birds ($\geq$150) effectively by arriving at the feeding site before birds are present. The birds can be classified as they move onto the site rather than while they are milling around.

3. Analysis of Data – It is important to maintain classification records associated with individual sites, because the principal use of these data are to track local sex ratios to determine if additional male harvest is warranted. If classification data from broader areas are combined, sex ratio estimates may not be as useful because localized problems may skew the overall ratio, or the averaging effect of several classifications may obscure a localized problem.

4. Disposition of Data – Data from winter classifications should be entered and maintained in spreadsheets developed for this purpose. Include data fields for the name and location of each count site and annual data including numbers of hens and toms classified and a tom:hen ratio for the site. Each year, results of winter classifications should also be summarized and analyzed in a job completion report. List names and locations of all count sites and identify any sites that were added or removed from the counts. If a JCR is not prepared, the biologist should retain file copies of data summaries and reports.

C. Brood Counts –

1. Rationale – Brood counts are normally done to assess annual reproduction (poult production). The information can also be useful for hunting season forecasts, based on a general correlation between brood counts and hunter success the subsequent fall and spring (Wunz and Ross 1990). At times, managers have also attempted to develop inferences about population densities (Bartush et al. 1985). However, brood data are not useful for this purpose unless a rigorous sampling protocol is consistently followed each year. In Wyoming, brood counts are done strictly to determine annual production. No attempt is made to estimate population densities or to depict trends. Personnel in northeast Wyoming attempted to standardize brood count routes beginning in 1994. The routes were surveyed annually from 1994-1997. Ultimately, too few birds were classified along the routes to be useful for monitoring population trends, or to develop reliable estimates of average brood sizes. After 1997, personnel resumed collection of brood data by recording incidental encounters.

2. Application – Data from brood counts are used to estimate the poult:hen ratio. As with any composition ratio, a large sample must be classified over a representative area to produce a reliable metric. However, sampling effort does not have to be consistent each year, because the data are not used to

develop inferences about population densities or trends. Accordingly, personnel can record sightings of turkey broods as they are incidentally encountered during other field activities, to increase the sample size. Broods typically are mobile and visible from the beginning of July to fall. However, by September poults are nearly as big as, and difficult to distinguish from hens. Therefore, brood counts should be conducted between early July and late August. Natural mortality of poults is high in early summer, so broods observed during earlier counts are considerably larger than broods observed later. If counts are conducted over too long a period, the attrition of brood sizes may confound managers' abilities to detect any real differences in poult production from year to year (Hubbard et al., 1999; Vangilder and Kurzejeski, 1995). Therefore, biologists should conduct counts during the same 1-month window each year. The data set used for annual comparisons should not include any broods observed outside the 1-month window. In northeast Wyoming, turkeys are more mobile and visible in August than July. Therefore, August is the most appropriate window for conducting brood counts in Wyoming.

At times, observers have attempted to distinguish between successful and unsuccessful hens by counting hens accompanied by broods in mixed flocks. However, such determinations are often difficult to make in the field, and inaccurate classifications can severely bias estimates of the number of successful hens. Consequently, this approach is not recommended.

3. Analysis of Data –The chief objective of brood counts is to assess annual reproduction in a population. Wunz and Ross (1990) determined the ratio of poults to successful hens had no correlation with hunter success in the fall or spring, whereas the ratio of poults to total hens did. Brood count data are analyzed by tracking records over several years to establish average production and a normal range of variation. After several years of records are compiled, data from each successive year can be compared to determine if production is above or below average. These data can also be compared against production figures published in the scientific literature.

4. Disposition of Data – Refer to Section II.B.4 (Census – Winter Counts) of this Chapter.

D. Spring Gobble Counts –

1. Rationale – Spring gobble counts can provide an index to the abundance of male wild turkeys (Lint et al., 1995; Porter and Ludwig, 1980). The intent is to compare relative abundance of toms from year-to-year, to detect trends over time. Therefore, a consistent sampling effort is essential. Lint et al. (1995) also determined spring gobble counts were closely correlated with the number of harvested toms. Both gobble counts and tom harvests were related to overall population trends. Since the Wyoming Game & Fish Dept. estimates

tom harvest annually, gobble counts would be a duplication of effort and are not done in the State.

2. Application – Consult Lint et al. (1995), Kurzejeski and Vangilder (1992), and Porter and Ludwig (1980).

III. HARVEST SURVEY –

A. Rationale – The Wyoming Game & Fish Department conducts a harvest survey annually by mail to estimate wild turkey harvest, hunter effort and success. The data are used for several management purposes including: track population status and trends, determine future license quotas, and provide fiscal information for the Department Annual Report.

B. Application – The Biological Services Section conducts an annual survey to estimate turkey harvest during fall and spring seasons. Survey cards are mailed to all hunters who were issued a limited quota turkey license, and to a random sample of general license holders. Harvest statistics are estimated using an extrapolation process, and are summarized in a harvest report.

C. Analysis of Data – Hunting success is correlated generally with the abundance of turkeys; therefore harvest data can be used to gauge the relative size of a turkey population. When turkeys are abundant, hunter success increases and effort typically decreases. If both sexes can be taken (as in fall hunting seasons), harvest statistics should be tracked separately. Field checks of harvested turkeys are not providing a useful means to verify the reliability of the mail survey. Although field checks are occasionally used to identify possible concerns with the big game harvest survey, turkey hunters are generally more dispersed, making it difficult to obtain an adequate sample of harvest data through field contacts.

D. Disposition of Data – Refer to Section II.B.4 (Census – Winter Counts).

IV. TRAPPING AND TRANSPLANTING –

A. Trapping Considerations – Trapping wild turkeys can be very time-consuming. Planning and coordination alone require a great deal of effort. Enough personnel must be on site to handle the captured birds quickly and efficiently, but too many people may cause the birds to become wary and avoid the trapping location. Turkeys that are fed in ranch compounds throughout the winter can appear quite tame, but quickly recognize unusual activity. If a trapping operation is unsuccessful, the birds can become extremely nervous and un-trappable for several days. To avoid spooking the target birds, all personnel involved in a trapping operation need to be stealthy from the outset. Some important considerations for planning a trapping operation are outlined below:

1. Have a roster of personnel to assist the trapping operation well in advance.

2. If the birds will be exported to another state, be sure all necessary permits and other paperwork are completed. A contact person from the other state should be available during the trapping operation to answer questions about shipping, transfer of the birds, blood testing, or other items.

3. The person supervising the operation needs to be aware of any disease testing required by the other state. Typically, blood samples will be drawn at the trapping site and sent to the receiving state via overnight mail. The trapping leader must have the correct shipping information.

4. Notify the Wyoming Game & Fish Department's Veterinary Services Section several months prior to the trapping operation. The trapping supervisor needs to ensure adequate blood letting supplies are available on site.

5. Schedule trapping operations on Monday, Tuesday, and/or Wednesday to assure the blood tests can be completed and the birds released promptly. If the receiving state's veterinary lab agrees to process samples on a weekend, it is acceptable to trap later in the week.

6. If birds are to be moved instate, no blood work is required, but Veterinary Services should still be notified in case they would like blood samples for other reasons.

7. An adequate supply of shipping boxes must be present at the trapping location. The person organizing a winter trapping operation should contact one of the state's NWTF technical committee representatives in late summer or early fall to assure enough boxes will be available.

8. Line the bottom of each shipping box with an absorbent material. In the past, newspaper has been used, but straw or wood chips work better to keep boxed turkeys dry and clean. Sawmills are an excellent source of free wood chips.

9. Test the trap beforehand to be sure it is in good working order. Adjust or repair any components that aren't working properly.

10. Pre-bait the trap with grain (corn, oats) for several days. If turkeys are being captured on private property, the landowner can acclimate the birds by feeding them in and around the trap.

11. Immediately move captured turkeys into shipping boxes. Turkeys left in the traps while other birds are processed can be injured.

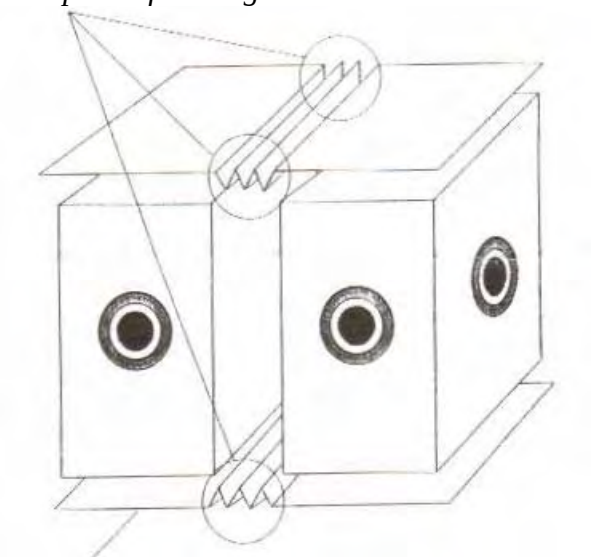
12. Place turkeys into shipping boxes feet first. The bird's head must be upright and mobile before the box is sealed. In the past, mortalities have resulted from improper containment when birds' heads were tucked under their breasts. Birds in this position may not be able to raise their heads upright within the confinement of the box.

13. Suitable equipment must be on hand to transport the birds. Horse trailers work well. Assure sufficient space is maintained between shipping boxes to allow proper ventilation. Boxes can be stacked two high, provided they are stable and will not fall over during shipping.

14. The NWTF has an agreement with Delta Airlines to ship turkeys. Contact the airline 2 days in advance so cargo handlers can prepare for the birds. Transportation to the airport is the responsibility of the trapping operation. A truck or a horse trailer is normally used for this purpose. If the turkeys will be driven to an airport in a neighboring state, the trapping supervisor needs to review the other state's regulations governing the shipment of wildlife and notify the appropriate contact within that state.

15. If the turkeys will be shipped by air, the transport boxes must be fitted with a device that prevents them from tipping over in transit. The structure in Fig. 1 has worked well in the past.

Step 1. Tape the folds together



Step 2. After the birds have been banded and blood taken (if necessary), their next stop is the airline. Tape the bottom spacer.
Step 3. Tape the top spacer.
Step 4. Tape around the top and bottom.
Step 5. Tape over the top and bottom, both directions.

Fig. 1. Cardboard spacers improve airflow to turkeys during transport. Spacers are available through the NWTF Conservation Programs Department. *Source: Cardoza et al. (undated) – National Wild Turkey Federation Technical Bulletin No. 3.*

B. Transplanting – Managers generally transplant wild turkeys to increase hunting opportunities. An agreement should be negotiated with landowners who receive birds to assure the public will be granted access for hunting. If the birds are released onto private land adjoining accessible public land, an access agreement may not be necessary because the birds will likely move onto the public land. Evaluate habitat conditions at the release site beforehand to assure the area is suitable to sustain a population of wild turkeys. Food sources and roost sites are essential (refer to Section V on habitat requirements). If food availability is limited during winter, this can be corrected by establishing food plots provided the transplant operation is planned far enough in advance.

C. Marking techniques – Transplanted turkeys need not be marked unless a study of some type is planned in conjunction with the transplant operation. Birds are typically captured and marked to study population characteristics including habitat use, home range, production and survival. Use of radio transmitters to mark birds should be cleared through the Biological Services Section to avoid frequency overlaps with other studies in the area.

1. Radio Backpacks – Refer to discussions in Hubbard (1997) and Wilson and Norman (1995).

2. Leg Bands – Leg bands are an inexpensive and effective means to identify birds that are handled during trapping operations. Band returns from harvested birds can provide managers with valuable insights about movements or dispersal. The biologist should maintain records of all band numbers and colors used in his district. The preferred band size for wild turkeys is No. 24.

D. Trapping Techniques – Several techniques have been used effectively to capture wild turkeys. The organizer of each trapping operation should select the method most suited to the specific circumstance and the objectives of the project.

1. Rocket Net –

a. Rationale – The rocket net can be used to capture a large number of turkeys in a single deployment. Rocket nets are most effective at sites where turkeys have been habituated to artificial feeding and are concentrated as a result.

b. Application –

i. Test fire the net before setting it up at a particular location to ensure there are no shorts in the circuitry and the battery is sufficiently charged.
ii. Lay the net out and stake it at the trapping location a couple of days bin advance so the birds can acclimate to it. Pre-bait in front of the net for several days so the birds become accustomed to feeding in that location.

iii. Fold the net back onto itself in small sections similar to an accordion. This will assure it unravels freely, without tangles, when it is fired.
iv. Aim the middle rockets straight forward and angle the outer rockets 2-3 degrees away from the firing line of the net. The angle cannot be too great or the rockets will deflect inward toward the center of the net when they reach the end of their tethers.
v. The evening before trapping, lay the detonation wire out on the ground. Tape all connections along the detonation wire or cover them with rocks to avoid frost buildup overnight. Frost can interfere with proper detonation.
vi. All personnel involved with trapping and handling the birds must be concealed, but able to access to the net quickly after it is fired. It is critical for personnel to remain well hidden and quiet as wild turkeys easily become nervous and wary.
vii. After the net is fired, personnel should immediately cover its edges to prevent the birds escaping from underneath. Quickly transfer captured turkeys into transport boxes lined with straw or wood chips.

2. Drop Net –

a. Rationale – The drop net is another alternative used to capture a large numbers of turkey in a single deployment. The number that can be caught depends on the size of the net. In Wyoming, high winds often limit the size of the net that can be used effectively. Ramsey (1968) and Glazener et al. (1964) determined nets of 60' x 60' to 75' x 75' were optimum in Texas. Drop nets can be used in places where firing a rocket net would be inappropriate or dangerous, for example towns or residential areas.

b. Application –
i. Select prospective trap sites along movement routes or at feeding sites.
ii. Remove all debris that might hold the net up or cause it to tangle. Clear a 10-foot border from around the outer edge of the net as well
iii. Pre-bait trap sites with grain. Scatter bait evenly under the net, but not within 10 feet of the outer edge. By keeping bait 10 ft and more inside the net edges, fewer birds will escape when the net is dropped. Don't attempt to trap until turkeys are visiting the site regularly.
iv. Schedule trapping operations prior to 1 March because turkeys may lose interest in the bait once breeding activity begins.
v. Suspend the net at least 8 feet off the ground. Some birds may refuse to walk beneath a net that is suspended lower.
vi. The net mesh should be 3 to 3.5 inches. Turkeys tend to slide out from under nets of smaller mesh, but become too tangled if the mesh is larger.
vii. After the net is dropped, turkeys can be calmed by laying burlap or plastic tarpaulins over the top.

viii. Personnel should monitor the number of birds under the net. When too many birds are present, the net may not stay down and more birds could escape.

3. Walk-in Trap –

   a. Rationale – The walk-in or funnel trap can be useful when time, budget, or personnel are limited, or if the landowner does not want a large crowd on his property. Dimensions vary, but 4'x 8'x10' is sufficient to capture a reasonable number of birds, while being portable enough to transport in the back of a pick-up truck. Traps can be constructed from 4'x 4'x 6' wire panels (Davis, 1994). One person can set up a funnel trap and handle the turkeys, but the method will not capture as many birds by comparison to a rocket or drop net.

   b. Application –

      i. Pre-bait the trap site with grain. Birds should be using the baited sites before the trap is set up.
      ii. Construct trap panels and the funnel well before trapping is scheduled.
      iii. Modular portions of the trap should be assembled at or near the bait site 2 to 4 days before the trapping. The trap should be completely assembled before dawn the day trapping is scheduled to begin.
      iv. Traps can be made larger by attaching more panels at one end. A greater number of turkeys can potentially be captured, however excessively wide traps may sag in the middle.
      v. Traps usually become effective within 2 days after they are set up. Check them 2 to 3 times per day during cool weather. If the temperature is warm, check traps more frequently (every 2 to 3 hours).
      vi. Use a 10-foot hook to remove birds from one end of the trap.
      vii. On average, traps captured 10 birds per day in Texas. This number may increase with a larger trap size. However, rocket nets or drop nets may be more appropriate if a large number of birds must be captured in a short time.
      viii. Turkeys commonly injure their heads by jumping and attempting to fly in funnel traps. Opaque tarps can be placed over the trap to minimize injuries as birds are being removed.

4. Chemical Immobilization – Several drugs can be used to immobilize turkeys. These include tribromoethanol, alpha-chloralose, and methoxymol. The Wyoming Game & Fish Dept. does not typically use drugs to capture wild turkeys because other methods have proven safer and more effective. Anyone interested in chemically immobilizing turkeys should contact Veterinary Services. Consult Williams et al. (1973) for a detailed discussion regarding the use of drugs to capture wild turkeys.

V. WILD TURKEY HABITAT –

A. Habitat Requirements – Several studies have described habitats used by Merriam's wild turkeys in Wyoming and in the Black Hills of South Dakota – consult Rumble and Anderson (1996 a, b, c), Rumble and Anderson (1993 a, b), and Hengel and Anderson (1990). Other studies of Merriam's turkey habitats include Flake et al. (1995), Wakeling and Rogers (1995), Hoffman et al. (1993), Shaw and Mollohan (1992), and McCabe and Flake (1985). Habitats used by Rio Grande turkeys have not been specifically studied in Wyoming, but studies done elsewhere include Keegan and Crawford (1997), Beasom and Wilson (1992), Ransom et al. (1987), and McCabe and Flake (1985).

B. Habitat Evaluation – A protocol for evaluating turkey habitat has not been developed specifically for Wyoming. Managers should consult the references cited above to obtain guidance with respect to turkey habitat requirements. For the most part, a dependable winter food supply is the limiting factor that must be present to sustain viable turkey populations in Wyoming. Turkeys adapt well to the nesting and roosting sites that are available so long as an adequate food supply is available in the area.

C. Habitat Improvement – In most cases, turkey habitats in Wyoming are improved by providing or enhancing food sources. A publication entitled, "Plantings for Wild Turkeys," available from the Wyoming Game & Fish Department, lists specific plants useful for turkey food plots in eastern Wyoming, Montana, Colorado, and western Nebraska. Additional information about turkey habitat and food plants is provided in "Habitat Needs and Developments for Wild Turkeys," Habitat Extension Bulletin No. 24 (Hengel 1994). Grain plots consisting of wheat, oats, or millet are good food sources for turkeys in winter. Food plots should be established in locations that do not accumulate drifting snow and remain accessible. Bailed grain can also be used as "mobile food plots." Grain bales can be placed away from ranch compounds to prevent turkeys from congregating near buildings and causing problems. At times, contracts have been developed with landowners to leave a portion of their grain crop standing or to bale grains for use as winter feed.

VI. AGING AND SEXING –

A. Age –

1. Distal Primaries –

a. Adult: all ten distal primaries are well rounded, with white barring extending to the end of the feathers.

b. Juvenile: the ninth and tenth distal primaries or only the tenth have pointed tips and the white barring does not extend to the tips of the feathers.

2. Rectrices –

   a. Adult: all tail rectrices are the same length, resulting in an even contour when the feathers are fanned out.

   b. Juvenile: the middle tail rectrices are longer than the outer rectrices (the middle juvenile feathers are first to molt and be replaced). At approximately 1.5 years, all rectrices will be equal length.

3. Upper, Major Secondary Coverts –

   a. Adult: the secondary coverts form a well-rounded, "moon" shape.

   b. Juvenile: the secondary coverts are shorter and of unequal length, forming an uneven contour. All juvenile coverts will be molted by 1.5 years.

B. Sex –

1. Breast Feathers –

   a. Male: tips of the breast feathers are flattened and black on males.

   b. Female: tips of the breast feathers are rounded and light brown or crème colored.

2. Leg –

   a. Male: the tarsus is approximately 6 inches long and bears a spur.

   b. Female: the tarsus is approximately 4-5 inches long and has no spur.

3. Beards – Although female wild turkeys do not generally have beards, the presence of a beard is not conclusive evidence of sex. Depending on the population, from one to twenty-nine percent of females may develop beards (Pelham and Dickson, 1992).

VII. DISEASE – Davidson and Wentworth (1992) provide a comprehensive treatise of the diseases and parasites that afflict wild turkeys.

VIII. SETTING HUNTING SEASONS – Strickland et al. (1994:463) recommended the following factors should be considered for setting wild turkey hunting season throughout the United States. Each manager should decide which factors are most important or pertinent in his area of responsibility.

Spring Hunting Season	Fall Hunting Season
Tradition (public expectations)	Tradition (public expectations)
Hunter densities (hunting quality)	Seasons that either coincide with or avoid deer season
Landowner tolerance	Landowner tolerance
Seasons that coincide with the peak of gobbling	Turkey population size
Turkey population size	Brood surveys
Access to turkey areas (weather)	Fall hunt may adversely affect the turkey population
Season timed to coincide with hens incubating	Access to turkey areas (weather)
Season ends before peak of hatch	Literature on turkeys
Literature on turkeys	

A. Spring Hunting Seasons – Only male wild turkeys are harvested during spring hunting seasons. Since turkeys are polygamous breeders, the removal of males does not typically affect the productivity of a population. Some managers have speculated heavy hunting pressure before hens breed in the spring could reduce productivity and increase the vulnerability of toms (Widner et al., 1998; Hoffman et al., 1993; Kurzejeski and Vangilder, 1992). In response, a number of states moved the opening date of hunting season later in the spring. However, it is doubtful hunting pressure in Wyoming has ever been sufficient to impact turkey breeding. Data from the Wyoming portion of the Black Hills have indicated there is no benefit from opening the hunting season later. Prior to 1989, the spring turkey season in the Black Hills opened the first Saturday in April. From 1989 through 1992, the opening date was changed to April 1. Under both season structures, the opening date preceded the peak of breeding, which typically occurs in mid-April. To avoid possible disruption of breeding, from 1993 through 1999 the annual opening date was delayed to April 20. Despite opening the season later during the 6-year period, an increase in turkey productivity was not detectable in the region. Miller et al. (1997) concluded later opening dates may needlessly restrict hunting opportunity without measurably benefiting the turkey population. In some areas of Wyoming spring season may be delayed, giving turkeys time to disperse away from winter feeding sites in ranch compounds.

B. Fall Season – In some circumstances, fall hunting seasons can potentially impact the size and productivity of a turkey population. Hen harvest in areas with good access and heavy hunting pressure could lead to a population decline (Pack et al., 1999; Little et al., 1990). However, excessive hen harvest is unlikely throughout much of Wyoming because access to private lands is limited and in the Black Hills, much of the fall turkey harvest is opportunistic and incidental to deer hunting. Managers in southeast Wyoming attempted an experiment that limited fall harvest to bearded turkeys only. However, landowners began to complain about the lack of hen harvest when turkey populations increased following several good hatches.

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Chapter 18

Migratory Game Birds

Larry Roberts

I. INTRODUCTION – This chapter addresses management techniques for coots, cranes, crows, doves, ducks, geese, mergansers, rails, snipe and swans.

A. Species, Status, and Habitats in Wyoming –

Wyoming is within the breeding ranges of the following migratory game birds:

[1] mourning dove (*Zenaida macroura)*	[3] northern pintail (*A. acuta*)
[2] greater sandhill crane (*Grus c. tabida*)	[2] wood duck (*Aix sponsa*)
[1] common snipe (*Gallinago gallinago*)	[2] redhead (*Aythya americana*)
[1] sora rail (*Porzana carolina*)	[3] canvasback (*A. valisineria*)
[1] Virginia rail (*Ralus limicola*)	[2] lesser scaup (*A. affinis*)
[1] American coot (*Fulica americana*)	[2] ring-necked duck (*Aythya collaris*)
[1] Canada goose (*Branta canadensis*)	[4] common goldeneye (*Bucephala clangula*)
[1] mallard (*Anas platyrhynchos*)	[3] Barrow's goldeneye (*B. islandica*)
[1] gadwall (*A. strepera*)	[3] bufflehead (*B. albeola*)
[1] northern shoveler (*A. clypeata*)	[3] ruddy duck (*Oxyura jamaicensis*)
[1] wigeon (*A. americana*)	[4] harlequin duck (*Histrionicus histrionicus*)
[3] green-winged teal (*A. crecca*)	[3] red-breasted merganser (*M. serrator*)
[3] blue-winged teal (*A. discors*)	[1] common merganser (*Mergus merganser*)
[2] cinnamon teal (*A. cyanoptera*)	[3] trumpeter swan (*Cygnus buccinator*)

[1] common [2] locally common [3] uncommon [4] rare

Breeding populations of most migratory game birds in Wyoming were stable or increasing through 2003, based on 5- and 10-year data sets. Based on call count records, the mourning dove population declined slightly, but the decline was non-significant. Population trends of snipe and rails are unknown, but believed stable. For more complete information about life histories and management of migratory game birds, consult Bellrose (1976) and Tacha and Braun (1994).

Mourning doves typically nest within shelterbelts, riparian zones, sagebrush habitats, and urban areas throughout the state, but they are most abundant near irrigated, small grain fields. Sandhill cranes nest predominantly in shallow marshes and wet meadows within inter-mountain basins of northwest and western Wyoming. Smaller numbers nest along major river drainages and higher elevations in western and central Wyoming. Ducks of the genera *Anas*, *Aythya* and *Oxyura* (puddle ducks and diver ducks) nest throughout the state, within or near shallow marshes, oxbow wetlands, beaver ponds, natural lakes, playas, stock ponds, reservoir

backwaters and reclaimed mine ponds. Wood ducks are cavity nesters that breed predominantly within cottonwood-dominated riparian habitats of eastern Wyoming. Goldeneyes, buffleheads, and common mergansers are also cavity nesters, but goldeneyes and buffleheads nest in boreal forest habitats surrounding lakes and streams in northwest Wyoming. Common mergansers nest in cottonwood riparian zones along larger river corridors throughout the state. Red-breasted mergansers nest on the ground in a variety of sites near reservoirs and streams that sustain fish populations. Canada geese select larger waters with open, often overgrazed shorelines. Favored nest sites are islands, peninsulas and man-made, nesting platforms. Rails and coots nest in shallow to deep emergent zones of marshes, ponds and lakes. Snipe nest in grassy cover adjoining marshes, sloughs, beaver ponds, and wet meadows, often at higher elevations.

During spring and fall, other segments of the species that breed in Wyoming migrate through the state enroute to breeding or wintering grounds elsewhere. In addition, several species that do not nest in Wyoming migrate through the state or have been documented here. They include:

[2] snow goose (*Chen caerulescens*)	[4] oldsquaw (*Clangula hyemalis*)
[2] Ross' goose (*Chen rossii*)	[4] tufted duck (*Aythya fuligula*)
[4] white-fronted goose (*Anser albifrons*)	[4] black scoter (*Melanita nigra*)
[4] black brant (*Branta bernicula*)	[4] white-winged scoter (*Melanita fusca*)
[2] lesser sandhill crane (*Grus c. canadensis*)	[4] surf scoter (*Melanitta perspicillata*)
[3] tundra swan (*Cygnus columbianus*)	[4] Eurasian wigeon (*Anas penelope*)
[3] greater scaup (*Aythya marila*)	[4] American black duck (*Anas rubripes*)

[1] common [2] locally common [3] uncommon [4] rare

Dependable winter habitats for migratory game birds are generally limited in Wyoming. Most species that nest in, or migrate through Wyoming spend winter elsewhere, in less harsh climates. During milder years, a substantial population of Canada geese may remain through the winter in southeast Wyoming. Smaller numbers of Canada geese winter on open rivers below dams and reservoirs in other regions of the state. Moderate numbers of cold-hearty species such as trumpeter swans, mallards, mergansers, goldeneyes, and even coots may winter in locations where discharges from springs or reservoirs maintain open water. However, winter populations of migratory game birds much smaller than those present during the breeding season or spring and fall migrations.

B. Flyways/Management Units

B. Rationale – Southward in fall and northward in spring, waterfowl have migrated along ancestral routes or "flyways" since the retreating glaciers left landmarks and watery stepping-stones as guideposts. Scientists and others have observed these bird migrations for centuries, but here in North America, the routes were not delineated and named until the early 20th century.

Frederick Lincoln is generally regarded as the originator of the waterfowl flyway concept in North America. According to Lincoln, "Recovery of banded ducks and geese accumulated so rapidly that by 1930 it was possible to map out the four waterfowl flyways' great geographical regions, each with breeding and wintering grounds connected by a complicated series of migration routes."

Lincoln clearly recognized the importance of the flyways in his statement, "Conservationists now know that the birds have a strong attachment for the ancestral flyways and they recognize the significance of this fact."

Lincoln's four flyways – Atlantic, Mississippi, Central, and Pacific – were based largely on band recoveries. Historically, numbered bands were the only means of marking individual birds; color marking was later employed to identify population segments or individual birds. Colored markers enabled observers to record multiple sightings without capturing or harvesting the bird to read a leg band.

Lincoln's flyway concept became the foundation of the administrative units implemented in 1948 by the Service to regulate sport hunting and to manage populations of migratory birds. Surprisingly few modifications have been made to the four Flyway boundaries since then. The flyway concept has been applied with notable success to manage various populations of Canada geese. In some instances, flyways have been subdivided to manage specific stocks of ducks. The High and Low Plains units of the Central Flyway and the Columbia Basin of the Pacific Flyway are examples.

2. Application – Four administrative bodies called flyway councils were created to establish a system of state and federal coordination within the 4 flyways. Each council is comprised of representatives from member states within the flyway. Annual meetings are held to evaluate migratory game bird populations and recommend hunting seasons. A technical committee of waterfowl biologists was also established to serve each flyway council. The Technical Committees compile and analyze management data, and recommend management actions for consideration by the Councils.

   Two Council meetings are held each year. During March, in conjunction with the North American Wildlife and Natural Resource Conference, basic regulations and early season hunting frameworks are reviewed. At a second Council meeting in July, waterfowl breeding ground data are reviewed and recommendations for the regular (late) season hunting frameworks are forwarded to the U.S. Fish and Wildlife Service (Service). Technical Committee meetings are held prior to each of these Council meetings. Standing subcommittees of the technical committees are assigned to review data and other information pertaining to various populations of migratory game birds, as well as projects and special studies. Flyway goals and objectives are reassessed annually. The Technical Committees also conduct an additional work session each winter. The focus of the winter meeting is to work on management plans and larger programmatic issues. Because Wyoming is divided between the Central and Pacific Flyways, the state maintains membership in each.

3. Designations for Management – Several populations or geographic units have been defined to manage various stocks of migratory game birds. The flyways have developed plans to organize data, identify issues and establish management strategies and criteria for most of these units or populations. Management delineations for species that breed in, or migrate through Wyoming are listed below:

Species & Distribution	Management Unit or Population Designation	Responsible Organization
webless species statewide (doves, snipe, rails)	Central Management Unit	Central Flyway
greater sandhill cranes, west & central Wyoming	Rocky Mountain Population	Central and Pacific Flyways
lesser sandhill cranes, eastern Wyoming	Mid-Continent Population	Central Flyway
large Canada geese, west and central Wyoming	Rocky Mountain Population (predominantly)	Central and Pacific Flyways
large Canada geese, eastern Wyoming	Hi-Line Population (predominantly)	Central Flyway
small Canada geese, eastern Wyoming	Short-Grass Prairie Population (predominantly)	Central Flyway
snow & Ross' geese	West-Central Flyway Population	Central Flyway
trumpeter swans, western Wyoming	Rocky Mountain Population	Pacific Flyway
tundra swans, western Wyoming	Western Population of Tundra Swans	Pacific Flyway
tundra swans, eastern Wyoming	Eastern Population of Tundra Swans	Central Flyway
ducks west of the Continental Divide	Pacific Flyway	Pacific Flyway
mallards west of the Continental Divide	Western & Mid-Continent Mallard Populations	Pacific Flyway
ducks east of the Continental Divide	Central Flyway	Central Flyway
Mallards east of the Continental Divide	Mid-Continent Population of Mallards	Central Flyway
coots, crows, mergansers	administratively distinguished by flyway	Central or Pacific Flyway as applicable

C. North American Waterfowl Management Plan –

1. History and Purpose – The North American Waterfowl Management Plan (NAWMP) was developed after waterfowl populations reached historically low levels during the early 1980s. Declining populations were the consequence of long-term habitat loss, exacerbated by severe drought. The NAWMP goals are habitat- and population-driven.

The Plan's fundamental purpose is to establish an infrastructure needed to identify and recover habitats that will sustain waterfowl populations at objective levels. The Canadian Minister of Environment and the U.S. Secretary of Interior initially signed the plan in 1986. Mexico became a signatory when the plan was updated in 1994. The Plan's vision was expanded in 1998 to encompass the following principles:

1) strengthen the biological foundation (conservation planning based on best available science and data);
2) progress toward landscape conservation (ecosystem-based, multiple species); and
3) broaden the scope of partnerships (include other bird initiatives and funding sources).

The overriding goal of the NAWMP is to restore the habitat base needed to sustain waterfowl populations and other migratory birds at levels present during the 1970s.

2. Population Goals –

Table 1. NAWMP goals for breeding populations of the 10 most common duck species in the traditional survey area[a] (USFWS 2000).

Species	Goals[b]
Mallard	8,199,000
Northern pintail	5,596,000
Gadwall	1,518,000
American wigeon	2,974,000
Green-winged teal	1,858,000
Blue-winged/cinnamon teal	4,653,000
Northern shoveler	1,990,000
Redhead	639,000
Canvasback	542,000
Scaup	6,302,000

[a] The surveyed area includes strata 1-18, 20-50 and 75-77 in the Spring Breeding Population and Habitat Survey (USFWS 2000).
[b] The average of 1970-1979 for the traditional survey area.

Table 2. NAWMP goals for populations of geese with distributions that overlap Wyoming.

Species and Population	Winter Index Goals (Year 2000)
Canada Goose	
Shortgrass Prairie	150,000
Hi-line	80,000
Rocky Mountain	50,000
Snow Goose	
Mid-continent Lesser	1,000,000
Western Central Flyway	110,000
Ross' Goose	100,000[a]
White-fronted goose	
Pacific Flyway	300,000

[a] Breeding population goals.

Table 3. NAWMP goals for North American swan populations.

Species and Population	Autumn/Winter Index Goal (Year 2000)
Tundra Swans	
Eastern Population	80,000
Western Population	60,000
Trumpeter Swans	
Rocky Mountain	5% annual growth rate
Interior	2,500

3. Habitat Goals – The 1998 NAWMP update seeks to protect 12.2 million acres of wetland habitats and to restore and enhance 15.2 million acres.

4. Implementation – Joint Ventures (JVs) are partnerships that transform the goals of the North American Waterfowl Management Plan (Plan) into on-the-ground projects. JVs are comprised of individuals, businesses, conservation organizations, and local, state, provincial, and federal agencies. Each JV administers projects within a geographic region.

   Fourteen habitat joint ventures currently exist in the United States (11) and Canada (3). In addition, 3 international joint ventures have been formed to address monitoring and

research needs for selected species. They include the Black Duck, Arctic Goose and Sea Duck Joint Ventures. We expect additional Joint Ventures will be established in Mexico in the near future.

D. Waterfowl Season Setting –

1. Flyway Meetings –

a. Rationale – In 1951, the International Association of Fish and Wildlife Agencies (IAFWA) adopted a resolution calling for establishment of a Council within each of the 4 flyways, and a National Flyway Council (NFC). The Flyway Councils would represent the states in matters pertaining to the management of migratory game birds, including the annual setting of hunting seasons. The NFC would deal with issues of national or international scope that require inter-flyway coordination. Shortly thereafter, the states formally organized the 4 Flyway Councils and established technical committees to advise the Councils. This system of cooperative state and federal management remains in place today.

In 1995, the IAFWA (renamed "Association of Fish and Wildlife Agencies" or AFWA in 2006) undertook a review of the flyway system. The final report endorsed some fundamental changes to the flyway mission. Most notably, the long-term vision of the Flyway Council System should be expanded to accommodate all migratory birds. The system should evolve into a cooperative, international approach that links efforts of a broad range of partners and conservation initiatives. Conservation should be a science-based, publicly supported program of coordinated actions that benefit migratory birds and their habitats. At the time this chapter was written, management of migratory game birds continued to be the major focus of the Council System. Development of an infrastructure to deal with all migratory birds was just beginning.

b. Application – The regulatory cycle involves several meetings each year. The Service has assigned a representative to each flyway ("flyway representative") who serves as a liaison between the Service, the flyway Technical Committee and the Council at these meetings. During December or January, the technical committees each hold a work session to review and update management plans for various populations of migratory game birds and to discuss preliminary information the flyway representatives may convey about the upcoming regulatory cycle. The technical committees also take up various other topics and issues such as surveys, harvest strategies, population models, pertinent legislation, research projects, and funding requests.

Two regulatory processes are administered annually for early and late migratory game bird seasons. In January each year, the Service Regulations Committee (SRC) meets to identify issues potentially significant to both regulatory processes. This information is conveyed by the Flyway Representatives to the Technical Committees. Initial recommendations for early migratory bird seasons are made by the Technical Committees at "spring" meetings held in March each year. The Flyway Councils vote on the technical committees' recommendations at a meeting held in conjunction with

the North American Wildlife and Natural Resources Conference in late March or early April. In June, the SRC takes recommendations from all 4 flyways under advisement and formally promulgates the early migratory game bird seasons. These seasons are published in the Federal Register in July. Early migratory bird seasons include special early sandhill crane and Canada goose seasons, early September teal seasons, and seasons for doves, band-tailed pigeons, snipe, gallinule, extended falconry (days falconers can hunt outside the regular gun season), and special youth waterfowl hunting days.

The process for setting late migratory game bird seasons is similar to that for the early seasons. Technical Committees hold "summer" meetings in late July to make the initial recommendations. The Flyway Councils vote on the Technical Committee Recommendations later in the week, in meetings held at the same locations. And at the end of July or the first few days of August, the SRC meets to take Council recommendations under advisement, and formally promulgates the late migratory game bird seasons. These seasons are published in the Federal Register in mid-September. Late migratory game bird seasons include the regular duck and goose seasons, late sandhill crane seasons, and tundra swan seasons.

The Technical Committees and Flyway Councils may act on variety of topics in addition to hunting seasons, such as research funding, harvest strategies, adoption of management plans, setting population objectives, and other matters related to migratory bird conservation at both the spring and summer meetings. These are open public meetings, often attended by a wide range of interests.

2. Adaptive Harvest Management –

   a. Rationale – In 1995, the U.S. Fish and Wildlife Service (Service) modified the process used to regulate duck harvests by changing to a system based upon adaptive resource management. Adaptive Harvest Management (AHM), as it is called, employs quantitative criteria for selecting hunting frameworks. The criteria or thresholds are incorporated into models that describe relationships among breeding mallard populations, habitat conditions (an index to recruitment), regulatory frameworks and harvest. As experience is gained, the criteria, models, and frameworks are refined. The AHM process was originally conceived to reduce disagreements and political haggling during the season-setting process by making decisions more data-driven. Another purpose is to improve knowledge about relationships between hunting regulations and harvests.

   The adaptive approach explicitly recognizes the effects of hunting regulations cannot be predicted with certainty and provides a system for making objective decisions in the face of uncertainty. Fundamentally, AHM is an iterative cycle of monitoring, evaluation, decision-making, and adjustments to clarify relationships among hunting regulations, harvests, and waterfowl abundance.

   b. Application – The 2 environmental variables used to select harvest regulations are: 1) an annual breeding ground survey of mallards in the Mid Continent Population, and 2)

numbers of ponds holding water within the surveyed area in May. The selection is "optimized" by weights given 4 competing models. The 4 models reflect the following sets of assumptions: 1) harvest mortality is additive and recruitment is density-independent (most conservative); 2) harvest mortality is additive and recruitment is density-dependent; 3) harvest mortality is compensatory and recruitment is density-independent; and 4) harvest mortality is compensatory and recruitment is density-dependent (most liberal). Each year, the model weights are updated to provide the closest fit between modeled predictions and realized harvests and breeding populations. As years of data are accumulated, confidence in model weights and accuracy of predictions improves.

Initially, AHM was based upon breeding ground data collected within the traditional survey area for the Mid-Continent Population of Mallards. The Service assumed other stocks of ducks followed similar trends and the dynamics of the Mid-Continent Population would provide a satisfactory basis to set hunting seasons for most other ducks. However, experience has demonstrated trends of other duck populations can deviate from those of the Mid-Continent population. To more accurately depict geographic variations, an AHM model based on Eastern Mallards was developed for the Atlantic Flyway and another model is under development for Western Mallards. Eastern mallards are distinct, however Western mallards commingle with Mid-Continent mallards so the Western and Mid-Continent models will be jointly optimized to set seasons for the Pacific Flyway. A future priority is to develop AHM models for selected species other than mallards that do not necessarily follow trends of mallard populations. Although this approach will enable managers to increase the specificity of regulations for some non-mallard ducks, it will also increase the complexity of regulations. Costs and data requirements will impose some practical constraints. Therefore, it is unlikely AHM models will be developed for more than 1 or 2 other species. Regulatory frameworks for most species will continue to be based on mallard trends.

3. Hunting Season Frameworks –

   a. Rationale – The 3 major purposes of hunting season frameworks are:
      1) to regulate harvest;
      2) to equitably distribute harvest opportunity; and
      3) to take into account, cultural values and traditions

   b. Application – Migratory waterfowl are a highly valued resource shared among several states and countries. To assure these species are harvested at sustainable levels, and to equitably distribute harvest opportunities, hunting seasons are set in accordance with international treaties and annual regulations promulgated by the U.S. Fish and Wildlife Service. The Migratory Bird Treaty Act of 1918 originally set forth the outside dates and allowable lengths of hunting seasons. Under the Treaty, no migratory game bird can be hunted before 1 September or after 10 March, nor can any species be hunted more than 107 days during that period. Exceptions are allowed to manage depredation and overabundant populations. Although the Treaty establishes

outside dates and maximum season lengths, more restrictive frameworks can be prescribed by regulation to assure species are harvested at sustainable levels. These restrictions include season lengths, bag limits, species limitations, and rules pertaining to configurations of geographic zones and season segments (splits) each state can adopt.

For ducks, 3 levels of regulatory packages have been defined to achieve target harvest rates – restrictive, moderate, and liberal. A fourth level, "very restrictive," was dropped from AHM in 2003. At the time this chapter was written, the following season lengths were applicable to Wyoming (Central Flyway includes additional "High Plains" season days):

	Season Length (days)	
Regulatory Alternative	Pacific Flyway	Central Flyway
Restrictive	60	51
Moderate	86	83
Liberal	107	97

c. Analysis – In general, a harvest of up to 10% of adult females and 20% of adult males is sustainable from the Mid-Continent Population of Mallards. Three regulatory frameworks have been devised to achieve the following overall harvest rates of mid-continent mallards (males and females combined):

Restrictive framework: 7%
Moderate framework: 11%
Liberal framework: 13%

The restrictive framework is designed to achieve growth toward population objectives. The moderate framework is intended to maintain the population and the liberal framework is intended to maintain or reduce the population. In the lower 48 states and Hawaii, the outside framework dates for moderate and liberal regulations are the Saturday nearest September 24 through the last Sunday in January. The outside framework dates for restrictive regulations are the Saturday nearest October 1 through the Sunday nearest January 20. Under each framework alternative, the Central Flyway portion of Wyoming is granted additional days known as the "High Plains" mallard season, which must be taken consecutively between the Saturday nearest December 10 and the close of the duck season.

The target harvest rates were originally estimated based upon outside framework dates between the Saturday nearest October 1 and the Sunday nearest January 20. In 2002, the outside framework dates for moderate and liberal regulatory alternatives were extended through a political action orchestrated by the southern tier of Mississippi Flyway states. At the time this chapter was written, the Service was still evaluating the impact of framework extensions upon harvest rates.

E. Waterfowl Management Areas –

1. Rationale – In 1984, the Waterfowl Program delineated 19 geographic units to serve as waterfowl management areas. These correspond to major watersheds or segments thereof. In 1998, the waterfowl management areas were digitized and incorporated into the Department's geographic information system (GIS) database (Fig. 1).

2. Application – Waterfowl management areas were based on the following criteria:

   a. Boundaries were hydrographic divides between watersheds of 3rd, 4th and/or 5th order streams.

   b. Some watersheds were subdivided based on marked differences in climate, agricultural practices or other land use characteristics.

   The waterfowl management areas (Table 4) are the basic geographic units for collecting, organizing, and reporting waterfowl population, harvest and habitat data. Waterfowl and sandhill crane objectives are established for each management area.

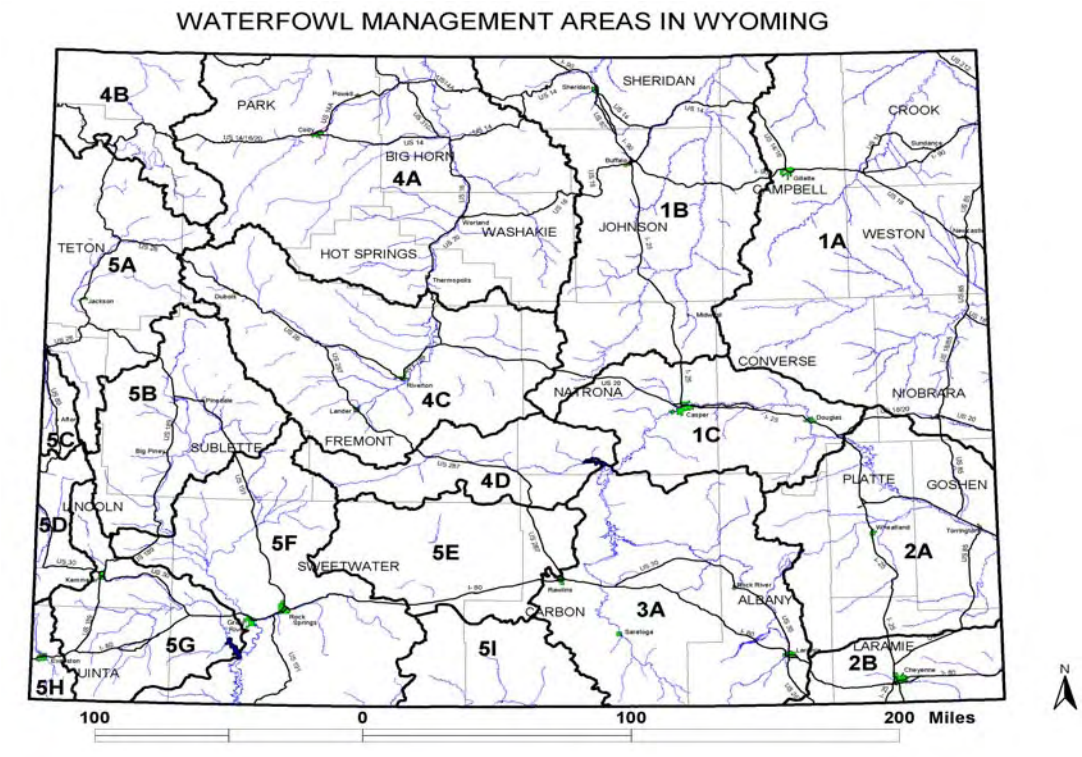

Fig. 1. Waterfowl management areas in Wyoming.

Table 4. Waterfowl/Wetland Management Areas in Wyoming.

WMA	Code	Flyway
Missouri, Cheyenne and Little Powder Rivers	1A	Central
Tongue, Little Bighorn and Powder Rivers	1B	Central
Central North Platte River	1C	Central
Lower North Platte River	2A	Central
South Platte River	2B	Central
Upper North Platte River	3A	Central
Laramie Plains	3B	Central
Big Horn River Basin	4A	Central
Madison - Yellowstone National Park	4B	Central/Pacific
Wind River Basin	4C	Central
Sweetwater River Basin	4D	Central
Snake River	5A	Pacific
Upper Green River Basin	5B	Pacific
Salt River	5C	Pacific
Lower Bear River	5D	Pacific
Great Divide Basin	5E	Pacific
Lower Green River Basin	5F	Pacific
Ham's Fork - Black Fork	5G	Pacific
Upper Bear River	5H	Pacific
Little Snake River	5I	Pacific

F. Management Area Codes –

1. Rationale – The waterfowl drainage codes identify geographic units in which data are collected. These codes area used to organize, sort, and compile data.

2. Application – Each record entered in the Wildlife Observation System (WOS) has a field in which the waterfowl drainage code can be recorded. The codes should be included in all waterfowl data entries. Codes are used to geographically index data.

II. CENSUS –

A variety of ground and aerial survey techniques are employed to monitor population trends of migratory game birds. Official surveys are not currently done to monitor crows, rails, snipe or mid-continent sandhill cranes.

A. Mourning Doves – Refer to: U.S. Fish and Wildlife Service Manual Part 722 Migratory Bird Surveys FW5 (USFWS 2003).

1. Call-Count Survey (CCS) –

   a. Rationale – Mourning doves are the most widely hunted game bird in the United States. Since 1960, dove populations have been divided into management units and hunting regulations are set accordingly. The units generally encompassed dove populations with similar characteristics, except the Central Management Unit includes 4 states divided between the Central and Pacific Flyways. Call-count surveys are done in late May and early June. Data from these counts are used to track population trends and set harvest regulations.

   b. Application – Eighteen call-count routes have been established in Wyoming. Route maps are on file in the Biological Services Section and at various field stations. All call-counts should be completed between May 20 and May 31. If inclement weather or other unavoidable circumstances delay the counts, the survey period can be extended to June 5. Do not conduct a survey if the wind exceeds 12 miles per hour or if precipitation is falling.

      Routes require approximately 2 hours to complete. Begin 0.5 hour before sunrise and maintain a driving speed of 35 mph between listening stations. Each route is 20 miles long beginning at the first listening station, with stops at 1-mile intervals thereafter. At each listening station, stop, turn the ignition off and step away from the vehicle. Listen and look for doves during a standard 3-minute interval. Record the following data: stop number, time of arrival, number of doves heard calling, and number of doves seen while stopped. Also count the number of doves seen while driving between stops and record this information on the data line of the prior stop. (Continue driving 1 mile past stop No. 20 to record data for that stop). Note any disturbances (noise, wind, etc.) or other conditions that may affect the observer's ability to detect doves at each station. At stations number 1 and 20, record air temperatures, vehicle mileage and wind velocity. Wind velocity is based on an index called the Beaufort scale outlined on the call-count survey form (Fig. 2).

   c. Analysis of Data – Talley doves heard and seen along each survey route. Results are reported as the mean number of doves heard calling per route in each state. Population trends are evaluated in each management unit.

   d. Disposition of Data – Mail the original forms directly to:

      Dove Section
      Division of Migratory Bird Management
      11500 American Holly Drive
      Laurel, Maryland 20708.

      Provide additional copies to the waterfowl biologist in Casper; Supervisor of Biological Services; and the Dove Survey Coordinator, US Fish & Wildlife Service, DMBM, P.O. Box 25486 DFC, Denver, CO 80225-0486. The observer should also retain one file copy. Contact Biological Services for instructs on submitting the data electronically to the Service.

Fig. 2. Mourning dove call-count survey form and instructions.

MOURNING DOVE CALL-COUNT SURVEY
U.S. FISH AND WILDLIFE SERVICE, DIVISION OF MIGRATORY BIRD MANAGEMENT,
1150 AMERICAN HOLLY DR., LAUREL, MD USA 20708-4016

SURVEY YEAR 2004

	STATE	**ROUTE NUMBER**
LOCATION OF ROUTE	**COUNTY**	**PHYSIOGRAPHIC REGION**

AT START - STOP NO. 1	**AT FINISH - MILE 20-0**	**DATE OF SURVEY** _____/_____/_____ MONTH DAY YEAR
WIND VELOCITY B- _____ TEMPERATURE _____F VEHICLE MILEAGE _____	WIND VELOCITY B- _____ TEMPERATURE _____F VEHICLE MILEAGE _____	
		LAST YEAR'S OBSERVER
OBSERVER'S NAME (PLEASE PRINT:FIRST - LAST) **-AGENCY STATE ___ FEDERAL ___ OTHER ___**		**LOCAL OFFICIAL** **SUNRISE TIME** _____A.M.
-Telephone (A/C)		
MAILING ADDRESS		DID YOU ENTER RESULTS THROUGH THE INTERNET? YES____ NO____

STOP NUMBER	**TIME AT STOP**	**DOVES HEARD**	**DOVES SEEN**		**DISTURBANCE**				**REMARKS** (or GPS coordinates)
		NO. OF INDIVIDUAL DOVES HEARD CALLING	WHILE STOPPED	WHILE DRIVING	NO	LOW	MOD	HI	
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
TOTALS					**TOTAL DOVES SEEN** (Stopped and Driving)				

FORM 3-159 (OVER) OMB FORM APPROVED NO. 1016-0010
(Revised August 2002) APPROVAL EXPIRES OCTOBER 31, 2005

INSTRUCTIONS FOR MOURNING DOVE CALL - COUNT SURVEY

DATES OF SURVEY Routes should be completed between **May 20 and May 31**, inclusive. *When unavoidable, the survey period will be extended to June 5.*

WEATHER CONDITIONS **Do not** conduct survey when (1) wind velocities exceed Beaufort 3 (12 mph), (2) rain or snow is falling

STARTING TIMES Start routes exactly **1/2 hour before sunrise.** Determine sunrise time from an official source adjusted to route locality.

OBSERVER When possible, the observer should run the same route in successive years. *The vehicle driver is the sole observer*. Persons accompanying the driver are not to assist the driver in the collection of dove data. When observer changes are being made and both observers are running the route, each person should record the data independently on separate forms without conferring.

SURVEY ROUTE Routes are 20 miles in length, with 20 stops (listening stations) at 1-mile intervals. The route begins at Stop #1 and ends 1-mile *past* Stop #20.

PROCEDURE

Special Note Survey requires about 2 hours to complete. Allow exactly 3 minutes for counts at each stop and an average of 3 minutes for recording and travel time between stops.

Bottom copy of the 5-ply survey form can be used as a field form.

At Stop #1 Record wind velocity a 0, 1, 2, 3, using Beaufort scale. Record temperature and vehicle mileage.

At Each Stop Stop vehicle, turn off ignition, leave vehicle. Listen and observe for **exactly 3 minutes**, standing away from vehicle.

Record:
(1) Actual time the count begins if different by more than 5 minutes from printed time.
(2) Total number of *individual doves* heard calling, **not individual calls**.
(3) Total number of doves seen while stopped.
(4) Disturbance affecting count at each stop.
(5) Remarks, if applicable to survey.

Between Stops Maintain driving speed of about **35 miles/hour** between stops.

Record: (1) Total number of doves seen while driving. Enter data on same line as previous stop number.

At Finish

Record:
(1) Weather conditions and vehicle mileage.
(2) Total all columns for doves heard and seen.

Check form for completeness and accuracy.

REPORTING ***Immediately after the completion of each route***:

(1) Mail the **original** form **directly** to Dove Survey, Division of Migratory Bird Management, 11500 American Holly Drive, Laurel, Maryland, 20708-4016.

(2) Mail the following to your State coordinator:
a. 1 copy of the form
b. 1 copy of the survey route map

(3) Retain a field copy for your personal file.

WIND VELOCITY

Beaufort Number	Velocity (mph)	Suggestions for Estimating Wind Velocity
0	Less than 1	Smoke rises vertically.
1	1 to 3	Direction of wind shown by smoke drift, but not by wind vanes.
2	4 to 7	Wind felt on face, leaves rustle, ordinary wind vanes moves.
3	8 to 12	Leaves and small twigs in constant motion, wind extends light flag.

DISTURBANCE

Disturbance	Description	Example
NO	No appreciate effect on route.	Occasional crow calling.
LOW	Slightly affecting count.	Distant tractor noise.
MOD	Moderately affecting count.	Intermittent traffic.
HI	Seriously affecting count.	Heavy-continuous traffic.

B. Rocky Mountain Population (RMP) of Greater Sandhill Cranes –

1. Fall Staging Survey –

a. Rationale – The crane population is estimated annually based on surveys conducted in mid-September to support harvest management decisions. The advantages of a survey at that time of year are: 1) The birds congregate on traditional staging areas before they migrate to the San Luis Valley, Colorado; and 2) there is minimal intermixing with other races/populations.

b. Application – The fall, pre-migration survey is a cooperative effort between the U.S. Fish and Wildlife Service and states within the range of the RMP. Survey area responsibilities are listed in the "Pacific Flyway Management Plan for the Rocky Mountain Population of Sandhill Cranes" (Pacific and Central Flyway Subcommittees for Rocky Mountain Population of Sandhill Cranes 2006). The Service's pilot/ biologist stationed in Denver selects the target dates during which all survey cooperators are requested to schedule their counts. The target period is 3 days within an outside window of 5 days. It is necessary to conduct all surveys during this period to obtain a maximum count, and to avoid duplicate counts of birds that may move from one staging area to another. The pilot/biologist relays the target survey dates to a member of the Pacific Flyway Study Committee, who is the keeper of the RMP Crane Plan. The keeper of the plan notifies all state cooperators of the survey dates, which are generally around 15 September.

The Service and WGFD share responsibilities for coverage of survey areas in Wyoming. The Department conducts aerial surveys within the Big Horn and Wind River Basins, and ground surveys within the Upper North Platte and Little Snake River Basins. The Service conducts aerial surveys within the Salt, Bear, and Blacks Fork River drainages, and the Farson-Eden area. In the past, a consultant has accompanied the Service during its portion of the surveys. The State Waterfowl Biologist maintains a file of survey coverage responsibilities.

Fly surveys on clear, calm days within the target period. If inclement weather prevents flying during the core, 3-day period, an additional 2 days are allowed for completion of the counts. The aircraft should be flown 70 knots (80 mph) or less, at an elevation of approximately 150 ft above ground level (AGL). Air speed should not exceed 90 knots (100 m.p.h.). The observer should direct the pilot to fly parallel strips or circle as needed to completely count each group of cranes encountered on the ground. Aerial counts are more effective on clear days when cranes cast shadows increase their contrast and visibility.

Record names of the pilot and observer, start and end times, wind speed, temperature, percent cloud cover and light conditions. Record numbers and locations (GPS coordinates) of each crane flock observed.

c. Analysis of Data – The waterfowl biologist transfers aerial survey data from a tape recorder to a database. All data collected by field personnel are entered on electronic forms and forwarded to the Waterfowl Biologist, who enters the information in the database. The waterfowl biologist compiles the counts for each waterfowl management area.

d. Disposition of Data – Counts are tallied for each survey area identified in the Flyway Management Plan, and then forwarded to the survey consultant and the U.S. Fish and Wildlife Service. The total RMP count is determined and included in a report prepared annually by the consultant. The total count is also recorded in a table that is updated annually in the Flyway Management Plan. The allowable harvest is determined using the fall, pre-migration count along with the result of an annual recruitment survey that is conducted in the San Luis Valley, Colorado, each October.

2. Establishment of New Hunt Areas for RMP Sandhill Cranes –
States within the range of the RMP may hunt cranes provided they meet the conditions and data collection requirements set forth by the Flyway Management Plan for Rocky Mountain Population of Greater Sandhill Cranes. Any proposal to establish a new hunt area must be submitted in writing, and is subject to approval of the Central and Pacific Technical Committees and Councils. The Management Plan for Rocky Mountain Sandhill Cranes has established monitoring requirements to determine the age, sex, and racial composition of the harvest. These data must be collected at check stations for 3 consecutive years and evaluated afterward, unless the new hunt area is exempted because other races of sandhill cranes are not present during the harvest period. Allowable, annual harvests are allocated on a statewide basis. Consequently, permits available in existing hunt areas may be reduced when a new hunt area is approved.

a. Permits and Check Station Requirements

i. Rationale – The RMP of greater sandhill cranes is comparatively small, numbering between 16,000 and 22,000. They are long-lived birds with relatively low annual recruitment (avg. = 8% juveniles). Consequently, harvest must be tightly regulated based on a permit quota system. When other subspecies are potentially present in a new hunt area, the proportion of the harvest that must be applied against the RMP quota is based on the racial composition of the harvest.

ii. Application – If cranes of mixed racial composition are potentially present in a new hunt area, mandatory check stations must be operated for a period of 3 years to obtain morphological data. Races of harvested birds are determined based on measurements of wing chord, tarsus, and posterior culmen (Schmitt and Hale 1977) or other appropriate methods. The following information must be reported annually during the first 3 years of the hunt:
Number of craned harvested;
Racial composition of the harvest (Schmitt and Hale 1997);
Age and sex composition of the harvest'

Numbers of cranes within the hunt area immediately before, during and after the hunting season;
Numbers of hunters participating;
Number of days all persons hunted;
Number of birds harvested per hunter (success rate; and
An assessment of the effectiveness of the hunting season.

When a new hunt becomes operational after the initial 3-year period, the state must continue to collect and report the following information annually:
Number of cranes harvested;
Number of hunters participating;
Number of days all persons hunted; and
Number of birds harvested per hunter (success rate).

During the 1980s and 1990s, endangered whooping cranes were introduced in the range of RMP sandhill cranes. The Whooping Crane Contingency Plan of the USFWS requires precautions to protect whooping cranes (*Grus americana*) that enter sandhill crane hunt areas, such as posting and partial closure of hunt areas, are required by the Service's Whooping Crane Contingency Plan. Whooping cranes were originally placed in the Pacific Flyway through experiments – several resulted from eggs that were cross-fostered into sandhill crane nests during the 1980s and 4 whooping cranes were released in conjunction with a migration study using an ultra-light aircraft in 1997-98. The experiments did not result in a self-sustaining population and at the writing of this chapter, only 2 free-flying whooping cranes were known to survive in the Rocky Mountain States. Cranes in both experiments were classified as "non-essential, experimental" under the Endangered Species Act.

iii. Analysis of Data – Check station data are compiled by the State Waterfowl Biologist and summarized in tabular format.

iv. Disposition of Data – The waterfowl biologist prepares a report that summarizes and evaluates all check station data. The report is presented to the Pacific Flyway Subcommittee for RMP Sandhill Cranes at the January work session. Total numbers of RMP cranes harvested by each state are recorded in a table that is appended to the Flyway Management Plan.

b. Morphological Measurements of Sandhill Cranes

i. Rationale – morphological measurements are used to distinguish several biological characteristics. These measurements are taken at check stations operated in conjunction with newly established hunt areas. The information is used to determine age, sex, and racial composition of hunted flocks.

ii. Application

age classes: Biologists distinguish 2 age classes of cranes for management purposes: adults have a bright, red crown on top of the head; juveniles exhibit gray or reddish-brown coloration on top of the head. This classification criterion is dependable until late October.

sex: Sex is determined by internal examination of sex organs. Instruct hunters not to field dress cranes before they are presented at check stations. Look for ovaries or testes inside the body cavity, next to the backbone at approximately the last set of ribs. Cut the left side of the abdominal cavity through the last rib. Lift viscera from the roof of the body cavity, exposing the left kidney and gonad, then press the viscera aside. Gonads are very small in immature cranes. Do not confuse them with the adrenal gland, which may be shaped like an ovary. Gonads are always whitish. Adrenal glands have more color – usually orange-yellow, occasionally light yellow, or in some instances, pink or red.

Testes lie on the roof of the body cavity, just forward of the kidneys. They are about the size of a little fingernail. The left teste is generally larger than the right. Testes appear as a smooth, solid mass compared to ovaries, which are pebbled or speckled. Testes can be light or dark-colored, but are usually darker in adults.

Just 1 ovary and 1 fully developed oviduct are present in most adult females. These are always on the left side. Many rounded follicles of differing sizes are visible within the ovary. These follicles are white or yellowish in the non-breeding season, when check stations are operated.

weight: Weight is one criterion used to distinguish subspecies. Always weigh birds whole, prior to field dressing, evisceration or examination of gonads. Weights of greater sandhill cranes range from 8 to 14 lbs and average 9.5 lbs.

culmen-postnares: The length of the upper bill (mandible) is measured from the rear edge of the nostril to the distal tip of the bill.

tarsus: The length is taken from articulation of the metatarsus and tibia (at the point of the joint) to the point of the joint at the base of the middle toe in front. The tarsometatarsus is to be articulated to show the position of the condyle.

wing chord: The length of the leading (anterior) edge of the wing is taken from the wrist joint to the end of the longest primary, with the wing closed in a naturally folded and unflattened position.

mid-toe: The length of the middle toe (phalanx) is taken along its dorsal surface from the articulation of the tarsometatarsus to the base of the claw at the distal end of the phalanx.

iii. Analysis of Data – Criteria described by Schmitt and Hale (1997) are applied to the above measurements to identify age, sex, and subspecies of sandhill cranes.

This information is compiled to estimate the harvest composition within new hunt areas and to establish management guidelines. The State Waterfowl Biologist is responsible for interpreting measurement data and compiling results.

iv. Disposition of Data – Refer to Section II.B.2.a.iv. (Establishment of New Hunt Areas – Permits and Check Station Requirements)

C. Waterfowl Surveys –

1. Mid-Winter Waterfowl Survey –

a. Rationale – The annual mid-winter waterfowl survey is a coordinated census of waterfowl within major wintering areas throughout North America. This inventory was begun in 1934 and is the longest continually running survey. It is jointly conducted by federal and state wildlife agencies, although some private organizations have participated in the past. The major objective is to monitor the distribution and size of major waterfowl groups the winter in North America. The validity of population estimates obtained from this survey has been questioned, but it is the only practical means available to monitor trends of several waterfowl populations. Mid-winter counts are less useful for managing duck populations, but are the principal indices used to manage several goose and swan populations.

b. Application – Generally, mid-winter surveys are conducted between January 1 and 14. Each year, the USFWS selects the survey dates and notifies cooperators. Flights are scheduled during morning hours on days when light conditions are sufficient to distinguish and count species. The observer needs to be proficient at identifying waterfowl and at estimating large concentrations of birds, which in can sometimes number in the thousands. In Wyoming, 2 days are required for one observer to complete the Central Flyway portion of the survey. The central and lower North Platte River are flown in a day and the Big Horn, Shoshone and Wind River Systems also require a day. An observer can fly the Pacific Flyway portion of the survey (Snake, Salt, and lower Green rivers) in 1 day.

Mid-winter counts are conducted from a high wing monoplane with side-by-side or tandem seating, flown 150 feet above ground level. Both the pilot and observer should look for waterfowl. Identify and record all waterfowl seen. When large concentrations of birds are encountered, circle the group as necessary to estimate the number. Record all observations on a tape recorder.

In addition, record the date the survey is flown, names of the pilot and observer, make of aircraft, waterfowl drainage code, and an assessment of surface water, ice and weather conditions (Fig. 3). Maintain a log of elapsed ferry and survey times and miles covered. The State Waterfowl Biologist retains survey route descriptions on file.

c. Analysis of Data – As soon as each survey is completed, transcribe all information from the tape recorder to data sheets. Tally counts of each species within each river

drainage system and transfer the information to permanent forms. Beginning in 2004, the information is entered into a USFWS database file.

d. Disposition of Data – Copies of the permanent data forms are forwarded to the Service's 2 Flyway Representatives who incorporate the information into various Flyway reports. The State Waterfowl Biologist also retains copies of all data sheets and permanent forms. The State Waterfowl Biologist is responsible for submitting database files from both the Central and Pacific Flyway surveys to the Service.

2. Classification of Canada Geese –

a. Rationale – Different races of Canada geese often commingle on staging areas and winter habitats. At times, it is necessary to distinguish races for various management purposes including harvest regulation and population estimates. However, races cannot be distinguished reliably during aerial counts. Instead, samples of geese are classified on the ground based on morphological characteristics, and the proportions are extrapolated to estimate the composition of geese counted from the air. This method is used to estimate the numbers of geese from the Short Grass Prairie Population (small geese) and the Hi-Line Population (large geese) counted during the mid-winter survey in southeast Wyoming.

b. Application – Canada geese are generally classified in Wyoming between January 1 and 14, on days when light conditions are sufficient to distinguish size characteristics. A sample of 4,000 is needed. Several observers assist during the classification effort, which takes place in Goshen and Platte counties and within the North Platte River Valley downstream from Kortes Dam. Each observer attempts to classify at least 100 geese.

Small geese generally comprise 5-15% of the Canada goose harvest in eastern Wyoming. However, harvested geese are not used to estimate the composition of the mid-winter count because harvest takes place throughout the season and may reflect periods when the composition differs from that during the mid-winter count. In addition, morphological criteria applied to goose tail fans are not completely reliable to distinguish different races and results from the wing-bee are not available until later in the winter. Hunter selectivity for larger geese may also bias the tail fan collection.

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Fig. 3. Mid-winter waterfowl survey data form.

MID-WINTER WATERFOWL SURVEY	DATE:
OBSERVER:	PILOT:
AIRCRAFT:	PERCENT CLOUD COVER:
LIGHT CONDITIONS (excellent, good, fair, poor):	PERCENT SNOW COVER:
TEMPERATURE:	WIND SPEED AND DIRECTION:
WETLAND CONDITIONS:	
TIME DEPART AIRPORT:	TIME RETURN TO AIRPORT:
COUNT START:	COUNT END:
BREAK STARTS:	BREAK ENDS:
BREAK LOCATIONS:	

DRAINAGE CODE	LOCATION*	CAGO GEESE	DUCKS	BAEA AD	BAEA IMM	GOEA AD	GOEA IMM	SWANS

* At each location, count each duck, goose, eagle, and swan species. Also record percent ice on water bodies.

Small-bodied geese migrate in response to severe weather more readily than large geese. Consequently, the proportion of small geese in Wyoming during early January can vary markedly. Ordinarily, they are not very abundant and it is common to observe flocks of large geese with just a single small goose. When greater numbers of

small geese are present, they may segregate into family groups. Look for family groups of small geese on the ground, apart from larger geese.

Observers are instructed to classify geese on the ground, with the aid of a spotting scope and binoculars. Table 5 contrasts several morphological features of large and small geese. The observer should not attempt to classify geese in flight unless he is confident of his ability and visibility is perfect. Body size is the trait most commonly used to classify large and small geese. This method is most dependable when applied to mixed flocks in which smaller geese can be contrasted with larger geese, or when other species of waterfowl such as snow geese or mallards are nearby and provide a reference to size. Neck length and coloration are also useful characteristics. Giant Canada geese have the longest neck in proportion to their body, while cackling Canada geese have the shortest. The most common, large goose in Wyoming is *Branta canadensis moffitti* (the Western Canada goose), and the most common small goose is *B. c. parvipes* (the lesser Canada goose). Westerns have proportionally longer necks than lesser Canada geese. Neck length is especially useful to classify flocks of a single subspecies, including those that are of intermediate body size. In addition, large Canada geese tend to be lighter-colored than small Canada geese.

Observers are asked to record numbers of geese classified as large and small, general locations of flocks that are classified, and note any conditions that may affect the accuracy of classifications. If the geese in a flock cannot be reliably classified as large or small, do not include the flock in the classification sample.

Table 5. Some morphological characteristics of large and small Canada geese.

Size Class	Total Length (inches)	Weight (lbs)	Bill Length (inches)	Wing Length (inches)	Tail Length (inches0	Tarsus (inches)
Large	34.5[1]	8.2-12.5	2.0-2.4	18.6-20.5	5.7-6.3	3.7+
Small	no data[2]	4.8-6.1	1.3-1.7	14.3-17.4	4.6-4.8	2.5-3.4

[1] Average length of *B.c. moffiti*, (Bellrose 1976)
[2] Length of *B.c. parvipes* is generally shorter than *B.c. moffiti*, but some large individuals can overlap.

c. Analysis of Data – Results of individual classifications are forwarded to the Central Flyway Waterfowl Biologist. Numbers of large and small geese in the classification samples are tallied and the ratio is applied to estimate the composition of geese counted during the mid-winter survey.

d. Disposition of Data – Permanent data forms from the mid-winter waterfowl survey are forwarded to the USFWS Central and Pacific Flyway representatives for inclusion in

various flyway reports. The Central Flyway goose counts include estimates of geese from the Hi-Line and Short Grass Prairie populations. The Waterfowl Biologist maintains copies of all data sheets and permanent forms.

3. Canada Goose Breeding Ground Survey

   a. Rationale – An aerial survey is flown annually to monitor population trends of resident (breeding) Canada geese. All geese that nest in Wyoming are Great Basin or Western Canada geese (*B. c. moffitti*). In the early 1950s, permanent survey routes were established within the major drainages in the state to determine the distribution and size of resident goose populations. Data have been collected annually since then, and used to construct long-term trends. In northeast Wyoming, the survey has been expanded to include new areas in which nesting geese have pioneered. However, a large region from Lusk north is still not surveyed due to personnel and financial limitations.

   b. Application – Breeding pair surveys are conducted immediately before clutches begin to hatch. Hatching dates vary annually depending on weather patterns. In general, flights should cover lower elevations during April and higher elevations in late April or early May. The survey in the Central Flyway portion of Wyoming is typically flown between April 15 and April 25. On the Pacific Flyway side, the appropriate survey period is the last two weeks of April and first week of May. Schedule flights on clear, calm days and complete the survey between 7 and 11 a.m. If necessary, surveys can be done between 4 and 7 p.m. weather permitting. However, surveys should not be during the midday period to flat light conditions. Survey procedures were developed and refined over a 50-year period. For general procedures and guidance regarding waterfowl surveys, refer to USFWS 1987 and 2003a.

      The observer should be familiar with nesting habits of Canada geese as well as the area surveyed. Conduct all surveys from a high-wing monoplane at airspeeds of 50 to 80 miles per hour and an elevation of 200 feet or less above ground level. The same pilot and observer should conduct surveys from year to year to maintain consistent observer bias and survey coverage.

      Systematically follow all river channels and shorelines of lakes and reservoirs. Both the pilot and observer should look for geese. Record the following information on a cassette tape: waterfowl drainage code, date, and numbers of pairs, females on nests, single birds and groups of birds encountered. Also note water levels and other information relevant to breeding conditions. The State Waterfowl Biologist maintains descriptions of survey routes.

   c. Analysis of Data – As soon as each flight is concluded, transcribe all data from the tape recorder to appropriate forms (Fig. 4). Data are compiled and summarized for each waterfowl management area. A breeding pair index is calculated by adding the numbers of females observed on nests, single geese representing males that are part of a pair bond, and pairs observed. The breeding population is estimated by doubling the

number of females on nests and single males, and then adding the number of birds observed as pairs and groups. A nesting pair index is derived by adding the number of females on nests to the actual number of pairs observed. All estimates and indices are adjusted by a factor of 2.0 to account for visibility bias. Decreasing population trends should be examined closely. When decreasing trends span several years of records, potential causes should be investigated. Evaluate habitat conditions, harvest information, band recoveries and other relevant data to determine possible factors depressing the population.

d. Disposition of Data – All data sheets are submitted to the State Waterfowl Biologist, who in turn forwards copies to the Service Flyway Representatives and applicable Subcommittees. Population-wide trends are evaluated by assembling breeding data from all states and provinces within the breeding range. This information is appended to management plans and published in various Service reports. The State Waterfowl Biologist retains copies of all breeding survey data.

Fig. 4. Canada goose breeding ground survey data form.

CANADA GOOSE BREEDING SURVEY	DATE:
OBSERVER:	PILOT:
AIRCRAFT:	PERCENT CLOUD COVER:
LIGHT CONDITIONS (excellent, good, fair, poor):	PERCENT SNOW COVER:
TEMPERATURE:	WIND SPEED AND DIRECTION:
WETLAND CONDITIONS:	
TIME DEPART AIRPORT:	TIME RETURN TO AIRPORT:
COUNT START:	COUNT END:
BREAK STARTS:	BREAK ENDS:
BREAK LOCATIONS:	

DRAINAGE CODE	LOCATION OR RIVER REACH	FEMALE ON NEST	FEMALE ON STRUCTURE	SINGLE MALE	PAIRS	GROUPS

4. Duck Breeding Ground Survey. [The duck breeding pair survey was suspended in Wyoming after the 1999 flight due to logistical constraints and because the Service no longer directly uses the data from Wyoming].

   a. Rationale – Breeding ground surveys are done annually by the USFWS to monitor breeding duck populations and to evaluate habitat conditions. The surveys are flown throughout a traditional survey area in Canada, the Dakotas and eastern Montana. In addition, several state cooperators conduct surveys outside the traditional area. Data from the traditional survey area are used to set annual hunting seasons in the United States. However, Wyoming is not within the survey blocks from which the status of continental duck populations is determined annually.

   b. Application – About 54,250 mi^2 of Wyoming (half the State's surface) is considered potential breeding habitat for waterfowl. In 1954, the Waterfowl Section, assisted by the University of Wyoming Statistics Department, delineated sample areas (survey blocks) in which breeding pair counts would be conducted. However, the sample areas were not stratified according to habitat zones. Eight survey blocks comprising 209 mi^2 were established in the Pacific Flyway (west of the Continental Divide), and 48 survey blocks totaling 2,090 mi^2 were established in the Central Flyway. A higher density of survey blocks was selected in the Central Flyway to address sampling issues associated with denser waterfowl use and variable habitat conditions from year to year. Areas with extremely low densities of breeding waterfowl, including deserts, national forests, and Yellowstone National Park, were excluded from the areas surveyed. The official survey blocks have been delimited on BLM 1:100,000 surface maps that are used to locate survey boundaries from the air. The State Waterfowl Biologist maintains copies of the maps.

      Procedures for conducting breeding waterfowl counts and assessment of breeding habitat conditions are described generally in Series 700 of the U.S. Fish and Wildlife Service Manual. In Wyoming, the following procedures are used:

      Duck breeding ground surveys are conducted during the middle 2 weeks of May and requiring about 80 hours of flight time. The observer should be proficient at identifying species and sex of waterfowl from the air. For consistency, the same

observer and pilot should conduct surveys from one year to the next. A high-wing, monoplane with side-by-side or tandem seating is used. The aircraft is flown between 50 and 80 mph at an average elevation of 150 ft above ground level. Fly parallel strips in areas with extensive surface water, and follow drainages in areas of sparser water. In order to accurately classify larger groups of waterfowl, it is sometimes necessary to circle a water body. Optimally, surveys should be completed between a half hour before sunrise and 10:00 a.m. on calm, clear days. In the event of weather delays, afternoon flights can be done after 1600, weather permitting, but they are less effective than morning flights.

Record the date of the survey, names of the pilot and observer, make of aircraft, name of the survey block, county, waterfowl drainage code, an assessment of surface water, and weather conditions (Fig, 5). Maintain a log of elapsed ferry and survey times. Record all observations on a cassette tape. Both the observer and pilot should look for waterfowl. When waterfowl are encountered, count the numbers of pairs, single males, single females, and grouped birds of each species. Distinguish sex within groups as possible.

Fig. 5 Duck breeding ground survey recording form.

DUCK BREEDING GROUND SURVEY	DATE:
SURVEY AREA/NUMBER:	SQUARE MILES IN AREA:
OBSERVER:	PILOT:
AIRCRAFT:	PERCENT CLOUD COVER:
MORNING: OR EVENING: FLIGHT	
VISIBILITY [light and wind] (excellent, good, fair, poor):	
TEMPERATURE:	WIND SPEED AND DIRECTION:
TIME DEPART AIRPORT:	TIME RETURN TO AIRPORT:
COUNT START:	COUNT END:
BREAK STARTS:	BREAK ENDS:
BREAK LOCATIONS:	

SPECIES	**PAIRS**	**SINGLE MALES**	**SINGLE FEMALES**	**GROUPS/ # AND SEX**
COMMON MERGANSER				
MALLARD				
GADWALL				
AMERICAN WIGEON				
GREEN-WINGED TEAL				
BLUE-WINGED TEAL				
CINNAMON TEAL				
UNIDENTIFIED TEAL				
NORTHERN SHOVELER				
NORTHERN PINTAIL				
WOOD DUCK				
UNIDENTIFIED DUCK				
REDHEAD				
CANVASBACK				
LESSER SCAUP				
RING-NECKED DUCK				
COMMON GOLDENEYE				

BARROW'S GOLDENEYE				
BUFFLEHEAD				
RUDDY DUCK				
TRUMPETER SWAN				
SANDHILL CRANE				
AMERICAN COOT				
CANADA GOOSE BROOD				
BALD EAGLE NEST LOCATION				

HABITAT COMMENTS: Circle appropriate descriptors)	High water	River high	Ponds/Res. full	No runoff
	Low water	River low	Ponds/Res. low	Runoff started
No irrigation	Normal water	Trees leafed	Ponds/Res. dry	No water in canals
Fields flooded	Good count	Fair count	Poor count	
Single Males - includes single males and 2-3 flocked drakes. Two drakes and a hen, in a group, are recorded as one pair and a drake.				
Groups - are either 4 or more flocked drakes or mixed.				

Observers' abilities to detect and identify duck species from the air vary. For this reason, a correction factor must be determined for each observer and for each species. Correction factors are estimated by conducting ground checks in small areas within the survey area. Ground check plots are thoroughly surveyed by an experienced crew of 3 or 4 persons while the observer conducts the aerial survey at the same time. The assumption is the ground crew detects all ducks in the area. The aerial survey data are compared against the ground count data to estimate a visibility correction factor for the observer.

c. Analysis of Data – Raw data from the aerial survey are extrapolated twice to obtain statewide estimates. The first extrapolation is based on the visibility bias correction. The second extrapolation is a geographic expansion based on the area of potential breeding habitat (54,249 mi^2) divided by the area actually surveyed (2,299 mi^2). For example, assume the observer detects 50 mallard pairs within the ground check plots and the ground crew detects 80. The observer's visibility correction factor is 50/80 or 0.625. Now assume the observer recorded 600 mallard pairs during the entire survey. The corrected number is 600 /0.625 or 960 mallard pairs. The geographic expansion factor for the statewide estimate is 54,249/2,299 or 23.6. The statewide estimate of mallard pairs is 960 X 23.6 or 22,656.

A similar procedure is used to extrapolate the number of grouped birds observed per species. The statewide estimate for each species is determined by doubling the estimate of breeding pairs and adding the statewide estimate of grouped birds. The estimate of total ducks is the sum of all species estimates.

Two statistics are calculated for each species. One is the total number of breeding pairs and the second is the total abundance. Statistics from the current and prior year, and long-term averages are compared. Proportionate changes are determined. In addition, a projection of the Fall Flight Index is made based on breeding pairs and

total numbers of ducks in the spring count, and an assessment of habitat conditions. This index is the number of ducks of each species expected to migrate south considering the spring population and expected recruitment.

d. Disposition of Data – Data from breeding duck surveys are forwarded to the U.S. Fish and Wildlife Service. The USFWS annually prepares a report that summarizes results of breeding duck surveys in traditional survey area, and data from state cooperators. The State Waterfowl Biologist maintains copies of all Wyoming data sheets.

5. Molting Canada Goose Survey –

a. Rationale – One of the management plan objectives for the Rocky Mountain Population (RMP) of Western Canada Geese is to maintain the distribution of molting geese within the population. Surveys are conducted annually to monitor numerical trends at known, major molting concentrations.

b. Application – All molting geese within the areas surveyed in Wyoming are considered RMP geese. Although HLP geese nest on the Laramie Plains, we don't currently know where they molt. We suspect they move north and east. The geographic divisions between RMP and HLP Canada geese are recognized differently for the goose breeding pair survey, the molting goose survey and harvest allocations.

The molting goose survey is conducted during the last week of June or first week of July. The objective is to fly when the geese are flightless. All Canada geese observed in each area are counted and the information is recorded on a cassette tape. The State Waterfowl Biologist maintains a list of areas surveyed. Because of distances and ferry time between molting areas, the survey requires 2 days to complete.

Obtain clearance from Teton National Park, the National Elk Refuge, and Yellowstone National Park, before flying over these administrative units. This is in part done as a courtesy, but also avoids complaints and inquiries after the flight is complete.

c. Analysis of Data – The waterfowl biologist transcribes data from tape to a spreadsheet after each flight. Numbers of geese counted are tallied for each molting area added to obtain a total count. The information is compared against counts from prior years to monitor trends.

d. Disposition of Data – Data from molting goose counts are summarized and forwarded annually to the Pacific Flyway Subcommittee for RMP Canada Geese (Subcommittee on Rocky Mountain Canada geese 1992). Results of molt surveys are periodically incorporated into updates of the RMP Management Plan.

D. Trumpeter and Tundra Swans

As there are no hunting seasons for swans in Wyoming. The Non-game Section has primary responsibility for swans (Refer to Chapter 19 – Non-game Birds). Swans observed during waterfowl surveys are recorded and the information is sent to the Non-game Section. The Pacific and Central Flyway Waterfowl biologists participate in swan subcommittees at the Flyway level.

III. HARVEST DATA –

A. Harvest Survey –

1. Rationale – Managers require estimates of migratory game bird harvests for a variety of purposes. Results from harvest surveys are used to determine if harvest quotas or objectives have been achieved or exceeded. Season structures are adjusted accordingly. Harvest mortality estimates are also included in population models for some species. Finally, harvest and effort data can provide useful insights regarding population trends of some species.

2. Application – Both the Department and the U.S. Fish and Wildlife Service conduct surveys to estimate migratory bird harvests. The Department obtains harvest information from its annual survey of small, upland game, and migratory game bird hunters. The survey is mailed to all persons who purchased a state game bird or small game license. Harvests of migratory game birds are estimated from data provided by the respondents who hunted migratory game birds. A third party contractor historically conducted the survey, however the Biological Services Section took it over following the 2002-03 hunting season. In addition, Biological Services does special surveys of limited quota permit holders for early sandhill crane and Canada goose hunts, and permit holders for the Light Goose Conservation Order.

   The U.S. Fish and Wildlife Service conducts harvest surveys through the Harvest Information Program (HIP). Each licensed hunter is required to obtain a HIP validation from each state in which the person hunts migratory game birds. When a HIP validation is issued, the person is asked to identify the species and numbers of migratory game birds harvested the prior year. The U.S. Fish and Wildlife Service uses this information to establish sample frames for conducting surveys to estimate harvests of various species. The Service also surveys holders of federal permits to hunt mid-continent, lesser sandhill cranes.

3. Analysis of Data – The Biological Services Section compiles harvest information obtained from the survey of small, upland game bird and migratory bird hunters. The Waterfowl Biologist compiles harvest information obtained from holders of limited quota permits for early sandhill crane and Canada goose hunts, and holders of permits for the Light Goose Conservation Order. Harvest estimates are simple extrapolations of the information provided by respondents, based on total numbers of licenses or permits issued. Harvest data are presumed the same for respondents and non-respondents to the small, upland game bird and migratory bird harvest survey, so a correction for non-response bias is not

applied. Non-response bias is corrected in the other two surveys by assuming harvest data for non-respondents are the same as data derived from respondents to a second mailing.

Based on HIP sample frames, the U.S. Fish and Wildlife Service develops harvest estimates of waterfowl and webless migratory game birds for each state and management zone. Annual harvest estimates from both state and federal surveys are appended to long-term data sets from which harvest trends and objectives can be evaluated.

4. Disposition of Data – The Department's estimates of migratory bird harvests are published in the "Annual Report of Upland Game and Furbearer Harvest." Both statewide and individual management area harvests are included. Harvest estimates from early sandhill crane and Canada goose hunts are summarized in spreadsheets provided to flyway subcommittees and the U.S. Fish and Wildlife Service. This information is periodically appended to tables in the applicable flyway management plans. Harvest estimates from the Light Goose Conservation Order are forwarded the U.S. Fish and Wildlife Service. The State Waterfowl Biologist maintains data files containing harvest estimates derived from all surveys conducted by the Department. Harvest estimates derived from the HIP are summarized in the annual flyway data books, prepared by the Service's Flyway Representatives.

IV. MORTALITY ESTIMATION (non-hunting) –

Sources of non-hunting mortality can include accidents (collisions with power lines and other obstacles, entanglement in nets or fishing line), diseases, poisoning from toxins or other environmental contaminants, entrapment in oil ponds, climatic events (hail, drought), poaching, predation, starvation, and agricultural activities such as haying and tilling. Impacts of most mortality events are localized, however some can have population-level significance. Waterfowl mortalities are predominantly detected through incidental observations. Structured surveys are only done to estimate losses during extremely large events such as cholera outbreaks, botulism poisoning, or oil spills.

A. Incidental Observations –

1. Rationale – Although many sources of mortality such as drought and disease are beyond the control of managers, the severity of some mortality events can be moderated if appropriate remedial actions are taken when a problem is identified. For this reason, mortalities of migratory game birds should be documented, especially when several mortalities are detected within a limited area or during a relatively short period. Mortality records can aid in identifying problems, provide useful evidence when illegal activities are suspected, and may provide a numerical basis to estimate the value of resources lost, for example, when oil and gas spills take place.

2. Application – Mortalities of migratory game birds should be recorded on wildlife observation forms for subsequent entry in the Department's Wildlife Observation System database. Identify the cause of death when it is apparent, for example, collisions with a power line, fence, or other obstacle, entrapment in an oil pond, predation, and so forth. If

disease or poisoning is suspected, notify the U.S. Fish and Wildlife Service agent in Casper and the Ecological Services Office in Cheyenne. Collect and preserve specimens in good condition for later necropsy and testing. Whenever illegal activities may be involved, notify a district game warden or the federal wildlife agent in Casper, but do not disturb the site. Always follow these notification procedures when a major mortality event is discovered (numerous dead or dying birds found within a limited area). If a large mortality event has taken place, it may be necessary to conduct a systematic survey of the area to estimate the total loss. The U.S. Fish and Wildlife Service will take the lead in determining appropriate methodologies for inventorying the site.

Remedial actions can be implemented when they are effective and economical. For example, a power line can be buried or markers attached to resolve chronic bird collisions in a specific location. Water level regimes can be managed to control avian botulism in ponds or wetlands that have water-regulating structures. In other cases, birds can be hazed away from areas in which toxic substances are chronically exposed. Habitats in which spent lead shot remain accessible to waterfowl can be disked to increase the depth toxic shot is buried. Oil waste ponds should be covered with mesh to exclude birds. Farmers can be encouraged to plant fall-seeded crops and to cut hay after mid-July to reduce mortality of nesting ducks. Predator control is sometimes justifiable in areas of unnaturally high predator densities and where non-indigenous predators have pioneered in response to land management practices. Other remedial actions must be tailored to address specific problems.

3. Analysis of Data – Mortality records provide important documentation. Compilations can be done to identify seasonal or spatial patterns, which can assist with identifying sources of mortality and planning remedial measures. Such records are especially useful in problem areas with recurring mortality events. When a significant mortality event has taken place, total losses are estimated by expanding (extrapolating) data from systematic surveys, based on the methodology employed.

4. Disposition of Data – All mortality records of migratory game birds are entered in the Department's Wildlife Observation System database. Any reports or other documentation prepared after major mortality events will be retained in the State Waterfowl Biologist's files and provided to the USFWS.

V. DISTRIBUTION AND MOVEMENT –

A detailed knowledge of seasonal ranges, migration corridors, crucial habitats, and population boundaries is essential to manage migratory game birds effectively. This information is also indispensable documentation for analyzing impacts of development projects and justifying mitigation. The Department often considers distribution and migration patterns when setting hunting seasons and the data are used for various planning purposes by other resource agencies, companies, and NGOs. Seasonal habitats and population boundaries are delineated on maps of waterfowl management areas maintained in the Casper Regional Office. Distribution and movement data are obtained from observations of marked birds, aerial surveys, and incidental observations.

A. Marking Studies –

1. Rational – Managers can obtain detailed information about migratory game bird distribution and movements from field studies of marked birds. Appropriate marking systems will depend on the study objectives, type of data required, observation or collection methods, and project budget. Birds can be fitted with leg bands, visible markers or radio signal transmitters.

2. Application – Depending on objectives of the study, locations of marked birds are recorded during systematic surveys, as legal harvests, or incidentally during other field activities. The information is accumulated in geographic databases.

3. Analysis of Data – Data are interpreted to improve knowledge about distribution, seasonal movements, and population interchange. Consideration is given to time of year, the effects of weather patterns such as snow cover and storm events, and hydrologic conditions.

4. Disposition of Data – Records of observations and other relevant information are compiled in a database and entered in the Wildlife Observation System. Conclusions are discussed in applicable JCRs. Interim and final project reports should be appended to the JCRs.

B. Aerial Surveys –

1. Rational – Aerial surveys are a relatively quick method used to document migratory game bird distributions and concentrations throughout large areas. Flights are scheduled to during the seasons in which distribution data are sought.

2. Application – Plan aerial surveys to make effective use of manpower, funds, and favorable weather conditions. Conduct flights in the early morning or late afternoon on clear days. Record drainage codes for each observation of a targeted species and enter this data in the Wildlife Observation System.

3. Analysis of Data – Compare distributions of migratory game birds documented during surveys to the seasonal habitats delineated on existing waterfowl management area maps. Update maps when seasonal distribution data obtained during normal or severe weather patterns indicate refinements are needed.

4. Disposition of Data – Results of distribution surveys should be evaluated and discussed the annual JCR. Enter each location into the Wildlife Observation System.

C. Incidental Observations –

1. Rationale – Knowledge of migratory game bird distribution is continually improved as additional data are gathered. Incidental observations are a non-structured means of obtaining data to document use of areas not previously surveyed, and may alert managers to shifts that have taken place in response to development or changing land management practices.

2. Application – Biologists should record incidental observations of migratory game birds when the location, time of year or other circumstances contribute further insight about distribution patterns. Give particular attention to areas in which changes in land uses are proposed or underway, and to previously unoccupied habitat.

3. Analysis of Data – Refer to Section V.B.3. (Aerial Surveys).

4. Disposition of Data – Records of incidental observations are entered in the Wildlife Observation System. Waterfowl management area maps are revised when distribution data indicate adjustments of boundaries or range delineations are warranted. All revisions and associated rationale should be described in the applicable JCR.

VI. CAPTURE METHODS –

A. Pre-season Duck Trapping and Banding –

1. Rationale – Recoveries of birds banded prior to the hunting season afford managers a means to estimate direct mortality rates attributed to hunting, and to map migration corridors from breeding areas to wintering grounds. Both a federal permit issued by the USFWS and a state permit issued by the jurisdictional wildlife agency are required to capture and band migratory birds. All prospective banders should obtain a copy of the *Bird Bander's Manual* (USFWS 1976) issued by the Service before attempting any banding.

2. Application – Several kinds of baited traps have been devised over the years to capture ducks. Some, like the Colorado ramp trap, require considerable effort to set up and are not very mobile. Panel-type traps, like the Salt Plains trap (Szymczak and Corey 1976) are easy to assemble and can be moved to new locations quite readily. Panel traps are used in Wyoming. The basic design of the Salt Plains trap is illustrated in Fig. 6. Baited traps are usually set in lakes, marshes or sloughs. Traps should be located in open pockets

of marsh vegetation or along shorelines accessible to both birds and banding personnel. The pond or marsh bottom should be firm for ease of walking. Pre-season trapping can begin in early August and continue until mid-September. Cereal grains are used as bait.

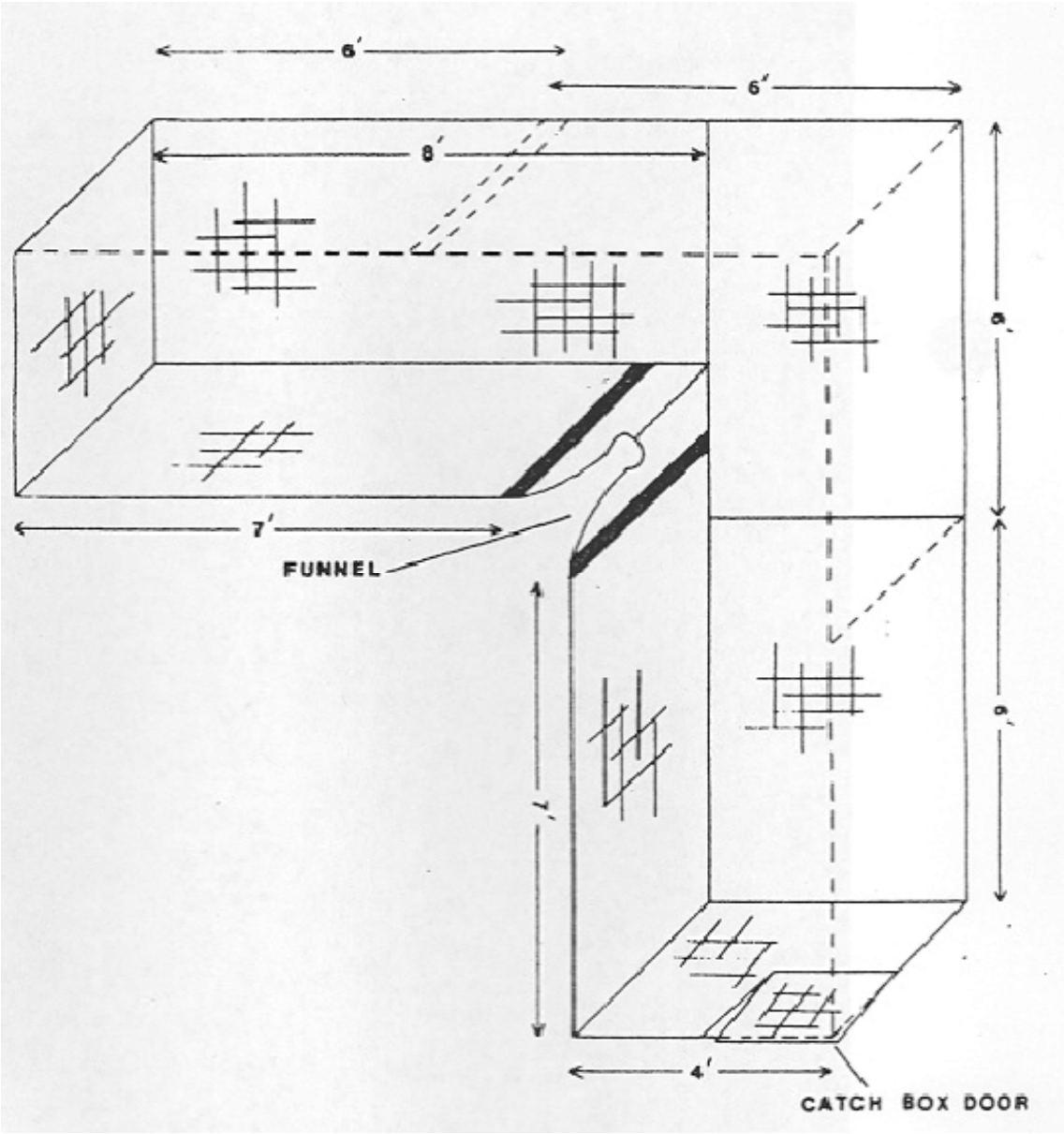

Fig. 6. Diagram of assembled modified salt plains duck trap (diagram by Shannon Heath).

It is more difficult to age and sex ducks captured during a pre-season banding operation than during winter trapping. A large variety of species in eclipse plumage and juveniles in varying stages of development will be encountered. Consequently, numerous criteria are used to identify species, age and sex. References include Bellrose (1976) and

Waterfowl Identification in the Central Flyway published by the Central Flyway Council (1999). Inexperienced personnel should consider attending one of the Flyway wingbees.

Cannon-nets are another effective means often used to capture large numbers of waterfowl. Either the mortar-type, which fires a projectile, or the newer rocket-propelled model is suitable. Cannon-nets are used to trap both geese and ducks, however one-inch mesh netting should be used to prevent ducks from entangling their wings. Suitable trapping sites include open fields and shorelines with low vegetation or crop stubble. Pre-baiting is essential to draw birds within the carrying distances of the netting. Refer to *Bird Bander's Manual* and to Dill (1969) for a detailed description of equipment and techniques.

The Supervisor of Biological Services orders all bands from the Bird Banding Laboratory, USGS Patuxent Wildlife Research Center, Laurel, Maryland. Refer to the *Bird Bander's Manual* to identify appropriate sizes of bands for various species. Reward bands are used in some studies to estimate band-reporting rates.

Always record the following information during banding operations: band number, species, age and sex when applicable, location and date. These data are entered on banding report forms and forwarded to the person responsible for maintaining the Band Manager Program in the Biological Services Section.

3. Analysis of Data – Whenever a banded duck or goose is recovered, the number of the band, name and address of the person who took the bird, and date and location of kill should be reported using the Bird Banding Laboratory's website. The Bird Banding Laboratory will notify the submitter of the date and location the bird was banded and the person or organization that banded the bird. Copies of this information should be sent to the person who harvested or found the banded bird, the person who reported the kill, the wildlife organization of the state in which the bird was recovered, and the bander. Band return data are subsequently analyzed to determine species movements, harvest mortality and effects of management adjustments. Returns from each banding location are plotted on band return maps of North America.

   Harvest is an important mortality factor in both duck and goose management. Continuous banding programs enable managers to estimate annual waterfowl mortality. Methods used to analyze band returns include Seber (1970), which applies only to adults, and Anderson and Burnham (1976), the time-varying survival rate method. Results of band data analyses are used to determine the geographic distribution of harvest and the impact of regulations on rates of harvest of various species.

4. Disposition of Data – Data from banding operations conducted in Wyoming are submitted to the Biological Services Section in Cheyenne at the end of the month in which the banding is conducted. Copies of the data are then forwarded to the USGS Bird Banding Laboratory by the 10th of the following month. The State Waterfowl Biologist also retains a copy in his files. Refer to the *Bird Bander's Manual* for band schedules and appropriate codes.

B. Post-season Duck Trapping and Banding –

1. Rationale – Waterfowl are banded on winter grounds, after the hunting season, to study movements and migration patterns. Historically, banding was done to define Flyway boundaries. Additional purposes, which aid in the management and conservation of various species, include studies of mortality, population dynamics, and migration chronology.

2. Application – Baited trap and cannon-net techniques, similar to those used in pre-season duck trapping, are used to capture waterfowl in winter. Post-season banding is usually done in areas that support concentrations of wintering birds. As availability of food and ice-free water decrease, birds congregate and larger numbers are trapped more efficiently.

   Baited traps are generally set up in locations that remain ice-free, such as warm water drains, creeks and rivers where birds concentrate. Trapping sites are pre-baited before and during trap construction to attract and precondition large numbers of birds. Trapping and banding usually begin in mid-January and continue through February. Baits vary with the location, but cereal grains are preferred in most cases.

   In Wyoming, mallards are generally targeted in post-season trapping and banding operations. Determining sex is no problem because plumage is distinctively dimorphic, but distinguishing immature and adult birds can be a challenge for inexperienced banders. Characteristics of the greater tertial coverts are the primary criteria used to determine ages of mallards. Immature birds have narrow and worn tertial coverts. In adults these feathers are broad and do not appear worn. Refer to Carney (1992) for a detailed explanation of age criteria. Anyone inexperienced at duck trapping and banding should consider attending one of the Flyway wingbees to learn wing characteristics used to identify species and determine ages and sexes of ducks.

3. Analysis of Data – Refer to Section VI.A.3. (Pre-season Duck Trapping and Banding).

4. Disposition of Data – Refer to Section VI.A.4. (Pre-season Duck Trapping and Banding).

C. Pre-season Canada Goose Trapping and Banding –

1. Rationale – Large numbers of Canada geese can be handled and banded efficiently at molt concentration areas during early summer. Recoveries of geese banded prior to the hunting season enable managers to estimate direct (hunting-caused) mortality rates, examine patterns of exploitation, and identify migration paths and seasonal habitat use.

2. Application – Before a banding operation can begin, the leader must acquire necessary state and federal permits. All prospective banders should obtain a copy of the *Bird Bander's Manual* available from the U.S. Fish and Wildlife Service's Bird Banding Office.

   Canada geese instinctively congregate on larger, remote waters to molt. Yearling and non-breeding adult geese may undertake extended migrations to traditional molting grounds. Reproductive adults and flightless broods congregate on large wetlands and lakes near breeding areas. The State Waterfowl Biologist maintains records of molting areas where capture operations can be conducted effectively.

   In Wyoming, wing traps are used to capture molting geese. The last 2 weeks of June are the optimum time to capture flightless geese. Wing traps are erected on a point or channel between 2 portions of a lake. The trap enclosure (capture pen) is a circular fence of 4-ft high nylon mesh with a 2-ft wide entryway, large enough to hold the maximum number of geese that may be captured (Fig. 7). Wing fences extend in a "V" configuration, 200-300 yards from the entryway, with the open end facing the direction from which geese will be driven. Where possible, shoreline features are incorporated into the trap layout, to provide a natural corridor into the wing fences. Wing fences are constructed of nylon mesh at least 3 ft high and extend below the surface of the water. The angle between the wings is approximately 110 degrees. The capture pen and wing segments within 50 yards must be reinforced to prevent excited geese from knocking the fence down and escaping. The outlying 100 yards of wing fence needn't be 3 feet high, but the mesh should extend into the water so geese cannot escape beneath the fences.

   Use 2 or 3 small, outboard boats to slowly haze geese toward the open end of the wing fences and into the trap. Once geese are in the trap, avoid excessive disturbance and human activity near the geese. Remove goslings immediately and transfer them to a separate holding pen to prevent injury. Goslings are banded and placed back in the separate pen. As adults are removed from the capture pen and banded, they should be placed in a third holding pen. When banding is completed, release all geese at the same time – adults first and goslings immediately afterward.

   Male and female Canada geese have identical plumage, so sex is determined by internal, cloacal examination. However, sex of captured geese is not recorded in Wyoming. Geese trapped post-season are not aged because criteria are not available to reliably distinguish between adult and immature birds at this time of year.

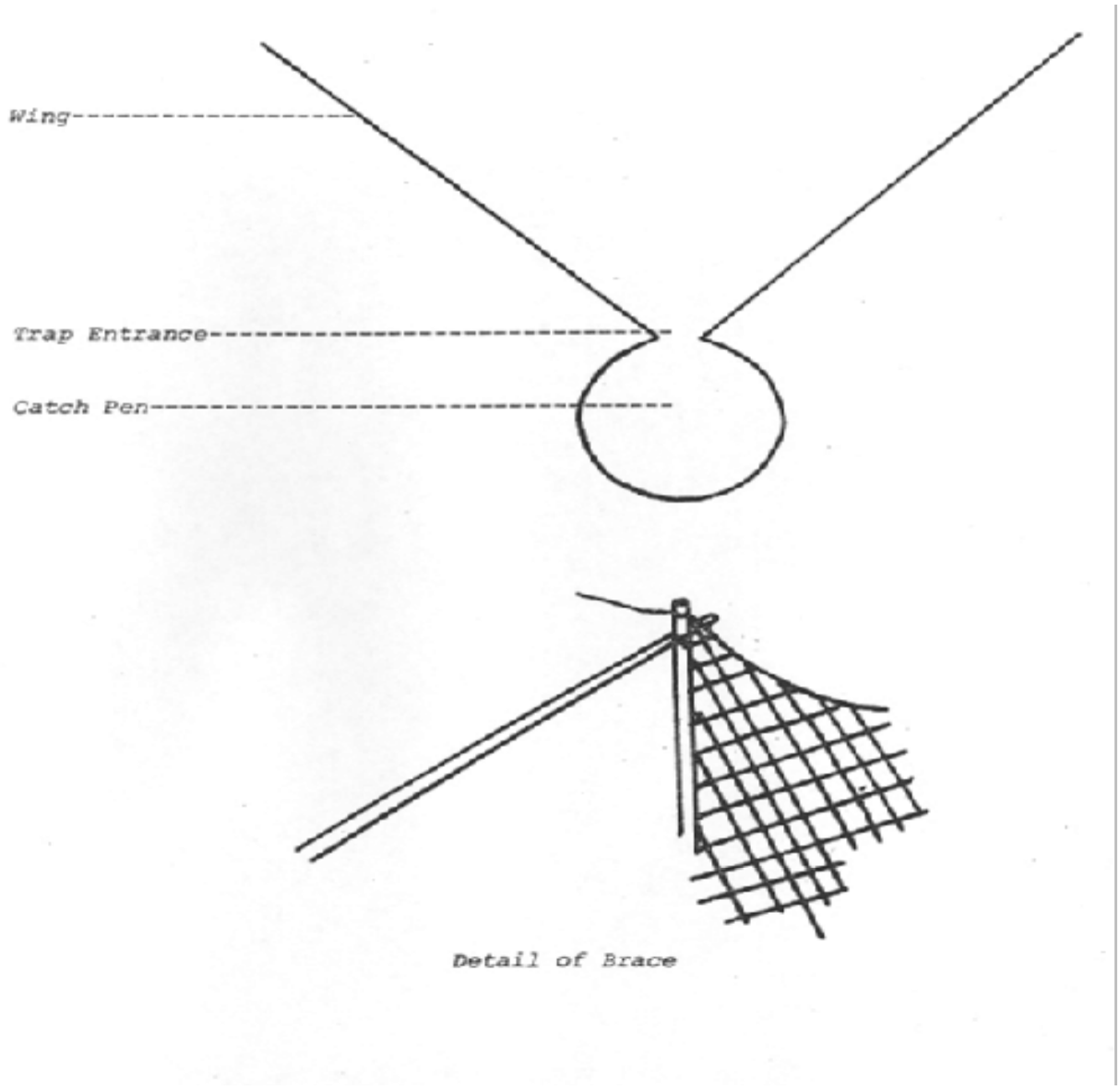

Fig. 7. Schematic diagram of Canada goose drive trap.

3. Analysis of Data – At the time of banding, the following data are recorded on forms provided by Waterfowl Biologist: band number, species, age and sex as applicable, location and date banded. Canada geese are classified as adult or juvenile. Since male and female geese cannot be distinguished based on plumage characteristics, sex of captured geese is not recorded in Wyoming. Sex can be determined through internal, cloacal examination.

   Harvest is an important mortality factor in management of Canada goose populations. When the number of direct (first year) band recoveries exceeds 20%, the population will generally begin to decline. Continuous banding programs enable managers to estimate annual mortality rates. Methods described by Seber (1970) and by Anderson and Burnham (1976) are commonly used. The Seber method applies only to banded adults. The Anderson and Burnham method is also known as the time-varying survival rate method. Results of band data analyses are used to determine the geographic distribution of harvest and the impact of regulations on rates of harvest, both major consideration in a waterfowl management program.

4. Disposition of Data – Data from all banding operations conducted in Wyoming are submitted to the Biological Services Section at the end of the month in which the banding is conducted. Copies of data are then forwarded to the USFWS Bird Banding Office by the 10^{th} of the following month. The State Waterfowl Biologist retains a copy in his files. Refer to the *Bird Bander's Manual* for band schedules and appropriate codes.

D. Relocating Canada Geese

1. Rationale – Historically, breeding populations were reestablished through gosling transplants in many areas of Wyoming. Goslings that are transplanted at an early age become imprinted on the transplant area, return to that location, and eventually nest there. Candidate areas should be evaluated to determine if suitable habitat is available to sustain nesting birds. In some cases, restricted hunting seasons may be necessary to protect the transplanted geese. Resident populations of Canada geese currently occupy suitable, vacant habitats in Wyoming, and in several cases, they are expanding into urban areas where they have increased to nuisance proportions. We do not anticipate a need for further transplants in Wyoming. However, transplants of goslings could potentially be considered to alleviate damage problems, provided this does not lead to further conflicts in the release area.

2. Application – Capture operations conducted during molting periods are the best source of goslings for transplants. Goslings should be at least six weeks old, but not capable of flying. The birds should always be transported in holding crates with proper ventilation. A trailer designed and constructed to transport geese is maintained on the Waterfowl Section's equipment inventory.

   Geese will not be transplanted for the purposes of establishing new populations when resident Canada goose populations are over objective.

3. Analysis of Data – All transplanted birds are banded to provide information on harvest distribution and mortality rates. Complete banding data forms as described in Section V.A.3 (Marking Studies). Consult the *Bird Bander's Manual* to obtain banding codes that designate transplanted birds.

4. Disposition of Data – Refer to Section VI. A. 4. (Pre-season Duck Trapping and Banding)

VIII. DEPREDATION

A. Rationale – Waterfowl depredation can damage growing, mature or stored crops, and grass on golf courses, pastures, and other locations. Crop depredation by waterfowl is often more perception than reality, however large concentrations of waterfowl can reduce crop yield when they feed on mature crops prior to harvest, or on growing crops. Waterfowl also cause problems in urban environments where they feed on lawns, parks and golf courses, and their excrements damage property, create public health and aesthetic issues, and impact water quality of urban ponds and lakes. In addition, airplane strikes have become serious safety hazards at some airports. Depredation takes place throughout the year.

In Wyoming, crop damage by cranes, ducks and geese is the most common form of waterfowl depredation. Cranes can damage crops from May through October, however most claims involve damage to grain crops during August through early September, just prior to harvest. Geese can damage emerging crops during spring through early summer, especially in fields near wetlands where broods are raised. Farmers tend to be concerned most about crop consumption by ducks and geese during August and September, prior to harvest of small grains, and during November when corn is harvested. Geese also forage on winter wheat during the fall and spring migration periods, however light to moderate grazing seldom reduce crop yield, because winter wheat re-sprouts after it is severed. Additional types of depredation can include consumption of grain and waste grain intended for livestock consumption in feedlots and harvested fields, respectively. In western Wyoming, we have received depredation complaints involving geese grazing in pastures and hayfields in spring and after the first cutting of hay in mid to late summer.

B. Application – State statute requires the Wyoming Game and Fish Department to compensate landowners for crop damage caused by big and trophy game animals or game birds. District game wardens investigate claims for compensation arising from damage allegations. Landowners experiencing damage often request advice or assistance from game wardens to protect their property. Various techniques are used to haze waterfowl away from fields in which depredation is taking place. Scare devices include products that discharge or explode (e.g., cracker shells), predator silhouettes, scarecrows, flagging, twirling objects, revolving lights, recorded alarm or distress calls, and other visual or noise-making deterrents. In some situations, chemicals are applied to make vegetation unpalatable. Drawbacks include costs and labor necessary to implement intensive measures, potential displacement of waterfowl depredation to other locations, and in some cases, acclimation of waterfowl to the scare device, which then loses its effectiveness. When damage occurs at times of year hunting is allowed, sport hunting can be an effective deterrent. Hunting associates danger with the source of disturbance, so birds are less likely to become acclimated. Hunting can also

increase the effectiveness of non-lethal, noise-making devices deployed in the same general area. Devices most commonly used in Wyoming are cherry bombs, bird bombs, cracker shells, and acetylene zon guns.

When migratory game birds are hazed away from an agricultural food source, alternative food sources should be available nearby to avoid merely relocating the depredation problem. It may be necessary to purchase lure crops or to grow food plots on habitat management areas or refuges to effectively alleviate depredation on private ground. If goose broods are damaging growing crops in the spring/summer period, erect low fences to prevent young and molting geese from accessing the fields. It may also be necessary to remove nesting structures from nearby wetlands.

C. Analysis – Personnel responsible for depredation management should continually assess effectiveness of various techniques and maintain written accounts for use by co-workers and successors. Workshop and symposia proceedings can sometimes be provide useful information. Additional references include: University of Nebraska (1994) and Demaree et al. (1991).

D. Disposition of Data – The following information is recorded during investigation and handling of depredation complaints: type of crops or other property affected, nature and amount of damage, location and timeframe, species and approximate number of birds or animals involved, prevention techniques deployed, equipment types and cost, and vehicle mileage and man-days expended to prevent or control damage. Data are compiled monthly and submitted to regional supervisors. Damage prevention reports and data compilations are maintained at regional offices. Reports should also be forwarded to the State Waterfowl Biologist when migratory game birds are involved. Formal claims for damage compensation are submitted to the Cheyenne Office of the Wyoming Game and Fish Department and maintained on record at that location.

VIII. EVALUATION AND MANAGEMENT OF WATERFOWL HABITAT

A. Wetlands – Wetlands are essential habitat for waterfowl and fulfill at least some seasonal habitat needs for 90% of all wildlife species in Wyoming (WY Game and Fish Dept. 1995). More than half the priority bird species listed in the Wyoming Non-Game Plan are wetland obligates (Oakleaf et al. 1996). Since the beginning of settlement, about 53 percent of wetland area in the conterminous United States (Dahl and Johnson 1991), and about 38% of the wetland area in Wyoming (Dahl 1990) have been eliminated.

1. Rationale – Wyoming is a semi-arid state with limited wetland resources comprising just 2 percent of the surface. In part because of their comparative scarcity, wetlands are an inordinately valuable resource in our State. However, various development activities and land use practices impact wetlands by converting them or otherwise decreasing their effectiveness for waterfowl. Opportunities also exist to create new wetlands or enhance existing wetlands.

2. Application – The State Waterfowl Biologist provides technical recommendations to reduce or mitigate impacts, and improve wetlands, by participating in various review, coordination, and outreach processes. These responsibilities include participation in the Department's environmental review process, coordination of management activities on Department habitat areas, and coordination and consultation with external groups such as Ducks Unlimited, Waterfowl Joint Ventures, other wetland habitat initiatives, and private landowners. Some wetland inventory and design references pertinent to Wyoming include WY Game and Fish Department (2003), Tessmann (2004), and Patla and Lockman (2004).

3. Analysis – When actions are proposed that may impact wetlands, the State Waterfowl Biologist review the project and recommends measures to avoid, minimize, or mitigate the impacts. Principal authorities for such participation include the National Environmental Policy Act of 1969, Section 404 of the Clean Water Act, the Fish and Wildlife Coordination Act, Executive Orders 11990 (floodplains) and 11998 (wetlands), the National Wildlife Refuge Improvement Act, the Surface Mining Control and Reclamation Act, and other federal permitting and planning legislation. In addition, the State Waterfowl Biologist participates in resource evaluation, planning, and grant application for wetland projects conducted by Ducks Unlimited, the Waterfowl Habitat Joint Ventures, and other wetland improvement initiatives.

4. Disposition of Data. The Wyoming portion of the National Wetland Inventory is key documentation used to support wetland protection or mitigation recommendations, and planning activities associated with wetland acquisition or enhancement projects. This database is housed in the Biological Services Section in Cheyenne. All project comments submitted through the Department's formal environmental review process are retained in an electronic database housed on the Department's intranet. The State Waterfowl Biologist also retains copies of wetland comments and project documentation in his files.

B. Goose Nest Structures and Islands

1. Rationale – Canada geese often nest at higher densities, and with greater success, in locations where artificial structures are available. State and federal agencies, clubs, and private individuals have installed and maintained nest structures for generations to enhance local goose production. Many river corridors and reservoirs within Wyoming lack secure nest sites, but have otherwise suitable habitat (food availability, cover, open water) to support goose broods. The Department began a nest structure program in the early 1950s when managers recognized a lack of suitable nest sites was limiting goose production on the Bear River. Artificial islands are also widely used to improve nesting success.

2. Application – Effective nest structures for Canada geese include large, wooden boxes or wash tubs mounted on posts or in trees, 55-gallon drums cut lengthwise in half and fixed to metal posts, and "missile" type structures which consist of a used tire attached to a platform of boards or plywood mounted on a single, metal post. The latter is the most widely used nest structure in Wyoming.

Goose nest structures can be located on shorelines of lakes, including prominent points and bays, and in shallow water where ice action will not damage the structure. On rivers, structures should be located on inside bends where bank erosion is not a problem. Steel or wooden posts are driven into the substrate, at a sufficient depth to support the structure. If structures are placed on land or in shallow water, the nest platform should be sufficiently high to deter jumping predators – usually 7 ft above ground. Structures should be placed in open areas, away from low trees or brush, affording geese an unobstructed view. Structures should also be located in places that are reasonably free of human disturbance during the nesting season.

Nest structures require annual maintenance. During late winter, after the hunting season and prior to arrival of breeding geese, personnel should place fresh straw in the bottoms of nest compartments. Any damage to structures should be repaired at this time. The latter half of February is a good time to do nest structure maintenance in Wyoming. Landscaping chips or scoria gravel are alternative bedding materials that persist in windy regions and do not require annual maintenance.

Artificial islands initially cost more to build, but can provide longer-term benefits with less maintenance. The Department has constructed a number of islands on its habitat units by depositing gravel and soil on ice during winter months. The material settles to the bottom as ice melts. In other cases, earth-moving equipment has been used to formed islands within basins of newly constructed wetlands and impoundments prior to flooding or during drought cycles.

Islands should be at least 50-100 feet from shore, and in deep enough water (24-30 inches) to discourage most mammalian predators. It is preferable to locate them in bays and other sheltered areas where wave action is minimal. The size of islands can vary, but they should be at least large enough to stabilize and persist for several years. Earthen islands can be seeded with a sod-forming grass mixture to prevent erosion and provide nesting cover. Islands can be made even more attractive to nesting geese by erecting nest platforms on them.

3. Analysis – An inventory of nesting structures should be maintained and their effectiveness (occupancy rate, hatching success) and condition should be continually monitored. Structures that are seldom used should be removed or relocated. Monitoring data will help managers improve design and placement of future structures. Maintenance records will assure structures are kept in serviceable condition.

4. Disposition of Data – The State waterfowl biologist maintains a statewide inventory of goose nesting structures. He is responsible for coordinating annual maintenance and for updating records in the database.

C. Other Habitats – A treatise on all aspects of managing migratory game bird habitats is beyond the scope of this chapter. The literature is replete with habitat studies and management

publications the reader can consult. Two additional habitats bear brief mentioning. They are "dense nesting cover" and "winter habitat."

Dense nesting cover is the most cost-effective means of increasing duck and mourning dove production in prairie environments. However, geese and cranes prefer to nest in sparser cover in which they can detect approaching predators. If the objective is to increase duck and dove production, then the area should be managed to provide dense nesting cover. If the objective is to provide crane and goose nesting habitat, cover should be kept short, for example, through grazing. Frequent prescribed burning (every 5-7 years) is an effective technique to manage for dense nesting cover. Burns should be rotated so no more than 1/3 of an area is treated at any one time.

Suitable winter habitats include permanently open water that is reasonably secure from disturbance, and is located near food sources such as waste grains or winter wheat. Because winter habitats are extremely limited in Wyoming, most waterfowl leave the state during the coldest months. The Department and cooperating organizations currently operate aerators in 3 locations to maintain open water throughout the late hunting season and winter period. These are located at Ocean Lake near Riverton, and at the Springer Reservoir and Table Mountain Units in Goshen County. In addition, several reservoirs and stream reaches are closed to hunting and serve as refuges that hold waterfowl later in the season. However, the high elevations and northerly latitude of Wyoming greatly limit the potential to manage areas of the state as winter habitat. Any effort to sustain large numbers of waterfowl over winter would be cost-prohibitive.

IX. SUPPLEMENTAL FEEDING – Supplemental feeding is not necessary to sustain waterfowl populations and is not practiced in Wyoming. Furthermore, intentional feeding immediately before or during the hunting season could constitute baiting under federal regulations. Forage crops are sometimes planted on Department habitat areas and lure crops have been grown to reduce depredations by cranes, ducks, and geese on private lands.

X. JOB COMPLETION REPORTS – Management information from the migratory game bird program is summarized annually in a Job Completion Report (JCR) prepared by the Waterfowl Section. Each Migratory Game Bird JCR includes results of aerial surveys, harvest data, classification data, disease assessments, management evaluations, applicable research reports, hunting seasons and justifications, and other pertinent information. The report also compares current survey and harvest data with recent trends. Copies of these reports are available at each regional office and the Cheyenne headquarters.

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CHAPTER 19

Nongame Birds

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I. CENSUS –

A. Population Trend Counts –

1. Roadside Surveys –

a. Rationale – Robbins and Van Velzen (1970) evaluated roadside surveys in the North American Breeding Bird Survey (BBS). Roadside surveys provide population trend data for many species. Standardized methods such as this provide a basis for comparing trends throughout North America. In addition, species composition and relative abundance can be estimated.

b. Application – Four roadside survey routes have been established in geographic regions delimited by each degree of latitude and longitude in Wyoming. The routes in each "latilong" or "degree block" are set up based upon sampling protocol developed by the BBS office. Maps of routes are kept in files maintained by the nongame bird biologist and at district offices. The BBS office annually distributes maps, forms, and instructions to persons conducting the surveys. A brief summary of instructions follows:

- Observer must be able to identify all birds in the route area based on appearance and vocalizations.
- Observer must be willing to participate at least 2 years.
- Observer must complete the BBS training program.
- Each route is 24.5 miles long and includes 50 stops distributed at 0.5-mile intervals.
- All surveys must be conducted in June or the first week of July.
- Avoid surveying when rain, fog, or smoke may impair visibility; wind velocity exceeds 12 mph (18 mph in prairie regions); or when cold weather inhibits bird song activity.
- Begin surveys 0.5 hour before sunrise, and complete each route in 4-5 hours.
- Spend 3 minutes looking and listening for birds at each stop.
- Record all birds seen within 0.25 mile, or heard from any distance.
- Transfer data from the field sheet to the summary sheet when each route is completed.

c. Analysis of Data – The Nongame Bird Biologist is the state BBS coordinator and works with Nongame Program personnel, Wildlife Management Coordinators,

District Biologists, biologists from other agencies, and volunteers to assign qualified observers to conduct surveys on established routes. The Nongame Bird Biologist compiles and presents data in annual completion reports.

Information recorded during the survey includes: observer, date of survey, start and stop times, avian species and number of individuals detected at each stop, temperature, wind speed (using Beaufort numbers), sky condition (using Weather Bureau code numbers), excessive noise, number of passing vehicles, and any problems encountered during the survey. In addition, a stop description form should be completed once for each route. Information recorded on this form includes the route name and number, date completed, observer's name and observer number, directions to the starting point (stop 1), a Geographical Positioning System location at each stop, and a description of any physical landmarks that may assist the observer in locating the stop. All Breeding Bird Survey data are compiled in a central database by the U.S. Geological Survey – Biological Resources Division and are available online (http://www.pwrc.usgs.gov/BBS/). The international Partners In Flight coalition uses BBS data to compile range-wide population trend information for landbirds. This Species Assessment Database is maintained and made available online through the Rocky Mountain Bird Observatory (http://www.rmbo.org/pif/pifdb.html).

d. Disposition of Data – Send completed survey forms to the BBS office. Data are incorporated into the Nongame Program's Threatened, Endangered, and Nongame Bird and Mammal Investigations Annual Completion Report, and are used to update the Wyoming Bird Conservation Plan, wildlife distribution maps, and databases including the Department's Wildlife Observation System database and the Atlas of Birds, Mammals, Amphibians, and Reptiles database.

2. Riparian Transects

a. Rationale – Streamside shrub and tree communities in Wyoming form narrow, irregular corridors. No other vegetation type in the state is populated by a greater variety or density of birds. A specialized sampling approach is required to survey bird communities in these unique habitats. The line transect method described below has been developed for this purpose. Roadside and line transect surveys yield the same type of data.

b. Application – Riparian transects are walked on foot, and are only conducted under favorable weather conditions (i.e. no precipitation or extreme wind). Each transect is completed between 5:00 and 9:00 a.m., and includes 20 stops distributed at 100-meter (328-foot) intervals. Observers spend 5 minutes looking and listening for birds at each stop. All birds seen or heard within 50 meters (164 feet) are identified and recorded. Transects may follow an irregular line depending on the extent and density of the vegetation and the nature of the river or stream channel (Diem 1976). However, the 50-meter (164-foot) radius at each

stop should not overlap any area counted from adjacent stops. The standardized form for recording data from riparian transects is provided in Attachment 1.

c. Analysis of Data – The Nongame Bird Biologist works with Nongame Program personnel, Wildlife Management Coordinators, District Biologists, biologists from other agencies, and volunteers to assign locations for these transects and assure the surveys are conducted. The Nongame Bird Biologist compiles datasets from spring surveys and presents them in annual completion reports.

Information recorded on riparian transects includes: route name and location; start and stop time, temperature, wind, and cloud cover; observer; assistant; total number of species; total number of individuals; and avian species and number of individuals detected at each stop. A Geographical Positioning System (GPS) location at each stop and a description of any physical landmarks that may assist the observer in locating each stop are also recommended.

d. Disposition of Data – Spring data sets are incorporated into the Nongame Program's Threatened, Endangered, and Nongame Bird and Mammal Investigations Annual Completion Report. Data from all seasons are used to update the Wyoming Bird Conservation Plan, wildlife distribution maps, and databases, including the Department's Wildlife Observation System database and the Atlas of Birds, Mammals, Amphibians, and Reptiles database.

3. Point Counts

a. Rationale – The point count is the standard method used to monitor populations of breeding landbirds in many countries. It is probably the most efficient and data-rich means of surveying bird communities. Data from point counts are used for annual comparisons of populations at fixed points, and for assessments of species composition, and abundance patterns among habitats. Counts can be conducted once or replicated several times at each point. The method is not reliable for surveying waterfowl and other species inhabiting open water; however, it is suitable for counting rails and wading birds. Some landbirds can be disproportionately counted because they are particularly quiet, loud, nocturnal, or gregarious; however, the method can be adjusted to deal with detection bias.

b. Application – Persons conducting point counts must be skillful at bird identification using both visual and auditory methods. Training opportunities are available through the Institute for Bird Populations (415-663-1436, www.birdpop.org). Tapes of bird songs and calls can be checked out from the Department's Nongame Bird Biologist. Also consult the Handbook of Field Methods for Monitoring Landbirds (Ralph et al. 1993).

Field equipment includes a 1:100,000 or larger scale map, a pencil and notebook, a watch that displays seconds, and binoculars. The route and observation points should be delineated on a map. If necessary, observation points can be marked in

the field with fluorescent tape or flags to assure the same points are found each year. The observer may travel on foot or by vehicle between points. Usually no more than 4 hours are required to complete a route depending on distance between points and the method of travel. All routes should be completed between 5:00 and 9:00 a.m. Surveys should not be conducted when rain or wind interferes with the intensity or audibility of bird songs and calls; when fog, rain, or smoke impair visibility; or when cold weather causes bird song activity to cease.

A comprehensive survey should intersect all habitats within a region, if possible. Use a systematic, rather than random sampling approach. Survey routes can be located along lightly traveled roads or off roads (on trails, if possible, in major habitats not covered by road systems). When survey routes are established along roads, tertiary roads are preferred, then secondary roads. Avoid wide, primary roads. Locate sampling points at regular intervals. Do not stratify sampling effort based on habitat types unless separate estimates are being made. If the goal is to monitor population trends throughout a management unit, point counts should be spaced evenly throughout the unit or along a road system. Up to 25 point counts can be completed in 1 morning along road routes. Off roads, a single observer can complete between 6 and 12 point counts.

Sampling points are spaced at least 250 meters (820 feet) apart in wooded habitats. Avoid counting individual birds recorded previously at another sampling point. More than 99% of individuals detected are within 125 meters (410 feet) of the observer in most habitats. The minimum distance between sampling points is greater in open environments where birds are more detectable. Sampling points should be at least 500 meters (1,640 feet) apart along roads traveled by vehicle. “Strip counts” can be conducted in very open terrain. In a strip count, all birds seen or heard are counted along designated sections of a trail. Segments are uniformly 100 meters (328 feet) or 250 meters (820 feet) long. The observer should spend consistent amounts of time covering each [e.g., 100 meters (328 feet) in 10 minutes].

The observer should cause the least possible disturbance when approaching each sampling point. Begin counts immediately upon reaching the census point. Spend 5 minutes looking and listening for birds at each point if travel time between points is less than 15 minutes and Spend 10 minutes if travel time is greater than 15 minutes. Ten minutes is appropriate when a survey is primarily for baseline inventory. Note separately those individuals seen or heard during the first 3 minutes (for comparison with Breeding Bird Surveys) and additional individuals detected during the remaining count period at each sampling point.

Record the date of the count, identification number of each point, and time. Record species in the order they are detected. Record separately the number of individuals detected within 50 meters (164 feet) of the observer, and those detected at 50 meters and beyond (to an unlimited distance). In noisy environments or dense foliage, use a 25-meter (82 feet) radius as the basis for

counting. Record the initial location of each bird; when birds displace in response to the observer's arrival, record their positions before they move. Record individuals detected flying over the point separately from individuals located within the vegetation. If several males of the same species are present, the observer can sketch arrows indicating the directions and distances of each from the count point. Such notations are made in the margins of the survey form. Talley juvenile birds or birds that fledged during the current breeding season separately from adults. If a flock is encountered, the observer can follow it after the count period to determine species and numbers; however, take no more than 10 minutes to do this. The source of an unknown song or call can also be tracked down following the count period to confirm the species' identity. However, decoys, calls, or other devices should not be used to attract birds except in some specialized counts targeting specific taxa.

Two types of data are obtained at each sample point: locations and counts. The location of each bird detected is recorded on the Point Count Location Mapping Form (Attachment 2). The circle on the map is the count radius, 4-letter alpha codes are used to designate species, and symbols identify birds' activities. Colored pencils are used to distinguish time periods. Afterward, data are transcribed onto the Point Count Data Form (Attachment 3). Record the information about each census point on the first 3 lines of the Point Count Location and Vegetation Form (Attachment 4).

In general, sample each station once per season. Counts can be replicated if greater precision is desired within specific areas, for example a rare wetland habitat. Routes should be surveyed the same time each year, within 7 days from the date of the first count. If the season phenology varies, the date can be adjusted. Counts should begin within 30 minutes of the time counts were started the first year. If possible, the same observer should census the route each year.

c. Analysis of Data – The Nongame Bird Biologist works with Nongame Program personnel, Wildlife Management Coordinators, District Biologists, biologists from other agencies, and volunteers to assign locations for these censuses and assure they are conducted. The Nongame Bird Biologist compiles and presents data in annual completion reports.

General information recorded during point counts includes the state, region, station, and date. Specific codes used for mapping at each point count location are presented on the data form in Attachment 2. Additional data recorded at each point include time, avian species detected, distance of detections [$\leq$50 meters (164 feet), >50 meters (164 feet), or fly-overs], and time frame of detections (0-3 minutes or 3-5 minutes). A location and vegetation form for each point should be completed including elevation; aspect; percent slope; plot radius; and species, height, and diameter of vegetation.

d. Disposition of Data – Forward completed data forms to the Nongame Bird Biologist. Data are incorporated into the Nongame Program's Threatened, Endangered, and Nongame Bird and Mammal Investigations Annual Completion Report, and are used to update the Wyoming Bird Conservation Plan, wildlife distribution maps, and databases, including the Department's Wildlife Observation System database and the Atlas of Birds, Mammals, Amphibians, and Reptiles database.

4. Spot Mapping –

a. Rationale – Spot mapping is based on the territorial behavior of birds. This method enables investigators to estimate the density of birds. However, spot mapping is not suitable for broad-scale monitoring because it requires more intensive fieldwork than point counts and line transects. The method is appropriate when managers seek fairly precise information about pair numbers and the distribution of territories in small study areas or patchy habitats. The standard mapping technique is less suitable for colonial species, non-territorial species, or species with large territories.

b. Application – Personnel assigned to conduct surveys must possess good identification skills, including knowledge of the songs and calls of birds. Contact the Institute for Bird Populations (415-663-1436, www.birdpop.org) for training opportunities. The Department's Nongame Bird Biologist can provide tapes of bird songs and calls. Review details of this technique in the Handbook of Field Methods for Monitoring Landbirds (Ralph et. al 1993).

Necessary equipment includes 30 to 40 copies of a detailed map, preferably 1:2000 scale (in open areas, 1:3000 scale may be acceptable), a pencil, a compass, and fluorescent flagging. The time required depends on the size and topography of the area being surveyed and the density of birds (at higher densities, more individuals must be mapped). In wooded areas, about 10-30 ha (25-75 acres) can be surveyed in 1 morning; in open areas 50-100 ha (125-250 acres) can reasonably be surveyed. Up to 25 hours may be required to mark the plot, 40 hours to prepare the species maps, and 5-10 hours to analyze them.

Boundaries of the survey area should be round or square to minimize border length (territories along edges are difficult to analyze). A detailed map, known as a visit map, is constructed (recommended scale is 1:2000) based on the survey area map (1:20,000) and field locations of habitat features. Map the boundaries of the survey area and the locations of habitat edges, streams, roads, paths, buildings, large rocks, trees, and other features. If natural landmarks are absent, establish a grid of 50-meter (164-foot) squares. The grid is drawn to scale on the map and marked on the ground, using fluorescent flags to designate corners. Coordinates should be written on each flag.

Because phenology of arrival and nesting varies, the visits should cover a period long enough to assure each species can be readily observed on at least 3 visits. A standard mapping of forest birds requires 10 visits. If the bird density is high and the nesting season is long, 12 visits are recommended. The visits should be evenly distributed through the census period. Fewer visits can suffice in open habitats where bird densities are usually lower than in forests, or where the nesting season is short (e.g., tundra or alpine grasslands).

Censuses should generally be done between 5:00 and 10:00 a.m. when birds sing most actively. Counting can be delayed following an abnormally cold night. During very warm weather, counting should be prolonged because birds become less active. Two evening visits should also be planned: the first in the beginning of the census period (to count thrushes) and the second about 2 or 3 weeks later (to count nocturnal singers). If species active at night or dusk breed in the area, 2 censuses targeting these periods should be added to the 10 morning visits. In northern, temperate zones, extra visits in March and April may be needed to census owls, woodpeckers, and crossbills, which breed early.

Use a clean map to record bird locations during each visit. The route followed should cover the census area as evenly as possible. The route should lie within 25 meters (82 feet) of all points in areas of dense vegetation or high bird densities, within 50 meters (164 feet) of all points in areas of sparse vegetation or few birds, or within 100 meters (328 feet) of all points in open habitats. The units of the grid on which the route is plotted should be twice the distances above [e.g., 50 meters (164 feet) in dense habitat]. The route must intersect all cells of the grid. Successive visits should begin at different points, especially if a portion of the area is receiving disproportionate attention. Carefully record multiple singing males of the same species so they can be separated from neighboring males after they have moved. Walk at a moderate pace and record birds as they are encountered. Stop frequently to look and listen for birds, particularly multiple individuals of the same species, and mark birds on the map. In open areas, search for birds with binoculars. Normally, an observer can census 5 to 6 hectares (12 to 15 acres) per hour. If bird density is high, census speed may slow to 3 to 4 hectares (7 to 10 acres) per hour. In areas of low bird density, spend at least 8 minutes per hectare (3 minutes per acre). Thorough, methodical censusing enables the observer to simultaneously detect several birds by following their territorial movements. Be particularly vigilant in looking for species that are difficult to detect – search for nests, and check those found earlier. Locations of all observations must be accurately transcribed from the field maps to individual species maps (a separate map should be kept for each species).

d. Analysis of Data – The Nongame Bird Biologist works with Nongame Program personnel, Wildlife Management Coordinators, District Biologists, biologists from other agencies, and volunteers to assign locations for these censuses and assure they are conducted. The Nongame Bird Biologist compiles and presents data in annual completion reports.

Information recorded during spot mapping includes: observer; date of census; start and stop times; a detailed map of the area incorporated in the census, including location, boundaries, and landmarks; and species, number, location, and behavior of territorial birds detected during each visit.

d. Disposition of Data – Maps and data are sent to the Nongame Bird Biologist. Data are incorporated into the Nongame Program's Threatened, Endangered, and Nongame Bird and Mammal Investigations Annual Completion Report, and are used to update the Wyoming Bird Conservation Plan, wildlife distribution maps, and databases, including the Department's Wildlife Observation System database and the Atlas of Birds, Mammals, Amphibians, and Reptiles database.

5. Area Search

a. Rationale – Area searches incorporate a series of 3 20-minute point counts during which the observer can move around in a somewhat restricted area. This limited mobility enables observers to track down unfamiliar birds and increases the likelihood of detecting quiet species. Inexperienced personnel can improve their skills by having knowledgeable observers accompany them as they walk plots prior to the formal survey.

b. Application – Personnel who conduct area searches must possess good identification skills, including knowledge of the songs and calls of birds. Contact the Institute for Bird Populations (415-663-1436, www.birdpop.org) for training opportunities. The Department's Nongame Bird Biologist can provide tapes of bird songs and calls. Review details of this technique in the Handbook of Field Methods for Monitoring Landbirds (Ralph et al. 1993).

In forested habitats, the plot should be sufficiently large to provide 3 separate search areas, each about 7 acres (3 ha). Larger search areas of 25 acres (10 ha) or more can be set up in more open habitats. In dense forest, smaller search areas of 2.5-5 acres (1-2 ha) may be necessary. The search areas can adjoin or they can be separated within the plot. It is acceptable to establish more than 3 search areas, but the same areas must be searched on each visit.

Area searches are intensive and can extend later into the morning than other methods. However, these searches should not continue beyond 5 hours after dawn. The observer should spend exactly 20 minutes in each search area, stopping or moving to investigate sightings or calls as appropriate. Record numbers of birds of each species seen or heard during this time. Birds detected outside the search area can be recorded separately. However, the observer must concentrate on finding as many birds as possible within the plot. Observations can be dictated onto a cassette tape to facilitate data recording during the survey. These data should be transferred onto data sheets promptly after the survey is completed. A second person can also accompany the observer and serve as a

recorder. A single survey is completed when at least 3 different areas have been searched within a plot.

e. Analysis of Data – The Nongame Bird Biologist works with Nongame Program personnel, Wildlife Management Coordinators, District Biologists, biologists from other agencies, and volunteers to assign locations for these searches and assure they are conducted. The Nongame Bird Biologist compiles and presents data in annual completion reports.

Information recorded during an area search includes: observer; location of search; date of search; start and stop times; general habitat in each search area and plot; weather conditions; and numbers of birds of each species observed, heard, or both observed and heard both on and off the search area.

d. Disposition of Data – A separate record is maintained for each search area; all records are forwarded to the Nongame Bird Biologist. Data are incorporated into the Nongame Program's Threatened, Endangered, and Nongame Bird and Mammal Investigations Annual Completion Report, and are used to update the Wyoming Bird Conservation Plan, wildlife distribution maps, and databases including the Department's Wildlife Observation System database and the Atlas of Birds, Mammals, Amphibians, and Reptiles database.

B. Raptor Nesting Surveys

1. Rationale – Raptors are culturally and ecologically significant. Many are sensitive to disturbance. Several species are also harvested for falconry purposes. Therefore, it is important to monitor populations. Raptors are most effectively surveyed during nesting seasons. Several species use traditional nest sites year after year. During other seasons, raptor densities and distribution are influenced by local fluctuations in prey and weather and may not represent valid population trends. Nesting surveys not only provide data relevant to population trends, but also enable managers to identify key nesting habitats that warrant special attention.

2. Application – Persons who conduct breeding raptor surveys should be familiar with nesting habits and territorial behavior. Nest searches should concentrate in likely habitats depending on species potentially present. From a distance, carefully glass cliff and rimrock faces, bluffs, outcrops, knolls, trees, snags, cavities, and other likely habitats or features. Pay particular attention to substrate, aspect or exposure, height, and other characteristics of sites typically selected for nesting. Look for nests, telltale "whitewash" streaks, birds returning or circling, and defensive behavior. There is no substitute for experience in conducting such searches. Record coordinates of all nests. Also describe landmarks and identifying features that will assist in locating the nest from year to year. Determine the nest's status and success (unoccupied, occupied active, incubating, fledglings present, etc.) from the greatest distance possible. Use existing terrain and vegetation as a screen where feasible. If success and production are to be determined, follow-up visits will be necessary. Adhere to

recommendations of Fyfe and Olendorff (1976) to minimize stress and disturbances to nesting raptors. The following parameters are useful for monitoring trends:

a. The number of breeding pairs that can be annually located in a study area.

b. The percent of traditional nesting territories that are occupied from one year to the next. This index is limited to species that are highly traditional in nesting. Percentages may vary depending on objectives of a specific study.

c. Annual production based on nest success, brood size, and productivity (i.e. number of young fledged from the nest).

Raptors are monitored over large areas (e.g., "latilong" blocks or statewide) based predominantly on the latter 2 parameters. Density data (first parameter) can be periodically obtained from scattered study areas. Baseline data used to evaluate proposed projects or land use changes should include all 3 parameters.

3. Analysis of Data – Raptor research has been hampered by inconsistent use of terms, calculations, and data interpretation (Postupalsky 1974). Until terminology is standardized nationwide, the following terms and definitions, similar to those recommended by Postupalsky (1974), will be used in Wyoming:

   Breeding territory or site: An area containing 1 or more nests within the range of 1 mated pair of birds.

   Occupied territory or site: Any territory or site at which one of the following activity patterns have been observed during a breeding season:
   i. Young were raised.
   ii. Eggs were laid.
   iii. One adult was observed sitting low in the nest, presumably incubating.
   iv. Two adults were present on or near the nest, provided there was no reason to suspect the pair had already been counted elsewhere.
   v. One adult was observed frequenting the site or maintaining a territory.
   vi. Fresh sticks (unweathered breaks) or boughs indicate the nest has been recently repaired.

   Unoccupied territory or site: None of the above conditions are met.

   Occupied active nest: A nest or ledge in which eggs have been laid. At least one of the activity patterns (i), (ii), or (iii) must be documented.

   Inactive nest: Not an acceptable term; see occupied or unoccupied definitions.

   Productive or successful nest: An occupied active nest or ledge from which at least 1 young fledged or was raised to an advanced stage of development.

Alternate nest: One of several nests within the breeding territory of a single pair of birds.

Frustration nest: An alternate nest built, repaired, or frequented by a pair of birds after another nest has failed during the same breeding season.

Surveys should be designed to support the following calculations:

Density: Number of occupied nests per square mile.

Historical occupancy rate: The percent of known breeding territories that were occupied in any particular year. The breeding territories used in this calculation must have been documented at least 1 year prior. Specify dates occupancy data were gathered. Occupancy rates estimated from surveys late in the nesting season are often biased low because failed nests may not be detected.

Percentage of occupied active nests: The number of occupied active nests divided by the number of sites occupied early in the nesting. Nests of unknown status are not counted in this calculation.

Nest success: The percent of occupied or occupied active breeding territories in which at least 1 young is fledged. Nest success and productivity should be calculated on the basis of both occupied and occupied active nests. Occupied or occupied active status must be determined prior to hatching.

Brood size: The number of young per successful nest.

Productivity: The number of young raised to an advanced stage of development per occupied or occupied active nest. Occupied or occupied active status must be documented before hatching. Specify whether the index was based on young per occupied nest or young per occupied active nest.

4. Disposition of Data: Nesting data are often summarized in inconsistent formats because individual biologists may use different indices. Table 1 is a format recommended to provide more comparable data summaries in the future. Investigators may not collect data to support calculations of all statistics. However, the format should be followed and statistics for which data are lacking should be noted.

TABLE 1. Suggested format for reporting raptor nest data (example).

Statistics [a]	1980
A. Historic nest sites checked [b]	24
B. Occupied nests	22
C. Number of occupied nests that were adequately observed to determined if eggs were laid	20
D. Occupied active nests	16
E. Successful nests	16
F. Number of young fledged	30
Indices	
Occupancy rate (historic sites): B/A	91.7%
Nest success (occupied sites): E/B	72.7%
Average brood size: F/E	1.88
Productivity (occupied sites): F/B	1.36
Productivity (occupied active sites): F/D	1.88

[a] Terminology as defined previously.

[b] Includes only sites that were checked thoroughly enough to determine occupied/ unoccupied status. Alternate nest sites must also be thoroughly covered.

Data gathered during raptor surveys are recorded on the following forms:

Raptor Nesting Survey Summary Form (Attachment 5): Data are recorded on this form when a raptor nest is located for the first time. This form provides a good synopsis of baseline data available for each raptor nest, and should be sufficiently detailed to enable a person unfamiliar with the site to locate the nest site in the field. Data are especially needed on the exact location of nesting sites used by species that return annually to the same site. Investigators are encouraged to submit any nesting information that may have been obtained on these species in the past. Investigators are also encouraged to fill out the forms as completely as possible; however, forms that give only the species observed nesting and a description of the location are still valuable and will be used. Any information that is approximated should be noted as such. If no birds were observed and the nest was identified by characteristics of the nest or sign, the word “potential” should be written in the species section. Potential sites are recorded to aid in follow-up work and to give an idea of the portion of the nesting habitat that is being utilized. However, only those investigators who have experience with raptor nesting habitats should record potential sites. Investigators are encouraged to attach maps and photographs indicating the location of nests. When providing information on dominant habitat of the area, the habitat categories used for the Wildlife Observation Form are preferable. A description of the specific habitat at the nest should be as detailed as possible. Alternate nests should be recorded under the additional remarks section and plotted on the associated map.

Raptor Nest Report Form (Attachment 6): This form is used to record nest occupancy status and production data, and should be filed with the Raptor Nesting Survey Summary Form (Attachment 5) completed for each nest. Raptor Nest Report Forms are organized based on species, latilong number, site name, and site number. The site name is assigned based on the location of the nest (e.g. Clear Creek nest, Hawk Springs Reservoir nest, Thompson Ranch nest). The site number is a 7-digit number comprised of Township, Range, and Section (e.g. T6N, R147W, Sec. 5 would be recorded as Site Number 0614705). If 2 or more nest sites of a single species are located in the same section, a decimal point is added to identify quarter section locations. The quarter section and digits 1-4 correspond to the coding system used in the Department's Wildlife Observation System (i.e. 1=NE, progressing counter clockwise). Raptor data are entered into the Wildlife Observation System database, although nest locations are sensitive information and are not included in detail. Raptor nest locations are entered into a Raptor Nest Database and plotted on maps maintained by the Nongame Bird Biologist.

Wildlife Observation Form (Appendix I): Record miscellaneous observations of nest sites on a Wildlife Observation Form. Carefully follow instructions for recording raptor nest observations so production indices may be accurately calculated. Forward completed forms to the Nongame Bird Biologist immediately after the nesting season.

Raptor nest locations are sensitive information and should be kept confidential. Exact locations of nests should not be provided to anyone who is not immediately involved in an approved study or management program. Reports intended for public distribution can include data summaries, but not location information.

C. Common Loon Surveys

1. Rationale – The common loon is a high interest species because of its public appeal, sensitivity to disturbance, and restricted breeding distribution in Wyoming. Loons can be observed statewide during spring and fall migration, and nonbreeding loons can be found throughout the state during summer; however, suitable breeding habitat is limited to northwest Wyoming. Much of the common loon breeding in Wyoming is within backcountry recreation areas. Excessive human activity has the potential to disturb breeding loons and impact their habitat. Surveys are conducted in preferred loon habitat to document additional loon breeding sites.

   Habitat suitable for loon breeding has the following characteristics: lakes substantially secluded from human activity; surface area of 10 acres or greater, elevation less than 8,000 feet (typically between 6,000 and 8,000 feet); minimum water clarity of 3 feet to permit visual contact with prey; islands or protected shore areas for nesting and raising young; abundant populations of small to mid-size fish; water depth greater than 6 feet to prevent winter kill of fish; and ice-free period lasting at least 4 months to allow young loons to fledge.

2. Application – In areas where common loons are known to nest, 3 surveys are conducted each year. Nest occupancy surveys are done in early to mid-June, production surveys in mid-July, and young survival surveys in mid- to late August. Surveys to locate new or previously unknown breeding sites should be conducted in early to mid-June. If common loons are observed, production and recruitment surveys should follow. If common loons are not observed but the habitat is suitable for nesting, a follow-up survey should be conducted in mid- to late July.

   The best times to observe loon broods are early morning and early evening. The observer(s) should sit quietly at a vantage point and glass the lake for activity. Loons may be quite visible or they may be feeding or loafing in emergent vegetation where they are more difficult to see. The observer should consistently expend sufficient effort glassing each lake to assume loons are detected if they are present. We suggest 45 minutes to 1 hour. If loons are observed sooner, glassing can be terminated when the observer is confident all loons have been counted.

   Record the number of adult and young loons observed and behavioral activities such as diving, hunting, feeding self or young, calling, flying, or loafing. If the lake has not been previously surveyed, sketch its shape and note where the loons were observed. Other comments (such as degree of human activity; locations of roads and trails; and type and distribution of shoreline habitat) are helpful for determining the overall suitability of the area for nesting loons.

3. Analysis of Data – The Nongame Bird Biologist works with Nongame Program personnel, volunteers, biologists from other agencies, the Wildlife Management Coordinator in each region, and District Biologists to assign locations for loon surveys and assure they are conducted. The Nongame Bird Biologist compiles data and prepares summaries for annual completion reports. Data are also forwarded to cooperating agencies.

   Data recorded during Common Loon surveys include observer contact information; lake name, location, size, and elevation; date of survey; start and stop times; number and behavior of adult and young loons observed; fish species present; and other species detected.

4. Disposition of Data – Data are recorded on the Common Loon Nesting Survey and Habitat Description Form (Attachment 7) and submitted to the Nongame Bird Biologist. Data are incorporated into the Nongame Program's Threatened, Endangered, and Nongame Bird and Mammal Investigations Annual Completion Report, and are used to update wildlife distribution maps and databases, including the Department's Wildlife Observation System database and the Atlas of Birds, Mammals, Amphibians, and Reptiles database.

D. Trumpeter Swan Surveys –

1. Rationale – Trumpeter swans were once abundant and widely distributed in North America. By the turn of the 20th century, excessive commercial hunting and habitat loss nearly caused their extinction (Banko 1960). Swans in Wyoming are part of the Rocky Mountain Population (RMP), which consists of swans nesting in the interior western U.S. and interior Canada (Pacific Flyway Council 1998, 2002). The portion of the RMP that nests in the U.S. (Idaho, Montana, and Wyoming) is known as the Tri-state Flock. Although the Canadian segment of the RMP has increased steadily since the 1980s, the U.S. portion declined sharply in the early 1990s. Since then, it has remained below historic highs achieved in the 1950s and 1980s. The decline coincided with the termination of winter feeding at Red Rock Lakes NWR in Montana. The theory that the current population level may be limited by availability of suitable natural habitats continues to be debated.

   The trumpeter swan is a high interest species because of its public appeal, conservation history, association with shallow wetland habitats, sensitivity to disturbance, and restricted breeding distribution in Wyoming. A small resident flock nests in traditional sites that are reoccupied annually in northwest and southwest Wyoming. A majority of those swans remain in Wyoming year round. Swans that nest in Canada migrate to the Tri-state Region each winter. A large influx increases the number of swans in western Wyoming by 5- to 7-fold from November through mid March. The status of the Tri-state Flock is closely monitored because of its comparatively small size, habitat concerns, and potential competition with wintering Canadian swans.

2. Application – Efforts to monitor swans are coordinated with Montana and Idaho through the Greater Yellowstone Trumpeter Swan Working Group (GYTSWG), the Pacific Flyway Council, and the U.S. Fish and Wildlife Service's (FWS) Division of Migratory Bird Management (DMBM). During the breeding season, at least 3 surveys are conducted to monitor known nesting areas. Accessible sites are monitored from the ground and inaccessible sites are monitored using an aircraft. Surveys are conducted in mid-late May to determine nest occupancy/incubation and in late June-early July to determine nest success and number of young hatched. An aerial survey is flown in early September to assess productivity and number of mature young. An aerial survey is also conducted in February to count the wintering population of swans. The September and February surveys are coordinated so all three states in the Tri-state Area are surveyed during the same 1-week window. Observers must be comfortable with flying, able to distinguish cygnets (young of the year) from adult swans, and know the specific locations where swans nest and winter. Flight schedules are coordinated with other agency personnel before surveys are conducted. New observers flying their initial survey should accompany more experienced personnel or at least fly with pilots who have conducted the surveys in prior years. Observers conducting ground surveys should be familiar with swan behavior to avoid disturbing nesting pairs and their young, or flushing wintering birds from secure habitat. When possible, investigate all reports of dead swans and collect

carcasses for laboratory analysis. Statewide press releases should be issued at least twice a year in summer and winter to 1) solicit observations from the public that will help document expansion of swan distribution within the state, and 2) document swan mortalities, especially in remote areas or on private land. Mortalities are most frequently reported in March after melting snow and ice expose carcasses of swans that died over winter. Physical and biological measurements of habitat, including submersed vegetation, should be collected periodically at nesting and wintering sites, especially if a traditional site remains unoccupied more than a few years. Partnerships with private landowners, land management agencies, and non-government organizations are encouraged to restore or create additional shallow wetland habitats for nesting and wintering swans.

3. Analysis of Data – The Nongame Biologist in the Jackson/Pinedale Region collects and compiles data from official surveys and is also responsible for consolidating data and observations reported by district personnel, other agency biologists and the public. Production data and estimates of summer/winter flock size are published in annual completion reports, along with 10-year summaries of this information. Additional data summaries are prepared for the annual GYTSWG meeting held in late October. Cooperating agencies attend the meeting to share data and coordinate planning and management strategies for the Tri-state Flock.

   The FWS DMBM in Denver compiles data from the September and February aerial surveys and publishes 2 reports annually, in which the total numbers of resident swans (fall report) and Canadian swans (winter survey total minus the resident birds counted the previous fall) are estimated.

4. Disposition of Data – Swan data are summarized in the Nongame Program's Threatened, Endangered, and Nongame Bird and Mammal Investigations Annual Completion Report. The data are also used to update wildlife distribution maps and databases including the Department's Wildlife Observation System database and the Atlas of Birds, Mammals, Amphibians, and Reptiles database. The GYTSWG publishes a summary of data from Tri-state Area Flocks in its annual meeting minutes. The FWS DMBM in Lakewood, Colorado, publishes annual reports in fall (Trumpeter Swan Survey of the Rocky Mountain Population, U.S. Breeding Segment) and winter (Trumpeter Swan Survey of the Rocky Mountain Population). Every 5 years, the FWS drafts a status report of Rocky Mountain, Pacific, and Interior populations of trumpeter swans (U.S. Fish and Wildlife Service 2002).

E. Colonial Waterbird Surveys –

1. Rationale – In Wyoming, secure breeding sites for colonial waterbirds are limited in distribution and their availability is uncertain from year to year due to fluctuating water conditions and land use changes. The sites with the most consistently ideal habitats are monitored annually. We also encourage periodic monitoring at sites with immature but developing marsh habitat, and inventory of sites with potential habitat.

2. Application – The primary goal of this survey is to document use or nonuse of traditional nesting sites by colonial nesting waterbirds listed as Species of Special Concern with a Native Species Status 3 or 4 (Oakleaf et al. 1996, Cerovski et al. 2004). These include the American white pelican, American bittern, black-crowned night-heron, snowy egret, white-faced ibis, Caspian tern, Forster's tern, black tern, western grebe, Clark's grebe, and Franklin's gull. A secondary goal is to record active nests of these species; however, numbers of active nests are estimated rather than counted. Presence of other species is also documented. A key to identify eggs of marshbirds and associated species is provided in Attachment 8.

   Colonial waterbird surveys are conducted in areas of suitable nesting habitat. Any large reservoir with islands may be suitable for nesting if foraging habitat is available nearby and human activity is not excessive. Caspian terns and American white pelicans will fly up to 20 and 45 miles, respectively, from nesting colonies to foraging areas. Smaller reservoirs, ponds, and lakes may be suitable for nesting if they contain an island or peninsula, or a wide fringe of bulrushes or cattails extending at least 720 ft from shore. In Wyoming, colonial nesting sites of species other than Caspian terns or pelicans tend to be located near irrigated pasture or cropland where birds forage. Most sites are within 5 miles of irrigated pasture or cropland, however birds may forage up to 20 miles or more. Several wetlands or reservoirs within 20 miles may provide suitable alternative foraging habitat. An isolated pond more than 20 miles from foraging habitat is unlikely to be used for nesting. The presence of gull nesting colonies is a good indication that other colonial nesting species may be present.

   Surveys are timed to coincide with late incubation/early hatching. If a colony is surveyed too early, the number of active nests will be underestimated because not all birds will have arrived at the colony. If a colony is surveyed late, active nests can also be underestimated because failed nests are missed. The dates we recommend for surveying colonial waterbirds identified as Species of Special Concern are approximate. Survey timing may require some adjustment from year to year, depending on weather conditions, water levels, human disturbance, or other factors. Birds in small colonies often nest later than birds in larger colonies within the same general area. Nest initiation dates also vary with latitude. Typically, colonial waterbird surveys should be conducted the last 2 weeks of June through the first week of July. This appears to be the best time to document nesting. Survey dates should be delayed to the last week in June through the first 12 days of July when spring weather is abnormally cold and wet. However, those later dates may not be ideal to accurately estimate numbers of active nests, so biologists should note possible limitations of data collected during years in which surveys are delayed.

   Surveys are conducted in early morning to reduce the potential for heat stress on young birds. Also, if chicks flush from their nests and get wet, there is ample time for them to dry before temperatures cool in the evening. Avoid surveying colonies on unseasonably cold or rainy days. As a rule, do not conduct surveys when the temperature is below 65^{o} F.

Aerial surveys are an effective means of searching large areas to locate nest colonies. Although nests cannot be accurately counted from the air, sites worth revisiting can be surveyed from the ground.

Before proceeding with a survey, assess each marsh and island site to determine if is suitable habitat for colonial nesting waterbirds. Sites with appropriate characteristics are surveyed an hour or longer in the evening or early morning (start before sunrise). Approach the area inconspicuously if possible to avoid flushing birds prematurely. In marsh habitats, a specific call-playback survey should be conducted in early morning or late evening to detect nesting American bitterns if they are present. The following behaviors may indicate presence of an active colony:

- Adults in breeding plumage persistently flying around one location. Birds are repeatedly observed entering and leaving the same spot.
- Adults persistently cluster in one place above the high water mark.
- Adults in breeding plumage are observed carrying food or nest material to one location.
- Courtship behavior, displays, or copulations are observed in a small area.
- Birds roost at night in one location, this location is especially evident among herons and ibises.
- Adults engage in nest defense behavior when people or animals enter specific areas.
- Clusters of regularly spaced adults are observed on the ground (terns and gulls) or in trees and shrubs (herons and ibises), especially at times other than dusk.
- Excrements produce whitewashed or odorous areas, suggestions of nests or nest "scoops" are present, or the area is densely covered with bird tracks.
- Clusters of adults on the ground or in trees and shrubs allow unusually close approach before flushing, then return to the same spots.

a. Marsh Surveys – Begin by observing the site quietly for several minutes. Then make a loud abrupt noise, such as slamming a vehicle door, firing a shotgun into the air, or discharging an M-80. This will flush birds off nests, revealing the location that needs to be searched and the species present.

   Determine the species and number of adult colonial nesting waterbirds and estimate the number of active nests. A canoe is very effective for conducting this type of survey. Launch the canoe away from the nesting colony, paddle quietly to a vantage point at the edge of emergents near the colony, create a loud disturbance to flush birds, and count adults and young of each species (Decide beforehand which species each observer will count). This method enables observers to count flushed birds quickly and efficiently without entering the colony or creating trails through vegetation that may attract predators. A direct count of nests can be made, if necessary, once the colony has been located.

   If counts of nests, eggs, or young, are required, observers may need to wade through the marsh to obtain these. Such counts should be done in the morning

well before midday heat. In larger marshes, observers may need to quarter back and forth and mark nests as they are encountered. A second observer should assist if the marsh is large enough that a single observer cannot complete the survey within 2 hours. The second observer helps to record data and navigate transects, and increases safety. Count all nests of waterbirds listed as Species of Special Concern, and estimate numbers of nests of other colonial species. Note the numbers of eggs, nest type(s), and nest material. Count the young that are nearly fledged when this can be done without excessive disturbance. Note other species observed during surveys. Attachment 8 provides a key to the eggs of marshbird species.

b. Island surveys – Use a spotting scope to obtain as complete a count of adults and nests as possible then approach by boat and watch for birds flushing from nests (this may happen while you are a few hundred yards away). While adults are off the nests, eggs and young are extremely vulnerable to predation, especially if gulls are in the area. Count nests and record all species quickly, preferably in less than 20 minutes and then leave directly. Do not enter colonies of more than 20 pelican nests. Notify the Nongame Bird Biologist promptly so an aerial survey can be scheduled.

Contact the Nongame Bird Biologist for specific information on actual or potential colonial waterbird nesting sites, survey instructions and forms, and descriptions of nests and eggs of colonial waterbirds and other similar species.

3. Analysis of Data – The Nongame Bird Biologist works with Wildlife Management Coordinators, District Biologists, biologists from other agencies, and volunteers to assign locations for these surveys and assure they are conducted. The Nongame Bird Biologist compiles and analyzes data, and incorporates results in annual completion reports. After several years of records are accumulated, trends in breeding populations can be examined.

Information recorded during colonial waterbird surveys includes: colony name, date of survey, start and stop times, colonial waterbird species and number of individuals detected in each colony, including information on nests, eggs, and young, if available; other species observed; a habitat map of the colony; impacts or disturbances; management opportunities; and nonconsumptive use potential. Photographs of the waterbird nesting and feeding areas are also encouraged.

4. Disposition of Data – Enter survey data on the Wyoming Colonial Waterbird Colony Description and Survey Form (Attachment 9) and photograph colony sites, if possible. Submit data sheets and photographs to the Nongame Bird Biologist. Data are incorporated into the Nongame Program's Threatened, Endangered, and Nongame Bird and Mammal Investigations Annual Completion Report, and are used to update wildlife distribution maps and databases, including the Department's Wildlife Observation System database and the Atlas of Birds, Mammals, Amphibians, and Reptiles database.

F. Forest Owl Surveys

1. Rationale – Forest owls typically inhabit mature coniferous and mixed coniferous and deciduous forests in Wyoming. These forests types are often commercially logged. Some forest owls require scattered, small openings for foraging, however removing large blocks of preferred habitat (clearcutting) can be devastating to local and regional populations.

   Most species of owl are predominately nocturnal and difficult to detect through casual observations. Survey forest transects at night during the peak of the breeding season to document presence of these species. If owls are detected, conduct more specific population or nest productivity surveys, as needed.

2. Application – Forest owl surveys are conducted during the peak of each species' breeding season as identified below. Routes should be surveyed twice; a minimum of 2 weeks is allotted between replications.

   Eastern and Western Screech-Owls: 1 February through 30 April; mature riparian deciduous forest, Douglas fir, cottonwood, and aspen; cavity nest.

   Great Horned Owl: 1 February through 31 March; coniferous forest and cottonwood below 9,000 feet; stick nest.

   Northern Pygmy-Owl: 1 April through 30 April and 1 September through 31 October; mixed spruce-fir, Douglas fir, and lodgepole pine; cavity nest.

   Great Gray Owl: 1 February through 31 March; mature lodgepole pine, Douglas fir, spruce-fir, and aspen; broken treetop or stick nest.

   Long-eared Owl: late February through 31 March; mature riparian deciduous forest, cottonwood, mixed open coniferous forest, below 8,000 feet; stick nest.

   Boreal Owl: 1 March through 15 April; mature spruce-fir and lodgepole pine; cavity nest.

   Northern Saw-whet Owl: 15 February through 30 April; coniferous forest, mixed aspen-coniferous forest, aspen, mature riparian deciduous forest; cavity nest.

   Use skis, snowshoes, or snow machines to conduct late winter surveys. Scout routes and mark them during daylight hours. Observer(s) should follow the entire route before dark to become familiar with habitat, terrain, and snow conditions. Mark each stop with a fluorescent flag or ribbon every 0.25-0.5 mi, depending on habitat. Route length depends on the amount of suitable habitat.

Begin surveys no earlier than 0.5 hour after sunset (when the first stars appear), and continue no later than 11:00 p.m. Forest owl species tend to be most vocal the first 2-3 hours after dark. Do not conduct surveys when winds exceed 5 miles per hour or during heavy precipitation.

Extinguish all lights at each stop. Alternately play owl call tapes and listen. Broadcast calls on each side of the trail or road, about twice as loud as an owl would normally call. (Keep the tape player warm between stops; cold tapes emit distorted sound). Begin at each stop by listening for 2 minutes. Play the desired call tape, listen 2 minutes for a response, play the tape for another 2 minutes, and listen for a final 2 minutes. If several owl species are surveyed concurrently, the observer(s) should: 1) begin with tapes of smaller owls, then proceed to the larger owls, or 2) start with tapes of the least common species, then proceed to the more common species. For example: 1) play the boreal owl vocalization and listen for a response, then play the great gray owl vocalization and listen for a response; or 2) play the northern pygmy-owl vocalization and listen for a response, then play the northern saw-whet owl vocalization and listen for a response.

All owls seen or heard are recorded on the survey forms. If an owl is heard from a distance and does not approach close enough for positive identification, move closer. Some forest owl species will call for 20 minutes or more. If an owl stops calling before it is identified, wait 1 minute, then play a single sequence of calls and listen. Repeat this 3-4 times to stimulate calling. To reduce the potential for predation, discontinue calling smaller owl species if a great horned owl is heard at the stop.

Necessary equipment includes: cross-country skis, snowshoes, or snowmachine; headlamp, flashlight, batteries; tape player suitable for calling wildlife, recharger; tapes of forest owls; survey forms and maps; clipboards and pencils; watch or timer; fluorescent flags and ribbon; binoculars; field identification guide; food and water; compass; first aid kit; survival kit; extra clothes; and a sleeping bag.

3. Analysis of Data – The Nongame Bird Biologist works with Wildlife Management Coordinators, District Biologists, biologists from other agencies, and volunteers to assign locations for these surveys and assure they are conducted. The Nongame Bird Biologist compiles and analyzes data, and incorporates results in annual completion reports.

   Information recorded on riparian transects includes: observer, date of survey, start and stop times, avian species and number of individuals detected at each stop. A Geographical Positioning System location at each stop and a description of any physical landmarks that may assist the observer in locating the stop are also useful.

4. Disposition of Data – Record data on the Forest Owl Survey Summary Form (Attachment 10) and Forest Owl Survey Route Form (Attachment 11) and submit these to the Nongame Bird Biologist. Data are incorporated into the Nongame Program's Threatened, Endangered, and Nongame Bird and Mammal Investigations

Annual Completion Report, and are used to update wildlife distribution maps and databases, including the Department's Wildlife Observation System database and the Atlas of Birds, Mammals, Amphibians, and Reptiles database.

II. DISTRIBUTION AND MOVEMENT –

A. Bird Sightings –

1. Wildlife Observation System –

a. Rationale – Organized records of bird sightings provide a means of assessing species distribution and abundance. Over time, these records enable managers to monitor expansion or contraction of species' ranges. In addition, wildlife observation records are frequently consulted to document potential impacts of agency actions. The Wildlife Observation Form is included in Appendix I.

b. Application – All avian observations are potentially useful; however, it is not possible to record everything. Especially useful observations include:

- Observations of nesting birds, especially common loons, colonial nesters, and raptors.
- Arrival and departure dates of migratory species.
- Any observation outside current distribution records in the Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming (Cerovski et al. 2004 – next section).
- Species listed in Table 2 – note the specific types of information needed.

c. Analysis of Data – Refer to the Chapter I, Section V.C.3 (Pronghorn – Distribution and Movement).

d. Disposition of Data – Data are maintained in the Department's Wildlife Observation System database and are incorporated into the overall wildlife distribution mapping effort.

2. Atlas of Birds, Mammals, Amphibians and Reptiles in Wyoming – Refer to:

Cerovski, A. O., M. Grenier, B. Oakleaf, L. Van Fleet, and S. Patla. 2004. Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming. Wyoming Game and Fish Department Nongame Program, Lander. 206pp.

a. Rationale – Important distribution information can be obtained from special surveys and studies, as well as knowledgeable bird watchers. The avian portion of the "Atlas" is designed to summarize these data in a useable form.

b. Application – The "Atlas" provides basic information on status and distribution of birds, mammals, amphibians, and reptiles in the state. The information is used to describe the environmental setting and analyze potential effects of resource management decisions, and is frequently consulted by individuals seeking to observe species of interest. The "Atlas" documents past observations and encourages use of the data to record new observations and distribution records for each species represented.

c. Analysis of Data – Data are solicited from qualified observers. Nongame Program personnel periodically update the "Atlas" as additional data are acquired.

d. Disposition of Data – Observation data will be compiled and used to update the "Atlas." Such information will also be stored in a computerized retrieval system for reference and for developing management policies.

TABLE 2. Avian observations that are especially needed.

Region	Species	Comments
Jackson	Trumpeter Swan	All nesting and production observations
Jackson, Cody, Lander	Harlequin Duck	All observations
All Regions	Common Loon	All observations, especially nesting sites
All Regions	Colonial Waterbirds	All observations, especially nesting sites
All Regions	Raptors	All nesting and production observations
All Regions	Cooper's Hawk	All observations
All Regions	Peregrine Falcon	All observations
All Regions	Virginia Rail	All observations during June and July
All Regions, especially Jackson/Pinedale	Whooping Crane	All observations; need to start documenting areas used by Whooping Cranes summering in the Daniel area
All Regions	Mountain Plover	All observations
All Regions	Upland Sandpiper	All observations
All Regions	Long-billed Curlew	All observations
All Regions	Franklin's Gull	All observations, especially nesting sites
All Regions	Yellow-billed Cuckoo	All observations
All Regions	Barn Owl	All observations
Jackson, Cody, Green River, Lander, Laramie	Northern Pygmy-Owl	All observations
All Regions	Burrowing Owl	All observations
Jackson, Cody, Lander	Great Gray Owl	All observations
All Regions	Short-eared Owl	All observations

Jackson, Cody, Green River, Lander, Laramie	Boreal Owl	All observations
All Regions	Northern Saw-whet Owl	All observations
All Regions	Lewis's Woodpecker	All observations, especially during summer
All Regions	American Three-toed Woodpecker	All observations
All Regions	Black-backed Woodpecker	All observations
All Regions	Willow Flycatcher	All observations
All Regions	Gray Flycatcher	All observations
All Regions	Eastern Phoebe	All observations
All Regions	Ash-throated Flycatcher	All observations
All Regions	Loggerhead Shrike	All observations
Green River, Laramie	Western Scrub-Jay	All observations
Cody, Green River, Laramie, Sheridan	Purple Martin	All observations
Green River, Laramie	Juniper Titmouse	All observations
Green River, Laramie	Bushtit	All observations
Jackson, Green River	Pygmy Nuthatch	All observations
Green River, Laramie	Bewick's Wren	All observations
Jackson, Cody	Winter Wren	All observations
All Regions	Blue-gray Gnatcatcher	All observations
Green River, Lander	Northern Mockingbird	All observations
All Regions	Sage Thrasher	All nesting and production observations
All Regions	Sprague's Pipit	All observations
All Regions	Orange-crowned Warbler	All observations
All Regions	Virginia's Warbler	All observations
Jackson, Cody, Green River, Lander	Black-throated Gray Warbler	All observations
Jackson, Cody, Green River, Lander	Townsend's Warbler	All observations
All Regions	American Redstart	All observations
All Regions	Ovenbird	All observations
All Regions	Brewer's Sparrow	All observations during June and July
All Regions	Field Sparrow	All observations
Green River	Black-throated Sparrow	All observations

All Regions	Sage Sparrow	All nesting and production observations
All Regions	Lark Bunting	All nesting and production observations
All Regions	Grasshopper Sparrow	All observations
Sheridan, Casper, Laramie	Baird's Sparrow	All observations
All Regions	McCown's Longspur	All observations during June and July
All Regions	Chestnut-collared Longspur	All observations during June and July
All Regions	Rose-breasted Grosbeak	All observations during June and July
All Regions	Blue Grosbeak	All observations
All Regions	Indigo Bunting	All observations
Sheridan, Green River, Casper, Laramie	Dickcissel	All observations
All Regions	Bobolink	All observations
Green River, Laramie	Scott's Oriole	All observations
Casper, Laramie, Sheridan	Orchard Oriole	All observations
Jackson, Cody, Sheridan, Lander, Laramie	Gray-crowned Rosy-Finch	All observations during June and July
Jackson, Cody, Sheridan, Lander, Laramie	Black Rosy-Finch	All observations during June and July
Laramie	Brown-capped Rosy-Finch	All observations during June and July

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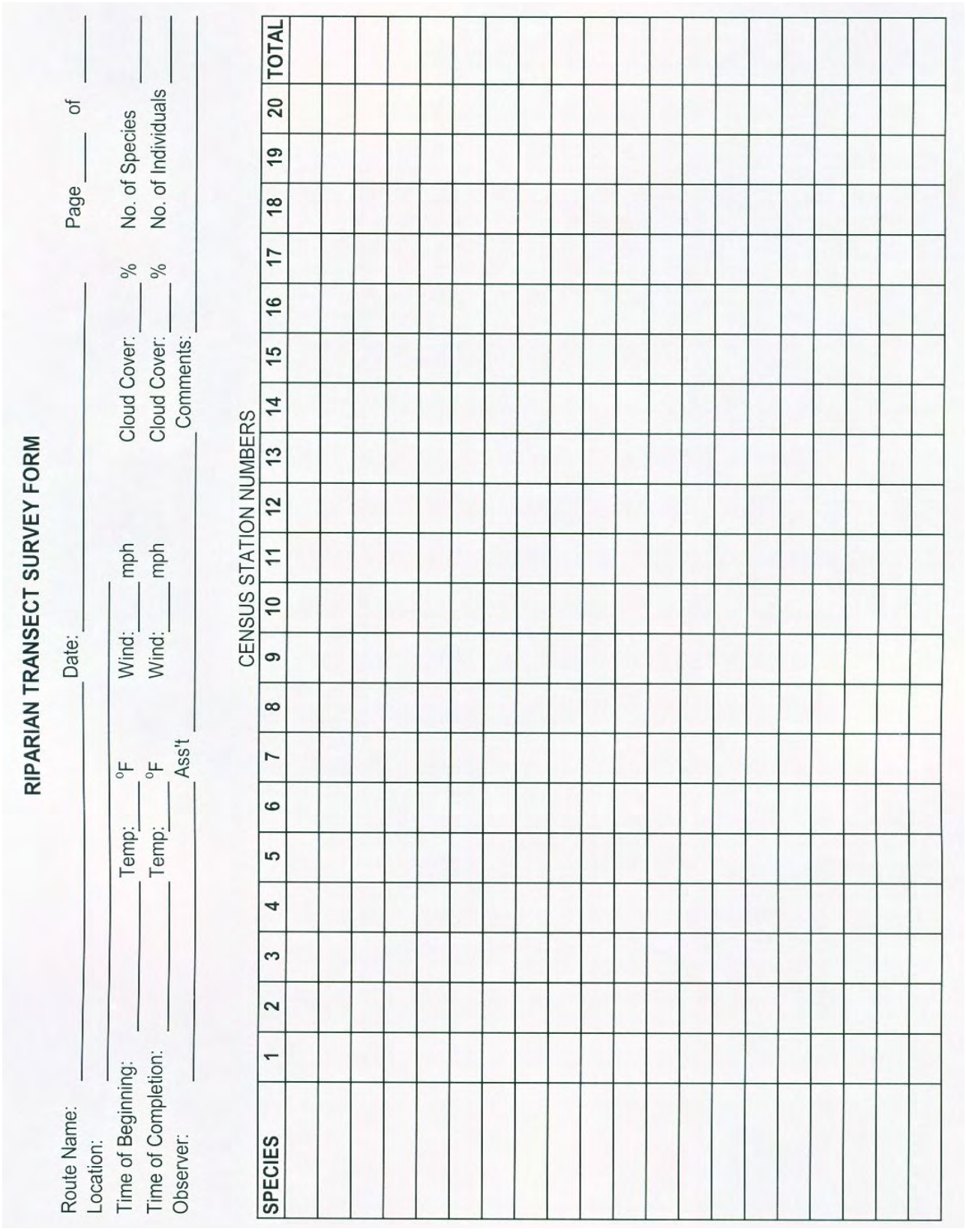
ATTACHMENT 1 RIPARIAN TRANSECT SURVEY FORM



RIPARIAN TRANSECT SURVEY FORM

Route Name: _____ Date: _____ Page ____ of ____

Location: _____

Time of Beginning: _____ Temp: ____ °F Wind: ____ mph Cloud Cover: ____ % No. of Species ____

Time of Completion: _____ Temp: ____ °F Wind: ____ mph Cloud Cover: ____ % No. of Individuals ____

Observer: _____ Ass't _____ Comments: _____

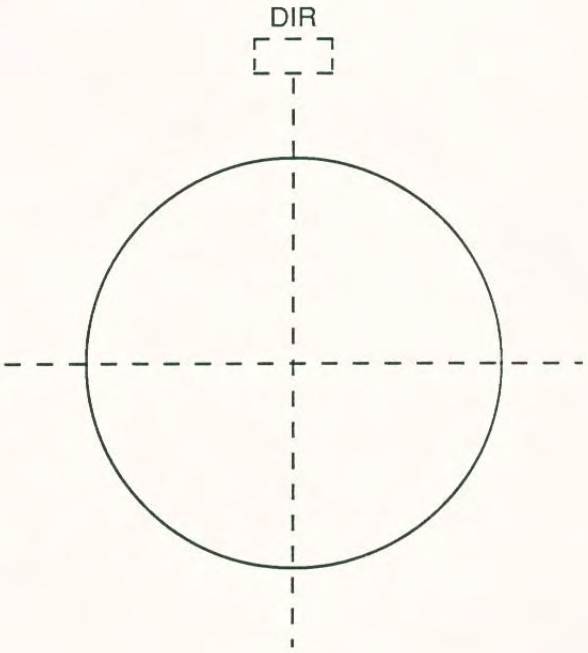
CENSUS STATION NUMBERS

SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	TOTAL

ATTACHMENT 2 POINT COUNT LOCATION MAPPING FORM

POINT COUNT LOCATION MAPPING

STATE | REGION | STATION | MONTH | DAY | YEAR | POINT



MAPPING SYMBOLS

CODE		
S	MAWA	Position of singing male
S	MAWA	Approximate position of singing male
S	MAWA — MAWA	Simultaneous song of 2 males
S	MAWA → MAWA	Known change in position
S	MAWA ⇢ MAWA	Assumed change in position
N	MAWA *	Nest

CODE		
M	MAWA	Male observed
F	MAWA	Female observed
C	MAWA	Calling, sex unknown
P	MAWA	Pair together assumed mated
O	MAWA	Observed, sex unknown

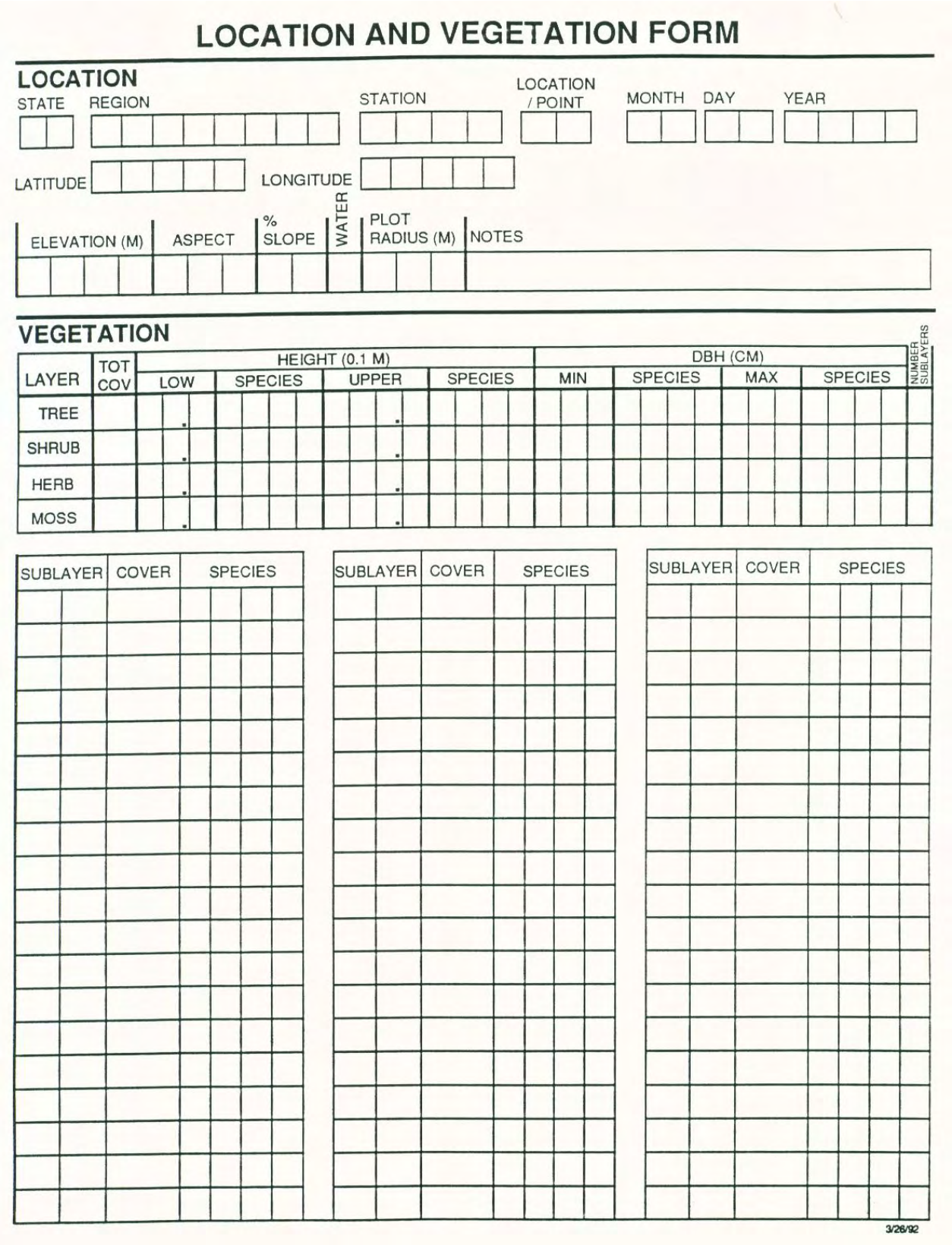
ATTACHMENT 3 POINT COUNT DATA FORM

POINT COUNT DATA FORM

STATE | REGION | STATION | MONTH | DAY | YEAR | VISIT NUMBER

PT. NUMBER	TIME	SPECIES	≤ 50 M		> 50 m		FLY-OVERS	
			0 - 3 MIN	3 - 5 MIN	0 - 3 MIN	3 - 5 MIN	0 - 3 MIN	3 - 5 MIN

ATTACHMENT 4 POINT COUNT LOCATION AND VEGETATION FORM



LOCATION AND VEGETATION FORM

LOCATION

STATE | REGION | STATION | LOCATION / POINT | MONTH | DAY | YEAR

LATITUDE | LONGITUDE

ELEVATION (M)	ASPECT	% SLOPE	WATER	PLOT RADIUS (M)	NOTES

VEGETATION

LAYER	TOT COV	HEIGHT (0.1 M) LOW	SPECIES	UPPER	SPECIES	DBH (CM) MIN	SPECIES	MAX	SPECIES	NUMBER SUBLAYERS
TREE		.		.						
SHRUB		.		.						
HERB		.		.						
MOSS		.		.						

SUBLAYER	COVER	SPECIES

SUBLAYER	COVER	SPECIES

SUBLAYER	COVER	SPECIES

3/26/92

ATTACHMENT 5 RAPTOR NESTING SURVEY SUMMARY FORM

RAPTOR NESTING SURVEY SUMMARY FORM

Species:_____

Observer:_____ **Date:**_____

Type of Survey (aerial, foot, vehicle, boat, etc.)**:**_____

Location of Survey:_____

Weather During Survey:_____

Nest Location Information – **Latilong or Degree Block Number:**_____

UTM Easting:_____ **UTM Northing:**_____

UTM Zone:_____ **UTM Datum:**_____

Latitude:_____ **Longitude:**_____

T _____ **N R** _____ **W Section** _____ **¼ Sec.**_____ **¼ ¼ Sec.**_____

Description of Nest Location:_____

_____

_____

Dominant Habitat of Area:_____

_____

Specific Habitat at Nest:_____

_____

_____

Structure Supporting Nest:_____

Aspect of Structure:_____ **Height of Nest:**_____ **Aspect of Nest:**_____

Adult Activity:_____

_____

Number of Nesting Pairs:_____ **Number of Eggs:**_____ **Number of Young:**_____

Class (Class I = all downy, no feathers; Class II = feathers visible, downy patches on body or head; Class III = completely feathered; Class IV = fledged)**:**_____

Additional Remarks:_____

_____

Updated 12 October 2006

ATTACHMENT 6 RAPTOR NEST REPORT FORM

RAPTOR NEST REPORT FORM

SPECIES _____ SITE NAME & NUMBER _____
ALTERNATE NEST(S) _____
_____
_____

Date	Observer	Number of Adults	Prehatch Occupied [a]	Status Occupied Active [a]	Number of Eggs	Number of Young	Age or Class [b]	Use of Alternate Nests	Comments

[a] Record as yes, no, or ? under both columns.
Occupied = an occupied nest with two adults present at or near the nest and/or fresh lining material in the nest.
Occupied Active = an occupied, active nest in which a breeding attempt was made, indicated by the presence of an incubating or brooding adult, eggs or young in the nest, or fledged young near the nest.

[b] Record age, or determine class designation of young: Class I = all downy; no feathers
Class II = feathers visible; downy patches on body or head
Class III = completely feathered
Class IV = fledged

Updated 12 October 2006

ATTACHMENT 7 COMMON LOON NESTING SURVEY AND HABITAT DESCRIPTION FORM

COMMON LOON NESTING SURVEY AND HABITAT DESCRIPTION FORM

Observer's Name_____ Phone #_____

Address_____ E-mail_____

Lake Name_____

Lake Location _____

(Circle the legal description used: UTM / Latitude, Longitude / Township, Range, Section)

Zone_____ Datum_____ Map Name_____

Lake Size (acres or hectares)_____ Lake Elevation (feet or meters)_____

Survey Date_____ Time Start_____ Time End_____

Common Loons Observed: No_____ Yes_____ (If yes, record # and behavior below)

Number of Adults Observed_____ Number of Young Observed_____

Describe Loon Behavior_____
_____
_____
_____
_____

Describe Lake Characteristics (Is shoreline convoluted? Is emergent vegetation present? Where are emergents located? What vegetation type is along shoreline? Are islands present? How many? What are islands made of? Is vegetation present on islands? What type? Is water level controlled?)_____
_____
_____
_____
_____
_____

Are Fish Present: Yes_____ No_____ Species_____

Other Species Observed_____
_____
_____

Observations WOFed: Yes_____ No_____ WOFed By:_____

ATTACHMENT 8 KEY TO THE EGGS OF MARSHBIRDS AND ASSOCIATED SPECIES

KEY TO THE EGGS OF MARSHBIRDS AND ASSOCIATED SPECIES

Forster's Tern Nests in colonies close together; birds are very social. Nest is a deeply hollowed, well-rounded, compactly woven platform lined with bits of reeds, grass. Also makes depression in mud and sand or pats down grass and soil, lined with shells, grass. Nests are often on muskrat houses, or occasionally (occ) uses nests of Western Grebe. Nest is similar to that of the Common Tern. Eggs are buff, marked with dark brown, often wreathed; 43 mm long, 30 mm wide; usually 3 eggs, occ 2-5.

Black Tern Nests in dense emergent vegetation (veg). Some nests are elaborate; most are only a loose floating mat of damp veg raising eggs just above water. Eggs are often wet. Nest is often on muskrat house, occ in abandoned grebe nest, occ no nest. Eggs are dark olive/buff, marked with dark brown, usually wreathed; 33 mm long, 23 mm wide; usually 3 eggs, occ 2-4.

White-faced Ibis Nests in emergent aquatic veg or more rarely on an island in a low shrub. Nest is a fairly large, substantial structure, deeper than that of a Black-crowned Night-Heron, made of coarse emergent veg and lined with finer materials. Eggs are greenish-blue/bluish-green, unmarked, and a little glossier and more elongated than those of Black-crowned Night-Herons. Eggs are 52 mm long, 34 mm wide; usually 3-4 eggs, occ 2-7.

Snowy Egret Nest is a flimsy platform of sticks and is lined with fine twigs, rushes. It is similar to ibis and night-heron nests, but the material is finer. Eggs are light bluish-green, unmarked, with a smooth shell having little or no gloss; smaller than ibis and night-heron eggs, 43 mm long, 33 mm wide; usually 3-5 eggs, occ 6.

Black-crowned Night-Heron Nest is similar to ibis nest but is not as deep and often contains some terrestrial veg. Eggs are light bluish/greenish, smooth, not glossy, and unmarked; 52 mm long, 36 mm wide; less elongated than ibis eggs; usually 4-5 eggs, occ 2-7.

American Bittern Nest is a scanty platform of available marsh veg; has a separate path for entrance and exit; sometimes there is an arch over the nest. Eggs are smooth, slightly glossy, plain brown to olive/buff, and unmarked; 48 mm long; usually 4-5 eggs, occ 2-7.

Western and Clark's Grebes Nest characteristics of these two species are similar. Both are strongly colonial and nest in marshes on a floating platform in shallow water. Nest is a compact mass of fresh and decayed veg, usually anchored to or built up over live veg; may be in the open or concealed. Eggs are bluish-white, chalky, or nest-stained buff/brown; 58 mm long; usually 3-4 eggs, occ 2-7.

Franklin's Gull Nest is a well maintained, floating platform of coarse veg lined with finer materials; materials added throughout incubation and brooding. Eggs are buff to greenish-buff, sparsely marked with brown; 52 mm long, 36 mm wide; usually 3 eggs, occ 2-4.

ATTACHMENT 8 (continued) KEY TO THE EGGS OF MARSHBIRDS AND ASSOCIATED SPECIES

Eared Grebe Nest is a floating platform in shallow water of fresh and decayed veg, anchored in emergent veg; more than one nest is built. Eggs are bluish-white, chalky, nest-stained buff or brown; 43 mm long, 30 mm wide; usually 3-5 eggs, occ 1-6.

Horned Grebe Nest is a floating platform in shallow water, often anchored in emergent veg; made of underwater plants, rotting veg, rubbish, mud. Building continues during laying and incubation. Eggs are bluish-white, chalky, usually nest-stained; 44 mm long; usually 4-7 eggs, occ 3-7.

Pied-billed Grebe Nest is an inconspicuous, shallow, sodden platform of decaying veg anchored in open water among reeds or rushes; of reeds, grass, often plastered with soft green scum. Eggs are bluish-white, chalky, nest-stained buff/brown; 43 mm long, 30 mm wide; usually 5-7 eggs, occ 3-10.

American Coot Nest is usually over water (1-4' deep), in veg tall enough to conceal it; is a large, floating cup of dead stems on platform anchored to veg, lined with finer materials. Other platforms for resting/roosting. Eggs are pinkish-buff, marked with blackish-brown; 49 mm long, 33 mm wide; usually 8-12 eggs, occ 2-12.

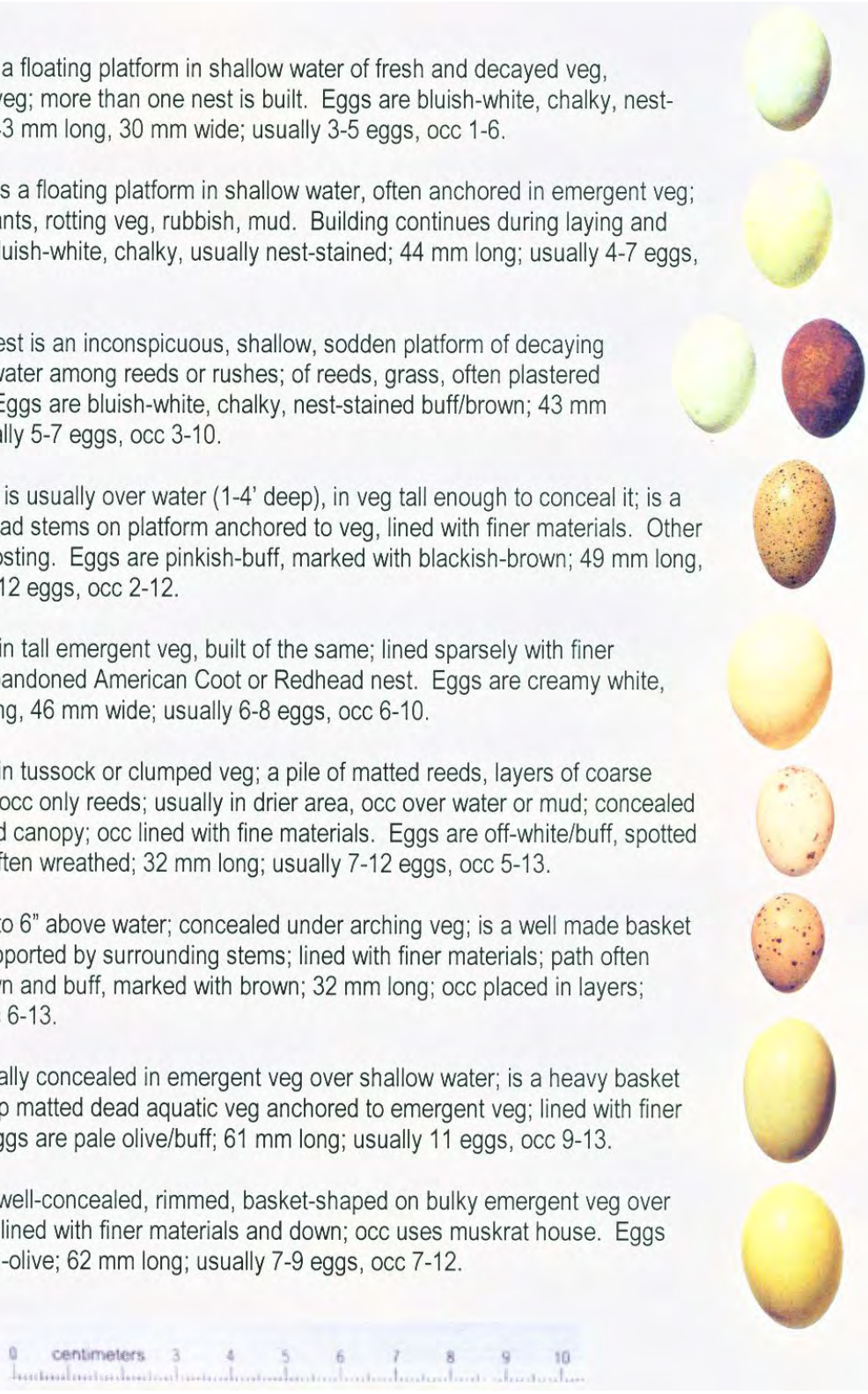
Ruddy Duck Nest is in tall emergent veg, built of the same; lined sparsely with finer materials. Occ uses abandoned American Coot or Redhead nest. Eggs are creamy white, nest-stained; 62 mm long, 46 mm wide; usually 6-8 eggs, occ 6-10.

Virginia Rail Nest is in tussock or clumped veg; a pile of matted reeds, layers of coarse aquatic veg and grass, occ only reeds; usually in drier area, occ over water or mud; concealed often with sedge or reed canopy; occ lined with fine materials. Eggs are off-white/buff, spotted with brown, occ gray, often wreathed; 32 mm long; usually 7-12 eggs, occ 5-13.

Sora Nest is built up to 6" above water; concealed under arching veg; is a well made basket of dead aquatic veg supported by surrounding stems; lined with finer materials; path often evident. Eggs are brown and buff, marked with brown; 32 mm long; occ placed in layers; usually 10-12 eggs, occ 6-13.

Redhead Nest is usually concealed in emergent veg over shallow water; is a heavy basket of rushes or cattails atop matted dead aquatic veg anchored to emergent veg; lined with finer materials and down. Eggs are pale olive/buff; 61 mm long; usually 11 eggs, occ 9-13.

Canvasback Nest is well-concealed, rimmed, basket-shaped on bulky emergent veg over water up to knee-deep; lined with finer materials and down; occ uses muskrat house. Eggs are grayish- or greenish-olive; 62 mm long; usually 7-9 eggs, occ 7-12.



ATTACHMENT 9 WYOMING COLONIAL WATERBIRD COLONY DESCRIPTION AND SURVEY FORM

WYOMING COLONIAL WATERBIRD COLONY DESCRIPTION & SURVEY FORM

COLONY NAME:_____ NUMBER:_____

LEGAL DESCRIPTION: ¼ ¼_____Sec. ¼_____Sec. Sec._____ T_____N R_____W

UTM E_____ UTM N_____ Zone_____ Datum_____

Latitude_____ Longitude_____

OBSERVER(S):_____

TYPE OF SURVEY (foot, canoe, aerial, etc.):_____

Note here _____ if a previous form is available that provides information on landowner, habitat, access, impacts, and management, and there are no changes in any of these categories.

LANDOWNER'S NAME, ADDRESS, PHONE (or name of Forest, District, Resource Area, etc.):

SURVEY DATE:_____ TIME START:_____ TIME END:_____

COLONIAL SPECIES OBSERVED NESTING (at a minimum, record number of adults and estimated number of active nests based on the number and behavior of adults observed; number of total nests, actual number of active nests, number of young, and number of eggs should only be counted if it does not cause excessive disturbance to the colony):

Species	# Adults	Estimate or Actual (circle one)		# Young	# Eggs
		Total Nests	Active Nests		

OTHER SPECIES OBSERVED (birds and mammals):

OBSERVATIONS WOFed: No_____ Yes_____ WOFed BY_____

ATTACHMENT 9 (continued)

WYOMING COLONIAL WATERBIRD COLONY DESCRIPTION AND SURVEY FORM

HABITAT MAP (show shoreline and vegetation types around the body of water, including the colony; indicate north; label nesting and feeding areas):

ACCESS MAP (show roads, buildings, colony location, north, and scale; give name and phone of other landowners controlling access):

_____
SCALE

IMPACTS/DISTURBANCES (woodcutting, houses, other buildings, erosion, agriculture, water fluctuation, recreation, vehicles, research, predation, water quality, etc.):

MANAGEMENT OPPORTUNITIES (water level control, vegetation management, island protection/development, access control, fencing, etc.):

NONCONSUMPTIVE USE POTENTIAL:

PHOTOS TAKEN? (Please attach): Nesting Areas_____ Feeding Areas_____

Updated 12 April 2006

ATTACHMENT 10 FOREST OWL SURVEY SUMMARY FORM

FOREST OWL SURVEY SUMMARY FORM

Date:_____ Time Start:_____ Time End:_____

Observer(s):_____

Survey Location:_____

Type of Survey:_____

Distance/Amount of Area Surveyed (attach map):_____

Habitat Type:_____

Elevation:_____ Moon Phase:_____

Temperature, Wind, Cloud Cover, Snow Depth and Condition:_____

_____

_____

Owls Heard or Observed (circle one): Yes No

Owl Species, Other Species, and Comments:_____

_____

_____

_____

_____

_____

ATTACHMENT 11 FOREST OWL SURVEY ROUTE FORM

FOREST OWL SURVEY ROUTE FORM

Date:_____ Time Start:_____ Time End:_____

Observer(s):_____

Survey Location:_____

Stop #	Time	Species & Number of Adults	Species & Number of Juveniles	Number – Species, Age, & Sex Unknown	Comments & Additional Information

Chapter 20

Nongame Mammals

Martin Grenier

I. INTRODUCTION –

Distribution and trends of many nongame mammals, especially Species of Special Concern (SSC) with Native Species Status (NSS) 4, are incompletely understood (see Oakleaf et al.1996, Cerovski et al. 2004). This dearth of basic status information is a substantial impediment to the effective management of nongame mammals. Standardized data collection and reporting protocols will improve our knowledge base for these species, thereby assisting wildlife professionals and benefiting enthusiasts, private landowners, land use planners and others in Wyoming.

Species data are currently collected and utilized by the Nongame Program for the following purposes: evaluate, monitor, and update status of nongame mammals; monitor and revise their distribution; determine program priorities; support environmental comments on proposed actions; assist planning efforts of land management agencies; and evaluate, support, or refute listing proposals under the Endangered Species Act. In addition, land and resource managers can utilize the data to monitor prey base, measure ecological diversity, and evaluate habitat quality.

II. CENSUS –

A. Trapping Transects (Small Mammals) –

1. Rationale – This type of survey is done to assess the composition and relative abundance of species within a small mammal community.

2. Application – Plan at least 500 trap-nights of catch effort over a 4-day period in each habitat type. Days of heavy precipitation should be excluded from the 4-day period. Space trapping stations 15 m apart, set 4 baited traps (e.g. one live trap, one rat and two mouse museum special snap traps) at each station. A total of 30 stations are placed along 450 m. The transect configuration can be adjusted to cover irregularly shaped habitats such as riparian zones. At least 5 pitfall traps should also be placed along each transect. The pitfalls are used to catch species such as shrews that may not be attracted to baits. Place pitfall traps where they are most effective (e.g. in dense cover, near water, etc.). Use a variety of baits (e.g. peanut butter & oatmeal, raisins, seeds, or others) on each transect. Set traps 24-hours a day to catch both diurnal and nocturnal species and check them twice a day, preferably mid-morning and mid-afternoon. To estimate relative abundance, animals caught in live traps

should be marked to prevent recounting. Ear tags are the preferred marking technique, although toe clipping is also utilized. Place live traps in the shade during summer months and cover them with plastic during cold weather. Always provide bedding material (e.g. cotton balls). Disinfect live traps with a 10% solution of bleach and water after each capture. Wear eye protection, latex gloves, and a facemask when checking traps and handling small mammals.

3. Analysis of Data – Report the total number of each species caught, and the number caught per 100 trap-nights.

4. Disposition of Data – Results of trapping will be entered in the Wildlife Observation System. Submit a written report to the Nongame Mammal Biologist by 1 December. Data will be incorporated into the Annual Completion Report of the Nongame Program.

B. Trapping Grid (Small Mammals) –

1. Rationale – Trapping grids are used to estimate sizes of small mammal populations.

2. Application – The use of trapping grids in mark-recapture studies has been studied extensively (Otis and others 1978, White and others 1982, and Skalski and Robson 1992). To reliably estimate population size, one generally needs a high capture probability (> 0.3), a large trapping grid (100-400 traps), and 5-10 nights of trapping (Thompson and others 1998 and Wilson and others 1996). Set traps in the morning if the target species is diurnal, or evening if it is nocturnal. Check traps once a day and close them during non-target survey periods. Ear tags are the preferred marking method, however toe clipping is acceptable and colored dye can be used for temporary or small grids. Live traps should be shaded in the summer, or covered with plastic during cold weather. Always provide bedding material (e.g. cotton balls). Disinfect live traps with a 10% solution of bleach and water after each capture. Wear eye protection, latex gloves, and a facemask when checking traps and handling small mammals.

3. Analysis of Data – Report the total number of each species caught, and the number caught per 100 trap-nights. If a mark-recapture study is being conducted, report the number of captures and recaptures, and a population estimate of the target species.

4. Disposition of Data – Refer to Section II.A.4. (Trapping Transects)

C. Track Plate Transects (Medium to Large Mammals) –

1. Rationale – This type of survey is used to assess the species composition of medium to large mammal communities. Relative abundance cannot be determined using this survey method.

2. Application – Notice that ethyl alcohol is a Hazardous Material. Contact the Nongame Mammal Biologist for additional information and operational procedures prior to initiating surveys.

   Construct track plates of 16-gauge steel cut into 2 ft x 2 ft squares. Transects are comprised of at least 5 stations, spaced 0.8 km (0.5 mi.) apart. Locate stations along public rights of way, approximately 3–10 m from the road shoulder. Spray track plates with an ethyl alcohol and talc powder mixture. Run transects 5 consecutive nights. Days of heavy precipitation should be excluded from the 5-day period.

   Mix 1 gallon of ethyl alcohol with approximately 1 cup of either white talc powder or a 50/50 mixture of colored carpenter's chalk and talc powder for additional contrast. Apply the mixture with a weed & lawn sprayer. Bait track plates with approximately 3 g of canned mackerel in prairie habitats or with one raw chicken drumstick in forested habitats. Set stations late in the afternoon and check them mid-morning the next day. Use clear plastic tape to lift voucher tracks left by each species detected. Save these by sticking the tape onto data sheets. For assistance with track identification consult Grenier et al. (2003). Olson et al. (1999**)** and Zielinski (1995) provide additional information on track plate surveys.

3. Analysis of Data – Report the total detections of each species, total track plate nights, detections of each species per track plate night, total number of miles surveyed and location of survey stations (UTME, UTMN, NAD83).

4. Disposition of Data – Refer to Section II.A.4. (Trapping Transects)

D. Spotlight Surveys

1. Rationale – Spotlight surveys are done to assess the species composition of a mammal community (nocturnal species) or to determine presence of a target species (e.g. black-footed ferret, swift fox). Relative abundance can also be determined using this method.

2. Application – Consult Clark et al. (1983) for specific protocol to conduct black-footed ferret surveys. Plan survey routes to cover the area effectively (e.g. one survey pass every 30-45 minutes is ideal). Delineate survey routes and boundaries on a 7.5-minute U.S.G.S. topographic map and provide these to all surveyors. Run surveys one half hour before sunset to sunrise. Conduct

surveys either from a vehicle or on foot in areas where vehicular travel is not permitted. Species commonly observed during black-footed ferret spotlight surveys are identified based on eye shine color as described in Clark et al. (1983).

3. Analysis of Data - Report the species detected, the total number of detections, total hours surveyed, location of surveys, and the detections of each species per hour.

4. Disposition of Data – Refer to Section II.A.4. (Trapping Transects)

E. Mist Nets (Bats) –

1. Rationale – Volant mammal communities (e.g. bats) are sampled with mist nets to assess the species composition or to capture specimens for research. Relative abundance can also be determined using this method.

2. Application – Only trained personnel with prophylactic rabies vaccinations should handle bats. Mist nets are highly effective for capturing bats at ground level, sub-canopy and high in the canopy. Mist nets can be deployed successfully in almost any location where bats are expected to fly. Capture success will increase if mist nets are set up near roosts, at water holes, foraging sites, and flyways such as natural forest gaps, man-made trails and mountain ridges. Identify additional sites by conducting acoustic surveys in advance (Refer to Section II.F – Acoustic Surveys). Set and open nets at least 0.5 hours before sundown. Monitor nets continuously for a minimum of 2.5 hours and remove captured bats as soon as possible. For additional information on deployment of nets, handling, aging and sexing bats, consult Kunz (1998) and Nicholoff and Grenier (2005**)** or contact the Nongame Mammal Biologist. Attachment 1 is a dichotomous key to the bats of Wyoming. Some bats, especially *Myotis spp*., are difficult to properly identify in hand even, by experienced biologists.

3. Analysis of Data – Report numbers of each species captured, age, sex and reproductive status. Also report the location and total number of hours surveyed after sunset.

4. Disposition of Data – Refer to Section II.A.4. (Trapping Transects)

F. Acoustic Surveys (Bats) –

1. Rationale – Acoustic surveys are used to establish presence of bats at specific locations (e.g. travel corridors, streams, ponds, etc.), and to identify roost sites (e.g. abandoned mines, buildings, caves, rock crevices, etc.). Ocular surveys done in conjunction with acoustic surveys can increase their effectiveness. Acoustic surveys are also used to identify potential locations for mist netting.

More sophisticated ultrasonic survey systems (e.g. ANABAT) can identify species, enabling researchers to assess the composition of a bat community.

2. Application – MINIBAT Ultrasonic detectors are used to determine presence of bats at a sampling site. Set the reception frequency at approximately 20 to 40 kHz for maximum detection. ANABAT Ultrasonic Bat Detectors will detect vocalization frequencies of all bat species in Wyoming. Begin surveys 0.5 hours before sunset and survey continuously for approximately 2.5 hours. For additional information about ultrasonic detectors, consult Nicholoff and Grenier (2005).

3. Analysis of Data – Report the total number of detections per survey period. Report the species detected if instrumentation capable of identifying species is used.

4. Disposition of Data – Report survey results to the Nongame Mammal Biologist as soon as practical. The information is used for planning and prioritization of additional surveys.

G. Prairie Dog Mapping –

1. Rationale – Mapping is done to document locations and sizes of prairie dog colonies and complexes. The information can be used to assess status, distribution and trends of prairie dogs. Other agencies or consultants may access data and maps for land use planning, pre-development resource inventories, or to determine if ferret surveys are necessary. In some cases, the data may be used to estimate the potential carrying capacity of an area for black-footed ferrets (refer to Biggins et al. 1993).

2. Application – The technique is applicable to both black-tailed and white-tailed prairie dog colonies. Recent advancements in remote sensing have enabled mapping to be done using various types of aerial and satellite images. Despite these advancements, the methodology for determining boundaries of colonies and complexes remains unchanged. Ground surveys, described in the following section, are arguably the most precise means of mapping prairie dog colonies.

   Circumnavigate the colony boundary and record the path traveled using a GPS unit. Record waypoints every 10-20 m. Colonies are considered separate and distinct if the minimum distance between them is at least 200 m. Repeat the process until all colonies within the area surveyed are mapped.

   A prairie dog complex is defined based on the 7-km Rule (Biggins et al. 1993). A complex is a group of prairie dog colonies with a maximum interstitial distance of 7 km. After prairie dog colonies are mapped, identify complexes by drawing 3.5 km buffers around colonies. Colonies with

overlapping buffers are considered part of the same complex. Complex size is determined by summing the areas (ha) of colonies within the defined complex. Note the interstitial distances do not contribute to the size of a complex. Only the actual areas of prairie dog colonies are included. For additional information consult Biggins et al. (1993).

3. Analysis of Data – Report the areas (ha) of each prairie dog colony and the total area (ha) of all colonies within a complex (i.e., complex size).

4. Disposition of Data – Colony locations are entered in the Wildlife Observation System. Submit a written report and map of colony locations to the Nongame Mammal Biologist by 1 December. Data will be incorporated into the Annual Completion Report of the Nongame Program. This information is also used to plan and prioritize additional surveys.

III. TRAPPING MARKING AND TRANSPLANTING –

A. Marking –

1. Rationale – Small mammals are marked to obtain information about dispersal, home range, longevity, and other individual, population, or community attributes.

2. Application – Numbered metal ear tags are the preferred marking method, though toe clipping is often used. For short-term studies, colored dyes can also be used. Marking bats is strongly discouraged due to their small size (e.g. < 10 g).

3. Disposition of Data – Data are entered in the Wildlife Observation System. Submit a written report to the Nongame Mammal Biologist by 1 December. The information will be incorporated into the Annual Completion Report of the Nongame Program.

IV. DISTRIBUTION AND MOVEMENT –

A. Mammal Observations –

1. Rationale – Field observations, whether from trapping or other sources, provide a means of determining distribution, responses to changing habitat conditions, and species presence including rare and uncommon species.

2. Application – All observations of mammals are potentially useful and should be recorded, especially Species of Special Concern with Native Species Status 4 or greater (see Oakleaf et al. 1996, Cerovski et al. 2004).

3. Analysis of Data – Refer to Chapter 1 (Pronghorn), Section V. (Distribution and Movement).

4. Disposition of Data – Record all observation on the Wildlife Observation Forms. These are subsequently entered in the Wildlife Observation System.

B. Atlas of Birds, Mammals, Reptiles and Amphibians in Wyoming –

1. Rationale – Important distribution information is obtained from special surveys, studies, and credible observations. The mammal portion of the Atlas summarizes these data in a useful format. Researchers and educational institutions, agencies, consultants and the public frequently consult the Atlas to obtain information about status, distribution and habitat use. Department personnel rely on the Atlas for documentation to support environmental comments on a variety of federal agency actions.

2. Application – The Atlas provides land managers, biologists and the wildlife enthusiast with current distribution data for all species in Wyoming.

3. Analysis of Data – Data are solicited from qualified observers. The Nongame Mammal Biologist will periodically update the Atlas as additional data are acquired.

4. Disposition of Data – Distribution data for nongame mammals are compiled in the Atlas and also maintained in a geo-referenced database.

V. LITERATURE CITED:

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ATTACHMENT 1

DICHOTOMOUS KEY TO THE BATS OF WYOMING
Revised August 2004

MARTIN GRENIER AND BOB LUCE

The criteria listed apply only to adult animals in which the metacarpal-phalangeal joint on the right second finger is bulbous and appears solid with no open spaces when viewed against a bright light.

1a. Tail fully within the interfemoral membrane or extending a few millimeters beyond the edge of the interfemoral membrane (FAMILY VESPERTILIONIDAE) 2
1b. Approximately 50% of the tail extending beyond the trailing edge of the interfemoral membrane (FAMILY MOLLOSSIDAE) 17

FAMILY VESPERTILIONIDAE

2a. Black dorsal fur; conspicuous white spot on each shoulder, one white spot on rump; ears 45 to 50 mm Spotted Bat (*Euderma maculatum*)
2b. Lacks white spots on rump and shoulders 3

3a. At least the anterior half of the dorsal surface of the interfemoral membrane is well-furred 4
3b. Dorsal surface of the interfemoral membrane naked or sparsely-furred. 6

4a. Uniform black dorsal fur with silver tips; black face Silver-haired Bat (*Lasionycteris noctivagans*)
4b. Dorsal fur color variable but not uniformly black; face not black 5

5a. Dorsal hair dark gray and tipped with band of white (hoary appearance); forearm length 46 to 58 mm; light colored ears distinctively edged in black Hoary Bat (*Lasiurus cinereus*)
5b. Dorsal hair bright reddish-orange to yellow fur Eastern Red Bat (*Lasiurus borealis*)

6a. Ear length 25 mm or more; Ear color translucent or paler than pelage 7
6b. Ear length 25 mm or less; Ear color variable, ranging from same as pelage to black 8

7a. Pale yellow-brown dorsal hair, lighter at base then tip; blunt snout; light colored translucent ears 25 to 33 mm long; forearm length 50 to 55 mm Pallid Bat (*Antrozous pallidous*)
7b. Slate gray or brown fur; prominent fleshy lumps above nose; ears 30 to 39 mm long Townsend's Big-eared Bat (*Corynorhinus townsendii*)

8a. Tri-colored dorsal hairs, brown at tip and base, yellow between; forearm length 30 to 35 mm; pink forearm Eastern Pipistrelle (*Pipistrellus subflavus*)
8b. Dorsal fur uniformly medium brown to pale brown 9

9a. Keel on calcar visible to the naked eye 10
9b. Keel without calcar 13

10a. Wingspan 325 to 350 mm; tragus round; forearm length > 42 mm
Big Brown Bat (*Eptesicus fuscus*)
10b. Wingspan < 300-mm; forearm length < 42 mm 11

11a. Underside of wing furred from side of body to the elbow; wingspan 250 to 270-mm; forearm length 35 to 41 mm Long-legged Myotis (*Myotis volans*)
11b. Underside of wing not furred from side of body to the elbow 12

12a. Tail extends slightly beyond the interfemoral membrane; black mask visible; no distinct rise in the braincase profile; forearm length 30 to 36 mm
Western Small-footed Myotis (*Myotis ciliolabrum*)
12b. Tail does not extend beyond the interfemoral membrane; black mask absent; distinct rise in the braincase profile; forearm length 30 to 36 mm
California Myotis (*Myotis californicus*)

13a. Distinct fringe of hair on trailing edge of interfemoral membrane visible to naked eye; ears 16 to 20-mm; forearm length 39 to 46 mm Fringed Myotis (*Myotis thysanodes*)
13b. Some hairs may be present but lacks distinct fringe on trailing edge 14

14a. Ears 19 to 25 mm long; Ears extend beyond nose when laid forward up to 7-mm; Tragus long and thin Long-eared Myotis (*Myotis evotis*)
14b. Ears < 19 mm long 15

15a. Ears 17 to 19 mm; ears extend < 2 mm beyond nose when laid forward; tragus long, thin and pointed; tragus > 50% of ear height
Northern Myotis (*Myotis septentrionalis*)
15a. Ears < 16 mm 16

16a. Ears generally darker than dorsal fur; forearm length 36 to 41 mm; usually 1 upper premolar; foot hairs usually extend past toes; pelage dark brown with silky sheen
Little Brown Myotist (*Myotis lucifugus*)
16b. Ears pale and nearly same color as dorsal fur; forearm length 32 to 38 mm; always 2 upper premolars; foot hairs do not extend past toes; pelage lacks silky sheen
Yuma Myotis (*Myotis yumanensis*)

FAMILY MOLLOSSIDAE

17a. Ears connected and joined at base before reaching top of nose; forearm length 44 to 50 mm
Big Free-tailed Bat (*Nyctinomops macrotis*)
17b. Ears not connected, although occasionally meeting before reaching top of nose; forearm length 36 to 46 mm Brazilian Free-tailed Bat (*Tadarida brasiliensis*)

Chapter 21

Furbearing Mammals

Reg. Rothwell

I. INTRODUCTION – Twenty-two species of mammals would be considered furbearing animals in Wyoming based on past commercial use of their pelts. However, not all are currently harvested for this purpose. Species and their current legal status are identified below:

Species	Status	Species	Status
bobcat	1,7	skunk	2
badger	1	white tail jackrabbit	2
pine marten	1	black tail jackrabbit	2
short tail weasel	1	gray wolf	2,5,6
long tail weasel	1	wolverine	3
mink	1	fisher	3
muskrat	1	river otter	3
beaver	1	gray fox	3
coyote	2	black-footed ferret	3,6
red fox	2	Canada lynx	3,6
raccoon	2	swift fox	4

[1] State-classified "furbearing animal" (Wyoming Statute 23-1-101)
[2] State-classified "predatory animal" (W.S. 23-1-101)
[3] State-classified "protected animal" (W.S. 23-1-101)
[4] State-classified "protected non-game mammal" (Chapter 52, Section 11 of the Wyoming Game and Fish Commission Regulations)
[5] State-classified "trophy game animal" (W.S. 23-1-101)
[6] Federally-listed, "threatened" or "endangered" species
[7] Federally-regulated interstate / international trade under CITES

Eight species are classified as "furbearing animals" by Wyoming statute. Persons holding a furbearer license can take these species by legal methods during open seasons. In addition, 6 species are classified as predatory animals. Predatory animals can be taken at any time, by any method, without a license. They are commonly trapped or hunted for their pelts. The gray wolf is classified as a predatory animal throughout much of Wyoming, and a trophy game animal in northwest portions of the State (W.S. 23-1-304 and Wyoming Gray Wolf Management Plan). As of this writing, wolves in the lower 48 states remain protected under the federal Endangered Species Act. However, the USFWS is proposing to remove wolves in Wyoming, Idaho, and Montana from the federal list of endangered and threatened species in early 2008, at which time the state will assume full management authority. Five furbearing species are fully protected under Wyoming Statute and may not be taken with traps or by any other

method. Among these are the Canada lynx and black-footed ferret, which are also federally listed endangered species. The bobcat is a state-designated furbearer, but it is also listed in Appendix II of the Convention on International Trade in Endangered Species (CITES). The CITES listing is based on the similarity of the bobcat to other spotted cats that are endangered. The Wyoming Game and Fish Department (WGFD) is required to submit a status report annually to the Division of Scientific Authority, U.S. Fish and Wildlife Service (USFWS), to certify the pelts were legally taken for interstate or international trade. The report must contain an analysis of the effect of harvest on bobcat populations. The species discussed in this chapter include the 8 species designated by the state as furbearing animals, and 6 species (excluding the wolf) designated as predatory animals.

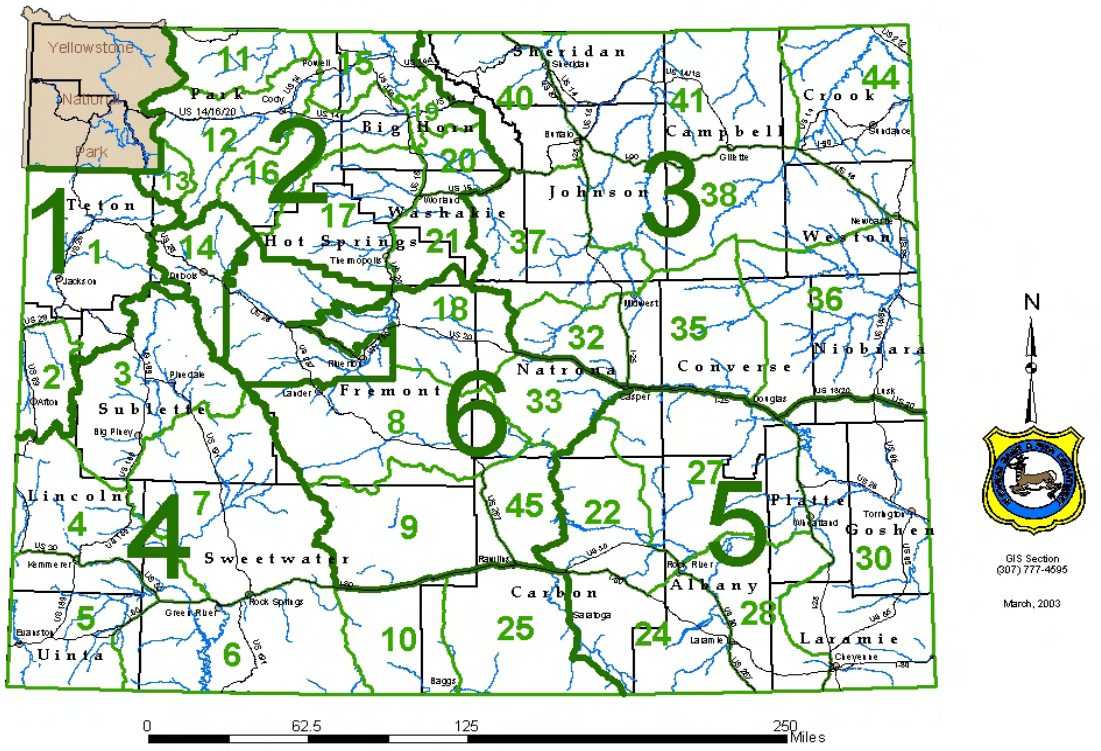
In recent years, sales of furbearer trapping licenses ranged from highs of 1300 to 1500 in the early and mid 1980s, to a low of 669 in 1990. License sales then rose through the 1990s and early 2000s to 1496 in 2005, generating $57,369 in sales that year.

II. DISTRIBUTION – The 14 furbearing and predatory animals occupy a variety of habitats throughout the state. Badgers primarily inhabit prairie, basin shrub, and foothill shrub communities, although they have been documented in some unlikely places such as spruce-fir forests at approximately 10,000 feet elevation in the Wind River Range and in alpine tundra. The marten is a semi-arboreal carnivore, found primarily in coniferous forests of the state's mountains. Raccoons are most commonly associated with riparian zones and urban and agricultural development at elevations lower than 6500 feet. The other terrestrial furbearers are generalists inhabiting most habitats. The 3 aquatic furbearers were historically found in all waters of the state below timberline and occupy most of these habitats today. Some historic beaver and river otter habitats are currently vacant.

III. MANAGEMENT FRAMEWORK – Furbearer management areas were delineated to collect, compile and summarize harvest data. Before 1999, aquatic and terrestrial furbearer management areas were separate. Although this distinction was logical, it created needless complexity because the state does not manage the species differentially. Bobcat data were compiled based on small and upland game management areas. To simplify data compilation, the same small and upland game management areas were adopted for all furbearers. Each of the 6 bobcat management areas encompasses 2 to 8 of the 34 furbearer management areas to maintain consistency with past data reporting (Figure 1). Management information for furbearers is included in the WGFD Annual Report of Small and Upland Game and Furbearer Harvest prepared by Biological Services each summer. More detailed analysis of bobcat data is provided in WGFD's CITES report to the USFWS Division of Scientific Authority. That report is prepared annually in late summer.

Fig. 1

Bobcat (1-6) and Furbearer Management Areas



Populations of furbearers other than bobcats are not estimated in Wyoming. A POP-II simulation model was historically used to estimate bobcat numbers based on annual harvest data and life history information from the literature. However, bobcat population trends are currently monitored through indices that include harvest success and trapping effort.

IV. MONITORING – The WGFD does not conduct annual surveys to determine the abundance of furbearers in the state. Harvest of furbearers at the statewide level is not great enough to affect their populations, and it is not feasible to survey furbearers at the scale or intensity necessary to reliably determine the species' status. The WGFD Nongame Section conducts scent post surveys to monitor swift fox in portions of eastern Wyoming and periodically surveys the Shirley Basin black-footed ferret reintroduction site to monitor status of that small population.

V. HARVEST MANAGEMENT – Furbearers classified as "predatory animals" can be harvested without restriction. Trapping and hunting seasons are not regulated (harvest can occur year-round), and the WGFD does not limit the numbers that can be taken. Seasons for species classified as "furbearing animals" generally allow harvest in the spring and fall. Opening and closing dates vary, but the seasons for most species open

October 1 (bobcat season opens in November) and extend through mid to late spring. Although "bag limits" are not generally imposed for most furbearers, harvest of marten and beaver is controlled in some areas of the state where field personnel believe the number of trappers and the harvest should be limited to prevent trapper crowding or depletion of especially vulnerable populations. The current trapping regulations for furbearing animals specify exact season dates and other limitations applicable to limited quota trapping areas. Seasons are tentatively established based on recommendations from field personnel in early summer and are finalized by the Wyoming Game and Fish Commission in midsummer (July Commission meeting) each year.

Until 2002, the Biological Services Section surveyed all holders of furbearer trapping licenses in the late spring of each year. Response was poor (typically 30% or less), and follow-up mailings produced little improvement. As a result, the harvest calculated from survey returns was considered a minimum estimate. We believe the low response rate was due in part to an increasingly complex survey that requested trappers to estimate trapping effort for each species. The furbearer harvest survey was suspended in 2002 due to the limited cooperation we received. However, in the absence of any type of survey, the Department had no data to document whether trapping seasons are impacting furbearer populations. Beginning in 2006, we resurrected a simplified survey in which we only request information about the numbers of each species harvested in each furbearer management area. Biological Services will estimate overall furbearer harvests from this survey, and will use trapping success (average number of each species harvested per trapper) as an index to gauge trends in furbearer populations.

The estimate of bobcat harvest has been based on the number of pelts tagged since 1992 because this has exceeded the number reported in the survey. Some bobcat trappers may not have their pelts tagged, so the harvest, determined from tagged pelts is also considered a minimum estimate. By regulation, all bobcats harvested in Wyoming must be presented for registration. A USFWS tag is attached to each pelt as part of the CITES program. Biological Services orders the pelt tags from the USFWS each year and distributes them to the regions before the trapping season begins. Tagging records and unused tags are returned to Biological Services after the trapping season. Prior to 2003, age and sex of bobcats were determined by collecting and submitting lower jaws for tooth analysis by the WGFD laboratory at the University of Wyoming. The age and sex composition of the harvest was summarized in the CITES report prepared annually by Biological Services. Since 2003, field personnel have collected information on trapper effort (number of trap days), age class (kitten/adult), and sex the information when pelts are presented for tagging. Teeth are no longer being aged by the WGFD lab.

On average, trappers reported harvesting 17,490 furbearers annually from 1991-2000. Reported harvests ranged from 4,099 in 2000 to 30,537 in 1991 (Wyoming Game and Fish Department, 1991 - 2000). Coyotes comprised 30-40% of the terrestrial furbearer harvest; beaver and muskrat in roughly equal proportions comprised over 90% of the aquatic furbearer harvest. The average annual bobcat harvest from 1994-2006 was 1635. Harvest ranged from 552 in 1995 to 3,617 in 2006 (Wyoming Game and Fish Department, 1994 – 2007).

VI. DISTRIBUTION AND MOVEMENT – The distributions of most furbearers are well known in Wyoming (Cerovski *et al*, 2004). However, better information is sought for certain species, primarily those listed as 'protected' under Wyoming Statute. Personnel should accurately document all observations and reports of lynx, otter, wolverine, fisher, black-footed ferret, swift fox, and gray fox. Locations and accompanying information should be entered in the WGFD Wildlife Observation System. These data are subsequently used for the Wyoming Bird and Mammal Atlas, and other geographic information databases. Additional distribution data are also sought for mink, both species of weasels, and spotted skunks.

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APPENDIX I WIDLIFE OBSERVATION (WOS) FORM AND INSTRUCTIONS

NAME _____ (_____) (_____) (_____) **WILDLIFE OBSERVATION FORM**

MONTH _____ YEAR _____ INFO SOURCE DISTRICT LEAVE BLANK

DAY	SPECIES	SEX	Circle All Estimates: Adult	Yrlg.	Juv.	Uncle	Spec. Age	Hunt Area No.	Degree Block No.	Hab. Type Code	Mort. Code	Animal ACT. Code	Obsv. Act. Code	LOCATION	OTHER INFORMATION
		M												S_____ T_____ R_____	
		F												Z_____ E_____ N_____	
		?												LAT_____ L_____	
		M												S_____ T_____ R_____	
		F												Z_____ E_____ N_____	
		?												LAT_____ L_____	
		M												S_____ T_____ R_____	
		F												Z_____ E_____ N_____	
		?												LAT_____ L_____	
		M												S_____ T_____ R_____	
		F												Z_____ E_____ N_____	
		?												LAT_____ L_____	
		M												S_____ T_____ R_____	
		F												Z_____ E_____ N_____	
		?												LAT_____ L_____	
		M												S_____ T_____ R_____	
		F												Z_____ E_____ N_____	
		?												LAT_____ L_____	
		M												S_____ T_____ R_____	
		F												Z_____ E_____ N_____	
		?												LAT_____ L_____	
		M												S_____ T_____ R_____	
		F												Z_____ E_____ N_____	
		?												LAT_____ L_____	

Use 1 line for each animal when specific age over 1+ is to be recorded.
Circle any number entered that represents a partial count of a group of animals

*Check (✓) one of the system columns to indicate location system used.
Also, use this column to indicate UTM easting zone (either Zone 12 or 13).

HABITAT TYPE CODES*

01.00 Conifer Forests
01.10 Lodgepole pine
01.20 Douglas fir
01.30 Englemann spruce-subalpine fir
01.40 Ponderosa pine (savannah)
01.50 Ponderosa pine-Douglas Fir
01.60 Limber pine
01.70 Whitebark pine
01.80 Pine-juniper
01.90 Other or mixed
02.00 Deciduous Forests
02.10 Aspen
02.20 Riparian-cottonwood
02.30 Cottonwood-dryland
02.40 Maple
02.50 Oak
02.60 Paper birch
02.70 Maple-elm-ash
02.80 other or mixed
03.00 Woodland-Chaparral
03.10 Gambel oak
03.20 Juniper
04.00 Basin-Prairie Shrub-Shrub Steppe
04.10 Sagebrush-grassland
04.20 Greasewood
04.30 Rabbitbrush
04.40 Saltbrush
04.50 Winterfat
04.60 Woody aster
04.70 Other or mixed
05.00 Mountain-Foothills Shrub-Shrub Steppe
05.10 Sagebrush-grassland
05.20 Rabbitbrush
05.30 Mountain mahogany
05.40 Bitterbrush
05.50 Service berry
05.60 Chokecherry
05.70 Hawthorne
05.80 Skunkbrush sumac
05.90 Other or mixed
06.00 Riparian shrub-shrub Steppe
06.10 Willow
06.20 Hawthorne-wild plum-dogwood
06.30 Water birch-dog birch
06.40 Alder
06.50 Shrubby cinquefoil
06.60 Buffaloberry
06.70 Tamarisk
06.80 Russian olive
06.90 Other or mixed
07.00 Grasslands
07.10 Eastern great plains grasslands
07.20 Great basin-foothills grasslands
07.30 Mountain-foothills grasslands
07.40 alpine grasslands
07.50 Alpine moss-lichen-forb
07.60 Wet-moist meadow grasslands
07.70 Kentucky bluegrass grasslands
07.80 Annual grasslands
08.00 Grasslike types
08.10 Sedge
08.20 Sedge/grass/rush meadow
09.00 Marsh-Swamp wetlands
09.10 Cattail
09.20 bulrush
09.30 Cattail/bulrush/sedge
10.00 aquatic
10.10 Lentic or standing water
10.20 Lotic or running water
11.00 Cropland/Agricultural Lands
11.10 Row Crop
11.20 Alfalfa
11.30 Irrigated native meadow
11.40 Irrigated introduced meadow
11.50 Small grains
11.60 Dryland grass pastures
11.70 Fallow lands
11.80 Stored crops
11.90 Rural development
12.00 Barren/Special Features
12.10 Cave
12.20 Cliffs (canyon,mountain)
12.30 Spires
12.40 Rock outcroptrock plies
12.50 Talus slopettalus fields
12.60 Sand dunalsand blowouts
12.70 shoreline
12.80 glacier
99.00 Disturbed Areas
99.10 Roadside/railroad banks
99.20 Mined area (unreclaimed)
99.30 Mined area (reclaimed)
99.40 sprayed area
99.50 Burned area
99.60 Logged1clearcut area
99.70 Loggedfthinned
99.80 Oil and gas sites
99.90 Urban/built up

* See Wildlife Observation Users Manual for expanded habitat codes.

INSIDE FRONT COVER OF WOS BOOK

INSTRUCTION FOR USING
THE WYOMING GAME AND FISH DEPARTMENT
WILDLIFE OBSERVATION FORM

All information must be legible or it will not be eligible for storage and will be returned.

There is a series of blanks at the top of each form game and Fish personnel will leave the first blank vacant and enter their supervisor district number above DISTRICT. All other observers will enter the number 1 above INFO SOURCE leaving the second blank vacant. All observers will leave the last space blank.

Species names should be complete and should be preferred common names. Names like deer, eagles, brown eagles, sage hens, grouse or rabbit will not be acceptable. Mule deer, bald eagle, sage grouse and cottontail rabbit will be acceptable.

Counts and classifications should be as accurate as possible. Use specific age column only when age is determined for individual animals. Yearling age individuals need only be entered under the yearling column.

Locations should be as specific as possible and may be entered to the nearest 40 acres. When entering quarters use only compass points, e.g. NE T21, R70 or NW36 or SENE2. It is not necessary to indicate 1/4 twp. if section is given.

Hunt area numbers can be determined from current game regulations and must be used year-round for all game species for which hunt areas are established. codes for habitat type, mortality and activity are listed on the facing page. Additional habitat codes are listed in the Users' Manual. Degree block is to be completed only when participating in nongame bird surveys. Be as specific as possible on habitat codes and mortality codes.

BACK COVER OF WOS BOOK

MORTALITY CODES

01.00 Cause Undetermined

02.00 Harvest*
- 02.01 Legal Harvest
- 02.02 Illegal Harvest
- 02.03 Cripple Loss
- 02.04 Depredation Harvest
- 02.05 Scientific Collection
- 02.06 Trapped & Transplanted

03.00 Accidents
- 03.01 Highway Accident
- 03.02 Railroad Accident
- 03.03 Electrocution
- 03.04 Drowning
- 03.05 Trapping Mortality
- 03.06 Urban Accident

04.00 Fence
- 04.01 Highway Right-of-way
- 04.02 Railroad Right-of-way
- 04.03 Range fence

05.00 Physiological Stress
- 05.01 Starvation
- 05.02 Dehydration
- 05.03 Parasitism
- 05.04 Exposure

06.00 Disease

07.00 Predation
- 07.01 Wild Mammal
- 07.02 Coyote
- 07.03 Bobcat
- 07.04 Mountain Lion
- 07.05 Black Bear
- 07.06 Grizzly Bear
- 07.07 Red Fox
- 07.08 Wolf
- 07.40 Feral Mammal
- 07.41 Dog
- 07.42 Feral Cat
- 07.50 Wild Avian
- 07.51 Golden Eagle

08.00 Pesticide and Pollution
- 08.10 Oil Well Ponds
- 08.11 Trona Ponds
- 08.12 Chemical Plant Ponds
- 08.20 Pipeline Rupture
- 08.21 Other Spills
- 08.30 Heavy Metal/Selenium Poisoning
- 08.50 Pesticides/Herbicides

OBSERVER ACTIVITY CODES

01 Casual Observation
02 Classification Counts
03 Aerial Trend Counts
04 Ground Trend counts
05 Live Trapping Operation-Animal
06 Permanent Check Station
07 Field Check
08 Other Check Station
09 General Census
10 Mortality Transacts
11 Nesting/Production survey
12 Marked Animal
13 Damage Control

10 Escape (direct flight)
11 Territorial Behavior
12 Predation
13 Standing
14 Walking
15 Running
16 Hiding
17 Flying
18 Swimming
19 Entrapped trapped in fence, etc.)
20 Trapped and Released
21 Trapped and Transplanted
22 Released from Transplant
23 Tagged Animal
24 Injured

ANIMAL ACTIVITY CODES

0 or blank if undetermined
01 Courtship (including leks)
02 Reproductive (breeding, nesting, etc.)
03 Loafing, Roosting, Resting, etc.
04 Migration
05 Feeding
06 Disturbed
07 Damage
08 Sign (tracks, scat,etc.)
09 Watering

* See Wildlife Observation Users Manual for expanded habitat codes.

EXAMPLE OF WOS FORM WITH DATA ENTRIES

NAME John Wos ( ) (5) ( ) **WILDLIFE OBSERVATION FORM**

MONTH _____ YEAR 2003 INFO SOURCE DISTRICT LEAVE BLANK

DAY	SPECIES	SEX	Circle All Estimates: Adult	Yrlg.	Juv.	Uncle	Spec. Age	Hunt Area No.	Degree Block No.	Hab. Type Code	Mort. Code	Animal ACT. Code	Obsv. Act. Code	LOCATION	OTHER INFORMATION
3	Prong-horn	M	1				4	111		11.10	02.01		07	S T R Z E N LAT L	
		F													
		?													
8	Northern Cardinal	M	1						21	06.10		03	01	S T R Z E N LAT L	2 miles west of Torrington
		F													
		?													
14	Mule Deer	M	5					139		05.10		05	03	S 27 T 33 N R 110 W Z E N LAT L	Use Sec., Township and Range
		F	20												
		?		7											
21	Golden Eagle	M							12	02.20		02	09	S T R Z 13 E 376152 N 4760026 LAT L	NEST in isolated cottonwood
		F													
		?	2		2										
30	Lynx	M								01.30		20	05	S T R Z E N LAT 42.834 L 110.636	Healthy, Radio#149.250
		F	1				5								
		?													
		M												S T R Z E N LAT L	
		F													
		?													
		M												S T R Z E N LAT L	
		F													
		?													
		M												S T R Z E N LAT L	
		F													
		?													

Use 1 line for each animal when specific age over 1+ is to be recorded.
Circle any number entered that represents a partial count of a group of animals.

*Check (✓) one of the system columns to indicate location system used.
Also, use this column to indicate UTM easting zone (either Zone 12 or 13).

APPENDIX II

Procedures for Estimating Pronghorn Abundance in Wyoming Using Aerial Line Transect Sampling.

Published by:

Wyoming Game and Fish Department
5400 Bishop Boulevard
Cheyenne, Wyoming 82006-0001

The most current version of the line transect sampling procedures can be downloaded from the following link:

http://gf.state.wy.us/wildlife/pronghorn%20working%20group/index.asp

Suggested citation:

Guenzel, R.J. 2007. Procedures for Estimating Pronghorn Abundance in Wyoming Using Aerial Line Transect Sampling. Wyoming Game and Fish Department, Cheyenne.

For more information about using Wyoming's technique for aerial line transect surveys, contact:

Rich Guenzel
Wildlife Biologist
Wyoming Game and Fish Dept.
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Laramie, WY 82070
(307) 745-4046

Reg. Rothwell
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Cheyenne, WY 82006
(307) 777-4580

APPENDIX III

Harvest Survey Program

Christine Leonard and Reg. Rothwell

I. INTRODUCTION –

Each year, the Wyoming Game and Fish Department conducts several harvest surveys to obtain biological and social data needed for management. Information from these surveys is used primarily to monitor status and trends of game populations, assess effectiveness of hunting seasons, determine future license quotas, and provide data for economic reporting. In addition, harvest summaries are published in several reports available to the public upon request and via the Internet.

Based on data from these surveys, we estimate harvest and hunter activity (participation rates, effort) with respect to the following species groups: big game (deer, elk, pronghorn, moose, bighorn sheep, and mountain goat), small and upland game, migratory game birds, wild turkey, and furbearing animals. Harvest statistics for big and trophy game and wild turkey are reported at several levels of aggregation including hunt areas, herd units, and statewide. Data are also reported according to license type (fee type) and residency status. Harvest statistics for small and upland game, migratory game birds, and furbearers are reported based on species management areas and at the statewide level. Harvest statistics for bison and falconry seasons are obtained from mandatory reporting records rather than formal surveys. Harvest statistics for black bear, mountain lion, and bobcat are obtained from a combination of mandatory harvest checks and surveys to estimate effort and success rates.

An external contractor performs the deer, elk and pronghorn survey, and the hunter effort portion of the black bear and mountain lion survey, collectively called the Big and Trophy Game Harvest Survey. The University of Wyoming Survey Research Center conducted the survey from the 1970s through 1995. Since that time, the survey has been outsourced based on a competitive bid process. PA Government Services of Madison, Wisconsin was awarded the contract in 1999 and remains the survey provider as of this publication (2007). Biological Services performs other species surveys "in-house." At one time, we also estimated archery harvest through a separate survey, however archery data have been captured in the regular big and trophy game harvest survey since 2006.

Sample frames for all harvest surveys are developed from the Department's license sales databases. As the automated "point-of-sale" system comes on line in 2008, license records from vendors will be loaded into the system in "real time," and should be more complete, accurate and consistent in format. Errors from manually keying in sales and personal information will be greatly reduced.

The harvest surveys are kept very basic. We try to limit the number of questions to reduce the burden and avoid respondent "burnout." The basic questions are: Did you hunt and if so, how many days?; what species, sex, age (adult/juvenile), and numbers of animals did you

harvest?; and what type of weapon did you use? We also provide the opportunity for hunters to submit their written comments. These comments tend to convey individual perspectives (both positive and negative) about the hunter's experience, and opinions and recommendations regarding various aspects of the Department's management programs. The survey format and questions vary among species. As information needs and research goals change, the questions we ask may also change.

II. BIG GAME HARVEST SURVEY –

The major purpose of the big game harvest survey is to estimate the harvest of each species in each hunt area and herd unit throughout the State. Harvest is estimated according to sex and age class (adult/yearling/juvenile) as applicable. Additional information derived from the survey includes numbers of active hunters, effort values (days per harvest), and hunter success rates. Biologists summarize and analyze these data in job completion reports (JCRs) prepared annually for each big game herd and trophy game management unit. Age- and sex-specific harvests are key data applied in models to estimate population size. Effort and success data are frequently consulted to verify population status and trends. Harvest statistics are also used to support season recommendations, environmental impact analyses, agency planning, and economic analyses. Hunters, researchers, consultants and other government agencies frequently consult the Department's harvest data.

A. Moose, Bighorn Sheep and Rocky Mountain Goat – The Biological Services Section conducts the moose, bighorn sheep, and mountain goat harvest surveys "in-house." All license holders are included in the survey. Although the response rate is high, there are always some hunters who do not respond. Up to 3 attempts are made to obtain information from non-respondents through follow-up surveys and/or telephone calls. Data from survey respondents are extrapolated based on the numbers of licenses sold in each sampling stratum. In the case of bighorn sheep and mountain goats, harvest is determined from mandatory registrations. However, sheep hunter effort is estimated through a follow-up mail survey that captures data from both successful and unsuccessful hunters.

In the past, we also surveyed mountain goat hunters by mail, but no longer do so. Since harvest success is close to 100%, the information we need is generally available from the goat registration cards. Missing data are retrieved by phoning the comparatively few hunters who did not register a harvested goat.

The Department also collects additional biological information from harvested moose, sheep, and goats for management purposes and to refine harvest estimates. These additional measures are briefly described below.

Moose – Teeth from harvested moose are submitted to the Department's lab in Laramie for aging. Prior to the hunting season, Biological Services mails each licensed moose hunter a "tooth box." Successful hunters are requested to extract the 2 lower incisors from the moose they harvested and return them to the lab. We achieve a very high level of cooperation in part, because hunters are interested in finding out the age of their

animal. When the lab finishes processing the moose teeth collection each year, a completed age database is sent to Biological Services. In prior years we compared the database of hunters who submitted teeth against the mail survey responses and identified additional harvests in the tooth data that were not reported in the mail survey. However, the tooth database reflects only successful hunters whereas the mail survey, in theory, represents a random cross-section of moose hunters. Thus, augmenting the harvest reported in the mail survey with additional harvests from the tooth sample would have skewed data toward successful hunters and biased any extrapolations. As of hunt year 2005, the tooth data are no longer used as proof of additional harvests, but the data are forwarded to regional wildlife biologists for their use.

Bighorn Sheep – Biological Services maintains a cumulative database of bighorn sheep registrations. Each successful sheep hunter, anyone acquiring the skull and horns from a dead sheep (called a "pick-up head"), and anyone possessing the head of a bighorn sheep in Wyoming is required to register the sheep. Registration records include the sheep hunter's (or owner's) name and address, days hunted, whether an outfitter or guide was used, the hunt area and specific location where the sheep was harvested or found, the estimated age, and several horn measurements. Biological Services cross-references this information against the mail survey data to verify every harvest reported by hunters.

Mountain Goat – Harvested mountain goats and "pick-up heads" must also be registered with the Department. The WGFD issues only about 16 to 20 mountain goat licenses annually. As with sheep, the mountain goat harvest database is a cumulative record.

Virtually all moose, sheep and mountain goat licenses are issued in the computer license draw. The single license draw (SLD) database is the source of the hunter information for the mail survey and follow-up contacts. The Department's license carryover process also has a particular bearing on the harvest surveys for these species due to the small numbers of licenses issued in each hunt area. Wyoming Statute provides that a hunter with legitimate medical or other reasons may be granted permission to carry his unused license over to the subsequent hunting season. These inactive licenses must be tracked and accounted for in the sheep, moose, and mountain goat harvest survey.

Governor's licenses can also impact the harvest survey results when they are exercised in hunt areas with small quotas. We obtain a list indicating the hunt areas where Governor's licenses will be exercised each year from the Wildlife Heritage Foundation. The information from these licenses must be manually added to the survey databases. The finalized lists are sent to the wildlife biologists and wildlife management coordinators for their reference. In the ideal, commissioners' and Governor's licenses for deer, elk, and antelope would be added to the "over-the-counter" (OTC) license databases or other big game license datasets. In the past, they have not been added due to the small number of licenses in proportion to the overall pool of deer, elk, and antelope licenses. Moose and sheep licenses on the other hand, are often very limited so a governor's license can significantly increase harvest (on a percentage basis) within a particular area.

1. Survey Process for Bighorn Sheep, Moose, and Mountain Goat Harvest Reporting – After all the drawings are completed, license and hunter data are downloaded from the network and copied to the appropriate ACCESS database maintained by the Harvest Survey Coordinator. Hunter and license information are extracted from the license draw database and included in an annual table created within each species' database. Tables are also added or maintained each year to update the carryover licenses, hunt areas, herd units, and hunt area/license type quotas in each database. An additional field in the survey database uniquely identifies each survey (by number) to track printing, mailing, and data entry.

2 Harvest Estimates – Extrapolations to estimate harvest and hunter activity parameters are based on the proportions of total license sales the useable survey responses comprise for each hunt area and license fee type. We assume the information reported by survey respondents is representative of all hunters. For example, if 1% of the respondents reported they did not hunt, we assume 1% of the non-respondents also did not hunt. We make similar assumptions with regard to the average number of days hunted, age and sex of animals harvested, harvest success, and so forth.

   In reality, characteristics of respondents and non-respondents differ somewhat. The Department commissioned 3 studies of non-response bias in the deer, elk, and antelope harvest surveys over past 3 decades. Generally speaking, the non-respondent is less likely to have hunted and less likely to have harvested an animal. If the non-respondent did harvest an animal, it was less likely to be an adult male. However, the biases detected were generally minor and inconsequential to harvest management decisions. In addition, bias factors were not consistent and often not statistically significant. Accordingly, we assume that characteristics of respondents and non-respondents are similar enough that we do not need to correct for non-response bias in our harvest surveys. (Data from bighorn sheep and mountain goat harvest registrations are not extrapolated because 100% of harvested animals are registered).

3. Precision standards – The goal for moose and bighorn sheep surveys is a response rate of 100%. If the response rate is less than 80% for any hunt area or license type, a second survey is mailed and/or follow-up telephone calls to non-respondents are made by either Biological Services or field personnel. When follow-up calls are necessary, they are usually associated with the moose harvest survey. Calls should be made after the preliminary harvest report is completed, but before the final report deadline.

4. Assumptions –

   Bighorn Sheep. Hunters place such a high value on the opportunity to hunt bighorn sheep that license recipients very seldom decline to hunt. Given historic participation rates, we assume all license recipients hunted unless they state otherwise on the sheep harvest survey or unless the license has been carried over due to medical or other reasons. This assumption affects our calculation of the total number of active

hunters, since we no longer extrapolate from the harvest survey responses to estimate overall participation rates. We also no longer extrapolate to estimate the total sheep harvest because this is derived from the mandatory harvest registrations. The only statistic we extrapolate from the harvest survey is the total number of days hunted. In this way, the effort of hunters who did not kill or register a sheep can be factored into the overall estimate of days hunted per sheep harvested. We assume the effort of non-respondents is the same as that of respondents. The total number of hunter days is calculated by multiplying the average number of days per sheep harvested by the total number of hunters. In 2006, we modified the sheep harvest survey instrument to collect information on the type of archery weapon (crossbow, longbow) archers used to hunt and harvest a bighorn sheep.

Moose. As previously discussed, we no longer use tooth submissions as proof of a harvest in order to adjust the estimates of total moose harvest, hunter participation, and effort. Tooth data represent only successful hunters, whereas the harvest survey is a random sample of all hunters. Therefore, combining these data can skew the accuracy of extrapolations. Beginning in hunt year 2006, moose harvest estimates will be extrapolated from just the survey data. Information from the tooth-aging database will be sent to field biologists. They can address any potential discrepancies they believe exist and explain their rationale in the JCRs. In 2006, we modified the moose harvest survey instrument to collect information on the type of archery weapon (crossbow, longbow) archers used to hunt and harvest a moose.

5. Disposition of Data – Harvest estimates and related information are compiled into the Annual Big & Trophy Game Harvest Report. Biologists consult these reports to prepare recommendations for license quotas, bag limits, season dates and so forth. The reports are sent to the Wyoming State Library, environmental consulting firms, conservation organizations, and government agencies. We also post harvest reports on the Department's public web site. The survey information is analyzed in the herd unit job completion reports (JCRs) prepared by each region, and total harvests and hunter participation are summarized in the Department's Annual Report.

   A preliminary harvest report is prepared after most of the surveys have been returned and preliminary harvest estimates are generated. Preliminary harvest reports are sent electronically to field biologists and wildlife management coordinators for use during the Department's season setting process, which occurs fairly early in the calendar year. The biologists and coordinators also review the reports for potential errors and inconsistent data. After field personnel have reviewed the preliminary estimates and any additional survey data we receive have been entered, final estimates are generated and incorporated into the final harvest report. The final estimates are also sent electronically to the field for use in drafting the JCRs each year. We generate separate harvest reports for each species. The reports summarize harvest and related statistics with respect to herd units, hunt areas, license types, and residency status. Statistics reported include numbers of licenses sold, numbers of licenses exercised (hunters in the field), effort (days expended per animal harvested), harvest success rates, and numbers of each age/sex harvested.

B. Big and Trophy Game Harvest Survey. The deer, elk, pronghorn, black bear and mountain lion survey is contracted to an outside provider. As of this publication, the survey is being done by PA Government Services of Madison, Wisconsin. State purchasing guidelines require large contracts (>$1,500) must be bid no less than every 3 years. A formal request for proposal (RFP) is completed to initiate the bid process. The contract can be renewed with the successful bidder up to 2 successive years pending satisfactory performance. Cost increases for items like postage may not exceed 10% per year and are subject to negotiation. The special provisions and performance stipulations in the harvest survey RFP are extensive and cover the metrics to be estimated, precision standards, report formats, timelines, penalties, and other specifications.

The Department provides the contractor with information from the big and trophy game license databases and other necessary details such as license types and limitations. The contractor selects a random sample of license holders to survey from each hunt area, as outlined in the RFP special provisions and data standards. The numbers of useable survey returns that must be obtained is a calculated percentage of the total number of licenses sold in each area, or the number needed to realize a 90% confidence interval that is ±10% of the male harvest estimate at the herd unit level. The required sample percentage is smaller in areas with greater numbers of licenses issued. For example, the number of useable returns from a hunt area with 700 licenses available may be 25% of the licenses issued, whereas all hunters would be receive a harvest survey in areas with less than 50 licenses issued, given the expectation of realizing at least a 40% response rate.

The contractor conducts separate surveys of pronghorn antelope, deer, elk, black bear license holders, and beginning in 2007, mountain lion hunters. Selected license holders are notified by postcard and requested to complete the survey form on a website hosted by the survey contractor. A mail survey is sent as a backup if the license holder does not respond to the Internet survey by a predetermined date. Specifications for the harvest reports and other deliverables are included in the RFP, and close coordination with the contractor is necessary throughout the year. We work with the survey contractor on the design of the survey instrument, process improvement, data transfer, and occasionally on supplemental surveys. The deliverables to WGFD field personnel include data tables used in the job completion reports, spreadsheets summarizing harvest information in various ways (herd units, hunt areas and statewide totals), results of hunter satisfaction questions, hunter comments received via the Internet, and written comment letters returned with the mail surveys. The contractor also provides us an annual report including thorough documentation of the methodology used and a summary of the year's survey processes and results.

1. Survey Contract & Special Provisions – The Department has segregated big game populations throughout the State into "herd units" for management purposes. A herd unit is (theoretically) a discrete population of animals having less than 10% interchange with adjoining herds. We estimate the size as well as the age and sex composition of each herd based on classification surveys, harvest field checks, mortality surveys, the harvest survey, and population modeling. The harvest survey

is an essential part of the Department's annual management program. Data from the harvest survey are used not only to establish harvest quotas, but also to estimate population size based on change-of-ratio modeling.

Herd units are subdivided into one or more hunt areas to manage the distribution of hunters and harvest. One to several license types may be issued in each hunt area. Some license types may be valid for more than one hunt area within one or more herd units. License types provide managers additional means of controlling the age and sex composition of the harvest, managing hunter densities or distribution through time, and directing harvest to specific portions of a hunt area.

The Department regulates black bear and mountain lion harvest through a quota system. Harvest status is updated in all hunt areas throughout the season. Bear and lion hunters are required to call a toll-free telephone "hotline" and listen to the most current recording to determine if the area they plan to hunt remains open each day. Successful hunters must register their harvested black bear or mountain lion within 72 hours. The biologist or warden who checks a harvested animal promptly reports the harvest to the Biological Services Section in Cheyenne and the hotline is updated.

The numbers of herd units and hunt areas included in the 2007 harvest survey are listed in Table 1.

Table 1. Herd units and hunt areas in 2007. *

SPECIES	# OF HERD UNITS	# OF HUNT AREAS
Elk	35	114
Mule Deer	39	151
White-tailed Deer	5	151
Pronghorn	44	110
Black Bear	N/A	31

* Herd units and hunt areas may be adjusted through time (sometimes they are combined or boundaries are modified). Not all hunt areas are necessarily open every season. The annual hunting regulations specify open hunt areas and limitations including quotas for each species.

Big and trophy game hunt areas and herd units are delimited independently for each species, except hunt areas for mule deer and white-tailed deer coincide. We have adopted this approach because the features that comprise barriers to interchange (i.e., boundaries of herd units), habitat preferences, and the species distribution differ.

Stratifying the sample of hunters to achieve target precision levels is a very complex undertaking. In addition, duplication caused by a hunters' ability to hunt in more than one hunt area or herd unit must be reconciled when hunt area totals are "summed" to estimate herd unit totals, and again when herd unit totals are "summed" to estimate statewide totals. The ability in some cases to hold multiple licenses for a single

species also adds to the complexity. License sales for 2006 are summarized in Table 2.

Table 2. Licenses sold in 2006 (pre-audit).

LICENSE TYPE		GENERAL	LIMITED QUOTA	TOTAL SOLD
Antelope	Quota	N/A	65410	
	# Sold	N/A	58138	58138
Deer	Quota	Unlimited	22270	
	# Sold	71545	19424	90969
Elk	Quota	Unlimited	30495	
	# Sold	28475	28993	57468
Black Bear	Quota	Unlimited	N/A	
	# Sold	2967	N/A	2967

III. SMALL AND UPLAND GAME HARVEST SURVEY –

Since 2002, the Biological Services Section has conducted the small and upland game (SMUG) harvest survey "in-house." Historically this survey was done by the University of Wyoming Survey Research Center and then by an independent private contractor. Harvest data for 12 species of small game and upland game birds are reported from 37 small and upland game management areas. In addition, harvest data for 6 species groups of migratory game birds are reported from 19 migratory bird management areas.

A. Small Game, Upland Game, and Migratory Game Bird Survey – This is our largest and most complex in-house harvest survey. It involves 2 different sets of management areas and 3 sets of species or species groups. The migratory bird species are ducks, geese, coots, rail, mourning doves, and snipe. The small game species are cottontail rabbit, snowshoe hare, and tree squirrels (red, gray, and fox squirrels). The upland game species are gray partridge, chukar partridge, pheasant, blue grouse, ruffed grouse, sharp-tailed grouse, and sage grouse. In 2006, 11 different license fee types were available to hunt these species. The fee types include resident lifetime licenses, resident and nonresident annual licenses, and resident and nonresident daily licenses in various combinations of license privileges (i.e., bird only, small game only, and bird and small game in combination). As new fee types and license privileges are added or discontinued, the structure of the survey and reporting requirements must be adjusted accordingly.

Sampling is stratified according to fee type. The types with smaller total sales are surveyed at 100%. The types with larger total sales are sampled at 25% to 50%. Virtually all licenses to hunt small and upland game, and migratory game birds are sold over the counter. The over the counter (OTC) license database is the main source of the hunter contact information for surveying harvests of these species. Lifetime license information is extracted from the lifetime license database.

1. Survey Process for Small and Upland Game and Migratory Game Bird Harvest Reporting – Once sufficient data from license sales have been entered to attain the target sample sizes, Biological Services creates an annual table in the SMUG database by running queries to extract the hunter and license information from the OTC and lifetime license data sets. Tables are also added or maintained each year to record survey response data based on hunt areas and license types. An additional field in the survey database uniquely identifies each survey (by number) to track printing, mailing, and data entry.

2. Data Extrapolation – Extrapolations to estimate harvest and hunter activity parameters are based on the proportions of total sales of each license fee type represented by the useable survey responses. We assume the information reported by survey respondents is representative of all hunters. For example, if 1% of the respondents reported they did not hunt, we assume 1% of the non-respondents also did not hunt. We make similar assumptions with respect to the areas hunted, number of days hunted, species harvested, and so forth.

   The SMUG extrapolation is complicated by the large number of sampling strata – 11 different fee types are each valid for a unique residency and hunting privilege combination. Survey responses are tallied in the appropriate fee type groups and then 11 weights (extrapolation factors) are calculated based on the total sales of each fee type divided by the number of usable responses. Harvest statistics for each fee type, such as total harvest and hunter days, are estimated by multiplying the survey response tallies by the applicable weighting factor.

3. Precision standards – Due to the complexity of the SMUG survey, the number of fee types with limited sales, and the number of management areas for which harvest is reported, no precision standard is applied. The goal is to achieve target sample sizes specified for each fee type.

   In addition, any attempt to determine confidence intervals is complicated by the fact we do not sell small and upland game licenses valid for individual species. Hunters have the ability to exercise their licenses for various combinations of species to the exclusion of other species, depending on the individual hunter's preference. Consequently, we have no way of relating the sample of hunters who say they hunted doves or blue grouse, for example, to the actual numbers of dove or blue grouse hunters in the state in order to calculate a confidence interval by conventional means. More sophisticated methods of estimating confidence intervals have been suggested by the Wyoming Survey and Analysis Center (WYSAC), but would require substantial reprogramming and may render the survey too costly and complex to conduct "in house."

   Lacking a straightforward way to estimate precision, we cushion our sample by selecting a very high proportion of license holders. The 2 fee types representing the largest numbers of licenses sold are resident annual game bird and resident annual

combination game bird/small game licenses. These are sampled at 30% of the total numbers issued. The 2 fee types representing mid-level sales are lifetime combination game bird/conservation stamp and non-resident daily game bird/small game. They are sampled at 50%; and the remaining 7 minor fee types are sampled at 100%. Grandjean et al. (2006) provide a detailed description of the statistical procedures they recommend to estimate variance within the complex sampling framework of the Department's small and upland game licensing system.

The response rate for the SMUG survey has varied from 15% to 40% depending on fee type. In an effort to improve response (and precision), we have mailed the initial survey earlier to improve hunter recall, conducted follow-up surveys, improved the design of the survey instrument, and provided the option of entering survey data on the Internet. Although we presume these measures have helped to increase the response rate, due to budget and time constraints, we are unable to measure the extent to which they have.

Since small and upland game licenses are valid statewide, survey samples of licenses exercised for some species and management area combinations can be quite small and variable. We presume the statewide estimates of harvest, effort, and hunter participation are reliable, however estimates for finer stratifications based on management area and fee type can become very imprecise and unreliable.

4. Assumptions – We assume the survey selection is a random sample of license holders; the information reported by survey respondents is representative of all hunters including non-respondents; and we are obtaining a representative sample of licenses exercised for each potential species/management area/license fee type combination (fee type can define residency status, as well as length of time and species group(s) for which the license is valid). We also assume respondents do not report information for more than one license fee type. These assumptions may not be rigorously met in all cases, but we feel they are reasonably defensible. Field personnel and managers can account for possible biases in formulating and justifying their management recommendations. Some aspects of hunter behavior differ among daily, annual, and lifetime license holders as well as residency status. To account for these possible differences, we stratify our sample based on fee types and we develop separate estimates by extrapolating from the data reported for each fee type. Management area and statewide harvest statistics are estimated by adding the fee type estimates together.

5. Reporting – Results of the SMUG survey are published in the Annual Report of Small and Upland Game Harvest. Estimates of hunter numbers (participation), harvest, and effort are provided for each species/species group and management area.

B. Wild Turkey Harvest Survey – The wild turkey harvest survey is conducted twice per year, once following the spring hunting season and again after the fall season. Although the surveys are done separately, results are combined to estimate the total harvest published in the Annual Small and Upland Game Harvest Report. Turkey licenses are

sold both through the Department's license draw system and over the counter. Limited quota and general licenses are issued depending on the hunt area. In an average year, at least twice as many turkey licenses are exercised during the spring season, making the harvest survey for that season a much larger effort compared to the fall season survey.

As turkey populations and their distribution expanded in Wyoming, additional hunt areas were converted from limited quota to general hunting seasons. This trend has complicated the harvest survey because the entire population of general license holders must be surveyed to obtain samples of hunters who exercised their licenses in specific hunt areas. Obtaining an adequate sample from some of the less popular, general hunt areas can be quite difficult.

The turkey survey has been modified for the 2007-08 season to include questions regarding the number of general areas hunted and the weapon type used to harvest a turkey. The Department is also considering a 2-turkey bag limit on a trial basis in 2008 and 2010, and this may require another license fee type in the general hunt areas.

1. Survey Process – We attempt to survey 100% of license holders, but are constrained to some degree by the timing of OTC license data entry. Over the past several years increasing numbers of general license receipts have been received from license selling agents later than would be optimal for the survey. Consequently, somewhat less than 100% of license holders are being surveyed. Hunter identification and license type information are downloaded from both the single license draw (SLD) and the OTC license databases. An additional field in the survey database uniquely identifies each survey (by number) to track printing, mailing, and data entry.

2. Data Extrapolation – Data obtained from general license holders are treated differently than data from limited quota licenses because not all general license hunters report the hunt area(s) in which they exercised their license. Limited quota licenses are only valid in a specified area, whereas general licenses can potentially be exercised in several areas. All data reported by limited quota license holders are used to estimate harvest statistics in the hunt area where the license is valid. Harvest statistics for general hunt areas can only be derived from the survey respondents who reported where they hunted. However, statewide harvest statistics are extrapolated from all general license data, including data from the respondents who did not identify their hunt area. The extrapolation factor for each limited quota area is the number of licenses issued for the area divided by the number of respondents. The extrapolation factor for general hunt areas is the statewide total of general licenses sold divided by the total number of respondents who indicated the area in which they hunted. The extrapolation factor for the statewide estimate of general license harvest is the statewide total of general licenses sold divided by the number of respondents who hunted with a general license.

3. Precision Standards – Estimating confidence intervals is rendered difficult for several of the reasons discussed in the SMUG survey methodology, i.e. the ability to exercise a license in more than one hunt area coupled with resident and nonresident fee types

(refer to Section III.A.3.). We assure estimates are as precise as can reasonably be achieved by surveying all license holders and implementing practices to improve response rates. In addition, we provide an Internet option to facilitate responding, which also reduces survey costs. As with the SMUG survey, we presume the statewide estimates of harvest, effort, and hunter participation are reliable, however estimates for finer stratifications based on hunt areas and resident/nonresident fee types can be very imprecise.

4. Assumptions – We assume the survey selection is a random sample of license holders; the information reported by survey respondents is representative of all hunters including non-respondents; and we are obtaining a representative sample of licenses exercised for each potential hunt area/license fee type combination. These assumptions may not be rigorously met in all cases, but we feel they are reasonably defensible. Field personnel and managers can account for possible biases in formulating and justifying their management recommendations. Some aspects of hunter behavior differ between resident and nonresident license holders. To account for these differences, we stratify our sample based on residency fee types and we develop separate estimates by extrapolating from the data reported for each fee type.

5. Reporting – Turkey harvest estimates are published in the Annual Report of Small and Upland Game Harvest. The Harvest Survey Coordinator prepares 3 separate reports each year: one summarizing spring harvest statistics, one summarizing fall harvest statistics, and the combined annual harvest statistics. Harvest statistics are reported for each hunt area and also according to residency status. The statewide harvest statistics are published in the Department's Annual Report.

C. Furbearer Survey – Historically, the furbearer survey required trappers to recall detailed information about numbers of traps, days traps were set, and harvest totals for a large array of species. The information was primarily needed to monitor bobcat harvest in order to fulfill reporting requirements of the Convention on International Trade in Endangered Species (CITES). However, we also compiled survey data to monitor trends of other furbearing species and assure the Department has sufficient data to justify trapping seasons. The furbearer survey was discontinued in 2002 due to a chronically low response rate ($\leq$30%) and was replaced with a mandatory bobcat registration and tagging requirement to comply with CITES. However, this left the Department with insufficient data for the remaining species, and truncated a long-standing data set.

The furbearer survey was reinstated in 2006 (covering the 2005-06 trapping season), but was greatly simplified to improve response rates. We are now requesting much less information – basically the number of each species trapped or harvested and identification of the furbearer management area(s) where the trapping took place. Effort data (trap days) for the bobcat harvest are obtained at the time pelts are registered, but are no longer requested on the furbearer survey form.

The furbearer harvest survey covers 11 species including: badger, bobcat, pine marten, weasel (longtail, shorttail, and least), coyote, raccoon, red fox, striped skunk, beaver,

mink and muskrat. Four of the species (fox, coyote, raccoon, and skunk) are legally classified as predatory animals rather than furbearing animals under Wyoming law and we considered dropping them to further simplify the survey. However, we decided to retain all species that are harvested for their fur.

The Department has designated 39 furbearer management areas and 6 bobcat management areas in Wyoming. Although bobcats are included in the furbearer harvest survey, the core statistics used for CITES reporting are obtained from the mandatory pelt tagging and reporting requirement.

Anyone who traps or hunts furbearing animals in Wyoming must obtain a resident or nonresident furbearer trapping license. Trapping licenses are unlimited in number and sold over the counter. License holder information for the furbearer survey is obtained from the OTC database. Although some beaver and pine marten trapping is done under limited quota permits, persons obtaining those permits must also have a furbearer trapping license and are surveyed as part of the statewide pool of trappers. Thus, beaver and marten harvests in limited quota areas are incorporated in the harvest figures for the applicable management area, but are not reported for the limited quota trapping areas.

1. Survey Process – We survey 100% of the trapping license holders due to the comparatively limited numbers of licenses sold each year and historically low response rates. The 2005-06 survey was conducted at the statewide level and data were reported for resident and nonresident trappers. Harvest estimates from future surveys will be reported from each furbearer management area, as was done historically. Estimates of firearm and trapping harvest will also be reported separately.

2. Data Extrapolation – Extrapolations to estimate harvest and trapper activity are based on the proportions of total license sales represented by the useable survey responses. We assume the information reported by survey respondents is representative of all trappers. For example, if 1% of the trappers reported they did not trap, we assume 1% of the non-respondents also did not trap. We make similar assumptions with respect to the areas trapped, species harvested, and so forth. To address actual and potential differences in behavior, separate extrapolations are done to estimate trapping statistics for resident and non-resident license holders. (See assumptions below)

3. Precision Standards – Response rates were exceedingly low during the last several years the furbearer trapping survey was conducted. Less than 30% of licensed trappers were responding to the survey at the time it was discontinued in 2002. Response improved modestly (32% overall) when a simplified survey was resurrected in 2006. Because of the sheer number of sample strata associated with 11 species, 39 management areas, and resident/nonresident license fee types, estimates for many strata (species/management area combinations) are highly imprecise (refer to the SMUG survey discussion in Section III.A.3.). The problem is compounded by the poor response rate and small sample size. We plan to explore strategies for

improving response rates through survey redesign, public outreach, and other means if time and budget allow.

4. Assumptions – We assume the survey selection is a random sample of license holders; the information reported by survey respondents is representative of all furbearer trappers including non-respondents; and we are obtaining a representative sample of licenses exercised for each potential management area and license fee type combination. These assumptions may not be rigorously met in all cases, but we feel deviations and resulting biases are minimal. Field personnel and managers can account for possible biases when formulating and justifying their management recommendations. Some aspects of trapper behavior differ between resident and nonresident license holders. To account for these differences, we stratify our sample based on residency fee types and develop separate estimates by extrapolating from the data reported for each fee type.

5. Reporting – The furbearer harvest survey is published each year in the Annual Report of Small and Upland Game Harvest. In 2006, results will be reported from within each management area, statewide, and according to residency status. Statewide harvest statistics are also reported in the Department's Annual Report.

IV. REFERENCES

Grandjean, B., T. Fergeson, and K. Gerow. A project for the Wyoming Game & Fish Department for improving the small and upland game harvest survey. Wyoming Survey and Technical Analysis Center Tech. Rep. No. SRC-613. University of Wyoming, Laramie. 21pp.

APPENDIX IVa

REPRODUCTIVE CONDITION FORM

Wyoming Game and Fish Laboratory Staff

SPECIES: _____ DATE OF KILL: _____
LOCATION OF KILL: Rng. _____ Twn. _____ Sec. _____ ¼ Sec. _____

I. CONDITION OF OVARIES:

Left ovary	Right ovary
_____ follicles (present/absent)	_____ follicles (present/absent)
_____ # CH*	_____ # CH*
_____ # CL*	_____ # CL*

II. CONDITION OF UTERUS:
anestrus; _____estrus; _____pregnant_____

*Left horn	*Right horn
_____ fetuses	_____ fetuses
C-R* _____	C-R* _____
_____	_____
_____	_____
_____	_____

III. DISPOSITION OF REPRODUCTIVE TRACT:
_____ discarded

_____ preserved, Laramie Lab., I.D. No. _____

_____ preserved, Univ. of Wyo. Museum I. D. No. _____

IV. DATA COLLECTED BY:
_____
_____
_____

V. DATA SUBMITTED BY:
_____
_____
_____

***** - Refer to Appendix IV-B, (Reproductive Definitions)

APPENDIX IVb

REPRODUCTIVE DEFINITIONS

Wyoming Game and Fish Lab Staff: ***Tom Moore, Bill Hepworth***

I. Ovarian Structures

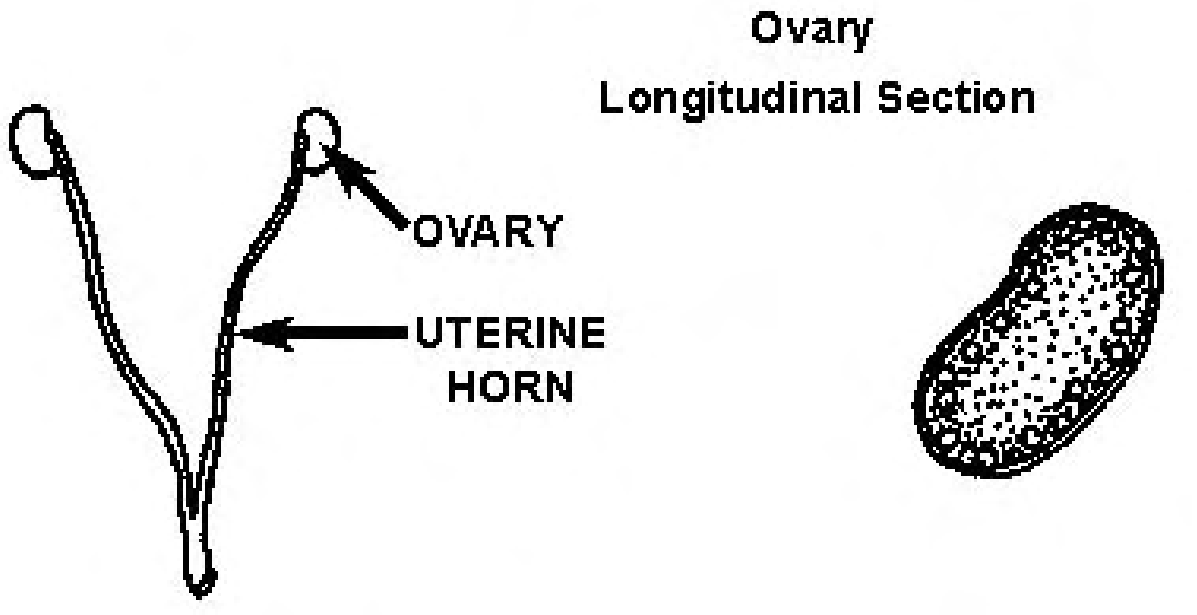
A. Corpora hemorrhagica (CH) – Appear as small blood-filled spots on the external surface of the ovary. They are present only if the animal has ovulated very recently. CH are formed at the site of each follicular rupture.

B. Corpora Lutea (CL) – These structures form in the ovary at the site of each follicular rupture. CL evolve from CH, however, unlike the CH they are not always visible on the surface of the ovary. Since they evolve from CH, their presence indicates a longer elapsed time from ovulation than is indicated by CH. The ovary must be sectioned longitudinally to determine if CL are present. CLs are generally an orange-pink color and are homogeneous in texture.

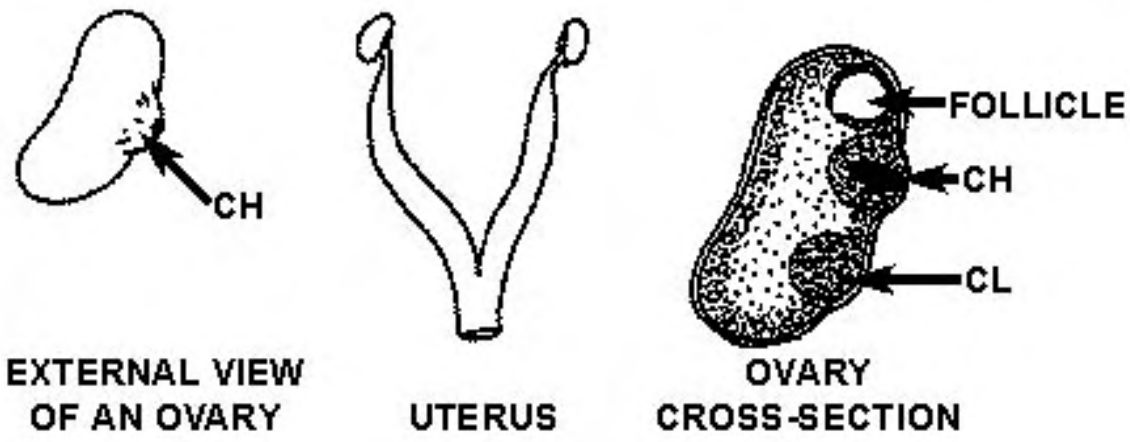
C. Follicles – are clear fluid filled sacs of varying size.

II. Uterine Condition

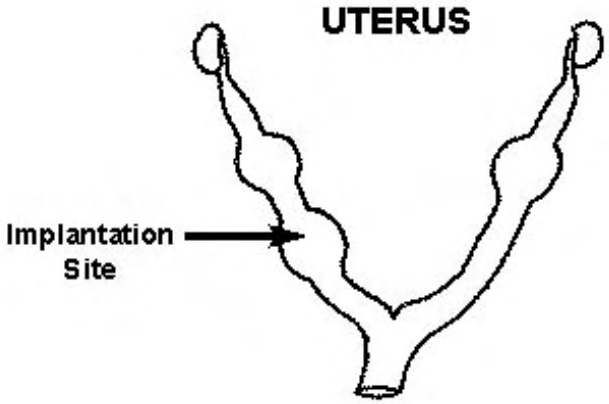
A. Anestrus – During anestrus there is no reproductive activity. The uterus is limp and collapsed in appearance. This condition is illustrated below.



B. Estrus – During estrus reproductive activity is imminent or in progress. The uterus is turgid and distended. At this time, either follicles, CH or CL may be present, depending upon the progression of the ovulation process. This condition is illustrated below:

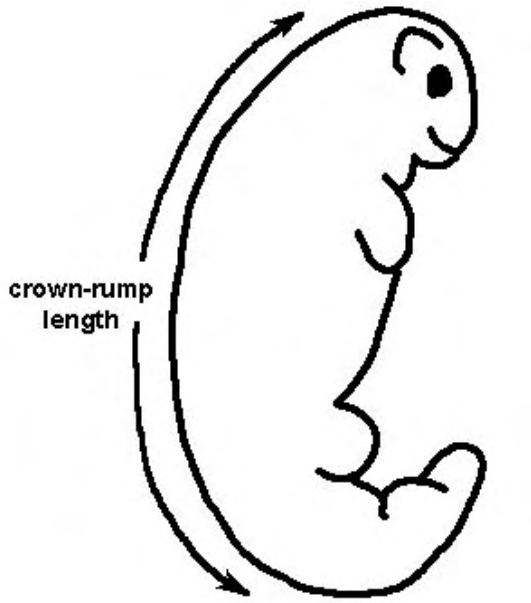


C. Pregnant – During pregnancy the uterus is very distended and turgid. Pregnant reproductive tracts cannot be identified macroscopically until the embryonic sites become pronounced. A reproductive tract in early pregnancy is illustrated below.



III. Crown-Rump Length (C-R)

A. Crown-rump length is the standard fetus measurement. The age of the fetus can be determined from this statistic. C-R is measured from the top of the head along the curvature of the back to the base of the tail.



IV. General Considerations

A. Right or left measurements always refer to animal's right or left.

B. When reproductive tracts are preserved, 75% ethanol is suitable as a "short duration" fixative (up to six weeks). For permanent fixation use "AFA" solution and prepare as follows:

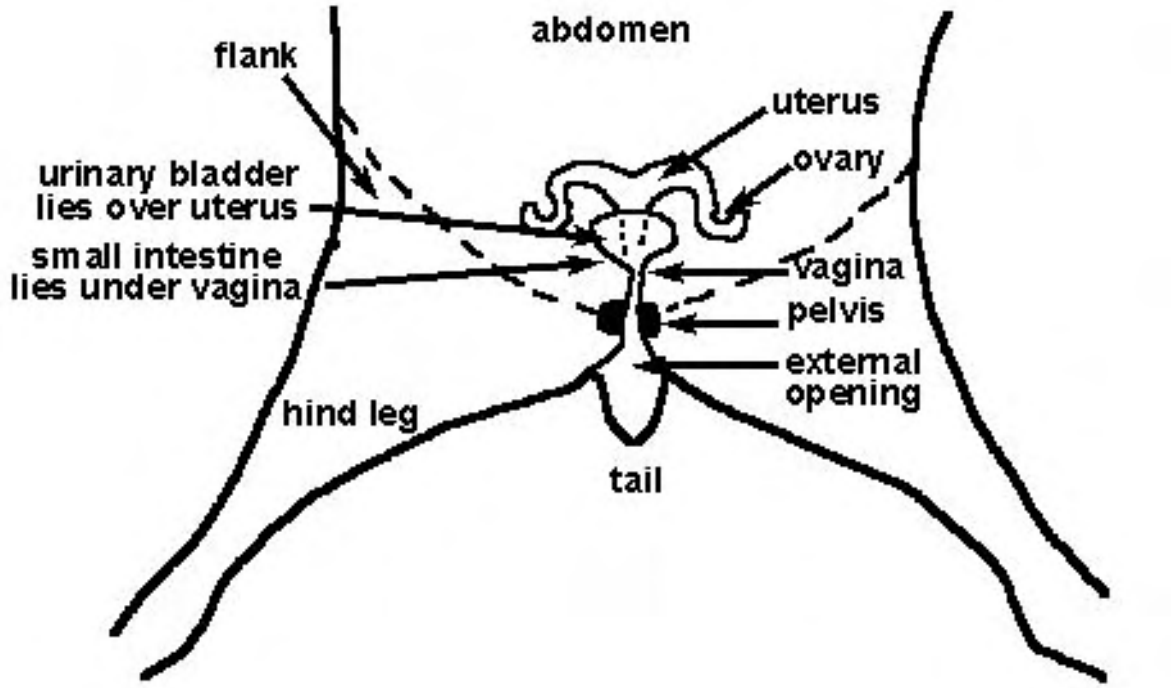
Distilled water_____ 50%
95% ethyl alcohol_____ 30%
40% formalin_____ 10%
Acetic acid_____ 10%

If these ingredients are not available, you may obtain this fixative through the Laramie Veterinary Services Laboratory.

C. When reproductive tracts are preserved, label the identifying number with pencil, as most ink is soluble in alcohol.

DIAGRAM AND INSTRUCTIONS
FOR COLLECTING

Reproductive Tract and Teeth of Female Big Game Animals



PLEASE COLLECT THE FOLLOWING ITEMS FROM YOUR DOE AND BRING THEM TO ONE OF THE CHECK STATIONS.

1. Collect the ovaries (2) and the uterus from the doe. Try To keep them in one piece. Place them in the plastic Bag you have been provided and seal it with on of the Numbered tags.
   *It is important that these organs do not dry out.

2. Be sure you have the head attached to the carcass as we will want to collect teeth and the head will also be needed for evidence of sex.

Be sure to return the plastic bag and its contents to one of the check stations.

Thank you for your cooperation.

Wyoming Game and Fish Department

FIELD COLLECTION AND POST MORTEM DATA SHEET

1.	Species	5.	Date
2.	Sex	6.	Location
3.	Age	7.	Time Collected
4.	Identification No.	8.	Collected By

9. WEIGHTS:

a.	Whole	Lbs.	j.	Lungs	g.
b.	*Hog dressed	Lbs.	k.	Heart	g.
c.	**Clean dressed	Lbs.	l.	Thyroid	g.
d.	Viscera	Lbs.	m.	Adrenals	g.
e.	Digestive tract	Lbs.	n.	Pituitary	g.
f.	Stomach (s)	Lbs.	o.	Other	
g.	Liver	Lbs.			
h.	Spleen	g.			
i.	Kidneys	g.			

* Hog dressed wt. – Eviscerated with hide, head, and legs attached.

** Clean dressed wt. – Carcass with viscera, hide, head, and legs removed at knees and hocks.

10. STOMACH CONTENTS:

a. Total wt. _____ b. Total vol. _____

11. MEASUREMENTS (in.):

a.	Total length (nose-tail tip)	f.	Horn or antler
b.	Tail length	g.	Fetus CR length & Sex a. b. c.
c.	Hind foot	h.	Fat depth – brisket -- rump
d.	Ear (notch to tip)		
e.	Shoulder muscle	i.	Other

12. GENERAL BODY CONDITION _____

13. OTHER SAMPLES COLLECTED:

a. Blood _____ e. _____
b. Fat _____ f. _____
c. Bone _____ g. _____
d. Striated muscle _____ h. _____

14. REMARKS: _____
_____
_____

Necropsy Protocol

Herd name/location _____ Animal ID (if any) _____
Location: Township _____ Range _____ Section _____ or UTM _____
WSVL Accession # _____ Date of necropsy _____
Species _____ Age _____ Sex _____
Weight "live" _____ Dressed weight _____
Hair coat quality: Excellent Good Fair Poor Very Poor
Species and number of external parasites: _____ Collected? _____

Body Muscle (0-5) _____Back fat score: 0 5 10 15
Mm fat on: Heart _____ Kidneys _____Omentum _____ Xyphoid _____
Bone Marrow Color _____ Texture _____
Internal Exam:

Species and number of internal parasites: _____Collected?_____

No. fetuses: _____ Weight: #1: _____#2: _____ Sex: #1:_____ #2:_____
Crown-Rump: #1:_____ #2: _____ Crown-nose #1: _____# 2: _____

Tissues fixed:

Heart _____
Liver _____
Spleen _____
Lung _____
Tongue _____
Muscle _____
Kidneys _____
Rumen _____
Reticulum _____
Omasum _____
Abomasum _____
Ileum _____
Gonads _____
Brain _____
Pancreas _____
Ileocecal LN _____
Bladder _____
Bone Marrow _____
Retropharyngeal LN ___

Tissues taken for laboratory evaluation:

Fecal (parasitology) _____ Abo wash _____
Blood (red tops) X 2 _____
Blood (purple tops) X 2 _____
Teeth (both I-1s) for aging _____
Others (list):

Tissues frozen:
Liver _____
Kidneys _____
Brain _____
Rumen contents _____
Muscle for DNA _____
Fat _____
Feces _____

APPENDIX V

AGING TECHNIQUES

Wyoming Game and Fish Lab Staff: ***Tom Moore***

I. INTRODUCTION –

Two methods are commonly applied to age big and trophy game, and furbearing animals. One is based on tooth replacement and wear, and the second on cementum annuli deposition in roots of incisors, canines, and premolar teeth. The replacement and wear techniques are used to age game animals in the field. Aging based on cementum annular rings is more accurate, but requires extraction of a tooth for laboratory processing.

II. FIELD TECHNIQUES FOR AGING –

A. Deer, Elk and Pronghorn –

Pojar (1997) described field techniques for aging deer, elk, and pronghorn (attached). Most age data are collected during hunting seasons, when large samples of harvested animals are available. Some individual variation results from a natural range of birth dates and genetic differences. Based on tooth replacement, wildlife managers can assign animals to age categories through the maximum age at which all deciduous teeth are replaced. Tooth wear criteria enable managers to place individuals into several year classes extending beyond the age at which permanent dentition is acquired. However, diet and soil conditions contribute to significant geographic variation in the rate and degree of tooth wear for any species (Dimmick and Pelton 1996). Based on Pojar's criteria, it is possible to age pronghorn up to 4.5 years, and mule, white-tailed deer and elk to 3.5 years. Tooth replacement in white-tailed deer is very similar to that of mule deer, except white-tails acquire a complete set of permanent dentition by age 20-24 months, the process in not completed until 24-30 months for mule deer.

B. Moose –

Deciduous teeth are replaced more rapidly in moose than in deer or elk. The process is completed by about 19 months of age. Criteria for aging older animals are based on measuring the height and width of the buccal teeth and the length of the jaw. This may not be practical in field situations, so aging based on cementum annular deposits in the first incisors is recommended.

C. Black Bear and Grizzly Bear –

Black bears acquire a complete, permanent dentition by two years (Marks 1966) and is probably true of grizzly bears, as well (Mundy 1964). Older bears are aged

based on cementum annular deposits in the upper premolar teeth. These teeth are easily extracted from live bears or carcasses without harm or mutilation of the animal. Roots of many lower premolars are broken in the socket, and this interferes with accurate aging based on cementum annuli.

D. Bobcats and Lynx –

Tooth replacement criteria are applicable to bobcats up to 240 days (Jackson 1988) and believed similarly applicable to lynx. Permanent teeth are acquired during the first winter. Kittens are distinguished from juveniles or adults based on body size, presents of spots, and tooth wear. Ages of older animals are based on cementum annuli. The foramen of the canine tooth closes at 13-14 months; however, kittens from late litters may retain open root canals during early months of their second winter. This could cause some miss-classifications of kittens and juveniles.

E. Mountain Lions –

Lions can be separated into three age classes based on weight, pelage characteristics, tooth eruption and wear, and tissue changes that indicate breeding by females (Lindsey 1987). Anderson (2000) developed criteria to estimate lion age classes based on body size, dentition, and presence of spots and bars on the pelage. These characteristics are depicted in Figs. 1-6, and are summarized below:

1..Estimating Mountain Lion Age Classes –
Reliability: (1) teeth, (2) bars, (3) spots

a. Kitten (5-6 months, Fig. 1) –
   i. At 4 months deciduous canines are fully erupted (10 mm). Permanent canines begin to erupt at 6-8 months and are fully erupted at 15-16 months.
   ii. Penis sheath is dark. Spots are present on hind leg, bar on foreleg.
   iii. Faded spots are present on outer forelegs. Faint spots are visible elsewhere on upper body.

b. Subadult (1.5-2.5 years, Fig 2) –
   i. Canine teeth are fully erupted (males>26 mm, females 22-25 mm); teeth are white and sharp, no canine ridge is present.
   ii. Bars are present on forelegs, spots inside hind legs. Penis sheath is dark.

c. Young Adult (2.5-4 years, Fig. 3)
   i. Teeth are slightly stained, very little wear is evident; canine ridge appears just below gums.

ii. Spots are present inside hind legs and bars on forelegs. Vulva spot on females is dark.

d. Older Adult (4+ years, Fig. 4)

i. Teeth are well stained, canine wear is evident, outer incisors are worn almost even with other incisors.
ii. Canine ridge is obvious and well below gums (4 mm).
iii. No spots on bars are evident on white fur of belly or legs.

e. Additional examples of tooth eruption, staining, and wear are depicted in Figs. 5 and 6.

f. Differences in male and female genital spots are shown in Fig. 7, and nipple size and shape for lactation status are shown in Fig. 8

g. Cementum annular deposits are not currently useful for aging mountain lions (Lindsey 1987). The technique is still under development. Matson (1996) reports cementum annuli are relatively indistinct. Cementum thickness, indistinct and inconsistent staining of annuli, and experience of technicians affect the accuracy. Matson rates the method as a little more than approximate. However, age results from Matson's lab and the Wyoming Game and Fish Lab have been comparable and are useful for confirming general age classes (Moore 2004, pers. commun.).

Note deciduous canines. Fully erupted at ~4months (10mm). Permanent canines begin to erupt at 6-8 months and are fully erupted at 15-16 months.

Note dark penis sheath, hind leg spots, and bar on foreleg (arrows).

Note faded spots on outer forelegs. Faint spots present elsewhere on upper body for this age class.

Fig. 1. Kitten (<12 months).

Subadult male (1.5-2.5 yrs). Canine teeth fully erupted (males >28mm, females 22-25mm); teeth white, sharp, no canine ridge.

Note bars on forelegs, spots inside hind legs, and dark penis sheath (arrows).

Fig. 2. Subadult (1-2.5 years).

Young Adult Female (3-4 yrs). Teeth slightly stained with very little wear. Canine ridge just below gums (arrows).

Note spots inside hind legs (presence variable) and bars on forelegs. Dark vulva spot is out of view.

Fig. 3. Young adult (3-4 years).

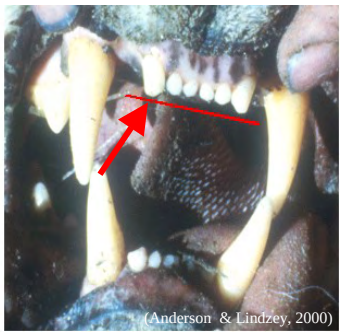
Older Adult Female (>4 yrs). Teeth well stained, canine wear evident, outer incisors worn almost even with other incisors (arrow). Canine ridge obvious (pen tip) and well below gums (≥4mm).

No spots or bars evident on white under-fur; bars may be present, but faint.

Fig. 4. Older adult (> 4years).

All permanent teeth erupted. Canines 1/3-1/2 extended. Note presence of deciduous canines. Known age: 9 months.

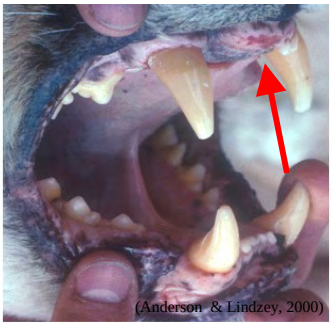
Teeth slightly stained with no wear. Canine ridge absent. Est. age: 1.5-2.5 (both sexes). If canine ridge present: female 2-3, male 3-4.



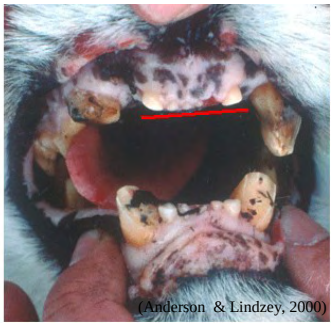
Teeth moderately stained with slight wear. Outer incisors worn at tips, canine ridge present just below gum line. Est. age: female 3-4, male 3-4 if any spotting/bars evident, 5-6 otherwise.

Fig. 5. Additional examples of tooth eruption, staining, and wear (note incisor curvature changes from concave to convex with age).

Notable wear and staining. Canines worn at tips, upper incisors worn close to gums with outer incisors worn nearly even with others. Canine ridge well below gum line (about 4mm). Est age: female 5-6, male 7-9.



Excessive wear and staining. 20% of canines worn off. Canine ridge well below gum line (>4mm). Incisors worn even or missing. Est. age: female 7-9, male 10+.



Most teeth worn to gum line with dark staining. Estimated age: 10+.

Fig. 6. Additional examples of staining and wear, continued.

Female (~1" from anus)

Male (4-5" from anus)

Fig. 7. Male and Female Genital Spots.

Has never lactated
(~4-5mm wide)

Has previously lactated
(~8mm wide)

Fig. 8. Nipple size and shape relative to lactation status. First lactation typically occurs at 2.5 years.

III. LABORATORY TECHNIQUES BASED ON CEMENTUM ANNULI –

Matson (1996) reports the status of the cementum annuli technique applied to 24 species of North American Mammals. He describes the standard tooth to collect from each species, criteria for identification of juveniles, clarity of cementum patterns, accuracy of the method applied to each species, and the amount of experience technicians need to competently analyze tooth sections. Cementum annuli are present in virtually all mammals. The technique is recommended for aging deer and elk older than 3.5 years, pronghorn older than 4.5 years and moose older than 1 year. It is the preferred method for aging bears and bobcats. However, the cementum technique is unnecessary when ages of younger mammals can be easily interpreted from the presence of deciduous teeth, thin root walls, open root tips, and sharp occulsal surfaces on incisors.

Cementum is deposited as layers on the roots of teeth each year. In cross-sectional view the bands close to the dentine are from earlier years and the current-year layer is near the exterior surface of the root. The animal's age is determined by counting annular layers. The annuli appear as narrow, darkly stained bands separated by broader, weakly stained bands. The age of a mule deer, for instance, is usually one more year than the number of dark annuli in the first permanent incisor. In most longitudinal root sections, the cementum annuli should be clearly visible. However, examine all of the cementum carefully as areas of resorption or tooth repair may be present, resulting in fewer annuli or false doublets or triplets. Other physiological stresses such as rut, diet, or estrus can also produce false annuli. Tracing the annuli

around the entire root section and observing where doublets or triplets separate and come back together can minimize the potential for error.

A. Collection of Teeth –

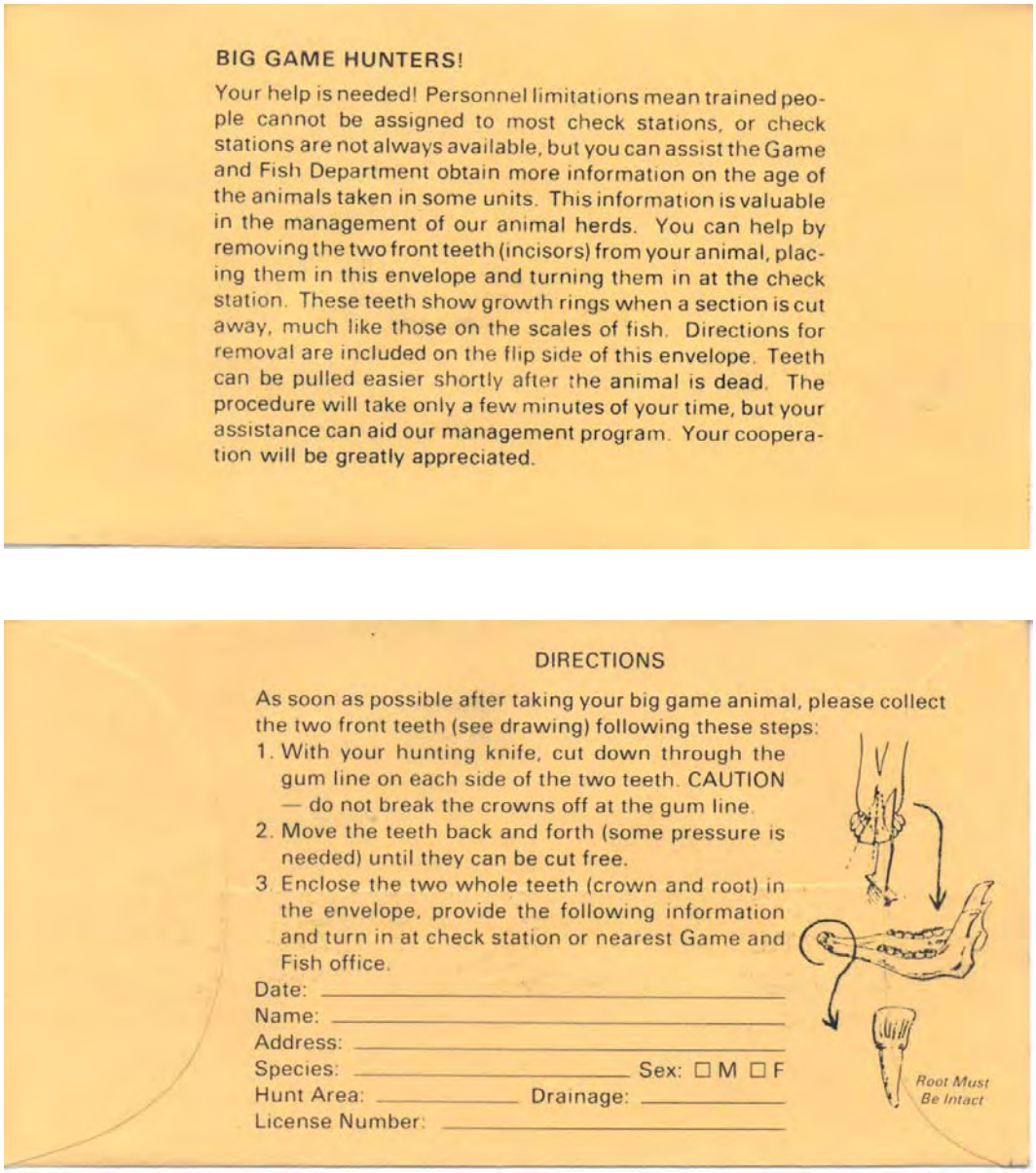
The following teeth are collected to age various species: Ungulates – the two central incisors; bears – the upper first premolar; cougars – the second upper premolar; and bobcats/lynx – the canine. The cementum of most ungulates is thickest on the anterior and posterior portions of the root tip. A 10 mm portion of the root that includes the tip is most useful for accurate age determination. Avoid breaking the root when the teeth are extracted. For ungulate teeth, use a knife to cut the gum tissue between the two central incisors and on each lateral side. Twist while pulling, to facilitate extraction (see attached tooth collection envelope diagram). Premolars can be removed with a dental elevator. If the premolar is taken from a carcass, cut the gum line from all sides of the root. Clasp the tooth with pliers and twist while pulling it. To remove canines, the jaw must be heated to 60-80º C for up to 12 hours before pulling. Use a bone hacksaw to cut off the anterior portion of bobcat jaws. Be sure not to damage the root of the canine. Jaw sections are then tagged and submitted to the lab where they are immersed in water and autoclaved for a short time to loosen the canines. Both canines are removed from the heated jaw with pliers by twisting and pulling. Teeth are stored in pre-labeled paper envelopes or tooth boxes. Do not store teeth in plastic bags or wrap because the plastic seals moisture in that leads to spoilage.

Teeth are solicited from big game hunters who extract and enclose them in postage-paid mailers with instructions. These are issued with the licenses. When an animal is killed, the hunter removes a tooth and mails it in the box supplied by Biological Services. Examples of the label and instructions for hunters are attached (Tooth Collection Envelopes, Fig. 9). The hunter is asked to provide the following information: name, complete address, date of kill, species, sex (M/F), hunt area and drainage. The department returns a notification of the animal's age to each hunter who submits teeth. Hunters are interested to learn the ages of animals they harvest. The notification is additional incentive to submit teeth for age determination

B. Laboratory Processing –

All teeth delivered to the laboratory are sorted according to species and assigned a unique identification number. The information on the envelope/box is recorded in a computer database. Packages containing elk, moose and bison teeth are opened, incisors are separated with bone shears, and teeth are prepared for sawing. Teeth from calves and yearlings are identified based on the presence of sharp occulsal surfaces, small size, thin root walls, and open apexes. These teeth are noted and removed from processing. The remaining teeth are clamped in a vice and a thin sectioning lapidary saw is used to remove the lower 10 mm of the root. The severed 10 mm root portions are placed in individual, pre-marked embedding

bags. The upper root and crown are returned to the original envelope. Teeth from deer, bear and bobcat are placed whole in pre-marked embedding bags. The root end is not cut off for these species.



BIG GAME HUNTERS!

Your help is needed! Personnel limitations mean trained people cannot be assigned to most check stations, or check stations are not always available, but you can assist the Game and Fish Department obtain more information on the age of the animals taken in some units. This information is valuable in the management of our animal herds. You can help by removing the two front teeth (incisors) from your animal, placing them in this envelope and turning them in at the check station. These teeth show growth rings when a section is cut away, much like those on the scales of fish. Directions for removal are included on the flip side of this envelope. Teeth can be pulled easier shortly after the animal is dead. The procedure will take only a few minutes of your time, but your assistance can aid our management program. Your cooperation will be greatly appreciated.

DIRECTIONS

As soon as possible after taking your big game animal, please collect the two front teeth (see drawing) following these steps:

1. With your hunting knife, cut down through the gum line on each side of the two teeth. CAUTION — do not break the crowns off at the gum line.
2. Move the teeth back and forth (some pressure is needed) until they can be cut free.
3. Enclose the two whole teeth (crown and root) in the envelope, provide the following information and turn in at check station or nearest Game and Fish office.

Date: _____

Name: _____

Address: _____

Species: _____ Sex: ☐ M ☐ F

Hunt Area: _____ Drainage: _____

License Number: _____

Fig. 9. Tooth collection envelope, instructions to hunter and directions for pulling teeth from ungulates.

Bagged teeth are immersed in a decalcification solution (buffered HCl) with stirring, until they are softened (24-72 hours depending on species.) Afterward, teeth are rinsed 24 hours in tap water, and then removed from the embedding bags. Teeth from elk, moose and bison are halved lengthwise with a sharp scalpel, placed in a pre-marked, embedding cassettes and set temporarily back in tap water. Cassettes with teeth are then loaded in a VIP® tissue processor and

passed through a series of alcohol, Pro-Par® clearing agent, and paraffin baths to obtain paraffin infiltration. This is followed by treatment in a vacuum infiltrator and finally, the root portion is mounted in base molds and embedded in paraffin using the Tissue Tek II® embedder. After the paraffin block containing the tooth is hardened, the block is ready for sectioning. A Leica® bench top microtome is used to face the paraffin tooth block and cut several sections 8-10 µm thick. The sections are then floated onto a labeled slide. These are permitted to dry overnight on a warming plate. Paraffin residues are removed from the slides through a second series of alcohol and Histo-solve® baths. The slides are dried and stained in Giemsa® staining solution.

Teeth from mule deer, white-tailed deer, and bobcat are sectioned in a frozen state, after decalcification. This procedure is faster but sacrifices some cytological detail. A Reichert-Jung Cryocut® microtome kept at (-) 18º C is utilized. Three to four sections, 8-10 µm thick are mounted on labeled slides, allowed to dry overnight and stained using Giemsa® staining solution. Stained slides are dried overnight before cover slipping. Each slide is examined under a compound microscope at 40X or greater magnification. Cementum annuli are counted and the number is marked on the slide.

The numbers of annuli recorded on each slide, calculated ages, and the ages of the calf and yearling teeth obtained by inspection are recorded in a computer database established for each species. Age estimation for various species, based on cementum annuli, follows the models developed and published by Matson (1981). Age reports are forwarded in hard copy or electronic form, to wildlife coordinators and regional biologists. A computer-generated post card is also sent to notify hunters, who submitted complete address information, of the age of their harvested animal.

Consult Vieyra et al. (2004) in the Wyoming Game and Fish Laboratory Tooth Aging Procedures Manual for additional details regarding tooth analysis procedures. This document is available from the Laboratory upon request.

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APPENDIX VIa FINAL-JULY 1990

Wyoming Chapter of the Wildlife Society

Report on

Standardized Definitions for Seasonal Wildlife Ranges

The Wyoming Chapter of The Wildlife Society (TWS) formed a committee to review, discuss and address the current Standardized Definitions for Seasonal Wildlife Ranges developed by the Chapter between 1984 and 1986 and subsequently adopted for Wyoming by the Soil Conservation Service (SCS), Bureau of Land Management (BLM), Forest Service (FS), United States Fish and Wildlife Service (USFWS) and the Wyoming Game and Fish Department (WGFD). The request, received from the WGFD and BLM, was to review the current standards, address criteria for quantifying the seasonal range definitions, develop necessary modifications and make recommendations.

Criteria for quantifying the seasonal ranges were discussed at great length. Among the criteria discussed were animal densities, percentage of a population occupying a designated seasonal range, frequency of observations, and indices of use among others. Attention was also directed at improving communication, cooperation, and data sharing among and between agency biologists, agency administrators, and interested publics.

Based upon our discussions and review along with input from TWS members, the committee finds and recommends the following:

1. The standardized definitions developed by TWS between 1984 and 1986 are still applicable and with, minor refinement, their use should be continued.

2. Two new seasonal wildlife range definitions have been included in Appendix A.

3. Additional quantification of these definitions, while an admirable goal, seems impractical on a statewide basis due to inherent variability among herd units in terms of habitat type and condition, population structure, habituation to existing disturbance, climate, land ownership, and inherent differences between big game species when coupled with existing wildlife staff levels and budgets.

4. Seasonal wildlife ranges should be quantified based on documented frequency of animal use over time. Documentation, in most instances, would be recorded observation of animals, however indications of animal use or potential use such as vegetation use, animal droppings, tracks, forage type, forage availability, and forage distribution in relation to cover should also be considered particularly for herds expanding their range or for transplanted animals.

5. The primary problem did not appear to be the current definitions or criteria, but the application of the information and communication among and between agency biologists, agency administrators and interested publics.

6. Each agency should agree to cooperate in data collection, data sharing and data transmission, in establishing and/or refining seasonal range boundaries and sharing in the collection of information. Agency biologists/conservationists having responsibility within a given herd unit or population of animals

should jointly develop seasonal ranges with sign-off provisions for concurrence with the final boundary delineations and any refinements made thereafter. Said concurrence must be developed at the field level with concurrence at the regional and state level as necessary.

7. Final seasonal wildlife range maps should be reviewed and approved by each agency before it is made available to other interested parties; and

8. Seasonal range maps should be reviewed at least annually. Proposed revisions based on new data or knowledge should be documented and agreed upon. Revisions should probably not be formalized until sufficient data is available to establish a trend differing from historical baseline information. This may require 3 to 5 years.

Recommended changes to the current Standardized Definitions for Seasonal Wildlife Ranges are included in Appendix A and a discussion of the Application and Use of Standardized Wildlife Range Designators is included in Appendix B for your review and consideration. We have also included an informational summary for big game species relative to species behavioral habits, habituation to disturbance, geographic variability in terms of habitat types, land ownership patterns, climatic conditions, migratory patterns, etc.

It is our recommendation that each agency review the attached changes and committee recommendations, adopt them following review and input, and develop appropriate agreements and procedures to cooperatively establish seasonal wildlife range boundaries and share in the collection of information.

Note: In early 2004, WGFD adopted standardized, statewide beginning and ending dates for use of WIN, WYL and SSF *seasonal ranges. Those date ranges are listed in italics at the end of the applicable seasonal range definitions in Appendix A.*

APPENDIX A

Recommended Changes to the Current
Standardized Definitions for Seasonal
Wildlife Ranges

These recommended changes to the current standardized definitions for seasonal wildlife ranges are directed primarily at big game and threatened and endangered species. The term 'documented' is construed as generally referring to recorded observation of animals, however evidence of their use based on such factors as forage utilization and fecal excretion in relation to forage type; forage availability and the spatial relationships of forage to cover among others may also be used to refine seasonal distribution boundaries or to delineate seasonal ranges for transplanted species or herds expanding their range.

Note: In early 2004, WGFD adopted standardized, statewide beginning and ending dates for use of WIN, WYL and SSF seasonal ranges. Those date ranges are listed in italics at the end of the applicable seasonal range definitions below.

Symbol	**Term**	**Definition**
CRU	Crucial	Crucial range can describe any particular seasonal range or habitat component (often winter or winter/yearlong range in Wyoming) but describes that component which has been documented as the determining factor in a population's ability to maintain itself at a certain level (theoretically at or above the WGFD population objective) over the long term. Example: The total crucial winter range for an elk herd unit should be available, relatively intact and allow a population at the objective to the objective to survive the winter in adequate body condition to maintain average reproductive rates 8 out of 10 years.
CRT	Critical Habitat*	Those areas designated as critical by the Secretary of the Interior or Commerce, for the survival and recovery of listed Threatened and Endangered Species (50 CFR, Parts 17 and 226**).** Because use of the term has legal implications, its use is limited to only those habitats officially determined as critical by the Secretary.
ESS	Essential Habitat*	Those areas possessing the same characteristics as critical habitat for Threatened and Endangered but not species declared critical habitat by the Secretary of the Interior or Commerce.
PAR	Parturition Areas (calving areas, fawning areas,	Documented birthing areas commonly used between 5/15 and 6/30 by the female segment members of a population. These

	lambing grounds)	areas may also be used as “nursery areas” by some species.

* Pertain to threatened and endangered species only.

SSF	Summer or Spring-Summer-Fall	A population or portion of a population of animals use the documented habitats within this range annually only (from the previous winter) to the onset of persistent winter conditions (variable, but commonly this period is between 5/1 and 11/30 or shorter in Wyoming). *(5/1 – 11/14, adopted by WGFD in 2004)*
SWR	Severe Winter Relief	A documented survival range which may or may not be considered a crucial range area as defined above. It is used to a great extent, only in occasionally extremely severe winters (e.g., 2 years out of 10). It may lack habitat characteristics which would make it attractive or capable of supporting major portions of the population during normal years but is used by and allows at least a significant portion of the population to survive the occasional extremely severe winter.
WIN	Winter	A population or portion of a population of animals use the documented suitable habitat within this range annually, in substantial numbers only during the winter (variable, but commonly between 12/1 and 4/30). *(11/15 – 4/30, adopted by WGFD in 2004)*
WYL	Winter/Yearlong	A population or a portion of a population of animals makes general use of the documented suitable habitat within this range on a year-round basis. But during the winter months (commonly between 12/1 and 4/30), there is a significant influx of additional animals into the area from other seasonal ranges. *(11/15 – 4/30, adopted by WGFD in 2004)*
YRL	Yearlong	A population or portion of a population of animals makes general use of the suitable documented habitat within the range on a year-round basis. Exception - occasionally, under severe conditions (extremely severe winters, drought) animals may leave the area.

Proposed new seasonal range definition follows:

UND	Undetermined/ Undocumented	Areas or habitats, which are expected to or do support a population or portion of a population of animals. The distribution and importance of the area to

		the population has not been sufficiently documented to designate seasonal range occupancy. The term is applicable to areas where animals have recently been or will be reintroduced; where animals have migrated into and are establishing a population; where a population is expanding its range; or where management actions or activities have been implemented which will accommodate a population to expand their range.
HIS	Historical Habitat	Areas or habitats which historically supported a population or portion of a population of animals. These areas may indicate potential reintroduction sites.

Other seasonal range designations commonly used by the WGFD and the BLM but not specifically addressed by this committee are included for your information. These appear to meet the criteria desired and should be retained and adopted as part of the standardized definitions for seasonal wildlife ranges

Symbol	Term	Definition
OUT	Out	Areas which do not contain enough animals to be important habitat, or habitats of limited importance to a species.
MR	Migration Routes	Definable routes followed during seasonal movements year after year.
→ →	General area of movements	
→ → →	Specific movement corridors	
Varies	Raptor Nests	Nesting areas for hawks, owls, and eagles. Examples Include: ◯ prairie falcon, ⊙ merlin, □ goshawk, ⊕ and great horned owl.
	Concentrated Wetland Area	
	Areas of scattered wetlands important to wildlife because of numerous playas, flooded meadows, beaver ponds, or impoundments.	
POT	Potential	Habitats identified for reintroduction of Threatened, Endangered, and Priority species (e.g., potential habitats for trumpeter swans and peregrine falcons).
BRE	Breeding Area	Documented courtship, nesting, and/or brood rearing areas, e.g.:
	Censused lek, strutting or dancing ground	
	Uncounted lek, strutting or dancing ground	
	Abandoned lek, strutting or dancing ground	
STA	Staging Area	Documented migration or pre/post-migration concentration areas.

Standardized Raptor Nesting Terminology for Wyoming
(BLM, 1987)

Nest Status	Symbol	Definition
Active Verified	AV	A nest/scrape in which a breeding attempt was made as indicated by: (1) eggs in nest; (2) young in nest or on cliff ledges or branches next to nest; (3) fledged young in proximity of nest/scrape which exhibits sign of nestling presence (extensive whitewash on nest/scrape, on cliff, branches, and/or ground beside and below nests or scrapes); (4) incubating/brooding adult.
Active Estimated	AE	1. A nest exhibiting one or more of the following: (1) fresh lining material greenery such as pine boughs, deciduous tree leaves, juniper leaves, etc.; most apparent on occupied nests of golden eagles, accipiters, and several buteos); (2) adult presence (one or more adults in immediate vicinity of nest); (3) recent and well-used perch sites-occurrence of well whitewashed perches in close proximity to nest. 2. A tended nest within the estimated bounds of a territory housing an 'active' nest. 3. An occupied nest built subsequent to the failure of an active nest. 4. A nest that is in good repair but was observed during the non-nesting season when the presence of adults would not be expected.
Inactive Verified	IV	1. A nest surveyed during the breeding season which exhibited no apparent recent use or adult presence. 2. A nest that has evolved to a state of ruin or decay due to weather, natural aging, and/or neglect.
Inactive Estimated	IE	A nest exhibiting no apparent recent use or adult presence that was surveyed during the non-breeding season.
Destroyed	DE	A nest that has been removed, destroyed, or does not exist at the present time.

TWS also reviewed some other definitions currently being used in Wyoming. The Shoshone National Forest has seasonal range designations for 'Crucial Preferred Winter Range' (CPWR) defined as an area within crucial winter range where concentrations of animals can be found each year during the period of 1/1 to 3/31. These areas are considered essential for the welfare and maintenance of the dependent populations and for 'Crucial Winter Range' (CWR) defined as an area where 75 percent of the individuals in a population can be expected to be found during periods of inclement weather from 1/1 through 6/30 each year (Shoshone National Forest FEIS). We recommend these definitions not be included in the final standardized definitions. They would not be applicable on a statewide basis.

APPENDIX B

Application and Use of Standardized Wildlife Range Designators in Wyoming

(Most of the information was prepared by John Emmerich)

HISTORICAL PERSPECTIVE

Prior to 1987 each agency, federal or state, sharing wildlife population or habitat management responsibilities in Wyoming were using their own set of wildlife seasonal range designators. This situation often led to confusion and made any exchange of information among agencies difficult. In addition, misunderstandings and mistrust among agencies and between the agencies, interested public and private landowners arose when discussions where held relative to seasonal ranges or providing comments on reviews on various activities or projects. As an example, the Wyoming Game and Fish Department (WGFD) used the term “critical”, to designate seasonal ranges that were considered the determining factor in a populations ability to maintain and reproduce itself over the long term. The term was used to designate limiting habitat associated with generally all wildlife species with mapped seasonal ranges. The term “critical” as well as “essential” have a much more restrictive application, however, on a federal level, since they are only associated with those wildlife species federally listed as threatened or endangered. This example is only one of many that were obvious sources of confusion and made the process of exchanging or discussing information much more difficult than it needed to be.

In an effort to rectify and reduce the confusion, communication, and information exchange problems the Wyoming Chapter of The Wildlife Society (TWS) formed a committee charged with the task of developing a set of standardized wildlife seasonal range designators with definitions. These designators would serve as the core set of seasonal range types to be recognized and used by all agencies but could be added to by individual agencies for special needs.

The original committee was made up of one representative from the U. S. Forest Service (USFS) (Dave Reeder), Bureau of Land Management (BLM) (Jack Welch) and the WGFD (John Emmerich). From late 1984 to late 1986 a set of wildlife seasonal range designators with definitions were developed. The final set adopted reflected considerable input and review from biologists representing each of the USFS occurring in Wyoming, from BLM resource area and state office biologists, and from personnel with the Soil Conservation Service (SCS), U. S. Fish and Wildlife service (USFS), WGFD and the state Land Board (SLB).

The current Standardized Definitions for Seasonal Wildlife Ranges were subsequently adopted by Forest service Regions 2 and 4 for Wyoming and by the WGFD in 1986 and the BLM in 1987. They were also recognized by the SCS, USFWS, and SLB. Since 1987 nearly all agencies with wildlife or habitat management responsibilities in Wyoming have either updated all of their seasonal range overlays using the standardized designators or have committed to do so as their scheduled overlay updates take place. The only exception appears to be the Shoshone National Forest.

In 1989 the WGFD and BLM requested the Wyoming Chapter of The Wildlife Society review the current definitions with particular attention to crucial and parturition habitat and additional quantification of definitions. TWS, under Chapter President Tom Ryder, formed a committee made up of representatives from USFS (Ihor Mereszczak, Tina Lanier), BLM (Jack Welsh, Bob McCarty), WGFD (Bill Gerhart, John Emmerich) and SCS (Dick Rintamaki) to address the request. Final recommendations from TWS were forwarded to participating agencies for review in early 1990.

APPLICATION AND USE

For the most part the definitions for each of the standardized seasonal ranges include sufficient criteria for determining when to apply a specific range designation. In nearly every case the frequency of use by animals is the criteria used to determine an areas importance as winter range, parturition range, or some other range designation. The number of animals using the area may be important but it is not a determining factor. An area were several cow elk with calves are seen once every five years would not warrant the status of parturition area, but an area where as few as five cows (a portion of the female members of a “population”) are seen nearly every spring with calves would be considered a parturition area. The definitions were intentionally written without the use of a set number of animals as criteria for applying the range designation, since numbers of animals can vary annually and certainly vary with different herd units having different population objectives. However, phrases like “commonly used" or “used eight years out of ten” were included intentionally in the definitions to emphasize the importance of frequency of use of an area as a criteria for applying a range designator.

The most difficult part of designating range types, in particular for big game species, is determining the location and extent of crucial range. These areas are absolutely necessary for the long term maintenance of a population of animals so they need to be accurately identified for protection and management purposes. Accurate identification is also important because land management agencies typically restrict the type and timing of activities that occur in these areas, restriction; that have significant effects on other users of the land.

The first step in determining the location of crucial habitat is an assessment of what habitat component, or components, are most limiting, in other words what habitat type is crucial. In Wyoming winter range is generally the most limiting habitat component because snow cover often makes forage less available than during summer months and restricts animal movements. In very dry areas good quality summer forage could be a limiting range type, especially if snow accumulation is typically light in the area. Good escape cover could be limiting for a big game species like bighorn sheep.

Once the range type or types considered limiting have been identified the next step is determining the location and extent of the range. The most accurate and reasonable process to delineate seasonal range boundaries is simply to get as many different observations as possible over time and under as many different kinds of situations as possible. For example, on crucial winter range or winter range as many observations as possible should be collected during early, mid, and late winter for several winters to document the extent of these ranges. Normally all agencies with wildlife population or habitat management responsibilities should pool their resources (i.e. personnel, flight time, etc.) to determine the distribution of animals during the season of the year when the range is considered limiting. This distribution information should be documented in a stored data format so several years of information can be compiled and evaluated to adequately identify those areas which are used most years (eight years out of ten) when conditions or time of the year cause animals to use the limiting or crucial habitat i.e. harsh winters if documenting crucial winter range. Input from landowners can also be

added to this database. Sharing resources among agency personnel and joint data collection and analysis gives all parties involved an opportunity to become involved and have a stake in determining the distribution patterns documented and the designation of crucial habitat locations. Differences in opinion as to location or extent of crucial habitat or other seasonal range designations should be resolved by the local biologists with on the ground analysis of distribution patterns. This analysis should include flight data, ground observations, and vegetation utilization data.

Once the crucial habitat has been documented and mapped it should be constantly evaluated. There is nearly always potential for refinement, in fact it is imperative that every attempt be made to refine crucial habitat designations so only that acreage necessary to sustain long term population objectives are designated as crucial. Despite the constant evaluation and refinement process it is recommended that actual map updates be drafted no more frequently than once every three to five years. Shifts in animal distribution or location of additional range previously not documented that suggest a need for realignment of crucial range boundaries should be documented over a period of time before maps are updated. This ensures that maps will not be needlessly changed for transient fluctuations in animal distribution that will not stand the eight years out of ten frequency of use test.

Refining the location and extent of crucial range should involve some evaluation of the forage available for the wildlife species of concern in the area defined as crucial. In public land areas of the state forage production information is available from the BLM and USFS. In private land areas of the state the SCS can provide potential forage production information by range site and in some cases range condition class and actual production information. A rough analysis of forage production and crucial range acreage information will point out if sufficient acreage of crucial habitat has been identified for objective numbers of animals or if more acreage has been identified than is actually necessary to sustain the objective number of animals. Failure to correlate the crucial winter range or other boundary designations with the actual habitat sites being used, often leads to boundaries encompassing large acreages, much of which is not actually providing crucial habitat. This can obscure the real value of the area of actual crucial habitat.

Forage type and quantity in relation to the numbers of animals to be sustained in an area are but two factors, biologists must also consider the distribution of forage in relation to cover and the availability forage and cover. Snow depth and snow distribution have a significant effect on the availability of forage and cover. Wind can and does play an important role as it influences snow depth and distribution patterns thereby influencing forage availability. Information on wind conditions and whether or not areas are blown free of snow most of the time can be important in refining the delineated boundaries. Correlations on the ground with browse use patterns and fecal pellet group concentrations can be very helpful in delineating winter use and crucial winter range boundaries also. In either case the crucial habitat ranges should be refined to correct for the problems identified.

Some discussion of severe winter relief range is probably necessary to help people properly identify this habitat type. Severe winter relief range can be a core area within crucial winter range or an area removed from the crucial winter range that is not normally used, where animals try to survive when winter conditions are abnormally extreme. These areas will not sustain objective numbers of animals but may allow a portion of the population to survive. They are generally managed in the same manner as crucial winter range in terms of protection and forage reservation if they are a core area within crucial winter range and are also used during normal winters. If the severe winter relief range is an area removed from the normal crucial winter range and use is infrequent and unpredictable the area may be managed differently

than crucial winter range. In this situation, it would not be practical to reserve forage every year for anticipated wildlife use since use normally occurs only two years out of ten. These areas, however, need to be identified so they can be protected from range type conversions or development that will render the area unusable in severe winters.

In many parts of Wyoming big game species display distinct seasonal migration patterns. Animals move from higher elevation summer range where snow accumulation is substantial to lower elevation winter range in late fall and vice versa in early spring. In those areas of the state where this migration pattern occurs winter range is normally a distinct range readily delineated and used nearly every winter. Some movement occurs within this winter range area as the winter season progresses, snow conditions change, and animals search for food. Availability of forage within the winter range, which can be influenced by summer grazing/browsing patterns and weather conditions during the growing season, also affects the distribution of animals within the winter range. For elk, moose, mule deer, and bighorn sheep these winter time movements are fairly minor as long as winter conditions do not become abnormally extreme (causing movements to severe winter relief range). Antelope, however, tend to display a higher level of variance in the degree of movement that occurs within their winter range. In a sense their winter range is less fixed in space as compared to most other big game species. Although they normally use the same area each winter the overall range used may be large because of their nomadic nature. In other words antelope can be found during the winter months in one part of the winter range where they did not occur earlier and be absent later in the winter from that portion of the winter range where they did occur earlier. Other big game animal populations can normally be found within a mile or two of the same area throughout the winter. As a consequence in those portions of the state where distinct seasonal ranges do not occur crucial winter range generally cannot be delineated as tightly particularly for antelope.

APPENDIX VIb

REVISING HERD UNIT SEASONAL RANGE MAPS AND MIGRATION CORRIDORS

Reg Rothwell

(July 2002)

Background

Knowing where big game seasonal ranges are and understanding how and when they are used are important for several reasons. Since wildlife and habitat are so closely tied, it is important to manage and protect habitat so wildlife has the seasonal life requirements necessary to persist. Simply managing populations is not enough to assure the long-term welfare of wildlife species. By understanding where wildlife occur during different seasons of the year and the value and make-up of these habitats, managers can maintain, increase, enhance and/or protect them. Seasonal range delineations depict lands important in each season for certain biological processes (i.e. birthing) within each herd unit. These delineations are based on decades of observation records, research and on the knowledge of Wyoming Game and Fish Department (Department) managers, other natural resource agency personnel and landowners.

The Department began delineating crucial winter ranges in the early 1960s. Herd unit maps and seasonal range overlays were first developed in the early 1970s as the Department began to manage big game based upon the ‘ management by objective’ system. Our first efforts to delineate seasonal ranges relied primarily on knowledge of local wildlife biologists and game wardens. The first step was to delineate boundaries of populations (herds) that were as discrete as could be determined at the time. The Department’s criterion for discreteness required less than 10% interchange with adjacent herds. The first delineations were done with the understanding herd unit boundaries would be refined as additional, more detailed information was collected. Over the years, dozens of tagging and radio collar studies have been used to refine these boundaries. Herd unit base maps were originally Bureau of Land Management (BLM) 1:126,720 scale surface status maps. Local managers then used current and historical information to draw seasonal ranges, seasonal movement patterns and specific migration corridors on clear Mylar overlays matched to each base map. When the BLM converted to 1: 100,000 scale surface status maps in the 1990s, all Department game herd unit base maps and seasonal range overlays were changed to this scale.

The Department originally delineated seasonal ranges based initially on definitions it developed. Federal agencies, including the BLM and U.S. Forest Service (USFS) used their own definitions at that time. In the mid-1980s, the Wyoming Chapter of the Wildlife Society (TWS) developed standard definitions that could be used by all agencies. In 1989, the BLM and the Department requested TWS to review and update these definitions. A committee of TWS members from several state and federal agencies, developed the current definitions (Attachment A).

Data to revise seasonal range revisions have come from three sources. Seasonal data from the Department's Wildlife Observation System (WOS), composed of sightings within time periods during the year that correspond to times animals would be using certain types of seasonal ranges, is the primary source. The WOS is a computer database developed by the Department in the 1970s, consisting of wildlife observations. Records are contributed by Department

personnel, other agencies, and industry biologists and consultants. WOS records include big game sex and age classifications, winter trend counts, harvest field checks, and surveys conducted specifically to document seasonal range use. The WOS contains well over a million records, and these records can be sorted and retrieved based upon combinations of attributes, including species, location and date.

Research data are also used to revise or update seasonal range maps. The Department, other agencies (such as the BLM and USFS), universities, and industry have performed investigations to study animal movements and to improve seasonal range delineations. In some cases, research has been conducted specifically to evaluate the integrity, or discreteness, of existing herd delineations. Usually, these investigations involve animals marked with neck or radio collars or ear tags. Other studies have provided collateral information about movements, seasonal ranges and herd unit integrity.

Finally, we consider the knowledge of field personnel and landowners who are familiar with the land, its use by wildlife and wildlife movements. Although not 'hard' data, this knowledge is critically important for interpreting information and judging data quality. In some cases, it is essential in filling gaps in the data.

The Department made two concerted efforts, first in the late 1970s then again in the mid-1980s, to review and update seasonal range overlays for big game herds. During these efforts, we emphasized delineation of winter ranges. All WOS records within the geographic area of each big game herd for all years since the last review were hand plotted onto the existing seasonal range overlays by Biological Services personnel in the Cheyenne office. Observations recorded during normal to severe winters were considered most representative of animals' use of winter, crucial winter and severe winter relief seasonal ranges. In essence, seasonal ranges are identified based upon the animals' repeated presence in specific locations during the appropriate times of year and weather conditions. During these statewide seasonal range revision efforts, patterns of observations were compared to the existing seasonal range delineations to provide a basis for revisions.

After the new data were plotted, each overlay was sent to the appropriate field personnel for review. These personnel confirmed existing delineations or made determinations about revisions based on the new information and provided other recommended revisions based on their knowledge of each herd. The overlays were then returned to Cheyenne for redrafting and distribution.

Not all revisions have been based on formal statewide efforts like those done in the 1970s and 1980s, or on the results of specific research projects. Field personnel have been encouraged to make revisions any time substantial new information indicates revisions are warranted. Personnel are encouraged to keep seasonal range overlays and herd unit maps as current as possible. In fact, since the two large-scale efforts in the 1970s and 1980s, all subsequent revisions have been made case-by-case based on the recommendations of field personnel. Many changes have been made to the herd unit maps since they were originally developed. Herd unit boundaries and seasonal range delineations have been refined as the technology used to collect information has improved and the amount of information has increased. Herd units have been combined and portions of one or more have been incorporated into others as managers have obtained better information. At the same time, seasonal ranges have become much more clearly delineated.

The previous standard method for seasonal range map revisions was as follows. When 'hard copy' maps and overlays were submitted for revision, recommended changes were depicted

on Mylar overlays by drawing new lines and noting lines that were to be deleted. The corrected overlay, accompanied by a written justification was sent to Biological Services in Cheyenne along with a written justification. A list for distribution of the revised overlay or updated GIS map was also provided. As is still the case, the proposed revision was evaluated by Biological Services and discussed with Wildlife Division administration. If the justification was adequate and there was concurrence in Cheyenne, the hard copy written revision justification was initialed and dated by the Supervisor of Biological Services and placed in the herd unit file maintained by Biological Services. Biological Services then forwarded a Services Division 'Project Request' form and the 'marked up' Mylar overlay to the Conservation Engineering Section, which redrafted the overlay. When the revision of a Mylar overlay was completed in draft form, a copy was sent to the field biologist for final review. Once the draft was accepted, a copy of the dated, revised overlay replaced the superceded overlay in the Biological Services files. Copies of Mylar overlays were also distributed to the appropriate Department regional offices and field personnel and others identified in the distribution list.

Despite decades of data collection and analysis, our knoweldge is still not complete. But, those who use our information have often acknowledged its usefulness in planning developments. And, new information continues to reinforce much of what earlier delineations depicted. For example, during hearings on Red Rim in the 1970s, the Department's authority to designate crucial winter ranges was challenged, and developers insinuated we had drawn lines there to prevent development. A 1964 map confirmed that winter range at Red Rim was known years before this controversy, and research on movement of antelope in the mid-1970s simply confirmed a long standing designation that had been based on field personnel's knowledge.

The Department has continually improved both the herd unit maps and the seasonal range overlays. New technologies like Geographical Information Systems (GIS) are enabling managers to more efficiently and accurately analyze the data and revise maps.

Procedures

Seasonal range delineations should be reviewed at 5-year intervals. More frequent reviews are encouraged if substantial new information (i.e. research data) indicates revisions are warranted. Revisions should be made upon completion of any research that documents changes are needed. Only data from winters of the appropriate severity are used to evaluate seasonal ranges classified as winter range, crucial winter range or severe winter relief range. Very mild winters, such as some of those in the late 1980s, do not necessarily force animals on to true winter habitats. In these conditions, only a portion of the population may move to the vicinity of true winter ranges. But, even those animals may be distributed over a broader area that includes other seasonal ranges. A substantial portion of a population, especially in a herd unit encompassing entirely low elevation habitats, may remain distributed across summer, yearlong or other seasonal ranges during mild winters. When normal to severe winters develop, a concerted effort should be made to document the locations of animals. Regional supervisors and wildlife management coordinators should adjust work schedules accordingly and direct personnel to collect these data. Attachment A (Wyoming Chapter of the Wildlife Society Report on Standardized Definitions for Seasonal Wildlife Ranges, Final - July 1990) provides guidance on recommended periods to collect seasonal distribution information.

The revision of a herd unit seasonal range map involves all personnel responsible for management of the herd unit, including wildlife biologists, habitat biologists and game

wardens. This collaboration ensures the most comprehensive knowledge base is used to make the revision. And, it assures the personnel most familiar with the herd agree with the revision. Department personnel also consult other agencies, particularly BLM and USFS where applicable, to assure their personnel are aware of the revision and have the opportunity to provide any information they may have.

Seasonal range boundaries are drawn as precise as possible. Unless experience indicates otherwise, the outermost observation locations dictate where lines are drawn. If seasonal range boundaries are adjusted based on professional judgement, the rational for this is explained in the documentation that accompanies the overlay correction or the revised electronic version sent to Cheyenne. Reviewers use information from several years to account for year-to-year variations in animal distributions and to avoid changes that might not reflect true shifts in use. When revisions are considered, both recent and past use are taken into account so the more recent information is considered in a historical context.

The seasonal range revision process in the headquarters office is now being done entirely by the GIS Coordinator. Recommended seasonal range changes are indicated by field personnel on Geographic Information Systems (GIS) based maps. The corrected electronic GIS map, accompanied by a written justification is then sent to Biological Services in Cheyenne. The written justification includes a description of the proposed change(s) and a rationale that indicates the informational basis for changes. All Department and non-Department personnel involved in the revision are identified. A list for distribution of the revised overlay or updated GIS map is also provided.

The proposed revision is evaluated by Biological Services and discussed with Wildlife Division administration. If they concur, the hard copy written revision justification is initialed and dated by the Supervisor of Biological Services and placed in the herd unit file maintained by Biological Services. If the written revision justification is in electronic format, the Supervisor of Biological Services types in "Approved by_____" and the date in the upper right hand corner of the first page.

If any seasonal range revisions are submitted in 'hard copy' (Mylar) format, Biological Services will arrange to have the herd unit overlay redrafted in GIS format. If the seasonal range revisions are submitted in GIS format, the GIS Coordinator may use the recommended revisions to make changes to existing digital maps. Or, the GIS Coordinator may simply include the GIS maps created in the field and reviewed by him for consistency with his conventions into the 'library' of seasonal range maps housed by the GIS Section in the Cheyenne headquarters.

If the GIS Section makes the revisions, the GIS Section may then provide a draft copy of the new overlay (in electronic or hard copy form) to the field biologist for verification of the changes, if necessary. Once the field review of the draft is completed and approved, or further corrections are noted by field personnel reviewing the draft, the final copy of the revision is made. The revised GIS based maps are then included in the GIS Section's electronic herd unit files, and the electronic maps are available from this source. Copies are sent by the GIS Section to the appropriate WGFD personnel, offices of the federal land management agencies and other entities indicated by the field personnel submitting the revisions.

Appendix VII

Marking Techniques

This appendix was transcribed from the 1982 edition of the Handbook of Biological Techniques (WGFD 1982:311-324). Several marking methods and materials have been improved or replaced since the original appendix was compiled. For example, many advancements have been achieved in telemetry technologies and capabilities over the past 20 years. However, some of the older, more basic methods may still prove useful in specific circumstances and where budgets are limited. Consult the following references for more recent information on marking methods:

Nietfield, M.T., M.W. Barrett, and N. Silvy. 1994. Wildlife Marking Techniques. Pages 140-168 in T.A. Bookhout (ed). Research and Management Techniques for Wildlife and Habitats. Fifth ed. The Wildlife Society, Bethesda, MD. 740pp.

Samuel, M.D., and M.R. Fuller. 1994. Wildlife Radiotelemetry. Pages 370-418 in T.A. Bookhout (ed). Research and Management Techniques for Wildlife and Habitats. Fifth ed. The Wildlife Society, Bethesda, MD. 740pp.

Gustafson, M.E., J. Hildenbrand and L. Metras. 1997. The North American Bird Banding Manual (Electronic Version). Version 1.0 http://www.pwrc.usgs.gov/BBL/manual/manual.htm

Gustafson, M., L. Metras, B.H. Powell, G. Smith, F. Soehnlein, J. Tautin, and H.R. Berry, Jr. 1998. Recommendations for improving bird banding permit policies and procedures. USFWS, Office of Migratory Bird Management. 725 FW 1, Policies and Responsibilities. http://www.pwrc.usgs.gov/BBL/resources/permapp2.htm

and the following web links:

Resources for Banders – http://www.pwrc.usgs.gov/BBL/homepage/resource.htm

All About Bird Bands – http://www.pwrc.usgs.gov/BBL/homepage/btypes.htm

All about Bird Markers – http://www.pwrc.usgs.gov/BBL/homepage/aboutaux.htm

I. BIG AND TROPHY GAME

A. Ear Tags – Serially numbered aluminum ear tags imprinted with a return request have been successfully used on big game. One tag in each ear is recommended. These tags should be ordered through the Supervisor of Biological Services. Tagging records of animals marked in the winter must be submitted by July 1.

For individual marking and identification of moose, 2.5 X 2.5 in. pendant-type plastic livestock ear tags have been used. Numbers or coded symbols can be placed on both sides (front and back). Tags are available in a variety of colors.

Colored nylon or plastic streamers have generally proven unsuccessful as they quickly become frayed and tattered.

Hornocker (1970) used colored aluminum cattle tags on mountain lion with good retention. Tags were placed close to the base of the ear, in the upper or leading edge. Each ear was also tattooed.

Bears have been successfully marked using hollow braid polypropylene rope as color markers. High success was achieved when they were used as an anchor for color coordinated polyvinyl-chloride tape flags (Craighead et al. 1960; Pearson 1971).

Tattoos have been used to permanently mark bears, allowing an individual to be identified even if the ear tags are lost. The tattoo is generally applied to the upper lip with a livestock tattooing machine. The tattoo should be well inked to ensure it is permanent.

B. Neck Bands – Neck bands are recommended to individually mark animals for observation. Many studies have used the neck band described by Knight (1966) for big game. This band has a long life, good retention, and is highly visibility.

Neck bands are constructed of plastic impregnated nylon ("Saflag" – Safety Flag Company of America, Pawtucket, RI) and nylon webbing. Strips of Saflag (3 X 36 in.) are sewed to the nylon webbing material for strength. Symbols or numbers cut from contrasting colors of Saflag may be sewn to the neckband.

Neck bands for females can be purchased pre-sewn or with riveted ends, ready to slip over the head of the animal. Neck bands can be fitted on males by attaching the ends after they are placed around the neck. Collars may be closed with rivets or hog rings. When excessive swelling of the male neck is expected during rut, an expandable collar should be used. No reports of expandable collars used on mule deer were found in the literature but it is assumed the collar Hawkins et al. (1967) described for white-tailed deer would work with mule deer.

Rope collars have been used for elk (Craighead et al. 1969) and may be suitable for other large ungulates. The collars were constructed of 38-in. lengths of 0.5-in. braided polyethylene rope (Puritan Cordage Mills, Inc., Marine Division, Louisville, KY) through which 7 3X9-in. flags of colored Saflag materials were strung and secured with No. 3 hog rings. Nylon rope collars have also been used successfully on mountain lions. (Seidensticker et al. 1973).

Collar size was temporarily reduced for juvenile animals with a strong rubber band made of a 0.375-in. (3/8-in.) section of 0.5-in. surgical tubing. As the neck size increases, the restricting band worked toward the pendant and later disintegrated.

Saflag material remained in readable condition during 5 years of observation. Lost collars, as determined by recaptures, averaged 7.3% per year. Individual collars could be identified at distances of approximately 4 mi. in good light with a 60X spotting scope.

Blunt (1965) reported proper fit is important to avoid undue wear and damage because discomfort will result in an animal attempting to remove the source of irritation. Suggested sizes of neck bands suited to various species are listed in Table 1.

Table 1. Neck band sizes appropriate for big game species.

Species	Sex	Inside Circumference (inches)	Type
Pronghorn	Male	25-26	Open
	Female	22	Pre-sewn
Elk	Male		
	Female	31	Pre-sewn
Mule Deer	Male	22	Open-expandable to 28.5 inches.
	Female	22	
White-tailed Deer	Male	21	Open-expandable to 28.5 inches.
	Female	17.75-19.75	Pre-sewn
Moose	Male		
	Female	34.5-35.5	Pre-sewn
Bighorn Sheep	Male	23-24	Open
	Female	23-24	Open

C. Dyes – The use of various dyes has met with some success. Nyansol "D" black dye, applied in the fall or early winter by aerial spray showed quite well until the spring molt (Hepworth 1966; Creek 1967). Fish planting tanks built for light aircraft were used to transport and "dump" the dye on pronghorn.

II. GAME BIRDS AND SMALL/MEDIUM MAMMALS –

A. Standard Marking and Banding Techniques –

1. Rationale – Many questions about the activities of wild or pen-reared birds can be answered by banding or marking them prior to release. Marking is generally done for one or more of the following purposes:

a. To determine the amount and distribution of harvest on pen-raised and released stock.
b. To determine daily and seasonal movements of individual mammals and birds, and in some cases, flocks of birds.
c. To provide a basis for determining survival rates and mortality causes for pen-raised wild-trapped birds and mammals.

2. Application – A variety of marking techniques have been developed and all have their place in management. Three basic types of marking are used. The first type generally requires the marked bird must be recaptured or harvested to retrieve the information. Included in this type of marking are leg bands, patagial tags and other inconspicuous markers. Conspicuous markers are the second type. These typically involve color or number combinations that enable observers to follow the movements and determine the fate of individual birds or flocks. Patagial streamers, poncho markers, neck, bands, plastic leg bands, dyes and colored feathers are included in this group. In some cases, conspicuous markings will be lost with first subsequent molt. The third marking system involves a means of locating birds via an attached transmitter and following their movements for the life of the transmitter. This practice allows one to locate a particular bird almost at will.

   Every technique has its limitations and these should be understood before technique is selected. Care should be exercised to prevent introducing a mortality bias. For example, using a highly conspicuous marker on birds that depend on camouflage for protection may increase predation. Poorly designed markers may restrict movements of some birds or cause them to become snared on brush. Heavy transmitters may also increase mortality. One should avoid marking techniques that produce a false mortality. Bands or tags that are easily lost or damaged may lead the observer to believe the marked bird is dead. At the very least, analysis and interpretation of data become biased. For example, if a bird is marked with an orange streamer that fades to yellow or white, it could be confused with other birds marked with yellow or white markers. Symbols used on markers should also be designed to minimize confusion when they are viewed at a distance.

   Marking techniques should be suitable for the intended purpose of the study. If the marker is a leg band and several thousand will be released and recovered over a period of years, accurate records should be kept to avoid duplicating numbers or symbols. Similarly, returned bands should be carefully logged and recorded to prevent duplications, omissions, or other errors. Always record causes of mortality when bands are recovered so legal harvests can be separated from other mortality. Small markers are not suitable for identifying individual marked birds from a distance. Leg bands, for example, cannot be read on birds that typically inhabit tall grass or during incubation. When patagial tags are used, place them on both wings for positive identification and ease of reading. If birds are to be observed primarily in flight, patagial markers should be affixed under the wings.

Maintaining marked birds in a population has several benefits. Some type of marker should generally be placed on wild birds that are transplanted and on pen-raised stock that are released. This will enable managers to obtain information about harvest rates, distribution, movements, and other biological data. After sufficient information has been gathered from the initial marking effort, assuming no further changes in management are proposed, further marking is unnecessary.

Each band or patagial marker should be stamped, "Return to WGFD" or similar direction. To assure accurate identification and facilitate information handling, standardized band prefixes should identify the district where the bird was released, species, and year. The first digit or alpha denotes the district, the second digit denotes species, and the third denotes the year of release according to the schedule below:

First Digit = District	Second Digit = Species	Third Digit = Year *
Jackson . . . . . = 1 (or JN)	Pheasant . . . . . = 1	2001 . . . = 1
Cody . . . . . = 2 (or CY)	Turkey . . . . . = 2	2002 . . . = 2
Sheridan . . . . . = 3 (or SN)	Chukar/Gray Partr. = 3	2003 . . . = 3
Green River . . . = 4 (or GR)	Sage-Grouse . . . . . = 4	2004 . . . = 4
Laramie . . . . . = 5 (or LE)	Blue Grouse . . . . . = 5	2005 . . . = 5
Lander . . . . . = 6 (or LR)	Ruffed Grouse . . . = 6	2006 . . . = 6
Casper . . . . . = 7 (or CR)	Ruffed Grouse . . . = 7	2007 . . . = 7
Open . . . . . = 8	Open . . . . . = 8	2008 . . . = 8
Open. . . . . = 9	Open . . . . . = 9	2009 . . . = 9
Open . . . . . = 0	Open . . . . . = 0	2010 . . . = 0
		Blank . . = Year not Specified

* Year designations rotate every 10 years (e.g., 2011 will be designated as a "1"). Since upland game birds seldom survive more than 1-2 years (sage-grouse somewhat longer), this rotation poses no risk of duplicate markers in the field.

Example: 516-000 = District 5 (Laramie) release, pheasant, 2006.

a. Materials – Table 2 lists approximate sizes of aluminum and plastic leg bands appropriate for use on upland game birds in Wyoming. Self-piercing tags for patagial markers and streamers are also listed. Sizes are approximate and should be tested prior to ordering supplies of tags.

   Wild birds can also be marked with highly visible markers such as poncho markers, patagial streamers (Fig. 1), neck bands or streamers (Fig. 2) or dyes. Patagial markers appear to perform the best. Plasticized polyvinyl chloride appears to be the best material for markers.

b. Dyeing – Applying Dyes to feathers is only a temporary means of marking birds, but is sometimes possible without having to capture the bird. Several types of

dyes and paints and their characteristics are listed in Table 3 (Modified from Taber and Cowan 1969:Table 18.1). Dyeing white or light-colored feathers yields the best results.

Dyes can be applied by spraying with portable spraying devices, or by remotely dispensing from devices set up where birds are known to congregate, for example, at strutting grounds. Dyes can be applied using a variety of innovative means such as squirt guns, weed sprayers, backpack pumps, etc. depending on the species and how close individuals can be approached.

Table 2. Leg band sizes for game birds.

Species	A.O.U. Leg Band	National Band and Tag Co. Equivalent	
		Metal	Plastic
Pheasant	♀6 ♂7A	♀10 ♂14	♀5 ♂7
Sage Grouse	♀6 ♂7A	♀12 ♂16	♀6 ♂8
Sarp-tailed Grouse	6	12	6
Ruffed Grouse	6-5	12-14	6-7
Blue Grouse	5	12	6
Gray Partridge	3A	10	5
Chukar Partridge	5-6	12	6
Turkey	9	24-28	12-14
Mourning Dove	3A		
Virginia Rail	3		
Sora Rail	3		
Common Snipe	3		
Canada/Cackling Goose	8		
Mallard	7A		
Gadwall	6		
Pintail	6		
Green-winged Teal	4		
Blue-winged Teal	5		
Cinnamon Teal	5		
American Wigeon	6		
Shoveler	6		
Wood Duck	5-6		
Redhead	6		
Ring-necked Duck	6		
Canvasback	7A		
Scaup	6-5		
Common Goldeneye	6		
Bufflehead	5-6		
Ruddy Duck	7A		
Hooded Merganser	5		
Common Merganser	7A		
Red-breasted Merganser	5-6		

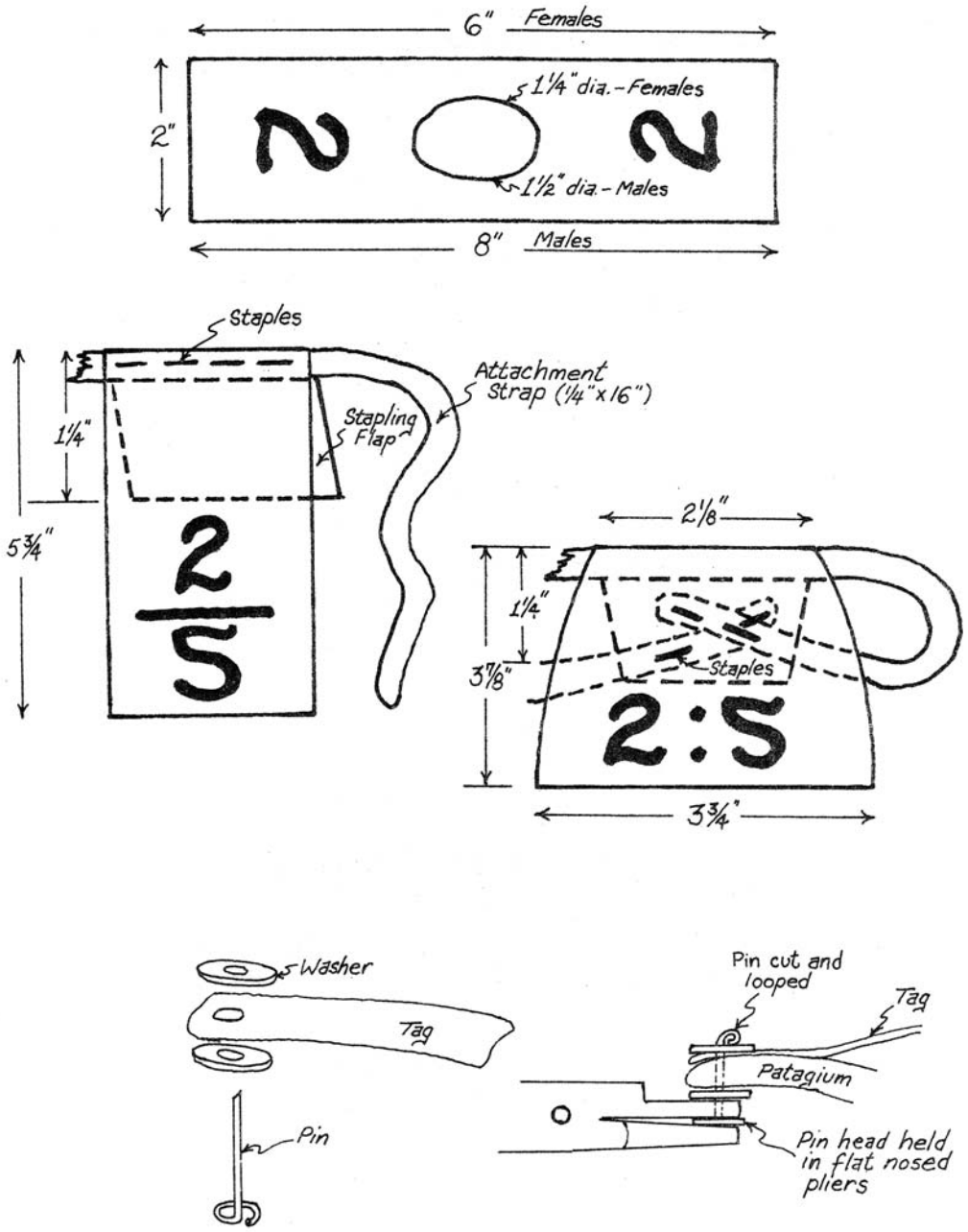

Fig. 1. MARKING AND BANDING. Poncho marker (top); back-tag marker (center); and patagial type marker (bottom).

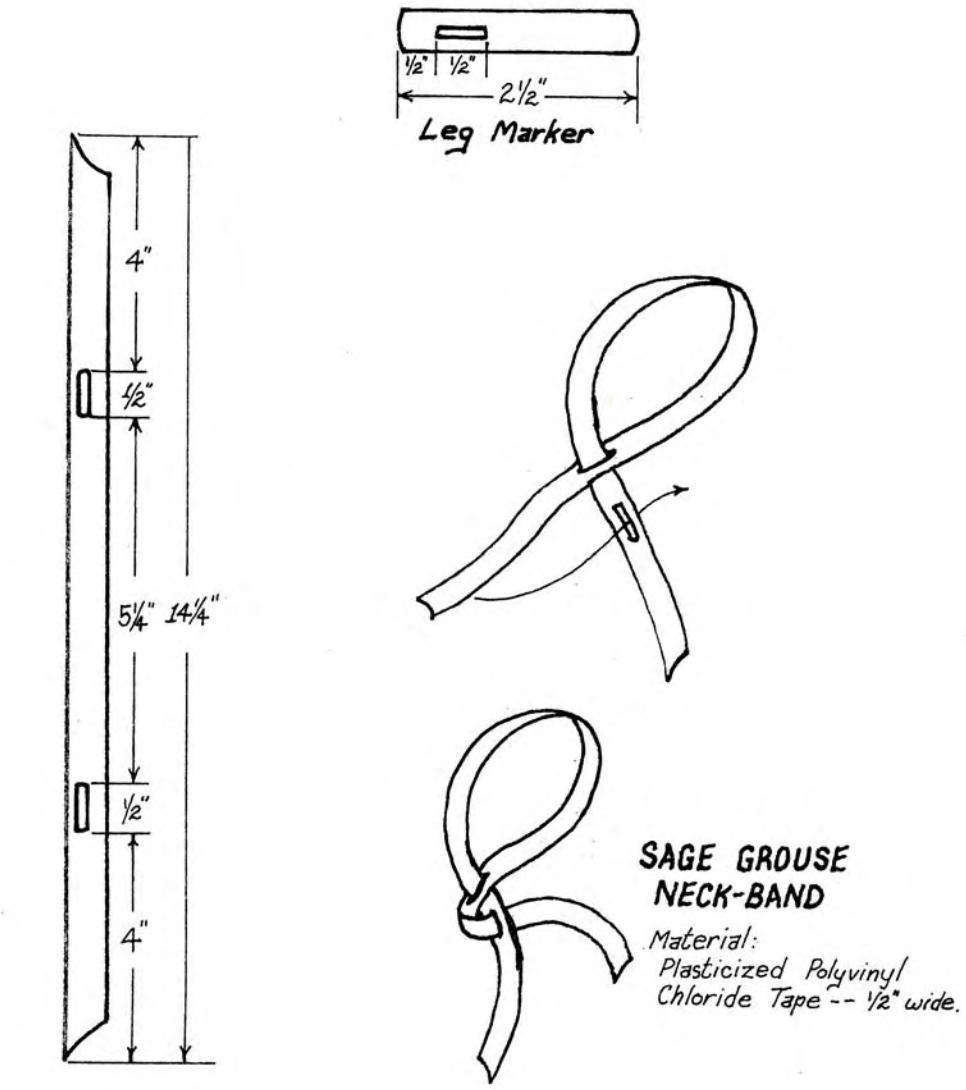

Fig. 2. MARKING AND BANDING. Plasticized polyvinyl chloride 0.5-in. tape, illustrating the neck band and leg marker.

c. Telemetry – Various radio and satellite telemetry devices have been used to track movements and activities of virtually all species of upland game birds. Consult Samuel and Fuller (1994) and other literature for current information on the use of telemetry to monitor and study upland game birds.

3. Disposition of Data – All bands must be ordered through the Biological Services Section, which maintains the banding databases for the Department. Be sure to anticipate and budget for banding supplies during the fiscal year (1 July – 30 June) in which banding will be conducted.

   All data from trapping and marking operations are to be maintained in a permanent file. Data and results are summarized in annual job completion reports prepared for the species being studied, or in a special report if a job completion report is not normally submitted.

Table 3. Characteristics of some dyes that have been used to mark birds and small mammals.

Coloring Agent	Species that have been marked using the referenced coloring agent	Other species on which coloring agent may be used.	Special Techniques	Duration of Color	Authority [Refer to Taber and Cowan (1969) for complete references]
Rhodamine B, Malachite Green and picric acid in alcohol	Snow and Ross' Goose	Any light-colored bird. If mortality is not important in the study, investigate usage on small mammals, hares, rabbits	Dipped wings and tails in dye.	Observable 3 to 6 months in the field.	Kozlik et al. 1959
Malachite Green, Brilliant Green, Rhodamine B extra, Purple Batik: in 33% alcohol + 66% H_2O	Pheasant	Sage grouse, sharp-tailed grouse, gray partridge, chukars, ruffed grouse	Applied with spray gun. Wetting agents useful with some dyes.	Observable 2+ months on the ground, 3-6 months on flushed birds.	Wadkins 1948
Rhodamine B, Suramine, Methyl Violet, Vistoria Green, in saturation in 95% ethanol	Ruffed grouse	Sage grouse, sharp-tailed grouse, gray partridge, chukars, ruffed grouse	Dipped tails of adults and rolled young in shallow pan or sprayed with atomizer.	Observable in the field (on shed feathers) and in the hand up to 8 months.	Gullion et al. 1961

Table 3. Continued.

"Airplane Dope" in white, yellow, red	Waterfowl; Mourning dove	Any species. Some "reflective" or fluorescent colors have been used on rabbits, color selection is more important with mammals.	On tail and outer primaries. Apply thin coat and hold feathers spread until dry to avoid sticking. On small species avoid loading wingtips.	Observable about 2 months when flushed.	Sowls 1955 Swank 1952
Aniline dyes in mixture of equal parts water and 95% grain alcohol	Sage grouse		Applied with remote control spray.	Not observed	Moffitt 1942
Aniline dyes in water, grain alcohol, acetic acid	Mourning dove; scaup	Any bird. Investigate possible usage on mammals	Birds dipped and held for drying.	Over 3 months.	Winston 1954
Nyanzol A: 20 gm/l of water hydrogen peroxide mixture in ratio of 2:1	Squirrel	Any mammal.	Apply as rings in broad bands on animal's body	Until molt.	Fitzwater 1943
Ammonium hydroxide (4%); 1 part to 2 qts. 3% hydrogen peroxide plus soap as above.	Pocket gopher	Recommended for mammals with dark pelage.		Until molt.	Morejohn and Howard 1956
Human black hair color (dye) with oil bases: apply with equal part 3% hydrogen peroxide plus granulated soap until liquid is thick.	Pocket gopher	Recommended for mammals with light pelage.		Until molt.	Morejohn and Howard 1956
			General – Dyeing techniques would normally influence mortality less if applied to nocturnal species.		

III. OTHER MARKING TECHNIQUES FOR GAME BIRDS

A. Plasticized Polyvinyl Chloride 0.5 Inch Tape (June 1963b) – A plasticized polyvinyl chloride tape material is available in several colors in 0.5-in. width. This material can be used in two ways: as a neck band and as a leg marker.

1. Plastic Tape Neckband – The plastic neck band has two 4-in. tails that hang down for visual identification. The loop is made using a "jess knot" (Craighead and Stockstad 1956), with the loop 5.25 in. in circumference (for sage grouse) to slip over the bird's head. Downing and Marshall (1959) devised a new knot or method of attachment to secure the plastic 0.5-in. tape neck band, which requires little pulling to secure the knot. This method involves passing a folded end of the marker through a hole in the opposite end to a point at which a pair of notches in each edge of the tape allows it to unfold and lock into place (Fig. 2).

2. Plastic Tape Leg Marker – The plastic leg marker (Campbell 1960) is used with color combinations to mark individual birds for visual observation. It is a strip of the plasticized 0.5-in. tape, 2.5 in. long, with a slit to allow the aluminum leg band to pass through, and is placed on the outside of the leg (Fig. 2). This polyvinyl chloride 0.5-in. tape material has been used effectively on sage grouse in a population dynamics study (June 1963b). The neck markers have lasted up to the life of the bird (up to 7 years) with minimal loss or detachment.

B. Poncho marker (Pyrah 1970) – A poncho-type field identification marker (Fig. 1) has been constructed of Naugahyde (U.S. Rubber) upholstering material cut into pieces 2 in wide and 6 in. long for female sage grouse, and 8 in. long for males. Naugahyde is available in many colors. Black plastic paint (vinyl and plastic, Fabspray, Nu-color of America) was used to write numbers on the Naugahyde poncho marker. The poncho marker is simply slipped over the heads of grouse before the birds are released. A round, 1.25-in. diameter hole is cut in the center of the markers to be fitted on female grouse; and a round, 1.5-in. hole is cut for males.

C. Back Tag Marker (Gullion et al. 1962, Labisky and Mann 1962) – A back tag type field identification marker (Fig. 1) can be constructed from several materials such as Masland Duran, U.S. Naugahyde, U.S. Fiberthin, Coverlight and Armor Tite. The back tags do not significantly affect the behavior or well-being of the birds. Back tags can be made into 2 general shapes with additional variations. These general shapes are rectangular and bell-shaped. The rectangular shapes are 2.125 in. wide and 7 in. long including a 1.25 in. stapling flap in the length. The bell shape is 3.75 in. wide at the base, 2.125 in. (2 1/8 in.) wide at the top, and 5.125 in long including a 1.25-in. stapling flap. The attachment strap is made of good quality leather or Fiberthin, 16 in. long and 0.25 in. wide.

The back tag marker is attached to the bird with the attachment strap in front of the wing, from the above side down under and backward, upward and across, and under the back tag being stapled to the stapling flap.

Use of back tags increased the vulnerability of grouse to predation, significantly shortening their survival and increasing the rate of population turnover (Gullion et al. 1962).

D. Patagial Markers – Numbered "Jiffy" wing tags fitted with plastic streamers (Fig. 1) have proven an effective means for marking wild turkeys. This type of marker is highly visible and has a reasonable life expectancy. Different colored streamers can be used to denote specific trap or release sites. Color combinations may also be used to identify individual birds. One or both wings can be marked in this manner.

E. Teflon Plastic (FEP Fluorocarbon) Material – Penney and Sladen (1966) tested use of Teflon plastic as flipper bands on penguins. This product offers many possibilities for use as a marking material. Samples of FEP Fluorocarbon film (3000 XF) were obtained from the DuPont Film Department, Rocky River, Cleveland, OH. The Teflon was available as transparent or colored film in sheets or strip rolls of varying thickness. It is pliable, yet exceptionally tough over a wide range of temperatures ranging from -180^{o} to $+260^{o}$ C. Low surface tension makes the material highly resistant to water adhesion and weather. It can be pre-shaped by dipping into boiling water and then quickly chilling.

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APPENDIX VIII

ANIMAL CAPTURE AND HANDLING

Information on animal capture and handling was extracted from the "Handbook of Wildlife Chemical Immobilization" by Terry J. Kreeger (1996). No part of this information can be reproduced or transmitted in any form without written permission of the copyright owner.

I. Legal Considerations – The possession and use of drugs used to capture wildlife is governed by both federal and state regulations. All drugs currently used to sedate or immobilize wild animals are prescription drugs and must be used by or on the order of a licensed veterinarian. To comply with this regulation, non-veterinarians should ensure a valid veterinarian-client-patient relationship exists. This requires a veterinarian must be involved in the process, but it does not necessarily mandate that a veterinarian be on site during the immobilization process. Non-veterinarians using prescription drugs should receive adequate training.

Some drugs used on wildlife are also classified as controlled drugs. Possession of controlled drugs requires a Drug Enforcement Agency registration number, special record keeping, and special storage requirements. If you have questions regarding the legalities of drug use, contact the Department's wildlife veterinarian.

II. Types of Drugs –

A. Paralytic Drugs – The neuromuscular blocking (NMB) or paralytic drugs are some of the earliest drugs used for the chemical immobilization of wildlife. Despite their long history of use, NMB drugs are generally inferior to modern drugs. There are two major deficiencies of NMB drugs. One is that NMB drugs have a very low safety margin and dosage errors of only 10% can result in either no effect (underdosing) or death by asphyxia (overdosing). Mortality rates as high as 70% have occurred. The second deficiency is that NMB drugs are virtually devoid of central nervous system effects because of their inability to cross the blood-brain barrier. Thus, an animal paralyzed with NMB drugs is conscious, aware of its surroundings, fully sensory, and, as such, can feel pain and experience psychogenic stress yet is physically unable to react. Because of these deficiencies, NMB drugs should be used judiciously.

There are, however, certain definite advantages to some NMB drugs. They are generally very fast-acting (3–5 min) and the duration of effect lasts only for a short while (15–30 min). Succinycholine, the most commonly used drug of this class, is also fairly safe for humans. Animals that have been given only

succinycholine and that have died or been euthanized using physical means (i.e., not other drugs) can be safely eaten by other animals, if needed. And lastly, succinycholine is extraordinarily cheap, perhaps the least expensive immobilizing agent available. This might explain why it is still in widespread use.

B. Tranquilizers/Sedatives – Tranquilizers are used primarily in wildlife immobilization as adjuncts to primary anesthetics (e.g., ketamine, carfentanil) to hasten and smooth induction and recovery and to reduce the amount of the primary agent required to achieve immobilization. Valium is used primarily for small mammals as an anticonvulsant adjunct to ketamine anesthesia and it is also an excellent muscle relaxant.

The alpha-adrenergic tranquilizers (e.g., xylazine or Rompun, medetomidine) are potent sedatives and can be completely antagonized. They are often combined with ketamine, Telazol, or carfentanil. By themselves, they are capable of heavily sedating animals, particularly ungulates, to the point of relatively safe handling. However, animals sedated with these tranquilizers generally can be aroused with stimulation and are capable of directed attack. Caution should always be exercised in such animals even though they appear harmless.

C. Dissociative Anesthetics – This group of drugs (ketamine, tiletamine) are characterized by producing a cataleptic state (a malleable rigidity of the limbs) in which the eyes remain open with intact corneal and light reflexes. Ketamine is probably one of the most widely used drugs for wildlife immobilization because of its efficacy and safety. Tiletamine is unavailable as a single product and it is combined in equal proportions with the diazepinone tranquilizer, zolazepam (e.g., Telazol).

When used singly, ketamine usually cause rough inductions and recoveries, and convulsions are not uncommon. Because of this, they are usually administered concurrently with tranquilizers or sedatives. There is no complete antagonist for ketamine or Telazol.

D. Opioid Anesthetics – The opioids have been used for animal immobilization since the 1960s and are the most potent drugs available for this purpose. The most commonly used opioid is carfentanil. A3080 is a new synthetic opioid not yet on the market, but early trials on ungulates are promising. A major advantage in the use of opioids is the availability of specific antagonists.

The potency of opioids, such as etorphine and carfentanil, is both an advantage and disadvantage. The advantage is the reduced volume of drug required for immobilization makes them the only class of drugs capable of remote immobilization of large animals. The disadvantage is that they are potentially toxic to humans. Death is almost always due to respiratory failure. Opioid immobilizing agents should never be used while working alone or without having

an antagonist immediately on hand. Anyone using these agents should be familiar with CPR.

III. Calculating Drug Dosages – It is essential to calculate drug dosages accurately in order to effectively anesthetize animals. Drug dosages in this text are given in the metric system as they are worldwide. Probably the only conversion that you need to remember is that 1 kilogram (kg) equals 2.2 pounds (lbs).

For example, consider immobilizing an animal that weighs 80 kg (176 lb) with Drug "X". The recommended dose of Drug X for this animal is 5 mg/kg. Drug X is available in a 100 mg/ml solution. First, calculate the total milligrams (mg) of drug needed for this animal by multiplying the animal's weight (80 kg) by the recommended drug dose (5 mg/kg):

mg Drug X needed = 80 kg x 5 mg/kg = 400 mg

Then calculate the volume of drug solution to withdraw from the bottle by dividing the needed total mg of Drug X (400 mg) by its concentration (100 mg/ml):

Volume = 400 mg ÷100 mg/ml = 4 ml

Four ml is the amount that you would withdraw from the vial to inject into the animal.

IV. Animal Capture

A. Have everything that you need with you –

Before you begin the immobilization procedure, be sure that you have all drugs and equipment that you may need. Fishing tackle boxes usually make good receptacles for all this and they come in a variety of sizes and shapes to suit almost all tastes. Vests with multiple pockets, such as a fly fishing or photographer's vest, can be used to carry most items and they free the hands to carry such things as dart guns and pole syringes.

B. Prepare dart(s) beforehand –

Have one or more darts loaded before you begin your approach. Be sure that all loaded darts are safely stored so as to prevent accidental injection; plastic test tubes or cigar holders make good holding devices.

C. Check darts and gun before using –

Always inspect your dart gun prior to use to insure that it is unloaded and the barrel clean and clear. If you are using any form of electronic sights, be sure that they are working (and always carry spare batteries!).

D. Don't load gun until ready to approach the animal –

Until you are actually in a position to approach and dart an animal, it is generally unnecessary to load your dart gun. At close ranges, dart guns can be lethal and they should always be treated like their bullet-firing counterparts.

E. Approach captive animals quietly and calmly –

Even if you are working with a captive animal restrained in a chute, or a trapped wild animal, you should approach it quietly and calmly. Do not make rapid or exaggerated movements that will panic the animal. If captive animals are accustomed to a routine such as feeding or cleaning, try to mimic that activity (at the same time of day) to allow a closer approach.

F. Use devices to approach free-ranging animals –

Wild animals can often be approached quite closely with a vehicle, but you must remain inside the vehicle even when taking a shot. If using a vehicle or helicopter to pursue and dart animals, try to limit the length of the chase.

G. Estimate distance and wind –

Many dart guns can be adjusted to deliver more or less propellant to the dart. Estimate the probable shooting distance that you expect to encounter, adjust the metering device, and use the power load appropriate for the distance and dart weight. However, be prepared to adjust these factors at the last moment; if in doubt, it is better not to shoot. Overpowered darts can cause severe wounds or death; underpowered darts can miss altogether (thus spooking the animal). Also be sure to consider wind speed, particularly with crosswinds, when using lightweight darts or shooting at long distances (>15 m).

H. Injection Administration Sites –

Immobilizing drugs are almost always administered intramuscularly (IM). The usual injection site is the large muscle masses of the hindlimb. Bears are usually injected in the shoulder.

I. Immobilization Signs –

Familiarity with the signs of anesthesia is essential – not knowing the depth of anesthesia can be lethal for both the animal and you! You can assess drug effect through changes in behavior, but to determine such effects, it is critical to be

familiar with the target species. Know what is normal and look for the abnormal. Once the animal is down, you need to assess the depth of anesthesia. Always exercise caution when checking a downed animal. Approach the animal slowly and quietly; approach dangerous animals from the rear and be sure you have an escape route. If the animal appears unconscious, check for ear twitch (touch inside of ear, ear twitches), pedal reflex (pinch toe, limb withdraws), swallowing reflex (pull tongue, release, animal swallows), palpebral reflex (touch eyelashes, animal blinks), and corneal reflex (touch cornea, animal blinks). If the animal has lost the ear twitch, it is probably at an appropriate stage of anesthesia for most field procedures.

J. Incomplete Immobilization –

If the animal is down but not fully immobilized, you should allow 10-15 minutes to elapse before giving booster doses. In general, it is often safe to re-administer 50% of the original dose with or without the tranquilizer. For example, you used 500 mg ketamine and 100 mg of xylazine to immobilize a deer. The dart bounced out almost immediately and 15 minutes later the deer was stumbling about or even lying down, but it would get up or walk away when you tried to approach it. A safe and effective booster dose in this case would be 250 mg ketamine and no more xylazine.

If no sign of drug effect is apparent after 20 minutes, you can assume that the animal probably received little or none of the original dose. If you are confident the drug(s) and dose(s) you originally selected were appropriate, then give the animal the same drug(s) and dose(s) again.

Animals can be kept immobilized for extended periods (several hours) with supplemental boosters of 33-50% of the initial immobilizing dose. This is particularly true when using ketamine. Where ketamine was given initially in combination with another agent, such as xylazine or promazine, usually only the ketamine needs to be given to maintain immobilization. Administer such doses when the animal shows initial signs of recovery (e.g., raises head, blinks, etc.).

V. Handling the Immobilized Animal

A. Position Body –

Ensure nothing impinges on breathing, i.e., neck straight, nose clear. Position ruminants sternally; if this is not possible, position on either side but watch for bloat. Most other animals can be placed on either side or sternally. The head should preferably be slightly lower than the thorax to avoid aspiration of fluids. Try to keep the animal on relatively flat ground to avoid occlusion of the trachea, pressure neuropathy, or circulatory impairment. If the animal is to remain immobilized for some time, roll the animal on its other side or sternally at least

every 60 min. It is preferable to roll ungulates across the sternum as opposed to across the back.

B. Cover eyes –

Covering the eyes protects them from harmful ultraviolet light from the sun, reduces drying, and prevents dirt and debris from entering them. Coating the eyes with a lubricant further prevents drying, however, some feel that eye ointments result in dirt and grit sticking to the eye. A saline wash (e.g., contact lens saline) can also be used. Covering the eyes also appears to further calm the animal even when it is effectively immobilized.

C. Hobble the legs –

This is particularly necessary with ungulates to avoid spontaneous kicking which may injure someone. Hobbles also prevent other human injuries or possible escape should the animal partially or spontaneously recover.

D. Check vital signs –

Once you have assured the animal's body position will not affect breathing, check its respiratory rate (RR). Respirations can be seen (watch the abdomen or chest), felt (place hand in front of nostrils), or heard (place ear by nostrils – a very sensitive technique). Slowed RRs are most likely drug-induced, but they can be caused by hypothermia. In cases of respiratory arrest or poor oxygenation, respiration can be supported mechanically or pharmacologically. Rapid RRs could indicate hyperthermia, bloat, aspiration, pulmonary edema, or shock.

Always carry a thermometer and use it continually throughout the immobilization period. Normal mammalian rectal temperatures range from 99.5º–104º F. You should probably take action to lower an animal's temperature if it is > 106º F. Also check for wounds, injuries, and general condition.

E. Recovery of the Immobilized Animal –

An animal should not be left unattended until it starts to recover from the immobilization. Ideally, you should remain with the animal until it can walk in a relatively coordinated manner (i.e., respond appropriately to objects, people, other animals), whether an antagonist was administered or not. At the minimum, you should stay with the animal until it can at least raise itself to a sternal position. Look around the recovery area for possible hazards such as sharp rocks and ledges. Either relocate the animal or stay with it through recovery to direct it away from such hazards. Keep the animal cool or warm, depending on weather conditions (i.e., out of the sun in summer, in the sun during winter), dry, and free from inter- or intraspecific harassment or aggression.

VI. Euthanasia –

Invariably, there will come a time when an animal must be euthanized either because it has been critically injured or it is terminally ill. If an animal needs to be euthanized, this should be done safely and effectively with some consideration for the dignity of the animal and the sensitivities of the public. Many methods of euthanasia, such as shooting and stunning, are effective and medically acceptable but are reprehensible to the public (or even other biologists!). Chemical euthanasia is generally the preferred method because it is safe, effective, and aesthetically acceptable.

Note: No animal that has been chemically immobilized and then euthanized by physical methods or one that has been directly euthanized via chemical methods can be used for human or animal food consumption.

A. Cervical Dislocation – Cervical dislocation can be used to euthanize birds, small rodents, and rabbits. For mice and rats, the thumb and index finger are placed on either side of the neck at the base of the skull. With the other hand, the hind limbs are quickly pulled, causing separation of the cervical vertebrae from the skull. For small rabbits, the head is held in one hand and the hind limbs in the other. The animal is stretched and the neck is hyperextended and dorsally twisted to separate the first cervical vertebra from the skull. For birds of poultry size or smaller, cervical dislocation is accomplished by stretching and twisting.

B. Decapitation – Decapitation is generally not acceptable due to animal (and public) distress.

C. Exsanguination – Exsanguination (bleeding to death) is acceptable only if the animal has been rendered unconscious by drugs or stunning. It is often a slow, messy, and unsightly process. Bilateral sectioning of the jugular or femoral veins can be effective, but often the blood flow slows after awhile. If possible, try to severe the major arteries leading from the heart by inserting a long-bladed knife into the junction of base of the neck and shoulder and slicing inwards and downwards.

D. Stunning – Stunning by a sharp blow to the head with a hard object can be used for smaller animals (< 5 kg). Stunning by a penetrating captive bolt can be used on larger animals including the largest hoofstock. The disadvantage of any method of stunning is that it may not cause death, so you must check that the animal is dead by monitoring heart rate, respiration, or pupillary reflex.

E. Gunshot – Gunshot is often the most practical, if not only, means of euthanizing wild animals. Ideally, the animal is under some sort of physical or chemical control so carefully-placed shots can be made. If the animal is not controlled, head or neck shots are preferable to heart or lung shots. If the animal is under physical control or chemically immobilized, the best target for shooting is at the

intersection of two imaginary lines connecting the ears with the contralateral eyes. A .22-caliber long rifle cartridge is adequate for animals < 200 lb if fired at a distance of < 1 foot. Large, heavy-skulled animals (e.g., bears) usually require more powerful cartridges. Whatever cartridge is used, remember that placement is more critical than caliber. Be sure that all personnel stand behind the shooter; bullets hitting bone can take off at unexpected angles. Place the muzzle of the gun as close to the animal as feasible and aim at juncture of the "X" connecting the ears and eyes. On large animals, or animals with heavy skulls, you may want to shoot at a point slightly off center of this imaginary intersection. Try to ensure the shot is placed as perpendicularly to the skull as possible; bullets fired at a shallow angle may bounce off thick skulls. Although euthanasia by gunshot (or penetrating captive bolt) is usually instantaneous, the animal may thrash and convulse for several seconds after the shot. Large ungulates can deliver bone-breaking kicks during this period, so wait several seconds after cessation of thrashing to handle the animal.

F. Chemical Methods – Several euthanasia products are formulated to include a barbituric acid derivative (usually sodium pentobarbital) with added local anesthetic agents (e.g., Beuthanasia®-D Special; FP-3®). These drugs are Schedule III controlled substances. Intravenous injection is the preferred route, although intraperitoneal and intrathoracic injections can be given to small animals and birds. Animals euthanized with barbiturate solutions must be cremated for disposal. It usually takes large volumes of commercial solution to euthanize an animal the size of an elk or moose (perhaps >100 ml!); potassium chloride may be preferred because of this.

Potassium chloride can be inexpensively obtained from chemical suppliers. Potassium chloride is also available in grocery stores as "light salt" which is a substitute for sodium chloride. To prepare, mix a solution of approximately 300 mg potassium chloride per ml of water. This solution must be given IV; cardiac arrest is quite rapid (< 30 sec) and should be verified by listening for heartbeat or feeling for a pulse.

VII. Equipment

A. Dart Guns – Dart guns propel darts by either the gas generated from a .22 caliber blank cartridge, compressed CO_2, or compressed atmospheric air. Effective ranges can be as far as 75 m, although 50 m is usually the farthest practical distance. Guns can be equipped with a variety of sights including adjustable open sights, rifle scopes, laser aiming devices, and light-intensifying scopes. Many professionals, especially those who dart animals from helicopters, prefer open sights.

The preferred dart gun/dart combination is a Dan-Inject adjustable CO_2 rifle equipped with a 0.50-caliber barrel that fires Pneu-Darts. This combination is the

most versatile and consistent system on the market. It is very expensive, however (>$1,600). A less expensive, but very good rifle is the Pneu-Dart 0.22-caliber adjustable rifle.

Pneu-Darts are the preferred darts even though they are not reusable. They are inexpensive, lightweight, quick to load, and accurate. All darts should be equipped with barbs so they stay in the animal long enough to discharge all the drug, and for easy retrieval once the animal is down. This is particularly true when using carfentanil; the easiest place to find the dart is in the animal as opposed to somewhere between where you shot it and where it went down! Darts can also be equipped with small radio transmitters enabling location of animals that have run off after being darted.

B. Equipment and Supply Checklist –

- Dart guns (.22-caliber blanks, $C0_2$, or compressed air)
- .22 charges (brown [lowest power], green, yellow, red [highest])
- CO_2 propellant
- Shotgun cleaning rod (to remove stuck or unused darts)
- Extra batteries for electronic sights
- Re-usable Powder Charge Darts
- Dart bodies (1, 2, 3, 5, 7 ml)
- Dart charges (1–3, 4–10 ml; keep dry)
- Dart needles
- Dart plungers
- Dart tailpieces
- Silicone lubricant (for dart plungers)
- Rod for pushing plunger through dart to lube
- Extra .22 adapters for Cap-Chur® guns
- Disposable Darts (powder and/or acid-base charged; 1, 2, 3, 5 ml)
- Compressed Air Darts
- Darts (2, 3, 5 ml)
- Dart needle sleeves or caps
- Tailpieces
- Coupler
- 20 ml syringe
- Plunger rod (for discharging reservoir)
- Pole Syringe
- Extra syringe barrels, parts
- Petroleum Jelly
- Marking pen, pencil
- Needles (25 ga x 0.75", 20 ga x 1", 18 ga x 1", 18 ga x 1.5", 16 ga x 1", 16 ga x 1.5")
- Syringes (1, 3, 5–6, 10–12, 20 ml)

- Blood collection tubes (with and without anticoagulant)
- Swiss Army knife/"leatherman"
- Pliers
- Cigar tubes (or other device to safely store loaded darts until used)
- Sterile water (for topping off darts)
- Propylene glycol (mix with drugs to act as antifreeze)
- Scalpel blades (for removing barbed darts)
- Flashlight (plus extra bulb and batteries)

C. List of Manufacturers and Major Distributors –

Animal Care Equipment and Services, Inc.
613 Leebert Way
Crestline, CA 92325 USA
Tel: 909-338-1791
(Distributor of animal capture equipment)

Animal Management Inc.
720 Eppley Road
Mechanicsburg, PA 17055-9786 USA
Tel: 800-745-8173
(Distributor of animal capture equipment)

Palmer Chemical & Equipment Co., Inc.
P.O. Box 867
Palmer Village
Douglasville, GA 30133 USA
Tel: 404-942-4395
(Dart guns, darts)

Pneu Dart, Inc.
P.O. Box 1415
Williamsport, PA 17703 USA
Tel: 717-323-2710
(Dart guns, darts)

Telinject USA, Inc.
9316 Soledad Canyon Road
Saugus, CA 91350 USA
Tel: 805-268-0915
(Dart guns, darts, blow pipes)

Wildlife Pharmaceuticals, Inc.
1401 Duff Drive
Suite 600
Fort Collins, CO 80524 USA
Tel: 970-484-5560
(Dart guns, darts, blow pipes, pole syringes)

Wiley & Sons, Inc.
Rte. 1 Box 303
Wills Point, TX 75169 USA
Tel: 903-848-7912)
(Distributor of animal capture equipment)

Zoolu Arms of Omaha
10315 Wright Street
Omaha, NE 68124 USA
(Dart guns, darts, blow pipes, pole syringes)

VIII. Drug Dosages –

BADGER (*Taxidea taxus*)
Weight: 4–12 kg
Recommended Drug: 4.4 mg/kg Telazol®
Antagonist: None
Alternative Drugs:
• 15 mg/kg ketamine plus 1 mg/kg xylazine
Comments: Badgers require care in drug administration because they struggle and resist handling; try to physically restrain the animal to insure accurate drug injection.

BEAR, BLACK (*Ursus americanus*)
Weight: 92–140 (f), 115–270 (m) kg
Recommended Drug: 4.4 mg/kg ketamine plus 2 mg/kg xylazine
Antagonist: 0.15 mg/kg yohimbine
Alternative Drugs:
• 7 mg/kg Telazol®
• 1.5 mg/kg ketamine plus 0.04 mg/kg medetomidine; antagonize with 0.2 mg/kg atipamezole
Comments: Anesthetic induction with Telazol® may take up to 20 min and recoveries may be prolonged. Recovery from ketamine-medetomidine after antagonism with atipamezole may be rapid – be prepared. Also, spontaneous recoveries *without* the antagonist may occur – watch carefully for signs of early recovery.

BEAR, GRIZZLY (*Ursus arctos*)
Weight: 100–325 kg
Recommended Drug: 8 mg/kg Telazol®
Antagonist: None
Alternative Drugs:
- 2 mg/kg Telazol® plus 0.06 mg/kg medetomidine; antagonize with 0.3 mg/kg atipamezole
- 11 mg/kg ketamine plus 11 mg/kg xylazine; antagonize with 0.125 mg/kg yohimbine
- 0.012 mg/kg carfentanil plus 0.3 mg/kg xylazine; antagonize with 100 mg naltrexone or naloxone per mg carfentanil given plus 0.125 mg/kg yohimbine

Comments: Spontaneous arousals may occur when ketamine-medetomidine is used; avoid loud or sharp noises; try to prevent vocalization of cubs when mother is immobilized.

BEAVER (*Castor canadensis*)
Weight: 12–25 kg
Recommended Drug: 10 mg/kg ketamine plus 1 mg/kg xylazine
Antagonist: None reported
Alternative Drugs:
- 11 mg/kg ketamine plus 0.22 mg/kg acepromazine
- 5 mg/kg Telazol®

BISON, AMERICAN (*Bison bison*)
Weight: 350–1,000 kg
Recommended Drug: 0.004 mg/kg carfentanil plus 0.07 mg/kg xylazine
Antagonist: 100 mg naltrexone or naloxone per mg carfentanil given plus 0.125 mg/kg yohimbine
Alternative Drugs:
- 4.4 mg/kg Telazol

BOBCAT (*Felis rufus*)
Weight: 4.1–15.3 kg
Recommended Drug: 10 mg/kg Telazol®
Antagonist: None
Alternative Drugs:
- 10 mg/kg ketamine plus 1.5 mg/kg xylazine
- 20 mg/kg ketamine plus 0.1 mg/kg acepromazine

COYOTE (*Canis latrans*)
Weight: 7–18 kg
Recommended Drug: 10 mg/kg Telazol®
Alternative Drugs:
- 10 mg/kg ketamine plus 0.1 mg/kg acepromazine
- 4 mg/kg ketamine plus 2 mg/kg xylazine, antagonize with 0.15 mg/kg yohimbine

DEER, MULE (*Odocoileus hemionus*)
Weight: 75–200 kg
Recommended Drug: 4.4 mg/kg Telazol® plus 2.2 mg/kg xylazine
Antagonist: 0.125 mg/kg yohimbine
Alternative Drugs:
- 7 mg/kg ketamine plus 0.7 mg/kg xylazine; antagonize with 0.125 mg/kg yohimbine
- 0.03 mg/kg carfentanil plus 0.7 mg/kg xylazine; antagonize with 100 mg naltrexone or naloxone per mg carfentanil given plus 0.125 mg/kg yohimbine
- 15 mg/kg Telazol®

Comments: When using ketamine-xylazine or Telazol®-xylazine for highly excited deer, the xylazine dose can be increased up to the dose of ketamine or Telazol® given (i.e., 7 mg/kg or 4.4 mg/kg, respectively).

DEER, WHITE-TAILED (*Odocoileus virginianus*)
Weight: 60–150 kg
Recommended Drug: 4.4 mg/kg Telazol® plus 2.2 mg/kg xylazine
Antagonist: 0.125 mg/kg yohimbine
Alternative Drugs:
- 7.5 mg/kg ketamine plus 1.5 mg/kg xylazine, antagonize with 0.125 mg/kg yohimbine
- 2 mg/kg ketamine plus 0.07 mg/kg medetomidine; antagonize with 0.35 mg/kg atipamezole

Comments: When using ketamine-xylazine or Telazol®-xylazine for highly excited deer, the xylazine dose can be increased up to the dose of ketamine or Telazol® given (i.e., 7.5 mg/kg or 4.4 mg/kg, respectively).

ELK, NORTH AMERICAN (*Cervus elaphus*)
Weight: 230–318 kg
Recommended Drug: 0.01 mg/kg carfentanil plus 0.1 mg/kg xylazine
Antagonist: 100 mg naltrexone or naloxone per mg carfentanil given plus 0.125 mg/kg yohimbine IV
Alternative Drugs:
- 2 mg/kg ketamine plus 0.07 mg/kg medetomidine; antagonize with 0.35 mg/kg atipamezole
- 3 mg/kg Telazol® plus 0.4 mg/kg xylazine; antagonize with 0.125 mg/kg yohimbine
- 4 mg/kg ketamine plus 2 mg/kg xylazine; antagonize with 0.125 mg/kg yohimbine

Comments: Monitor elk carefully for overheating or bloat. For highly excited elk, the carfentanil dose can be increased to 0.013 mg/kg; the xylazine dose remains the same (i.e., 0.1 mg/kg).

FISHER *Martes pennanti*)
Weight: 2.6–5.5 kg
Recommended Drug: 25 mg/kg ketamine plus 5 mg/kg xylazine
Antagonist: None reported
Alternative Drugs:
• 20 mg/kg ketamine plus 0.1 mg/kg acepromazine

FOX, RED (*Vulpes vulpes*)
Weight: 4.1–4.5 (f), 4.5–5.4 (m) kg
Recommended Drug: 10 mg/kg Telazol®
Alternative Drugs:
• 20 mg/kg ketamine plus 0.2 mg/kg acepromazine
• 20 mg/kg ketamine plus 1 mg/kg xylazine, antagonize with 0.15 mg/kg yohimbine
• 25 mg/kg ketamine plus 1 mg/kg midazolam
Comments: If using xylazine, wait at least 45 min after last ketamine injection before administering yohimbine.

FOX, SWIFT (*Vulpes velox*)
Weight: 1.8–3 kg
Recommended Drug: 10 mg/kg Telazol®
Alternative Drugs:
• 20 mg/kg ketamine plus 0.2 mg/kg acepromazine

GOAT, MOUNTAIN (*Oreamnos americanus*)
Weight: 46–140 kg
Recommended Drug: 1.5 mg/kg ketamine plus 0.07 mg/kg medetomidine
Antagonist: 0.35 mg/kg atipamezole; give 1/2 dose IV, 1/2 IM
Alternative Drugs:
• 2.75 mg carfentanil; antagonize with 100 mg naloxone or naltrexone per mg carfentanil given

HORSE, NORTH AMERICAN WILD (*Equus caballus*)
Weight: 250–530 kg
Recommended Drug: 0.02 mg/kg carfentanil plus 0.6 mg/kg xylazine
Antagonist: 100 mg naltrexone or naloxone per mg carfentanil given
Comments: Yohimbine must be administered to horses receiving xylazine.

LION, MOUNTAIN (*Felis concolor*)
Weight: 30–75 kg
Recommended Drug: 2 mg/kg ketamine plus 0.075 mg/kg medetomidine
Antagonist: 0.3 mg/kg atipamezole
Alternative Drugs:
• 8 mg/kg Telazol®
• 10 mg/kg ketamine plus 2 mg/kg xylazine; antagonize with 0.125 mg/kg yohimbine

LYNX, *Lynx canadensis*
Weight: 5.1–17.2 kg
Recommended Drug: 5 mg/kg Telazol®
Antagonist: None
Alternative Drugs:
- 10 mg/kg ketamine plus 2 mg/kg xylazine

MOOSE (*Alces alces*)
Weight: 400–600 kg
Recommended Drug: 0.01 mg/kg carfentanil
Antagonist: 100 mg naltrexone or naloxone per mg carfentanil given
Alternative Drugs:
- 1.5 mg/kg ketamine plus 0.06 mg/kg medetomidine; antagonize with 0.3 mg/kg atipamezole
- 4 mg/kg ketamine plus 1 mg/kg xylazine; antagonize with 0.25 mg/kg tolazoline
- 5 mg/kg Telazol®

Comments: Xylazine (0.1 mg/kg) may be added to the carfentanil to get better muscle relaxation; however, xylazine increases the possibility of regurgitation leading to aspiration and pneumonia.

PORCUPINE, NORTH AMERICAN (*Erethizon dorsatum*)
Weight: 3.5–10 kg
Recommended Drug: 10 mg/kg Telazol®
Antagonist: None

PRONGHORN (*Antilocapra americana*)
Weight: 40–50 kg
Recommended Drug: 0.05 mg/kg carfentanil plus 1 mg/kg xylazine
Antagonist: 100 mg naltrexone or naloxone per mg carfentanil given plus 0.125 mg/kg yohimbine
Comments: In general, pronghorn are extraordinarily difficult to immobilize; carfentanil and xylazine has been the only drug combination that has been shown to be effective.

RACCOON (*Procyon lotor*)
Weight: 2–12 kg
Recommended Drug: 20 mg/kg ketamine plus 4 mg/kg xylazine
Antagonist: 0.15 mg/kg yohimbine
Alternative Drugs:
- 20 mg/kg ketamine plus 0.1 mg/kg acepromazine
- 12 mg/kg Telazol®

SHEEP, BIGHORN (*Ovis canadensis*)
Weight: 65–150 kg
Recommended Drug: 0.03 mg/kg carfentanil plus 0.2 mg/kg xylazine
Antagonist: 100 mg naltrexone or naloxone per mg carfentanil given plus 0.125 mg/kg yohimbine
Comments: Bighorn sheep are very susceptible to capture myopathy and hyperthermia; careful monitoring of the animal is required. Sheep can be sensitive to xylazine; monitor carefully and always give an antagonist.

SKUNK, SPOTTED (*Spilogale spp.*)
Weight: 0.2–1 kg
Recommended Drug: 10 mg/kg Telazol®
Antagonist: None
Alternative Drugs:
- 15 mg/kg ketamine plus 0.2 mg/kg acepromazine

SKUNK, STRIPED, *Mephitis mephitis*
Weight: 2–3 kg
Recommended Drug: 10 mg/kg Telazol®
Antagonist: None
Alternative Drugs: 15 mg/kg ketamine plus 0.2 mg/kg acepromazine

WOLF, GRAY (*Canis lupus*)
Weight: 27–60 kg
Recommended Drug: 10 mg/kg ketamine plus 2 mg/kg xylazine
Antagonist: 0.15 mg/kg yohimbine
Alternative Drugs:
- 4 mg/kg ketamine plus 0.08 mg/kg medetomidine; antagonize with 0.4 mg/kg atipamezole
- 10 mg/kg Telazol® plus 1.5 mg/kg xylazine
- 10 mg/kg ketamine plus 0.15 mg/kg acepromazine

Comments: If using ketamine (or Telazol®) and xylazine, wait at least 45 min after last ketamine or Telazol® injection before administering yohimbine. Calm, captive wolves may be immobilized with 4 mg/kg ketamine plus 2 mg/kg xylazine. This combination is more readily antagonized by yohimbine than when higher doses of ketamine are used.

WOLVERINE (*Gulo gulo*)
Weight: 7–32 kg
Recommended Drug: 5 mg/kg ketamine plus 0.1 mg/kg medetomidine
Antagonist: 0.2 mg/kg atipamezole; give 1/2 dose IV, 1/2 IM
Alternative Drugs:
- 20 mg/kg ketamine plus 0.2 mg/kg acepromazine

APPENDIX IX

Population Modeling

Reg. Rothwell, Bill Rudd, Daryl Lutz, Joe Bohne

I. INTRODUCTION – From the inception of modern game management in the early 20th century through approximately the 1970s, wildlife managers relied on comparatively rudimentary techniques to formulate hunting season frameworks and harvest quotas. Although managers and researchers attempted to estimate animal numbers for various purposes, by today's standards, their methods were crude and inaccurate, often consisting of extrapolations based on rough counts.

For at least a half century, the wildlife profession devised, tested and applied various formulae and models to estimate population sizes. These "estimators" have been used in lieu of, or in conjunction with, other direct and indirect indicators of abundance. Many estimation techniques required large data sets and the calculations often took hours or days to complete. When computers became widely available in the early 1970s, more sophisticated techniques were much more practical to apply.

About the same time (by the 1970s), managers needed more dependable and precise means of estimating populations to address a number of emerging issues. Harvest pressure was increasing and the public began scrutinizing management programs, particularly after big game declined in the late 1970s following an extraordinary abundance during the 1950s and 60s. Competition and conflicts were increasing between wildlife and other resource demands, especially agriculture and mineral development. In the public's mind, boom and bust cycles of game populations were becoming less acceptable and state wildlife agencies were responsible for preventing the "busts." This required an improved understanding of big game population dynamics. The agencies also needed a more effective means of projecting population trends and conveying this information to the public. Land management agencies sought more accurate population estimates to support resource allocation decisions in long-term management plans. The increasing demands for accurate estimates and sound management objectives prompted development of estimation techniques that were more sophisticated, but also feasible for wildlife managers to use on a regular basis throughout the State.

Population models are designed to simulate (or mimic) what the wildlife manager observes in the field. Models help organize and analyze data, test different management scenarios, and generate questions or hypotheses about vital population parameters and other considerations. If data quality or sample adequacy are issues, these can almost always be identified during modeling exercises. A simulation model is essentially a computerized accounting system with a graphics package, and it relies on a life table to project a population's response to changes in reproduction and mortality. Among other things, a population model enables managers to rapidly simulate scenarios that test the effects of hunting seasons on big game populations,

without actually having to conduct a hunting season to demonstrate the effects. Changes in other parameters can also be tested.

The first simulation model used by the Department was ONEPOP, developed by Jack Gross in the early 1970s. This early model was very cumbersome and slow because the data had to be entered on keypunch cards and processed in batches on a large, mainframe computer. Biologists were also required to do a great deal of data preparation beforehand.

ONEPOP-6, an improved version of ONEPOP, added effort values to the harvest function of the model and was easier to use, but still required batch processing. POP50 was developed to eliminate batch processing and provide a better system for modeling big game populations (Biological Services Section 1987). It was easier and faster to use, could be loaded and run in a desktop computer and had better graphics. Features added to POP50 included an annual mortality severity index, simplified control of the initial population size, and age class groupings by subadults and adults. POP50 also had a desired density feature that allowed managers to more easily test the effects of proposed hunting seasons.

The availability of personal computers led to the development of POP-II (Biological Services Section 1987). This program afforded personnel the convenience of modeling locally rather than having to travel and stay in one central location in the state during modeling exercises. Other improvements included the addition of mortality severity indices to adjust mortality both pre- and post-hunting season, the capability to direct harvest at certain age classes, and faster processing speeds. POP-II also enabled the user to update data and correct errors more easily, and to retrieve data more selectively.

POP-II has been revised several times for the Department and other state wildlife agencies since it was originally developed. During a 30-year history of modeling with POP-II and previous models, the Department has been involved to some degree with all of the revisions. In some cases, the Department contracted the model's originator or other programmers to have revisions done. In other cases, we were asked to review the changes requested by others, suggest additional modifications, and participate in beta testing the new version because of our personnel's extensive knowledge of and experience with the product. The Department is currently using POP-II for Windows, version 1.2.5 (Bartholow 2000).

Wildlife managers have developed and applied many different computerized models to simulate wildlife populations. Each type of model has advantages and disadvantages. The Wyoming Game and Fish Department periodically evaluates other models, but to this date has elected to retain POP-II at it works best for us and has been revised repeatedly to meet our needs.

Over 150 big game herds are currently recognized in Wyoming. At one time or another, the Department has attempted to model all of them. Initially, over 200 herds were delineated. Many were consolidated because data from sources such as modeling, ear tagging, neck banding, or radio telemetry studies indicated they were not discrete.

II. Modeling Considerations – Anyone who uses a simulation model for management purposes should consider potential sources of error in a model's output. First and foremost, POP-II is

intended for discrete or closed populations. Although some degree of interchange takes place between most adjoining herds in Wyoming, the Department considers populations sufficiently discrete if no more than 10% of the herd immigrates or emigrates. Models seem to function reasonably well when this assumption is met. For most herds, delineation is a practical compromise between assuring discreteness and identifying a reasonable geographic area for management. Herds that extend across state lines (interstate herds) are especially problematic. For years, biologists in Wyoming have attempted to improve data collection and management of interstate herds by coordinating with adjacent states, but have realized varying success.

The discreteness issue can compound the impact of data quality on model performance. We rely on the literature to define certain parameters such as sex ratio at birth, natural mortality, and wounding loss. Other parameters, particularly harvest and herd composition ratios, are estimated annually based on data collected from mail questionnaires (harvest statistics) and field surveys. However, accurately estimating age and sex ratios requires a statistically valid, well-distributed classification sample. Adequate classifications are difficult to obtain for white-tailed deer and for specific herds of other species, most typically moose and bighorn sheep.

The primary independent (input) variables of the POP-II model are herd age and sex ratios (J:100♀ and ♂:100♀), harvest estimates, natural mortality rates before and after the hunting season (pre- and post-hunt), initial population size and proportions, wounding loss, number of age classes, sex ratio at birth, and reproductive rates. Beginning and ending years are also required to initialize a model. Secondary parameters include mortality severity indices and effort values, which can be modified once a model is functioning. The number of age classes in the population is generally based on the oldest animal of known age that is harvested, encountered as a road kill, or found during winter mortality surveys. Typically, older animals are encountered more often during winter mortality surveys than in samples taken from hunters.

Although biologists often use population models to archive data, generally, model runs should be limited to the most recent 5 years and should not project more than 3-5 years into the future. Projections can be used to evaluate outcomes of alternative harvest strategies such as antlerless hunting, spikes excluded, and changing license quotas, based on the assumption other parameters will approximate average conditions. However, errors associated with “real world” departures from average conditions are compounded [propagated] each year, rendering longer-term projections pointless. The population model doesn’t seem to accommodate drastic changes in input values after a major perturbation, such as a severe winter with high mortality. Consequently, the model may have to be restarted the year following an extreme event.

Classification data should be collected based on well-distributed, statistically adequate sample to achieve a tight confidence interval. A model’s performance can be checked against trend counts provided they are done at the appropriate time of year, under consistent conditions, and detection rates are both adequate and unbiased (or bias is consistent and accounted for). To afford a valid comparison against model estimates, detection rates assumed during trend counts must be verified or at least must be a reasonable approximation based on the literature. If they area accurate, the simulated population estimates should exceed the trend counts because not

all animals are seen**.** The biologist must consider how much of the occupied habitat was surveyed, the distribution of animals, and the effects weather, light conditions, cover and terrain, and aircraft height and speed have on visibility and detection of animals. Most observers tend to overestimate their ability to see animals during trend surveys. Based on studies of aerial surveys for various species in various cover types and topographies, detection rates can range from 30% to 80%. In locations where elk are fed, it may be possible to count up to 90% of a population. Even in this unique situation, some annual variation results from effects of weather and changing numbers of elk that winter off the feedgrounds. It is important to align the simulation within the range of correction for the detection bias, and the trends must agree. The fundamental use of trend counts in modeling is to assure the model mimics trends in the population itself.

Harvest estimates used for population modeling are derived from the Department's annual survey of big game harvest. If an adequate sample is obtained, the age composition of the harvest can be estimated from field-checked animals. Hunters do not selectively harvest specific age classes of adult females, so the age structure of field-checked animals affords an unbiased approximation of the age structure of the female segment of the population.

Mortality severity indices (MSIs) have been calculated from weather data, based on methods developed by Reeve and Lindzey (1991) and Christiansen (1991). Where this approach is used, field Biologists compile weather data annually from selected NOAA weather stations in their areas of responsibility. However, actual mortality rates are often influenced by several other factors including drought, forage quality on summer and transition ranges, condition of animals as they enter the winter, and the pattern and timing of winter storms, which are not reflected in weather data averages. In several cases, winter MSIs derived from weather data are not dependably correlated with measured changes in fawn:doe ratios (e.g., in western Wyoming). In some areas of the state, weather data are used in conjunction with body condition (fat deposition) of harvested animals to help assess the potential severity of winter mortality. A modification being tested in parts of western Wyoming is based on differences measured between post-hunt and spring classifications, combined with results of spring mortality transects and winter weather parameters. This method is being investigated for potentially broader application and may supplant the current method in locations where requisite data are collected**.** An effective means to calibrate elk population models is to align predicted yearling ratios with those observed in harvests (females) or classification surveys (males). This method can also be applied with caution to some mule deer and pronghorn models where adequate data are consistently collected (classifications of yearling bucks can be inherently inaccurate, however the proportion of yearling does in the harvest is a reasonable approximation of the proportion in the population where the harvest sample is sufficiently large). Alignment is achieved by adjusting winter severity indices to account for realized mortality of juveniles over the prior winter.

Herd classifications may underrepresent the yearling buck deer and pronghorn in a population because yearling males are sometimes misidentified as adult females or they are more difficult to observe due to behavioral differences. However, in herds where adequate classification samples are achieved annually and samples are well distributed throughout occupied habitat, yearling buck ratios may have some utility for estimating the prior winter's MIS values. The

limitations and assumptions underlying this method should be disclosed and evaluated where it is applied.

A good model is constructed using the best data that are realistically attainable. And, it is important that the model align well with field data. However, datasets occasionally contain outlying values or "flyers" even when the sample sizes are large. Reasons for this can include improper sampling procedures, poor survey conditions, inexperienced personnel, or chance. A model that fits the data well may have one or two aberrant data points and it may be necessary to ignore them. Modeling is useful if data are adequate and model results are applied in their proper context. If a model mimics the observed data consistently and criteria for data adequacy are met, we presume the model provides a reasonable simulation of the population's trend and a plausible estimate of the population for the year in which harvest and classification data are most current and adequate. Modeling has contributed to improvements in management, but can also be misinterpreted. As a consequence, models can sometimes lead to suspicion or criticism from the public. Managers need to acknowledge the limitations of their data and the modeling process.

Population models can be excellent tools for depicting population trends. However, POP-II can generate a range of reasonable population estimates for a given herd depending on modeling assumptions, values used for standard modeling parameters, and adjustments made to align the model. In the introduction of the POP-II manual, Bartholow (1990) states, "POP-II is a computer program designed to simulate the *dynamics* (emphasis added) of wildlife populations." Statistically adequate data are often difficult to collect. To a large degree, models rely on generalized assumptions from the literature to define many parameters. Therefore, modeling results should be interpreted cautiously and other supporting information should be considered in management decisions or during public discussions of population estimates.

Although the accuracy of models can vary, the resulting trend in population estimates is valid and usable if error is held relatively constant through time. A population model is fundamentally based on measured changes in age or sex proportions resulting from known harvests, so the model will cease to work if differences between the actual and simulated populations become too great. Nonetheless, it is important for managers to consider other types of data such as trends in harvest, hunter effort, hunter success, and perceptions of field personnel, landowners and hunters when evaluating a model's performance. If the model adequately represents actual changes in the population, the simulated population should follow comparable trends. To minimize the potential for personal bias to influence calibration of a model, the biologist should not consider the resulting population estimates (in Table 1 of the model output) until the model is performing satisfactorily.

Several years after Department personnel had begun using POP-II, we did a comparative analysis and discovered some inconsistencies in the values being used for fecundity rates, mortality rates, number of age classes, age- and sex-specific mortality rates, and other parameters. Although the majority of personnel were using comparable values, some deviations exceeded what was believed reasonable. In several instances, the values resulted from personnel aligning models by adjusting variables that should properly be treated as

independent input parameters. To assure independent modeling parameters are assigned values within a range that is reasonably supported by the literature, in April 2003 the Wildlife Division established standardized ranges of modeling parameters for each big game species (Attachment 1). Values of independent parameters should be within the ranges recommended by this guidance unless deviations are rigorously supported by data from special studies or the scientific literature. The standardized ranges of modeling parameters will be reviewed periodically and may be updated when new data indicate adjustments are warranted.

The POP-II documentation (Bartholow 1990, Bartholow 2000) has instructions and tips for entering data, an explanation of the program and its components, general information about modeling, some precautionary statements, and details about information messages produced by the software. Novice users should read the documentation thoroughly and consult it often as they are learning to use POP-II. Even managers with considerable experience should periodically review the documentation to refresh their understanding of the model's purposes and limitations.

A. Considerations for Modeling –

a. Pronghorn – Pronghorn are classified in August and September when they congregate in larger groups just prior to the breeding season and it is easier to distinguish fawns from adults. Since pronghorn are classified at the end of the summer, but prior to hunting seasons, estimating preseason mortality is a comparatively straightforward exercise. Estimating postseason mortality is more difficult due to the time that lapses between herd classifications and the end of the biological year, and the influence various factors, such as long-term drought, have on susceptibility of pronghorn to winter mortality. Because of this, it is important to monitor summer habitat conditions. Insights about the probable condition of animals can also be inferred from summer severity indices that have been adjusted to align the model simulation with the observed ratio of juveniles per 100 females. This process accounts for preseason mortality.

Aerial line transect surveys are conducted to estimate sizes of most pronghorn herds in Wyoming. Refer to Chapter 1, Section II.D. (Pronghorn – Aerial Line Transects) and Appendix II (Line Transect Sampling Methodology). These surveys are done in late May or early June when pronghorn are highly visible against a contrasting background of green vegetation. Line transect surveys are scheduled on a 3-year rotation within each herd unit. The resulting estimates and measures of error afford an independent verification of end-of-year population estimates and are used to calibrate pronghorn population models. This capability is a distinct advantage because reliable means of directly estimating other big game populations are not generally available or feasible.

Pronghorn harvest data are very accurate, in part, because all pronghorn hunting seasons are limited quota and this simplifies the harvest survey sample frame. In addition, the Department has an accurate list of all license holders. Since pronghorn hunting seasons are typically held in early fall, harvest rates are less affected by weather. Therefore, estimates of pronghorn harvest, one of the most important model

parameters, tend to be more consistent and reliable than harvest estimates for the other big game species.

Postseason mortality is difficult to estimate because pronghorn tend to be quite mobile and their distribution is dynamic on wintering areas. Few traditional wintering areas lend themselves to mortality surveys that can be compared among years. In addition, it is not possible to accurately estimate change in ratio of fawns to adults because it is difficult to distinguish the physical differences between fawn and yearling females in spring.

Pronghorn can be aged reliably to 4+ years by examining incisor replacement during field checks of harvested animals. This provides a partial age distribution of harvested animals. Harvested adult females are presumed to be an unbiased sample of the adult female segment of the population. The availability of a simple field technique to age pronghorn through 4+ years provides some management advantage in that age distribution data can be compared against estimates in the population model.

b. Mule Deer – It can be more difficult to construct functioning models that simulate mule deer populations based on change of herd composition ratios, specifically age and sex ratios. In addition, a reliable, cost-effective method is not available to independently verify the population size or monitor trends in order to calibrate a model. In all likelihood, the modeling process yields more approximate estimates of mule deer population trends. Our ability to collect statistically valid data is also constrained by funding and personnel limitations. Department personnel make an effort to collect minimum classification samples and, to a large extent, rely on helicopters to cover herd units as uniformly as possible. However, we still have a tendency to classify disproportionately within the areas of known deer concentrations rather than covering all occupied habitats in a random or systematic fashion. This interjects an un-quantifiable bias in the observed ratios and in the model's calculations.

During herd classifications, the sample of does and fawns is typically large; therefore, the observed proportions of does and fawns are presumed accurate and representative of the overall population. We align simulated doe:fawn ratios so they agree with the observed ratios from classification data. However, the basic mechanism of modeling relies on the measured response of the buck:doe ratios to known harvests over time. Unfortunately, buck:doe ratios are considered less accurate. Bucks (particularly mature bucks) tend to be solitary or they associate in small groups, often markedly separated from doe and fawn groups. As a result, they are more difficult to observe. In concept, if classifications were done during the rut, bucks should be near doe/fawn groups and therefore observed in proportion to their presence in the population. However, classifications are commonly done outside this timeframe. Consequently, bucks are underrepresented in classification samples. To compensate for this in our population models, we usually simulate buck:doe ratios slightly above observed ratios. Underrepresenting males in classifications can substantially impact the accuracy and reliability of a model. This means sampling errors in the observed buck:doe ratios confound the ability to assess the model's performance and reliability.

Although mule deer models are subject to a number of potential biases and data problems, reasonable models can be constructed and are useful for many herds if managers maintain their objectivity and recognize and account for the limitations of the data. Models should always be used in conjunction with other corroborating information, such as trends in hunter success, effort, age composition of the harvest, and changes in the proportions of yearling and adult males in post-hunt classifications. These data are not without their own inherent biases and harvest data are frequently based on small samples. Apparent trends can be skewed by weather patterns affecting animal and hunter distribution, and ultimately harvest, success and effort. It is important to remember that changes in harvest statistics from one year to the next do not constitute a trend. Such analyses should consider at a minimum, 3 consecutive years of harvest data and preferably 5. The assumptions and potential limitations of modeling should always be conveyed to others when results are discussed.

c. Elk – Elk are easier to classify than other big game because they tend to congregate in larger herds during winter. In Wyoming, most winter ranges used by elk are open grass and shrub dominated vegetation, conifer savannahs or open woodlands where these large ungulates are readily observable. However, mature bulls tend to segrgate from large cow and calf groups and can be missed during ground and even aerial surveys unless all likley winter range is covered thoroughly. As with deer, modeling usually requires running the simulated bull:cow ratios slightly higher than the observed ratios. In more rugged terrain or forested winter ranges, animals are less detectable during surveys, and observability bias becomes more likely. On feedgrounds, the proportions of bulls and calves will often be significantly different from the proportions observed on native winter range. Precautions regarding the utility and accuracy of population models for deer similarly apply to elk.

Since accurate classifications of yearling bulls are fairly easy to obtain, the yearling bull:cow ratio provides a reliable means of estimating winter MSIs to account for overwinter mortality of calves. This is achieved by aligning adjusting winter MSIs to align the simulated and observed yearling bull:cow ratios in the model.

Elk are less susceptible to winter mortality than are mule deer, but substantial losses can take place during severe winters in areas where winter ranges are limited or of poor quality. Calf production is generally lower following a severe winter and in drought years. The mortality rate of neonatal calves can be a good indicator of habitat conditions and reproductive fitness. In areas with high bear populations, predation of elk calves can be substantial. However, such predation is probably at least partially compensatory and unlikely to have a significant impact on overall recruitment. In poor quality habitat, predation can have a greater impact because calves are concentrated in smaller areas of suitable habitat and tend not to be as large or vigorous as calves born in better habitat. If calf survival is chronically low, it may be necessary to evaluate habitat conditions and conduct detailed population studies to identify specific causes.

d. Moose – Moose are difficult to survey because they tend to be solitary and, during winter, spend considerable time in dense stands of conifers. As a consequence, it's tough to obtain adequate classification samples. Generally, helicopter surveys are the best way to classify moose, but flight time is expensive making extensive use of this method impractical. Although moose utilize mountain shrub, aspen and willow stands in early winter, they move into closed conifer stands as deeper snow accumulates and crusts over later in the season. Detection is very poor within conifer habitats. Moose are generally classified in conjunction with elk surveys to save money. Typically, surveys only cover the best winter habitats, however moose have the ability to winter in a wide range of habitats and in relatively deep snow. "Sightability" surveys may be the best method of obtaining data for generating population and precision estimates in a Pop II model. However, sightability surveys take more time and effort compared to conventional trend and classification surveys.

When reliable classification data are not available, as is often the case, population trends can be evaluated based on harvest information. For some herds, harvest statistics, including ages obtained from tooth samples, are the only quantitative data collected. However, annual variation can be substantial because samples of teeth from harvested animals tend to be small and several factors, including weather and access, can impact harvest success and effort. Within some larger moose populations, biologists are able to obtain age and sex composition data from reasonable classification samples and from relatively large numbers of harvested moose. A population model is calibrated by aligning the proportion of yearling females simulated by the model with the proportion detected in the harvest, and by comparing the age composition of the harvest with the proportions of animals in each age class projected by the model. In addition, simple trends in hunter success and effort (days per animal taken) are useful indicators of population trends. However, these data can vary greatly from year to year and should be interpreted cautiously. Ideally, harvest trends should be viewed over a relatively long period (5 to 10 years) before inferences are made regarding population trends.

The age at which female moose first conceive is an important variable impacting a model's performance. Most cow moose in the Jackson Moose Herd do not become pregnant until age 3 (Berger et al. 1999). By contrast, moose first give birth at age 2 in more productive regions. The proportion of twins in the Jackson Herd was also very low, indicating poor habitat conditions and low reproductive fitness. The modeling protocol for age at first reproduction and fecundity rates (Attachment 1) are based on data from the Jackson Moose Herd, but this may be atypical of other herds in better habitat, and of introduced populations such as the Bighorn or Snowy Range Moose Herds. Pregnancy rates within other Wyoming moose herds may warrant additional investigation for modeling purposes.

Bighorn sheep – Reliable estimates of the age and sex composition of a sheep population are essential to develop working simulation models. However, biologists' abilities to classify adequate samples vary greatly among sheep herds. For example,

large sheep populations in the high elevations of the Wind and Absaroka Ranges typically occupy extensive, open habitats where they are readily observed. On the other hand, bighorn sheep can be difficult to locate in small, widely dispersed populations inhabiting partially forested habitats at lower elevations because they are usually scattered in small bands and often use timber for security or thermal cover.

Generally, bighorn sheep are classified in early December when they congregate during the rut. Known rutting sites should be checked, but all habitats occupied at that time of year should be surveyed. A helicopter is the most effective means of covering large, inaccessible areas to classify bighorn sheep. Unfortunately, yearling males are difficult to distinguish from ewes and 2-year old males during aerial surveys. The ratio of yearling males to ewes is compared to the lamb:ewe ratio from the prior year to estimate mortality and help calibrate the population model. For this purpose, the most accurate classifications of yearling males are done from the ground.

Like elk, female bighorn sheep do not conceive until they are 2 years old. This should be taken into account when defining age-specific reproductive rates for constructing a model.

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ATTACHMENT 1

Standardized ranges of parameters recommended for modeling big game herds in Wyoming.[1] 4/1/03

	Mule Deer	Pronghorn	Elk	Moose	Bighorn Sheep
Wounding Loss Rate [2]	10%	10%	10%	10%	25% rams, 10% other
Number of Age Classes [3]	12-15	12-15	15-20	15-18	12-15
Fecundity Rates: Age Classes (No/100 ♀s)	1: 0; 2→max.: 170	1: 0; 2→max.: 180	1: 0; 2: 0-30; 3→max.: 90	1: 0; 2: 0; 3→max.: 90	1: 0; 2: 0; 3→max.: 90
Sex ratio at Birth [4]	50:50	50:50	50:50	50:50	50:50
Juvenile Mortality Rate (pre-season) [5]	50%	50%	40%	40%	40%
Juvenile Mortality Rate (post-season) [6]	30-55%	30-55%	10-20%	15-25%	20-35%
Adult Mortality Rate (pre-season) [7]	2%	2%	1%	1%	2%
Prime-age Adult Mortality Rate (post-season) [8]	3-10% for age classes 2-5	3-10% for age classes 2-5	3-10% for age classes 2-6	3-10% for age classes 2-6	3-10% for age classes 2-6
Post-prime Adult Mortality Rate (post-season) [9]	Increases incrementally after age class 5, reaching 100% in oldest age classes	Increases incrementally after age class 5, reaching 100% in oldest age classes	Increases incrementally after age class 6, reaching 100% in oldest age classes	Increases incrementally after age class 6, reaching 100% in oldest age classes	Increases incrementally after age class 6, reaching 100% in oldest age classes
Sex-Based Differential Mortality (post-hunt) [9]	♂ mortality > ♀ mortality after class 5	♂ mortality > ♀ mortality after class 5	♂ mortality > ♀ mortality after class 6	♂ mortality > ♀ mortality after class 6	♂ mortality > ♀ mortality after class 6
MSI (pre-season) [10]	1.0 = normal summer	1.0 = normal summer	1.0 = normal summer	1.0 = normal summer	1.0 = normal summer
MSI (post-season) [11]	1.0 = normal winter	1.0 = normal winter	1.0 = normal winter	1.0 = normal winter	1.0 = normal winter

[1] All model parameters are recommended for use with POP II, Version 1.2.5 by Fossil Creek Software. Ranges of "acceptable" values are provided for several modeling parameters, however biologists and coordinators should strive to use consistent parameter values among models unless data or other information support alternative values in specific herd models.

[2] Use of wounding rates other than those listed and use of age- or sex-based, differential wounding rates must be justified with data or studies applicable to the herd being modeled.

[3] The number of age classes is based on tooth data and recoveries or observations of known-age, marked animals. Generally, the number of age classes will be within the recommended ranges unless data or observations indicate otherwise. By convention, Age Class 1 represents young of the year, Age Class 2 represents yearlings, and Age Classes 3 and higher represents adults.

[4] Always assume 50:50 sex ratio at birth.

[5] Pre-season (summer) juvenile mortality rates are fixed. Alignment of fall fawn:doe ratios is achieved by adjusting the pre-season MSIs.

[6] Post-season juvenile mortality rates may be adjusted within the recommended ranges to align modeled ratios or population estimates consistently with observed values. Post-season mortality rates of juvenile males may be up to 10-20% higher than for females, based upon Wyoming data for pronghorn, and based upon findings of Unsworth et al. (1999) and Conolly (1981) for mule deer. However, mortality rates outside the recommended ranges must be documented with data or studies that are applicable to the herd being modeled.

[7] Pre-season adult mortality rates are fixed. These are modified by the pre-season MSI needed to align fawn:doe ratios, so it is assumed changes in fawn mortality are also reflected in the adult segment.

[8] Post-season mortality rates of prime adults may be adjusted within the recommended ranges to align modeled ratios or population estimates consistently with observed values. However, mortality rates outside the recommended ranges must be documented with data or studies that are applicable to the herd being modeled.

[9] Post-season mortality rates of post-prime adults increase incrementally to reach 100% by the oldest female age classes. Mortality rates of post-prime adult males generally increase at a faster rate, reaching 100% several years before the oldest female age class. The rates of increase and magnitude of differential should be determined from the best data or information that is available for each herd being modeled. These parameters may be developed through iterative modeling exercises until modeled sex or age ratios, or population estimates align consistently with observed values.

[10] Pre-season MSIs are adjusted as needed to align simulated ratios of juveniles to age 1+ females, with the ratios observed in pre- or post-season classifications.

[11] An MSI of 1 is assumed to represent “normal” conditions. The linear MSI option should be used unless there is good justification for use of a curvilinear model. Post-season MSIs should be adjusted based upon either environmental data, for example weather severity indices, or alignment of modeled parameters. When post-season MSIs are adjusted through iterative modeling exercises, the modeler should evaluate whether the resulting MSIs are a reasonable representation of environmental or biological factors such as severe weather, drought, habitat condition, disease, or population density.

APPENDIX X

Environmental Review Procedures

Steve Tessmann and Vern Stelter

I. INTRODUCTION –

Wyoming Statutes establish the Wyoming Game and Fish Commission shall conduct activities necessary to manage all wildlife within Wyoming (W.S. 23-1-103 and W.S. 23-1-302). To a large degree, the Commission exercises its authorities by regulating take and possession of wildlife (i.e., setting hunting seasons, enforcing wildlife statutes). However, wildlife cannot be managed apart from the habitat base upon which they depend. Although the Commission has no direct authority (except on limited land holdings) to manage habitat, several federal statutes and regulations require consultation with state wildlife agencies before federal actions are approved or taken. Such provisions enable the Commission, through the Department, to recommend many conservation practices at local, regional, and programmatic levels. Given that 47% of the land surface in Wyoming is managed by federal agencies, and many activities on private lands are also federally regulated, participation in environmental review processes enables the Department to influence how land use practices affect wildlife habitats throughout Wyoming. Other federal actions, such as listing proposals under the Endangered Species Act, directly impact the Department's principal management authorities. Accordingly, the Department and Commission have made participation in environmental reviews a high priority for all field personnel over the past 20+ years.

The National Environmental Policy Act of 1969 (NEPA) is the umbrella legislation that formally establishes a public review process for all federally funded, authorized or permitted actions excepting certain actions taken in the interest of national security. CFR 40, Section 1501.7(a)(1) stipulates, "As part of the scoping process, the lead agency shall invite the participation of affected Federal, State, and local agencies …" Sections 1503.1(a)(2)(i) and (iii) provide further that, "After preparing a draft environmental impact statement and before preparing a final environmental impact statement the agency shall request comments of appropriate State and local agencies which are authorized to develop and enforce environmental standards … and any agency which has requested that it receive statements on actions of the kind proposed." Section 1503.1(a)(4) also requires the lead agency shall "Request comments from the public, affirmatively soliciting comments from those persons or organizations who may be interested or affected." Specific consultation clauses are also provided by many legislations such as the Fish and Wildlife Coordination Act of 1934 as amended, the Clean Water Act, the Surface Mining Control and Reclamation Act of 1977, and others (refer to: Bean 1983).

Some of the most intact, native ecosystems remaining in the lower 48 states are still found in Wyoming. Many important ecosystems exist wholly or partially on federal lands administered by the Bureau of Land Management (BLM) and the U.S. Forest Service (USFS). These federal estates are both managed according to principals of multiple use and sustain yield, as set for the by the Federal Land Policy and Management Act of 1976 (BLM) and the Multiple Use and Sustained Yield Act of 1960 (USFS). Although wildlife habitat is designated a principle land use within the National Forest System and lands administered by the BLM, numerous other principal uses including timber and mineral development, grazing, recreation, scenic resources, and public easements are also authorized. It is obvious these major uses of the public lands have potential to conflict in numerous circumstances. The underpinning philosophy of "multiple use management" is to manage the lands for a combination of balanced and diverse resource uses that takes into account the long-term needs of future generations for renewable and nonrenewable resources, including but not limited to wildlife and fish, and natural scenic, scientific and historical values; and harmonious and coordinated management of the various resources without permanent impairment of the productivity of the land and the quality of the environment [CFR 43, Sec. 1702(c)]. Through NEPA consultation, state wildlife agencies are often relied upon to provide expert recommendations regarding the value of wildlife resources and appropriate integration of wildlife habitat into multiple use management. It is of paramount importance to the Department and the public that such recommendations are made in order to protect the habitat base for the State's wildlife.

II. POLICIES AND GUIDANCE FOR ENVIRONMENTAL COMMENTS –

The Commission and Department have prepared documents to assist field and administrative staffs with environmental reviews. Field biologists are directed to read the Commission Mitigation Policy (1998), which can be downloaded from 2 sources, both accessible through the "Network Application Launcher" (NAL) installed on each biologist's computer workstation. Select the "NAL" icon, and the "All" icon, then click "PolicyManual" and "New Policy Manual." Scroll down to Policy No.: VII H (page 134 as of this writing) – Issue Date: April 28, 1998. For a stand-alone version of the Commission Mitigation Policy, click on "HabitatProtection," "POLICY," and "MitigationPolicy.doc." All biologists should become familiar with the Commission Mitigation Policy. The Department's environmental comments must be consistent with this policy.

The Department's Habitat Protection Program has also developed a comprehensive document entitled, "Environmental Commenting: Policies & Procedures Guidelines," dated November 22, 1998. These guidelines contain detailed explanations of the Habitat Protection Program, the environmental review and commenting process, and the roles of various entities involved in generating or handling comments within and outside the agency. Biologists are directed to become familiar with the environmental commenting guidelines. The document can be downloaded from the

Department NAL site by clicking on "All," "HabitatProtection," "Policy," and EnvrCommentGdl.doc". The portion of the 1998 version that address the role of the Governor's Clearing House is no longer applicable, however the remainder of the document accurately describes the existing policies and procedures for environmental reviews.

III. USEFUL RESOURCES FOR CONDUCTING ENVIRONMENTAL REVIEWS –

The effectiveness of our comments largely depends upon maintaining a high standard of agency credibility. To achieve this, comments should be objective, reasonable, grammatically correct, and supported by sound technical justification. Comments should provide clear, concise direction to the recipient agency and should always address similar situations in a consistent manner. The Department maintains several resources to assist biologists when they conduct environmental reviews and prepare comments.

One of the most important considerations is to make consistent recommendations regarding specific types of activities that have similar impacts. Nothing detracts more from the agency's professional credibility than conflicting recommendations regarding items such as seasonal closures, protective buffer zones, reclamation standards, project designs, and so forth. Since this has been a problem in the past, the Habitat Protection Program has assembled "standard comments" applicable to various types of development and land use activities. The biologist can download these from the "NAL" site by clicking "All," "HabitatProtection," "Std. Recommendations," and one of the following, as applicable: "standard aquatic," "standard cbm reclamation," "standard definitions," "standard grazing," or "standard wildlife." The standard definitions pertain to terminologies and criteria used to identify important habitats. The definitions are a companion document to the Commission Mitigation Policy. Specifications for highway fence recommendations can be found under "WYDOT" by clicking "wydotfencespecs". Dept. of Transportation fence policy can be viewed by clicking, "WYDOT-fencepolicy."

During 2004, a Department working group drafted, "Minimum Recommendations for Development of Oil and Gas Resources within Crucial and Important Wildlife Habitats on BLM Lands." The recommendations and supporting documentation pertain to BLM Resource Management Planning and oil and gas field development plans. The document can be viewed or downloaded from the Department's Internet Home Page at www.gf.state.wy.us – scroll down to the section entitled, "On the Trail." It is also available from the Biological Services Section.

Standard comments and recommendations were developed to assure environmental reviews are done consistently, based on sound technical justification. If a biologist believes he has reason modify a standard recommendation, he may do so provided he includes a justification for the change. Biologists should also be careful about

generating "laundry lists" of standard comments. Use only those comments that are relevant to the project under review.

Archives of past and current review letters are maintained on the HabitatProtection NAL site and comprise another useful source of information. These are located under "letters by WER #". WER is an acronym for "Wildlife Environmental Review." New biologists can obtain a sense of common environmental issues and concerns by examining a sample of Department comment letters from various types of projects. Whenever a biologist is asked to review an ongoing project, he should look at previous comment letters to assure he maintains continuity of the review. Some comment letters can also be used as templates for constructing reviews of similar projects.

Resources posted on the HabitatProtection NAL site may be changed or updated over time. The site's purpose is to assist field personnel with environmental reviews. Biologists should become familiar with the site and its contents, and periodically check it for revised or new materials.

IV. ADDITIONAL TECHNICAL AND LEGAL DOCUMENTATION –

The main objective of the Department's Habitat Protection Program is to achieve positive results for wildlife by making effective environmental comments. The effectiveness of the Department's comments can be often be enhanced with technical documentation and in some cases, legal documentation.

A. Technical Documentation – The Department maintains several data sources and maps that can provide technical justifications for specific comments. The majority of these resources are available from the Biological Services Section of the Wildlife Division in Cheyenne. Individual biologists generally keep copies of data and other information from their districts, and regional offices also maintain resource data. Biologists are encouraged to support their comments by making references to appropriate technical information when it is available. Data sets, reports and maps maintained by Biological Services include:
   – Wildlife Observation System (geographical database)
   – Job Completion Report Database (big game harvest and population statistics)
   – Electronic Versions of Job Completion Reports
   – Annual Completion Reports
   – Small, Upland Game, and Big Game Annual Harvest Survey Reports
   – Seasonal Range Maps
   – Sage Grouse Maps
   – National Wetland Inventory Maps
   – Atlas of Birds, Mammals, Reptiles and Amphibians in Wyoming
   – Nongame Bird and Mammal Plan

   When appropriate, scientific references from journal articles and other sources can greatly strengthen comments. This is particularly important if a federal

agency or company questions a particular impact (e.g., displacement from roads, noise effects), or mitigation recommendation (e.g., wetland mitigation ratios). Biologists' familiarity with literature varies, so it is often helpful to "share" expertise. For example, someone's comments on a similar type of project may contain useful, scientific references. It is legitimate to "borrow" germane references from other comments. Bibliographical references of disturbance literature have also been compiled by various interests (e.g., references section of "Minimum Recommendations for Oil and Gas Development …"). Also see "Highway Literature" under "WYDOT" file in the "HabitatProtection NAL site.

B. Legal Documentation – Personnel who develop policy interpretations or review programmatic documents such as legislative proposals occasionally need to research and cite legal references including statutes, regulations, policies, orders, directives, handbooks, guidelines, cooperative agreements, instructional memoranda, and so forth. Policy reviews are generally handled by administration in Cheyenne. For the most part, field personnel should focus on technical issues associated with each project. However, a working knowledge of applicable statutes and regulations will help the biologist write more effective comments, better understand the constraints and capabilities of agency programs, and negotiate more effectively at meetings. On more than one occasion, a federal regulation has been ignored or misconstrued by the lead agency. Knowledge is the best defense. Therefore, it is useful to review the laws, policies, and regulations that govern the specific activities under review. Where appropriate and necessary, citations can be included, however the Habitat Protection Program does not require legal citations to accompany most technical comments.

Nowadays, federal program guidance, including statutes and regulations, can be accessed through links or searches from most agency home pages. Also consult Attachment 1 for additional Internet resources. The National Environmental Policy Act, Clean Water Act, and regulations of the Council on Environmental Quality (CEQ) can be accessed from the home page of the Environmental Protection Agency (www.epa.gov). Information about other, major federal programs in Wyoming can be accessed through the following web sites:

www.blm.gov (Bureau of Reclamation)
- Federal Land Policy and Management Act
- Oil and Gas Regulations, Grazing Regulations, other Land Use Regulations
- BLM Handbook, BLM Instructional Memoranda

www.fs.fed.us (U.S. Forest Service)
- Multiple Use and Sustained Yield Act
- Forest Management Act
- Forest Management Prescriptions, Policies

www.fws.gov (U.S. Fish and Wildlife Service)
- Federal Endangered Species Act
- Convention on International Trade in Endangered Species
- Migratory Bird Treaty Act
- Wildlife Refuge Improvement Act

Fish and Wildlife Service Handbook
Vertebrate Policy on Distinct Population Segments, Other Policies
www.usace.army.mil (U.S. Army Corps of Engineers)
Section 404 of the Clean Water Act
404(b)(1) Guidelines
Section 10 of the Rivers and Harbors Act
www.usbr.gov (U.S. Bureau of Reclamation)
General Information on Bureau of Reclamation Programs
www.fhwa.dot.gov (Federal Highway Administration)
National Transportation Equity Act for the 21st Century
Various Directives and Policy Memorandums
www.osmre.gov (Federal Office of Surface Mining)
Surface Mining Control and Reclamation Act of 1977
Federal Surface Mining Regulations
www.nrcs.usda.gov (Natural Resources Conservation Service)
Swampbuster Provision of the Food Security Act
Conservation Reserve Program, Grassland Reserve Program, Wetland Reserve Program, Wildlife Habitat Incentives
www.usda.gov (U.S. Department of Agriculture)
www.ferc.gov (federal energy regulatory commission)

V. COMMENT PROCESS, CONTENT, AND FORMAT –

A. Comment Process – Biologists should consult "Environmental Commenting: Policies & Procedures Guidelines," to obtain comprehensive direction regarding the process for preparing and submitting environmental comments. A general description of the process follows:

The Statewide Habitat Protection (SHP) Section of the Director's Office coordinates and assigns all environmental reviews. Comment requests are received from agencies, consultants, organizations, and occasionally the Governor's Office. Generally, these are sent to the Director's Office or the Habitat Protection Coordinator. Sometimes, field staff receive comment requests directly from district or regional offices of federal agencies. These should be referred to the SHP Section. The Habitat Protection Coordinator and his Staff Biologists review the comment requests to determine if the Department has an interest in commenting on the project and whether the Cheyenne Office or field staff will handle the request. All projects are assigned a "Wildlife Environmental Review" (WER) number. A decimal or lower case letter attached to the WER number may designate continuations or phases of the same project. Project review assignments are sent by E-mail to field personnel and copied to the Regional Wildlife Coordinator or Regional Fisheries Supervisor. Review materials (e.g., project descriptions, request letters, EISs) are either attached to the E-mail or available on the Habitat Protection NAL site in "ReviewDocuments by WER#." Very large documents such as a several-hundred page, draft EIS may be

sent by conventional mail. A due date is specified for each WER assignment. Depending on what they entail, project review requests may be sent to several personnel. The Population or Habitat Biologist completes his review, and then forwards comments to the Regional Wildlife Management Coordinator or the Regional Fisheries Supervisor, as applicable. These reviews are then forwarded to the SHP Section by the due date. SHP reviews all comments to assure they are reasonable, consistent with Department policy, clear, concise, and grammatically correct. In rare instances, political ramifications of some recommendations may also be considered. Comments are then assembled into a letter for the Director's signature.

B. Content and Format – Again, refer to "Environmental Commenting: Policies & Procedures Guidelines," for comprehensive instruction regarding content and format. Some general guidance follows:

1. Content – The biologist should begin by evaluating the location and nature of the proposed activity. If it is a programmatic action (e.g., a land use or resource management plan), the biologist should consider the nature of activities that would be authorized, and their potential effects throughout the geographic area covered by the plan. NEPA documents (i.e., an EA or EIS) should contain adequate descriptions of the affected environment and potential consequences of the proposed action. This is the most important function of a NEPA analysis and is explicitly required by CEQ Regulations. If the descriptions are not comprehensive and quantitative in their treatment, the biologist should focus his review comments on the deficiencies.

   If review request is for a specific, localized project [such as a small mine permit or an application for permit to drill (APD)], the lead agency will generally depend upon the biologist to identify the affected wildlife resources, potential impacts, and recommended mitigation.

   In either case, the biologist should rely upon his knowledge of the wildlife resources and habitats that would be affected by the proposed action. If a NEPA document, the reviewer should identify deficient content and analyses; if a localized project or permitting action, the reviewer should describe affected wildlife resources. The biologist should also recommend reasonable, effective, and appropriate monitoring, mitigation, and reclamation. To the extent practical, statements regarding affected wildlife resources, the nature of the anticipated impacts, and recommended mitigation should be documented with Department data and reference to relevant scientific literature. If the biologist has reason to believe the lead agency is out of compliance with specific laws or regulations, he may wish to cite these as well.

2. Format – Number comments and reference the page or section to which they pertain. Avoid repeating a detailed description of the project proposal because this is redundant information for the recipient agency. Identify specific

features or activities causing impacts. Write comments in a clear and concise form. Avoid editorializing or making disparaging remarks. Each comment should identify a concern and should recommend an action to resolve the concern. In other words, comments should convey a specific action or result. For example, it is not sufficient to only note the description of affected wildlife resources is not adequate. The comment should identify the resources that have been overlooked, or should describe the types of studies necessarily to adequately characterize them. Likewise, it is not satisfactory to indicate only that the proposal fails to include effective mitigation. The comment should describe the mitigation that is needed.

VI. REFERENCES –

Bean, M.J. 1983. The Evolution of National Wildlife Law. Praeger Publishers, New York, NY. 449pp.

Wyoming Game and Fish Commission. 1998. Mitigation – Policy No. VII H. Pages 134-142 in Wyoming Game and Fish Commission Policy Manual. Cheyenne, WY.

Wyoming Game and Fish Department. 1998. Environmental Commenting: Policies & Procedures Guidelines. Cheyenne, WY. 33pp.

Wyoming Game and Fish Department. 2004. Minimum Recommendations for Development of Oil and Gas Resources within Crucial Wildlife Habitats on BLM Lands. Cheyenne, WY. 178pp.

Attachment 1

Internet Sources of Reference Materials

Several independent sources, particularly some that are sponsored by Universities, offer free access and search capabilities to view federal laws and regulations. Some of these sites include:

Federal Register ……. www.gpoaccess.gov/fr/
Code of Federal Regulations …. www.gpoaccess.gov/cfr/
Pending Congressional Action .. www.thomas.loc.gov/
Federal Legislation ……. www4.law.cornell.edu/uscode/

Studies and interpretations of resource issues can be downloaded from a variety of non-governmental sources by performing a key word search of relevant topics on one of the major Internet search engines, "GOOGLE" for example. When using such information, always consider the potential for biases associated with special interest sponsors of the web site.

Some Internet Sources of Laws, Regulations, Policies, and Manuals Pertinent to Resource Management Planning on BLM-Administered Lands.

- National Environmental Policy Act of 1969 (NEPA)
  http://tis.eh.doe.gov/nepa/policy/policy.htm
- CEQ Regulations for Implementing NEPA
  http://ceq.eh.doe.gov/nepa/regs/ceq/toc_ceq.htm
- Federal Land Policy and Management Act of 1975 (FLPMA)
  www4.law.cornell.edu/uscode/43/1701.html
- National Mining and Minerals Policy Act
  www4.law.cornell.edu.uscode/30/21a.html
- Regulations Governing Lease of Oil and Gas Lands
  www4.law.cornell.edu/uscode/30/226.html
- Energy Policy and Conservation Act of 1975 (EPCA)
  www4.law.cornell.edu/uscode/42/ch77.html
- Executive Order 13212, Actions to Expedite Energy-Related Projects
  www.eere.energy.gov/femp/resources/exec13212.html
- BLM Instruction Memorandum No. 2003-234, Integration of the Energy Policy and Conservation Act (EPCA) Inventory Results into Oil and Gas Exploration and Development Use Authorizations
  www.blm.gov/nhp/efoia/wo/fy03/im2003-234.htm
- The ACEC Process, Battle Mountain Field Office, BLM
  www.nv.blm.gov/bmountain/acec/acec_process.htm
- 43 CFR 161-.7-2, Designation of Areas of Critical Environmental Concern
  http://a257.g.akamaitech.net/7/257/2422/05dec20031700/edocket.access.gpo.gov/cfr_2003/octqtr/43cfr1610.7-2.htm
- BLM Manual, Section 1613, Areas of Critical Environmental Concern

www.co.blm.gov/gsra/ACEC%20manual%201613.pdf

- BLM Land Use Planning Manual, Section 1601
  www.blm.gov/nhp/200/wo210/landuse_man.pdf
- BLM Land Use Planning Handbook
  www.blm.gov/nhp/200/wo210/landuse_hb.pdf
- Best Management Practices for Oil and Gas Development
  www.blm.gov/nhp/300/wo310/oil_patch/
- Special Designations on Public Lands, Synopsis
  www.id.blm.gov/planning/bruneau/data/specdesig.pdf
- BLM News Release, Scoping Notice for Rawlins RMP
  http://www.wy.blm.gov/newsreleases/2002/feb/2-07greatdividermp.htm
- Appendix B, Preliminary Planning Criteria for the Rawlins RMP
  www.rawlinsrmp.com/documents/appendix/APPENDIX_B_Planning_Criteria.pdf
- BLM News Release, Scoping Notice for Pinedale RMP
  http://www.wy.blm.gov/newsreleases/2002/jan/1-24PinedaleRMP.htm
- Endangered Species Act of 1973 (ESA)
  http://endangered.fws.gov/esa.html
- Wyoming Game and Fish Commission Mitigation Policy
  Policy No. VII H, Dated April 28, 1998
  Pages 134-142, Department Policy Manual, Accessible on Department NAL Site.
- List of Wildlife References Consulted by BLM to prepare RMPs in Wyoming
  http://www.wy.blm.gov/wildlife/biodocs/be-chap5.pdf

APPENDIX XI

DETERMINATION OF SAMPLE SIZES FOR CLASSIFICATIONS OF BIG GAME HERDS

Adequate sample sizes for populations of various sizes may be determined from Fig. 1. The approximate confidence intervals associated with these curves are given in Table 1.

The 2 examples that follow illustrate the use of these data to determine necessary sample sizes.

Example 1:

Biologists desire to estimate the pre-season fawn:doe ratio in a mule deer herd. Current estimates suggest approximately 3,000 does and fawns are present in the population.

Based on curve A (Fig. 1), the number of does and fawn required for the sample is 520. If the final fawn:doe ratio is approximately 70 fawns per 100 does, the 90 percent confidence interval is $\pm$9:100, i.e., 70 $\pm$ 9 fawns per 100 does.

Assuming the sample procedure is random and unbiased, there is a 90 percent chance that the true fawn:doe ratio of the herd lies between 61 fawns per 100 does and 79 fawns per 100 does. If one desires a smaller confidence interval, then curve B or C from Fig. 1 should be selected. The sample size would be larger in both cases.

Example 2:

Biologists desire to estimate the postseason bull:cow ratio in an elk herd. Current estimates suggest there are approximately 5,000 bulls and cows in the herd.

Based on curve A (Fig. 1), the minimum recommended sample size is 560. If 560 bulls and cows are classified and the bull:cow ratio approximates 20:100, then the 90 percent confidence level from Table 1 would be 20 $\pm$4:100. As in the previous example, "tighter" confidence intervals would require larger sample sizes refer to curves B and C (Fig. 1) and to Table 1.

Fig. 1. Recommended number of animals to be classified for estimating herd ratios at various population sizes.

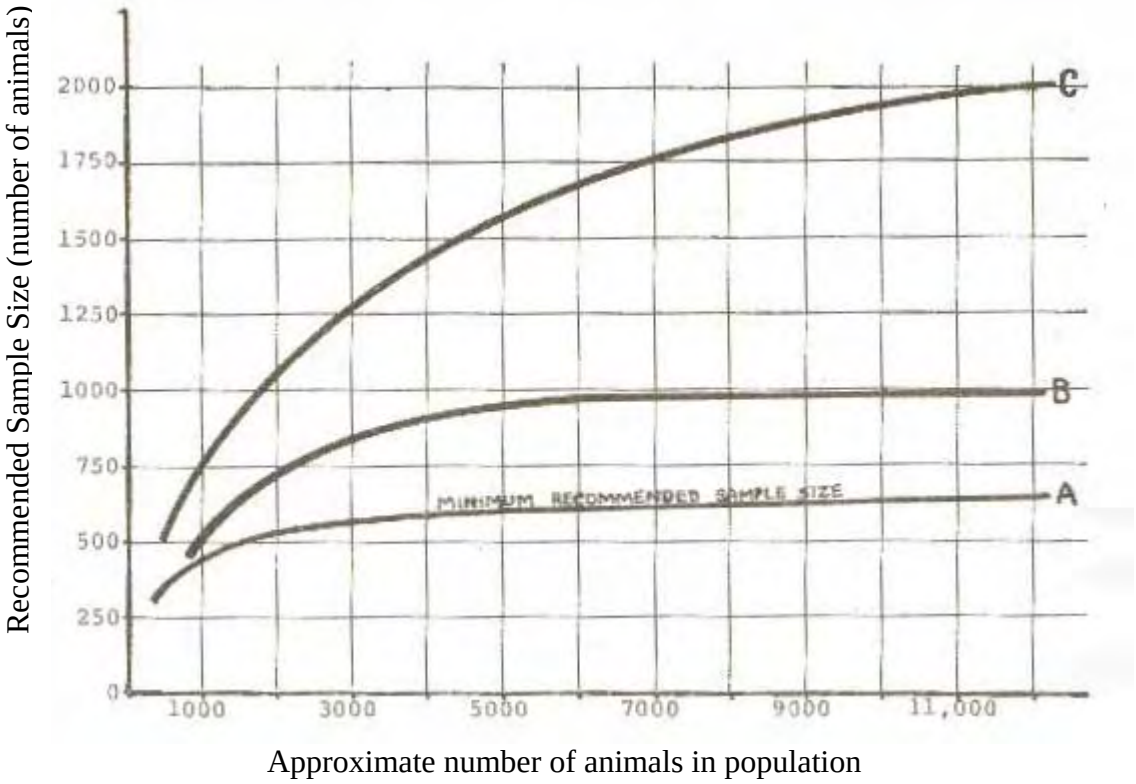


Table 1. Confidence intervals for Fig. 1 at various herd ratios at the 90% level ($\propto = 0.1$).

Curve No. from Fig. 1	20:100	40:100	50:100	70:100	100:100
A	±4:100	±6:100	±7:100	±9:100	±13:100
B	±3:100	±4:100	±5:100	±7:100	±10:100
C	±2:100	±3:100	±4:100	±5:100	±7:100

While Fig. 1 and Table 1 provide the means for determining the necessary sample size for herd classifications and allow approximation of confidence intervals, one may place a more definitive confidence interval around an estimate after the classification has been completed. The formulae needed are presented below:

$$c = t\sqrt{\frac{100a(N-n)}{(100+a)^2Nn}} \qquad (1)$$

$$b = \frac{100c}{1 - \frac{100a}{(100+a)^2} - \frac{a}{100+a} - c^2} \qquad (2)$$

where: a = the number of animals of the first type per 100 of the second type, e.g., a = 27 if the herd ratio was determined to be 27 bucks per 100 does.

b = confidence interval size in the form a $\pm$ b:100, e.g., b = 4 and a = 27 if the confidence interval is 27 $\pm$4 bucks per 100 does.

c = confidence interval size expressed as a true proportion (calculated from equation 1).

N = estimated number of animals of the 2 classifications in the population, e.g., 2,000 bucks and does.

n = number of animals classified, e.g., 511 bucks and does.

t = value of the 2-tail t statistic for the desired probability, e.g., t = 1.645 for the 90 percent level, $\propto = 0.1$, with n-1 degrees of freedom). If other intervals are desired, the appropriate t statistic may be found in nay statistics book.

Example:

A biologist observes 109 bucks and 502 does during an unbiased, random sample in a postseason mule deer herd classification. The herd ratio would be 109:27.1 bucks per 100 does. Therefore, a = 27.1 and n = 109 + 402 = 511. Biologists have estimated the herd is comprised of approximately 2,000 bucks and does (N = 2,000). The 90 percent confidence interval is desired; therefore, the value of t = 1.645 is used. The value of c and b are computed from equations 1 and 2 as follows:

$$c = 1.645\sqrt{\frac{(100)(27.1)(2000 - 511)}{(100+27.1)^2(2000)(511)}}$$

$$c = 1.645\sqrt{\frac{(2{,}710)\ (1{,}489)}{(16{,}154.41)\ (1{,}022{,}000)}}$$

$$c = 1.645\sqrt{0.0002444}$$

$c = 1.645\ (0.01563$

$c = 0.02571$

$$b = \frac{100\ (0.02571)}{1 - \frac{100((27.1)}{(100 + 27.1)^2} - \frac{27.1}{100+27.1} - (0.02571)^2}$$

$$b = \frac{2.571}{1 - \frac{2,710}{16,154.41} - \frac{27.1}{127.1} - (0.000661)}$$

$$b = \frac{2.571}{1 - 0.1678 - 0.2132 - 0.000661}$$

$$b = \frac{2.571}{0.6184}$$

$b = 4.1575$ (approximately 4.2)

Therefore, there is a 90 percent probability that the true herd ratio in this example is 27.1 $\pm$4.2 bucks per 100 does.

REFERENCES:

Czaplewski, R.L., D.M. Crowe, and L.L. McDonald. 1983. Sample sizes and confidence intervals for wildlife population ratios. Wildl. Soc. Bull. 11:121-128.

WGFD Wildlife Division
VegetationlHabitat Monitoring Protocol

FINAL - 8/1/04

Requested by Jay Lawson and John Emmerich to be monitored a1JllUally by wildlife biologists and game wardens starting in fall of2004. Developed by Steve Kilpatrick, Jerry Alterma1t, Rick Straw, Keith Schoup, Gal:y Butler and Bill Gerhart with input and feedback from wildlife maIIagement coordinators and others.

Purpose: Provide baseline habitat trend data that increases the awareness of habitat condition/trend among wildlife biologists and game wardens as they manage wildlife populations.

Primary Uses and Sideboards:

- Use vegetation and habitat trend data to assist with justification of season recOlllinendations and population objectives. Results will be slUllinarized by habitat biologists and reported aImually in JCRs by wildlife biologists.
- Increase awareness of wildlife biologists, galne waI'dens, others, and the public of annual vegetation condition and long-term u'ends.
- Keep the process relatively simple for allllUal monitoring and assessment and include a minimum of one traIISect for each warden district and two transects for each population biologist district. Each U'aJlsect will be visited at a minimum twice each year with data collected in the fall and in the spring. Historical transect locations and coordination with other land management agencies should be considered too.
- Vegetation monitOling priority is in sagebrush and sagebrush steppe cOlllinunities, however, other shrub conllllUlities and other vegetation type commlUlities will be monitored as identified by Regional persOllllel.
- TraIISect Locations, NlUnbers, Types and Other Considerations:
    1. Regional persOllllel will detennine monitoring transect nlUnbers, locations, and vegetation types within various herd lUlits or other saIlIpling stratification they deem appropriate.
    2. Wildlife Administration requested sagebrush monitoring sites within each Region, and to have at least one transect each game warden was responsible for and two transects each wildlife biologist was responsible for and that each lTallSect would be visited by the game warden or wildlife biologist once in the spling and once in the fall, data collected thereon, slUlllnarized by the habitat biologist for inclusion in JCRs by the wildlife biologist and used as one of the tools for season and population recollunendations.
    3. Habitat persOllllel will assist with initial transect establisillnent, data collection and slUIllllarization and provide u'aining the first year. Thereafter, data collection will be the responsibility of the game warden and/or wildlife biologists, and will be slUllilIaI'ized by the habitat biologist, included in JCRs by the wildlife biologist and used as one of the tools for hunting season and population objective recommendations.
- Long term monitoring may be established at sites deemed appropriate by Regional persOllllel.

Much of the basic protocol and procedure as well as more detailed explanations, purposes and uses for collecting the information is outlined in the Appendix XIII of the Handbook of Biological Techniques, WGFD 1982, pages 360-420 and Handbook of Investigative Techniques, WGFD 1981 which are, in part, attached as a PDF to the end of this document.

Transect monitoring protocol and minimum information collection follows:

- Transect location determination should be a cooperative effort of Regional personnel. Transects shall be established in "key" or "indicator" areas that appear to reflect what is occurring within the larger area and where you believe the vegetation community may show reactions or changes to population management. Small, isolated areas of severe use should not be selected for monitoring. Conversely, areas that receive unrepresentative light use should also be avoided. Transect location should be placed in relatively large vegetative complexes representative of the community or type you are sampling such that you can cover at a minimum one-eight mile and preferably one-quarter mile or more in length.
- Transect location marking will be done with a witness post (steel or metal "T" post) at the established starting point. Photo points as noted in the Techniques Manual are pipe or rebar located approximately 25' from the witness post (compass direction noted from witness) in the general line of travel of the transect. This post serves as the photo point for close-up oblique and aspect view photo of basic transects and of the cage.
- One permanent comparison 4' x 4' hog panel or horse panel cage is located adjacent to but offset left of the transect general line of travel. It shall be located approximately 5' from the photo point stake along the left hand side of general line of travel and no closer than about 10' from the 3' x 3' close-up plot.
- Monitoring sites will be permanent with steel witness posts, photo stakes, etc. Permission should be obtained from the landowner/manager prior to putting out stakes, cages, etc. These may be run adjacent to or in conjunction with current or past monitoring efforts. Data collected, photos, procedures and where the information is stored or housed should be documented for each transect within the appropriate JCR files and maintained by wildlife biologist and habitat biologist.
- **Minimum data collection requirements for the monitoring stations established regardless of vegetation community type or specific plant species include:**
    1. Annual production collected in late summer/fall after plant growth and prior to leaf drop or loss.
    2. Annual utilization (additional temporary cage sampling may be required if period of use and/or different ungulate species are using the area and there is a desire or need to separate the use periods) collected in late winter or early spring prior to plant growth and after most animals have left the area.
    3. Pellet group density collected during the spring (additional description in following sections).
    4. Repeat photos (3 photos) collected in the spring and fall.
    5. Nearby weather station summaries (use JCR weather information summaries) or on-site data if collected.

6. Permanent 4'x4' hog wire cage to show large ungulate non-use as compared to use areas.
7. Shrub/tree age class categories for monitoring stations in shrub/tree vegetation types collected in the fall.
8. Shrub/tree hedging class categories for monitoring stations in shrub/tree vegetation types collected in the fall.

- **Basic Techniques:** (Please refer to Appendix XIII of the Handbook of Biological Techniques, WGFD 1982, pages 360-420 and Handbook of Investigative Techniques, WGFD 1981 as many of the techniques are the same or very similar). **Note**: Basic techniques apply to both shrub and herbaceous transects unless differentiated below and underlined.
    1. Transect location is delineated with a witness stake, either a steel post or pipe, a unique name or identification assigned and UTM recorded in datum NAD27 with a GPS unit.
    2. Rebar or pipe set for taking photo points (generally in digital format) including close-up oblique with corner stakes or rebar marking and the 3'x3' wood or PVC photo-marking frame, aspect view and a protected cage view as per Laramie Region and similar to Biological Techniques pages 361-362 and shown below.
    3. Transect ID photo form and transect data sheets as per Laramie Region included herein which shows transect name and date.
    4. Herbaceous transects production clipped, bagged, air-dried and weighed from a minimum of 10 plots in fall after forage growth is complete or spring prior to green-up to determine total production, Additional temporary cage sampling may be required if period of use and/or different ungulate species are using the area and there is a desire or need to separate the summer from total use periods. This would require the use of temporary welded wire fabric cages to provide caged and protected forage areas that can be clipped and weighed for comparison to at least 10 unprotected areas to determine what is removed after the summer use period. The temporary cages would then be moved in the fall at the time of clipping and the unprotected sites clipped again in the spring for total utilizations assessment similar to Biological Techniques pages 400 – 402 and cages and utilization record on pages 365 and 366 and Cody Region procedures included herein.
    5. Shrub or tree transect - measure current annual production on a minimum of 5 leaders with a plastic ruler from at least 50 plants at paced intervals (fall) as per the Laramie Region for extensive browse utilization.
    6. Shrub or tree transect - measure annual utilization depending on species as either # of leaders browsed or bitten from a minimum of 10 leaders from 50 plants at paced intervals, as an option, if desired or deemed appropriate you may also measure the leader lengths from a minimum of 5 leaders with a plastic ruler from 50 plants at paced intervals (note or summer/fall/winter or other time frames for different seasons of use or ungulate users may be required too) as described in the Laramie Region procedures for extensive browse utilization.

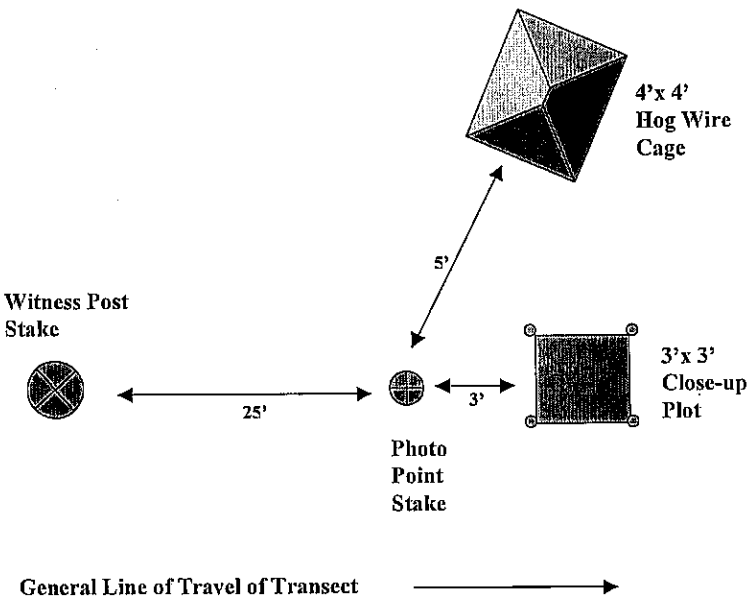
7. Read at least 10 circular 1/100 acre plots (stake with 11.78ft. rope string as radius) to collect pellet group density at the 5, 10, 15, 20, 25, 30, 35, 40 and 45 paced intervals similar to the method as described in Biological Techniques pages 415-418 during the spring collection period as described in more detail below.
8. Shrub or tree transect - record hedging and age class on a minimum of 50 plants along the paced interval as described in the Laramie Region procedures.

- Basic Equipment List:
    1. Standardized data sheets
    2. Digital camera or other camera
    3. GPS unit
    4. Clippers
    5. Paper bags for samples
    6. Watch with second hand
    7. Plastic ruler and tape
    8. Stake with 11.78ft. rope for radius of pellet group density plots
    9. Hog wire cage, steel t-posts, and rebar
    10. Transect Photo ID 8 ½" x 11" minimum to ID site location with transect name and date
    11. 3'x3' plot frame material alternately painted red/white in 6" intervals
    12. Welded fabric wire cages and stakes for herbaceous production and utilization where there is seasonal and dual or more ungulate use assessment required

Other techniques and procedures are included as additional review material and are viewed as informational, however, the shrub/tree technique described and used for the most part in the Laramie Region and the herbaceous technique described for the Cody represent the minimum annual data collection needs. Additional information may be collected as long as the minimum is collected each year. The additional information is provided in Appendix A.

Photo Point Schematic for Transect Monitoring Sites

1) Photo point stake (pipe or rebar) is established 25' from witness post in the general line of travel of the transect.
2) Camera is held at normal standing position at eye level for all 3 photos.
3) Close-up oblique photo is taken from the photo point in the general line of travel of the transect of the 3' x 3' plot marked on the corners with short rebar stakes located 3' from the photo point with the transect ID in the plot corner.
4) Aspect view photo is taken from the photo point in the general line of travel of the transect with 10% of the skyline or horizon in the back ground and with the transect ID in center fore ground.
5) Cage close-up photo is taken from the photo point centered on the cage bottom with the transect ID at the lower front corner of the cage. The cage is off-set left of the general line of travel of the transect about 10' from the 3' x 3' plot at 5' from the photo point stake.
6) All 3 photos should be taken during the fall and spring sampling periods.



Circular 1/100 Acre Pellet Group Plots

Each plot is measured by using a rod or stake with an 11.78' chain or rope attached. The 11.78' radius samples an area equal to 1/100 of an acre. All pellet groups, cow patties, horse piles, sage grouse droppings, turkey droppings or other species desired should be recorded. All groups that appear to be current years will be recorded if ½ or more of the groups is within the plot. Scattered pellet droppings will be counted as one group if more than ½ of the normal dropping is determined to be within the plot. At a minimum plots will be read in the spring. Plots may be read during the fall or other times if additional or seasonal data is desired. Pellet groups can be dot-tallied by species and

reported by species and as groups/acre. Pellet groups do not need to be cleared nor reported as average animal days use. We are using this as an index of annual fecal deposition by species only.

Pellet Group Count (Dot Tally)												
Transect ID				Date				Observers				
Dot#/Species	1	2	3	4	5	6	7	8	9	10	Sum	Group/Acre
Deer												
Elk												
Pronghorn												
Cattle												

Observations/Notes:

Minimum Standard Protocol for Monitoring Shrubs/Trees

Protocol for monitoring shrubs (currently used by the Laramie Region).

Reference Appendix B for data forms you will need for some measurements and transect photo examples.

Shrub Leader Production

Leader production measurements are used to gauge the production capabilities of a particular shrub stand and to monitor annual and long-term fluctuations in winter range browse forage production. The resulting data can be used to evaluate the effects of weather and climate and predict big game winter survival and fawn production. Measurements are taken in September or October after significant seasonal growth has ceased.

Multiple shrub species can be measured on each transect. However, if only one species is measured the productivity of the single species cannot then be used as production indices for the other species in the stand as they have different growth habits, forms, root systems, etc. In stands containing two or more forage shrubs, professional judgment is used to select the most important browse species, or you may select all of the species and sample separately.

The transect should be established in a "key area" or an "indicator area" to reflect what is happening on a larger area. Small, isolated areas of severe utilization should not be selected for monitoring. Conversely, areas that receive unrepresentative light use should be avoided. The key question to ask is: "Will the vegetation community show reaction to changes in population management?"

Cage exclosure setup: One permanent 4' x 4' hog wire cage fastened together with hog rings or strong wire should be placed over a representative key shrub or shrubs immediately adjacent to the starting point of the transect in the fall. The cage will be permanently set and wired to rebar or steel T-posts. If left in place over a long period of time, this small exclosure can provide a visual reference for long-term shrub growth potential for the site protected from browsing use. (Refer to previous discussion, too.)

Photopoints: Photopoints should be established at the cage and taken each fall and again each spring. A digital camera is preferred, but any camera available can be substituted. A close-up photo of the cage and shrub should be taken in the same direction as the transect line. This should include an 8 ½" x 11" (minimum) transect name identification and the date the photo is taken (see Appendix B Figure 7). In addition, an aspect view photo should be taken down the transect line to include a landscape view of the shrub community and the overall condition of the habitat type (Appendix B, Figure 9). The aspect view should also include the transect name and date in the photo. These repeat photos (close-up and aspect views) should be taken annually in the fall and spring. (Refer to previous discussion, too.)

The technique for selecting the area of the plant to examine production is essentially the same as that used when measuring utilization as discussed below:

1. After the plant to be evaluated has been identified and recorded on the data form, note the position of the second hand on your watch.
2. Using your route of travel as the 12 o'clock and 6 o'clock go to the area of the plant that is indicated by the second hand on your watch. If the second hand of your watch is on the upper right side of the face (i.e. on or near 3) you will select an available branch from that location on the plant. Use the equivalent second reading if using a digital watch (i.e. 20 seconds represents the 4 o'clock position). Only examine leaders from an area of the plant that is available to browsing, generally the top or upper portion of the sides.
3. At least 5 leaders (you can measure 10 leaders) should be examined from a minimum of 50 plants. Measurements are taken in millimeters or centimeters and expressed as average leader length for the stand. If any are browsed at the time you are conducting production please record the number browsed and discuss in the comments or notes section.

Again, we recommend minimum of 50 plants be measured across the community. More plants can be examined if desirable. If five or ten leaders are not available on the first branch selected, an adjacent branch can also be used. In most cases, only leaders that appear to be available to be browsed are selected, however, in communities where leader production has been poor, any leaders that can be found may have to be used in order to get a total of five or ten. In stands where production has declined to that level, the situation should be described in the comment section of the reporting form. These situations are particularly common in stands of true mountain mahogany. **Note:** This is optional and does not substitute for minimum protocol.

Although individual plant selection using a standard pace interval is the standard protocol recommended since it is the least labor intensive, another option is to tag 50 individual shrubs with numbered aluminum tags at paced intervals. This allows you to visit the same plant each year and to track the health and fate of the individual plant. When a plant dies the tag is placed on an adjacent plant and the same number is used with alphabet letters added, for example plant 14 dies, an adjacent plant is then tagged with 14A, if it dies than 14B, and so on. This has been used on sagebrush in a number of areas. Another option used by some Regions and researchers is to twist a small piece of wire on the individual branch of the tagged plant and measure production and utilization on the stems above the twisted piece of wire. **Note:** This is optional and does not substitute for minimum protocol.

Recommended data recording form for shrub production:

SHRUB LEADER PRODUCTION

Transect Name _____

Date _____ **Observer(s)** _____

Shrub Species _____

Note this would be done for a minimum of 50 plants. Also record number of leaders measured/plant.

Plant #	1	2	3	4	5	6	7	8	9	10
LEADER LENGTH										
TOTAL										

Comments:

Recommended summary form for annual leader production:

ANNUAL LEADER PRODUCTION				
SPECIES	Sampling Date	# OF LEADERS MEASURED	AVERAGE LEADER LENGTH (cm)	Comment

Shrub Utilization (Mainly adapted from the extensive browse technique).
Leader utilization measurements are used to gauge the use occurring within particular shrub stands and to monitor annual and long-term fluctuations in winter range browse forage utilization. The resulting data can be used to evaluate the effects of weather and climate, predict future big game survival and fawn recruitment and to evaluate the influence of use on the shrub species or shrub community and the long-term viability of the community or need for treatment or more intensive management. Measurements are taken in late winter/early spring (March-May) after most significant use has occurred and animals have left and prior to the initiation of plant growth.

Transect location and plant selection will be determined using the standard techniques discussed above. We recommend sampling no fewer than 50 plants. Utilization surveys should be conducted in spring after big games herds have left the winter range and before the plants begin active growth. The plant species name and percent utilization will be recorded on the browse utilization form shown at the bottom of this section. Percent utilization will be determined as follows:

1. After the plant to be evaluated has been identified and recorded on the data form, note the position of the second hand on your watch or digital watch equivalent.
2. Using your route of travel as the 12 o'clock and 6 o'clock go to the area of the plant that is indicated by the second hand on your watch. If the second hand of your watch is on the upper right side of the face (i.e. on or near 3) you will select an available branch from that location on the plant (in this case upper right). Only examine leaders from an area of the plant that is available to browsing, generally the top or upper portion of the sides.
3. Randomly examine ten leaders of annual growth and determine the number of these leaders which show evidence of use. Convert this number to a percent (i.e. 2 leaders used of 10 leaders examined = 20%). Record the value by dot tally recorded in the appropriate column. Results will be summarized as average percent of leaders utilized by species. Additional notations should be made in each column to indicate when utilization has gone into the wood produced in the previous year.
4. Optional. An additional measure may be collected for various shrub/tree species as follows: at lease 5 leaders (you can measure 10 leaders) should be examined from a minimum of 50 plants. Leader lengths are measured in millimeters or centimeters and expressed as average leader length remaining in the spring for the stand. This is occasionally being done on mountain mahogany, bitterbrush, willow and aspen. **Note:** This is optional and does not substitute for minimum protocol.

Recommended field data recording form for shrub utilization. Data can be expressed simply as a (%) utilization by species and does not need to be presented in tabular form:

Transect Name:						UTM:				
Date:	Observers:									
Percent Utilization										
Species	0	10	20	30	40	50	60	70	80	90	100

Hedging Class (Adapted from the extensive browse utilization technique.)
Hedging classification is an ocular estimation of current and historic plant utilization. The major shrub species in the stand are examined and placed in one of three classes. Plants in Class One – (Little or No Hedging) refer to plants that have received light use in the last 3 to 4 years. Plants placed in Class Two – (Moderate Hedging) have experienced use in the past 3 to 4 years that has caused much development of lateral branching and a more complex growth form. Those plants placed in Class Three – (Severely Hedged) have been subjected to heavy use in the past 3 to 4 years which has caused a clubbed or broomed appearance. The assumption is that the entire plant is available to be browsed. If this is not the case, then another plant should be examined. Results are recorded as a percent of the total number of plants examined (We recommend 100 plants and a minimum of 50) found in each form class. Hedging surveys can be conducted anytime during the year, however, the condition of deciduous plants is most evident following leaf drop.

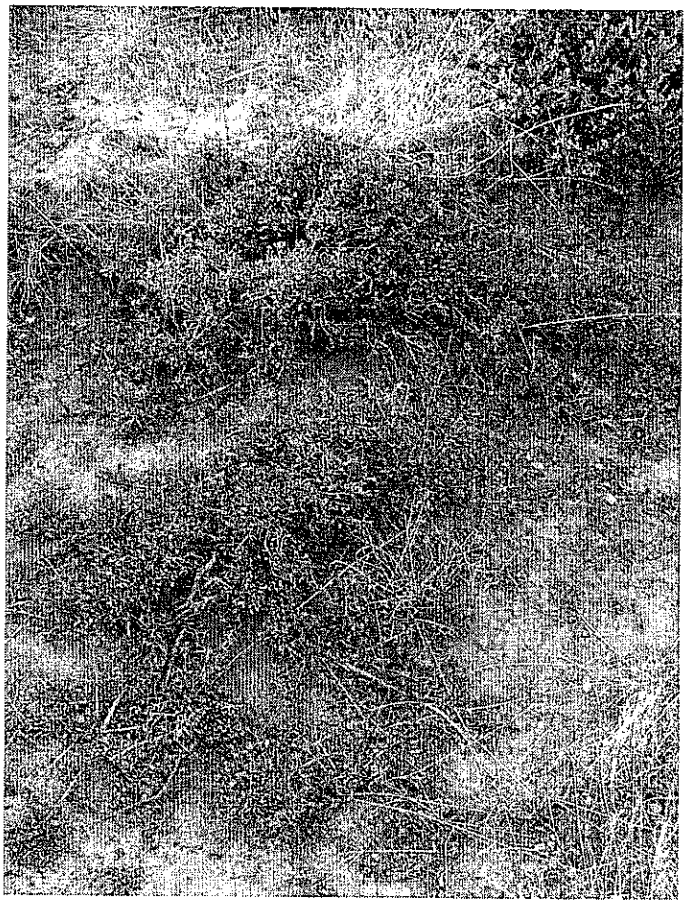


Figure 1. Severely hedged antelope bitterbrush.

Recommended summary and field data recording forms for shrub hedging:

HEDGING CLASSIFICATION

SAMPLING DATE:

HEDGING CLASS	DESCRIPTION
1	**Little or no hedging – Indicates light use in the past 3 to 4 years.**
2	**Moderate hedging – Use in past 3 to 4 years caused much development of lateral branching and more complex growth form.**
3	**Severely hedged – Heavy use in the past 3 to 4 years caused a very much clubbed or broomed appearance.**

SHRUB SPECIES	HEDGING CLASS

Location:	Date:		
Observers:			
SPECIES	Form Class		
	1 Light	2 Moderate	3 Severe

Hedging Class 1: Light or no hedging: 2-year-old wood is relatively long and unaltered or only slightly altered from the normal growth form. Less than 40 percent of the growing season leaders occur as extensions from lateral buds off of 2-year-old wood. Most of the 2 year old stems have current growing season leaders that extend directly from terminal bud apexes.

Hedging Class 2: Moderate hedging; 2-year-old wood is not strongly altered from the normal growth form. Between 40 percent and 70 percent of the current growing season leaders occur as extensions from lateral buds off 2-year-old wood. The remaining 30 percent to 60 percent of the 2-year-old stems have current growing season leaders that extend directly from terminal bud apexes.

Hedging Class 3: Heavy hedging; 2-year-old wood is relatively short and strongly altered from the normal growth form. Recurrent use has resulted in the development of much lateral branching or a very "clubbed" or "broomed" appearance. More than 70 percent of the current growing season leaders occur as clumped lateral and/or adventitious sprouts. Less than 29 percent of the 2-year-old stems have current growing season leaders that

Fig. 2. Criteria used for hedging class determination.

Examples of hedging classes follow:

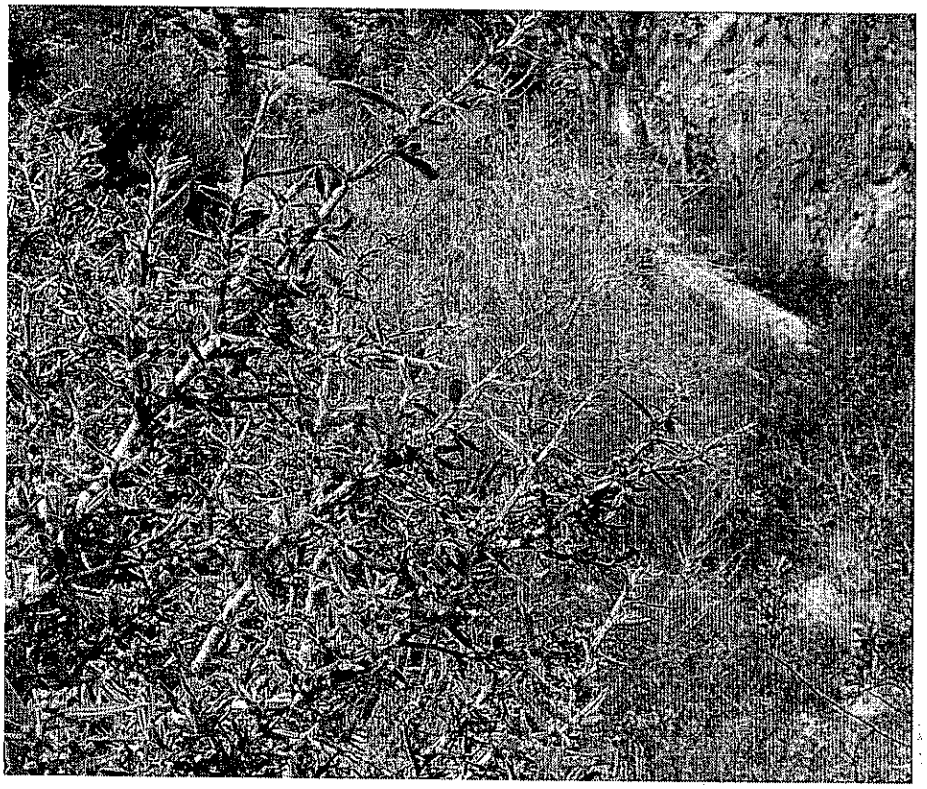


Fig. 3. Hedging Class 1.

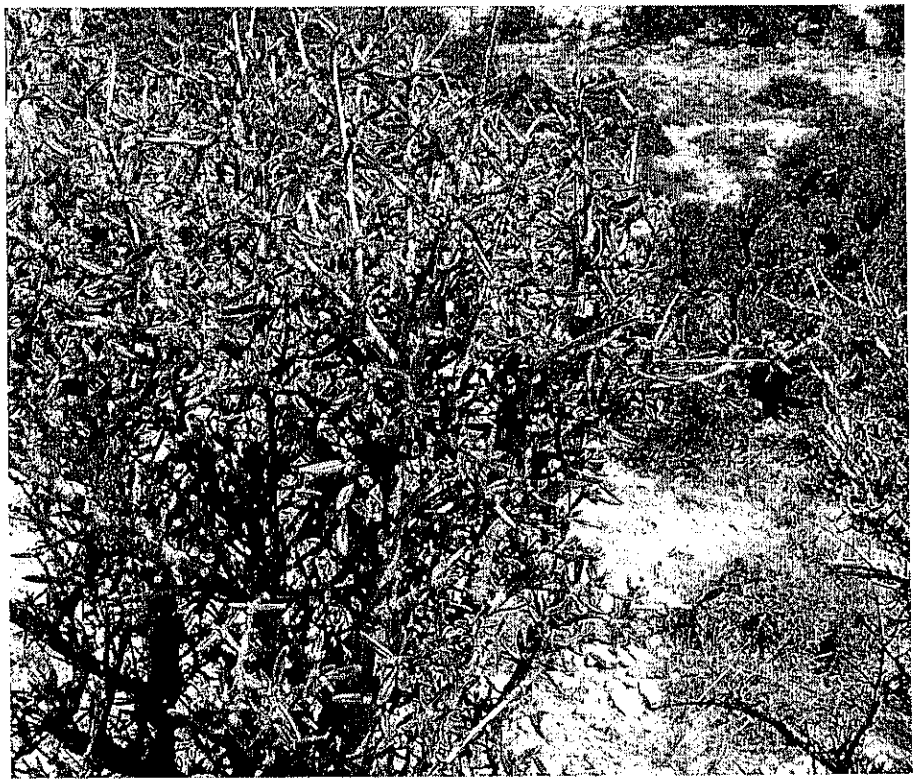


Fig. 4. Hedging class 2.

Fig. 5. Hedging Class 3.

Stand Age Classification

Shrub stand age data is collected as it may be reflective of the health of the overall shrub community, individual shrub species health, interval between perturbations, natural range of variability, potential vigor, recruitment and replacement of shrubs and palatability to browsing animals. The following age classification techniques can be used with true mountain mahogany, bitterbrush, skunkbush sumac, sagebrush and other species as appropriate.

Data will be collected on the transects and for those shrub/tree species previous established and discussed above and re-discussed below. In general as previously noted: select a segment of the community that is a minimum of one-eight to one-quarter mile long and set a metal "T" post at the established starting point, photo point stakes and 4'x4' cage. Plants are sampled at approximately three pace intervals, beginning at the starting point and progressing towards a distant land or vegetation feature. A compass should be used to determine the general line of travel and this information entered into the records for each transect. At the end of each three pace interval the observer should locate the browse plant nearest and within a 180° arc to the front of his lead toe. We recommend sampling no fewer than 50 plants. The number of species to be examined is up to the observers. Each procedure will be conducted at each transect every year.

Shrub Age Classification (Primarily from the extensive browse utilization technique): Shrub age classifications give a measure of the condition of the stand by providing a determination of the percent of the stand that is young, mature old, dying or dead. Age classifications also provide insight into whether or not the stand is replacing itself through recruitment. Use the standard technique to locate plants to be evaluated as previously discussed . The species name should be recorded and a dot count tally made in the appropriate column of the field data form. Plant age (or condition) determinations should be made using the following criteria:

Young – Basil stem diameter not over one quarter inch, simple branching on elongate growth.

Mature – Heavy growth, often gnarled stems, complex branching, crown made up of more than half living wood.

Decadent - Same as mature made up of more than one half dead wood. Note: Some researchers and managers define decadent when 25% or more of the plant is dead wood. You need to specify which % you will use.

Dead - The plant is dead with no signs it will regrow.

Age classifications should be conducted before leaf drop to ensure the greatest degree of accuracy in identifying dead and decadent deciduous shrubs.

A recommended data recording form for shrub age classification is shown below. The same form can be used for summarization by changing the headings to read % mature, young, decadent and dead and enter results after making calculations. Results are expressed as a percent of the total number of plants examined.

Species	Mature Plants	Young Plants	Decadent Plants	Dead Plants
	*Not Sampled by Age Class			

***Plant species whose age cannot be accurately determined (i.e. fringed sagewort). Specify which decadent % you use.**

More detailed examples of permanent monitoring stations and data collection information and summarization for the Laramie Region is included in Appendix B.

Minimum Standard Protocol for Monitoring Herbaceous Vegetation

Recommnded protocol for monitoring production/utilization of herbaceous vegetation (currently used by the Cody Region)

Purpose

This method is used to determine both production and utilization of herbaceous vegetation. All herbaceous species can be recorded or, if desired, only "key species". Please refer to Biological Techniques Manual.

Equipment

- Data sheets (see Techniques Manual pages 366 and 401 for general format)
- 4'X4' hog panel or horse panel steel cage
- Plot frames – see below for recommended sizes and material
- Clipping shears
- Paper sacks
- Spring scale (grams)
- GPS unit
- Digital camera or other camera
- Transect photo ID 8 ½" x 11" minimum to ID site location with transect name and date
- May or may not need welded wire cages as described in the Techniques Manual page 365

Establishment

The transect should be established in a "key area" or an "indicator area" to reflect what is happening on a larger area. Small, isolated areas of severe utilization should not be selected for monitoring. Conversely, areas that receive unrepresentative light use should be avoided. The key question to ask is: "Will this herbaceous community show reaction to changes in population management?" One permanent 4'X4' hog wire cage should be placed at each transect location and UTMs recorded with a GPS. If needed to differentiate growing season use from annual use, temporary welded fabric wire cages should be placed in the area within vegetation that is representative of the general area. If vegetation is not uniformly used and/or if both fall production and spring utilization estimates are desired, more than five cages may be desired or warranted. If cages are used, at least 2 plots should be clipped from within each cage and appropiate number outside each cage for a minimum of 10 plots depending on data needs.

Plot Frames

Plot frames can be either rectangular or circular. Rectangular frames can be easily made from ½" PVC. Old band saw blades with teeth ground off, cut to size and brazed together make excellent "hoop" frames. Frames may be sized so the mathematical

conversion from grams per plot to pounds per acre is simple. The following hoop sizes convert easily:

Area of plot frame (ft^2)	Radius (inches)	Circumference (inches)	To convert grams/plot to pounds/acre multiply by
0.96	6.64	41.67	100
1.92	9.38	58.93	50
2.40	10.49	65.88	40
4.80	14.84	93.17	20
9.60	20.98	131.77	10

Larger hoop sizes should be used in lower precipitation bunch grass communities or where vegetation is not uniform.

Production/Utilization

Sampling Procedure:

Monitoring for production should be done annually, ideally after full production and before environmental processes such as wind and snow removes or destroys standing plant material. Monitoring of utilization should occur after the use period. If utilization by wildlife on winter ranges is monitored, samples inside and outside cages should be clipped after wildlife leave the winter range. If only an estimation of utilization of previous years growth is desired, plots should be clipped before significant green-up occurs. After green-up, an effort to separate current and previous year's growth should be made. A minimum of 10 plots should be clipped during each sampling period. Sample as follows:

1. Take a close-up and an aspect photo with the cage in one half of the photo and part of the horizon or a prominent landmark in the background for reference. A photo board with date and location information should be stood up against a corner of the cage.
2. Remove wire cage to gain access to clip protected plots if temporary welded fabric wire cages are used or needed.
3. Place a plot frame inside the caged area and clip all herbaceous within the frame. If production and/or utilization of only key species are desired, clip only those species. Plants should be clipped between ¼ and ½ inches above the ground level surface to simulate what a 'normal' grazing animal could bite. Plot frame size will vary according to the density and uniformity of the vegetative community. If clipping is done in the summer/fall for production and utilization will be monitored the following spring, leave enough room in the cage for another plot to be clipped in the spring. If a larger plot size is required, however, more cages may be necessary. Place all clippings in a paper bag and label accordingly.
4. When utilization is monitored, randomly place the same plot frame outside the cage, clip and place clippings in a separate bag and label as unprotected plots. Place the plot frame at least 20 feet from the cage to avoid heavier use around the cage. If the vegetation is not uniform and utilization is uneven, clip additional

plots as determined to be needed by Region personnel. Make sure the number of plots clipped and plot frame size is clearly marked on bags.

5. Content of bags should be air dried before weighing with a gram scale and calculating production and utilization.

Calculations

Production is calculated by multiplying the weight of the protected plots by the appropriate conversion factor above.

Calculate the percent utilization as follows:

$$\%\ \text{utilization} = \frac{\text{Total protected weight} - \text{Total unprotected weight}}{\text{Total protected weight}} \times 100$$

If an unequal number of protected and unprotected plots

$$\%\ \text{utilization} = \frac{\text{Average weight for protected plots} - \text{Average weight for unprotected plots}}{\text{Average weight for protected plots}} \times 100$$

Appendix A

Aspen Treatement Stand/Clone Evaluations

Recommended protocol for monitoring aspen (currently used by the Jackson Region)

Sampling Methodology for Aspen

The following methodology has been use by habitat managers in NW Wyoming to assess stem densities within treated and untreated stands/clones. The following methodology was part of a paper presented at the Conference on Fire, Fuel Treatments and Restoration: Proper Place, Appropriate Time, April 16-18, 2002, Ft. Collins, CO. The paper was subsequently peer reviewed and published in the conference proceedings. The following sampling protocol has proven to be an efficient methodology in acquiring statistically reliable aspen stem densities. Managers felt sampling efficiency was acceptable for acquiring sample sizes necessary for predicting aspen stem densities with 80% confidence. In addition to density, height and annual leader growth are also collected. Once on site, a clone/stand can be sampled in 1 – 2 hours with two individuals.

Sampling steps

- Randomly establish a permanent photo point near the center of the clone/stand (five-foot steel post optional). Record GPS coordinates (including Datum).
- Take photos in one to all four cardinal directions.
- Select a random azimuth from the permanent photo point.
- Select a random pace distance.
- Select circular plot size. (Recommend 1/50 to 1/100 ac. for pre-treatment mature tree densities estimated at 150 – 250 trees/acre. Recommend 1/100 – 1/500 acre plots size for post-treatment densities of 4,000 –15,000 stems/acre, respectively. Also, increase the plot size with increased stand/clone heterogeneity.
- Proceed along random azimuth sampling plots at the selected random pace interval. Record: a) number of stems per plot by height or dbh class (eg. <1, 1-2, 2-3.....>10 & < 2"dbh). If stems are connected above the ground level, it is counted as one stem. If stems are connected below the ground it is counted as multiple stems.)
  b) annual leader growth on 2 stems/plot) .
- Stop proceeding along random azimuth when a different community type or ecotone is encountered.
- Select a new random azimuth that intercepts the stand/clone and proceed sampling with the same random pace interval and plot size as above.

- Continue the above procedure until the required sample size and statistical reliability is achieved using the following formula (eg. 80% reliability) .

$$N = (t)^2 * (s)^2 / (P * x)^2$$

N = required sample size
t = t table value for desired distribution (eg. 80% , 90% C.I.)
s = standard deviation
P = percent error (eg. 20% = 0.20)
x = mean # stems/plot

An example of our sampling methodology is illustrated in Figure 1. Bartos and Winward, (2000), recommend the following post-treatment conditions for successful aspen clone reestablishment; > 1,000 stems/acre, > 10 feet in height within 10 years post-treatment. They also suggest mean sucker height should increase by one foot/year post-treatment. The above recommendations are often transformed into objectives for aspen treatments.

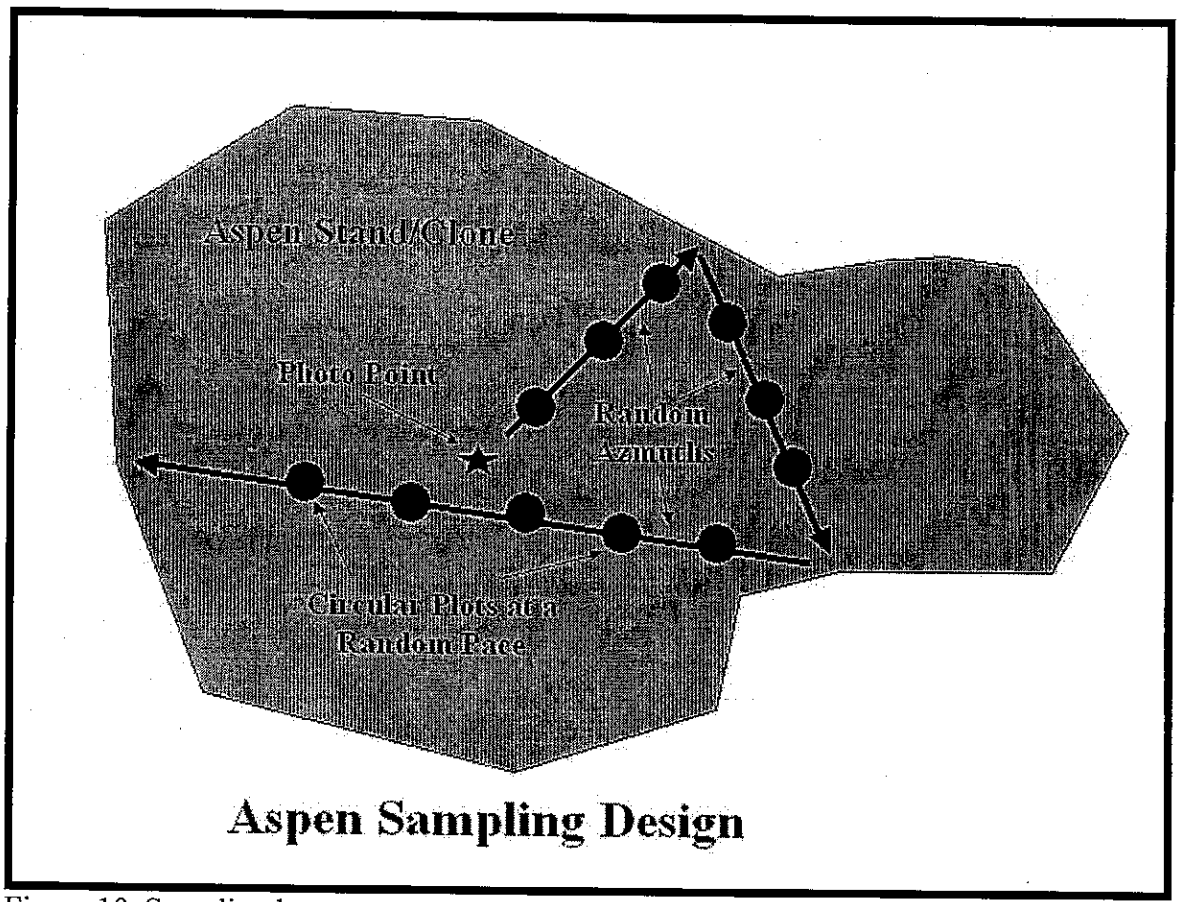


Figure 10. Sampling layout

ASPEN CIRCULAR PLOT DATA SHEET

SITE/NAME/#:	DATE:	PLOT SIZE:	Other
RECORDED BY:		PHOTO LOCATION: E	N NAD
COMMENTS:			

PLOT #

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Tot #	Stems/acre
Height Class	<1																					0	
	1-2																					0	
	2-3																					0	
	3-4																					0	
	4-5																					0	
	5-6																					0	
	6-7																					0	
	7-8																					0	
	8-9																					0	
	9-10																					0	
>10 & <2"																						0	
2-4" dbh																						0	
>4" dbh																						0	
Annual leader growth of 2 stems																						0	
																						0	
Mean annual leader growth		###																					
																			Total Stems/ac				

Riparian/Willow Monitoring Evauations

Suggested protocol for monitoring willows (currently used by the Jackson Region)

Sampling Methodology for Willows

The following methodology has been partly taken from "Monitoring the Vegetation Resources in Riparian Areas" by Alma Winward (USDA General Technical Report, April 2000). Additionally, these methods have been discussed between WGFD personnel and Alma Winward in field trips to NW Wyoming. Managers have determined this methodology to be an efficient way to get useful, repeatable data on long-term riparian transects. These transects should be read in the spring and fall in the same way except offtake will only be read in the spring.

Sampling steps

- Randomly establish 5 transects, perpendicular to the waterway. These transects should be randomly placed in such a way as to best represent the entire complex (use aerial photography when possible).
- The five transects should have beginning and ending points permanently marked with stakes. The stakes should be far enough back into the non-riparian area (usually several feet) to allow subsequent quantification in case the riparian area expands in size. At the beginning of each transect establish a permanent photopoint and record GPS coordinates (including Datum) at the start and end of the transects.
- A minimum of 50 sites will be sampled at predetermined pace intervals. Divide the approximate total length (ft.) of the five transects by 50 to determine the pace intervals at which you will sample. (Example: transect length is 1 mile (5,280 ft). 5,280/50 = 106 ft. between sampling sites. The average pace (2 steps) is 6.5 ft. 106/6.5 = 16 paces (32 steps) between sampling sites. At the end of each pace interval the following needs to be recorded on the closest willow plant:
    1) Plant species
    2) Plant age class (sprout, young, mature, dead)
    3) Plant height class (one-foot increments)
    4) Offtake percent of leaders hit (spring only)

Details on how to record the necessary information:

Species could be difficult to determine in the spring. If you are unable to identify the species in the spring, record the information as an unknown species. It will need to be collected and submitted to a taxonomist for identification.

Plant age classes are indicated as follows:

Clumped, multiple-stemmed species (most willows):

Number of stems at ground surface	Age class
1	Sprout
2-10	Young
>10	Mature
0 stems alive	Dead

Single-stemmed species:
For shrub and tree species that tend to grow more single stemmed, such as coyote and wolf willow, count each stem that occurs 12 inches or more from any other at ground level as a separate plant, and age them by pre-established categories. If other woody species are present and one wishes to monitor them such as birch (*Betula* spp.), alder (*Alnus* spp.), cottonwoods or quaking aspen (*Populus* spp.), do those in the same way. As a minimum, four categories—sprout, young, mature, and dead—should be developed based on a combination of both growth rings and unbrowsed height.

Example:

Growth rings	Height	Age class
1-2	<1/4 mature	sprout
3-10	<1/2 mature	young
>10	bear full	mature
--	--	dead

Plant Height should be recorded in one-foot increments and to the nearest foot in total height. Each one-foot increment should include the six inches before and after the foot mark (example: 6'3" would be recorded as 6' and 6'10" would be recorded as 7'). When the plant has an extensive number of stems, the plant should be randomly quartered using the second hand on the watch (seconds indicating quarters of a circle). Within this quarter, randomly sample 10 stems for height. When there are fewer than 10 stems within the quarter, use the whole plant for height measurements.

Offtake should be recorded in the same random way as plant height, using a random quarter of the willow clump when stems are numerous. When the 10 leaders are sampled for height, also record the number of hits and non-hits from the past winter's browsing. Be sure not to count 1+ yr.-old browsing.

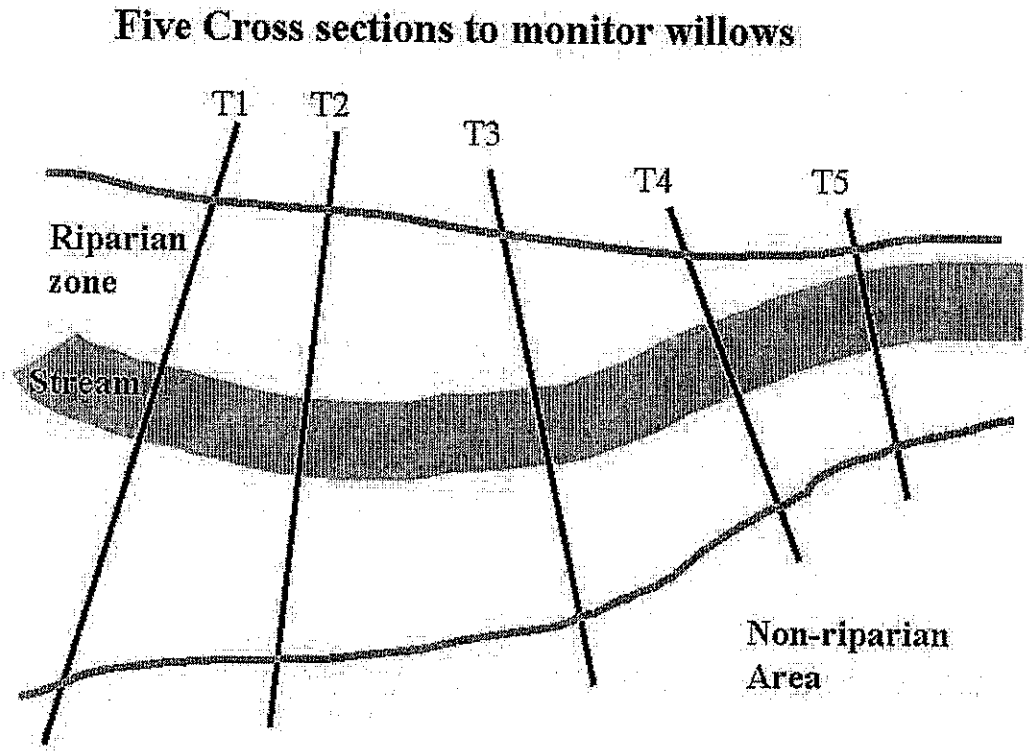


Figure 11. Willow monitoring cross sections.

Willow Data Sheet:

Drainage/Name/#			Date:		
Recorders:			GPS Datum (NAD):		
T1	Starting UTM E	N	Ending UTM E	N	
T2	Starting UTM E	N	Ending UTM E	N	
T3	Starting UTM E	N	Ending UTM E	N	
T4	Starting UTM E	N	Ending UTM E	N	
T5	Starting UTM E	N	Ending UTM E	N	

Plant #	Species	Age				Height Class													Total Height	Average Height	Use on 10 Leaders		% Use
		S	Y	M	D	1	2	3	4	5	6	7	8	9	10	11	12	>12			Y	N	
1																							
2																							
3																							
4																							
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Casper Shrub Production Sampling Design

Step transects are located in key or "heaviest used" areas of crucial winter ranges for big game species. The transects are permanently marked with T-posts, a GPS reading is recorded, and compass bearings are taken to determine the direction in which they run. We tag 25 (this should be increased to 50) shrubs occurring nearest the toe in a 180-degree arc in front of the observer at 3 pace intervals. We place a tag on each plant for ease of relocation, and the tags are numbered in sequential order. We tag only those plants that are available to big game species during the winter period. Big sagebrush production is estimated by measuring to the nearest millimeter 10 randomly located current annual leaders. A spot on each shrub is selected by noting the second hand on a wristwatch, moving to that position within the browsing zone, and measuring 5 leaders. Five additional leaders are assessed on the opposite side of the plant.
Mountain shrub (i.e., true mountain mahogany, curlleaf mountain mahogany, antelope bitterbrush, etc.) production is estimated by measuring to the nearest millimeter, 10 current annual leaders located above a tag on a marked a stem. This stem will be randomly selected by noting the second-hand on a wristwatch. The same current annual leaders measured for production will be used to estimate utilization (actual use).

All production data is collected during September.

Casper Shrub Utilization Sampling Design

Step transects are located in key or "heaviest used" areas of crucial winter ranges for big game species. The transects are permanently marked with T-posts, a GPS reading is recorded, and a compass bearing is taken to determine the direction in which they run. We tag 25 (this should be increased to 50) shrubs occurring nearest the toe in a 180-degree arc in front of the observer at 3 pace intervals. We place a tag on each plant for ease of relocation, and the tags are numbered in sequential order. We tag only those plants that are available to big game species during the winter period. Each shrub is assessed for utilization (percent leaders browsed) and characterized according to hedging and age class criterion. Big sagebrush utilization (percent leaders browsed) is estimated and recorded to the nearest 5 percent (+ or - 10 percent). Utilization is estimated by trying to mentally reconstruct the plant, as it would have appeared had it not been utilized because leader counts or measurements are not feasible with big sagebrush. Big sagebrush actual use is very difficult to measure, therefore we have instituted an ocular assessment, which is described previously in this paragraph.

Mountain shrub (i.e., true mountain mahogany, curlleaf mountain mahogany, antelope bitterbrush, etc.) utilization (actual use) is determined by measuring 10 leaders on a marked stem. This stem is randomly selected by noting the second-hand on a wristwatch. In addition, all current annual leaders are measured to the nearest quarter inch above the tag. The tag is used for ease of location, and is numbered in sequential order. The same

leaders are re-measured the following spring to determine utilization (actual use). If the entire leader has been removed, a zero is recorded.

All utilization data is collected in late April through early May, prior to the shrubs initiating growth.

The criterion for hedging and age classifications are outlined below.

Hedging Class 1: Light or no hedging; 2 year old wood is relatively long and unaltered or only slightly altered from the normal growth form. Less than 40 percent of the growing season leaders occur as extensions from lateral buds off of 2-year-old wood. Most of the 2 year old stems have current growing season leaders that extend directly from terminal bud apexes.

Hedging Class 2: Moderate hedging; 2-year-old wood is not strongly altered from the normal growth form. Between 40 percent and 70 percent of the current growing season leaders occur as extensions from lateral buds off 2-year-old wood. The remaining 30 percent to 60 percent of the 2 year old stems have current growing season leaders that extend directly from terminal bud apexes.

Hedging Class 3: Heavy hedging; 2-year-old wood is relatively short and strongly altered from the normal growth form. Recurrent use has resulted in the development of much lateral branching or a very "clubbed" or "broomed" appearance. More than 70 percent of the current growing season leaders occur as clumped lateral and/or adventitious sprouts. Less than 29 percent of the 2-year-old stems have current growing season leaders that extend directly from terminal bud apexes.

Young (Y): intermediate age plant between seedling and mature; exhibits more complex branching, more fibrous bark, and greater root development than a seedling, but the branching is still simple, on elongated growth, and the plant does not produce seed. The basal stem diameters for evergreen species are usually less than 1/4 inch, and for deciduous species usually less than 1/2 inch.

Mature (M): plant producing seed when healthy (vigorous), stems heavier and often gnarled, branching complex, and foliar crown made up of more than 50% living branches.

Decadent (D): plant in a state of decline that exhibits 50% or more dead branches regardless of age.

Dead (DE): plant that exhibits 100% dead branches.

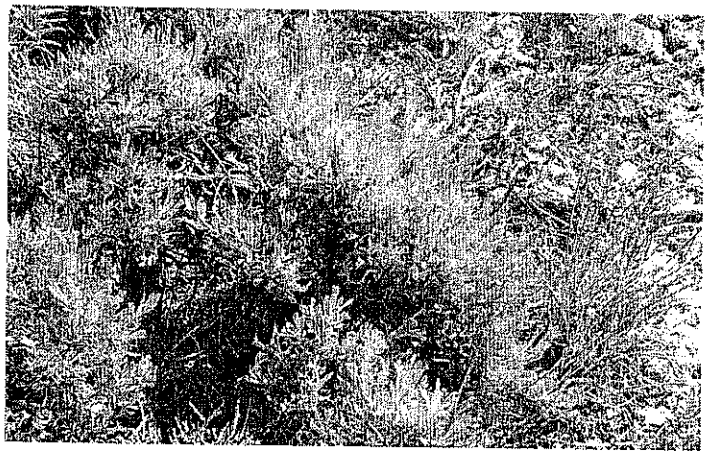

Figure 12. Hedge Class 2
Age Class - Mature

Figure 13. Hedge Class 3
Age Class - Mature

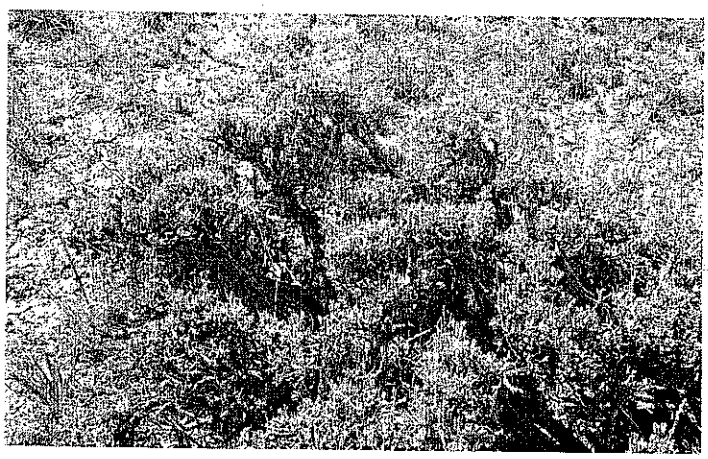

Figure 14. Hedge Class 3
Age Class - Mature

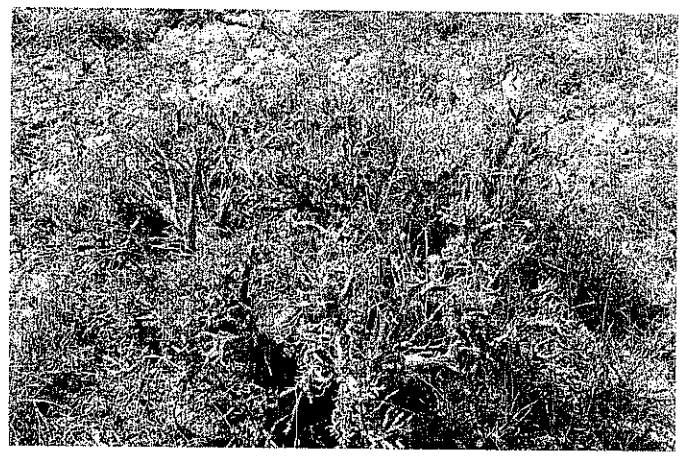

Figure 15. Hedge Class 3
Age Class - Decadent

The Casper Region uses the following methods for long-term monitoring.

Vegetative Plot Sampling Protocol

A 66-foot baseline is extended perpendicular to the slope from a marker (i.e., reinforcing bar, t-post, etc.), a GPS reading is recorded and a compass bearing is taken to determine which direction it lies. The zero footmark is placed to the left as you face upslope, or on the west end (west to east) on flat areas. A marker is placed approximately 50 feet from the end of each baseline to allow relocation for monitoring efforts. Subsequently, multiplying a random number generated on a calculator by 66 identifies five random

starting points along the baseline. The transects are placed perpendicular to the baseline (parallel to the slope) beginning at each starting point, and canopy coverage, ground coverage, nested-rooted frequency, and shrub density by age class is estimated along each transect.

Canopy coverage is estimated, as defined by Daubenmire (1959), for shrubs and trees using the line intercept technique. Canopy intercept is measured to the nearest inch along each transect. Canopy coverage for each graminoid and forb encountered in a microplot is occularly assessed to the nearest percent. Microplots are 20-inch (50.8 cm. square) square quadrat frames. Five microplots are placed to the right of the transect line with the lower left corner of the microplot frame located at the 8, 16, 24, 32, 40, 48, 56 and 64 foot marks on each transect.

Ground (basal) coverage is estimated by point sampling at designated marks on the microplot frame. Eight points are sampled at each microplot location. The point intercept is recorded by vegetative life form class, or as rock, gravel, litter, or bare ground.

Nested-rooted frequency is estimated within each microplot. The microplot frame is sectioned into four quadrants of 20 x 20 inches (50.8 x 50.8 cm.), 20 x 10 inches (50.8 x 25.4 cm.), 10 x 10 inches (25.4 x 25.4 cm.), and 2 x 2 inches (5.08 x 5.08 cm.) to derive the estimate. Plants are recorded according to the smallest quadrant in the microplot they were rooted in.

Density of important shrubs within macroplots is estimated using 3.3 x 66 foot (1.02 x 20.12 m.) belt transects. Belt transects are established by carrying a 3 ft. 4 in. section of lath held parallel to the transect line along the left side. Should one belt transect overlap another, the right side of the adjacent transect is recorded instead. Each key shrub occurring in the belt transect is recorded according to the age class criteria outlined below.

Vegetative plot sampling is usually conducted from late May through June, dependent upon plant growth which aids in plant identification. This timeframe may change from year to year and location to location.

Appendix B

Following are examples of completed data forms and sheets used to summarize information from a shrub transect at Cedar Hills in the Laramie Region.

Laramie Region Field Report Summary Sheet

Transect Name: Cedar Hills

Date Established (m-d-y): 8/2/01

Established by: Rick Straw, Michele Turner

Herd Units Represented: Mule Deer 541 & Antelope 528

Witness Post GPS Location: 13T0357758 4581722

GPS Indicated Altitude: 7284

Community Type: ArTrWy, PuTr, ChVi

Estimated Slope: 30 degrees

Estimated Aspect (azimuth): 280 degrees

Animal Use: Mule deer, horse

Transect & Exclosure Photo Taken: No

Soil Sample Taken: No

Shrub Recruitment Belt Transect: Yes

Nutrient Sample Taken: Yes

Shrub Stems Taken for Age Determination: Yes

Exclosure Installed: Yes

Fecal Sample Collected (species): Yes (Mule deer)

Field Observations

Area receives very high use during severe winters. Rocky mountain juniper present, many of which have been high lined.

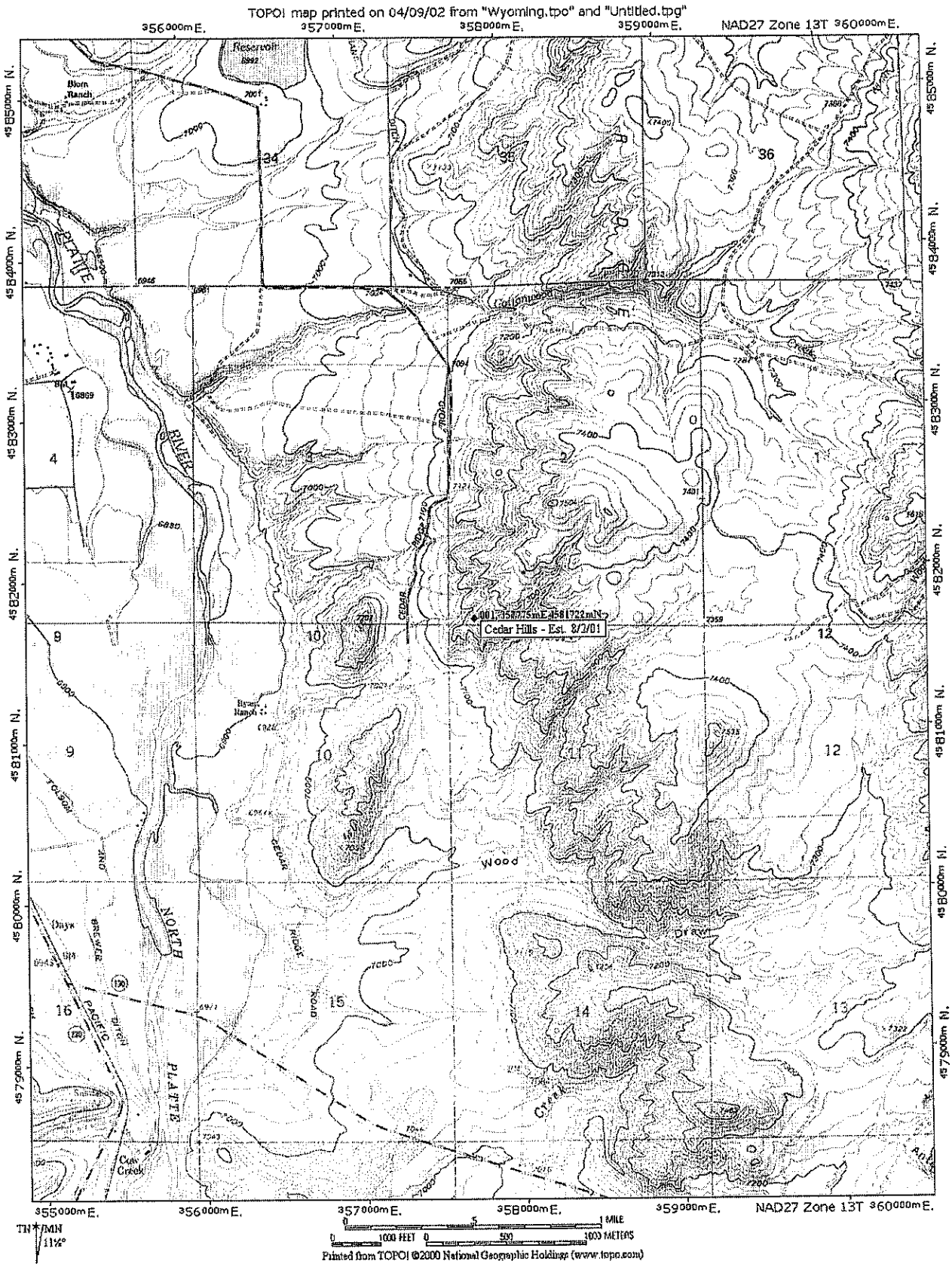
TOPO! map printed on 04/09/02 from "Wyoming.tpo" and "Untitled.tpg"
356000mE.
357000mE.
358000mE.
359000mE.
NAD27 Zone 13T 360000mE.
458500m N.
458400m N.
458300m N.
458200m N.
458100m N.
458000m N.
457900m N.
Reservoir
6992
Horn Ranch
7001
34
35
36
PLATTE
RIVER
7055
Cottonwood
SH
16989
4
1
7094
7000
7400
7401
7359
001 358775mE 458172mN
Cedar Hills - Est. 8/3/01
8
9
10
12
Horn Ranch
Wood
NORTH
Dayk
BREWER
PACIFIC
DITCH
RIDGE
ROAD
15
14
13
Drain
Creek
Cow Creek
355000mE.
356000mE.
357000mE.
358000mE.
359000mE.
NAD27 Zone 13T 360000mE.
TN 11½°
MAGN
1 MILE
1000 FEET
500
1000 METERS
Printed from TOPO! ©2000 National Geographic Holdings (www.topo.com)

Figure 7. Cage at Cedar Hills. 7/29/03.

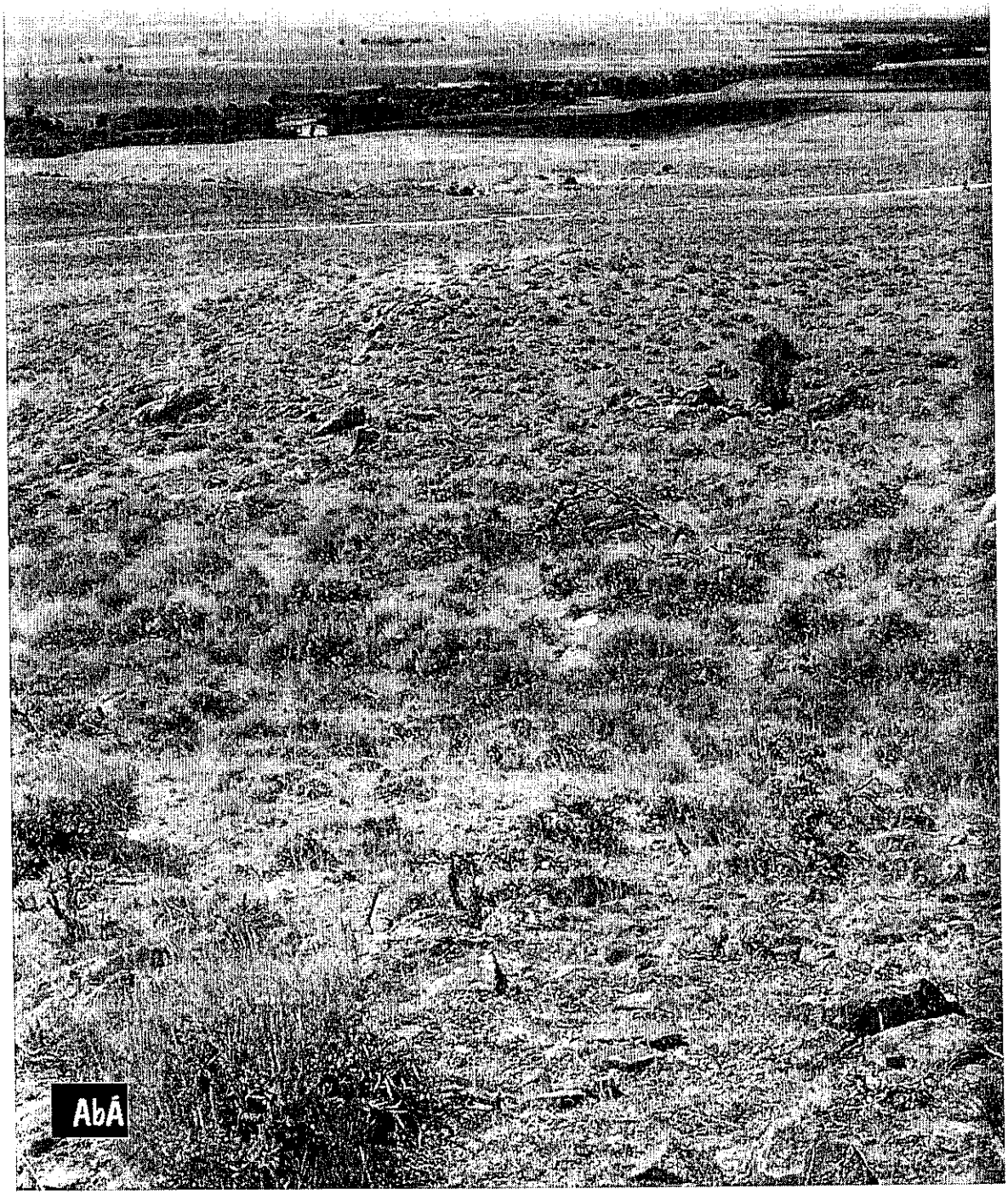

Figure 8. Landscape at monitoring station.

Figure 9. Transect line. 7/29/03.

ANNUAL LEADER PRODUCTION				
SPECIES	Sampling Date	# OF LEADERS MEASURED	AVERAGE LEADER LENGTH (cm)	Comment
ArtTriW	9/27/01	100	4.00	Good production on PurTri and ArtTriW. Both species producing smaller plants with many relatively long leaders. Bitterbrush disappears at the end of the transect and is "replaced" by ChVi.
ArtTriW	2002	100	2.07	
ArtTriW	9/16/03	100	2.72	

Platte Valley Mule Deer HU						
TRANSECT NAME	SPECIES	AVG. % UTILIZATION				SUGGESTED LEVELS OF USE
		2003/ 2004	2004/ 2005	2005/ 2006	2006/ 2007	
Prospect	Antelope Bitterbrush	66.5				60 – 65%
School Creek	Antelope Bitterbrush	51.8				60 – 65%
Cedar Hills	Mt. Big Sagebrush	48.5				45%

Collection Date: 8/02/01

HEDGING CLASSIFICATION

SAMPLING DATE: 7/29/03

HEDGING CLASS	DESCRIPTION
1	**Little or no hedging – Indicates light use in the past 3 to 4 years.**
2	**Moderate hedging – Use in past 3 to 4 years caused much development of lateral branching and more complex growth form.**
3	**Severely hedged – Heavy use in the past 3 to 4 years caused a very much clubbed or broomed appearance.**

SHRUB SPECIES	HEDGING CLASS
PurTri	**3**
ArtTriW	**3**

POINT FRAME MEASUREMENTS

Relative Frequency = Total Number of Intercepts Per Category
Total Number of Points Sampled

Sampling Date: 8/2/01

Intercept Category	Frequency (%)
ArTrWy	8
ChVi	4
PuTr	5
Cushion Plant?	7
Sedge	7
Phlox	1
Rock	15
Litter	17
Bare Ground	25

LIVE SHRUB CANOPY MEASUREMENTS*

Sampling Date – 7/29/03

Species	Total Inches Intercepted	% Live Canopy Coverage
ArtTriV	214	18%
PurTri	19	2%
ChrVis	44	4%

*% Live Canopy Cover = Total Inches Live Canopy Intercepted/Species X 100
Total Inches in Transect (1200)

SHRUB (STEM) DENSITY/RECRUITMENT PER ACRE

Sampling Date – 7/29/03

Species	No. and % Mature Plants	No. and % Young Plants	No. and % Decadent Plants	No. and % Dead Plants	Total Plants Per Acre
ArtTriV	58 – 43%	6 – 4%	64 – 47%	7 – 5%	4320
PurTri	5 – 23%	0	15 – 68%	2 – 9%	702
ArtFri	Not Sampled by Age Class				32
ChrVis	Not Sampled by Age Class				1248

Comments: Very heavy BroTec infestation.

SHRUB AGE CLASSIFICATION

Species	Age				
ArtTriW	88	74	80	77	77
PurTri	48	52	32	44	37

Interpretation:

FECAL ANALYSIS

Species – Mule Deer

PLANT GENUS	Agropyron	Hordeum	Poa	Stipa	Artemesia tridentata type	Atriplex	Cactus	Composite	Juniperus	Lesquerella	Purshia	Sphaeralcea				
Mean % Relative Density	2.43	7.05	0.81	3.33	21.77	0.72	0.72	3.35	17.88	5.17	11.96	0.81				

* Highest mean percent relative density in sample.
* Shrub and tree genus' found in sample.

SHRUB NUTRIENT ANALYSIS

	PLANT SPECIES				
	Artemisia tridentata wyomingensis	Chrysothamnus viscidiflorus	Purshia tridentata		
P% (Phosphorous)	0.103	0.188	0.122		
Ca% (Calcium)	0.828	1.371	0.698		
Fe ppm (Iron)	136.9	386.1	163.5		
Cu ppm (Copper)	12.20	18.3	4.0		
ADF%	27.75	22.98	34.97		
Total C (Carbon)	59.65	57.45	58.66		
Total N (Nitrogen)	2.274	2.576	1.973		
CP% (Crude Protein)	14.21	16.10	12.33		

Collection Date:8/2/01

PRECIPITATION DATA

(Western Regional Climate Center)

Station Name	Recording Period-Precip. Mean	Station Elevation (Feet)	Station Location Lat/Long	Current Reading Previous 2 Yrs.
Saratoga 1 SSE	1948 – 2000 – 9.76 Inches	6790	4127 – 10648	2001 – 5.47 2002 – 5.94

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Mountain-Prairie Region

IN REPLY REFER TO:
FWS/NWRS
Mail Stop 60130

MAILING ADDRESS:
Post Office Box 25486
Denver Federal Center
Denver, Colorado 80225-0486

STREET LOCATION:
134 Union Boulevard
Lakewood, Colorado 80228-1807

APR 08 2013

Scott Talbott, Director
Wyoming Game and Fish Department
5400 Bishop Boulevard
Cheyenne, Wyoming 82006

Dear Mr. Talbott: Scott

The Bison and Elk Management Plan (BEMP) for the National Elk Refuge (NER) and the Grand Teton National Park was completed in April 2007 with the assistance of the Wyoming Game and Fish Department (WGFD). Since then, the WGFD has been a strong partner and worked in cooperation with the NER to implement the strategies identified in the BEMP. We appreciate the support and assistance provided by the WGFD to implement the BEMP.

We desire to continue this important partnership by inviting the WGFD to collaborate in the development of an Adaptive Management Plan (AMP) as identified in the BEMP. The AMP will provide a dynamic framework for decreasing the need for supplemental feeding on the refuge while adaptively managing the bison and elk herds in a manner that contributes to the state's herd objectives. It also ensures the biological integrity and environmental health of refuge resources to be sustained.

Significant progress has been made in implementing management strategies as outlined in the BEMP. Yet, herd management objectives have not been met. We hope to enlist the expertise and cooperation of the WGFD in not only developing this AMP but also in achieving the mutually identified objectives, goals, and desired conditions as outlined in the BEMP.

The initial AMP meeting is tentatively scheduled for late April 2013 at the NER Headquarters in Jackson, Wyoming. NER Refuge Manager Steve Kallin will be sending you an invitation with more details and contact information. We welcome WGFD involvement and encourage participation by a representative who can offer recommendations and strategic solutions to address the challenges of achieving the outcomes outlined in the BEMP.

Sincerely,

Regional Director

Wyoming Game and Fish Department

WILDLIFE DAMAGE CLAIM REPORT

FISCAL YEAR 2013 WITH 10-YEAR SUMMARY

WILDLIFE DIVISION

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PREFACE

Common law in America, which has been continually reinforced in the United States courts, holds that the people of the state own the wildlife. No individual holds absolute property right to wildlife regardless of the status of the land on which the animal is found. Since wildlife belongs to everyone, the courts contend that everyone must share in its keep. As a result, courts have ruled the states are immune from liability for damage caused by wild animals, unless the state assumes that responsibility. Wyoming has assumed limited liability through legislation for some species of wildlife and under specific circumstances(see W.S. § 23-1-901 on page 38).

Wyoming Statute W.S. § 23-2-101(e) was passed by the legislature in an effort to provide a funding source for the payment of big or trophy game animal and game bird damage claims. That source of money is generated from a nonresident application fee of $14 and a resident application fee of $5 for any limited quota big or trophy game license issued through a drawing or for a wild bison license. The statute provides for 25% of the fees collected from license applications to be set aside to establish and maintain a fund of $500,000 to compensate landowners or lessees for property damaged by big or trophy game animals and game birds.

Wildlife damage management is a major component of the Wyoming Game and Fish Department's (WGFD) Wildlife Management Program. Considerable efforts are made to prevent damage including hazing, use of zon guns, providing materials for stackyard fences, relocating trophy game animals, increasing harvest, depredation seasons and, as a last resort, "kill" permits.

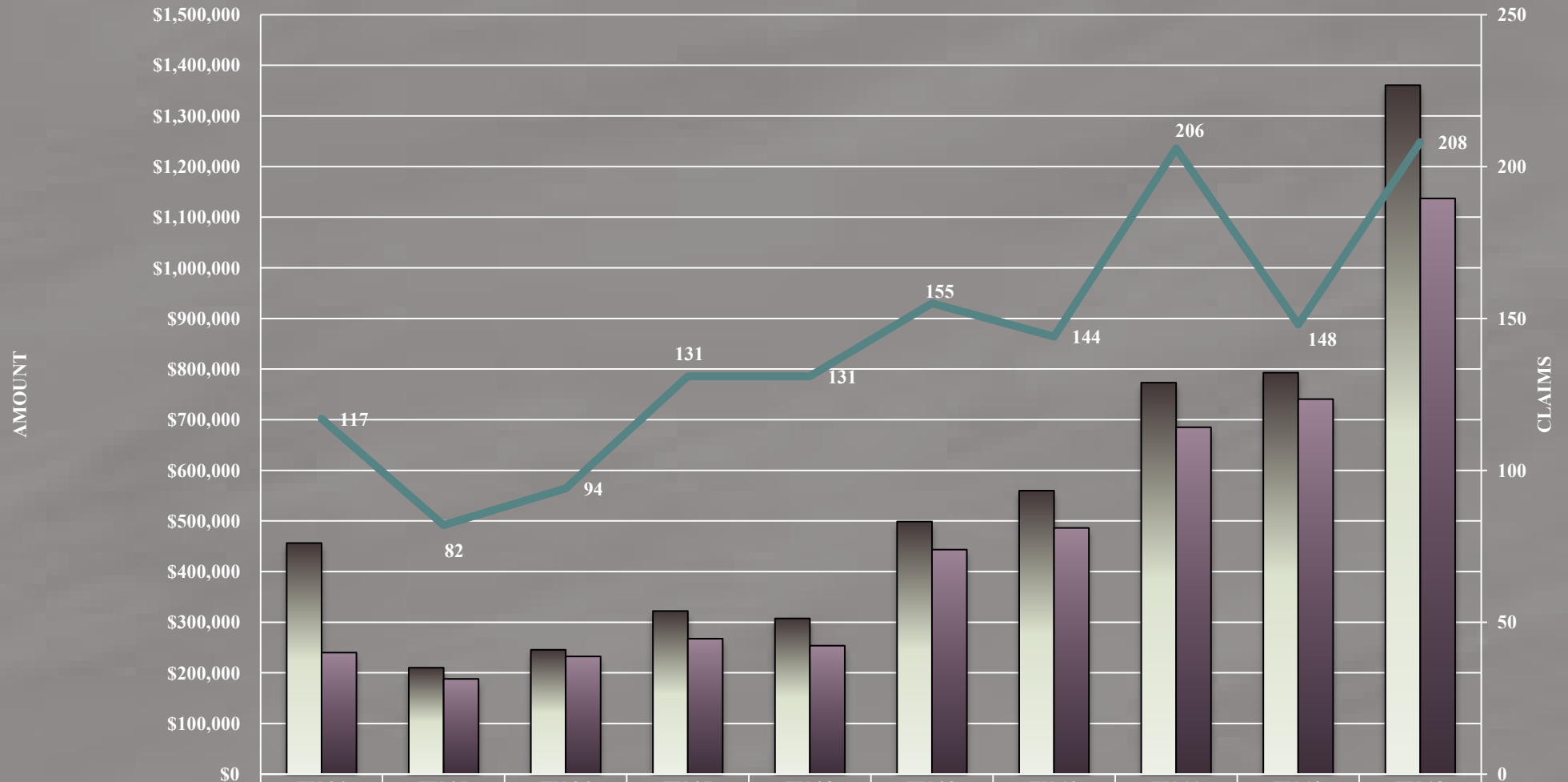
A landowner may submit a verified claim requesting compensation for damage. Claimants must meet all statutory and regulatory requirements in notifying WGFD personnel and filing the claim. WGFD personnel investigate the claim and verify the claimed damage using guidelines established by the WGFD in *The Handbook of Wildlife Depredation Techniques*. Claimants who do not wish to accept the WGFD's offer of payment may appeal the claim to the Wyoming Game and Fish Commission. If the claimant wishes to appeal the decision of the Commission, the claim may be appealed to an arbitration board and proceed on to District Court (see the Damage Claim procedure flow chart on pages 46).

Figures in this summary represent information obtained from verified claims of damage occurring in the depicted fiscal years. These figures will vary from information in the WGFD's Annual Report because program and personnel costs are combined in the Annual Report and payments of claims in the Annual Report only reflect actual payments made in that fiscal year. The Wildlife Damage Claim Summary is an effort to reflect the damage claim amounts and the amounts paid on claims which includes both claim amounts and amounts paid as if they occurred in the same fiscal year.

10-YEAR SUMMARY OF DAMAGE CLAIM ACTIONS

FISCAL YEAR	# OF CLAIMS	% OF CLAIMS PAID	% PAID IN FULL	% PAID PARTIALLY	% DENIED 15 DAY NOTICE	% DENIED 60 DAY FILING	% DISALLOWED (for other reasons covered by statute)	% APPEALED TO COMMISSION	% APPEALED TO ARBITRATION
04	117	95%	77%	18%	1%	3%	1%	5%	1%
05	82	100%	74%	26%	0%	0%	0%	2%	0%
06	94	97%	80%	17%	1%	1%	1%	1%	0%
07	131	97%	75%	22%	0%	2%	2%	1%	1%
08	131	95%	81%	13%	0%	4%	1%	1%	0%
09	155	97%	75%	22%	1%	2%	<1%	1%	1%
10	144	100%	82%	18%	0%	0%	0%	3%	1%
11	206	99%	84%	15%	<1%	0%	0%	1%	<1%
12	148	98%	82%	16%	0%	1%	1%	<1%	0%
13	208	99%	78%	20%	0%	0%	<2%	<1%	0%

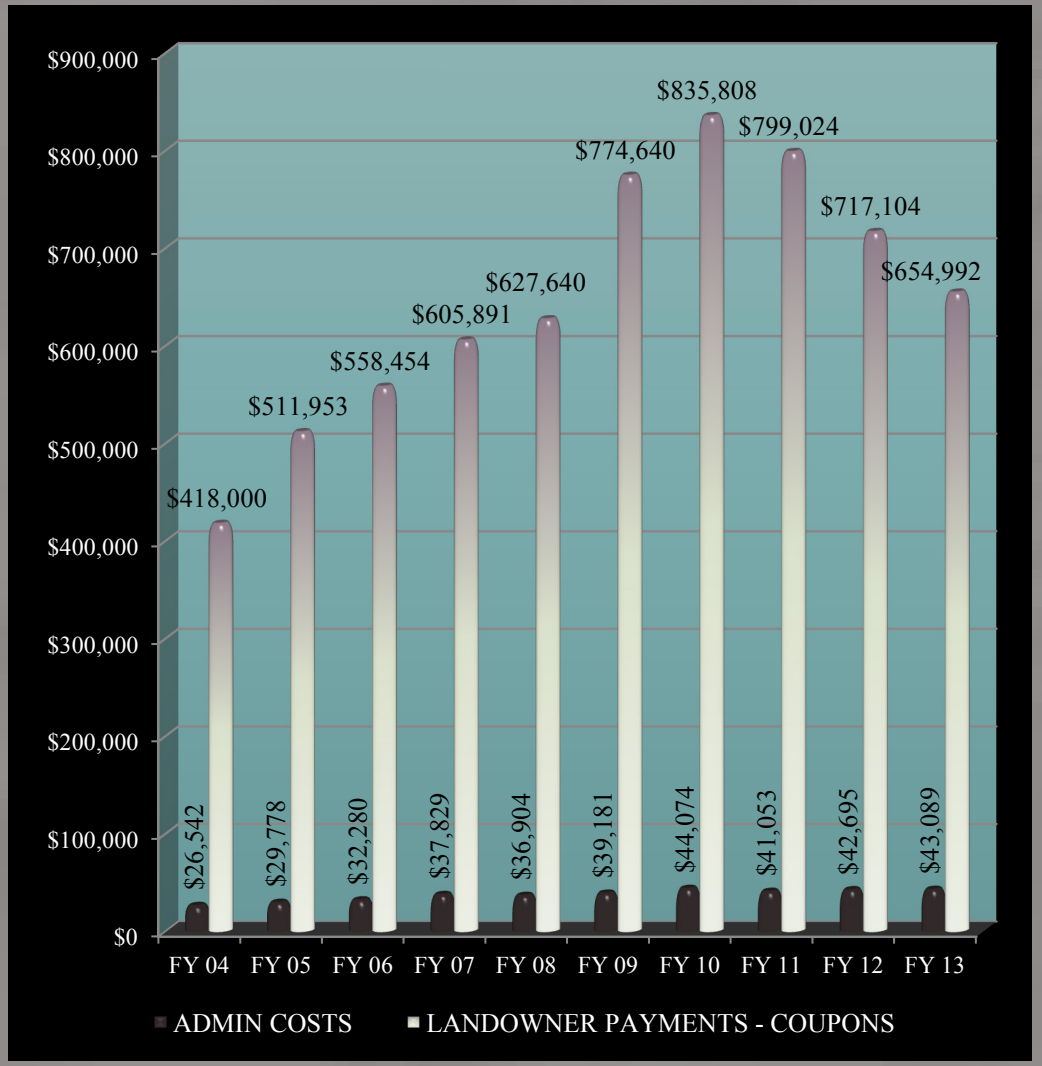
10-YEAR DAMAGE CLAIM PAYMENT SUMMARY



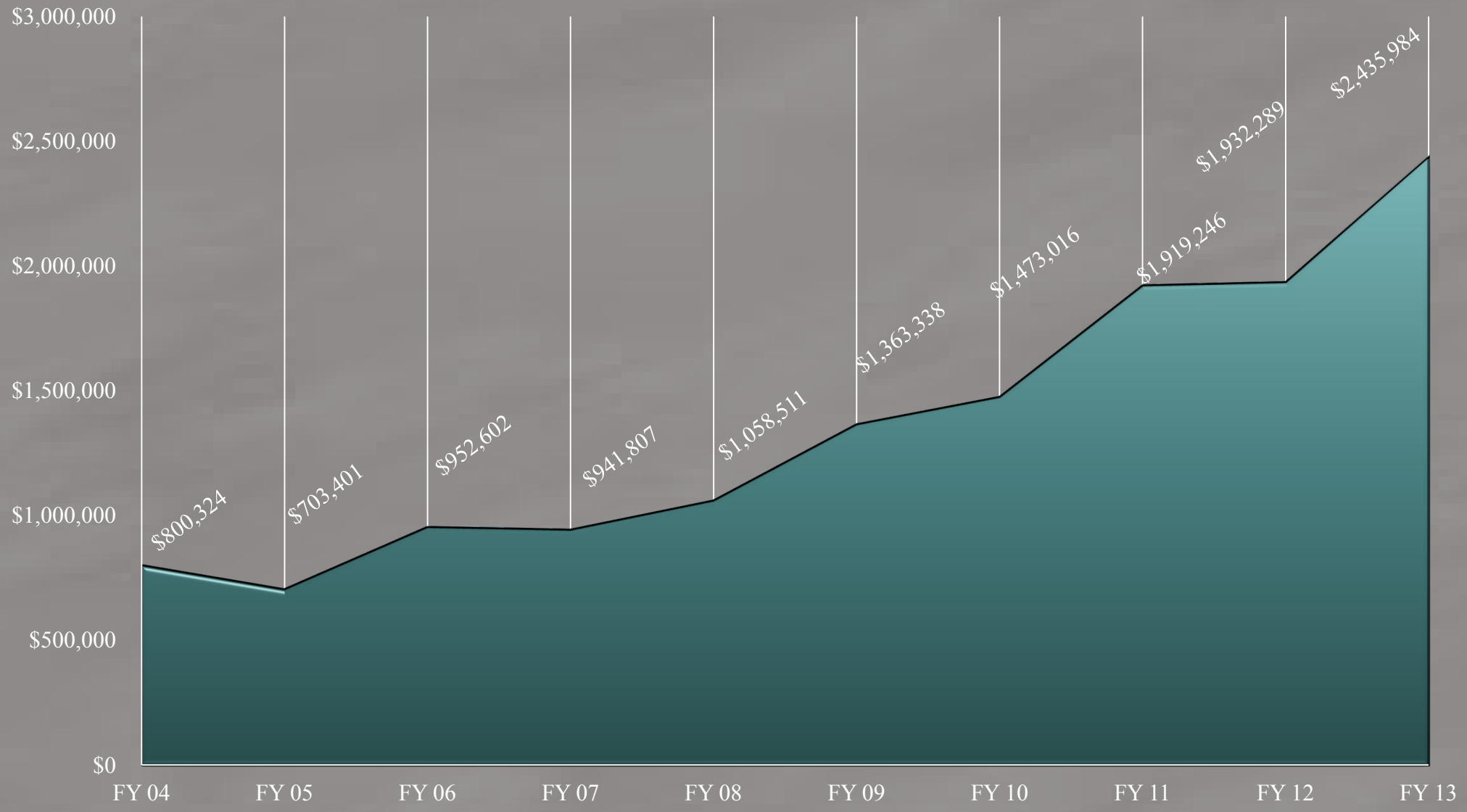
	FY 04	FY 05	FY 06	FY 07	FY 08	FY 09	FY 10	FY 11	FY 12	FY 13
AMOUNT CLAIMED	456,406	210,189	245,653	322,153	307,504	498,914	559,876	773,154	792,950	1,360,735
AMOUNT PAID **	240,055	188,087	232,460	267,525	253,734	443,450	486,306	685,143	740,712	1,137,085
#CLAIMS	117	82	94	131	131	155	144	206	148	208

** Amount paid reflects the total dollar amount paid for claims filed in each fiscal year. In some cases, actual payment was made in FY 13 for claims filed in the previous fiscal year. For this reason, these figures may differ with figures in the Department's Annual Report.

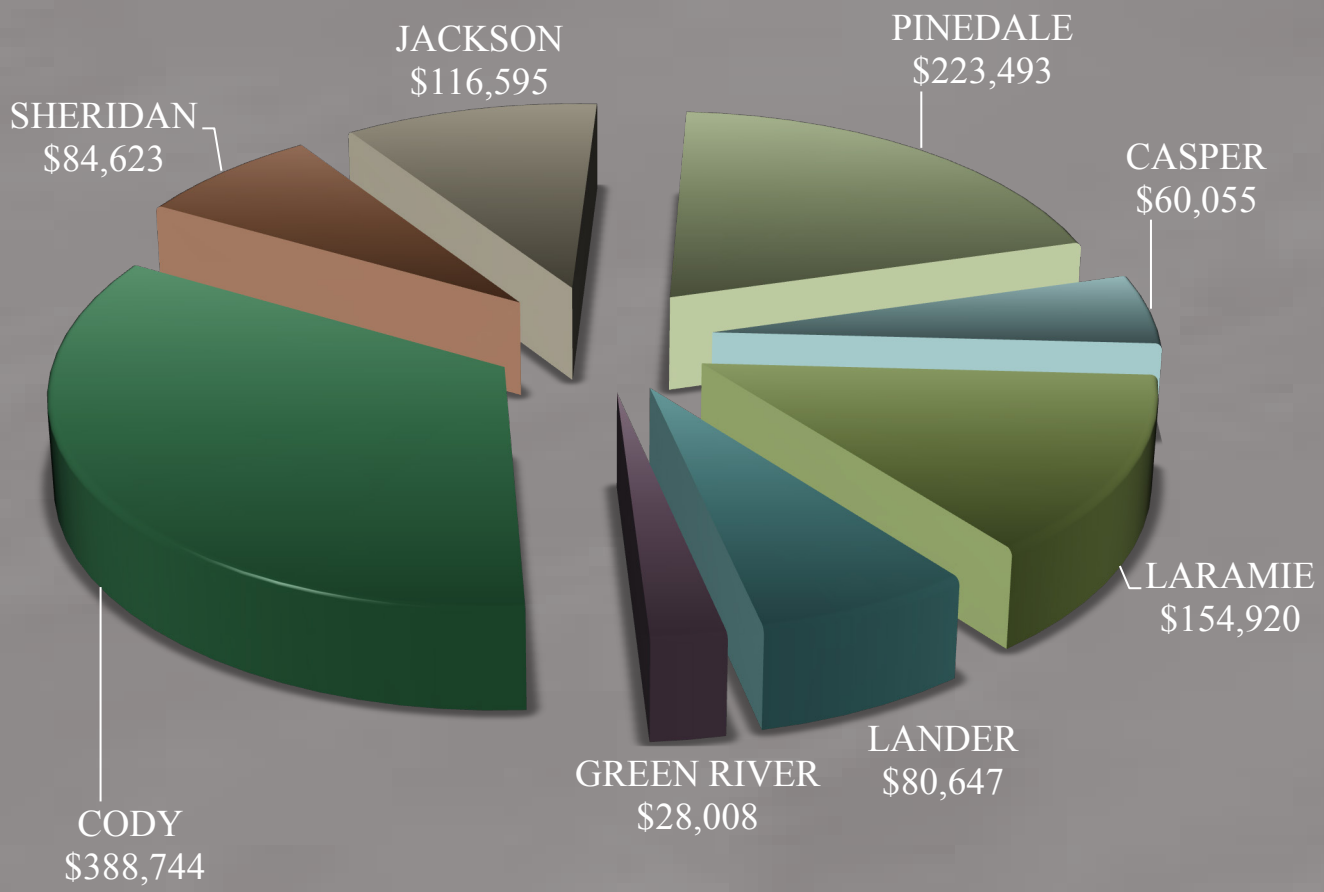
10-YEAR SUMMARY OF PREVENTION, HANDLING AND ADMINISTRATION COSTS



10-YEAR SUMMARY TOTAL DAMAGE PROGRAM COSTS



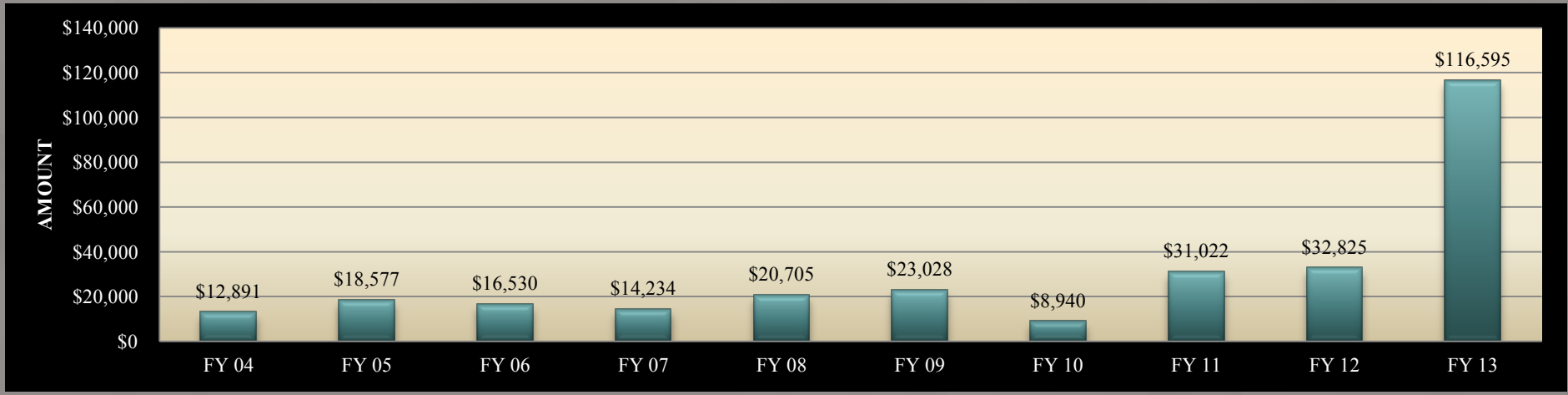
FY 13 AMOUNT, PERCENTAGE AND NUMBER OF CLAIMS PAID BY REGION

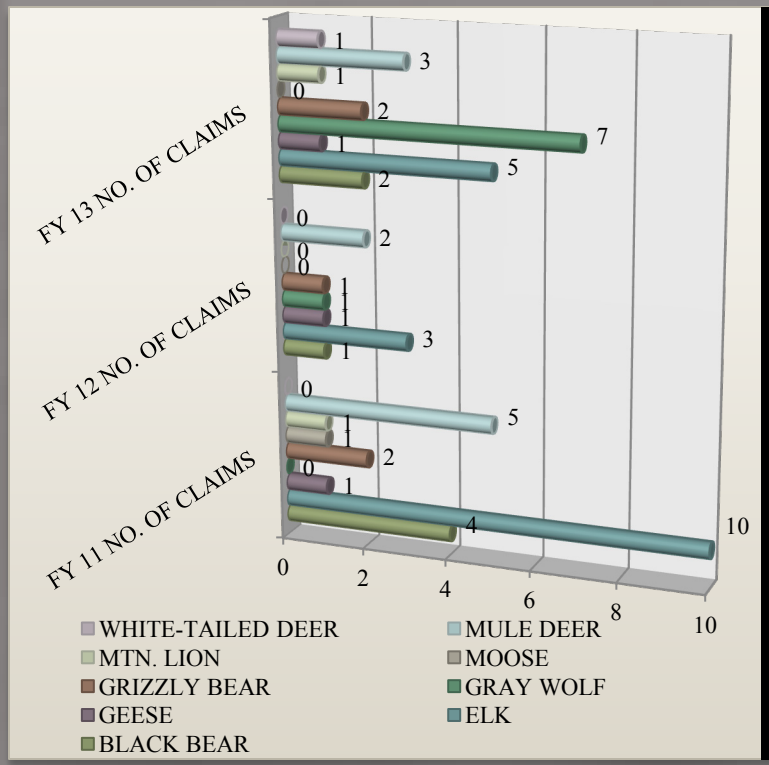


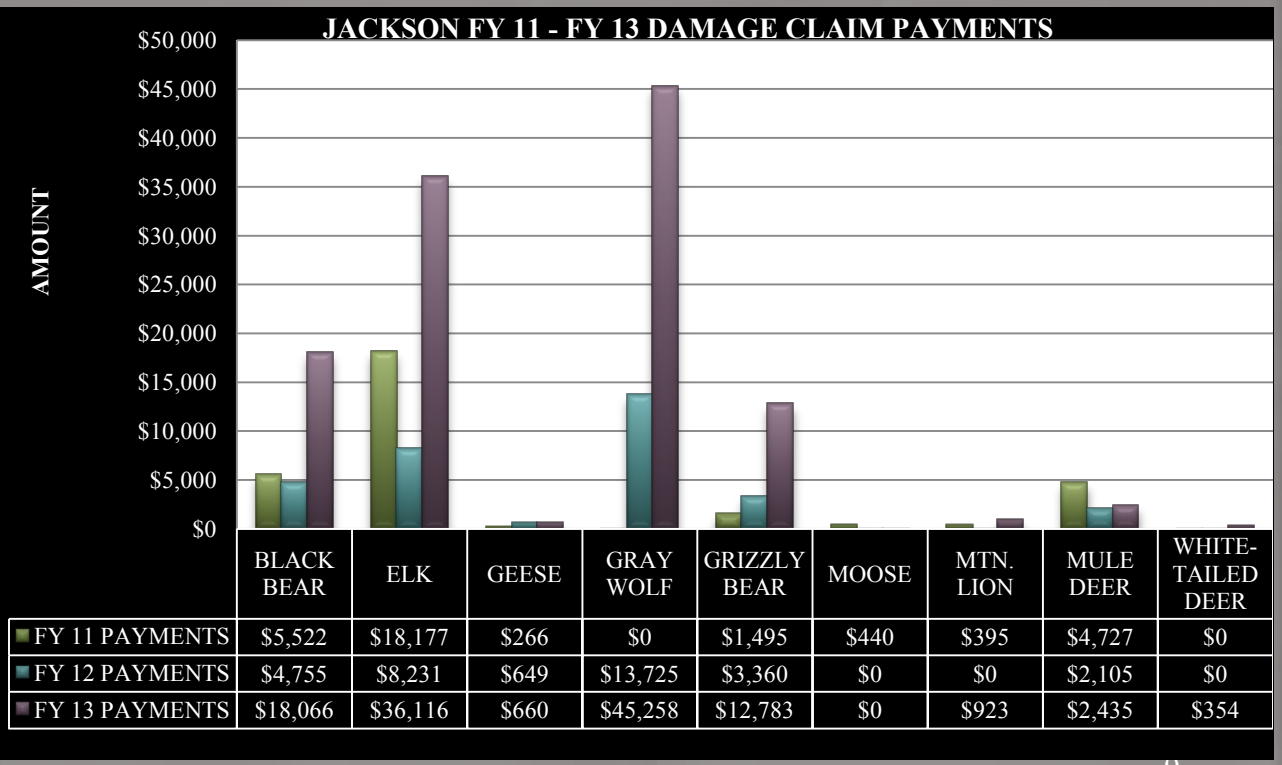
REGION	AMOUNT PAID	PERCENTAGE	NUMBER OF CLAIMS
JACKSON	$116,595	10%	14
CODY	$388,744	34%	76
SHERIDAN	$84,623	7%	21
GREEN RIVER	$28,008*	3%	13
LARAMIE	$154,920	14%	24
LANDER	$80,647	7%	12
CASPER	$60,055	5%	21
PINEDALE	$223,493	20%	27
TOTAL FY 13 DAMAGE AMOUNT PAID	**$1,137,085**		**208**

* This amount paid figure includes a Department approved payment for $765.00 that, as of this report date, is pending action from the claimant.

JACKSON REGION

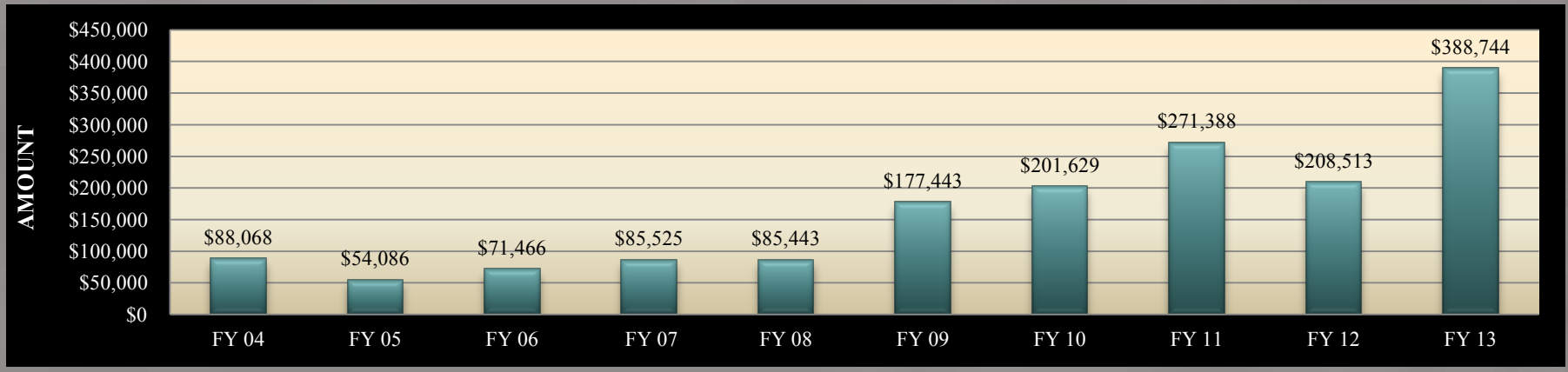


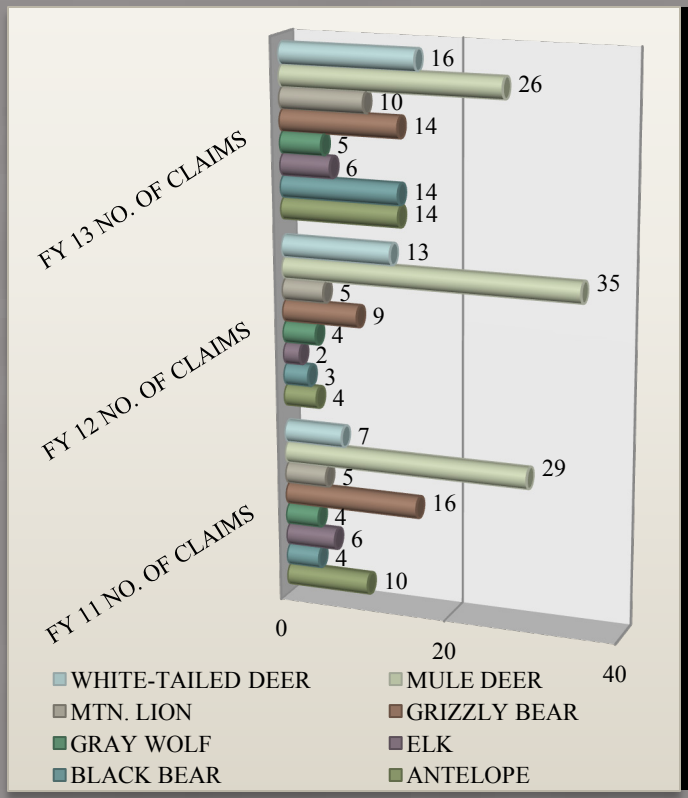


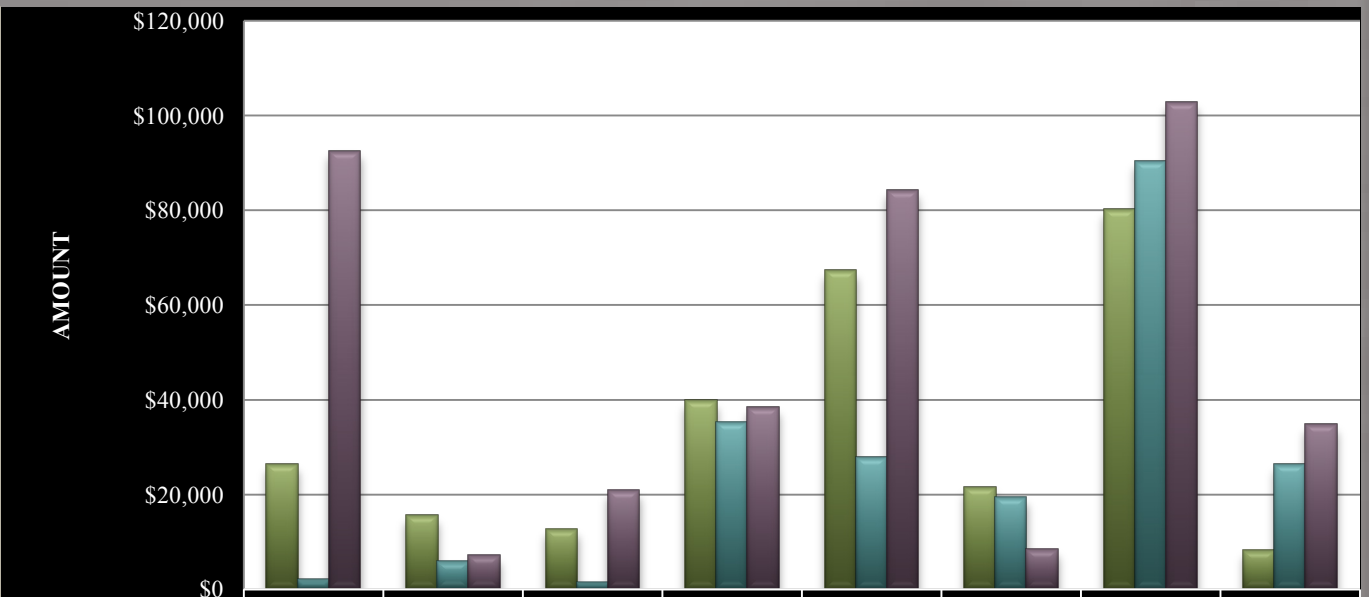


	BLACK BEAR	ELK	GEESE	GRAY WOLF	GRIZZLY BEAR	MOOSE	MTN. LION	MULE DEER	WHITE-TAILED DEER
FY 11 PAYMENTS	$5,522	$18,177	$266	$0	$1,495	$440	$395	$4,727	$0
FY 12 PAYMENTS	$4,755	$8,231	$649	$13,725	$3,360	$0	$0	$2,105	$0
FY 13 PAYMENTS	$18,066	$36,116	$660	$45,258	$12,783	$0	$923	$2,435	$354

CODY REGION

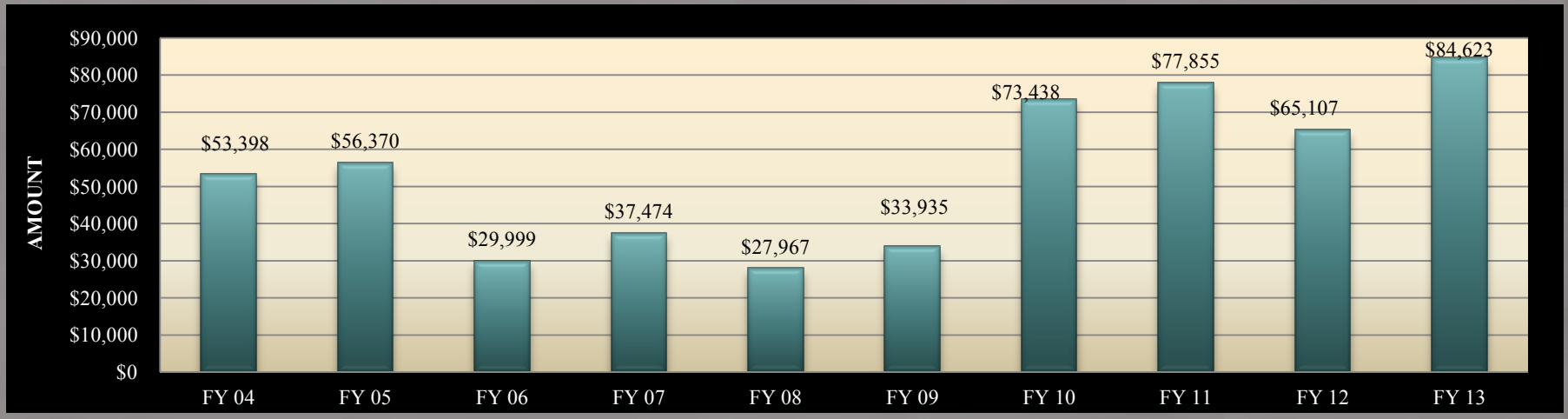


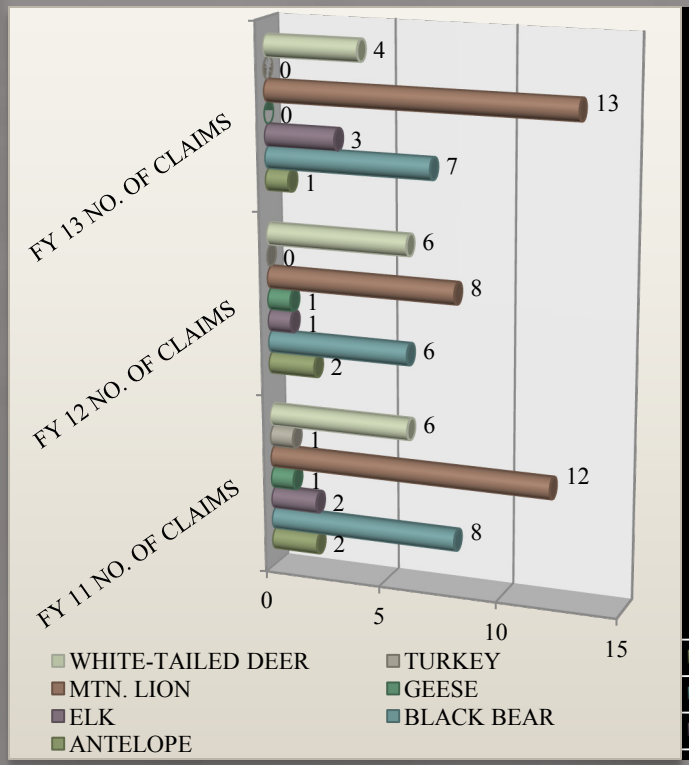


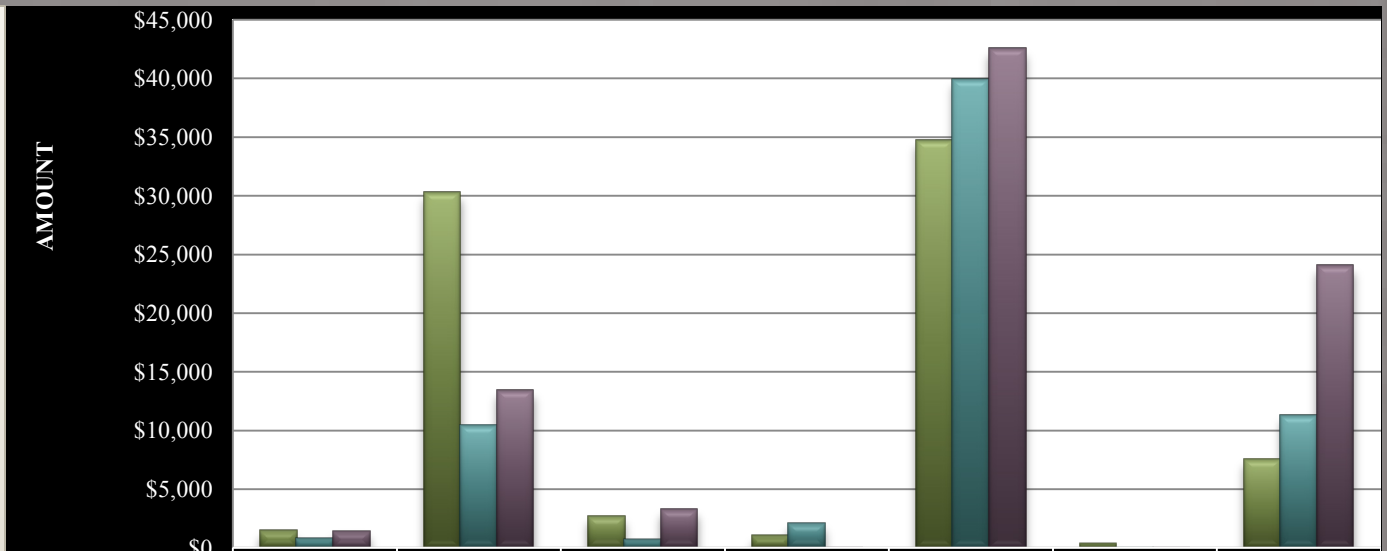


	ANTELOPE	BLACK BEAR	ELK	GRAY WOLF	GRIZZLY BEAR	MTN. LION	MULE DEER	WHITE-TAILED DEER
FY 11 PAYMENTS	$26,357	$15,553	$12,716	$39,781	$67,179	$21,505	$80,096	$8,201
FY 12 PAYMENTS	$2,147	$5,821	$1,436	$35,168	$27,853	$19,446	$90,300	$26,342
FY 13 PAYMENTS	$92,388	$7,086	$20,733	$38,420	$84,122	$8,433	$102,823	$34,739

SHERIDAN REGION

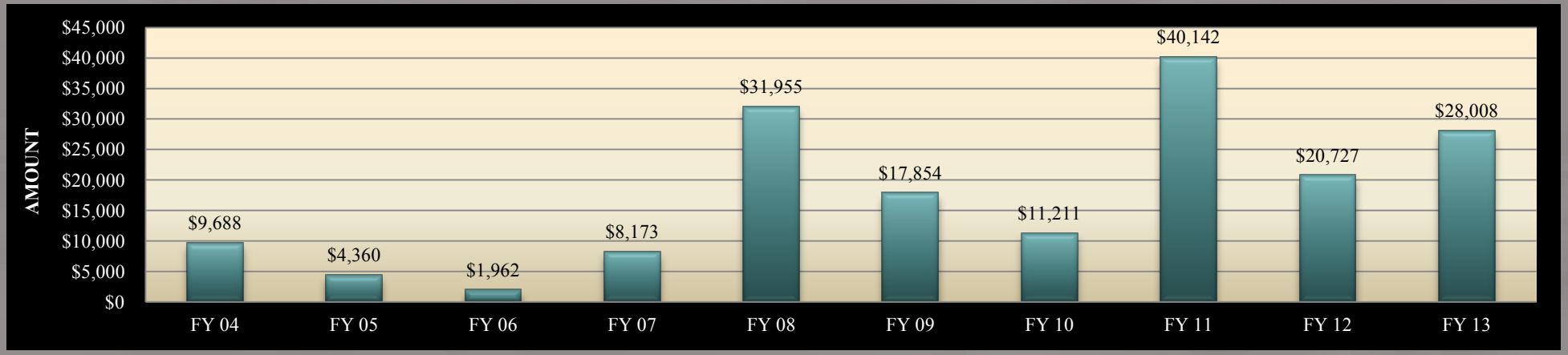


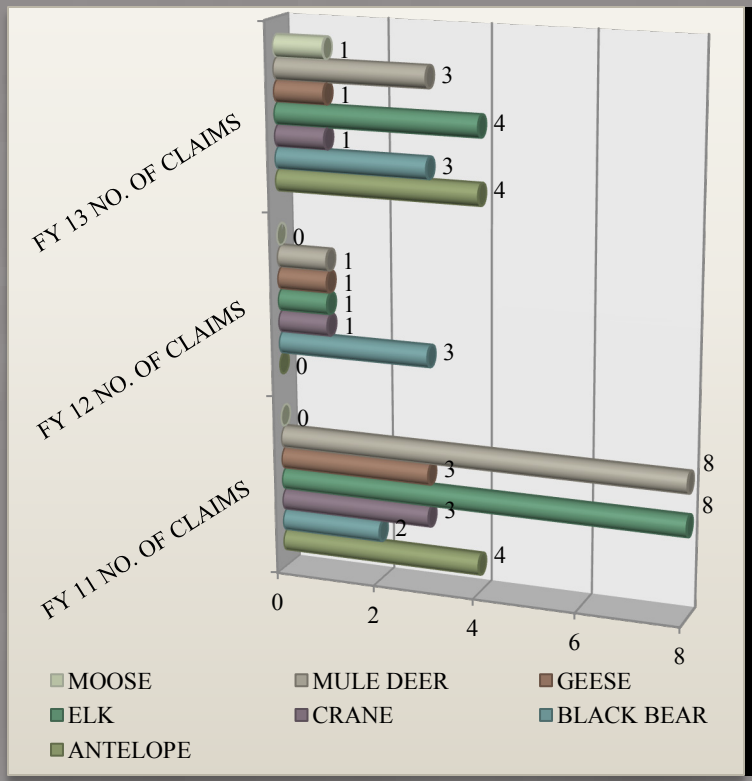


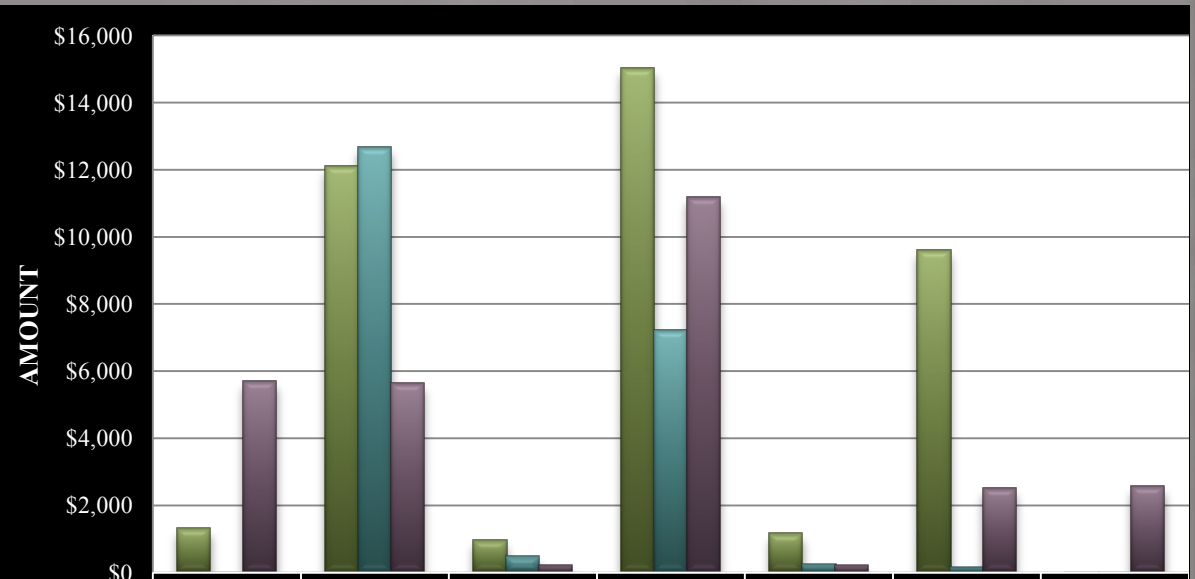


	ANTELOPE	BLACK BEAR	ELK	GEESE	MTN. LION	TURKEY	WHITE-TAILED DEER
FY 11 PAYMENTS	$1,419	$30,263	$2,650	$984	$34,690	$340	$7,509
FY 12 PAYMENTS	$805	$10,387	$656	$2,074	$39,901	$0	$11,284
FY 13 PAYMENTS	$1,400	$13,416	$3,274	$0	$42,511	$0	$24,022

GREEN RIVER REGION

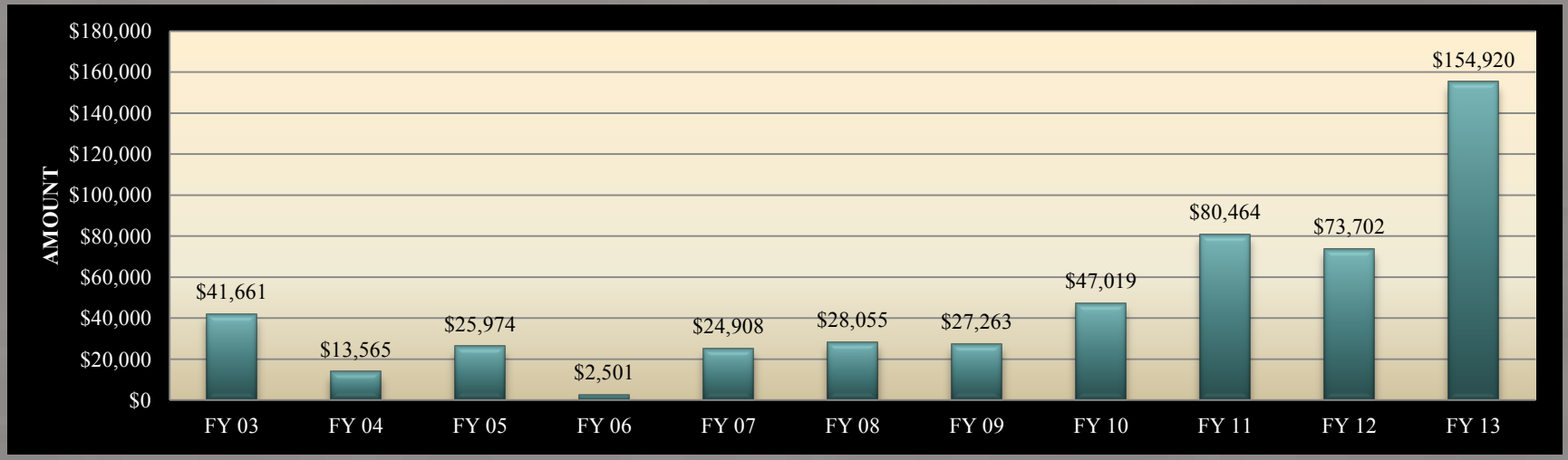


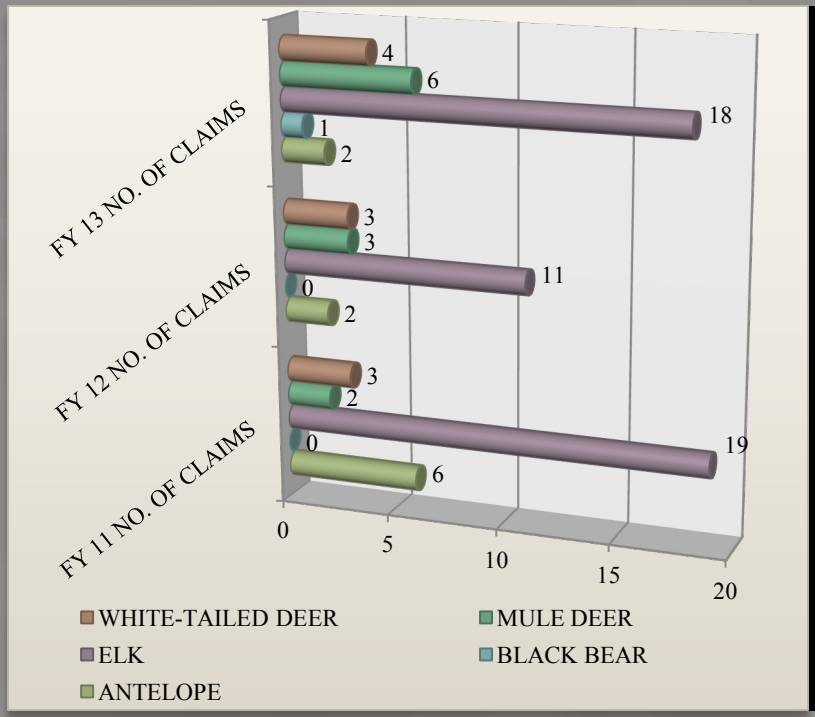


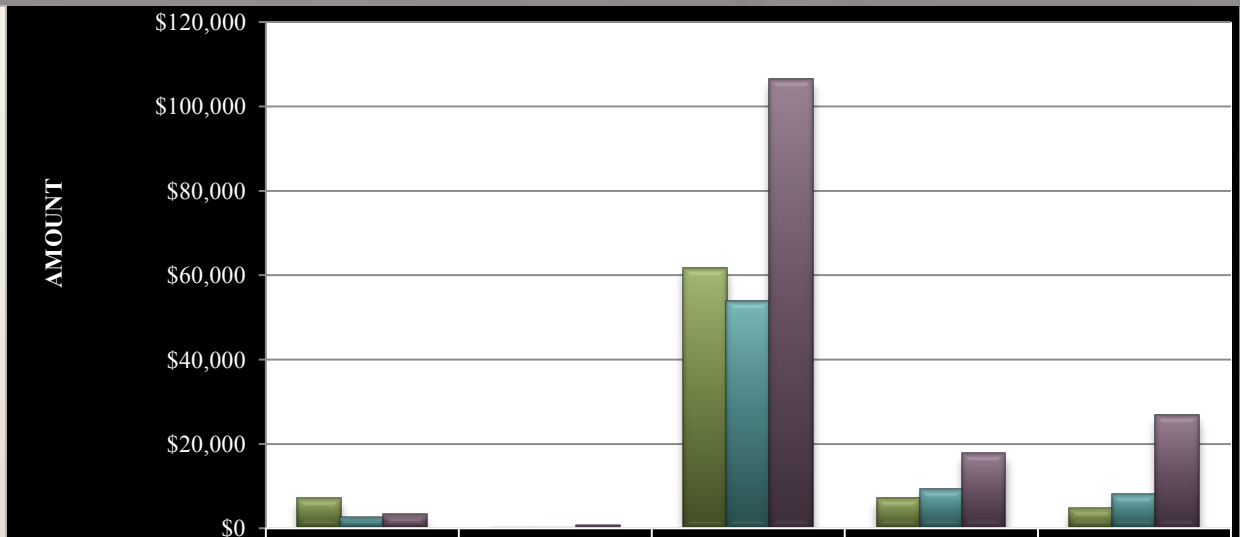


	ANTELOPE	BLACK BEAR	CRANE	ELK	GEESE	MULE DEER	MOOSE
FY11 PAYMENTS	$1,307	$12,105	$964	$15,018	$1,149	$9,599	$0
FY12 PAYMENTS	$0	$12,660	$479	$7,200	$239	$149	$0
FY 13 PAYMENTS	$5,696	$5,629	$215	$11,169	$211	$2,518	$2,570

LARAMIE REGION

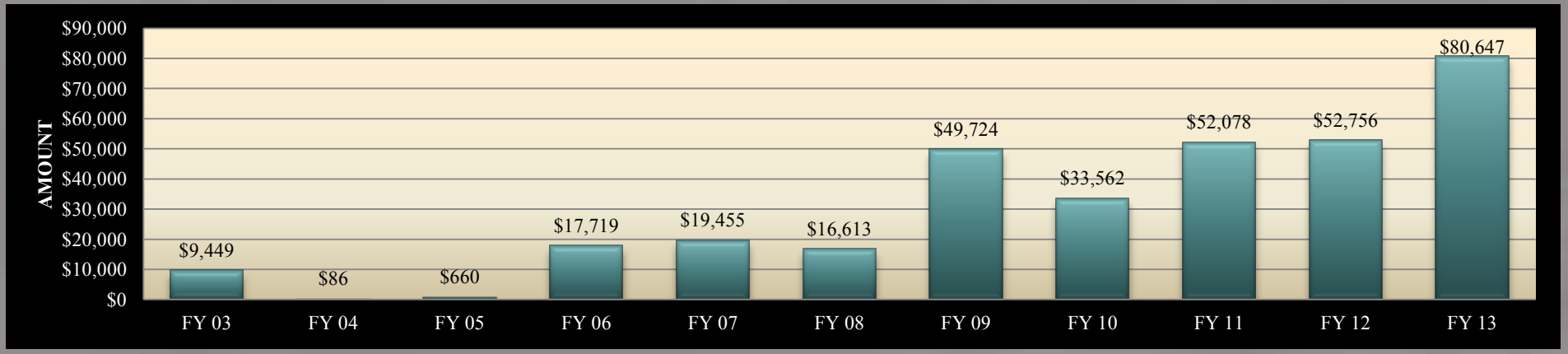


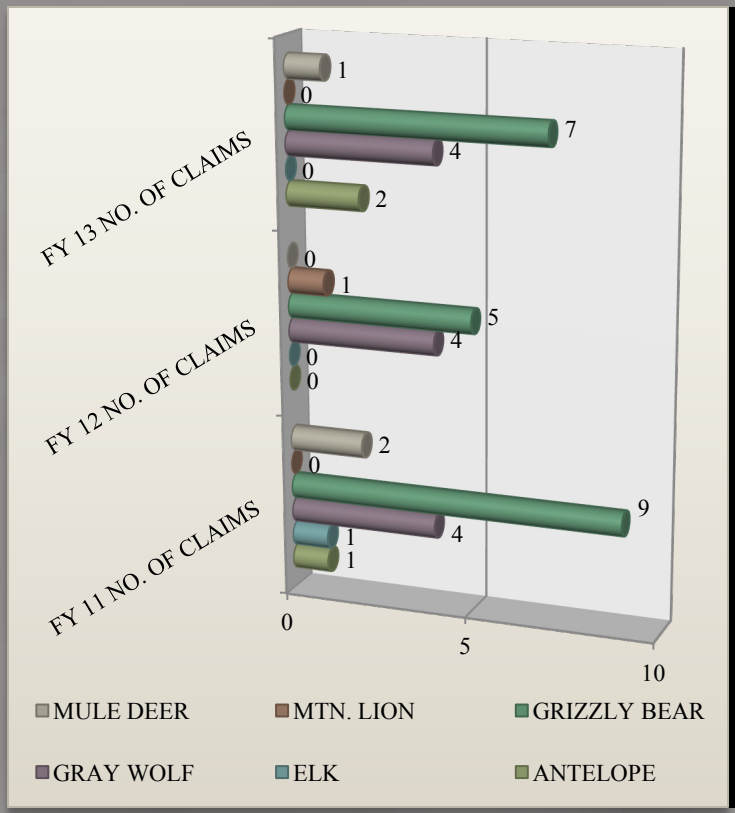


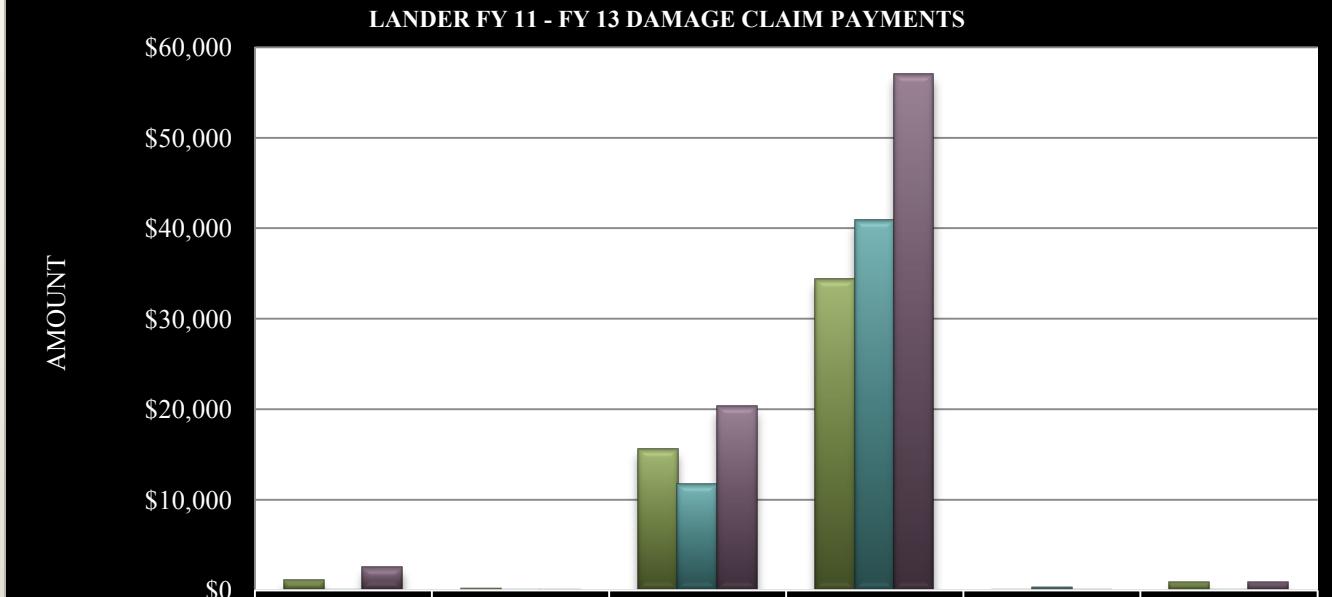


	ANTELOPE	BLACK BEAR	ELK	MULE DEER	WHITE-TAILED DEER
FY 11 PAYMENTS	$7,087	$0	$61,552	$7,198	$4,627
FY 12 PAYMENTS	$2,554	$0	$53,824	$9,311	$8,013
FY 13 PAYMENTS	$3,205	$765	$106,376	$17,689	$26,885

LANDER REGION

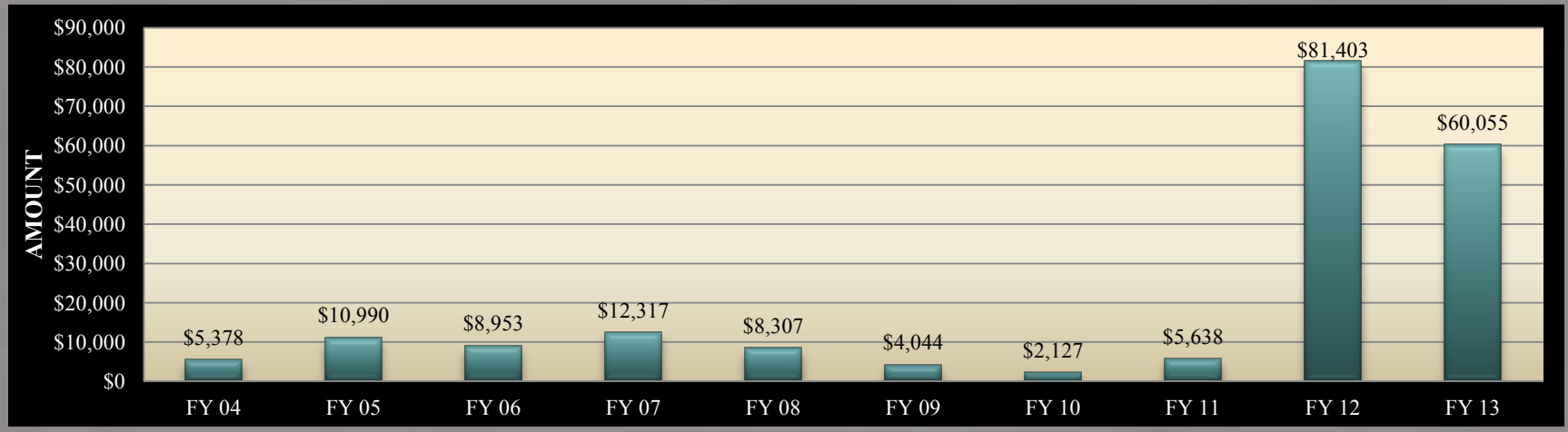


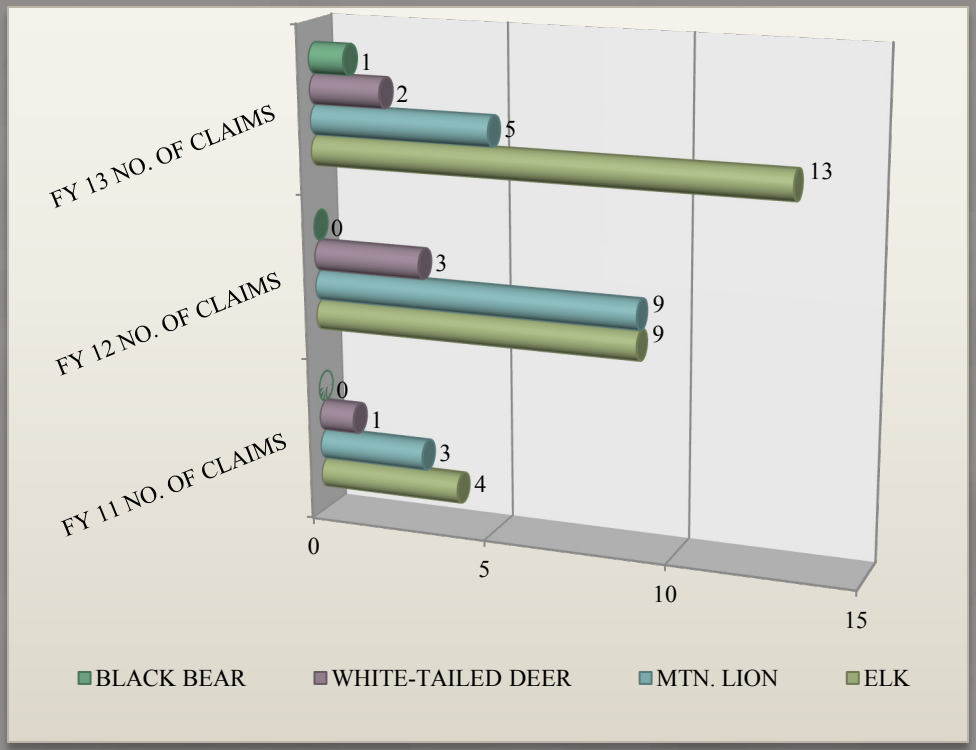


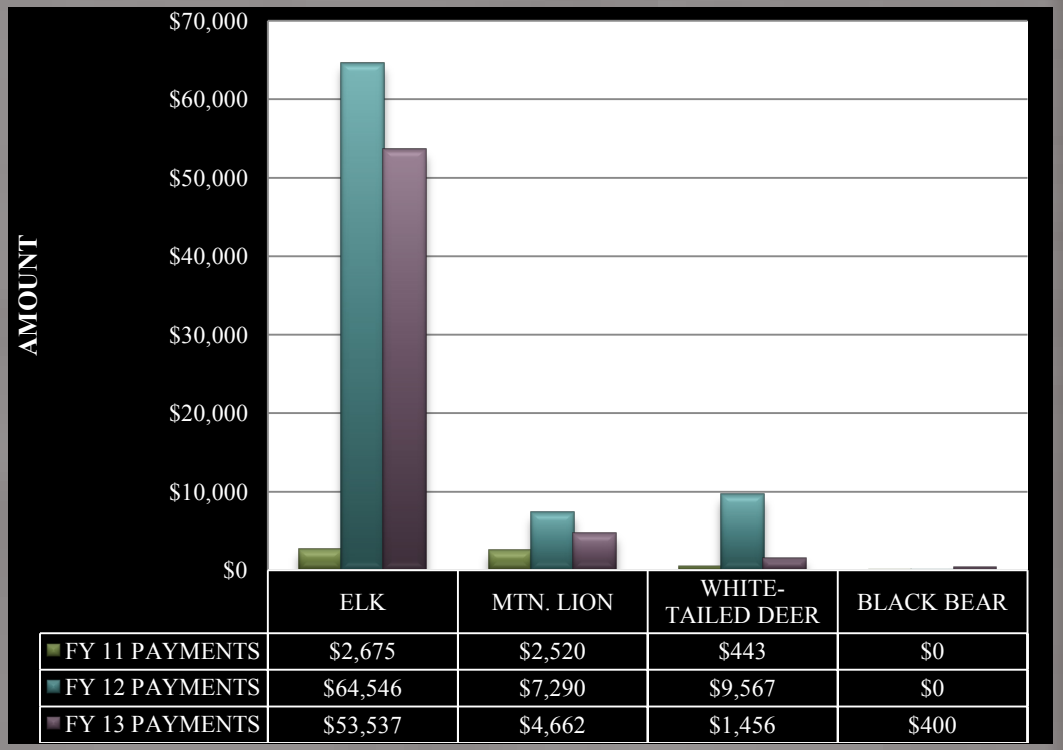


	ANTELOPE	ELK	GRAY WOLF	GRIZZLY BEAR	MTN. LION	MULE DEER
FY 11 PAYMENTS	$1,138	$150	$15,545	$34,377	$0	$868
FY 12 PAYMENTS	$0	$0	$11,636	$40,850	$270	$0
FY 13 PAYMENTS	$2,513	$0	$20,245	$56,998	$0	$891

CASPER REGION

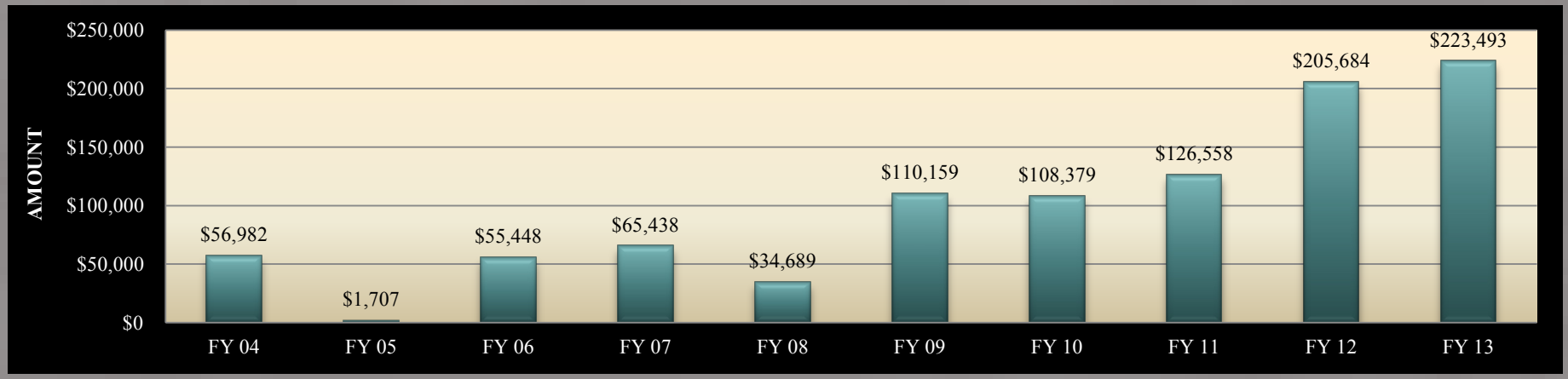


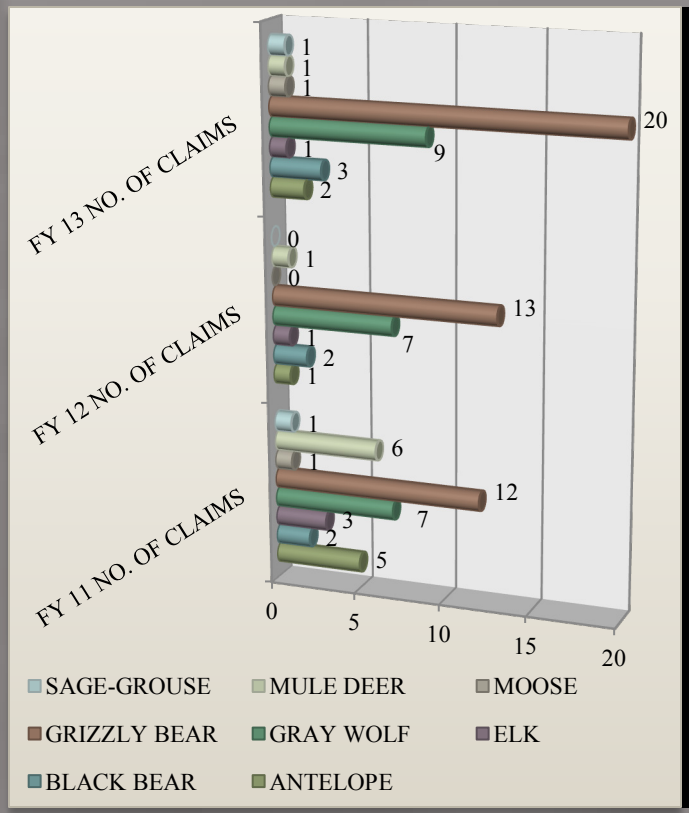


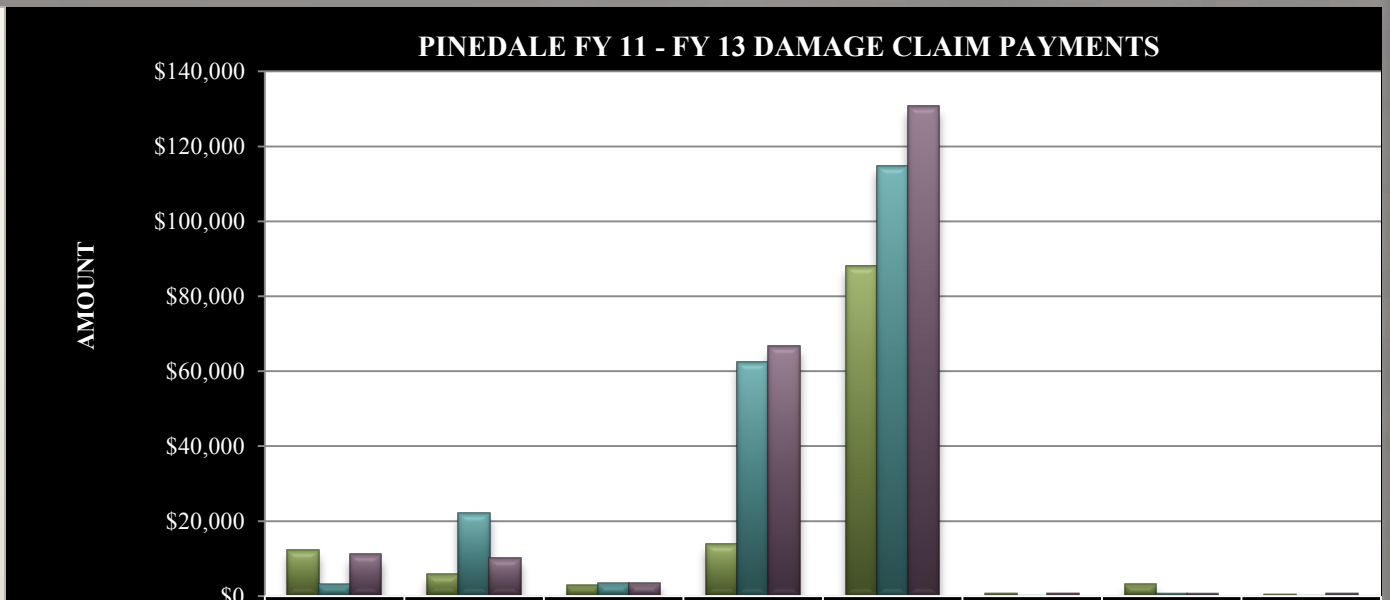


	ELK	MTN. LION	WHITE-TAILED DEER	BLACK BEAR
FY 11 PAYMENTS	$2,675	$2,520	$443	$0
FY 12 PAYMENTS	$64,546	$7,290	$9,567	$0
FY 13 PAYMENTS	$53,537	$4,662	$1,456	$400

PINEDALE REGION

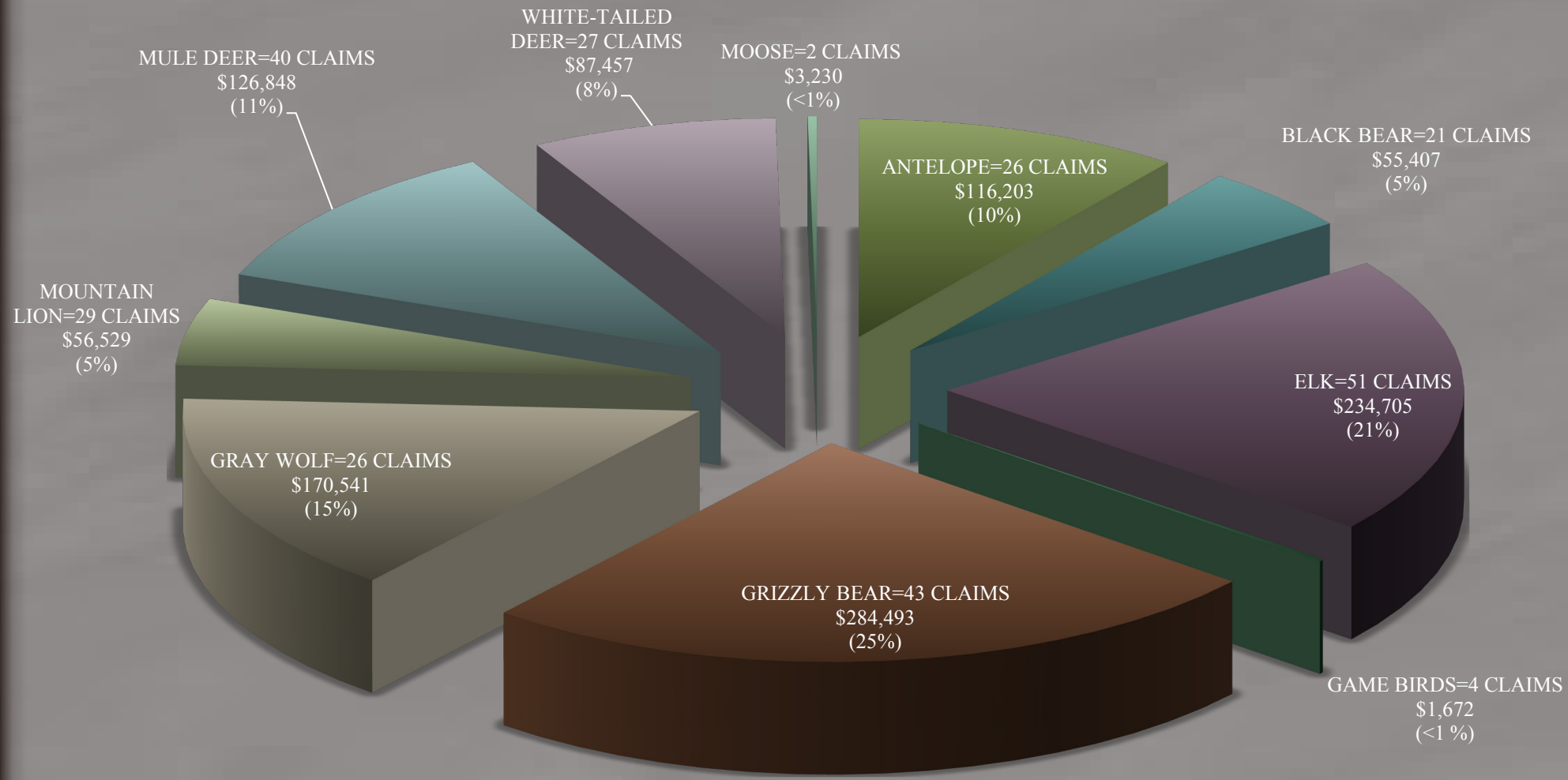






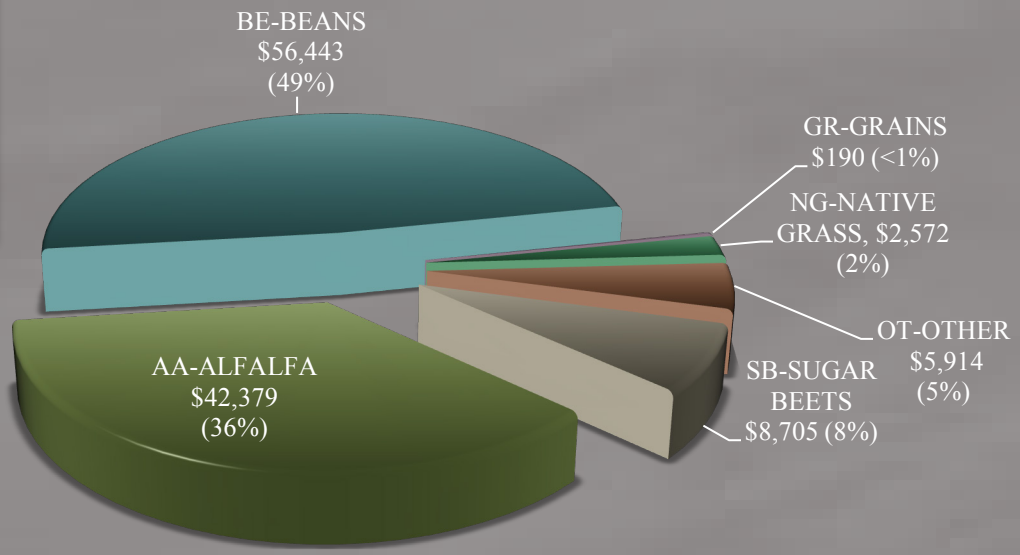
	ANTELOPE	BLACK BEAR	ELK	GRAY WOLF	GRIZZLY BEAR	MOOSE	MULE DEER	SAGE-GROUSE
FY 11 PAYMENTS	$12,130	$5,654	$2,731	$13,895	$88,081	$530	$3,153	$384
FY 12 PAYMENTS	$2,927	$21,978	$3,295	$62,434	$114,576	$0	$474	$0
FY 13 PAYMENTS	$11,002	$10,045	$3,500	$66,617	$130,591	$660	$492	$586

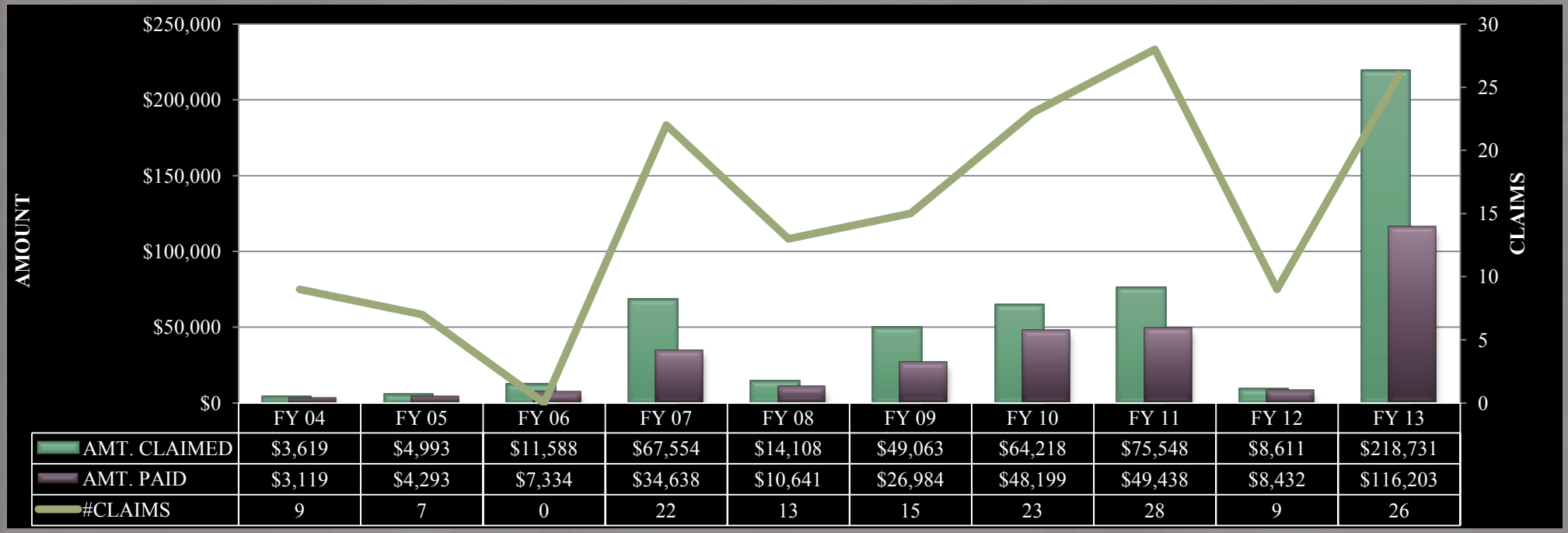
FY 13 AMOUNT AND PERCENTAGE OF CLAIMS PAID PER SPECIES



ANTELOPE

- 10-YEAR DAMAGE SUMMARY
- FY 13 PERCENTAGE OF DAMAGE BY CATEGORY

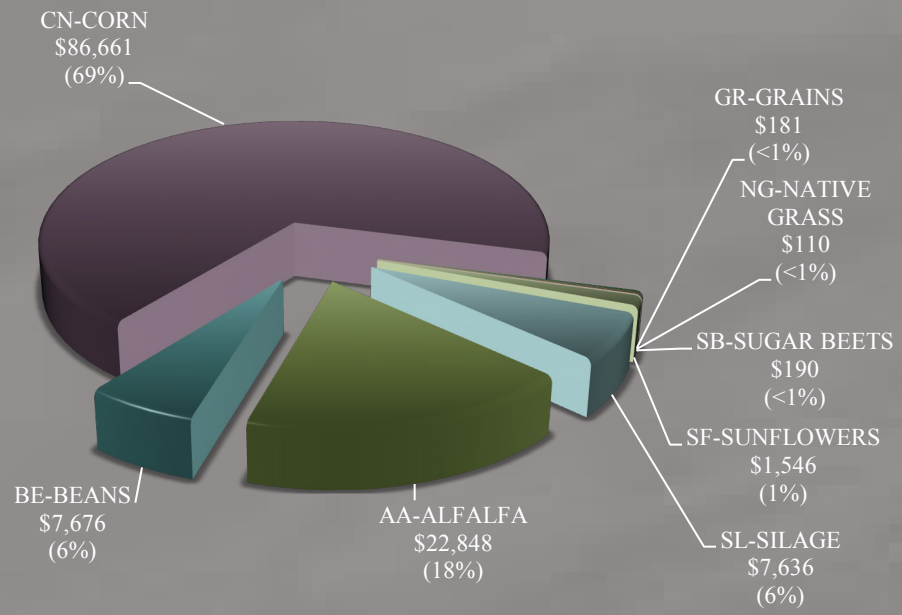


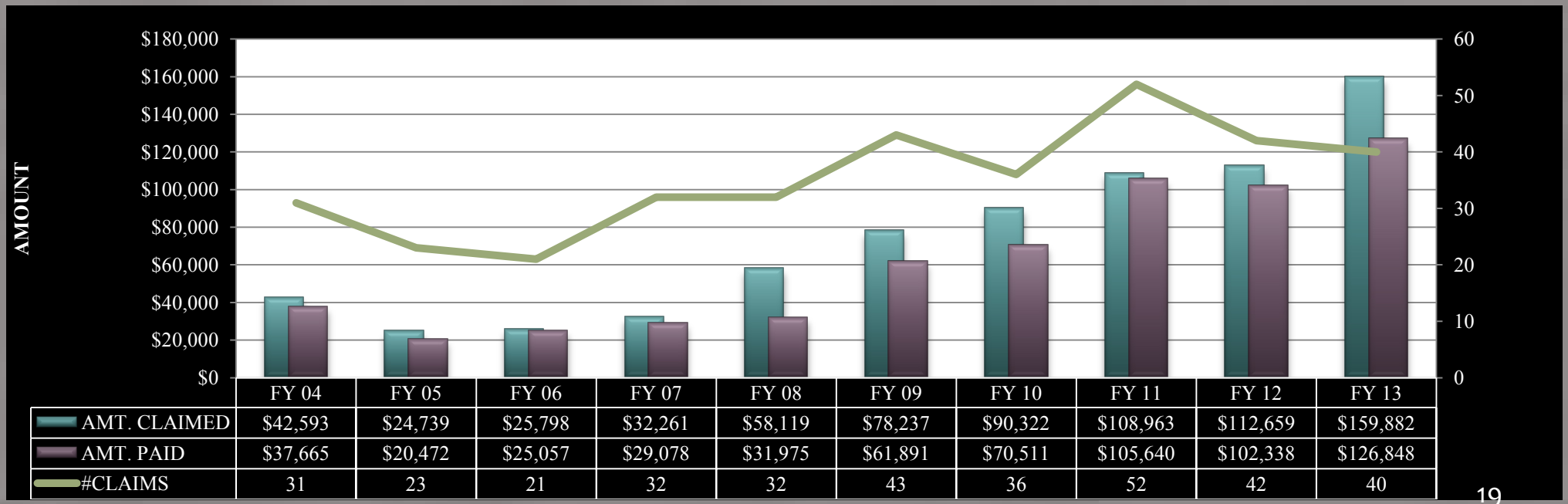


	FY 04	FY 05	FY 06	FY 07	FY 08	FY 09	FY 10	FY 11	FY 12	FY 13
AMT. CLAIMED	$3,619	$4,993	$11,588	$67,554	$14,108	$49,063	$64,218	$75,548	$8,611	$218,731
AMT. PAID	$3,119	$4,293	$7,334	$34,638	$10,641	$26,984	$48,199	$49,438	$8,432	$116,203
#CLAIMS	9	7	0	22	13	15	23	28	9	26

MULE DEER

- 10-YEAR DAMAGE SUMMARY
- FY 13 PERCENTAGE OF DAMAGE BY CATEGORY

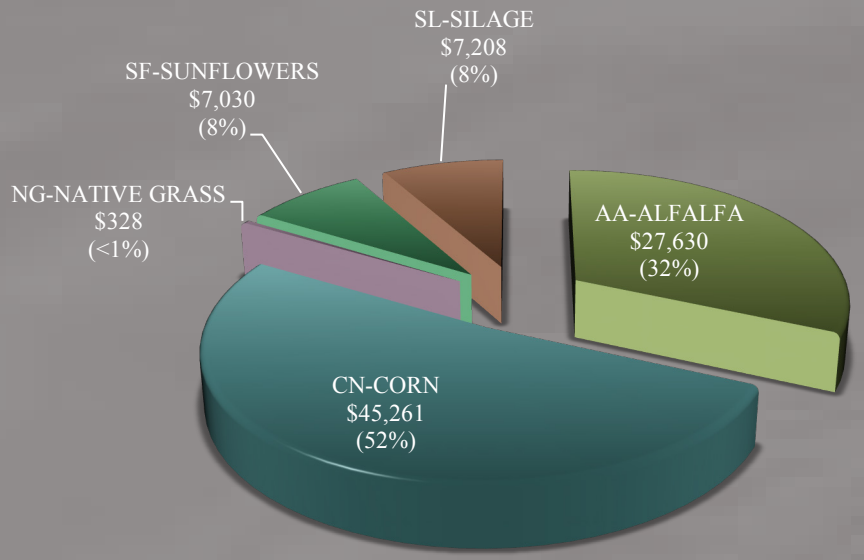


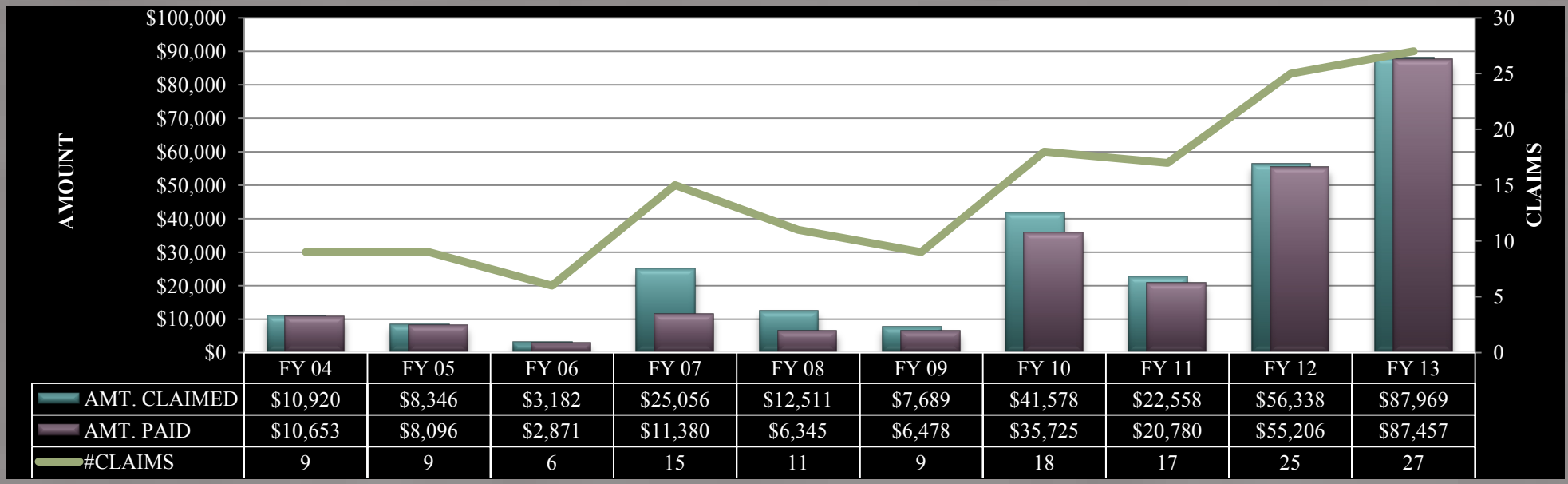


	FY 04	FY 05	FY 06	FY 07	FY 08	FY 09	FY 10	FY 11	FY 12	FY 13
AMT. CLAIMED	$42,593	$24,739	$25,798	$32,261	$58,119	$78,237	$90,322	$108,963	$112,659	$159,882
AMT. PAID	$37,665	$20,472	$25,057	$29,078	$31,975	$61,891	$70,511	$105,640	$102,338	$126,848
#CLAIMS	31	23	21	32	32	43	36	52	42	40

WHITE-TAILED DEER

- 10-YEAR DAMAGE SUMMARY
- FY 13 PERCENTAGE OF DAMAGE BY CATEGORY

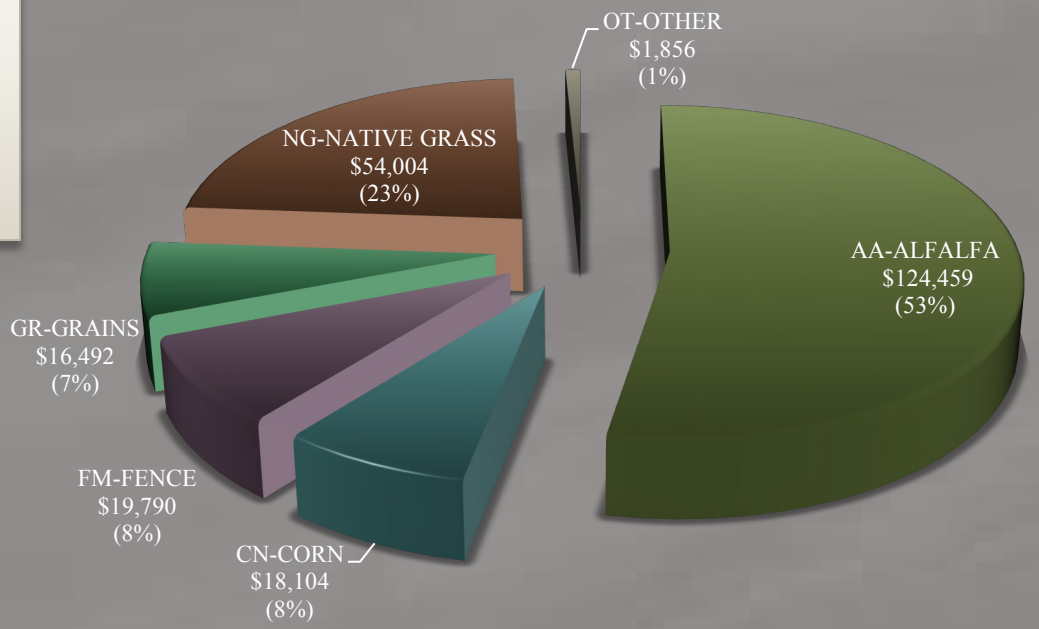


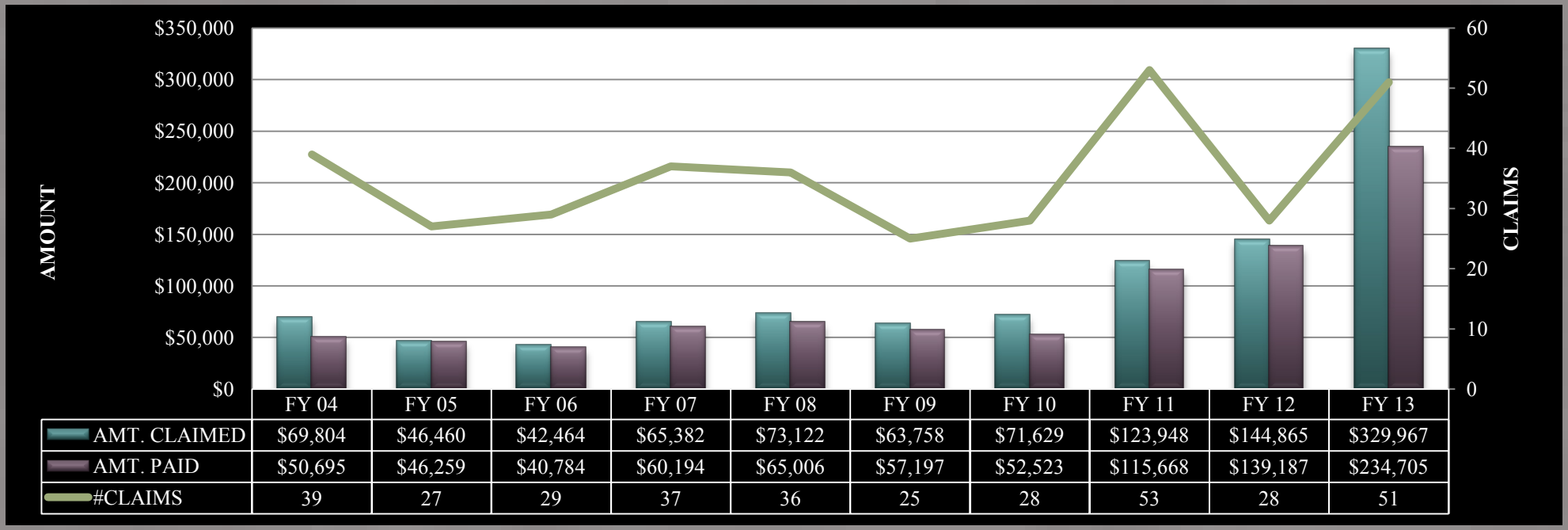


	FY 04	FY 05	FY 06	FY 07	FY 08	FY 09	FY 10	FY 11	FY 12	FY 13
AMT. CLAIMED	$10,920	$8,346	$3,182	$25,056	$12,511	$7,689	$41,578	$22,558	$56,338	$87,969
AMT. PAID	$10,653	$8,096	$2,871	$11,380	$6,345	$6,478	$35,725	$20,780	$55,206	$87,457
#CLAIMS	9	9	6	15	11	9	18	17	25	27

ELK

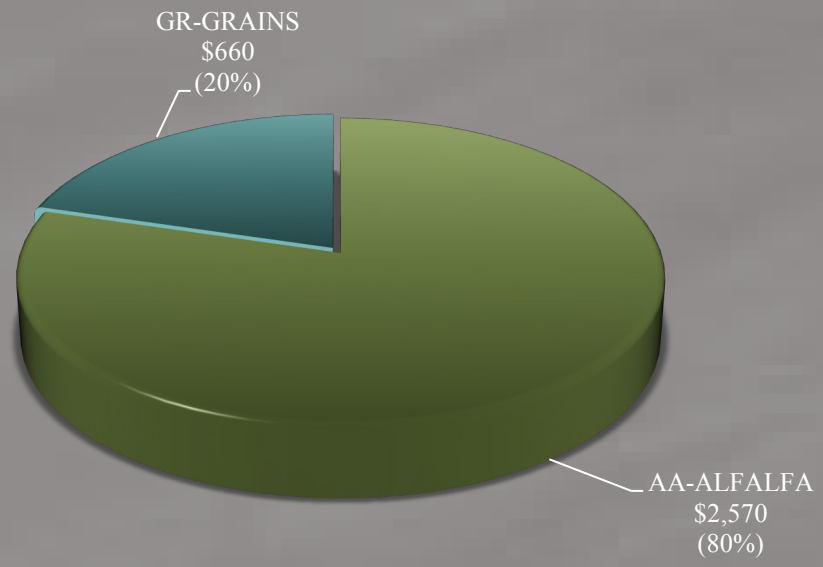
- 10-YEAR DAMAGE SUMMARY
- FY 13 PERCENTAGE OF DAMAGE BY CATEGORY





	FY 04	FY 05	FY 06	FY 07	FY 08	FY 09	FY 10	FY 11	FY 12	FY 13
AMT. CLAIMED	$69,804	$46,460	$42,464	$65,382	$73,122	$63,758	$71,629	$123,948	$144,865	$329,967
AMT. PAID	$50,695	$46,259	$40,784	$60,194	$65,006	$57,197	$52,523	$115,668	$139,187	$234,705
#CLAIMS	39	27	29	37	36	25	28	53	28	51

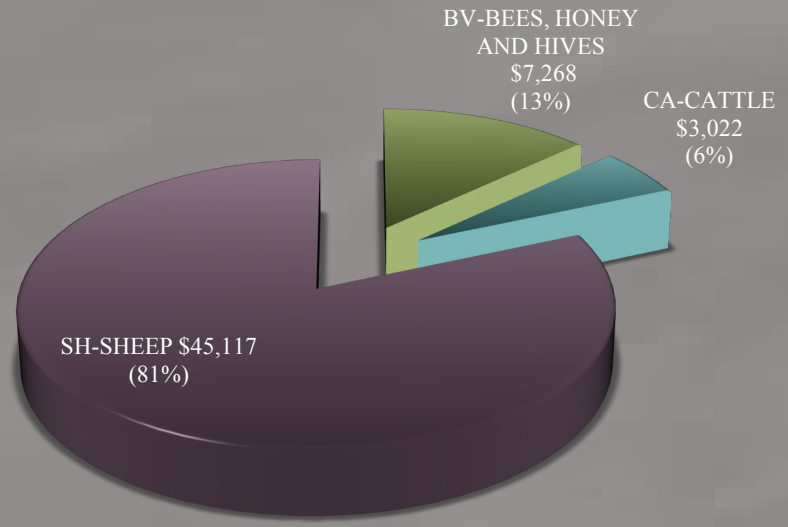
MOOSE
- 10-YEAR DAMAGE SUMMARY
- FY 13 PERCENTAGE OF DAMAGE BY CATEGORY

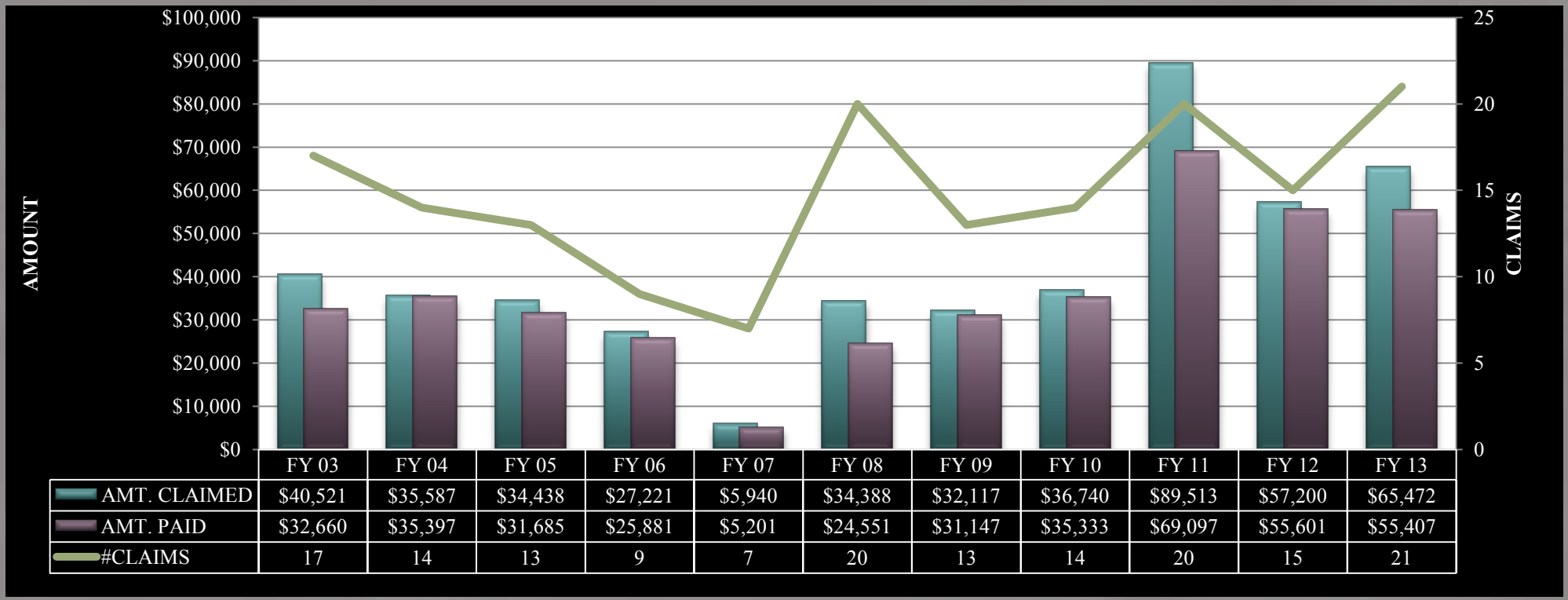


	FY 04	FY 05	FY 06	FY 07	FY 08	FY 09	FY 10	FY 11	FY 12	FY 13
AMT. CLAIMED	$1,543	$85	$144	$0	$0	$0	$60	$970	$0	$3,230
AMT. PAID	$1,443	$64	$144	$0	$0	$0	$60	$970	$0	$3,230
#CLAIMS	6	1	1	0	0	0	1	2	0	2

BLACK BEAR

- 10-YEAR DAMAGE SUMMARY
- FY 13 PERCENTAGE OF DAMAGE BY CATEGORY

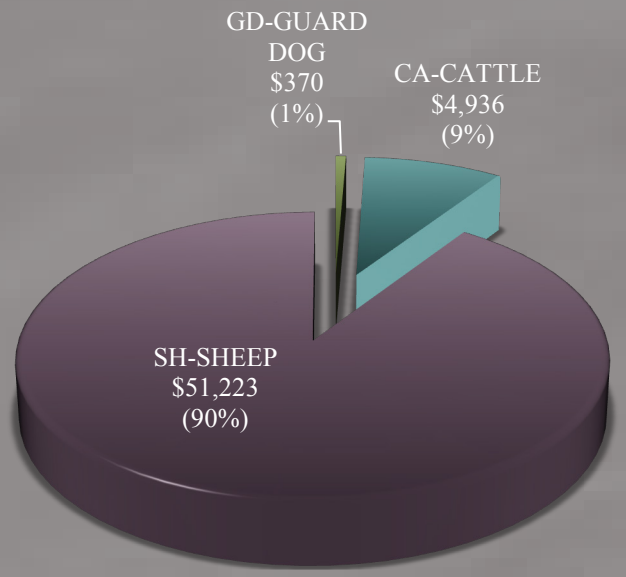


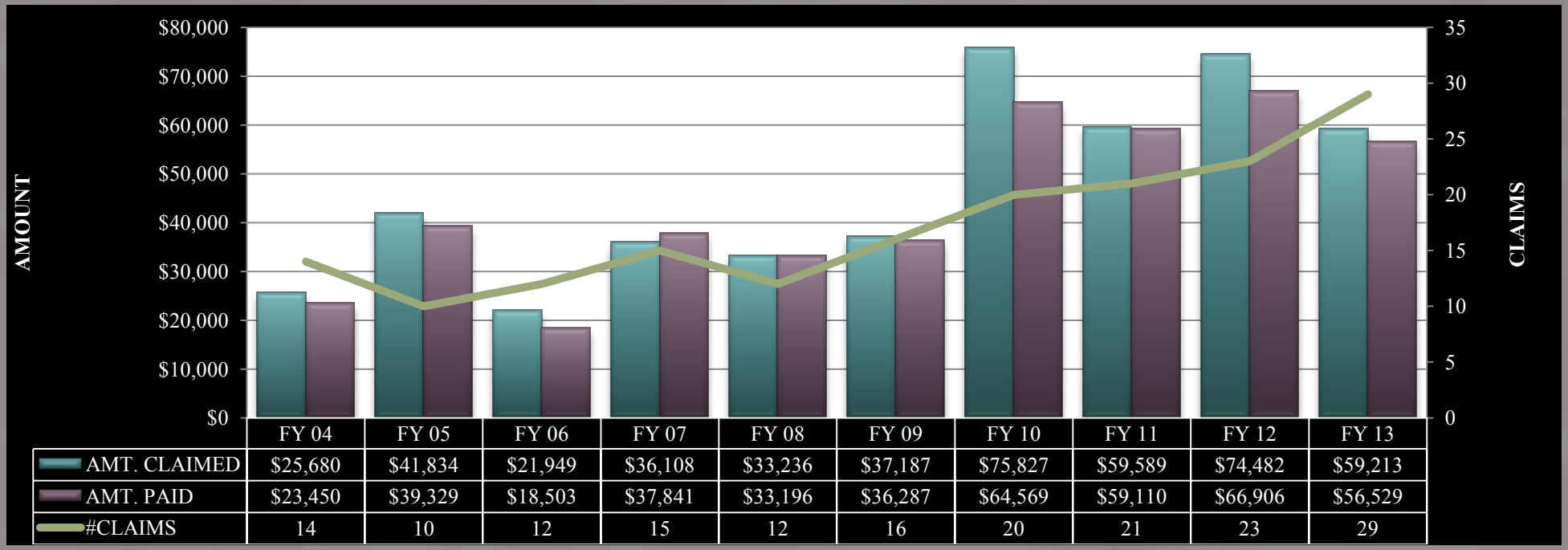


	FY 03	FY 04	FY 05	FY 06	FY 07	FY 08	FY 09	FY 10	FY 11	FY 12	FY 13
AMT. CLAIMED	$40,521	$35,587	$34,438	$27,221	$5,940	$34,388	$32,117	$36,740	$89,513	$57,200	$65,472
AMT. PAID	$32,660	$35,397	$31,685	$25,881	$5,201	$24,551	$31,147	$35,333	$69,097	$55,601	$55,407
#CLAIMS	17	14	13	9	7	20	13	14	20	15	21

MOUNTAIN LION

- 10-YEAR DAMAGE SUMMARY
- FY 13 PERCENTAGE OF DAMAGE BY CATEGORY

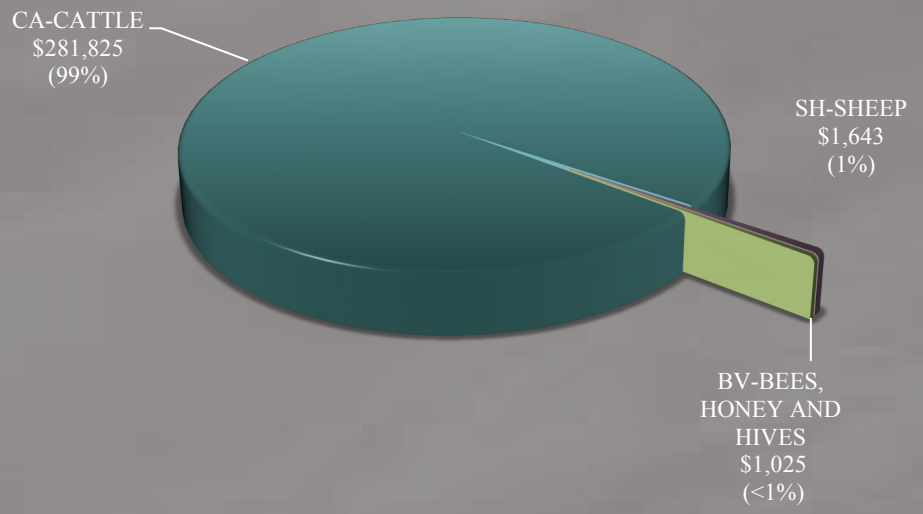


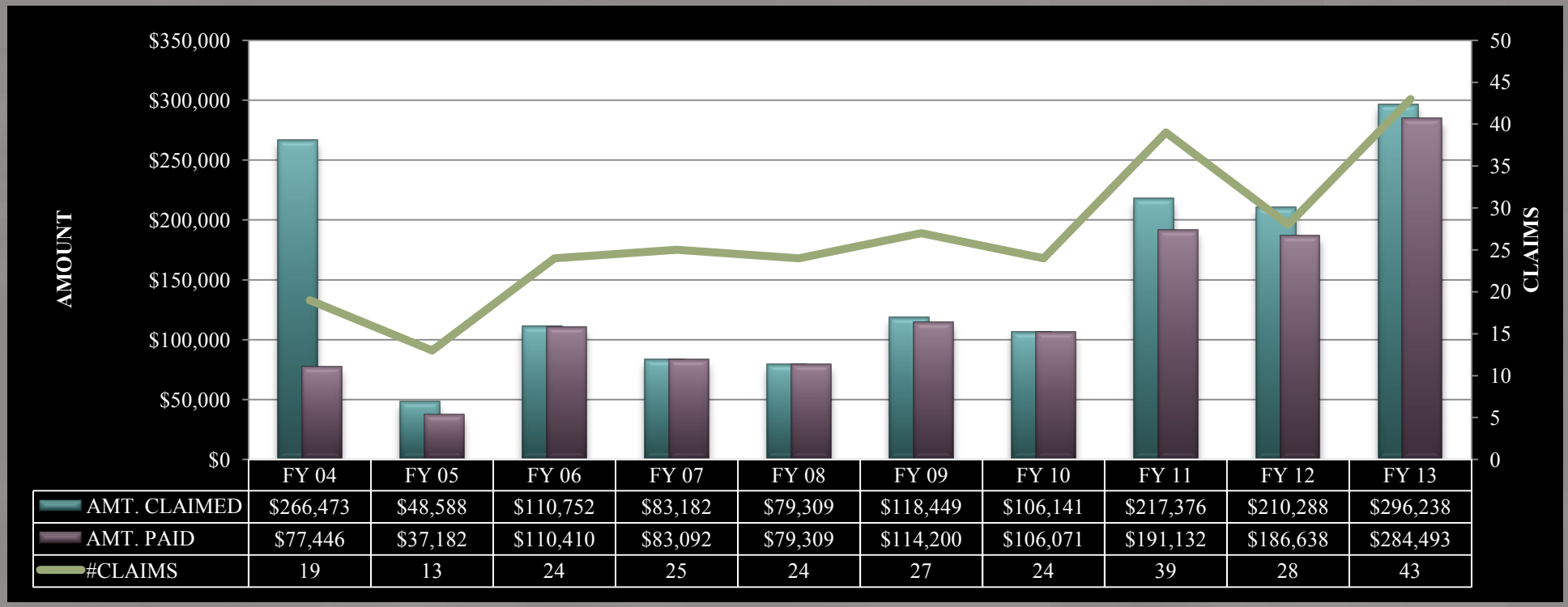


	FY 04	FY 05	FY 06	FY 07	FY 08	FY 09	FY 10	FY 11	FY 12	FY 13
AMT. CLAIMED	$25,680	$41,834	$21,949	$36,108	$33,236	$37,187	$75,827	$59,589	$74,482	$59,213
AMT. PAID	$23,450	$39,329	$18,503	$37,841	$33,196	$36,287	$64,569	$59,110	$66,906	$56,529
#CLAIMS	14	10	12	15	12	16	20	21	23	29

GRIZZLY BEAR

- 10-YEAR DAMAGE SUMMARY
- FY 13 PERCENTAGE OF DAMAGE BY CATEGORY

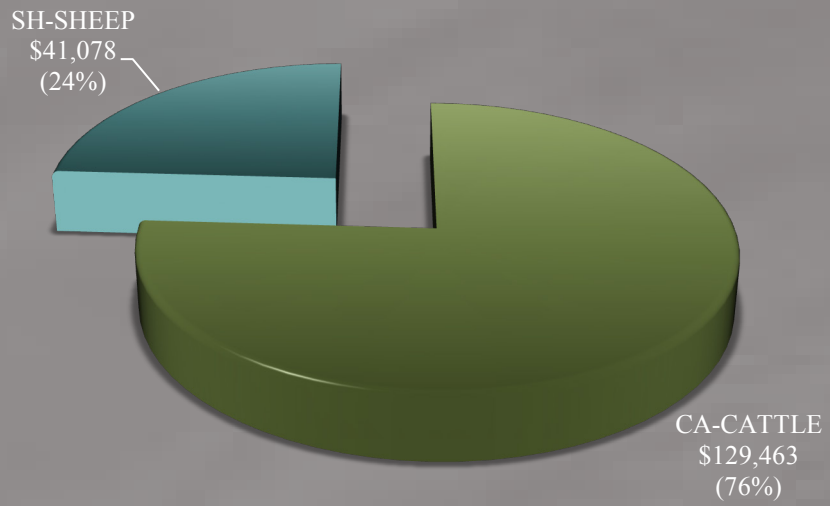


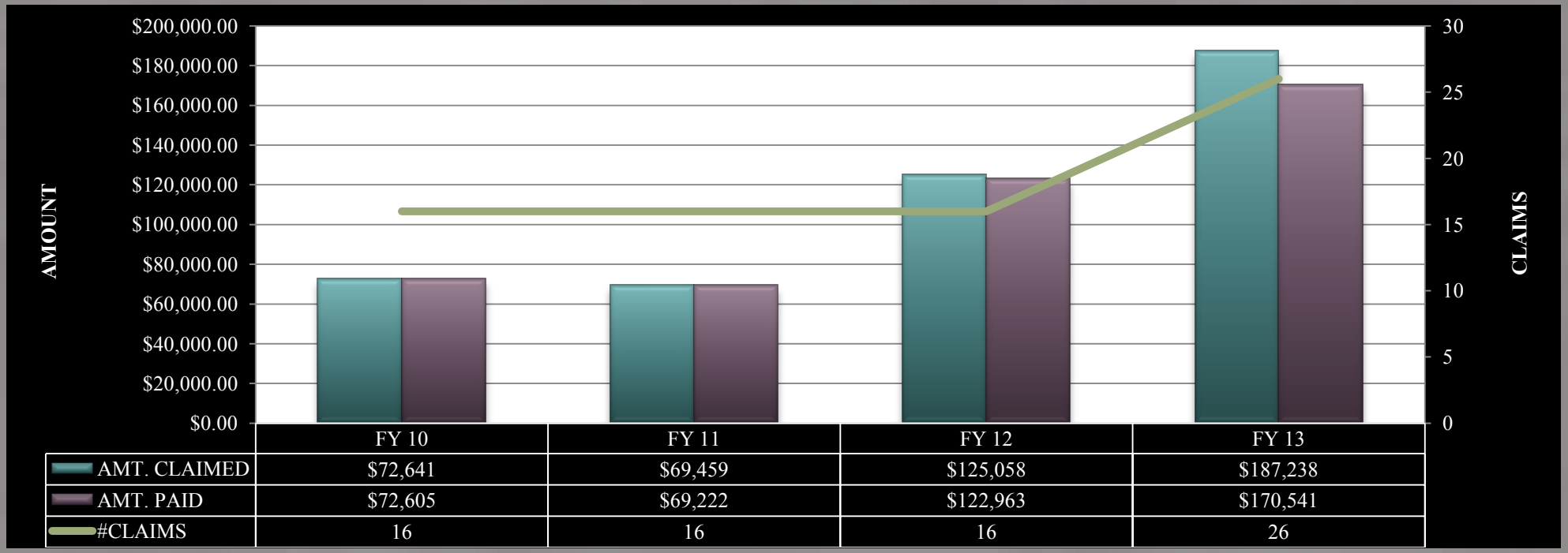


	FY 04	FY 05	FY 06	FY 07	FY 08	FY 09	FY 10	FY 11	FY 12	FY 13
AMT. CLAIMED	$266,473	$48,588	$110,752	$83,182	$79,309	$118,449	$106,141	$217,376	$210,288	$296,238
AMT. PAID	$77,446	$37,182	$110,410	$83,092	$79,309	$114,200	$106,071	$191,132	$186,638	$284,493
#CLAIMS	19	13	24	25	24	27	24	39	28	43

GRAY WOLF

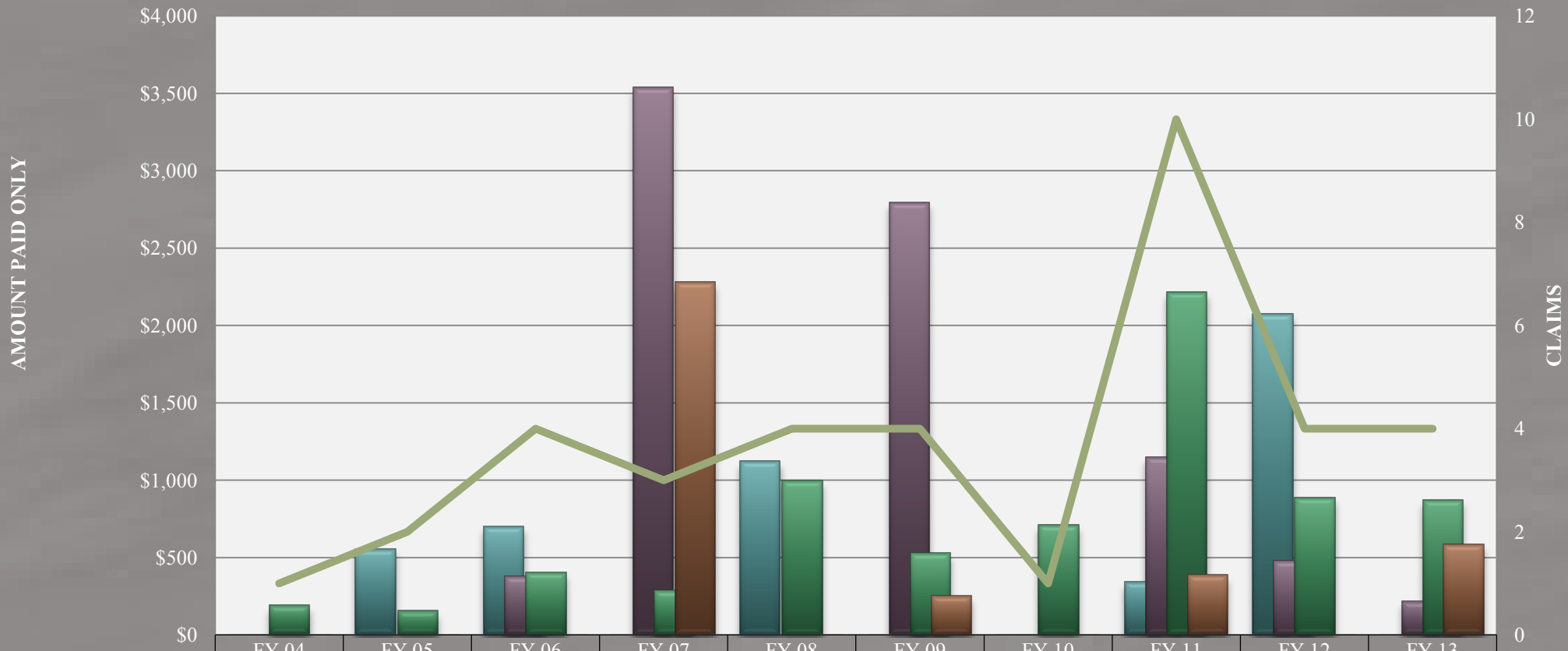
- 4-YEAR DAMAGE SUMMARY
- FY 13 PERCENTAGE OF DAMAGE BY CATEGORY





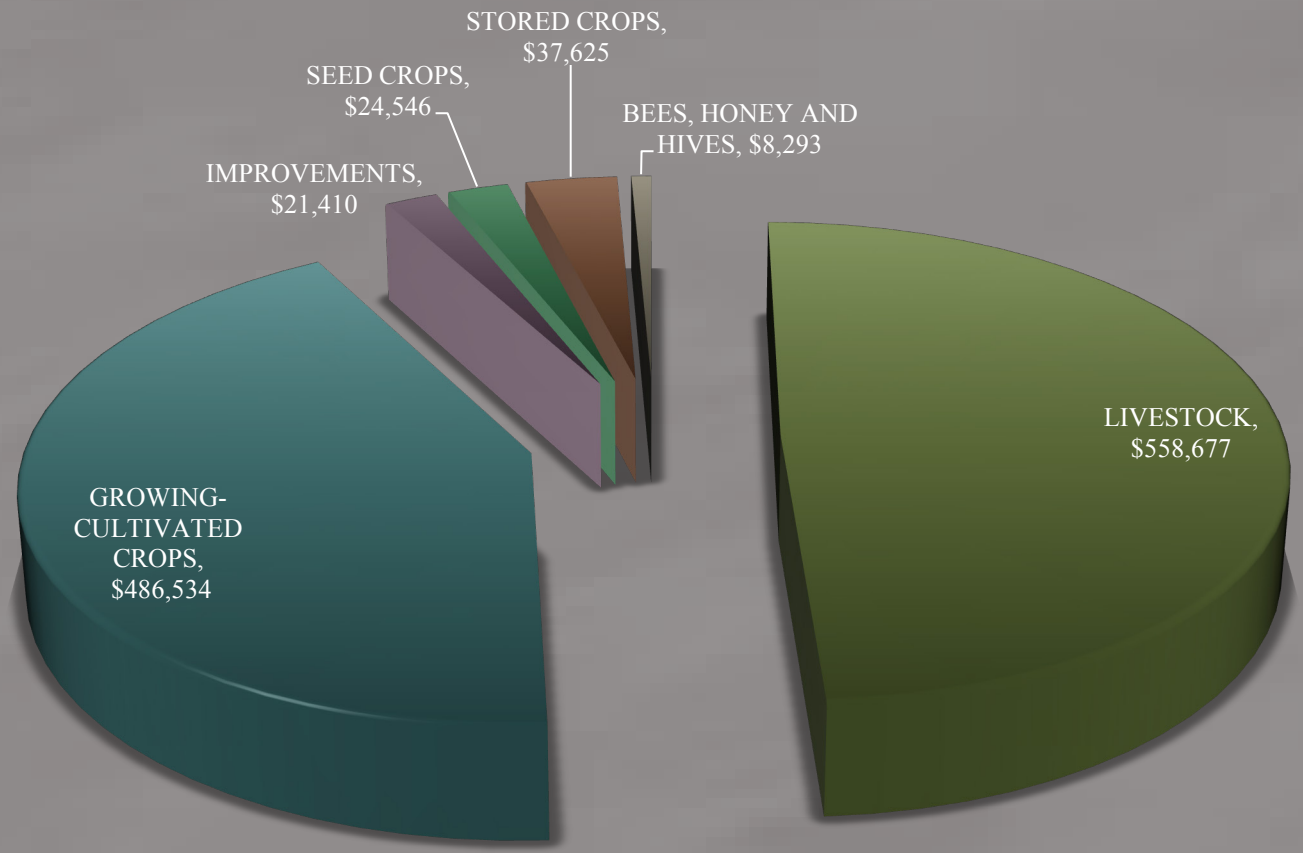
	FY 10	FY 11	FY 12	FY 13
AMT. CLAIMED	$72,641	$69,459	$125,058	$187,238
AMT. PAID	$72,605	$69,222	$122,963	$170,541
#CLAIMS	16	16	16	26

GAME BIRDS
•10-YEAR DAMAGE SUMMARY



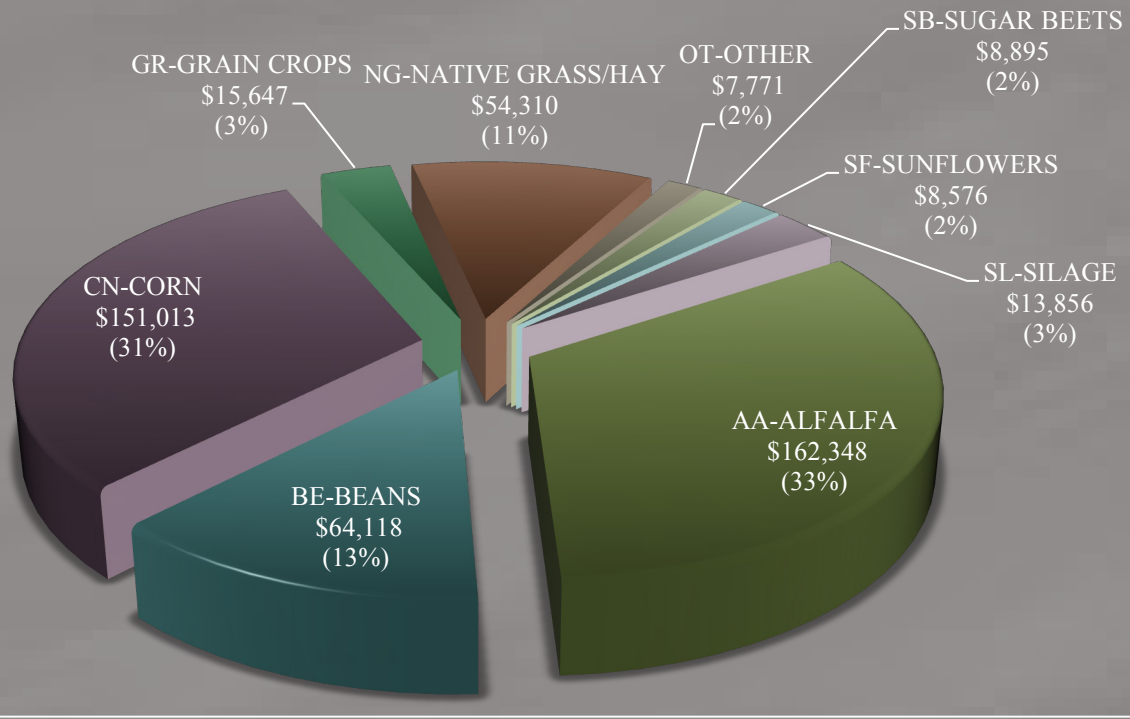
	FY 04	FY 05	FY 06	FY 07	FY 08	FY 09	FY 10	FY 11	FY 12	FY 13
TURKEYS	$0	$553	$698	$0	$1,118	$0	$0	$340	$2,074	$0
CRANES	$0	$0	$375	$3,539	$0	$2,795	$0	$1,149	$479	$215
GEESE	$187	$153	$404	$285	$995	$525	$711	$2,214	$888	$871
SAGE-GROUSE	$0	$0	$0	$2,277	$0	$254	$0	$384	$0	$586
# CLAIMS	1	2	4	3	4	4	1	10	4	4

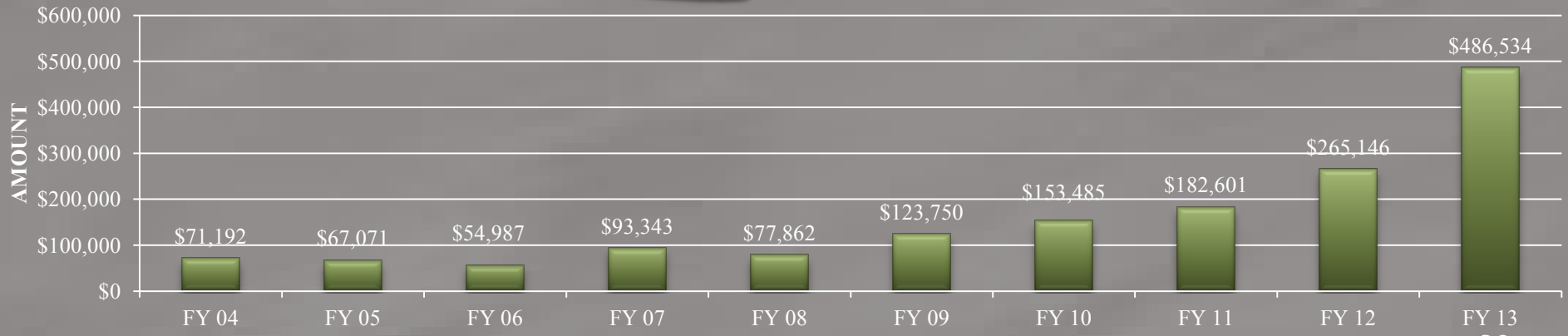
FY 13 AMOUNT AND PERCENTAGE OF CLAIMS PAID BY CATEGORY



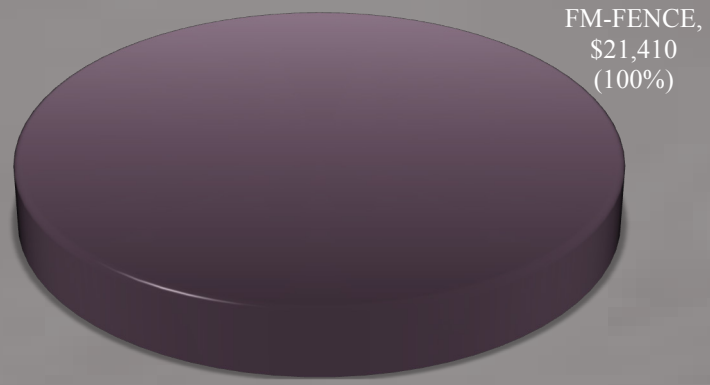
CATEGORY	AMOUNT PAID	PERCENTAGE
GROWING-CULTIVATED CROPS	$486,534	43%
IMPROVEMENTS	$21,410	2%
SEED CROPS	$24,546	2%
STORED CROPS	$37,625	3%
BEES, HONEY AND HIVES	$8,293	1%
LIVESTOCK	$558,677	49%
TOTAL FY 13 DAMAGE AMOUNT PAID	**$1,137,085**	

FY 13 GROWING-CULTIVATED CROPS &10-YEAR DAMAGE SUMMARY

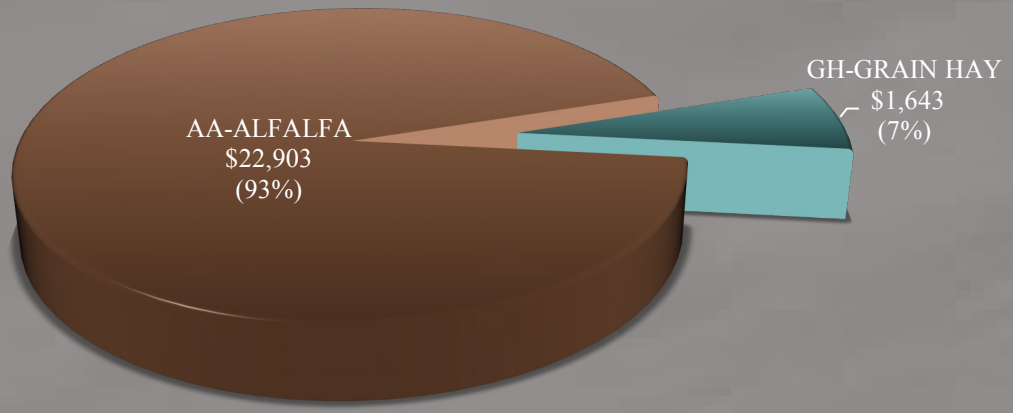


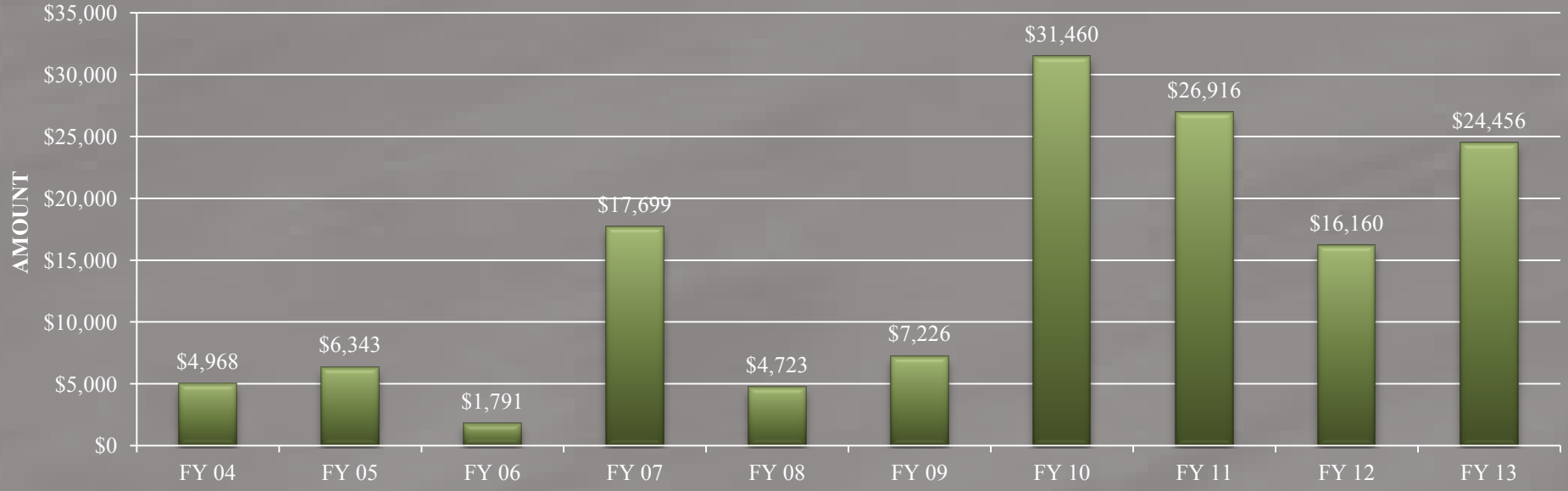


FY 13 IMPROVEMENTS &10-YEAR DAMAGE SUMMARY

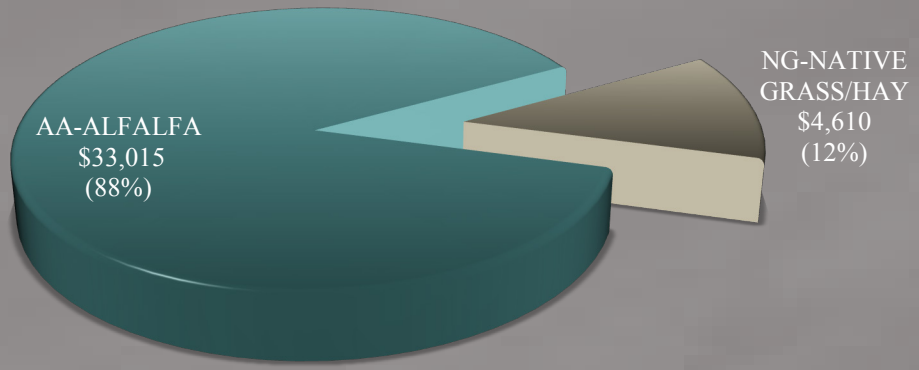


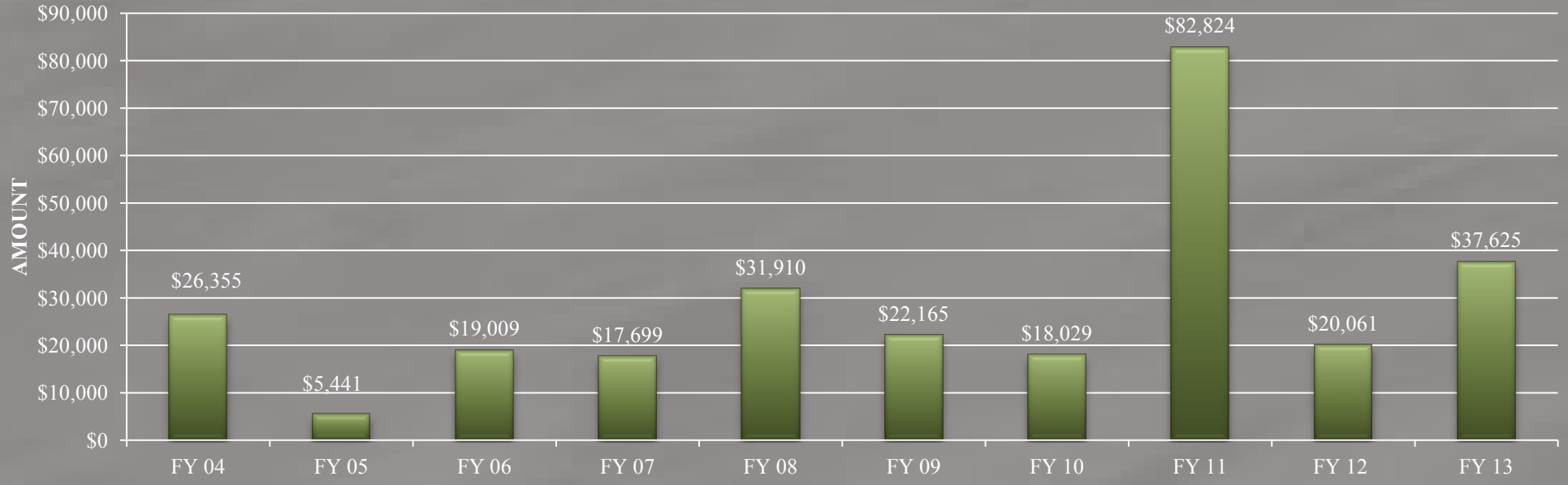
FY 13 SEED CROPS &10-YEAR DAMAGE SUMMARY



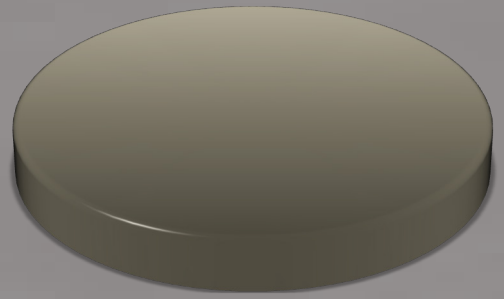


FY 13 STORED CROPS &10-YEAR DAMAGE SUMMARY

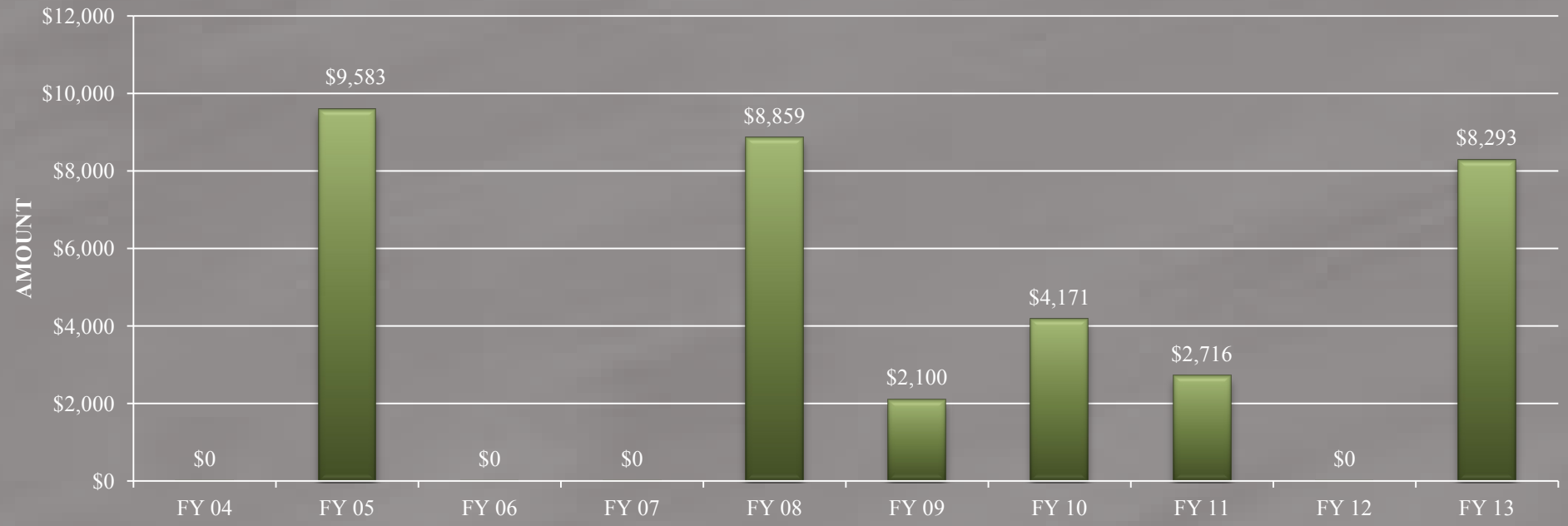




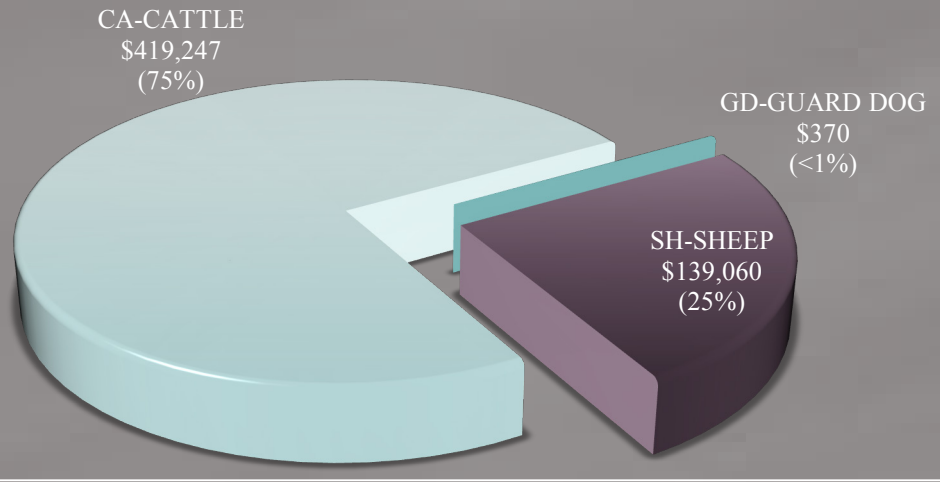
FY 13 BEES, HONEY AND HIVES &10-YEAR DAMAGE SUMMARY



BV-BEES, HONEY AND HIVES $8,293 (100%)



FY 13 LIVESTOCK &10-YEAR DAMAGE SUMMARY



FY 13 DAMAGE PAYMENTS BY SPECIES HERD UNIT

SPECIES	HERD UNIT/MGMT AREA	HERD CODE	AMOUNT PAID
ANTELOPE	COPPER MOUNTAIN	A203	$77,542.02
	FIFTEENMILE	A204	$5,981.25
	CARTER MOUNTAIN	A205	$8,864.50
	CARTER LEASE	A419	$1,472.22
	CRAZY WOMAN	A318	$1,400.00
	SUBLETTE	A401	$11,001.55
	UINTA-CEDAR MOUNTAIN	A411	$4,224.00
	DWYER	A524	$3,204.65
	BEAVER RIM	A632	$437.50
	PROJECT	A635	$2,075.00
		TOTAL PAID	**$116,202.69**
BLACK BEAR	GREY RIVER	BB102	$24,032.46
	ABSAROKA	BB201	$6,502.69
	BIGHORNS	BB301	$13,998.99
	SIERRA MADRE	BB401	$1,824.38
	UINTA	BB402	$860.00
	WIND RIVER	BB601	$7,023.08
	OUTSIDE MGMT AREA	NA	$1,165.00
		TOTAL PAID	**$55,406.60**
ELK	JACKSON	E102	$260.00
	FALL CREEK	E103	$35,856.08
	UPPER GREEN RIVER	E107	$3,500.00
	MEDICINE LODGE	E211	$1,857.30
	BLACK HILLS	E740	$15,335.50
	GOOSEBERRY	E214	$15,169.84
	CODY	E216	$3,474.62
	NORTH BIGHORN	E321	$2,177.82
	RAWHIDE	E730	$8,921.83
	SOUTH BIGHORN	E322	$1,096.00
	CLARK'S FORK	E217	$231.00
	UINTA	E423	$1,885.00
	SIERRA MADRE	E425	$3,976.80
	STEAMBOAT	E426	$5,307.50
	IRON MOUNTAIN	E531	$34,264.45
	SNOWY RANGE	E533	$17,536.09
	LAR. PEAK/MUDDY MTN	E741	$83,854.99
		TOTAL PAID	**$234,704.82**
MOOSE	SUBLETTE	MO105	$660.00
	LINCOLN	MO423	$2,570.00
		TOTAL PAID	**$3,230.00**

SPECIES	HERD UNIT/MGMT AREA	HERD CODE	AMOUNT PAID
MOUNTAIN LION	WEST	L101	$922.50
	NORTH-CENTRAL	L301	$45,701.16
	NORTHEAST	L701	$9,905.48
		TOTAL PAID	**$56,529.14**
MULE DEER	SUBLETTE	MD104	$4,404.20
	WYOMING RANGE	MD131	$886.14
	PAINTROCK	MD207	$11,362.70
	GREYBULL RIVER	MD210	$19,670.89
	SHOSHONE RIVER	MD211	$23,225.36
	SOUTHWEST BIGHORN	MD208	$4,137.09
	UPPER SHOSHONE	MD215	$3,300.00
	CLARK'S FORK	MD216	$21,818.89
	NORTH BIGHORN	MD321	$19,308.25
	UINTA	MD432	$154.00
	GOSHEN RIM	MD534	$17,166.69
	LARAMIE MTNS.	MD537	$522.00
	PROJECT	MD643	$892.00
		TOTAL PAID	**$126,848.21**
WHITE-TAILED DEER	BIGHORN BASIN	WT201	$34,738.65
	POWDER RIVER	WT303	$24,022.40
	SOUTHEAST WYOMING	WT504	$26,885.43
	CENTRAL	WT707	$1,160.00
	BLACK HILLS	WT706	$295.95
	NON HERD UNIT	WT999	$355.00
		TOTAL PAID	**$87,457.43**
GRAY WOLF	CLARK'S FORK	HUNT AREA 1	$16,575.30
	SUNLIGHT	HUNT AREA 2	$8,326.92
	GREYBULL	HUNT AREA 4	$13,517.96
	WIND RIVER	HUNT AREA 5	$17,842.56
	PACIFIC CREEK	HUNT AREA 6	$876.00
	TARGHEE	HUNT AREA 7	$309.75
	FISH CREEK	HUNT AREA 8	$1,904.00
	CRYSTAL CREEK	HUNT AREA 9	$1,400.00
	RIM	HUNT AREA 10	$2,402.55
	GREEN RIVER	HUNT AREA 11	$66,617.32
	ALPINE	HUNT AREA 12	$40,768.69
		TOTAL PAID	**$170,541.05**
GAME BIRDS	STATEWIDE	**TOTAL PAID**	**$1,671.24**
GRIZZLY BEAR	CRANDALL/SUNLIGHT	BMU6	$9,730.35
	SOUTH ABSAROKA	BMU16	$9,975.00
	CLARK'S FORK	BMU23	$17,872.47
	MEETEETSE	BMU24	$56,519.08
	WIND RIVER	BMU25	$10,059.19
	GROS VENTRE	BMU26	$63,705.75
	BACON CREEK	BMU32	$28,999.62
	BONDURANT	BMU33	$11,408.99
	WHISKEY	BMU34	$41,985.65
	UPPER GREEN	BMU35	$28,300.86
	OUTSIDE MGMT AREA	BMU999	$5,936.51
		TOTAL PAID	**$284,493.47**

KEY TO CATEGORIES AND TYPE OF DAMAGE

TYPES OF LIVESTOCK
CA-CATTLE
SH-SHEEP
HR-HORSE
GT-GOAT
SW-SWINE
LL-LLAMA
GD-GUARD DOG
OT-OTHER

TYPES OF STORED CROPS
AA-ALFALFA
CN-CORN
HL-HAYLAGE
WT- WHEAT
GR-GRAIN
GH-GRAIN HAY
NG-GRASS/NATIVE HAY
SL-SILAGE
OT-OTHER

TYPES OF EXTRAORDINARY DAMAGE TO GRASS
NG-GRASS/NATIVE HAY
OT-OTHER

TYPES OF IMPROVEMENTS
FM-FENCE
OR-ORNAMENTAL

TYPES OF GROWING-CULTIVATED CROPS
AA-ALFALFA
BE-BEANS
CN-CORN
GN-GARDEN
GR-GRAIN
NG-GRASS/NATIVE HAY
NS-COMMERCIAL NURSERY
SF-SUNFLOWER
SB-SUGAR BEETS
SL-SILAGE
WT-WHEAT
OT-OTHER

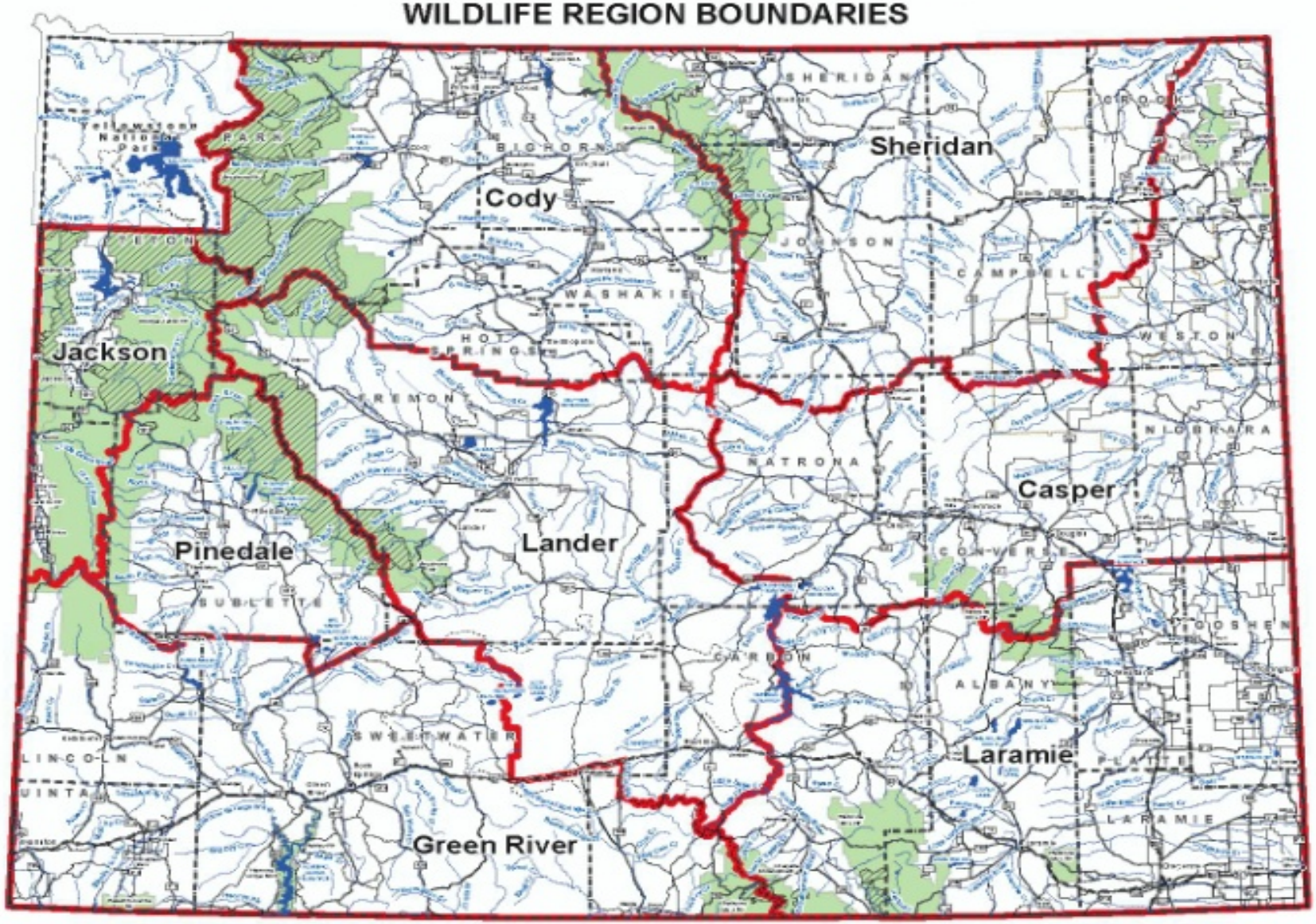
TYPES OF BEES, HONEY or HIVES
BV-BEES, HONEY, HIVES
OT-OTHER

TYPES OF SEED CROPS
AA-ALFALFA
CN-CORN
GH-GRAIN HAY
OT-OTHER

SPECIES	PROGRAM CODE
ANTELOPE	BC
ELK	BD
BIGHORN SHEEP	BE
MOOSE	BF
MOUNTAIN GOAT	BG
MOUNTAIN LION	BJ
BLACK BEAR	BK
GRIZZLY BEAR	BL
MULE DEER	BM
WHITE-TAILED DEER	BN
GRAY WOLF	BW
PHEASANT	CC
TURKEYS	CF
SAGE-GROUSE	CT
GEESE	DB
DUCKS	DC
CRANES	DF

CATEGORY OF DAMAGE
LIVESTOCK
STORED CROPS
GROWING-CULTIVATED CROPS
BEES, HONEY OR HIVES
EXTRAORDINARY DAMAGE TO GRASS
SEED CROPS
IMPROVEMENTS

WYOMING GAME AND FISH DEPARTMENT
WILDLIFE REGION BOUNDARIES



Version Date: 3 September 2013

WYOMING STATUTE W.S. §23-1-901 GOVERNING DAMAGE CLAIMS

W.S. §23-1-901. Owner of damaged property to report damage; claims for damages; time for filing; determination; appeal; arbitration.

(a) Any landowner, lessee or agent whose property is being damaged by any of the big or trophy game animals or game birds of this state shall, not later than fifteen (15) days after the damage is discovered by the owner of the property or the representative of the owner, report the damage to the nearest game warden, damage control warden, supervisor or commission member.

(b) Any landowner, lessee or agent claiming damages from the state for injury or destruction of property by big or trophy game animals or game birds of this state shall present a verified claim for the damages to the Wyoming game and fish department not later than sixty (60) days after the damage or last item of damage is discovered. The claim shall specify the damage and amount claimed. As used in this subsection, "verified claim" means a claim, which the claimant has signed and sworn to be accurate before a person authorized to administer oaths.

(c) The department shall consider the claims based upon a description of the livestock or bees damaged or killed by a trophy game animal, the damaged land, growing cultivated crops, stored crops including honey and hives, seed crops, improvements and extraordinary damage to grass. The commission is authorized to establish by rule, methods, factors and formulas to be used for determining the amount to compensate any landowner, lessee or agent for livestock damaged as a result of, missing as a result of, or killed by trophy game animals. Claims shall be investigated by the department and rejected or allowed within ninety (90) days after submission, and paid in the amount determined to be due. In the event the department fails to act within ninety (90) days, the claim, including interest based on local bank preferred rates, shall be deemed to have been allowed. No award shall be allowed to any landowner who has not permitted hunting on his property during authorized hunting seasons. Any person failing to comply with any provision of this section is barred from making any claim against the department for damages. Any claimant aggrieved by the decision of the department may appeal to the commission within thirty (30) days after receipt of the decision of the department as provided by rules of practice and procedure promulgated by the commission. The commission shall review the department decision at its next meeting following receipt of notice of request for review. The commission shall review the investigative report of the department, and it may approve, modify or reverse the decision of the department.

(d) Within ninety (90) days after receiving notice of the decision of the commission, the claimant may in writing to the department call for arbitration. Within fifteen (15) days after the department receives the call for arbitration, the claimant and the department shall each appoint a disinterested arbitrator who is an elector residing in the county where the damage occurred and notify each other of the appointment. Within twenty (20) days after their appointment, the two (2) arbitrators shall appoint a third arbitrator possessing the same qualifications. If the third arbitrator is not appointed within the time prescribed, the judge of the district court of the county or the court commissioner in the absence of the judge shall appoint the third arbitrator upon the application of either arbitrator.

(e) At least twenty (20) days before the hearing, the board of arbitrators shall provide the claimant and department notice of the time and place in the county when and where the parties will be heard and the claim investigated and decided by the board. A written copy of the decision shall be promptly served upon each party. Within ten (10) days after receipt of the decision, either party may apply to the board for modification of the decision under W.S. 1-36-111. Either party may apply to the district court for vacation of a decision under W.S. 1-36-114(a) or correction or modification of a decision under W.S. 1-36-115 within thirty (30) days after receipt of the decision or within twenty (20) days after action by the board on an application for modification under W.S. 1-36-111.

(f) If no applications under subsection (e) of this section are made after receipt of the decision, the commission shall promptly pay the amount, if any, including interest based on local bank preferred rates, awarded by the board. Within thirty (30) days after the award is final, the board's reasonable service and expense charges shall be paid by:

(i) The claimant if the award is no greater than the amount originally authorized by the commission;

(ii) Otherwise, the commission.

(g) For purposes of this section, “trophy game animals” shall include gray wolves located in the area described in W.S. 23-1-101(a)(xii)(B)(II) regardless of the date on which the damage occurs.

WYOMING GAME AND FISH COMMISSION
CHAPTER 28 REGULATION GOVERNING BIG OR TROPHY GAME ANIMAL OR GAME BIRD DAMAGE CLAIMS

Section 1. Authority. This regulation is promulgated by authority of W.S. §23-1-101, §23-1-102, §23-1-302, §23-1-304 and §23-1-901.

Section 2. Definitions. Definitions shall be as set forth in Title 23, Wyoming Statutes, Commission regulations, and the Commission also adopts the following definitions:

(a) "Authorized hunting seasons" means any hunting season during the twelve (12) month period immediately preceding the date when the claimant filed the verified claim with the Office of the Department that is established by Commission regulation, including Depredation Prevention Hunting Seasons and kill permits, for the harvest of the species of big game animals, trophy game animals, or game birds for which the verified claim was filed.

(b) "Award" means compensation for damage offered to a claimant by the Department.

(c) "Board" means a board of arbitrators.

(d) "Claimant" means any landowner, lessee or agent whose livestock, bees, hives or honey have been damaged or killed by a trophy game animal; or, whose land, growing cultivated crops, stored crops, seed crops, or improvements have been damaged by big game animals or game birds; or, whose grass has been extraordinarily damaged by big game animals or game birds.

(e) "Commercial garden" means a business that grows fruits or vegetables for commercial sale.

(f) "Commercial nursery" means a business that grows or stores trees, shrubs or plants solely for commercial sale and that is required under W.S. § 39-15-106 to be licensed with the Wyoming Department of Revenue to collect and remit sales and use tax.

(g) "Commercial orchard" means a business that grows trees for fruit or nut production for commercial sale.

(h) "Confirmed by the Department or its representative" means the Department or its representative conducted an inspection or investigation of the damage and determined the damage was more likely than not caused by a big or trophy game animal or game bird.

(i) "Consequential damages" means damage, loss, or injury that does not flow directly and immediately from the act of the big game animal, trophy game animal or game bird, but only from some of the consequences or results of such act. Consequential damages include, but are not necessarily limited to, future or anticipated production (except as otherwise provided in this regulation for young of the year livestock), sentimental value, and labor or equipment costs to remove damaged property.

(j) "Damage" means actual damage to land, growing cultivated crops, stored crops, seed crops or improvements that is caused by big game animals or game birds, and sworn by the claimant on the verified claim to have occurred; or, extraordinary damage to grass that is caused by big game animals or game birds and sworn by the claimant on the verified claim to have occurred; and, actual damage to livestock or bees including honey and hives, that is caused by trophy game animals and sworn by the claimant on the verified claim to have occurred. Damage shall not include damage to other real or personal property including, but not necessarily limited to: other vegetation or animals; motor vehicles; structures; damages caused by animals other than big game animals, trophy game animals or game birds; diseases; lost profits; consequential damages; or, any other damages whatsoever that are not specified in this regulation.

(k) "Disinterested arbitrator" means an elector residing in the county where the damage occurred, who is capable of making a reasoned and unbiased decision based on evidence presented to the Board by the claimant and the Department.

(l) "Extraordinary damage to grass" means the loss or harm as proven by the landowner, lessee, or agent that significantly exceeds the usual, customary or average use of non-cultivated grass plants of the Family Graminae.

(m) “Growing cultivated crops” means crops or other vegetation that are grown on privately owned or leased land and harvested or utilized annually for commercial sale or to feed livestock, or for human consumption. “Growing cultivated crops” can include grasses and legumes maturing for harvest, small grains, row crops and vegetables, plants grown in commercial nurseries, commercial orchards, commercial gardens, and native hay meadows that are managed for hay or livestock forage. If the crop is not harvested or utilized annually, it is not a growing cultivated crop unless it requires more than one (1) year to become established and ready for harvest. “Growing cultivated crops” do not include rangelands managed for livestock forage, or products of nurseries, orchards, and gardens that are not intended for commercial sale.

(n) “Hearing” means a procedurally correct arbitration hearing as described in Section 8 of this Regulation that shall be conducted in such manner as to afford the claimant and the Department the opportunity to present, examine, and cross-examine all witnesses and other forms of evidence presented to the Board.

(o) “Hives” means an artificial structure designed and constructed specifically for housing bees.

(p) “Improvements” means a valuable addition made to real estate to increase the productivity or value of land, including fences and man made structures erected or windbreaks or shelterbelts planted on privately owned or leased land to enhance or improve crop or livestock production or grazing management or as a protection for livestock. Improvements shall not include windbreaks or shelterbelts, if they are not planted solely to enhance or improve crop production or grazing management or as a protection for livestock.

(q) “Investigated by the Department” means an inspection determined by the Department to be a reasonable assessment of the damage caused by big or trophy game animals or game birds.

(r) “Kill permit” means a permit authorized by a Game and Fish Commissioner and the Chief Game Warden granting authority to take big game animals, trophy game animals or game birds that are causing substantial damage to property.

(s) “Land” means soil on privately owned or leased land.

(t) “Lessee” means a person who leases fee title land or State land for agricultural purposes.

(u) “More likely than not” means evidence reasonably tending to support the conclusion. Evidence that is competent, relevant, and material, and which to a rational and impartial mind naturally leads, or involuntarily leads to conclusion for which there is valid, just and reasonable substantiation.

(v) “Office of the Department” means the Wyoming Game and Fish Department, 5400 Bishop Blvd., Cheyenne, Wyoming 82006-0001 or the Wyoming Game and Fish Department, 3030 Energy Lane, Casper, Wyoming 82604.

(w) “Permitted hunting during authorized hunting seasons” means permitted hunting as described in Section 4 of this regulation.

(x) “Promptly served upon each party” means within ten (10) days following the arbitration hearing, the Board shall serve a written copy of its decision to the Office of the Department and the claimant.

(y) “Property” means livestock or bees, land, growing cultivated crops, stored crops including honey and hives, seed crops, improvements or grass that has been extraordinarily damaged.

(z) “Reasonable expense charges” means compensation given to an arbitrator while performing duties as an arbitrator that is the same compensation rate afforded to State employees by State statute for per diem and vehicular mileage; and, actual expenses incurred by the arbitrator and documented by receipt including, but not necessarily limited to, telephone calls, paper supplies, and mail service.

(aa) “Reasonable service charges” means reimbursement in the amount of one hundred ($100) dollars per day for performing duties as an arbitrator.

(bb) “Seed crops” means any crop intentionally planted, managed, and grown in accordance with accepted agricultural practices on privately owned or leased land for the production of seed for future propagation and that is harvested annually by manual or mechanical means. If the crop is not harvested annually, it shall not be classified as a seed crop unless the crop normally requires an establishment period of longer than one (1) year to be harvested or unless the crop is alfalfa seed or crested wheat grass seed.

(cc) “Stored crops” means crops that have been harvested and saved or stored for future use in accordance with accepted agricultural practices.

(dd) “Supervisor” means Regional Wildlife Supervisor.

(ee) “Trophy game animals” means black bear, gray wolf, grizzly bear or mountain lion or gray wolf in accordance with W.S. §23-1-901(g).

(ff) “Value of livestock” means the monetary value of individual livestock on the date the verified claim was filed with the Office of the Department based upon the fair market value on that date for like livestock at a rate substantiated by a livestock sales barn or other credible written valuation of the livestock provided by the claimant. However, the monetary value of young of the year livestock on the date the verified claim was filed with the Office of the Department shall be based upon the fair market value on that date for like livestock at the weaning weight substantiated by a livestock sales barn or other credible written valuation of the livestock provided by the claimant.

(gg) “Verified claim” means a Trophy Game Animal Damage Claim Affidavit or a Big Game Animal or Game Bird Damage Claim Affidavit that has been signed by the claimant and sworn to be accurate before a person authorized to administer oaths, that has been filed with the Office of the Department and contains all information required in Section 9 of this regulation.

Section 3. Damage to Livestock by Trophy Game Animals. Except as specified in subsection (a) of this section, the Department shall only offer payment for damage to individual livestock confirmed by the Department or its representative as having been injured or killed by a trophy game animal.

(a) In geographic areas determined by the Department to have terrain, topography, and vegetative characteristics that influence the ability of the claimant and Department to find missing calves and sheep that are believed to have been damaged as a result of a trophy game animal, the Department shall utilize the methods, factors and formulas in this subsection to determine the amount to compensate any landowner, lessee or agent for calves and sheep missing as a result of damage caused by a trophy game animal.

(i) Any claimant whose verified claim is for missing sheep or calves believed to have been damaged as a result of a trophy game animal, shall include on his verified claim the total known death loss, including missing animals, for the sheep or calves for the grazing season together with the number of such losses known to be due to causes other than damage by a trophy game animal.

(ii) Notwithstanding the use of the formulas in this section, the Department shall not offer compensation for more than the total known death loss less the number of such losses known to be due to causes other than damage by a black bear, grizzly bear, mountain lion, or gray wolf in those areas where gray wolves are designated as trophy game animals in accordance with Commission regulation. In order to utilize any formula, the Department or its representative must have confirmed the claimant had at least one (1) calf or one (1) sheep injured or killed by a trophy game animal.

(A) Calves and sheep in areas occupied by grizzly bears. To determine the amount of compensation due to a claimant for calves and sheep believed to be missing as a result of being damaged by a black bear, grizzly bear, or mountain lion in areas occupied by grizzly bears, the Department shall utilize the following formula:

(I) Number of individual calves or sheep confirmed by the Department or its representative killed by a black bear, grizzly bear, or mountain lion multiplied by three and one-half (3.5) multiplied by the value of livestock equals the amount of compensation.

(II) Sheep in areas not occupied by grizzly bears. To determine the amount of compensation due to a claimant for sheep believed to be missing as a result of being damaged by a black bear or mountain lion in areas not occupied by grizzly bears, the Department shall utilize the following formula:

(III) Number of individual sheep confirmed by the Department or its representative killed by a black bear or mountain lion multiplied by three (3) multiplied by the value of livestock equals the amount of compensation.

(iii) Sheep in areas set forth by Commission regulation where gray wolves are designated as trophy game animals. To determine the amount of compensation due to a claimant for sheep believed to be missing as a result of being damaged by gray wolves, in areas occupied by wolves, the Department shall utilize the following formula:

(A) Number of individual sheep confirmed by the Department or its representative killed by a gray wolf multiplied by seven (7) multiplied by the value of livestock equals the amount of compensation.

(iv) Calves in areas set forth by Commission regulation where gray wolves are designated as trophy game animals. To determine the amount of compensation due to the claimant for calves believed to be missing as a result of being damaged by gray wolves, in area occupied by gray wolves, the Department shall utilize the following formula:

(A) Number of individual calves confirmed by the Department or its representative killed by gray wolves multiplied by seven (7) multiplied by the value of livestock equals the amount of compensation.

(b) Veterinary costs for the treatment of individual livestock that have been injured by a trophy game animal shall be considered up to a maximum amount that is not to exceed the value of the livestock injured, only in cases where a licensed veterinarian believes the individual livestock in question had a reasonable chance to survive and return to a productive state. If the individual livestock died as a result of an injury inflicted by a trophy game animal, even though the livestock received veterinary care, payment shall only be made up to a maximum of the value of the livestock.

Section 4. Permitted Hunting During Authorized Hunting Seasons.

(a) A landowner shall not be eligible to receive an award for damage caused by big game animals, trophy game animals, or game birds unless the landowner has permitted hunting during authorized hunting seasons for the species for which the verified claim has been filed on his privately owned or leased land and adjoining Federal or State land within the herd unit in which the damage occurred in accordance with this section. For an award to be allowed, the landowner shall permit hunting during authorized hunting seasons delineated in subsection (i)(A) if the species of big game animals, trophy game animals, or game birds for which the verified claim was filed were present on the landowner's privately owned or leased land and adjoining Federal or State land during authorized hunting seasons delineated in subsection (i)(A). If the species of big game animals, trophy game animals, or game birds for which the verified claim has been filed were not present on the landowner's privately owned or leased land and adjoining Federal or State land during the authorized hunting seasons as delineated in subsection (i)(A), for an award to be allowed the landowner shall permit hunting during authorized hunting seasons delineated in (i)(B) and (i)(C) if requested by the Department. The landowner shall permit hunting during authorized hunting seasons delineated in (i)(B) and (i)(C) without access fees to hunters or the Department.

(i) Authorized hunting seasons include:

(A) Hunting seasons as established by Wyoming Game and Fish Commission rule and regulation;

(B) Depredation prevention hunting seasons as approved by a District Wyoming Game and Fish Commissioner and the Chief Game Warden; or,

(C) Lethal taking of wildlife through a kill permit as approved by a District Wyoming Game and Fish Commissioner and the Chief Game Warden.

(b) The Department shall determine if the landowner permitted hunting during authorized hunting seasons for the species of big game animals, trophy game animals, or game birds for which the verified claim has been filed. For an award to be allowed, the Department shall have to determine the landowner allowed sufficient numbers of hunters to access his privately owned or leased land and adjoining Federal or State land to harvest more than the number of big game animals, trophy game animals or game birds recruited in the preceding twelve (12) months into the segment of the population responsible for doing damage. The landowner shall contact the game warden to whom he reported the damage to determine how many big game animals, trophy game animals, or game birds meets the requirement of more than the number of big game animals, trophy game animals or game birds recruited in the preceding twelve (12) months into the segment of the population responsible for doing damage. An award may be allowed if the Department determines a reduction in big game animals, trophy game animals or game birds affects the Department's ability to sustain the population at the objective the Commission has established for the herd unit.

Section 5. Notification of Damage and Filing of Damage Claims.

(a) Any claimant who has incurred damage as defined in Section 2 of this Regulation shall report the damage to the nearest game warden, supervisor, or Commission member within fifteen (15) consecutive days following the date damage was discovered. If the claimant intends to take actions that prevent the damage being investigated by the Department, such as harvest of damaged crops or removal of damaged livestock, the claimant shall notify the nearest game warden, supervisor, or Commission member as soon as reasonably possible after discovery of the damage so the damage can be investigated by the Department prior to removal, harvest, modification, or destruction of the damaged property; however, in no case shall the claimant take actions that preclude the damage being investigated by the Department. If the claimant denies or precludes the damage being investigated by the Department, the Department shall deny the verified claim.

(b) The claimant shall present a verified claim in accordance with Section 9 of this regulation to the Office of the Department within sixty (60) consecutive days following the date the last item of damage was discovered.

(i) For verified claims of damage to individual livestock by a trophy game animal, the sixty-day (60) period shall commence from the last date the livestock were present on the grazing allotment or geographic location where the damage occurred;

(ii) For verified claims of damage to bees, honey, and hives by a trophy game animal, the sixty (60) day period shall commence from the last date damage occurred or from the last date the bees, honey, or hives were present on the location where the damage occurred, whichever date occurs first; and,

(iii) For verified claims of damage to land, growing cultivated crops, seed crops, stored crops, improvements, or extraordinary damage to grass by big game animals or game birds, the sixty (60) day period shall commence from the last date the growing cultivated crop or seed crop was harvested or the land, stored crops, or improvements were damaged or the extraordinary damage to grass occurred.

(c) If a claimant chooses to appeal the Department's decision regarding a verified claim to the Commission, the claimant shall file a written appeal that is received by the Office of the Department within thirty (30) consecutive days from the date the claimant received the Department's notification of its decision on the verified claim.

(d) The claimant shall have no right of appeal to the Commission of the Department's denial of the claim if based upon the information provided by the claimant in the verified claim, the claimant failed to comply with subsection (a) or (b) of this section. The claimant shall have no right of appeal to the Commission of the Department's decision on a verified claim if the claimant failed to comply with subsection (c) of this section.

Section 6. Investigation and Payment of Verified Claims.

(a) When investigating damage claims, the Department shall utilize the standard of "more likely than not" in determining whether or not the damage was the result of big or trophy game animals or game birds.

(b) The Department shall consider damage that was discovered by the claimant and reported to the nearest game warden, supervisor or Commission member within fifteen (15) consecutive days after the date the damage was discovered. Any damage that was reported more than fifteen (15) consecutive days after the date it was discovered by the claimant shall not be considered by the Department as damage under this regulation.

(c) The Department shall investigate the verified claim and either reject the claim or provide for full or partial payment to the claimant within ninety (90) consecutive days following the date the Office of the Department received the verified claim.

Section 7. Reasons for Denial of a Verified Claim.

(a) The Department shall deny the verified claim for any of the reasons specified in this subsection.

(i) The claimant did not report the damage to the nearest game warden, supervisor or Commission member within fifteen (15) consecutive days after the date the damage was discovered. Any damage that was reported more than fifteen (15) consecutive days after the date it was discovered by the claimant shall not be considered by the Department as damage under this regulation.

(ii) The damage was caused by animals or wildlife other than big game animals, trophy game animals or game birds.

(iii) The big or trophy game animals or game birds causing damage were on the landowner's privately owned or leased land and adjoining Federal or State land during authorized hunting seasons as specified in Section 4(a)(i)(A), and the landowner did not permit hunting in accordance with Section 4(a) of this regulation.

(iv) The big or trophy game animals or game birds causing damage were not on the landowner's privately owned or leased land and adjoining Federal or State land during authorized hunting seasons as specified in Section 4(a)(i)(A), and the landowner would not agree to the Department's implementation of a depredation prevention hunting season as specified in Section 4(a)(i)(B) or insisted on charging an access fee to hunters to participate in a depredation prevention hunting season as specified in Section 4(a).

(v) The big or trophy game animals or game birds causing damage were not on the landowner's privately owned or leased land and adjoining Federal or State land during authorized hunting seasons as specified in Section 4(a)(i)(A), and the landowner would not agree to the Department's implementation of a kill permit as specified in Section 4(a)(i)(C) or insisted on charging an access fee to the Department to implement a kill permit as specified in Section 4(a).

(vi) The verified claim was for property not defined as property in Section 2 of this regulation.

(vii) The claimant was compensated by crop or livestock insurance or a Federal subsidy program for the property damaged to the extent the claimant received compensation under that insurance or program.

(viii) The claimant did not present a verified claim complete with all required information specified in Section 9 of this regulation to the Office of the Department within sixty (60) days after the damage or last item of damage was discovered by the claimant.

(ix) The verified claim was for consequential damages.

(x) Hunting was not permitted during authorized hunting seasons on land in a platted subdivision where the damage occurred due to the actions of a municipal or county ordinance, or homeowners' association covenant prohibiting the discharge of firearms.

(xi) Due to actions of the claimant, the damage was not investigated by the Department.

(xii) The landowner prevented the Department's attempts to mitigate or alleviate the damage through such actions as moving the big or trophy game animals or game birds responsible for the damage or the claimant refused to utilize fencing materials provided by the Department to protect stored crops, including honey and hives.

Section 8. Arbitration.

(a) If the claimant wishes to appeal the Commission's decision regarding a verified claim, the claimant shall file a written call for arbitration with the Office of the Department within ninety (90) consecutive days from the date the claimant received written notice from the Office of the Department of the Commission's decision.

(b) If the claimant calls for arbitration, the claimant and the Office of the Department shall each appoint a disinterested arbitrator within fifteen (15) consecutive days from the date the Office of the Department received the written call for arbitration.

(c) When the claimant and the Office of the Department appoint arbitrators, written notification of the name, mailing address, and telephone number of arbitrators they selected shall be made by each party to the other within fifteen (15) consecutive days from the date the Office of the Department received the written call for arbitration.

(d) Within twenty (20) consecutive days after their appointment, the two (2) arbitrators shall appoint a third arbitrator. The two (2) arbitrators selected shall notify both the claimant and the Office of the Department in writing of the name, mailing address, and telephone number of the third arbitrator selected. If the third arbitrator is not appointed within this time period, the judge of the district court of the county or the court commissioner in the absence of the judge shall appoint the third arbitrator upon the application of either arbitrator.

(e) The three (3) arbitrators shall appoint a chairman who shall chair the Board and serve as secretary to carry out the correspondence of the Board.

(f) At least twenty (20) consecutive days before the hearing, the Board shall provide the claimant and the Office of the Department written notice of the time and place in the county when and where the testimony of the claimant and the Department shall be heard and the claim investigated and decided by the Board.

(g) Following the arbitration hearing, the Board shall within ten (10) days provide a written copy of its decision to the Office of the Department and the claimant.

(h) Unless otherwise specified in this section, the Uniform Arbitration Act, W.S. § 1-36-101 et seq. shall apply to the hearing.

(i) The decision of the Board shall become part of the Office of the Department's file and shall be made part of the record in the event of an appeal of the Board's decision and any appeal to district court shall be conducted in conformity with the Uniform Arbitration Act, W.S. §1-36-114(a) or W.S. §1-36-115.

Section 9. Verified Claim Requirements. The verified claim required by W.S. 23-1-901(b) shall be submitted on the form prescribed by the Department. The verified claim shall contain the following information:

(a) A description of the land on which the damage occurred, including the legal description (section, range, township), the county in which the land is located, and whether the land is privately owned, leased, or federally owned;

(b) Whether the claimant is the landowner, lessee, or agent of the landowner or lessee;

(c) A description of individual livestock, including the number, age class and sex if known, or description of bees, including honey and hives, damaged or killed by a trophy game animal;

(d) A description of the land, growing cultivated crops, stored crops, seed crops, or improvements damaged by a big game animal or game bird; or a description of the grass extraordinarily damaged by a big game animal or game bird;

(e) Competent, relevant and material evidence provided by the claimant that a big game animal, trophy game animal, or game bird caused the damage;

(f) The dates during which damage took place, to include the specific date the damage was discovered by the claimant and the specific date the damage ended;

(g) The amount and value of livestock or property damaged, including all calculations and evidence supporting the value determination;

(h) The species and number, if known, of big or trophy game animals or game birds that caused the damage;

(i) The name of the game warden, supervisor or Commission member to whom the claimant reported the damage and the specific date it was reported;

(j) Information to allow the Department to determine whether or not the landowner permitted hunting during authorized hunting seasons for the species causing damage in accordance with Section 4 of this regulation;

(k) Information as to whether or not an access fee was charged by the claimant for permitting hunting during authorized hunting seasons for the species of big game animal, trophy game animal or game bird for which the verified claim was filed; the total amount of access fee charged per hunter; and, the total number of hunters permitted to hunt during authorized hunting seasons for the species causing damage;

(l) Information by which the Office of the Department can recognize the claimant signed and swore before a person authorized to administer oaths (notarized) the verified claim to be accurate;

(m) For verified claims for calves and sheep missing as a result of damage by a trophy game animal, the total known death loss, including missing animals, for the sheep or calves for the grazing season together with the number of such losses known to be due to causes other than damage by a trophy game animal;

(n) Information to indicate if all or what portion of the property damaged was compensated for by crop or livestock insurance or a Federal subsidy program to the extent the claimant received compensation under that insurance or program; and,

(o) The claimant may submit additional supporting information, which shall be considered as part of the verified claim.

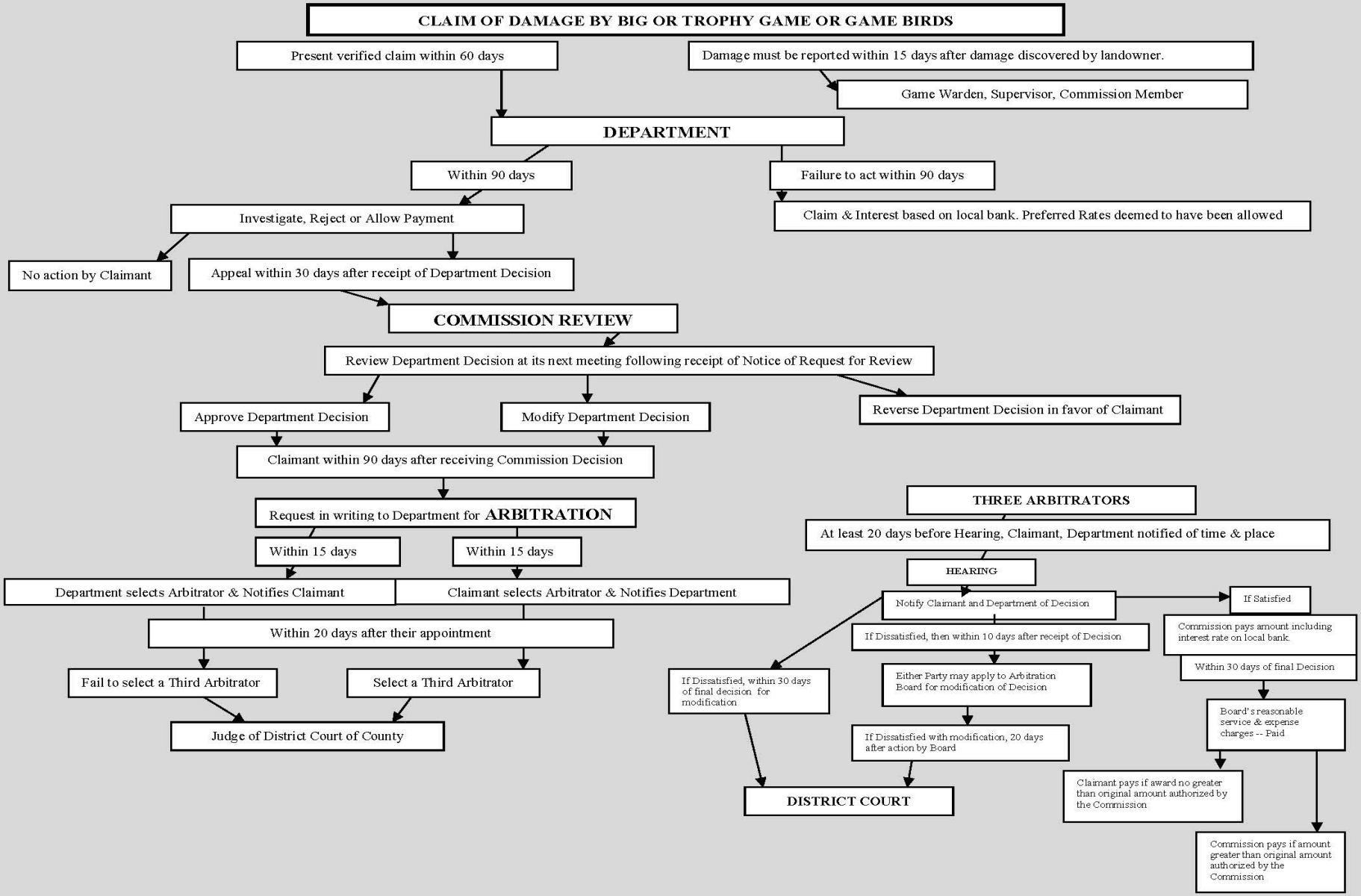
WYOMING GAME AND FISH COMMISSION

By: _____

Mike Healy, President

Dated: January 22, 2014

DAMAGE CLAIM PROCEDURE FLOW CHART



ESTIMATING FORAGE PRODUCTION AND WINTER SEVERITY ON THE NATIONAL ELK REFUGE, JACKSON WY

Eric K. Cole [1] and Phillip E. Farnes [2]

ABSTRACT

Each October through November, elk and bison migrate to the National Elk Refuge (NER) near Jackson, WY to feed on native forage produced on the Refuge. Usually by late January, standing forage has been utilized or becomes unavailable because of snow and ice, and the Refuge then supplies supplemental feed in the form of alfalfa pellets. Supplemental feeding typically ends in early April, when elk and bison migrate back to summer ranges.

For the past 34 years, NER staff has estimated total annual forage produced on the Refuge by clipping vegetation within different plant community types. Average forage production in each plant community type is then accumulated by the number of acres represented by each type to obtain total forage produced on the Refuge.

Keetch Byram Drought Index (KBDI), and growing degree days (GDD) based on daily average temperature threshold of 5^0 C have been calculated daily for Jackson and Moose climatological stations since 1949. Also, daily snow water equivalent (SWE) has been estimated for these stations using climatological records. Critical temperatures (-18^0 C for elk) have been summarized using departure from daily minimum temperatures. SWE, forage production, and critical temperatures are weighted and combined to determine Index of Winter Severity (IWS) for elk and bison.

Methods for calculating the IWS for elk and bison and how the IWS is used for Refuge operations will be presented. Average KBDI for different accumulations of GDD and spring precipitation are compared to production of grass and forbs on 34 different plant community groups. Methods and results for estimating forage production using KBDI, GDD, and precipitation are presented.

INTRODUCTION

Approximately 7500 elk and 1000 bison migrate from Yellowstone National Park, Grand Teton National Park and Bridger-Teton National Forest to the National Elk Refuge (NER) each winter. Usually, there is enough forage produced on the NER to support the animals until late January. When natural forage availability becomes limited or when ice and snow prevent the animals from obtaining the forage, feeding of alfalfa pellets is initiated. Supplemental feeding continues until animals begin foraging on green grass growth in the spring and move off the Refuge to their summer ranges. The amount of forage produced during the growing season may influence when supplemental feeding begins. NER staff clips forage plots each fall to obtain an estimate of forage produced on the Refuge. Forage produced on a high year is about twice that produced on a low year and is related to amount and timing of spring and summer precipitation. The Index of Winter Severity (IWS) allows Refuge managers to compare the relative severity of each winter and how it will impact the wintering animals and reproduction.

STUDY AREA

The National Elk Refuge is located adjacent to and north of Jackson, Wyoming in the upper Snake River drainage. The Refuge covers an area of approximately 10,120 hectares. Elevations vary from about 1890 meters to 1980 meters. Approximately 13,000 elk and 1000 bison currently inhabit the upper Snake River drainage with about 60 percent of the elk herd and almost all of the bison wintering on the NER. Snow typically covers the lower areas of the NER from December through March. Higher elevations are snow covered from about mid-November through mid-April. There are two National Weather Service climatological stations near the Refuge, one at Jackson, WY at 1899 meters elevation and the other at Moose, WY at 1972 meters elevation. Maximum and minimum

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air temperatures, precipitation, snowfall and snow depths are recorded daily at both stations. There currently are 65 transects that encompass 34 community groups across the Refuge where forage was measured by clipping each fall. Over the past 34 years different methods have been used. The current method was used in 1995 and from 1998 through present.

METHODS

Daily snow water equivalent (SWE) is estimated using snow depth, precipitation,, and temperature from the climatological stations. The SWE is estimated to start the day snow depth starts. The SWE was equal to the accumulated precipitation until daily average temperatures exceed -2^0 C. Melt was determined using degree-day method and melt rates were determined from historic melt vs. degree-day relationships based on melt at nearby SNOTEL sites. Densities were capped at around 45 percent. Normal probabilities were run using period of record for maximum SWE for the season.

Each species has different critical temperature. This is the point where increased metabolism is needed in order to maintain body temperature. For elk, the critical temperature is -18^0 C and for bison it is -34^0 C. The difference between daily minimum temperatures and the critical temperature were accumulated for the winter.

Forage has been determined by clipping plots on the NER since 1973. Clipping was generally done in September. Different methods have been used over time to determine total herbaceous forage. Double-mass analysis has been used to adjust these different methods to current methods. Relationships have been established to develop an estimate of forage production using spring and summer precipitation and Keetch Byram Drought Index (KBDI) (as surrogate for soil moisture deficit) and growing degree-days (GDD) and are discussed later in this paper. Normal probabilities were run for total herbaceous forage production for the previous fall for use in the IWS.

The IWS was scaled from – 4 to + 4. The following equation was used to scale the normal probability, in percent, (1 to 99 with 50 being average) to the index. A separate index was developed for SWE, critical temperatures, and available forage.

$$\text{Index} = \frac{\text{Probability} - 50}{12.25}$$

In general, an IWS of + 4 is the mildest winter of record, a – 4 is the worst and 0 is about average. For single birth species, values above 0 are similar in their effect. An IWS of 0 to – 2 generally effects reproduction and – 2 to – 4 generally indicates mortality. For multiple birth species, 0 to + 2 relates to the number of successful births while an IWS of 0 to – 4 represent similar effects as for single birth species.

Forage available on the NER has been determined by clippings since 1973. Methods have been changed over time. Since 1995, 65 transects have been clipped annually. These transects cover 34 different community type with most being some combination of grasses and a few are predominately forbs. Different combinations of KBDI and growing degree-days (based on average daily temperature threshold of 5^0 C) were correlated with forage production. Also, the May-July and May-August precipitation were correlated with total forage production.

RESULTS AND DISCUSSION

The IWS for elk was weighted as 45 % for SWE, 35 % for critical temperature, and 20 % for forage. The IWS based on Jackson, WY climatological station plus one-half Moose, WY climatological station for elk is shown in Figure 1. For bison, the weightings are 70 % for SWE and 30 % for forage. The critical temperature for bison is so low that there are only a few days each year that it is exceeded and it is not used in the IWS for bison. The IWS for bison based on Jackson plus one-half of Moose is shown in Figure 2. The Jackson station represents a large portion of the Refuge but the Moose station represents the northern portion. Therefore, all of the weightings use Jackson plus one-half of Moose values.

The highest correlation of herbaceous forage production on the NER was using the May through August precipitation at Jackson and Moose (Figure 3). The best combination using KBDI was the average KBDI plus 0.3 times maximum KBDI for the first 1100 GDD for Jackson and Moose (Figure 4).

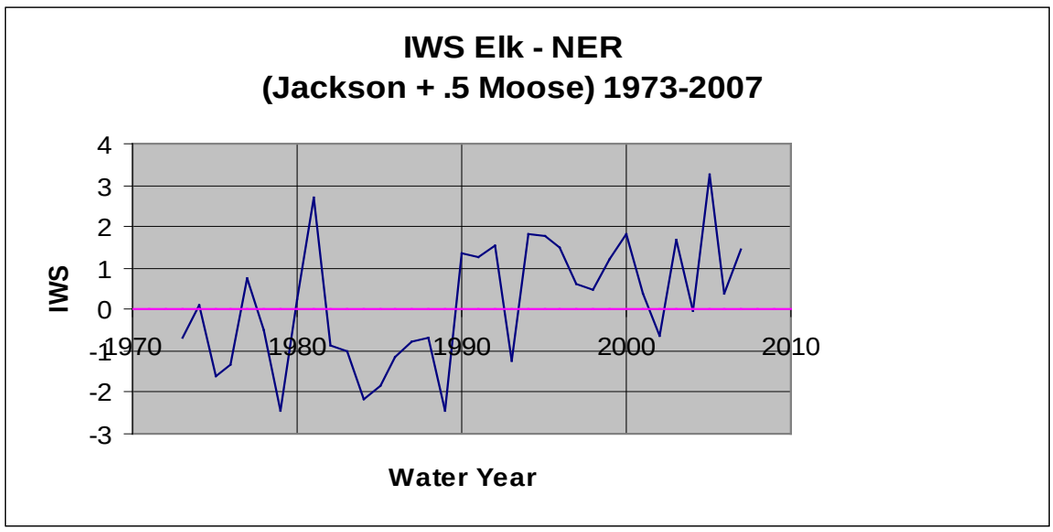

Figure 1. IWS for elk on National Elk Refuge 1973-2007.

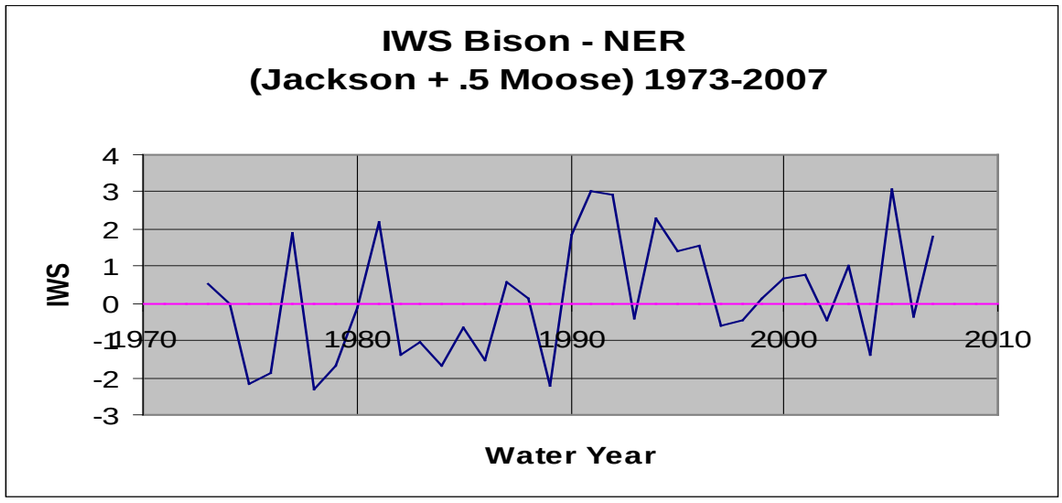

Figure 2. IWS for bison on National Elk Refuge 1973-1007.

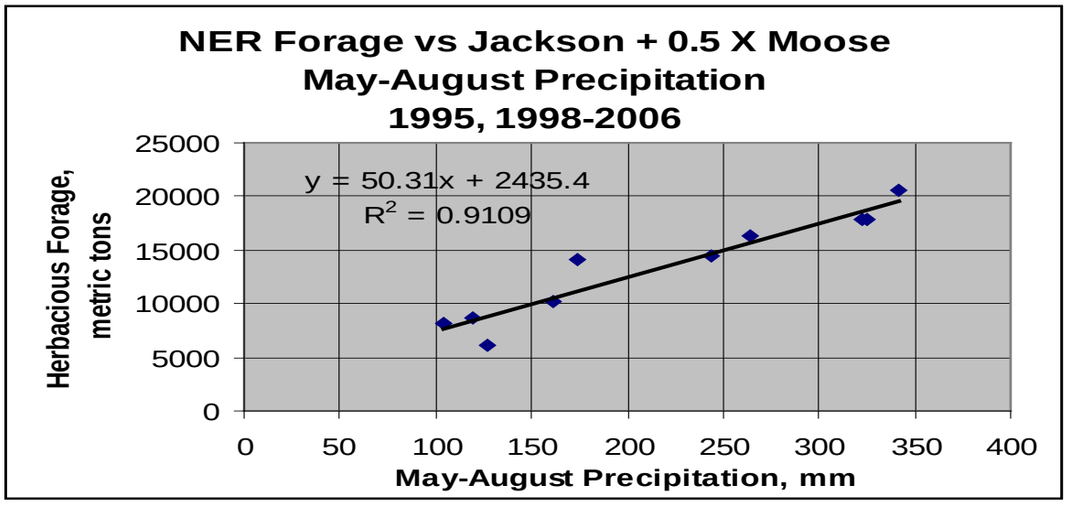

Figure 3. Forage produced on National Elk Refuge compared to May through August precipitation at Jackson plus ½ of Moose for years where 36 plant community types were clipped.

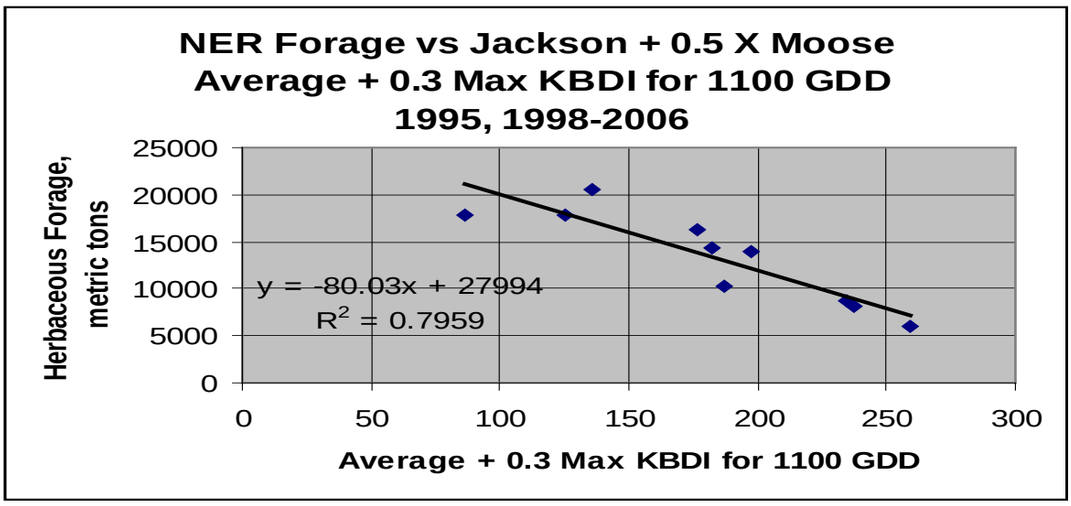

Figure 4. Forage produced on National Elk Refuge compared to average plus 0.3 times maximum KBDI for the first 1100 GDD for years where 36 plant community types were clipped.

CONCLUSIONS

The IWS provides Refuge managers with a numerical scale of how severe or mild any given winter might be and provides a reference to similar years. It also provides some continuity between biologists through their observations and narrative reports

Determining the amount of native forage produced on the Refuge and wintering conditions are important components for managing elk and bison on the NER. If a satisfactory method for estimating forage can be developed using climatic data, it may be possible to reduce the manual clipping at plots and would provide a method to estimate forage production since 1949. This would expand the number of years with data for both production and IWS. Also, it would provide a method to relate the three or four different methods used to determine total forage produced using clipping data since 1973. Retrospective analysis of historic IWS values and historic supplemental feeding initiation dates may allow Refuge managers to predict when supplemental feeding will be necessary based on early weather conditions.

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