Yellowstone Grizzly Bear Investigations 2015

Annual Report of the Interagency Grizzly Bear Study Team

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YELLOWSTONE GRIZZLY BEAR

INVESTIGATIONS

Annual Report of the Interagency Grizzly Bear Study Team

2015

U.S. Geological Survey
Wyoming Game and Fish Department
National Park Service
U.S. Fish and Wildlife Service
Montana Fish, Wildlife and Parks
U.S. Forest Service
Idaho Department of Fish and Game
Eastern Shoshone and Northern Arapaho Tribal Fish and Game Department

Edited by Frank T. van Manen, Mark A. Haroldson, and Bryn E. Karabensh

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IGBST Partner Websites

Interagency Grizzly Bear Study Team (USGS):
http://www.usgs.gov/norock/igbst

Grizzly Bear Recovery (U.S. Fish and Wildlife Service):
https://www.fws.gov/mountain-prairie/es/grizzlyBear.php

Yellowstone and Grand Teton National Parks (National Park Service):
http://www.nps.gov/yell/planyourvisit/bearsafety.htm
http://www.nps.gov/grte/planyourvisit/bearsafety.htm

Wyoming Game and Fish Department:
https://wgfd.wyo.gov/Wildlife-in-Wyoming/More-Wildlife/Large-Carnivore/Grizzly-Bear-Management

Montana Fish, Wildlife and Parks:
http://fwp.mt.gov/fishAndWildlife/livingWithWildlife/grizzlyBears/default.html

Idaho Fish and Game:
http://fishandgame.idaho.gov/public/wildlife/?getPage=248

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Introduction

Frank T. van Manen and Mark A. Haroldson, U.S. Geological Survey, Interagency Grizzly Bear Study Team

This Report

This Annual Report summarizes results of grizzly bear (*Ursus arctos*) monitoring and research conducted in the Greater Yellowstone Ecosystem (GYE) by the Interagency Grizzly Bear Study Team (IGBST) during 2015. The report also contains a summary of grizzly bear management actions to address conflict situations.

Forty Years of Grizzly Bear Recovery

The year 2015 marked the 40th year of grizzly bear recovery in the GYE, after the 1975 listing of all remaining grizzly bears in the lower 48 states as Threatened under the Endangered Species Act. Research and monitoring data collected by the Interagency Grizzly Bear Study Team (IGBST) have played an instrumental role towards a science-based approach to population recovery. The extensive datasets collected by IGBST were particularly instrumental in this past year, with several new publications exploring long-term genetic trends and changes in population demographics.

A comprehensive genetic study by Kamath et al. (2015) focused on effective population size (N_e) of Yellowstone grizzly bears, or the number of individuals that contribute offspring to the next generation. Reanalyzing historical data, they found that the effective population size increased from approximately 80 bears in the 1910s–1960s to about 280 in the contemporary population. Based on one of several other methods (estimator by parentage assignment), they found that estimates of effective population size increased from approximately 100 bears in the 1980s to 450 in the 2000s. These findings provide evidence that Yellowstone grizzly bears are approaching the effective population size necessary for long-term genetic viability, a criterion established by geneticists long ago (Franklin 1980). Although the GYE grizzly bear population is isolated, genetic diversity remained stable and inbreeding was relatively low (0.2%) over the time period 1985–2010. Kamath et al. (2015) concluded that the current effective population size is sufficiently large to avoid substantial accumulation of inbreeding depression, reducing concerns regarding genetic factors affecting the viability of the population. Nevertheless, the historically small effective population size, relatively low diversity, and isolation over many generations suggest the grizzly population could benefit from increased fitness following the restoration of gene flow. With recent records of grizzly bears from the Northern Continental Divide Ecosystem (NCDE) as close as 85 km to occupied grizzly bear range in the GYE, and with the outer extent of occupied range of both ecosystems separated by about 110 km, the likelihood of natural gene flow via dispersal is promising. Even without natural genetic linkage, if future data indicate a decline in genetic diversity, translocation of a small number of bears from the NCDE would be an effective management option.

A demographic study investigated potential causes for the slowing of population growth that started in the early 2000s, as documented by the IGBST in 2011 (IGBST 2012). A longitudinal study by van Manen et al. (2016) attempted to start teasing apart potential effects of food declines versus intra-specific effects of bear density on vital rates. They used remote sensing data to assess the degree of whitebark pine (*Pinus albicaulis*) impact experienced by individual bears over a 30-year period (1983–2012). Similarly, they developed an index of grizzly bear density by combining life-history and telemetry data and measured this index for all bears in the analysis. Both indices varied depending on the area within the GYE and over time. Cub survival and, to a lesser degree, reproductive transition from females having no cubs-of-the-year (hereafter, cubs) to having cubs were lower in areas where bear densities were greater. The conclusion from this study was that the slowing of population growth was associated with increasing density of grizzly bears rather than the decline of a calorie-rich fall food resource, whitebark pine. Nevertheless, population changes brought about by density effects may still be linked with food resources and carrying capacity of the environment. The possibility exists that decline of whitebark pine and other resources reduced carrying capacity, which could have reduced cub survival and reproductive transitions in a density-dependent fashion through direct competition for resources.

This effect would be difficult to separate from that of interference competition. If this were the case, however, we would have expected home-range size and movements to increase (McLoughlin et al. 2000), bears to have relied on lower-energy food resources (McLellan 2011), and body condition to have declined as a consequence (Robbins et al. 2004). To date, there is little evidence for these conditions in the Yellowstone Ecosystem: female home ranges have decreased in size where bear densities have increased (Bjornlie et al. 2014), daily movements have not changed for females or males during fall hyperphagia (Costello et al. 2014), bears continue to use high-quality foods (Fortin et al. 2013), body mass has not declined (Schwartz et al. 2014), and percent body fat among females in fall has not changed (Interagency Grizzly Bear Study Team 2013). Finally, current evidence suggests grizzly bears responded to declines in whitebark pine (Costello et al. 2014) and cutthroat trout (*Oncorhynchus clarkii*; Fortin et al. 2013) by shifting their diets, indicating grizzly bears were able to compensate for the decline of these particular foods so far.

Population and Habitat Monitoring

We continue to follow monitoring protocols established under the Revised Demographic Recovery Criteria (U.S. Fish and Wildlife Service [USFWS] 2007*a*) and the demographic monitoring section of the Final Conservation Strategy for the Grizzly Bear in the Greater Yellowstone Area (USFWS 2007*b*). In our 2014 annual report we noted that 2015 would be another important benchmark to further assess potential influence of changes in food resources on the population. In 2015 we estimated 51 unique females with cubs in the ecosystem, 46 of which were within the Demographic Monitoring Area (see "***Estimating Number of Females with Cubs***"). This number was lower than 2014, when we documented 64 females with cubs in the entire ecosystem, of which 59 were in the Demographic Monitoring Area. Consequently, the overall population estimate changed from 757 in 2014 to 717 in 2015. Given that IGBST data support the interpretation that the population may be nearing carrying capacity in some portions of the ecosystem, population oscillations around a long-term mean are to be expected. Given that population estimates peaked in 2013 and 2014, we may be seeing the first manifestations of this.

We continued our efforts to assess a mark-resight technique to estimate the number of females with cubs (Higgs et al 2013; in collaboration with scientists and students at Montana State University, Department of Mathematical Sciences. Implementation of this technique is desirable because it addresses the underestimation bias associated with the Chao2 estimator, on which we have reported in previously. However, implementation has been contingent on the ability of the technique to detect changes in population trend over time, which we assessed recently. A summary of this analysis is provided in this report (see "***Estimating Number of Females with Cubs, Mark-Resight***") as well as an Appendix containing the full report submitted to IGBST (Appendix C). The primary conclusion from this work is that current sample sizes are insufficient to provide early detection of changes in population trend.

Although monitoring requirements under the Conservation Strategy (USFWS 2007*b*) do not apply since the GYE grizzly bear population was relisted in 2009, the U.S. Forest Service continues to report on items identified in the Conservation Strategy including changes in secure habitat, livestock allotments, and developed sites from the 1998 baseline levels in each Bear Management Unit (BMU) subunit. This year, the 8th report detailing this monitoring program is provided by documenting: 1) changes in secure habitat, open motorized access route density, and total motorized route density inside the Primary Conservation Area (PCA; equivalent to the U.S. Fish and Wildlife Service Recovery Zone); 2) changes in number and capacity of developed sites inside the PCA; and 3) changes in number of commercial livestock allotments, changes in the number of permitted domestic sheep animal months inside the PCA, and livestock allotments with grizzly bear conflicts during the last 5 years (Appendix A).

Habitat monitoring includes documenting the abundance of 4 high-calorie foods throughout the GYE: 1) winter ungulate carcasses, 2) cutthroat trout spawning numbers, 3) bear use of army cutworm moth (*Euxoa auxiliaris*) sites, and 4) whitebark pine cone production. These protocols have been monitored and reported by the IGBST for numerous years and are reported here. Additionally, we continued monitoring the health of whitebark pine in the ecosystem in cooperation with the Greater Yellowstone Whitebark Pine Monitoring Working Group. We reference these monitoring efforts in Appendix B. The protocol has been modified to document mortality rate in whitebark pine from all causes, including mountain pine beetle (*Dendroctonus ponderosae*).

The annual reports of the IGBST summarize annual data collection. Because additional information can be obtained after publication, data summaries are subject to change. For that reason, data analyses and summaries presented in this report supersede all previously published data. Descriptions of the study area and sampling techniques are reported by Blanchard (1985), Mattson et al. (1991*a*), Haroldson et al. (1998), and Schwartz et al. (2006).

History and Purpose of the IGBST

It was recognized as early as 1973 that a better understanding of the dynamics of grizzly bears in the GYE would best be accomplished by a centralized research group responsible for collecting, managing, analyzing, and distributing information. To meet this need, agencies formed the IGBST, a cooperative effort among the U.S. Geological Survey, National Park Service, U.S. Forest Service, U.S. Fish and Wildlife Service, and the state wildlife agencies of Idaho, Montana, and Wyoming. The Eastern Shoshone and Northern Arapaho Tribes formally joined the study team in 2009. Responsibilities of the IGBST are to: 1) conduct short- and long-term research projects addressing information needs for bear management; 2) monitor the bear population, including status and trend, numbers, reproduction, and mortality; 3) monitor grizzly bear habitats, foods, and impacts of humans; and 4) provide technical support to agencies and other groups responsible for the immediate and long-term management of grizzly bears in the GYE. Additional details can be obtained at our web site: http://www.usgs.gov/norock/igbst.

Quantitative data on grizzly bear abundance, distribution, survival, mortality, nuisance activity, and bear foods are critical to formulating management strategies and decisions. Moreover, this information is necessary to evaluate the recovery process. The IGBST coordinates data collection and analysis on an ecosystem scale, prevents duplication of effort, and pools limited economic and personnel resources.

Previous Research

Some of the earliest research on grizzlies within Yellowstone National Park was conducted by John and Frank Craighead. Their book, "The Grizzly Bears of Yellowstone" provides a detailed summary of this early research (Craighead et al. 1995). With the closing of open-pit garbage dumps and cessation of the ungulate reduction program in Yellowstone National Park in 1967, bear demographics (Knight and Eberhardt 1985), food habits (Mattson et al. 1991*a*), and growth patterns (Blanchard 1987) for grizzly bears changed. Since 1975, the IGBST has produced annual reports and numerous scientific publications summarizing the team's monitoring and research efforts within the GYE. We have obtained substantial insights into the historic distribution of grizzly bears within the GYE (Basile 1982, Blanchard et al. 1992), movement patterns (Blanchard and Knight 1991), food habits (Mattson et al. 1991*a*, IGBST 2013), habitat use and habitat security (Knight et al. 1984, Schwartz et al. 2010), population dynamics (Knight and Eberhardt 1985, Eberhardt et al. 1994, Eberhardt 1995, Schwartz et al. 2006, IGBST 2012, van Manen et al. 2016), and genetics (Haroldson et al. 2010, Kamath et al. 2015). Development and enhancement of data collection and analysis techniques continues. As our summaries of recent longitudinal studies underscore, through long-term research and monitoring we continue to collect detailed data to support a variety of analyses, providing researchers and managers with a comprehensive assessment of population dynamics.

Acknowledgments

This report is a combined effort of the partner agencies and individual members of the IGBST and many individuals contributed either directly or indirectly to its preparation. To that end, we have identified author(s). We also wish to thank the following individuals for their contributions to data collection, analysis, and other phases of IGBST research; **IDFG**: B. Aber, C. Anderson, P. Atwood, A. Blackwood, R. Cavallaro, L. Cepenzski, S.

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Finally, at the end of April 2016, Grizzly Bear Recovery Coordinator for the U.S. Fish and Wildlife Service, Dr. Chris Servheen retired. His professional career spanned 35 years and was fully dedicated to grizzly bear recovery in the lower 48 states. He showed remarkable focus in pursuing this goal, and always advocated science as a central guiding principle for decision making by the Interagency Grizzly Bear Committee and its subcommittees. There are many controversial aspects to grizzly bear conservation and science. Chris was always willing to listen to perspectives and views from many different stakeholders. He was a steady hand at the helm of a ship that was tugged by many currents, but he never lost track of the crucial role of science to inform the decision process, which has been an inspiration to many of us. When Chris started as the recovery coordinator in 1981, very few people would have imagined the GYE grizzly bear population would grow more than 3-fold in size and occupy more than twice as much habitat over the next 35 years. Regardless of the legal status of the Yellowstone grizzly bear population, this is a remarkable conservation success story, in which Chris played a pivotal role. We wish him well in his retirement.

Bear Monitoring and Population Trend

***Marked Animals** (Mark A. Haroldson and Chad Dickinson, Interagency Grizzly Bear Study Team; and Dan D. Bjornlie, Wyoming Game and Fish Department)*

During the 2015 field season, we captured 89 individual grizzly bears on 106 occasions (Table 1), including 24 females (13 adult), 65 males (39 adult). Sixty-three individuals (71%) were bears not previously marked. The percent of previously unmarked individual grizzly bears captured annually during 1998–2015 has remained relatively constant, averaging 62%, with no evidence ($F = 0.503$, 1 df, $P = 0.488$) of a change in trend (Figure 1). This result supports the notion that we are encountering new (i.e., previously unmarked) individuals at a relatively constant rate. The increase in the number of individual bears captured during 2015, compared with 2013 and 2014, is likely a result of more fall conflicts during 2015, which resulted in more management captures.

We conducted research trapping efforts for a total 655 trap days (1 trap day = 1 trap set for 1 day). During research trapping operations we had 35 captures of 30 individual grizzly bears for a trapping success rate of 1 grizzly capture every 18.7 trap days.

There were 72 management captures of 62 individual bears in the GYE during 2015 (Tables 1 and 2), including 21 females (10 adults), and 41 males (20 adults). Thirty-six individual bears (12 females, 24 males), were relocated on 40 occasions because of conflict situations (Table 1). Thirty-two individuals were transported once and 4 bears were transported on 2 separate occasions. Three (all males) of the transported bears were considered non-target captures. Two additional non-target captures (1 adult male, 1 yearling male) were released short distances (<3 km) from their capture sites. Two bears, 1 adult female and 1 adult male (820, Table 1), were captured at both research and management trap sites. The female (#822, Table 1) was initially captured and transported for cattle depredation. She was subsequently captured at a research trap site and eventually traveled back to the initial conflict site, continued cattle depredations, and was removed from the population. In total, there were 29 management captures that resulted in removals (10 females, 19 males) during 2015 (Table 1). Additionally, 1 male cub (Unm12, Table 1) captured at a cattle depredation site died during handling.

We radiomonitored 102 individual grizzly bears during the 2015 field season, including 32 (28 adults) females (Tables 2 and 3). Fifty-eight grizzly bears entered their winter dens wearing active transmitters. Two bears not located since spring are considered missing (Table 3). Since 1975, 835 individual grizzly bears have been radio-marked in the GYE.

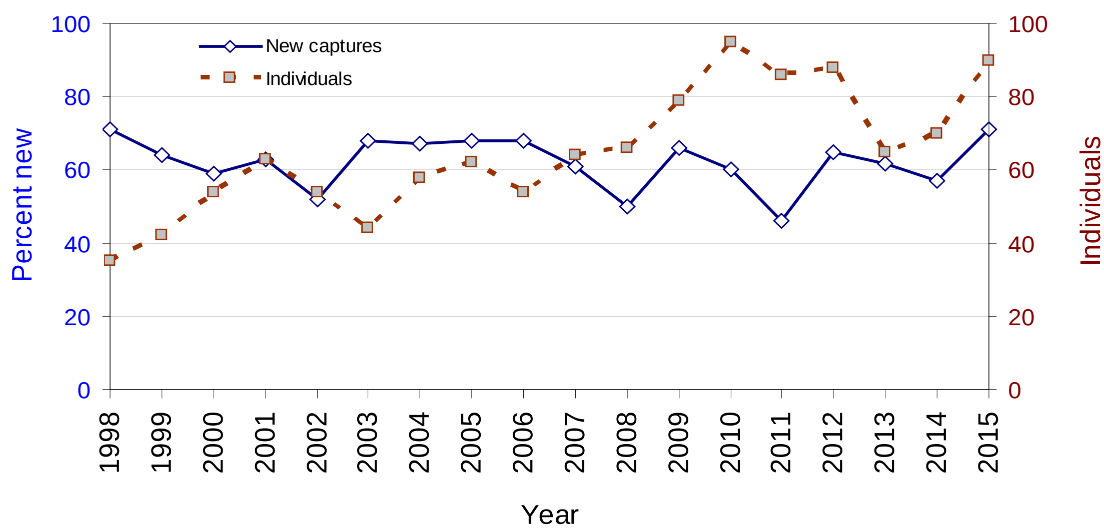

Figure 1. Percent of previously unmarked and total number of grizzly bears captured annually in the Greater Yellowstone Ecosystem, 1998–2015.

Table 1. Grizzly bears captured in the Greater Yellowstone Ecosystem during 2015.

Bear	Sex	Age	Date	General location[a]	Capture type	Release site[a]	Handler[b]
802	Male	Subadult	4/17/2015	Snake River, PR-WY	Management	Pilgrim Crk, GTNP	WGFD/GTNP
802	Male	Subadult	5/14/2015	Warm Springs Crk, PR-WY	Management	Glade Crk, JDRMP	WGFD/GTNP
803	Male	Subadult	5/7/2015	Dick Crk, SNF	Research	On site	WGFD
804	Male	Subadult	5/8/2015	Oxbow Crk, YNP	Research	On site	YNP
805	Male	Subadult	5/13/2015	Pacific Crk, GTNP	Research	On site	IGBST
806	Male	Adult	5/10/2015	South Fork Shoshone River, SNF	Management	Corral Crk, SNF	WGFD
807	Male	Adult	5/12/2015	South Fork Shoshone River, SNF	Management	Corral Crk, SNF	WGFD
808	Male	Subadult	5/14/2015	Owl Crk, PR-WY	Management	Fox Crk, SNF	WGFD
809	Male	Adult	5/13/2015	Greybull River, PR-WY	Research	On site	WGFD
810	Male	Adult	5/15/2015	Dick Crk, SNF	Research	On site	WGFD
G201	Male	Subadult	5/16/2015	Grove Crk, PR-MT	Management	On site	WS/MTFWP
G202	Male	Adult	5/17/2015	Francs Fork, SNF	Research	On site	WGFD
811	Male	Adult	5/19/2015	Spread Crk, GTNP	Research	On site	IGBST
812	Male	Adult	5/21/2015	Oxbow Crk, YNP	Research	On site	YNP/IGBST
813	Male	Adult	5/22/2015	Stephens Crk, YNP	Research	On site	IGBST
Unm1	Male	Adult	5/22/2015	Grove Crk, PR-MT	Management	Removed	WS
Unm2	Male	Adult	5/22/2015	Grove Crk, PR-MT	Management	Removed	WS
G203	Male	Adult	5/26/2015	Greybull River, PR-WY	Research	On site	WGFD
814	Male	Adult	6/3/2015	Stephens Crk, YNP	Research	On site	IGBST
815	Female	Adult	6/10/2015	Gibbon River, YNP	Research	On site	IGBST
816	Male	Adult	6/10/2015	Spread Crk, GTNP	Research	On site	IGBST
G204	Male	Subadult	6/11/2015	Grinnell, SNF	Management	Middle Bone Crk, CTNF	WGFD
G205	Male	Subadult	6/11/2015	Grinnell, SNF	Management	Middle Bone Crk, CTNF	WGFD
817	Male	Subadult	6/18/2015	Pelican Crk, YNP	Research	On site	IGBST
656	Male	Adult	6/26/2015	Tosi Crk, BTNF	Management	Removed	WGFD
G206	Male	Subadult	6/27/2015	Wagon Crk, BTNF	Management	North Fork Shoshone, SNF	WGFD
Unm3	Male	Subadult	6/27/2015	Wind River, PR-WY	Management	Removed	WGFD
356	Male	Adult	7/3/2015	Wiggins Fork, PR-WY	Management	Removed	WGFD
783	Male	Adult	7/4/2015	Snake River, GTNP	Research	On site	IGBST
783	Male	Adult	9/14/2015	Lizard Crk, GTNP	Research	On site	IGBST
783	Male	Adult	9/15/2015	Lizard Crk, GTNP	Research	On site	IGBST
818	Male	Subadult	7/6/2015	Hominy Crk, CTNF	Research	On site	WGFD
819	Male	Adult	7/7/2015	Snake River, GTNP	Research	On site	IGBST
719	Male	Adult	7/12/2015	Gypsum Crk, BTNF	Management	Removed	WGFD
820	Male	Adult	7/19/2015	Pilot Crk, SNF	Research	On site	IGBST
820	Male	Adult	10/22/2015	Squaw Crk, PR-WY	Management	Removed	WGFD
821	Male	Adult	7/22/2015	Dry Crk, CTNF	Research	On site	WGFD
821	Male	Adult	9/10/2015	Lizard Crk, GTNP	Research	On site	IGBST
548	Male	Adult	7/22/2015	Horn Crk, BDNF	Management	Removed	WS/MTFWP
822	Female	Adult	7/24/2015	Bear Crk, PR-MT	Management	Teepee Crk, State-MT	WS/MTFWP
822	Female	Adult	8/5/2015	Pine Crk, GNF	Research	On site	IGBST

Table 1. Continued

Bear	Sex	Age	Date	General location[a]	Capture type	Release site[a]	Handler[b]
822	Female	Adult	10/1/2015	East Fork Fiddle Crk, ST-MT	Management	Removed	WS
Unm4	Male	Subadult	7/24/2015	Bear Crk, PR-MT	Management	Teepee Crk, State-MT	WS/MTFWP
780	Male	Adult	7/25/2015	Gypsum Crk, BTNF	Management	Removed	WGFD
G207	Female	Subadult	7/25/2015	Muddy Crk, SNF	Management	Bailey Crk, BTNF	WGFD
G208	Male	Subadult	7/25/2015	Muddy Crk, SNF	Management	Bailey Crk, BTNF	WGFD
824	Male	Subadult	8/2/2015	Tepee Crk, BTNF	Management	Mormon Crk, SNF	WGFD
825	Male	Adult	8/3/2015	Lime Crk, BTNF	Management	Sunlight Crk, SNF	WGFD
826	Male	Adult	8/7/2015	Rawhide Crk, PR-WY	Management	Boone Crk, CTNF	WGFD
826	Male	Adult	8/20/2015	Green River, PR-WY	Management	Removed	WGFD
728	Female	Adult	8/7/2015	Henrys Fork, CTNF	Research	On site	IDFG
827	Male	Subadult	8/8/2015	Grass Crk, PR-WY	Management	Bailey Crk, BTNF	WGFD
827	Male	Subadult	9/8/2015	East Fork Wind River, PR-WY	Management	Mormon Crk, SNF	WGFD
827	Male	Subadult	10/17/2015	Sulphur Crk, BLM-WY	Management	Removed	WGFD
Unm5	Female	Adult	8/8/2015	Yellowstone River, YNP	Management	Removed	YNP
Unm6	Female	Subadult	8/10/2015	Yellowstone River, YNP	Management	Removed	YNP
Unm7	Female	Subadult	8/9/2015	Yellowstone River, YNP	Management	Removed	YNP
Unm5	Female	Adult	8/8/2015	Yellowstone River, YNP	Management	Removed	YNP
Unm6	Female	Subadult	8/10/2015	Yellowstone River, YNP	Management	Removed	YNP
Unm7	Female	Subadult	8/9/2015	Yellowstone River, YNP	Management	Removed	YNP
Unm8	Female	Subadult	8/8/2015	Crooked Crk, PR-WY	Management	Removed	WGFD
Unm9	Male	Adult	8/11/2015	Sheridan Crk, SNF	Management	Removed	WGFD
658	Female	Adult	8/13/2015	Dry Crk, PR-WY	Management	Removed	WGFD
828	Male	Adult	8/15/2015	Bootjack Crk, CTNF	Research	On site	IDFG
G209	Female	Subadult	8/20/2015	Sheep Crk, PR-WY	Management	Fox Crk, SNF	WGFD
829	Male	Adult	8/21/2015	Dry Crk, PR-WY	Management	Dailey Crk, BTNF	WGFD
830	Male	Adult	8/21/2015	Ellis Crk, PR-MT	Management	On site	WS/MTFWP
Unm10	Male	Adult	8/24/2015	South Fork Shoshone, PR-WY	Management	Removed	WGFD
479	Male	Adult	8/24/2015	Elk Crk, PR-ID	Management	Removed	IGFG
831	Female	Adult	8/25/2015	Plateau Crk, BTNF	Research	On site	WGFD
832	Male	Subadult	8/29/2015	Wagon, Crk, BTNF	Management	North Fork Shoshone, SNF	WGFD
832	Male	Subadult	9/19/2015	Tosi Crk, PR-WY	Management	Removed	WGFD
211	Male	Adult	8/31/2015	Antelope Crk, YNP	Research	On site	IGBST
833	Female	Adult	9/1/2015	North Fork Shoshone, PR-WY	Management	Fox Crk, SNF	WGFD
834	Male	Adult	9/2/2015	North Fork Shoshone, PR-WY	Management	Painter Gulch, SNF	WGFD
835	Female	Adult	9/3/2015	North Fork Shoshone, PR-WY	Management	Boone Crk, CTNF	WGFD
835	Female	Adult	10/8/2015	Falls River, PR-ID	Management	Removed	IDFG
843	Male	Subadult	9/3/2015	North Fork Shoshone, PR-WY	Management	Boone Crk, CTNF	WGFD
843	Male	Subadult	10/8/2015	Falls River, PR-ID	Management	Snow Creek, CTNF	IDFG
844	Male	Subadult	9/3/2015	North Fork Shoshone, PR-WY	Management	Boone Crk, CTNF	WGFD
844	Male	Subadult	10/8/2015	Falls River, PR-ID	Management	Snow Creek, CTNF	IDFG

Table 1. Continued

Bear	Sex	Age	Date	General location[a]	Capture type	Release site[a]	Handler[b]
836	Female	Subadult	9/6/2015	Tepee Crk, BNTF	Management	North Fork Shoshone, SNF	WGFD
837	Male	Subadult	9/9/2015	Skull Crk, PR-WY	Management	Mormon Crk, SNF	WGFD
837	Male	Subadult	9/23/2015	Golf Crk, SNF	Management	Removed	WGFD
Unm11	Male	Subadult	9/10/2015	Henrys Lake Outlet, ST-ID	Management	Removed	IDFG
439	Female	Adult	9/10/2015	Dago Crk, BTNF	Management	Russel Crk, SNF	WGFD
G212	Male	Subadult	9/10/2015	Dago Crk, BTNF	Management	Russel Crk, SNF	WGFD
798	Male	Adult	9/11/2015	Spring Crk, PR-WY	Management	North Fork Shoshone, SNF	WTGF
Unm12	Female	Subadult	9/11/2015	Dago Crk, BTNF	Management	Handling mortality	WGFD
838	Male	Adult	9/11/2015	Lizard Crk, GTNP	Research	On site	IGBST
679	Male	Adult	9/12/2015	Bailey Crk, GTNP	Research	On site	IGBST
299	Male	Adult	9/12/2015	Coyote Crk, YNP	Research	On site	IGBST
839	Male	Adult	9/13/2015	South Fork Shoshone, PR-WY	Management	Wind River, SNF	WGFD
747	Female	Adult	9/16/2016	Clint Crk, SNF	Management	North Fork Shoshone, SNF	WGFD
773	Female	Adult	9/21/2015	South Fork Shoshone, PR-WY	Management	Boone Crk, CTNF	WGFD
840	Male	Subadult	9/25/2015	Wagon Crk, BTNF	Management	Fox Crk, SNF	WGFD
787	Male	Subadult	9/25/2015	Wagon Crk, BTNF	Management	Removed	WGFD
841	Male	Subadult	9/26/2015	Crow Crk, BNFT	Management	Fox Crk, SNF	WGFD
Unm13	Male	Subadult	10/6/2015	Greybull River, PR-WY	Management	Removed	WGFD
842	Male	Adult	10/7/2015	Jasper Crk, YNP	Research	On site	IGBST
842	Male	Adult	10/13/2015	Jasper Crk, YNP	Research	On site	IGBST
704	Male	Adult	10/8/2015	Jasper Crk, YNP	Research	On site	IGBST
704	Male	Adult	10/10/2015	Jasper Crk, YNP	Research	On site	IGBST
213	Female	Adult	10/17/2015	Taylor's Fork, PR-MT	Management	Removed	MTFWP
Unm14	Female	Subadult	10/18/2015	Taylor's Fork, PR-MT	Management	Removed	MTFWP
Unm15	Female	Subadult	10/18/2015	Taylor's Fork, PR-MT	Management	Removed	MTFWP
743	Female	Adult	10/28/2015	Spring Crk, BLM-WY	Management	Split Rock Crk, BTNF	WGFD
G213	Female	Subadult	10/30/2015	Spring Crk, BLM-WY	Management	Split Rock Crk, BTNF	WGFD
G214	Female	Subadult	10/30/2015	Spring Crk, BLM-WY	Management	Split Rock Crk, BTNF	WGFD

[a] BLM = Bureau of Land Management; BTNF = Bridger-Teton National Forest, CTNF = Caribou-Targhee National Forest, GNF = Gallatin National Forest, SNF = Shoshone National Forest, YNP = Yellowstone National Park, WRIR = Wind River Reservation, PR = private.
[b] IDFG = Idaho Fish and Game; IGBST = Interagency Grizzly Bear Study Team, USGS; MTFWP = Montana Fish, Wildlife and Park; WS = Wildlife Services; WGFD = Wyoming Game and Fish Department; YNP = Yellowstone National Park.

Table 2. Annual number of grizzly bears monitored, captured, and transported in the Greater Yellowstone Ecosystem, 1980–2015.

Year	Number monitored	Individuals trapped	Total captures: Research	Total captures: Management	Transports
1980	34	28	32	0	0
1981	43	36	30	35	31
1982	46	30	27	25	17
1983	26	14	0	18	13
1984	35	33	20	22	16
1985	21	4	0	5	2
1986	29	36	19	31	19
1987	30	21	15	10	8
1988	46	36	23	21	15
1989	40	15	14	3	3
1990	35	15	4	13	9
1991	42	27	28	3	4
1992	41	16	15	1	0
1993	43	21	13	8	6
1994	60	43	23	31	28
1995	71	39	26	28	22
1996	76	36	25	15	10
1997	70	24	20	8	6
1998	58	35	32	8	5
1999	65	42	31	16	13
2000	84	54	38	27	12
2001	82	63	41	32	15
2002	81	54	50	22	15
2003	80	44	40	14	11
2004	78	58	38	29	20
2005	91	63	47	27	20
2006	92	54	36	25	23
2007	86	65	54	19	8
2008	87	66	39	40	30
2009	97	79	63	34	25
2010	85	95	36	75	52
2011	92	86	61	46	24
2012	112	88	47	56	35
2013	88	65	58	30	20
2014	94	70	51	30	20
2015	101	89	34	72	41

Table 3. Grizzly bears radiomonitored in the Greater Yellowstone Ecosystem, 2015.						
Bear	Sex	Age	Offspring[a]	Monitored		Current status
				Out of den	Into den	
193	F	Adult	None	Yes	Yes	Active
211	M	Adult		Yes	Yes	Active
227	M	Adult		Yes	No	Cast
299	M	Adult		No	Yes	Active
423	F	Adult	2 2-year-olds	Yes	No	Cast
439	F	Adult	2 cubs, 1 died during capture	No	Yes	Active
479	M	Adult		Yes	No	Dead
499	F	Adult	3 yearlings	Yes	No	Cast
506	M	Adult		Yes	Yes	Active
541	F	Adult	2 2-year-olds	Yes	No	Cast
592	M	Adult		Yes		Missing
610	F	Adult	2 cubs	Yes	Yes	Active
627	F	Adult	2 yearlings	Yes	Yes	Active
644	M	Adult		Yes	Yes	Active
655	M	Adult		Yes	Yes	Active
672	F	Adult	2 2-year-olds	Yes	Yes	Active
676	F	Adult	None	Yes	No	Cast
679	M	Adult		Yes	Yes	Active
704	M	Adult		No	Yes	Active
706	F	Adult	None	Yes	No	Cast
711	M	Adult		No		Missing
713	M	Adult		Yes	No	Cast
725	F	Adult	2 cubs, lost when mother died	Yes	No	Dead
728	F	Adult	3 cubs	No	Yes	Active
732	F	Adult	2 yearlings	Yes	Yes	Active
742	M	Adult		Yes	No	Cast
743	F	Adult	2 cubs	Yes	Yes	Active
747	F	Adult		No	Yes	Active
759	F	Adult	None	Yes	No	Cast
761	M	Adult		Yes	No	Cast
762	F	Adult	1 cub, lost	Yes	Yes	Active
770	F	Adult		Yes	No	Cast
772	M	Adult		Yes	No	Cast
773	F	Adult	1 cub	Yes	Yes	Active

Table 3. Continued.

Bear	Sex	Age	Offspring[a]	Monitored		Current status
				Out of den	Into den	
775	M	Adult		Yes	No	Cast
776	M	Adult		Yes	No	Cast
777	M	Adult		Yes	No	Cast
779	F	Adult	Not seen	Yes	Yes	Active
780	M	Adult		Yes	No	Dead
782	M	Subadult		Yes	Yes	Active
783	M	Subadult		yes	Yes	Active
784	F	Adult	Not seen	Yes	No	Cast/Dead?
785	M	Adult		Yes	No	Cast
786	F	Subadult	None	Yes	Yes	Active
787	M	Subadult		Yes	No	Cast
788	M	Subadult		Yes	Yes	Active
789	M	Adult		Yes	Yes	Active
790	M	Subadult		Yes	Yes	Active
791	M	Subadult		Yes	Yes	Active
792	M	Adult		Yes	No	Cast
793	F	Adult	3 yearlings, lost	Yes	Yes	Active
794	M	Adult		No	No	Cast
795	M	Subadult		Yes	No	Cast
796	M	Adult		Yes	No	Cast
797	M	Adult		Yes	No	Cast
798	M	Adult		Yes	Yes	Active
799	F	Adult	None	Yes	Yes	Active
800	F	Subadult	None	Yes	No	Cast
801	F	Subadult	None	Yes	No	Cast/Dead?
802	M	Subadult		No	No	Cast
803	M	Subadult		No	Yes	Active
804	M	Adult		No	Yes	Active
805	M	Subadult		No	Yes	Active
806	M	Adult		No	No	Cast
807	M	Adult		No	Yes	Active
808	M	Subadult		No	Yes	Active
809	M	Adult		No	No	Cast
810	M	Adult		No	Yes	Active
811	M	Adult		No	No	Cast
812	M	Adult		No	No	Cast
813	M	Adult		No	Yes	Active

Table 3. Continued.

Bear	Sex	Age	Offspring[a]	Monitored		Current status
				Out of den	Into den	
814	M	Adult		No	No	Cast
815	F	Adult	None	No	Yes	Active
816	M	Adult		No	Yes	Active
817	M	Adult		No	Yes	Active
818	M	Adult		No	Yes	Active
819	M	Adult		No	Yes	Active
820	M	Adult		No	No	Dead
821	M	Adult		No	Yes	Active
822	F	Adult	1 cub, lost	No	No	Dead
824	M	Subadult		No	Yes	Active
825	M	Adult		No	Yes	Active
826	M	Adult		No	No	Dead
827	M	Subadult		No	No	Dead
828	M	Adult		No	Yes	Active
829	M	Adult		No	No	Cast
830	M	Adult	1 cub	No	Yes	Active
831	F	Adult	1 cub	No	Yes	Active
832	M	Subadult		No	No	Dead
833	F	Adult	None	No	Yes	Active
834	M	Adult		No	Yes	Active
835	F	Adult	2 yearlings	No	No	Dead
836	F	Subadult	None	No	Yes	Active
837	M	Subadult		No	No	Dead
838	M	Adult		No	Yes	Active
839	M	Adult		No	Yes	Active
840	M	Subadult		No	Yes	Active
841	M	Adult		No	Yes	Active
842	M	Adult		No	Yes	Active
843	M	Subadult		No	Yes	Active
844	M	Subadult		No	Yes	Active

Estimating Number of Females with Cubs *(Mark A. Haroldson and Frank T. van Manen, Interagency Grizzly Bear Study Team; and Daniel D. Bjornlie, Wyoming Game and Fish Department)*

I. Assessing Trend and Estimating Population Size from Observations of Unique Females with Cubs

Background

Under the Revised Demographic Recovery Criteria (USFWS 2007*b*) of the Grizzly Bear Recovery Plan (USFWS 1993), IGBST is tasked with annually estimating the number of female grizzly bears with cubs (<1 year old) in the GYE population, determining trend for this segment of the population, and estimating size of specific population segments to assess annual mortalities relative to population size. During 2011, results of our trend analysis indicated the trajectory for this annual estimate was changing (Haroldson 2012). This result triggered a demographic review (USFWS 2007*b*), which was held during February 2012. Data from 2002–2011 indicated that several vital rates for the population had changed (IGBST 2012). A consequence of these changed vital rates was that the rate of increase for the grizzly bear population had also changed. Trend estimates using 2002–2011 vital rates suggest the population was stable to slightly increasing during the period (IGBST 2012). Because vital rates and trend had changed, it followed that age structure for the population had also changed. Thus, it is appropriate to use updated vital rates and ratios for specific population segments to estimate size of those segments when assessing annual mortality limits presented in the application protocols (USFWS 2013). Here, we present our 2015 findings for counts of unique females with cubs, and the population estimate derived from numbers of females with cubs observed within the Demographic Monitoring Area (DMA) and 2002–2011 vital rates (IGBST 2012)

Methods

Specific procedures used to accomplish the above-mentioned tasks under the previous protocols are presented in IGBST (2005, 2006) and Harris et al. (2007). Under the updated protocols only females with cubs observed within the DMA (Figure 2) are counted to derive a population estimate. Updated vital rates and ratios for numerical estimation of specific population segments under the updated criteria are specified in IGBST (2012).

Briefly, the Knight et al. (1995) rule set is used to estimate the number of unique females with cubs and tabulate sighting frequencies for each family. We then apply the Chao2 estimator (Chao 1989, Wilson and Collins 1992, Keating et al. 2002, Cherry et al. 2007) to sighting frequencies for each unique family. This estimator accounts for individual sighting heterogeneity and produces an estimate for the total number of females with cubs present in the population. Next, we estimate trend and rate of change (λ) for the number of unique females with cubs in the population from the natural log (ln) of the annual $\hat{N}_{Chao2}$ estimates using linear and quadratic regressions with model averaging (Burnham and Anderson 2002). The quadratic model is included to detect changes in trend. Model AIC_c (Akaike Information Criterion) will favor the quadratic model if the rate of change levels off or begins to decline (IGBST 2006, Harris et al. 2007). This process smoothes variation in annual estimates that result from sampling error or pulses in numbers of females producing cubs due to natural processes (i.e., process variation). Some changes in previous model-averaged estimates for unique females with cubs ($\hat{N}_{MAFC}$) are expected with each additional year of data. Retrospective adjustments to previous estimates are not done (IGBST 2006). Demographic Recovery Criterion 1 (USFWS 2007*b*) specifies a minimum requirement of 48 females with cubs for the current year ($\hat{N}_{MAFC}$). Model-averaged estimates below 48 for 2 consecutive years will trigger a biology and management review, as will a shift in AIC_c that favors the quadratic model (i.e., AIC_c weight > 0.50, USFWS 2007*b*). Given the assumption of a reasonably stable sex and age structure, trend for the females with cubs represents the rate of change for the entire population (IGBST 2006, Harris et al. 2007). It follows that estimates for specific population segments can be derived from $\hat{N}_{MAFC}$ and the estimated stable age distribution for the population. Estimates for specific population segments and associated confidence intervals follow IGBST (2005, 2006) for the previous protocol and IGBST (2012) for the updated protocol, which

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incorporates observed changes in vital rates during 2002–2011 and is based on the DMA.

2015 Sightings of Females with Cubs

We documented 156 verified sightings of females with cubs during 2015 in the GYE. Seven of the sighting (4.5%) occurred outside the DMA (Figure 2). Observations were almost evenly split between ground (51.9%) and aerial (48.1%) sources (Table 4). We were able to differentiate 46 unique females from the 156 sightings using the rule set described by Knight et al. (1995). Two of the 46 unique females were only observed ($n = 2$ sightings) outside the DMA. One of these females had a 1-cub litter and the other had a 2-cub litter. Sixty-nine (44.2%) observations from an estimated 14 unique females with cubs occurred within the boundary of Yellowstone National Park.

Total number of cubs observed during initial sightings of the 46 unique females with cubs was 90 and mean litter size was 1.96 (Table 5). There were 15 single cub litters, 18 litters of twins, and 13 litters of triplets (Table 5). No quadruplet litters were observed during 2015 (Table 5). Excluding observations that occurred outside the DMA, there were 44 unique females with a total of 87 cubs during initial sightings and a mean litter size of 1.98.

2015 DMA Chao2 and Population Estimate

Excluding the 2 families (2 sightings) only observed outside the DMA, there were 131 observations of 41 families obtained without the aid of telemetry. Using sighting frequencies for these families produced an estimate for unique females with cubs within the DMA of $\hat{N}_{DMAChao2} = 46$. Using this revised estimate in our linear and quadratic regression analyses produced a model-averaged estimate for 2015 of $\hat{N}_{DMAChao2} = 56$ (95% CI = 44–71). This estimate does not retrospectively exclude unique families observed outside the DMA for years prior to 2012. However, if those sighting of unique families observed outside the DMA were excluded, changes in our estimates of trend and population size would be small because nearly all females with cubs are sighted within the DMA (IGBST 2012). Applying the updated 2002–2011 vital rates to $\hat{N}_{DMAChao2}$ produces a total population estimate for the DMA of 717 (Table 7).

We used the annual $\hat{N}_{DMAChao2}$ for the period 1983–2015 (Table 6) to estimate the rate of population change (Figure 3) for the female with cubs segment of the population. With the 2015 addition, AIC_c weights (Table 8) exhibited unambiguous support for the quadratic (79%) over the linear (21%) models. Additionally, the estimated quadratic effect ($\beta = -0.00105$) was significant ($P = 0.030$, Table 8). This is the first year we report model results using Chao2 estimates from 2012–2015 that were restricted to the DMA. We note that findings from Schwartz et al. (2008) indicated the Chao2 estimate is biased low and becomes more biased with increasing population size. The support for a leveling off of population growth for the more restricted geographic area of the DMA was not unexpected and is consistent with findings from other analyses (e.g., IGBST 2012, van Manen et al. 2016).

Table 4. Method of observation for female grizzly bears with cubs sighted in the Greater Yellowstone Ecosystem, 2015.

Method of observation	Frequency	%	Cumulative %
Fixed-wing aircraft – other researcher	4	2.6	2.6
Fixed-wing aircraft – observation flight	43	27.6	30.1
Fixed-wing aircraft – telemetry flight	24	15.4	45.5
Fixed-wing aircraft – ferry time	4	2.6	48.1
Ground sighting	78	50	98.1
Trap	3	1.9	100
Total	156	100	

Table 5. Number of unique females with cubs ($\hat{N}_{Obs}$), litter frequencies, total number of cubs, and average litter size at initial observation, Greater Yellowstone Ecosystem, 1983–2015.

Year	$\hat{N}_{Obs}$	Total # sightings	Litter Size				Total # cubs	Mean litter size
			1 cub	2 cubs	3 cubs	4 cubs		
1983	13	15	6	5	2	0	22	1.69
1984	17	41	5	10	2	0	31	1.82
1985	9	17	3	5	1	0	16	1.78
1986	25	85	6	15	4	0	48	1.92
1987	13	21	1	8	4	0	29	2.23
1988	19	39	1	14	4	0	41	2.16
1989	16	33	7	5	4	0	29	1.81
1990	25	53	4	10	10	1	58	2.32
1991[a]	24	62	6	14	3	0	43	1.87
1992	25	39	2	12	10	1	60	2.40
1993	20	32	4	11	5	0	41	2.05
1994	20	34	1	11	8	0	47	2.35
1995	17	25	2	10	5	0	37	2.18
1996	33	56	6	15	12	0	72	2.18
1997	31	80	5	21	5	0	62	2.00
1998	35	86	9	17	9	0	70	2.00
1999	33	108	11	14	8	0	63	1.91
2000	37	100	9	21	7	0	72	1.95
2001	42	105	13	22	7	0	78	1.86
2002	52	153	14	26	12	0	102	1.96
2003	38	60	6	27	5	0	75	1.97
2004	49	223	14	23	12	0	96	1.96
2005	31	93	11	14	6	0	57	1.84
2006	47	172	12	21	14	0	96	2.04
2007	50	335	10	22	18	0	108	2.16
2008	44	118	10	28	6	0	84	1.91
2009	42	117	10	19	11	2	89	2.12
2010	51	286	15	23	12	1	101	1.98
2011	39	134	13	17	9	0	74	1.90
2012	49	124	14	25	10	0	94	1.92
2013	58	183	8	35	14	3	126	2.17
2014	50	119	16	22	12	0	96	1.92
2015	46	156	15	18	13	0	90	1.96

[a] One female with unknown number of cubs; average litter size was calculated using 23 females.

Table 6. Annual Chao2 estimates for the numbers of female grizzly bears with cubs in the Greater Yellowstone Ecosystem, 1983–2015. Estimates in parenthesis for 2012–2015 are specific to the Demographic Monitoring Area (DMA). The number of unique females observed ($\hat{N}_{Obs}$) includes those located using radio telemetry; *m* is the number of unique females observed using random sightings only; and $\hat{N}_{Chao2}$ gives the nonparametric bias-corrected estimate, per Chao (1989). Also included are the number of females with cubs sighted once (f_1) or twice (f_2), and the annual estimate of relative sample size ($n/\hat{N}_{Chao2}$), where n is the total number of observations obtained without the aid of telemetry. Unique females with cubs sighted ≥ 3 time can be derived ($f_3+ = m - (f_1 + f_2)$).

Year	$\hat{N}_{Obs}$	m	f_1	f_2	$\hat{N}_{Chao2}$	n	$n/\hat{N}_{Chao2}$
1983	13	10	8	2	19	12	0.6
1984	17	17	7	3	22	40	1.8
1985	9	8	5	0	18	17	0.9
1986	25	24	7	5	28	82	3
1987	13	12	7	3	17	20	1.2
1988	19	17	7	4	21	36	1.7
1989	16	14	7	5	18	28	1.6
1990	25	22	7	6	25	49	2
1991	24	24	11	3	38	62	1.6
1992	25	23	15	5	41	37	0.9
1993	20	18	8	8	21	30	1.4
1994	20	18	9	7	23	29	1.3
1995	17	17	13	2	43	25	0.6
1996	33	28	15	10	38	45	1.2
1997	31	29	13	7	39	65	1.7
1998	35	33	11	13	37	75	2.0
1999	33	30	9	5	36	96	2.7
2000	37	34	18	8	51	76	1.5
2001	42	39	16	12	48	84	1.7
2002	52	49	17	14	58	145	2.5
2003	38	35	19	14	46	54	1.2
2004	49	48	15	10	58	202	3.5
2005	31	29	6	8	31	86	2.8
2006	47	43	8	16	45	140	3.3
2007	50	48	12	12	53	275	5.1
2008	44	43	16	8	56	102	1.8
2009	42	39	11	11	44	100	2.3
2010	51	51	11	9	56	256	4.6
2011	39	39	14	10	47	123	2.6
2012	49 (48)	44 (43)	16 (15)	7 (7)	59 (56)	110 (108)	1.9 (1.9)
2013	58 (57)	53 (52)	13 (14)	11 (11)	60 (60)	160 (152)	2.6 (2.5)
2014	50 (47)	46 (44)	23 (21)	13 (13)	64 (59)	92 (90)	1.4 (1.5)
2015	46 (44)	43 (41)	14 (12)	10 (12)	51 (46)	135 (131)	2.6 (2.8)

Table 7. Estimates and 95% confidence intervals (CI) for population segments and total grizzly bear population size derived using the Chao2 estimate for females with cubs within the Demographic Monitoring Area, 2015.

Population segment	Estimate	95%CI	
		Lower	Upper
Independent females (≥2 years old)	247	187	297
Independent males (≥2 years old)	247	192	302
Dependent young (cubs and yearlings)	223	200	245
Total	717	639	794

Table 8. Parameter estimates and model selection results from fitting the linear and quadratic models for $Ln(\hat{N}_{Chao2})$ with years for female grizzly bears with cubs during 1983–2015. Chao2 estimates were restricted to the Demographic Monitoring Area during 2012–2015.

Model	Parameter	Estimate	Standard error	*t* value	Pr(>*t*)
Linear					
	β_0	2.98998	0.08139	36.73708	<0.0001
	β_1	0.03563	0.00418	8.52918	<0.0001
	SSE	1.61826			
	AIC_c	-92.67251			
	AIC_c weight	0.21061			
Quadratic					
	β_0	2.78211	0.11918	23.34424	<0.0001
	β_1	0.07126	0.01616	4.4095	0.00012
	β_2	-0.00105	0.00046	-2.27298	0.03035
	SSE	1.38052			
	AIC_c	-95.31505			
	AIC_c weight	0.78939			

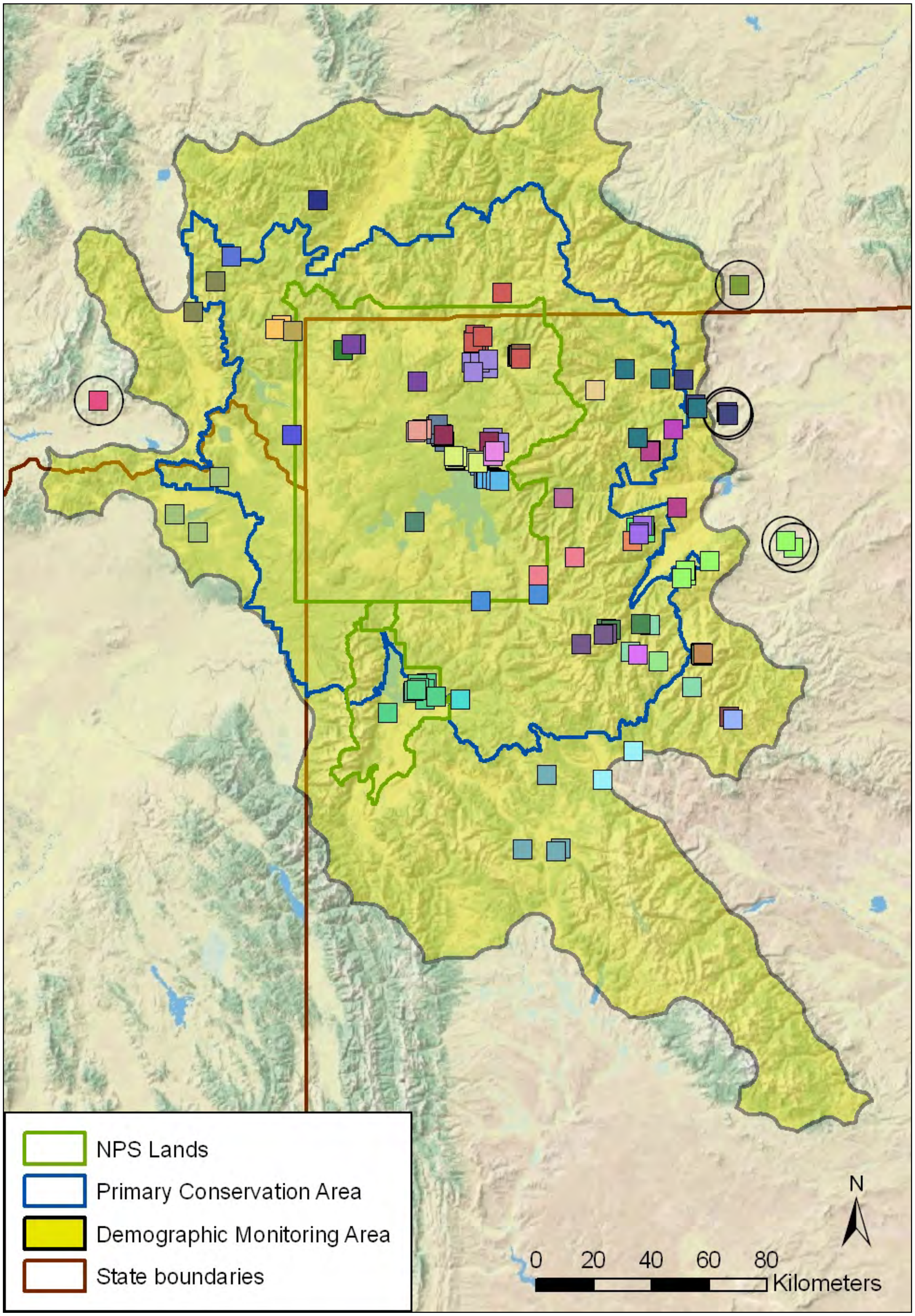

Figure 2. Distribution of 156 sightings of 46 (indicated by unique colors) unduplicated female grizzly bears with cubs (<1 year old) observed in the Greater Yellowstone Ecosystem, 2015. Only sightings from females with cubs occurring within the Demographic Monitoring Area are used for population estimation. During 2015, 7 sightings from 4 unique females with cubs occurred outside the DMA (black circles). Two of these females (1 observation each) were only observed outside the DMA.

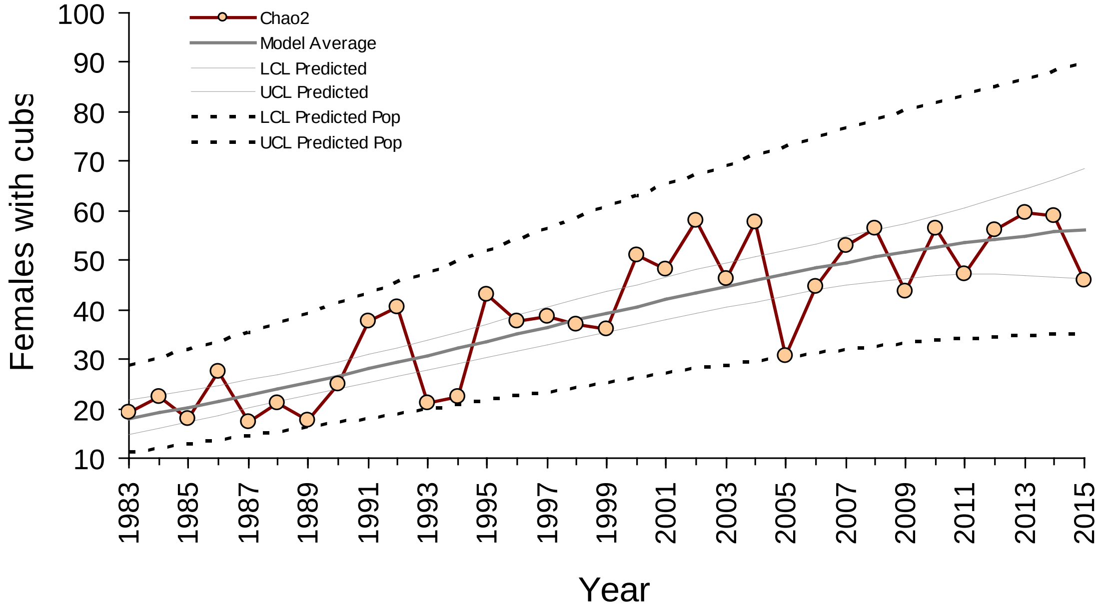

Figure 3. Model-averaged estimates for the number of unique female grizzly bears with cubs, 1983–2015, where the linear and quadratic models of trend were fitted. Estimates for 2012–2015 were restricted to the Demographic Monitoring Area. The inner set of light solid lines represents a 95% confidence interval on the predicted population size, whereas the outer set of dashed lines represents a 95% confidence interval for the individual population estimates.

II. Mark-Resight Technique to Estimate Females with Cubs

Schwartz et al. (2008) demonstrated biases inherent in the method of estimating population size based on the Chao2 estimator (see previous section) using counts of unique females with cubs and the associated rule set of Knight et al. (1995). The IGBST invited partner agencies and quantitative ecologists to participate in 3 workshops held in February 2011, July 2011, and February 2012 to consider alternative approaches. An important product of these workshops was a recommendation to transition from the current protocol for estimating abundance to a mark-resight estimator using systematic flight observation data conducted since 1997. The mark-resight estimator yields an annual estimate of the number of females with cubs based on (1) the presence of a radio-marked sample, and (2) 2 systematic observation flights/year, during which all bears observed are recorded and, following observation, checked for marks (i.e., radio collar) using telemetry. Pilots note whether family groups observed include cubs, yearlings, or 2-year-old offspring. Mark-resight designs for population estimation are commonly used for wildlife monitoring because they can provide a cost-efficient and reliable monitoring tool. However, inference from such designs is limited when data are sparse, either from a low number of marked animals, a low probability of detection, or both. In the GYE, annual mark-resight data collected for female grizzly bears with cubs suffer from both limitations. As an important outcome of the 3 workshops, Higgs et al. (2013) developed a technique to overcome difficulties due to data sparseness by assuming homogeneity in sighting probabilities over 16 years (1997–2012) of biannual aerial surveys. They modeled counts of marked and unmarked grizzly bears with cubs as multinomial random variables, using the capture frequencies of marked females with cubs for inference regarding the latent multinomial frequencies for unmarked females with cubs (Figure 4).

One important assumption of the mark-resight technique is that the geographic distribution of radio-marked female bears is generally representative of the geographic distribution and relative density of female bears in the population. Conclusions from workshop discussions were that this assumption is likely not violated within the GYE, with one exception. A subset of bears in the GYE annually spend 6 to 10 weeks in late summer (mid-Jul to late Sep) in alpine scree slopes feeding on army cutworm moths (*Euxoa auxiliaris*; Mattson et al. 1991*b*, Bjornlie and Haroldson 2011). These bears are highly visible and constitute a substantial proportion of bears seen during observation flights. However, capturing and marking of bears is difficult because these remote, high-elevation areas are snow-covered early in the capture season and access is limited. When access improves later in the season, most bears have already begun feeding on army cutworm moths and are difficult to capture. Thus, the proportion of radio-marked females with cubs among those feeding on these high-visibility sites is lower than in the remainder of the ecosystem. Applying mark-resight estimates to the entire ecosystem without considering these moth sites would result in overestimation bias. However, moth sites are now well defined and the study team annually monitors these sites (see "***Grizzly Bear Use of Insect Aggregation Sites***"). Thus, the decision was made to exclude confirmed moth sites (defined as areas within 500 m from sites where multiple observations of bears feeding occurred >1 year) from the mark-resight analyses and conduct separate aerial census surveys of confirmed moth sites to add the observed number of females with cubs (marked and unmarked) to the mark-resight estimate for that year. Here, we present 2015 mark-resight results using only sightings of females with cubs.

2015 Mark-Resight Results

Two female grizzly bears with cubs wore functioning radio-transmitters during June-August 2015 when aerial observation flights were conducted and were available for observation sighting. One of these families was observed once during observation flights >500 m from a moth site and was included in the Mark-Resight analysis. The second radio-marked female with cubs was only observed on a moth site during observation flights and was therefore excluded from the 2015 analysis. We observed 22 unmarked females >500 m from moth sites (Table 9). Using the method of Higgs et al. (2013) with updated 1997–2015 data and excluding observations at army cutworm moth aggregation sites, our 2015 mark-resight estimate for unique females with cubs was 96 (95% inter-quartile range = 54–162) with a $P < 0.010$ probability of ≤48 females with cubs (Table 10, Figure 4). Moth site-only flights during 2015 yielded 16 additional unique females with cubs observed on moth sites, compared with 19 during 2014. The mark-resight 3-year-moving average for 2014 (using 2013–2015 results) was 90 unique females with cubs (95% inter-quartile range = 57–139), with a $P < 0.001$ probability of ≤48 females with cubs (Table 11, Figure 4).

Higgs et al. (2013) performed simulations based on a known population of 50 females with cubs and resighting frequencies and proportions of bears sighted 0, 1, and 2 times from our observation flight data to determine accuracy and precision of the mark-resight technique. Accuracy was high, indicating that this technique addressed the bias concerns associated with estimates based on the Chao2 estimator. However, the simulations also indicated that precision was relatively low and the authors recommended that other data sources should be considered to increase precision and decrease variability among years. One source of data that could increase sample size may be observations of females with yearlings. During the spring of 2014 we investigated the effect on precision of including observations of radio-marked and unmarked females with yearlings to the analysis. We did not observe an increase in precision, likely because of the small number of observations of both marked and unmarked females with yearlings (M. Higgs, Montana State University, personal communication, 5 May 2014). To support further implementation of the mark-resight technique, we focused new research efforts on propagating different sources of variance when deriving total population estimates and determining the power of the technique to detect population trends.

Mark-Resight Power Analysis

Peck (2016, Appendix C) used simulations of the mark-resight process to conduct a power analysis. He used the Mark-Resight technique presented in Higgs et al. (2013) on a simulated dataset with known properties. Starting with a known population of 70 females with cubs, he simulated scenarios of annual population declines of 1%, 2.5%, and 5% in the true number of females with cubs, each over time frames of 5, 10, and 20 years. Sighting probabilities were based on actual observation data collected by IGBST (Higgs et al.

2013). As expected, the ability to detect the true decline increased with the number of years considered and increased with the level of decline. The ability to detect declines after 5 years was poor, regardless of the annual percent of decline, as evidenced by the wide range of posterior probabilities (Appendix C-Figure 4). The 10-year time frame also indicated a poor ability of the mark-resight technique to detect declines of 1% and 2.5% per year, but was moderately effective at detecting a 5% per year decline. These findings suggest that the mark-resight technique does not currently possess enough precision to detect gradual declines in numbers of females with cubs within reasonable time frames, and thus would not provide reliable inference for trend detection given current sample sizes. A substantial increase in the sample size of radio-marked females would be necessary to obtain acceptable levels of precision for trend detection, which may be difficult to achieve given logistical and budgetary constraints. The method does provide relatively unbiased estimates and would likely detect large changes in numbers of females with cubs. Therefore, whereas we plan to continue the application of this technique to obtain annual estimates of females with cubs, we currently do not intend to use the mark-resight technique for trend monitoring.

Table 9. Data used in mark-resight analysis on female grizzly bears with cubs, Greater Yellowstone Ecosystem, 1997–2015, including number of radio-marked female grizzly bears available for sighting during observation flights (*m*), the number seen zero time (Y_0), seen once (Y_1), the number seen twice (Y_2), and the number of unmarked females bears with cubs (*S*). Estimates exclude females with cubs observed <500 m of army cutworm moth aggregation sites.

Year	*m*	Y_0	Y_1	Y_2	*S*
1997	6	4	2	0	4
1998	4	2	2	0	7
1999	6	5	1	0	7
2000	7	7	0	0	11
2001	8	4	4	0	17[a]
2002	5	5	0	0	29[a]
2003	4	3	1	0	7
2004	4	2	2	0	20
2005	3	3	0	0	14
2006	7	7	0	0	23[a]
2007	5	3	2	0	23[b]
2008	5	3	1	1	19[a]
2009	6	6	0	0	14
2010	3	3	0	0	23[a]
2011	3	2	1	0	16
2012	5	3	2	0	12
2013	10	10	0	0	28[c]
2014	5	4	1	0	12
2015	1	0	1	0	22

[a] Numbers decreased from 2013 data due to boundary changes of moth sites.

[b] Numbers increased from 20 to 23 due to boundary changes of moth sites.

[c] Correction from previously reported value of 24.

Table 10. Results from mark-resight analysis of female grizzly bears with cubs, Greater Yellowstone Ecosystem, 1997–2015. Data from all years were used to inform sightability, and previous years' posterior distributions were updated based on data from radio-marked females with cubs in 2015. Estimates exclude females with cubs observed <500 m of army cutworm moth aggregation sites.

					Quartile		
Year	Sighted	Marked	Mean	Median	0.025	0.975	$P \leq 48$[a]
1997	4	6	18	16	5	40	0.99
1998	7	4	31	29	12	61	0.90
1999	7	6	31	28	12	61	0.90
2000	11	7	48	45	23	88	0.55
2001	17	8	75	71	39	128	0.09
2002	29	5	127	122	74	207	0
2003	7	4	31	29	12	61	0.90
2004	20	4	88	84	48	149	0.02
2005	14	3	61	58	31	108	0.26
2006	23	7	101	97	56	167	0
2007	23	5	101	97	57	167	0
2008	19	5	83	80	45	142	0.04
2009	14	6	61	58	31	108	0.26
2010	23	3	101	97	57	168	0
2011	16	3	70	67	37	122	0.13
2012	12	5	53	50	25	96	0.45
2013	28	10	122	118	71	199	0
2014	12	5	53	50	26	95	0.45
2015	22	1	96	92	54	162	0.01

[a] Probability of mark-resight estimate ≤48 females with cubs.

Aerial observation of female grizzly bear with 3 cubs, Yellowstone National Park, 5 July 2015 (photo courtesy of Steve Ard).

Table 11. Three-year moving average for estimated number of female grizzly bears with cubs in the Greater Yellowstone Ecosystem during 1998–2014, using the mark-resight method of Higgs et al. (2013). Estimates exclude females with cubs observed <500 m of army cutworm moth aggregation sites.

				Quartile		
Year	Mean	Median	Mode	0.025	0.975	$P \leq 48$[a]
1998	26.3	25	23	14	45	0.99
1999	36.5	35	33	21	60	0.88
2000	51.1	49	46	30	82	0.46
2001	83.1	81	76	52	129	0.01
2002	77.4	75	69	48	121	0.03
2003	81.7	79	74	51	127	0.01
2004	59.9	58	56	36	95	0.22
2005	83.2	81	76	52	129	0.01
2006	87.6	85	81	55	135	0
2007	94.9	92	86	60	146	0
2008	81.8	79	74	51	127	0.01
2009	81.8	79	75	51	127	0.01
2010	77.4	75	70	48	120	0.03
2011	74.5	72	66	46	116	0.04
2012	81.7	79	74	51	126	0.01
2013	75.8	73	72	47	118	0.03
2014	90.4	88	84	57	139	0

[a] Probability of mark-resight estimate ≤48 females with cubs.

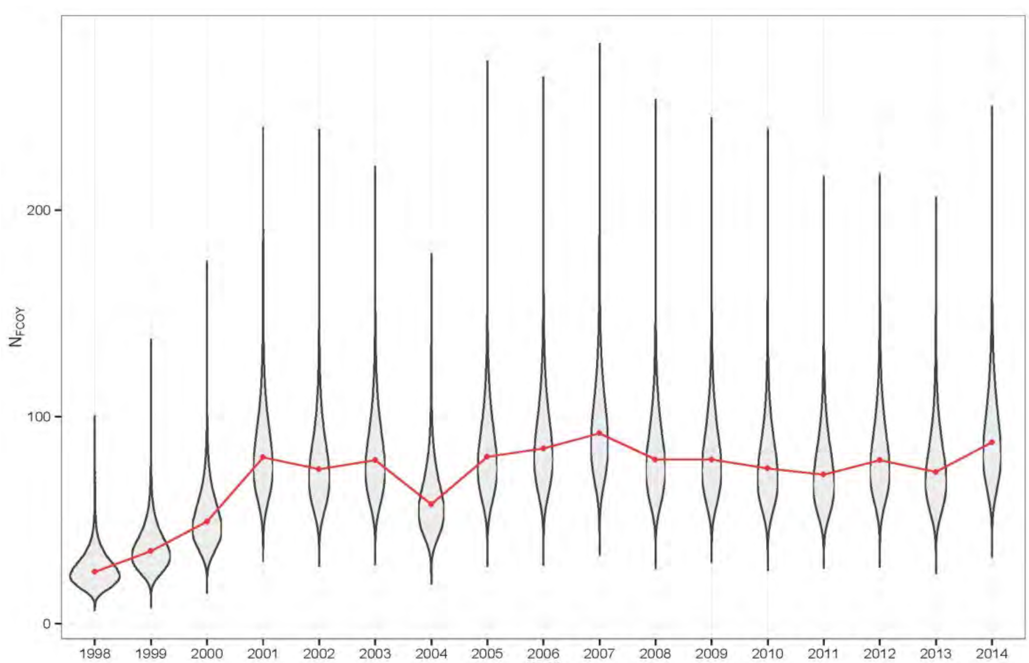

Figure 4. Annual mark-resight estimates (95 % inter quartile; gray area) of female grizzly bears with cubs and 3-year moving average (solid red line), Greater Yellowstone Ecosystem, 1997–2014. Estimates exclude females with cubs observed <500 m of army cutworm moth aggregation sites.

Occupancy of Bear Management Units (BMU) by Females with Young *(Mark A. Haroldson, Interagency Grizzly Bear Study Team)*

Dispersion of reproductive females throughout the ecosystem is assessed by verified observations of female grizzly bears with young (cubs, yearlings, 2-year-olds, and/or young of unknown age) by BMU. The requirements specified in the Demographic Recovery Criteria (USFWS 2007*b*) state that 16 of the 18 BMUs must be occupied by females with young on a running 6-year sum with no 2 adjacent BMUs unoccupied. Seventeen of 18 BMUs had verified observations of female grizzly bears with young during 2015 (Table 12). Eighteen of 18 BMUs contained verified observations of females with young in at least 4 years of the last 6-year (2010–2015) period.

Table 12. Bear Management Units in the Greater Yellowstone Ecosystem occupied by females with young (cubs, yearlings, 2-year-olds, or young of unknown age), as determined by verified reports, 2010–2015.

Bear Management Unit	2010	2011	2012	2013	2014	2015	Years occupied
1) Hilgard	X	X	X	X	X	X	6
2) Gallatin	X	X	X	X	X	X	6
3) Hellroaring/Bear	X	X	X	X	X	X	6
4) Boulder/Slough	X	X	X	X	X	X	6
5) Lamar	X	X	X	X	X	X	6
6) Crandall/Sunlight	X	X	X	X	X	X	6
7) Shoshone	X	X	X	X	X	X	6
8) Pelican/Clear	X	X	X	X	X	X	6
9) Washburn	X		X	X	X	X	5
10) Firehole/Hayden	X	X	X	X	X	X	6
11) Madison	X	X		X	X	X	5
12) Henry's Lake	X	X	X	X	X	X	6
13) Plateau	X			X	X	X	4
14) Two Ocean/Lake	X	X	X	X	X	X	6
15) Thorofare	X	X	X	X	X	X	6
16) South Absaroka	X	X	X	X	X	X	6
17) Buffalo/Spread Creek	X	X	X	X	X	X	6
18) Bechler/Teton	X	X		X	X		4
Total	18	16	15	18	18	17	

Observation Flights *(Stephanie Schmitz and Bryn E. Karabensh, Interagency Grizzly Bear Study Team)*

Fifty-four Bear Observation Areas (BOAs, Figure 5) were established in 2014. In 2015, two rounds of observation flights were conducted: 52 BOAs were surveyed during Round 1 (1 Jun–21 Jul) and 44 during Round 2 (1 Jul–31 Aug). Total duration of observation flight time was 104.0 hours for Round 1 and 88.6 hours for Round 2; average duration of individual flights was 2.0 hours (Table 13).

Three hundred fifty-one bear sightings, excluding dependent young, were recorded during observation flights. This included 8 radio-marked bears (3 females with young, 3 females without young, and 2 males), 268 solitary unmarked bears, and 75 unmarked females with young (Table 13). Our observation rate was 1.82 bears/hour for all bears. One hundred fifty young (82 cubs, 60 yearlings, 4 2-year-olds, and 1 female with 4 young of unknown age) were observed (Table 14). Observation rates for females with dependent young were 0.40 females with young/hour and 0.23 females with cubs/hour (Table 13).

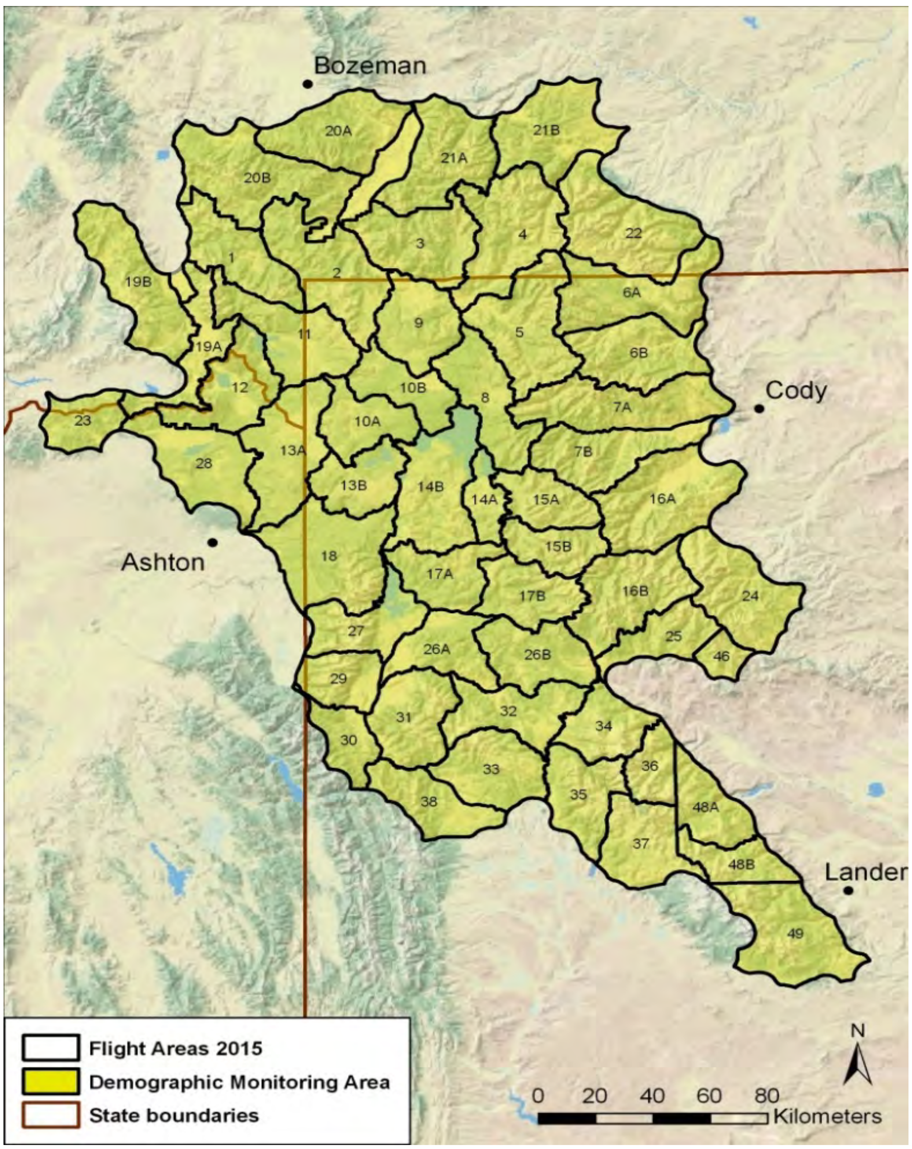

Figure 5. Grizzly bear observation flight areas within the Greater Yellowstone Ecosystem, 2015. Numbers represent the 54 Bear Observation Areas.

Table 13. Annual summary statistics for grizzly bear observation flights conducted in the Greater Yellowstone Ecosystem, 2002–2015.

					Bears seen					Observation rate (bears/hour)		
					Marked		Unmarked					
Date	Observation period	Total hours	Number of flights	Average hours/flight	Lone	With young	Lone	With young	Number of groups	All groups	With young	With cubs
2002[a]	Round 1	84.0	36	2.3	3	0	88	34	125	1.49		
	Round 2	79.3	35	2.3	6	0	117	46	169	2.13		
	Total	163.3	71	2.3	9	0	205	80	294	1.8	0.49	0.4
2003[a]	Round 1	78.2	36	2.2	2	0	75	32	109	1.39		
	Round 2	75.8	36	2.1	1	1	72	19	93	1.23		
	Total	154.0	72	2.1	3	1	147	51	202	1.31	0.34	0.17
2004[a]	Round 1	84.1	37	2.3	0	0	43	12	55	0.65		
	Round 2	76.6	37	2.1	1	2	94	38	135	1.76		
	Total	160.8	74	2.2	1	2	137	50	190	1.18	0.32	0.23
2005[a]	Round 1	86.3	37	2.3	1	0	70	20	91	1.05		
	Round 2	86.2	37	2.3	0	0	72	28	100	1.16		
	Total	172.5	74	2.3	1	0	142	48	191	1.11	0.28	0.13
2006[a]	Round 1	89.3	37	2.4	2	1	106	35	144	1.61		
	Round 2	77.0	33	2.3	3	1	76	24	104	1.35		
	Total	166.3	70	2.3	5	2	182	59	248	1.49	0.37	0.27
2007[a]	Round 1	99.0	44	2.3	2	1	125	53	181	1.83		
	Round 2	75.1	30	2.5	0	4	96	20	120	1.6		
	Total	174.1	74	2.4	2	5	221	73	301	1.73	0.45	0.29
2008[a]	Round 1	97.6	46	2.1	2	1	87	36	126	1.29		
	Round 2	101.5	45	2.3	2	3	185	53	243	2.39		
	Total	199.1	91	2.2	4	4	272	89	369	1.85	0.47	0.23
2009[a]	Round 1	90.3	47	1.9	1	0	85	21	107	1.19		
	Round 2	93.6	47	2.0	2	0	157	34	193	2.06		
	Total	183.9	94	2.0	3	0	242	55	300	1.63	0.3	0.15
2010[a]	Round 1	101.1	48	2.1	0	2	93	22	117	1.16		
	Round 2	93.3	46	2.0	0	0	161	41	202	2.16		
	Total	194.4	94	2.1	0	2	254	63	319	1.64	0.33	0.2
2011[a]	Round 1	88.9	47	1.9	2	1	153	31	187	2.1		
	Round 2	71.0	35	2.0	4	0	109	23	136	1.92		
	Total	159.8	82	1.9	6	1	262	54	323	2.02	0.34	0.18
2012[a]	Round 1	95.4	48	2.0	4	2	178	35	219	2.97		
	Round 2	73.7	35	2.1	2	1	117	30	150	2.04		
	Total	169.1	83	2.0	6	3	295	65	369	2.18	0.4	0.23
2013[a]	Round 1	97.0	48	2.0	2	1	152	44	199	2.05		
	Round 2	72.8	35	2.1	4	1	171	48	224	3.05		
	Total	169.8	83	2.1	6	2	323	92	423	2.49	0.55	0.39
2014[a]	Round 1	104.0	52	2.0	2	2	170	47	221	2.13		
	Round 2	88.6	43	2.1	3	1	188	60	252	2.84		
	Total	192.6	95	2.1	5	3	358	107	473	2.46	0.57	0.27
2015[a]	Round 1	104.0	52	2.0	4	1	126	34	165	1.59		
	Round 2	88.6	44	2.0	1	2	142	41	186	2.1		
	Total	192.7	96	2.0	5	3	268	75	351	1.82	0.4	0.23

[a] Dates of flights (Round 1, Round 2): 2002 (12 Jun–22 Jul, 13 Jul–28 Aug); 2003 (12 Jun–28 Jul, 11 Jul–13 Sep); 2004 (12 Jun–26 Jul, 3 Jul–31 Aug); 2005 (4 Jun–26 Jul, 1 Jul–31 Aug); 2006 (5 Jun–9 Aug, 30 Jun–28 Aug); 2007 (24 May–2 Aug, 21 Jun–14 Aug); 2008 (12 Jun–26 Jul, 1 Jul–23 Aug); 2009 (26 May–17 Jul, 8 Jul–27 Aug); 2010 (8 Jun–22 Jul, 10 Jul–24 Aug); 2011 (15 Jun–17 Aug, 21 Jul–29 Aug); 2012 (29 May–30 Jul, 9 Jul-23 Aug); 2013 (6 Jun–25 Jul, 7 Jul–20 Aug); 2014 (10 Jun-25 Jul, 7 Jul-29 Aug); 2015 (1 Jun–21 Jul, 1 Jul–31 Aug).

Table 14. Size and age composition of grizzly bear family groups seen during observation flights in the Greater Yellowstone Ecosystem, 2002–2015.

		Females with cubs (number of cubs)			Females with yearlings (number of yearlings)			Females with 2-year-olds or young of unknown age (number of young)		
Year	Round	1	2	3	1	2	3	1	2	3
2002[a]	Round 1	8	15	5	3	2	0	0	0	1
	Round 2	9	19	9	2	4	2	0	1	0
	Total	17	34	14	5	6	2	0	1	1
2003[a]	Round 1	2	12	2	2	6	2	3	3	0
	Round 2	2	5	3	2	5	0	2	0	1
	Total	4	17	5	4	11	2	5	3	1
2004[a]	Round 1	4	1	3	1	1	0	2	0	0
	Round 2	6	16	7	4	7	0	0	0	0
	Total	10	17	10	5	8	0	2	0	0
2005[a]	Round 1	5	5	3	2	3	1	0	1	0
	Round 2	4	4	1	3	6	3	5	2	0
	Total	9	9	4	5	9	4	5	3	0
2006[a]	Round 1	8	12	7	4	2	2	1	0	0
	Round 2	5	11	2	2	1	0	2	2	0
	Total	13	23	9	6	3	2	3	2	0
2007[a]	Round 1	7	21	9	8	6	0	2	1	0
	Round 2	2	6	6	3	2	3	0	2	0
	Total	9	27	15	11	8	3	2	3	0
2008[a]	Round 1	3	10	0	9	5	2[b]	6	2	0
	Round 2	9	21	3	7	8	3	3	2	0
	Total	12	31	3	16	13	5	9	4	0
2009[a]	Round 1	0	6	4	2	3	1	3	1	0
	Round 2	6	11	1	3	7	1	4	1	1
	Total	6	17	5	5	10	2	7	1	1
2010[a]	Round 1	2	7	2	2	6	1	4	0	0
	Round 2	10	10	7	5	4	3	1	4	3
	Total	12	17	9	7	10	4	5	4	3
2011[a]	Round 1	4	8	3	3	6	1	2	2	3
	Round 2	2	8	4	2	2	1	1	3	0
	Total	6	16	7	5	8	2	3	5	3
2012[a]	Round 1	5	19	1	2	3	4	0	2	1
	Round 2	5	9	0	4	6	2	1	3	1
	Total	10	28	1	6	9	6	1	5	2
2013[a]	Round 1	8	20	4	1	5	0	3	4	0
	Round 2	11	21	3[c]	2	7	0	0	5	0
	Total	19	41	7	3	12	0	3	9	0
2014[a]	Round 1	8	17	3	6	14	0	1	0	0
	Round 2	1	15	8	11	18	3	2	2	1
	Total	9	32	11	17	32	3	3	2	1
2015[a]	Round 1	6	18	15	2	20	6	0	2	0
	Round 2	9	22	12	2	24	6	2	0	4[d]
	Total	15	40	27	4	44	12	2	2	4[d]

[a] Dates of flights (Round 1, Round 2): 2002 (12 Jun–22 Jul, 13 Jul–28 Aug); 2003 (12 Jun–28 Jul, 11 Jul–13 Sep); 2004 (12 Jun–26 Jul, 3 Jul–31 Aug); 2005 (4 Jun–26 Jul, 1 Jul–31 Aug); 2006 (5 Jun–9 Aug, 30 Jun–28 Aug); 2007 (24 May–2 Aug, 21 Jun–14 Aug); 2008 (12 Jun–26 Jul, 1 Jul–23 Aug); 2009 (26 May–17 Jul, 8 Jul–27 Aug); 2010 (8 Jun–22 Jul, 10 Jul–24 Aug); 2011 (15 Jun–17 Aug, 21 Jul-29 Aug); 2012 (29 May–30 Jul, 9 Jul-23 Aug); 2013 (6 Jun–25 Jul, 7 Jul–20 Aug); 2014 (10 Jun-25 Jul, 7 Jul-29 Aug); 2015 (1 Jun–21 Jul, 1 Jul–31 Aug).

[b] Includes 1 female with 4 yearlings.

[c] Includes 1 female with 4 cubs.

[d] Includes 1 female with 4 young of unknown age.

Telemetry Location Flights *(Bryn E. Karabensh and Stephanie Schmitz, Interagency Grizzly Bear Study Team)*

Ninety-five telemetry location flights were conducted during 2015, resulting in 345.7 hours of search time (ferry time to and from airports excluded; Table 15). Flights were conducted at least once during all months, with 76% of telemetry flights occurring in May–November. During telemetry flights, 867 locations of bears equipped with radio transmitters were collected, 221 (25.5%) of which included a visual sighting. Forty-one sightings of unmarked bears were also obtained during telemetry flights, including 32 solitary bears, 7 females with cubs, 2 females with yearlings, and no females with 2-year-olds. Rate of observation for all unmarked bears during telemetry flights was 0.12 bears/hour. The telemetry flights rate of observations for unmarked females with cubs was 0.02, in contrast to the rate from the observation flights of 0.21 females with cubs/hour).

In an effort to reduce flight time and costs associated with aerial telemetry and obtain higher-frequency data, we began deploying satellite GPS collars in 2012 using Argos and Iridium platforms. These GPS collars are different from those that store GPS locations onboard, which we have deployed since 2000, by providing the ability to download GPS location data via satellites. Only Iridium platforms were on the air in 2015. We deployed 23 Iridium GPS collars in 2015, obtaining 50,036 GPS locations from 39 active Iridium collars (newly and previously deployed GPS collars).

Table 15. Summary statistics for radio-telemetry flights to locate grizzly bears in the Greater Yellowstone Ecosystem, 2015.

				Radioed bears			Unmarked bears observed				Observation rate (groups/hour)	
								Females				
Month	Hours	Number of flights	Mean hours per flight	Number of locations	Number seen	Observation rate (groups/hr)	Lone bears	With cubs	With yearlings	With young	All groups	Females with cubs
January	20.4	6	3.39	51	1	0.05	0	0	0	0	0	---
February	11.2	5	2.23	51	0	0	0	0	0	0	0	---
March	10.9	4	2.72	48	1	0.09	0	0	0	0	0	---
April	16.6	5	3.31	46	14	0.84	0	0	0	0	0	---
May	45.7	13	3.52	121	41	90	11	1	0	0	0.26	0.02
June	43.1	12	3.59	100	37	0.86	2	3	1	0	0.14	0.07
July	48.5	14	3.46	117	42	0.87	10	1	0	0	0.23	0.02
August	38.6	9	4.29	84	28	0.73	3	1	1	0	0.13	0.03
September	46.7	11	4.25	114	36	0.77	3	0	0	0	0.06	---
October	23.3	6	3.89	44	14	0.6	3	1	0	0	0.17	0.04
November	27.5	7	3.93	53	6	0.22	0	0	0	0	0	---
December	13.3	3	4.43	38	1	0.08	0	0	0	0	0	---
Total	345.7	95	3.64	867	221	0.64	32	7	2	0	0.12	0.02

Documented Grizzly Bear Mortalities in the GYE and Estimated Percent Mortality for the Demographic Monitoring Area *(Mark A. Haroldson, Interagency Grizzly Bear Study Team; and Kevin L. Frey, Montana Fish, Wildlife and Parks)*

The IGBST is tasked with documenting grizzly bear mortalities occurring in the GYE, and since 2012 we have been evaluating mortality levels for the Demographic Monitoring Area (DMA; USFWS 2013). We evaluate mortalities for population segments within the DMA by deriving estimates of total mortality for independent-aged (≥2 years old) females and independent-aged males, which includes estimates of unknown/unreported mortalities (Cherry et al. 2002). We then determine the total annual mortality rate for these segments as a percent of their respective population estimates. For dependent bears (≤2 years old) we determine the percent of human-caused mortality relative to size of the population segment but do not include estimates of unknown/unreported mortality. Here, we report numbers of known and probably mortalities in the GYE, numbers by sex and age class inside and outside the DMA, and provide estimates of percent total mortality relative to population segments within the DMA.

We use the definitions provided in Craighead et al. (1988) to classify grizzly bear mortalities in the GYE relative to the degree of certainty regarding each event. Cases in which a carcass is physically inspected or when a management removal occurs are classified as "known" mortalities. Instances are classified as "probable" where evidence strongly suggests a mortality has occurred but no carcass is recovered. When evidence is circumstantial, with no prospect for additional information, a "possible" mortality is designated. Possible mortalities are excluded from assessments of percent annual mortalities. We continue to tabulate possible mortalities because they provide an additional source of location information for grizzly bears and possible causes of mortalities in the GYE.

2015 Mortality

We documented 61 known and probable mortalities in the GYE during 2015; 53 were attributable to human causes (Table 16, Figure 6). Six of the 61 known and probable losses that occurred during 2015 remain under investigation by USFWS and state law enforcement agencies (Table 16). Specific information related to these mortalities is not provided because of ongoing investigations. However, these events are included in the following summary. Thirty-one (58.5 %) of the 53 human-caused losses involved management removals due to either livestock depredations (n = 14) or site conflicts (n = 16). One additional livestock related losses was an accidental handling mortality of a cub captured with its mother and 2 siblings at a cattle depredation trap site. Sixteen (30.2 %) of the human-caused losses were hunting related, including 2 mistaken identity kills by black bear hunters and 14 losses from self-defense kills. Two of the hunting related self-defense kills were adult females accompanied by 3 cubs each. Other human-caused losses were road kills (n = 4) and bears that were maliciously shot (n = 2). We documented 3 natural mortalities (Table 16). One of the natural mortalities was a cub lost from a radio-marked female; 2 (1 cub, 1 independent-aged bear) were bears killed by other bears. We also documented 5 mortalities from undetermined causes (Table 16). These included loss of a radio-collared female with 2 cubs during early May, a yearling, and remains of an adult female found during February of 2016 that likely died during spring of 2015.

We documented 3 incidents considered possible mortalities during 2015 (Table 16). Two were related to vehicle collisions where bears left the scene with no obvious evidence they incurred serious injury. The other involved a female with young that was wounded in a lower front leg during an encounter with a hunter. This bear was tracked for several hours with no evidence of mortality. We evaluated known and probable mortalities relative to population estimates only for the DMA (USFWS 2013).

Of the 61 known and probable mortalities documented during 2015, 50 occurred within the boundaries of the DMA (Table 17, Figure 6). We documented 12 mortalities for independent-aged females within the DMA during 2015 (Table 17). There were 3 management removal, 1 radio-instrumented loss, and 8 reported losses for independent-aged females during 2015 (Table 18). Estimated percent total mortality for independent-aged females was 10.1 % of the 2015 estimate for this segment of the population (Table 18). Twenty-one known and probable mortalities for independent-aged males occurred within the DMA (Table 17). We documented 13 management removals, 1 radioed, and 7 reported losses of independent-aged males within the DMA (Table 17). Estimated percent total mortality for independent-aged males was 13.0 % of the 2015 estimate for this segment of the population (Table 18). There were 13 known and probable human-caused losses of dependent young documented in the DMA during 2015 (Table 18). Estimated human-caused loss for dependent young was 5.8 % within the DMA (Table 18).

One documented mortality from 2012 remains under investigation, as do 3 from 2013, and 3 from 2014. None of the mortalities documented during 2009, 2010, or 2011 remain under investigation. Specific information pertaining to closed mortality investigations will be updated in the respective annual Mortality Lists (see IGBST 2015 mortality table) as they become available. We remind readers that some cases can remain open and under investigation for extended periods. The study team cooperates with federal and state law enforcement agencies and cannot release information that could compromise ongoing investigations.

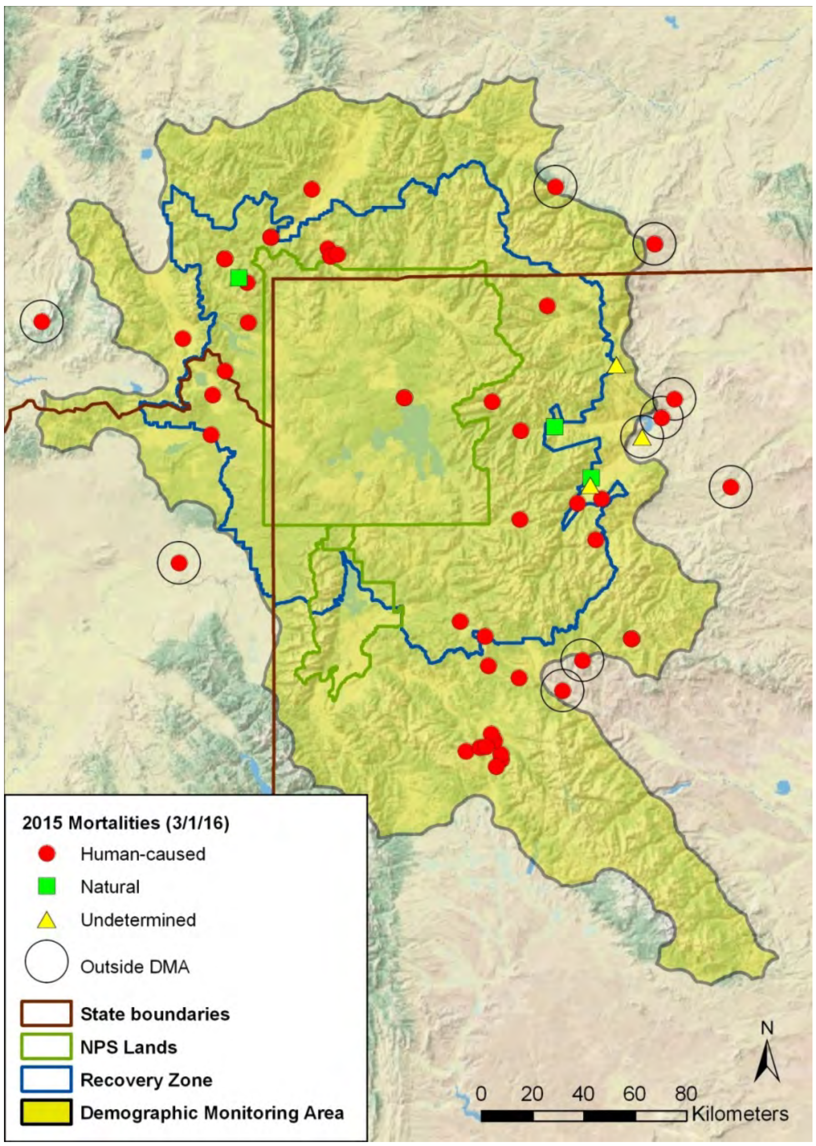

Figure 6. Distribution of 61 known and probable grizzly bear mortalities documented in the Greater Yellowstone Ecosystem, 2015. Fifty mortalities occurred within the Demographic Monitoring Area (DMA) boundary of which 43 were attributed to human causes; 11 were outside the DMA with 10 of those human-caused.

Table 16. Grizzly bear mortalities documented in the Greater Yellowstone Ecosystem, 2015.

Unique	Bear[a]	Sex[b]	Age[c]	Date	Location[d]	Monitoring area[e]	Certainty	Cause
201501	Unm	Unk	Cub	5/7/2015	Clearwater Crk, SNF-WY	In DMA	Known	Natural, killed by adult male grizzly.
201502				2015	WY	In DMA	Known	UNDER INVESTIGATION
201503	Unm	M	Adult	5/22/2015	Grove Crk, PR-MT	Outside DMA	Known	Human-caused, management removal for cattle depredations.
201504	Unm	M	Adult	5/22/2015	Grove Crk, PR-MT	Outside DMA	Known	Human-caused, management removal for cattle depredations.
201505	Unm	M	Subadult	5/22/2015	East Fork Blacktail Deer Crk, BLM-MT	Outside DMA	Known	Human-caused, mistaken identity by black bear hunter; illegal take
201506	718	F	Adult	6/25/2015	Blackwater Crk, BTNF-WY	In DMA	Known	Human-caused, grizzly bear #718 road killed.
201507	725	F	Adult	5/16/2015	Dry Fork, SNF-WY	In DMA	Known	Undetermined caused, #725 found dead, discovery due to telemetry. Carcass had been scavenged. Last alive on 5/11 seen with 2 cubs. First mortality signal on 5/21, mortality date is midpoint between the 2 dates.
201508	Unm	Unk	Cub	5/16/2015	Dry Fork, SNF-WY	In DMA	Probable	Undetermined cause, 1st of 2 cubs of #725.
201509	Unm	Unk	Cub	5/16/2015	Dry Fork, SNF-WY	In DMA	Probable	Undetermined cause, 2nd of 2 cubs of #725.
201510	656	M	Adult	6/27/2015	Tosi Crk, BTNF-WY	In DMA	Known	Human-caused, management removal of bear #656 for repeated cattle depredations.
201511	Unm	M	Subadult	6/27/2015	Wind River, PR-WY	Outside DMA	Known	Human-caused, management removal for obtaining numerous food reward, extreme habituation, and food-conditioned behavior.
201512	356	M	Adult	7/3/2015	Wiggins Fork, PR-WY	Outside DMA	Known	Human-caused, management removal of bear #356 for repeated cattle depredations.
201513	719	M	Adult	7/12/2015	Gypsum Crk, BTNF-WY	In DMA	Known	Human-caused, management removal of bear #719 for repeated cattle depredations.

Table 16. Continued.

Unique	Bear[a]	Sex[b]	Age[c]	Date	Location[d]	Monitoring Area[e]	Certainty	Cause
201514	548	M	Adult	7/23/2015	Horn Crk, BDNF-MT	In DMA	Known	Human-caused, management removal of bear #548 for cattle depredations.
201515	780	M	Adult	7/25/2015	Gypsum Crk, BTNF-WY	In DMA	Known	Human-caused, management removal of bear #780 for cattle depredations, was collared when removed.
201516	Unm	F	Subadult	8/8/2015	Crooked Crk, PR-WY	In DMA	Known	Human-caused, management removal for multiple property damage and food rewards, extremely habituated and frequenting youth camp.
201517	Unm	M	Adult	8/11/2015	Sheridan Crk, SNF-WY	In DMA	Known	Human-caused, management removal for multiple cattle depredations.
201518	Unm	F	Adult	8/8/2015	Yellowstone River, YNP	In DMA	Known	Human-caused, management removal for human fatality, was accompanied by 2 cubs.
201519	Unm	F	Cub	8/9/2015	Yellowstone River, YNP	In DMA	Known	Human-caused, live removal to zoo, 1st of 2 cubs of female that was involved in human fatality.
201520	Unm	F	Cub	8/10/2015	Yellowstone River, YNP	In DMA	Known	Human-caused, live removal to zoo, 2nd of 2 cubs of female that was involved in human fatality.
201521	658	F	Adult	8/13/2015	Dry Crk, PR-WY	Outside DMA	Known	Human-caused, management removal of #658 for multiple food rewards from garbage conflicts and livestock depredations.
201522	826	M	Adult	8/20/2015	Green River, PR-WY	In DMA	Known	Human-caused, management removal of #826 for multiple property damages and food rewards.
201523	Unm	M	Adult	8/24/2015	South Fork Shoshone, PR-WY	In DMA	Known	Human-caused, management removal for property damage and livestock depredations, bear had few teeth left and was in poor condition.
201524	479	M	Adult	8/24/2015	Elk Crk, PR-ID	In DMA	Known	Human-caused, management removal of bear #479 for repeated property damage and obtaining food rewards.
201525	Unm	F	Adult	8/23/2015	South Fork Shoshone, PR-WY	In DMA	Known	Natural, adult size bear killed and consumed by another grizzly bear; DNA determination of sex indicated female.

Table 16. Continued.

Unique	Bear[a]	Sex[b]	Age[c]	Date	Location[d]	Monitoring Area[e]	Certainty	Cause
201526	Unm	M	Adult	9/10/2015	Henrys Lake Outlet, ST-ID	In DMA	Known	Human-caused, management removal for multiple cattle depredations, property damages, and anthropogenic food rewards.
201527	Unm	F	Cub	9/11/2015	Dago Crk, BTNF	In DMA	Known	Human-caused, accidental handling mortality, management capture for mother's cattle depredations.
201528				2015	WY	In DMA	Known	UNDER INVESTIGATION.
201529	832	M	Adult	9/19/2015	Tosi Crk, PR-WY	In DMA	Known	Human-caused, management removal of bear #832 for repeated cattle depredations.
201530	Unm	M	Yearling	9/21/2015	Yellowstone River, Federal Highway	In DMA	Known	Human-caused, road kill.
201531	634	M	Adult	9/16/2015	Anderson Crk, SNF	In DMA	Known	Human-caused, mistaken identity of bear #634 by black bear hunter; illegal take.
201532	837	M	Subadult	9/23/2015	Golf Crk, SNF	In DMA	Known	Human-caused, management removal of bear #837 for multiple anthropogenic food rewards and increasingly bold behaviors.
201533				2015	WY	In DMA	Known	UNDER INVESTIGATION.
201534	787	M	Subadult	9/25/2015	Wagon Crk, BTNF	In DMA	Known	Human-caused, management removal of bear #787 for repeated cattle depredations.
201535	Unm	M	Subadult	9/27/2015	Howard Crk, CTNF	In DMA	Known	Human-caused, road kill.
201536	822	F	Adult	10/1/2015	East Fork Fiddle Crk, ST-MT	Outside DMA	Known	Human-caused, management removal of bear #822 for repeated cattle depredations.
201537	Unm	F	Adult	10/1/2015	Lake Crk, SNF	In DMA	Known	Human-caused, hunting related self-defense kill of female with 3 cubs.
201538	Unm	M	Cub	10/1/2015	Lake Crk, SNF	In DMA	Known	Human-caused, 1st of 3 cubs of female killed in self-defense, cub was killed by female after she was shot.
201539	Unm	Unk	Cub	10/1/2015	Lake Crk, SNF	In DMA	Probable	Human-caused, 2nd of 3 cubs of female killed in self-defense.
201540	Unm	Unk	Cub	10/1/2015	Lake Crk, SNF	In DMA	Probable	Human-caused, 3rd of 3 cubs of female killed in self-defense.

Table 16. Continued.								
Unique	Bear[a]	Sex[b]	Age[c]	Date	Location[d]	Monitoring Area[e]	Certainty	Cause
201541	647	M	Adult	10/1/2015	Green River, BTNF	In DMA	Known	Human-caused, hunting related self-defense kill of bear #647.
201542	Unm	M	Cub	7/30/2015	Canyon Crk, GNF	In DMA	Probable	Human-caused, cub of female #822 lost after family was transported for cattle depredation. Date is midpoint between last seen with cub (7/24) and first observation without her cub (8/5). Location was associated with 7/30 from GPS data.
201543	Unm	M	Adult	10/5/2015	Greybull River, PR-WY	Outside DMA	Known	Human-caused, management removal for property damage and obtaining food rewards (apiary).
201544	M	Unk	Unknown	10/6/2015	Yellowstone River, Federal Highway	In DMA	Probable	Human-caused, hit by vehicle, no carcass recovered but damage to vehicle and blood on highway suggest substantial injuries to bear. DNA determination of sex indicated male.
201545	835	F	Adult	10/8/2015	Falls River, PR-ID	Outside DMA	Known	Human-caused, management removal of bear #835 for repeat conflicts in developed areas related to obtaining food rewards (apples) and habituated behavior.
201546				2015	WY	In DMA	Known	UNDER INVESTIGATION
201547	827	M	Subadult	10/17/2015	Sulphur Crk, BLM-WY	Outside DMA	Known	Human-caused, management removal of bear #827 for repeated nuisance activity in developed areas.
201548	213	F	Adult	10/17/2015	Taylor's Fork, PR-MT	In DMA	Known	Human-caused, management removal of bear #213 (with 2 cubs) for property damage and obtaining food rewards (broke into house and got food).
201549	Unm	F	Cub	10/18/2015	Taylor's Fork, PR-MT	In DMA	Known	Human-caused, management removal of 1st of 2 cubs from female #213 for property damage and obtaining food rewards with mother.
201550	Unm	F	Cub	10/18/2015	Taylor's Fork, PR-MT	In DMA	Known	Human-caused, management removal of 2nd of 2 cubs from female #213 for property damage and obtaining food rewards with mother.

Table 16. Continued.

Unique	Bear[a]	Sex[b]	Age[c]	Date	Location[d]	Monitoring Area[e]	Certainty	Cause
201551	820	M	Adult	10/22/2015	Squaw Crk, PR-WY	In DMA	Known	Human-caused, management removal of bear #820 for repeated property damages.
201552	Unm	F	Adult	10/28/2015	Big Crk, ST-MT	In DMA	Known	Human-caused, hunting related self-defense.
201553				2015	MT	In DMA	Known	UNDER INVESTIGATION.
201554	Unm	F	Adult	11/15/2015	Soldier Crk, PR-MT	In DMA	Known	Human-caused, hunting related self-defense kill of female with 3 cubs.
201555	Unm	Unk	Cub	11/15/2015	Soldier Crk, PR-MT	In DMA	Probable	Human-caused, 1st of 3 cubs of female killed in self-defense.
201556	Unm	Unk	Cub	11/15/2015	Soldier Crk, PR-MT	In DMA	Probable	Human-caused, 2nd of 3 cubs of female killed in self-defense.
201557	Unm	Unk	Cub	11/15/2015	Soldier Crk, PR-MT	In DMA	Probable	Human-caused, 3rd of 3 cubs of female killed in self-defense.
201558				2015	MT	In DMA	Known	UNDER INVESTIGATION.
201559	G209	F	Yearling	11/26/2015	South Fork Shoshone, PR-WY	Outside DMA	Known	Undetermined cause, #G209 found dead on 11/28, estimated mortality date is 11/26. No evidence of foul play. Carcass sent to lab for necropsy.
201560	667	F	Adult	Spring 2015	South Fork Shoshone, PR-WY	In DMA	Known	Undetermined cause, #667 remains found on 02/05/2016, estimated mortality date was spring 2015. Few remains left at site. Bear was not collared.
201561	Unm	Unk	Cub	5/11/2015	Sage Crk, GNF	In DMA	Probable	Natural, cub of radio-collared female #762 lost between 5/14 and 5/18. Mortality date and location are approximate.
201562	Unm	Unk	Unk	9/22/2015	Pilgrim Crk, GTNP	In DMA	Possible	Human-caused, bear was struck by vehicle; bear ran away from the incident. No evidence of bear was found, no blood from impact on vehicle.

Table 16. Continued.

Unique	Bear[a]	Sex[b]	Age[c]	Date	Location[d]	Monitoring Area[e]	Certainty	Cause
201563	Unm	F	Adult	10/1/2015	Reenegerg Crk, SNF_WY	In DMA	Possible	Human-caused, hunting related self-defense, female with 2 cubs thought to be shot in a front leg, trailed for 3 hours uphill before she stopped leaving sign. Bear appear to be moving OK. Wound not thought to be a life-threatening.
201464	Unm	Unk	Unk	10/3/2015	Soda Butte Crk, GNF	In DMA	Possible	Human-caused, bear was struck by vehicle; bear rolled up away from the vehicle and ran into heavy cover along Soda Butte Crk. No evidence of bear was found on 10/4 by the driver of the vehicle.

[a] Unm = unmarked bear; number indicates bear number, Mkd = previously marked bear but identity unknown.

[b] Unk = unknown sex.

[c] Cub = offspring <1 year old, Unk = unknown age.

[d] BTNF = Bridger-Teton National Forest, BLM = Bureau of Land Management, CTNF = Caribou-Targhee National Forest, GNF = Gallatin National Forest, GTNP = Grand Teton National Park, SNF = Shoshone National Forest, YNP = Yellowstone National Park, Pr = private.

[e] Location relative to the Demographic Monitoring Area (DMA).

Table 17. Counts of documented known and probably grizzly bear mortalities by sex, age class, and location relative to the Demographic Monitoring Area (DMA) boundary, 2015.

		Age class		
Area	Sex	Dependent (<2 years old)	Independent (≥2 years old)	Total
Inside DMA	Female	5	12	17
	Male	3	21	24
	Unknown	9	0	9
	Total	17	33	50
Outside DMA	Female	1	3	3
	Male	0	7	7
	Unknown	0	0	0
	Total	1	10	11

Table 18. Annual estimates ($\hat{N}$), estimated total mortalities, and % mortality by population segment for the Demographic Monitoring Area (DMA), 2015. Population estimates for the DMA were derived using the most recent vital rates (IGBST 2012). Only human-caused losses are counted against the mortality threshold for dependent young.

Population segment	$\hat{N}$	Human-caused loss	Sanctioned removals (a)	Radiomarked loss (b)	Reported loss	Estimated[a] reported and unreported loss (c)	Estimated total mortality (a + b + c)	Annual mortality (%)
Dependent young	223	13						5.8
Females 2+	247	9	3	1	8 [b]	21	25	10.1
Males 2+	247	21	13	1	7 [b]	18	32	13.0

[a] Method of estimation for unknown and unreported mortality based on Cherry et al. (2002).

Monitoring of Grizzly Bear Foods

Spring Ungulate Availability and Use by Grizzly Bears in Yellowstone National Park. *(Kerry Gunther and Travis Wyman Yellowstone National Park)*

Ungulate carrion is frequently consumed by grizzly bears in the GYE (Mealey 1975, Green 1994, Mattson 1997). The number of ungulate carcasses available to grizzly bears during the spring is correlated with measures of snow-water equivalency (depth, density, and moisture content) in the snowpack (Podruzny et al. 2012). Competition with reintroduced wolves (*Canis lupus*) for carrion and changes in bison (*Bison bison*) and elk (*Cervus elaphus*) management in the GYE have the potential to affect carcass availability and use by grizzly bears. For these and other reasons, we continue to survey historic carcass transects in Yellowstone National Park. In 2015, we surveyed 28 routes in ungulate winter ranges to monitor the relative abundance of spring ungulate carcasses (Figure 7).

We surveyed each route once for carcasses between 23 March and 22 May. Because spring snow depths influence ungulate distribution and the area we can survey, we used a GPS to accurately measure the actual distance traveled on each route each year. At each carcass, we collected a site description (location, aspect, slope, elevation, habitat type, distance to forest edge), carcass data (species, age, sex, cause of death), and information about scavengers using the carcasses (evidence of scavenger species present, percent of carcass consumed). We were unable to calculate the actual biomass consumed by bears, wolves, or other large scavengers with our survey methodology.
In 2015, we recorded 25 ungulate carcasses on 270.7 km of survey routes, for a total of 0.09 ungulate carcasses/km surveyed (Table 19). The number of carcasses observed annually since 1992 have been highly variable among years (Figure 8).

Northern Ungulate Winter Range

We surveyed 12 routes on Yellowstone's Northern Range totaling 144.3 km traveled (Figure 9). One route was not surveyed to avoid disturbing an active wolf den. We counted 23 carcasses, including 16 elk, 4 bison, 2 mule deer (*Odocoileus hemionus*), and 1 pronghorn (*Antilocapra americana*), which equated to 0.16 ungulate carcasses/km of survey route (Table 19). Sex and age of carcasses found are shown in Table 20. Sixteen of the 23 carcasses were 76–99% consumed by scavengers when we found them. Five carcasses were 51–75% consumed and 1 carcass was 1–25% consumed when found. One carcasses was untouched by scavengers when found (0% consumed). Three bison carcasses had evidence of scavenging by grizzly bears. One of the 3 bison carcasses had also been fed on by a black bear. Three elk carcasses were scavenged by bears where the species of bear could not be determined. One of the elk carcasses had been fed on by a mountain lion. The species that scavenged 13 of the elk carcasses could not be determined. Grizzly bears or their sign (e.g., tracks, scats, daybeds, rub trees, feeding activity) was observed along 7 of the 12 survey routes. We identified 10 bear feeding sites along the survey routes. Feeding activities included: 1) scavenging ungulate carcasses (elk, bison), 2) consuming geothermal soil, and 3) digging thistle roots.

Interior Winter Ranges

We surveyed a total of 126.4 km along 16 survey routes in 4 thermally influenced interior ungulate winter ranges including the Firehole River area, Norris Geyser Basin, Heart Lake area (Witch Creek and Rustic Geyser Basin and associated thermal areas), and Mud Volcano Geyser Basin. We documented 2 bison carcasses for a total of 0.02 carcasses/km of survey route. Grizzly bear activity was documented along 14 of the 16 survey routes.

Firehole River Area

We surveyed 8 routes in the Firehole drainage in the central interior of the park covering 74.3 km (Figure 10). We found 2 bison carcasses (0.03 carcasses/km). Sex and age of carcasses found are shown in Table 20. One of the bison carcasses had evidence of being scavenged by a grizzly bear and 1 carcass had been scavenged by an unknown species of bear. The carcasses that had been scavenged by grizzly bears also had evidence of scavenging by wolves. Grizzly bears or their sign were observed along all 8 survey routes. We identified 10 bear feeding sites along the survey routes. Primary feeding activities identified at these locations included: 1) scavenging on bison carcasses, 2) digging ants, 3) digging earthworms (Lumbricidae), 4) digging pocket gophers (*Thomomys talpoides*) and their food caches of plant roots, and 5) consuming geothermal soil.

Norris Geyser Basin

We surveyed 4 routes in the Norris Geyser Basin in the central interior of the park traveling 23.4 km (Figure 11). No ungulate carcasses were observed. Grizzly bear tracks were observed along 2 of the 4 survey routes. No bear feeding sites were observed.

Heart Lake

We surveyed 3 routes in the Heart Lake area in the south central interior of the park covering 22.5 km (Figure 12). No ungulate carcasses were observed. Grizzly bear tracks, scats, feeding sites, and rub trees were observed on all 3 survey routes. We identified 2 bear feeding sites along the survey routes. At 1 site bears had dug earthworms and at another site bears had dug up pocket gophers and their food caches.

Mud Volcano

We surveyed a single route in the Mud Volcano thermal area of the central interior of the park covering 6.2 km (Figure 13). No ungulate carcasses were observed. Grizzly bear tracks, feeding sites, daybeds, and rub trees were observed along the survey route. We identified 3 bear feeding sites, including 2 sites where bears consumed geothermal soil and 1 site where bears had dug earthworms.

Discussion

There were relatively few ungulate carcasses observed per km of survey route on both the northern ungulate winter range (0.16 carcasses/km) and on interior ungulate winter ranges (0.02 carcasses/km) in 2015. Examination of feeding sites indicated that in addition to scavenging elk and bison carcasses, grizzly bears dug earthworms, ants, thistle roots, and pocket gophers and their food caches. Bears also consumed geothermal soil. Ingestion of geothermal soil may serve to restore mineral deficiencies because it contains high concentrations of potassium, magnesium, and sulfur (Mattson et al. 1999).

Table 19. Ungulate carcasses found and visitation of carcasses by bears, wolves, and unknown large carnivores along surveyed routes in Yellowstone National Park, spring 2015.

Survey area (# routes)	Elk				Bison				Bighorn sheep, pronghorn, and mule deer				Total carcasses/ km
	Number Of Carcasses	# Visited by Species			Number Of Carcasses	# Visited by Species			Number Of Carcasses	# Visited by Species			
		Bear	Wolf	Unk		Bear	Wolf	Unk		Bear	Wolf	Unk	
Northern Range (12)	16	3	0	13	4	3	1	1	3	0	0	3	0.16
Firehole (8)	0	0	0	0	2	2	0	0	0	0	0	0	0.03
Norris (4)	0	0	0	0	0	0	0	0	0	0	0	0	0
Heart Lake (3)	0	0	0	0	0	0	0	0	0	0	0	0	0
Mud Volcano (1)	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Winter Ranges	16	3	0	13	6	5	1	1	3	0	0	3	0.09

[a]Two mule deer and one pronghorn.

Table 20. Age classes and sex of elk and bison carcasses found, by area, along surveyed routes in Yellowstone National Park , 2015.

	Elk						Bison					
	Northern Range	Firehole	Norris	Heart Lake	Mud Volcano	Total	Northern Range	Firehole	Norris	Heart Lake	Mud Volcano	Total
Age												
Adult	13	0	0	0	0	13	4	2	0	0	0	6
Yearling	2	0	0	0	0	2	0	0	0	0	0	0
Calf	1	0	0	0	0	1	0	0	0	0	0	0
Unknown	0	0	0	0	0	0	0	0	0	0	0	0
Sex												
Male	4	0	0	0	0	4	4	1	0	0	0	5
Female	6	0	0	0	0	6	0	1	0	0	0	1
Unknown	6	0	0	0	0	6	0	0	0	0	0	12

Elk carcass, Northern Ungulate Winter Range, Yellowstone National Park (photo IGBST/Frank T. van Manen).

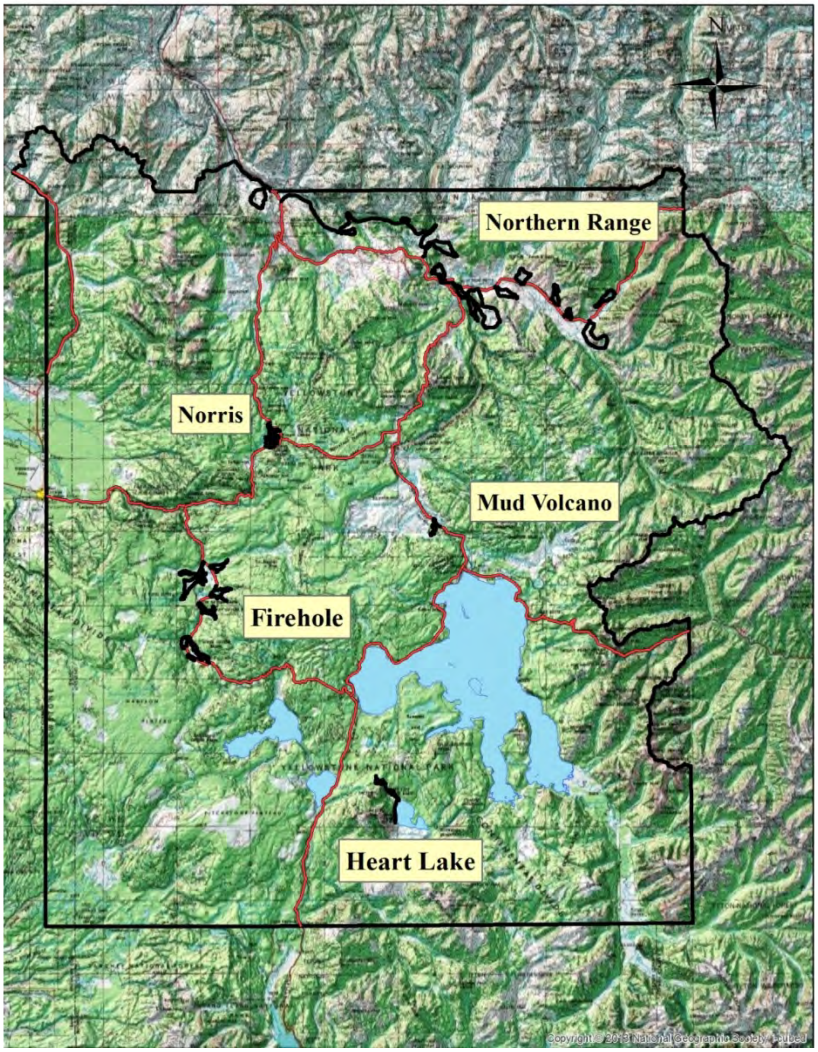

Figure 7. Spring ungulate carcass survey routes in 5 ungulate winter ranges of Yellowstone National Park, 2015.

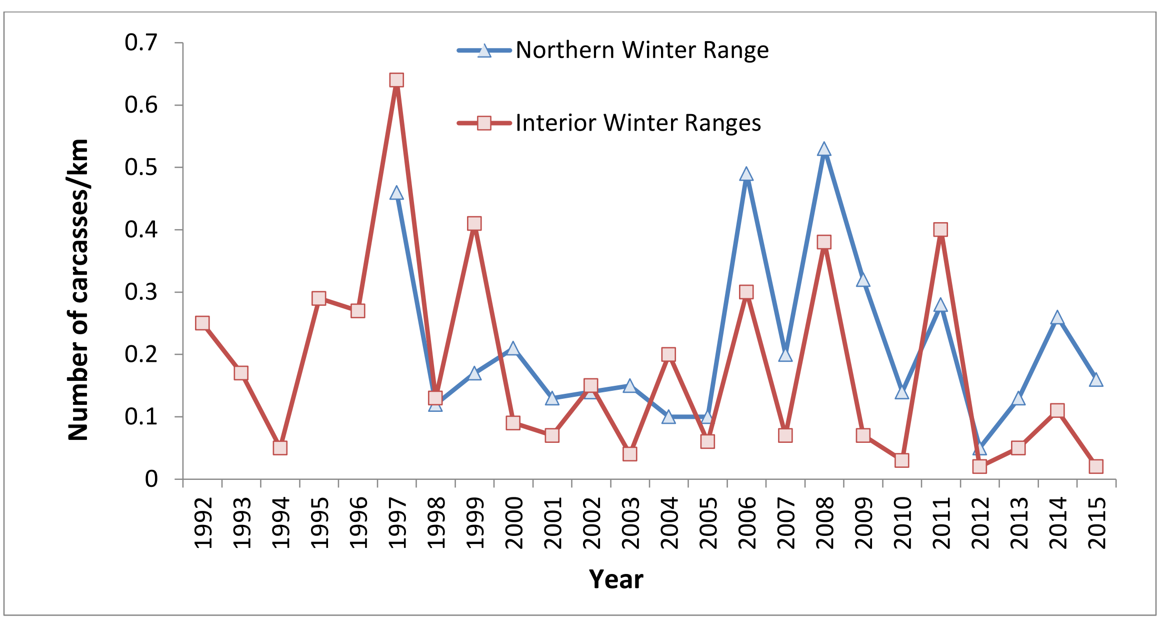

Figure 8. Annual ungulate carcasses/km found on spring survey routes on the northern winter range and interior winter ranges of Yellowstone National Park, 1992–2015.

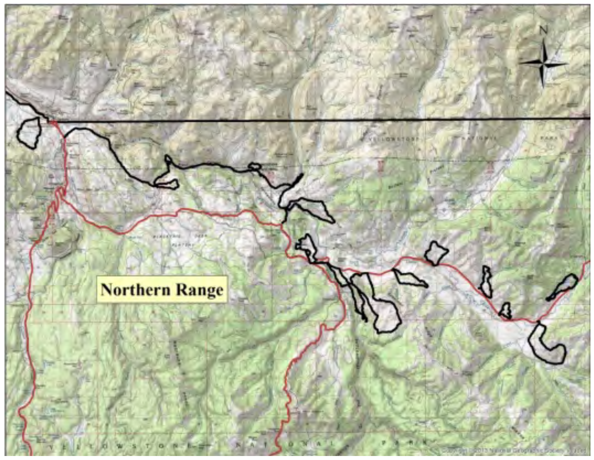

Figure 9. Spring ungulate carcass survey routes (black lines) on the Northern Ungulate Winter Range in Yellowstone National Park, 2015.

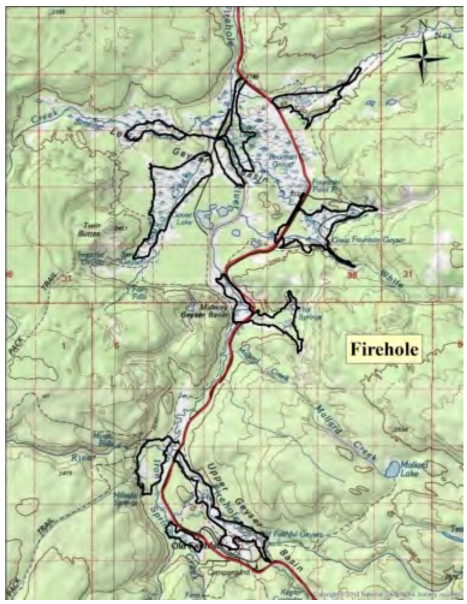

Figure 10. Spring ungulate carcass survey routes (black lines) in the Firehole River area of Yellowstone National Park, 2015.

Figure 11. Spring ungulate carcass survey routes (black lines) in the Norris Geyser Basin, Yellowstone National Park, 2015.

Figure 12. Spring ungluate carcass survey routes (black lines) in the Heart Lake area, Yellowstone National Park, 2015.

Figure 13. Spring ungulate carcass survey route (black line) in the Mud Volcano thermal basin in Yellowstone National Park, 2015.

***Spawning Cutthroat Trout Availability and Use by Grizzly Bears in Yellowstone National Park** (Kerry A. Gunther, Eric Reinertson, Todd M. Koel, Patricia E. Bigelow, and Brian Ertel, Yellowstone National Park)*

In spring and early summer, grizzly bears with home ranges near Yellowstone Lake feed on spawning Yellowstone cutthroat trout (YCT, *Oncorhynchus clarkii*) during years when trout are abundant in tributary streams (Gunther et al. 2014). Bears also occasionally prey on cutthroat trout in other areas of the park, including Fan Creek (westslope cutthroat trout, YCT, or westslope × YCT hybrid) in the northwest section of the park and the inlet creek to Trout Lake (YCT or YCT × rainbow trout hybrids) located in the northeast section of the park.

Non-native lake trout (*Salvelinus namaycush*), whirling disease caused by an exotic parasite (*Myxobolus cerebralis*), and drought have substantially reduced the native YCT population in Yellowstone Lake and associated bear fishing activity (Haroldson et al. 2005; Koel et al. 2005, 2006). The combined effect of all these factors has reduced the Yellowstone Lake cutthroat trout population by 90% (Koel et al. 2010*a*). Because of the decline and past use of YCT as a food source by some grizzly bears, monitoring of the cutthroat trout population is a component of the bear foods and habitat monitoring program of the Conservation Strategy for the Grizzly Bear in the Greater Yellowstone Area (USFWS 2003). The YCT population has been monitored through counts at a fish trap located on Clear Creek on the east-shore of Yellowstone Lake, and through visual stream surveys conducted along North Shore and West Thumb tributaries of the lake (Figure 14). Visual stream surveys are also conducted along the Trout Lake inlet creek in the northeast section of the park. In 2014, we added 4 Yellowstone Lake backcountry spawning streams to our YCT monitoring program, including 3 streams on the west shore and 1 stream on the east side of Yellowstone Lake.

Yellowstone Lake

Fish Trap Surveys

Historically, the number of spawning YCT migrating upstream were counted most years from a weir with a fish trap located at the mouth of Clear Creek on the east side of Yellowstone Lake (Figure 15, Koel et al. 2005). The fish trap was generally installed in May, the exact date depending on winter snow accumulation, weather conditions, and spring snow melt. Fish were counted by dip netting trout that entered the upstream trap box and/or visually counting trout as they swam through wooden chutes attached to the trap. In 2008, unusually high spring run-off damaged the Clear Creek weir and necessitated its removal. Due to removal of the weir, counts of the number of spawning cutthroat trout ascending Clear Creek have not been obtained since 2007. In the fall of 2012, the remnants of the weir were removed, stream banks stabilized, and a suitable platform for an electronic sonar fish counter was installed. Installation and calibration of the sonar fish counter began in the summer 2013 and continued through 2015. It is anticipated that the sonar fish counter will be fully operational sometime in the next few years.

Front Country Visual Stream Surveys

Beginning as early as mid-April depending on snowpack and ice off, several streams including Lodge Creek, Hatchery Creek, Incinerator Creek, Wells Creek, and Bridge Creek, on the North Shore of Yellowstone Lake, and Sandy Creek, Sewer Creek, Little Thumb Creek, and un-named stream #1167 in the West Thumb area are checked periodically to detect the presence of adult YCT (Andrascik 1992, Olliff 1992). Once adult YCT are found (i.e., onset of spawning), weekly surveys of cutthroat trout in these streams are conducted. Sample methods follow Reinhart (1990), as modified by Andrascik (1992) and Olliff (1992). In each stream on each sample day, a minimum of two people walk from the stream mouth to the upstream extent that fish have been observed in past years, and record the number of adult trout counted. Sampling continues one day per week until two consecutive weeks when no trout are observed in the creek (i.e., end of spawn). The length of the spawning season is calculated as the number of days from the first day spawning trout are observed through the last day spawning trout are observed. The average number of spawning cutthroat trout counted per stream survey conducted during the spawning season is used to identify annual trends in the number of cutthroat trout spawning in Yellowstone Lake tributaries.

Data collected in 2015 continued to show low numbers of spawning YCT in North Shore and West Thumb tributary streams (Table 21). In North Shore streams, only 31 spawning YCT were counted. Seven spawning YCT were counted in Lodge Creek and 24 in Bridge Creek. No spawning YCT were observed in Hatchery Creek, Incinerator Creek, or Wells Creek. Partially consumed cutthroat trout were observed along Bridge Creek on 7 May, however, there were no associated bear tracks or scats to positively link this predation to grizzly or black bears. No evidence of bear fishing activity (observations of bears fishing, fish parts, bear scats containing fish parts) was observed along Lodge Creek, Hatchery Creek, Incinerator Creek, or Wells Creek in 2015. However, grizzly bear tracks were observed along Incinerator Creek during 3 of the surveys. In addition, we documented grizzly bears successfully fishing for YCT in stream #1090 (unofficially referred to as Lake Butte Creek) through photo documentation (stream #1090 is not a stream we regularly survey).

On West Thumb streams, 228 spawning YCT were counted, including 219 in Little Thumb Creek, 6 in Sewer Creek, and 3 in Sandy Creek. No spawning YCT were observed in stream #1167. Evidence of grizzly bear predation on YCT (fish parts with associated grizzly bear tracks or scats) was found on Little Thumb Creek during 3 separate surveys. No evidence (observations of bears fishing, fish parts, bear scats containing fish parts) of grizzly bear fishing activity was observed along Sandy Creek, Sewer Creek, or stream #1167 in 2015. However, grizzly bear tracks without evidence of fishing activity were found on Sewer Creek and on Sandy Creek during 2 surveys of each creek. Black bear tracks were also observed on Sandy Creek during 1 survey.

The number of spawning YCT counted in the North Shore (Figure C) and West Thumb (Figure 17) streams has decreased significantly since 1989. Although the increased spawning activity in Little Thumb Creek in recent years is promising, very few spawning YCT have been observed in all other North Shore and West Thumb streams.

Backcountry Visual Stream Surveys

In 2014, we added 4 backcountry tributary streams to our Yellowstone Lake spawning stream monitoring program. Backcountry stream surveys follow the same methods used on front-country streams. We surveyed Flat Mountain Creek, un-named stream #1138, un-named stream #1141, and Columbine Creek. We chose Flat Mountain Creek, stream #1138, and Columbine Creek because when surveyed in the late 1990s, they had high numbers of spawning YCT and were frequented by more individual bears than most creeks around the lake (Haroldson et al. 2005). Stream #1141 was chosen because it is conveniently located between Flat Mountain Creek and stream #1138, making it time and cost efficient to survey. In backcountry streams, 78 spawning YCT were counted in 2015. Thirty-eight spawning YCT were counted in stream #1138, 22 in Flat Mountain Creek, and 18 in stream #1141. No spawning YCT were observed in Columbine Creek. Evidence of grizzly bear predation on YCT (fish parts and associated grizzly bear tracks) was found along stream #1138. No evidence (observations of bears fishing, fish parts, bear scats containing fish parts) of bear fishing activity was observed along Flat Mountain Creek, stream #1141, or Columbine Creek in 2015. However, grizzly bear tracks without evidence of fishing were observed on Flat Mountain Creek during 4 surveys and along both stream #1141 and Columbine Creek during 1 survey each.

Trout Lake

Visual Stream Surveys

Beginning in mid-May of each year, the Trout Lake inlet creek is checked once per week for the presence of spawning cutthroat trout (and/or cutthroat x rainbow trout hybrids). Once spawning trout are detected (i.e. onset of spawning), weekly surveys of adult trout in the inlet creek are conducted. On each sample day, two people walk from the stream mouth to the upstream extent that fish have been observed in past years, and record the number of adult trout counted. Sampling continues one day per week until two consecutive weeks when no trout are observed in the creek and all trout have returned to Trout Lake (i.e. end of spawn). The length of the spawning season is calculated as the number of days from the first day spawning trout are observed through the last day spawning trout are observed. The mean number of spawning trout observed per visit is calculated by dividing the total number of adult trout counted by the number of surveys conducted during the spawning season.

In 2015, the first movement of spawning trout from Trout Lake into the inlet creek was observed on 6 June. The spawn lasted approximately 33 days with the last spawning trout observed in the inlet creek on 8 July. During the once per week visual surveys, 261 spawning cutthroat (and/or cutthroat trout x rainbow trout hybrids) were counted, an average of 44 per visit during the spawning season (Table 21). The number of fish observed per survey has ranged from a low of 31 in 2004, to a high of 306 in 2010 (Figure 18). No grizzly bears or black bears, bear sign, or evidence of bear fishing activity was observed along Trout Lake or the inlet creek during the surveys in 2015.

Outlook for Cutthroat Trout

The number of spawning cutthroat trout counted in all surveyed tributary streams of Yellowstone Lake reached a nadir in approximately 2004 (Figures. 15, 16, and 17). A Native Fish Conservation Plan/Environmental Assessment was completed in 2011 (Koel et al. 2010*b*). The plan outlines a program of management efforts designed to protect the native YCT population through lake trout suppression and other methods. As part of these management efforts, park fisheries biologists and private-sector (contracted) netters caught and removed 315,724 lake trout from Yellowstone Lake in 2015 (Koel et al., 2016). Population models indicate the removal program has slowed lake trout population growth and likely started to send the population into decline (Syslo et al. 2011, Gresswell et al., 2015). If the removal program results in a significant long-term reduction in predatory lake trout, native YCT will likely reestablish at higher numbers in Yellowstone Lake and its tributary streams and once again become a more important diet item for grizzly bears in the Yellowstone Lake watershed. In 2015, we documented grizzly bears fishing for YCT in Little Thumb Creek, stream #1090, stream #1138, and possibly in Bridge Creek, suggesting that the YCT population may be increasing at least in some streams. Evidence of grizzly bears once again fishing for YCT indicates that the Lake trout removal program may be beginning to show signs of success.

Table 21. Start of spawn, end of spawn, duration of spawn, and average number of spawning cutthroat trout counted per survey in Yellowstone National Park, 2015.

Stream	Start of spawn	Last day of spawn	Duration of spawn (days)	Number of surveys during spawning period	Number of fish counted	Average fish/survey
North Shore						
Lodge Creek	5/7/2015	5/12/2015	6	2	7	3.5
Hatchery Creek			No spawn			
Incinerator Creek			No spawn			
Wells Creek			No spawn			
Bridge Creek	5/7/2015	5/19/2015	13	3	24	8.0
West Thumb						
1167 Creek			No spawn			
Sandy Creek	5/12/2015	5/19/2015	8	2	3	1.5
Sewer Creek	5/12/2015	5/19/2015	8	2	6	3.0
Little Thumb Creek	5/12/2015	6/16/2015	36	6	219	36.5
Total frontcountry[a]				15	259	17.3
Backcountry						
Flat Mountain Creek	5/18/2015	5/25/2015	8	2	22	11.0
#1141 Creek	5/18/2015	6/2/2015	16	3	18	6.0
#1138 Creek	5/18/2015	6/2/2015	16	3	38	12.6
Columbine Creek			No spawn			
Total backcountry				8	78	9.8
Northern Range						
Trout Lake Inlet	6/6/2015	7/8/2015	33	6	261	43.5

[a] Total for North Shore and West Thumb Streams that had a spawn.

Figure 14. Locations of Yellowstone Lake cutthroat trout spawning streams surveyed in 2015 (stream #1090 was not surveyed but grizzly bear fishing activity was photo documented).

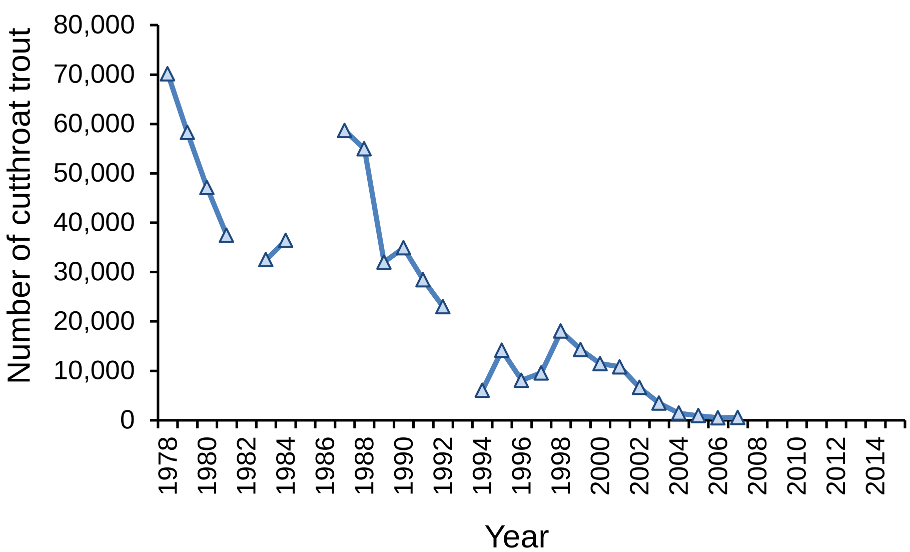

Figure 15. Number of spawning cutthroat trout counted at the Clear Creek fish trap on the east shore of Yellowstone Lake, Yellowstone National Park, 1977–2015 (2007 was the last year a fish count was obtained at Clear Creek).

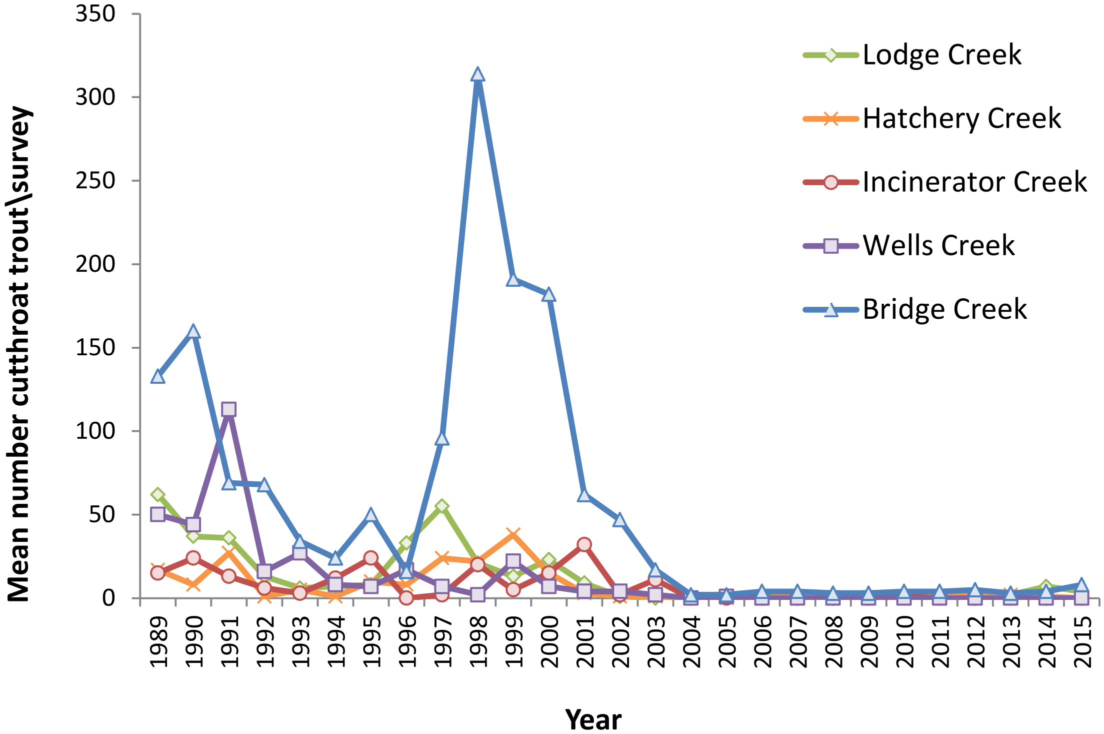

Figure 16. Mean number of spawning cutthroat trout observed during weekly visual surveys of 5 North Shore spawning streams tributary to Yellowstone Lake, Yellowstone National Park, 1989–2015.

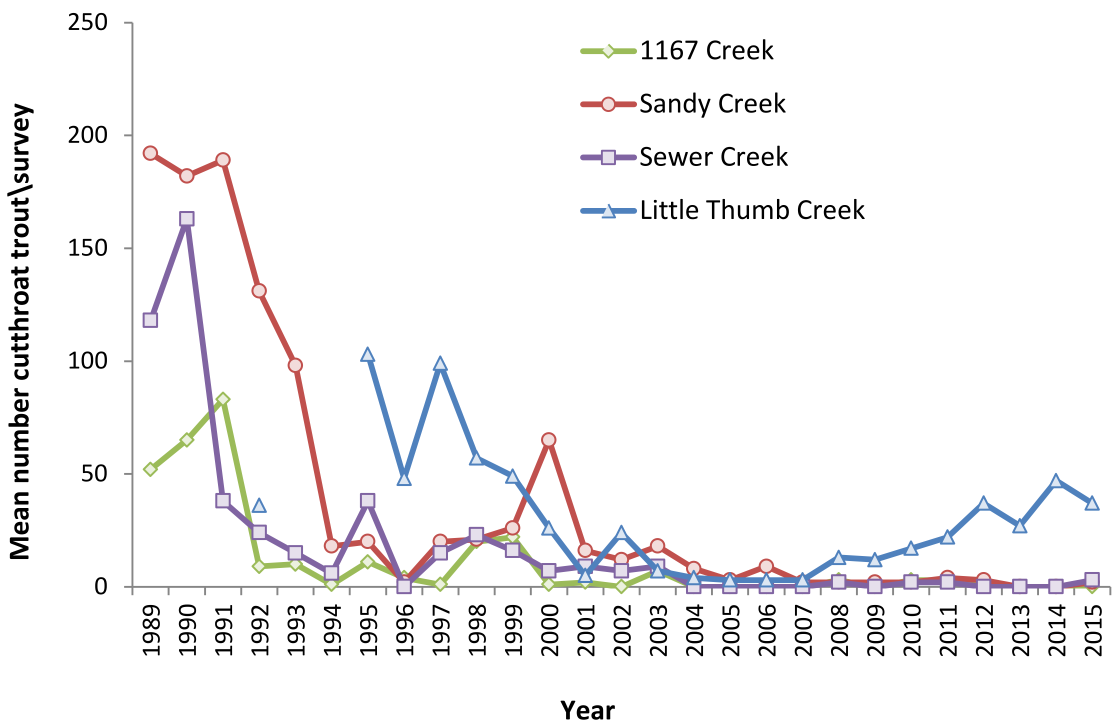

Figure 17. Mean number of spawning cutthroat trout observed during weekly visual surveys of 4 West Thumb spawning streams tributary to Yellowstone Lake, Yellowstone National Park, 1989–2015.

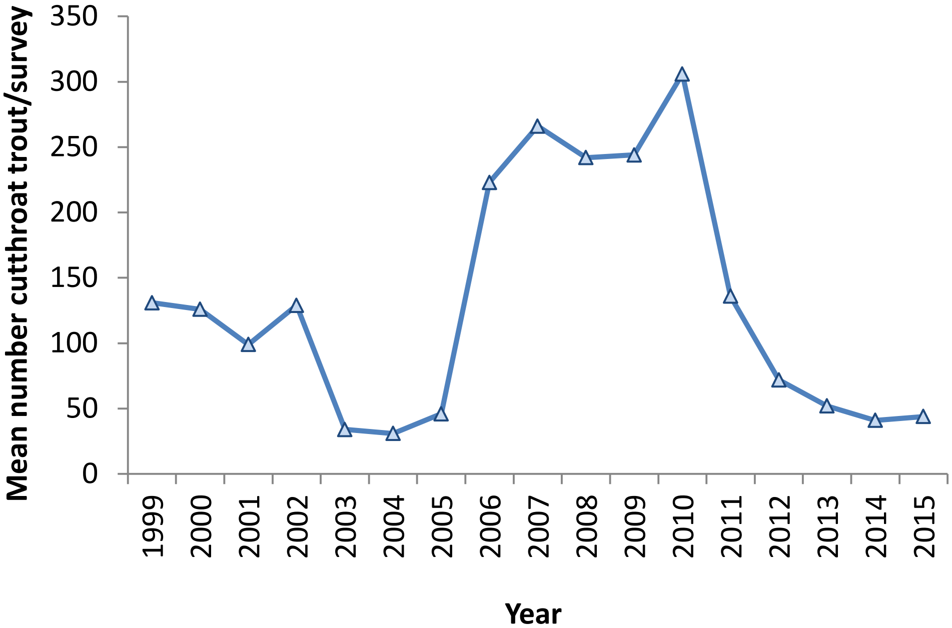

Figure 18. Mean number of spawning cutthroat (including cutthroat × rainbow trout hybrids) observed during weekly visual spawning surveys of the Trout Lake inlet creek, Yellowstone National Park, 1999–2015.

Cutthroat trout remains after bear feeding, Yellowstone National Park, 2001 (photo IGBST archives). In 2015, grizzly bears were documented fishing for cutthroat trout in Little Thumb Creek, stream #1090, stream #1138, and possibly Bridge Creek.

Grizzly Bear Use of Insect Aggregation Sites *(Dan D. Bjornlie, Wyoming Game and Fish Department; and Mark A. Haroldson, Interagency Grizzly Bear Study Team)*

Army cutworm moths (*Euxoa auxiliaris*) were first recognized as an important food source for grizzly bears in the GYE during the mid 1980s (Mattson et al. 1991*b*, French et al. 1994). Early observations indicated that moths, and subsequently bears, showed specific site fidelity. These sites are generally high alpine areas dominated by talus and scree adjacent to areas with abundant alpine flowers. Because insects other than army cutworm moths may be present and consumed by bears (e.g., ladybird beetles [Coccinellidae family]) as well, we generally refer to such areas as "insect aggregation sites." Within the GYE, observations indicate army cutworm moths are the primary food source at these sites.

Since their discovery, numerous bears have been counted on or near these aggregation sites due to excellent sightability from a lack of trees and simultaneous use by multiple bears. However, complete tabulation of grizzly presence at insect sites is extremely difficult. Only a few sites have been investigated by ground reconnaissance and the boundaries of sites are not clearly known. In addition, it is likely that the size and location of aggregation sites fluctuate from year to year with moth abundance and variation in environmental factors such as snow cover.

Since 1986, when insect aggregation sites were initially included in aerial observation surveys, our knowledge of these sites has increased annually. Our techniques for monitoring grizzly bear use of these sites have changed in response to this increase in knowledge. Prior to 1997, we delineated insect aggregation sites with convex polygons drawn around locations of bears seen feeding on moths and buffered these polygons by 500 m. However, this technique overlooked small sites due to the inability to create polygons around sites with fewer than 3 locations. During1997–1999, the method for defining insect aggregation sites was to inscribe a 1-km circle around the center of clusters of observations in which bears were seen feeding on insects in talus and scree habitats (Ternent and Haroldson 2000). This method allowed trend in bear use of sites to be annually monitored by recording the number of bears documented in each circle (i.e., site).

We developed a new technique in 2000 (D. Bjornlie, Wyoming Game and Fish Department, unpublished data) that delineates sites by buffering only the locations of bears observed actively feeding at insect aggregation sites by 500 m; this distance was used to account for error in aerial telemetry locations. The borders of the overlapping buffers at individual insect sites are dissolved to produce a single polygon for each site. These sites are identified as "confirmed" sites. Because these polygons are only created around feeding locations, the resulting site conforms to the topography of the mountain or ridge top where bears feed and does not include large areas of non-talus habitat that are not suitable for cutworm moths. Records from the grizzly bear location database from July 1 through September 30 of each year are then overlaid on these polygons and enumerated. This new technique substantially decreased the number of sites described in prior years, in which locations from both feeding and non-feeding bears were used. Therefore, we use this technique for the annual analysis completed for all years. Areas suspected as insect aggregation sites but dropped from the list of confirmed sites using this technique, and sites with only one observation of an actively feeding bear or multiple observations in a single year, are termed "possible" sites and will be monitored in subsequent years for additional observations of actively feeding bears. These sites may then be added to the confirmed sites list. When possible sites are changed to confirmed sites, analysis is done on all data back to 1986 to determine the historic use of that site. Therefore, the number of bears using insect aggregation sites in past years may change as new sites are added, and data from this annual report may not match that of past reports. In addition, as new observations of actively feeding bears are added along the periphery of existing sites, the polygons defining these sites increase in size and, thus, more overlaid locations fall within the site. This retrospective analysis brings us closer each year to the "true" number of bears using insect aggregation sites in past years.

Analysis of grizzly bear use of confirmed sites in 2015 resulted in the merging of 2 previously separate confirmed sites into one confirmed site as site boundaries grew together. Also, an additional observation of actively feeding grizzly bears on a nearby possible site led to this site being merged with sites above. There were no observations of actively feeding grizzly bears at previously undocumented sites and therefore, there were no new possible sites added in 2015. The new confirmed site, and merging the 2 previously confirmed sites, produced 30 confirmed sites and 14 possible sites for 2015.

Overall insect aggregation site use by grizzly bears decreased in 2015 (n = 222) compared with the increasing trend for years 2010–2015 (Table 22). The number of grizzly bears observed on sites and the percentage of confirmed sites with documented use by grizzly bears varies from year to year, suggesting that some years have higher moth activity than others (Figure 19), which may be due to variable snow conditions or the number of moths migrating from the plains. In 1993, a year with unusually high snowpack, the percentage of confirmed sites used by bears (Figure 19) and the number of observations recorded at insect sites (Table 22) were very low. In all other years, the percentage of insect aggregation sites used by grizzly bears fluctuated between 50 and 80% and in 2015 remained above 70% for the third consecutive year (Figure 19).

The decrease in use of insect aggregation sites by grizzly bears in 2015 is also apparent when only bears observed during regularly-conducted observation flights (see "***Observation Flights***") are included (Figure 20). Because effort, as measured by hours flown, in the bear management units containing all known insect aggregation sites has remained consistent since 1997, the change in the number of grizzly bears using insect aggregation sites suggests this decrease was not due to change in observation effort (Figure 20). The increase in reported observations of grizzly bears using insect aggregation sites from ground-based observers and our increased use of GPS collars with satellite technology has resulted in the need to censor these locations to prevent a bias in comparisons with previous years. Therefore, the number of aerial telemetry locations and observations from Table 22 reflect this change and may differ from previous annual reports.

The IGBST maintains an annual list of unique females observed with cubs (see Table 5 in "***Estimating Number of Females with Cubs***"). Since 1986, 1,061 initial sightings of unique females with cubs have been recorded, of which 298 (28.1%) have occurred at (<500 m, n = 280) or near (<1,500 m, n = 18) insect aggregation sites (Table 23). In 2015, 11 of the 46 (23.9%) initial sightings of unique females with cubs were observed at insect aggregation sites; slightly below the mean of 25.7% for the previous five years (2010–2014, Table 23).

Survey flights at or near (<1,500 m) insect aggregation sites contribute to the count of unique females with cubs; however, it is typically low, with a 10-year mean of 11.9 initial sightings/year since 2006 (Table 23). If these sightings are excluded, a similar trend in the annual number of unique sightings of females with cubs is still evident (Figure 21), suggesting that other factors besides observation effort at insect aggregation sites are responsible for the increase in sightings of females with cubs.

Table 22. Number of confirmed insect aggregation sites in the Greater Yellowstone Ecosystem, the number used by bears, and the total number of aerial telemetry relocations and ground or aerial observations of bears recorded at sites, 1986–2015.

Year	Number of confirmed moth sites[a]	Number of sites used[b]	Number of aerial telemetry relocations	Number of ground or aerial observations
1986	4	2	6	5
1987	5	3	3	11
1988	5	3	11	28
1989	9	7	9	41
1990	14	11	9	77
1991	16	12	12	168
1992	17	11	6	104
1993	18	3	1	2
1994	18	9	1	30
1995	20	11	7	38
1996	21	14	21	67
1997	22	15	17	83
1998	25	21	10	182
1999	25	14	25	156
2000	25	13	47	95
2001	26	18	23	127
2002	27	20	30	251
2003	27	20	9	163
2004	27	16	2	134
2005	29	19	16	193
2006	29	16	14	146
2007	29	19	19	160
2008	29	22	15	178
2009	30	22	6	169
2010	30	18	2	132
2011	30	19	9	159
2012	30	22	16	252
2013	30	22	25	294
2014	30	23	11	342
2015	30	21	13	209
Total			395	3996

[a] The year of discovery was considered the first year a telemetry location or aerial observation was documented at a site. Sites were considered confirmed after additional locations or observations in a subsequent year and every year thereafter regardless of whether or not additional locations were documented.

[b] A site was considered used if ≥1 location or observation was documented within the site during July through September of that year.

Table 23. Number of initial sightings of unique females with cubs that occurred on or near insect aggregation sites, number of sites where such sightings were documented, and the mean number of sightings per site in the Greater Yellowstone Ecosystem, 1986–2015.

Year	Unique females with cubs[a]	Number of moth sites with an initial sighting[b]	Initial sightings: Within 500 m[b] *n*	Initial sightings: Within 500 m[b] %	Initial sightings: Within 1,500 m[c] *n*	Initial sightings: Within 1,500 m[c] %
1986	25	0	0	0	0	0
1987	13	0	0	0	0	0
1988	19	1	2	10.5	2	10.5
1989	16	1	1	6.3	1	6.3
1990	25	4	4	16	5	20
1991	24	7	13	54.2	14	58.3
1992	25	5	7	28	9	36
1993	20	1	1	5	1	5
1994	20	3	5	25	5	25
1995	17	2	2	11.8	2	11.8
1996	33	7	7	21.2	8	24.2
1997	31	8	11	35.5	11	35.5
1998	35	10	13	37.1	13	37.1
1999	33	3	6	18.2	7	21.2
2000	37	6	9	24.3	10	27
2001	42	7	13	31	13	31
2002	52	11	18	34.6	18	34.6
2003	38	11	20	52.6	20	52.6
2004	49	11	17	34.7	17	34.7
2005	31	5	7	22.6	8	25.8
2006	47	11	15	31.9	16	34
2007	50	10	17	34	17	34
2008	44	7	11	25	14	31.8
2009	42	4	6	14.3	7	16.7
2010	51	7	9	17.6	9	17.6
2011	39	6	7	17.9	7	17.9
2012	49	6	13	26.5	13	26.5
2013	58	8	14	24.1	15	25.9
2014	50	11	21	42	23	46
2015	46	7	11	23.9	13	28.3
Total	1,061		280		298	
Mean	35.4	6	9.3	24.2	9.9	25.8

[a] Initial sightings of unique females with cubs; see Table 5.

[b] Insect aggregation site is defined as a 500-m distance around a cluster of observations of bears actively feeding.

[c] This distance is 3 times what is defined as an insect aggregation site for this analysis because some observations may be of bears traveling to and from insect aggregation sites.

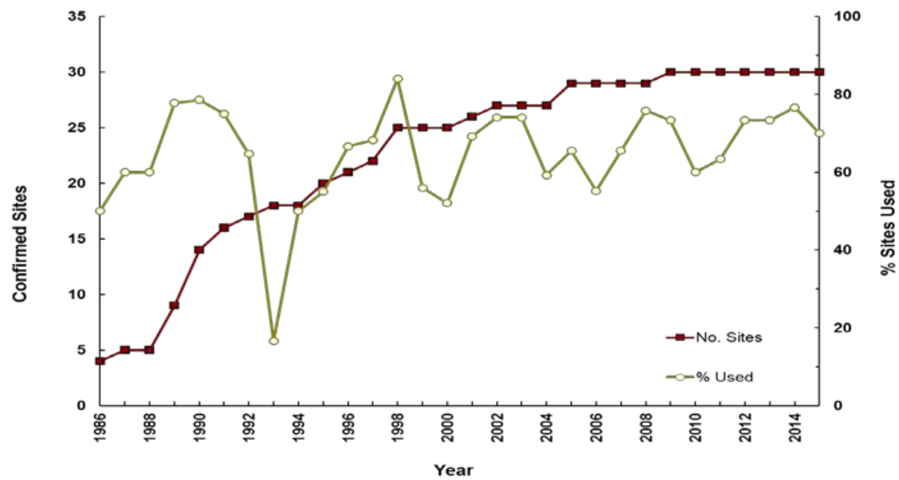

Figure 19. Annual number of confirmed insect aggregation sites and percent of those sites at which either telemetry relocations of marked bears or visual observations of unmarked bears were recorded, Greater Yellowstone Ecosystem, 1986–2015.

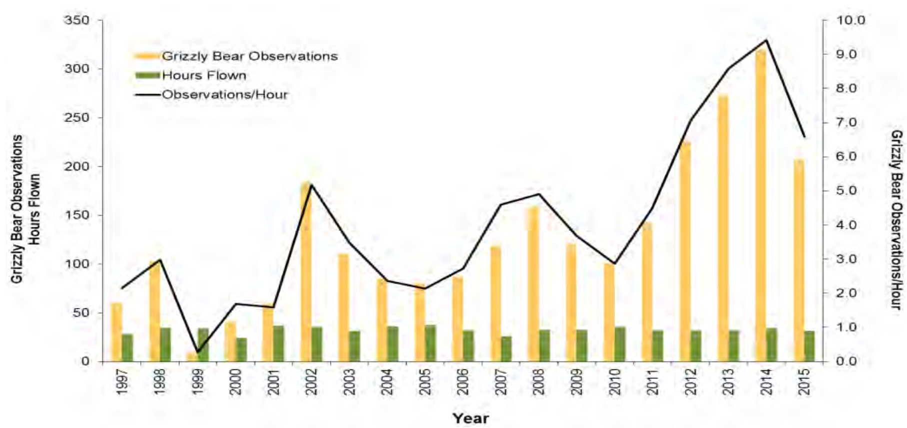

Figure 20. Number of grizzly bears observed (tan bars) on insect aggregation sites during observation flights only, hours flown (green bars) for these bear management units (BMU), and grizzly bear observations per hour (black line) during observation flights of BMUs containing all known insect aggregation sites, Greater Yellowstone Ecosystem, 1997─2015.

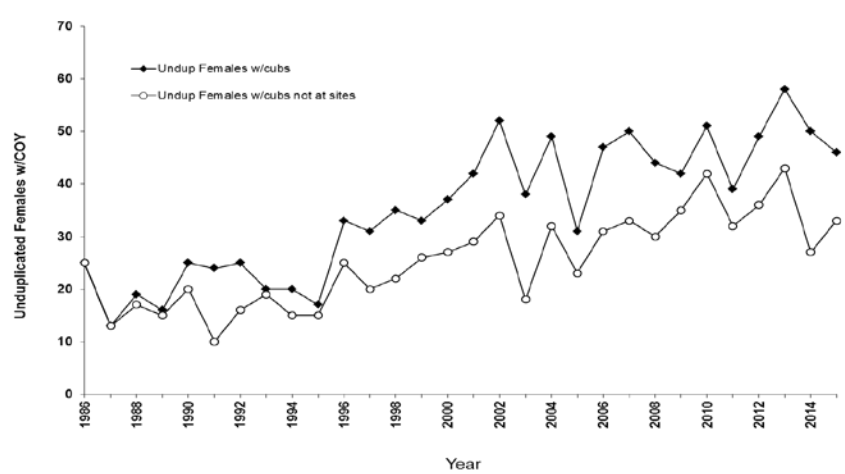

Figure 21. The total number of unique females with cubs observed annually in the Greater Yellowstone Ecosystem and the number of unique females with cubs not found within 1,500 m of known insect aggregation sites, 1986–2015.

Whitebark Pine Cone Production *(Mark A. Haroldson, Interagency Grizzly Bear Study Team)*

Whitebark pine (*Pinus albicaulis*) surveys on 21 established transects indicated average cone production during 2015 (Figure 22). Overall, the mean number of observed cones/tree was 15.89 (Table 24), which was near the average ($\bar{x}$ = 16.0) for the period 1980–2015 (Figure 23). Cone production was variable with 4 transect averaging >30 cones/tree (max = 64 cones/tree) and 10 transect averaging ≤5 cones/tree (Table 25).

Although we continue to observe tree mortality caused by mountain pine beetle (*Dendroctonus ponderosae*) in stands that contain our cone production transects, we observed no additional beetle-caused mortalities in 2015 among individual trees surveyed since 2002. Total mortality on these transect trees since 2002 remains at 75.3% (143/190) with 100% (19/19) of transects containing beetle-killed trees. Although tree mortality from mountain pine beetle is still occurring, the rate of loss among our cone production transects has slowed (Figure 24). These data support the notion that, at least in the vicinity of these transects, the current mountain pine beetle outbreak has run its course. Six (85.7%) of the 7 transects established during 2007 also exhibited beetle-caused mortality among transect trees. Preliminary results of efforts to monitor the health of whitebark pine forests across the GYE are presented in Appendix B of this report (Greater Yellowstone Whitebark Pine Monitoring Working Group, 2016)

Table 24. Summary statistics for whitebark pine cone production transects surveyed in the Greater Yellowstone Ecosystem, 2015.

Total			Trees				Transect			
Cones	Trees	Transects	Mean cones	SD	Min	Max	Mean cones	SD	Min	Max
2,797	176	21	15.89	24.82	0	150	129.05	165.71	0	648

Whitebark pine stand with some tree mortality near Amphitheatre Lake, Grand Teton National Park, 2014. Cone production in 2015 was near the average since monitoring began in 1980 (photo IGBST/Frank T. van Manen).

Table 25. Whitebark pine cone production transect results, Greater Yellowstone Ecosystem, 2015.

Transect	Cones	Trees	Mean	SD
A	19	5	3.8	5.2
B	114	10	11.4	9.5
C	20	10	2	4.2
D1	7	10	0.7	1.1
F1		-----Transect retired in 2008-----		
G	21	10	2.1	3.9
H		-----Transect retired in 2008-----		
J	94	10	9.4	11.8
K	311	7	44.4	24.9
L	203	9	22.6	13.7
M	99	10	9.9	9.7
N	648	10	64.8	45.9
P	43	9	4.8	6.2
Q1	21	10	2.1	2.8
R		-----Transect retired in 2009-----		
S		-----Transect retired in 2010-----		
T		-----Transect retired in 2008-----		
U	0	1	0	
AA	292	10	29.2	28.2
CSA	50	10	5	7.1
CSB	404	10	40.4	32.6
CSC	0	10	0	0
CSD	59	9	6.6	6.2
CSE	22	2	11	15.6
CSF	57	4	14.3	6.3
CSG	313	10	31.3	26.3

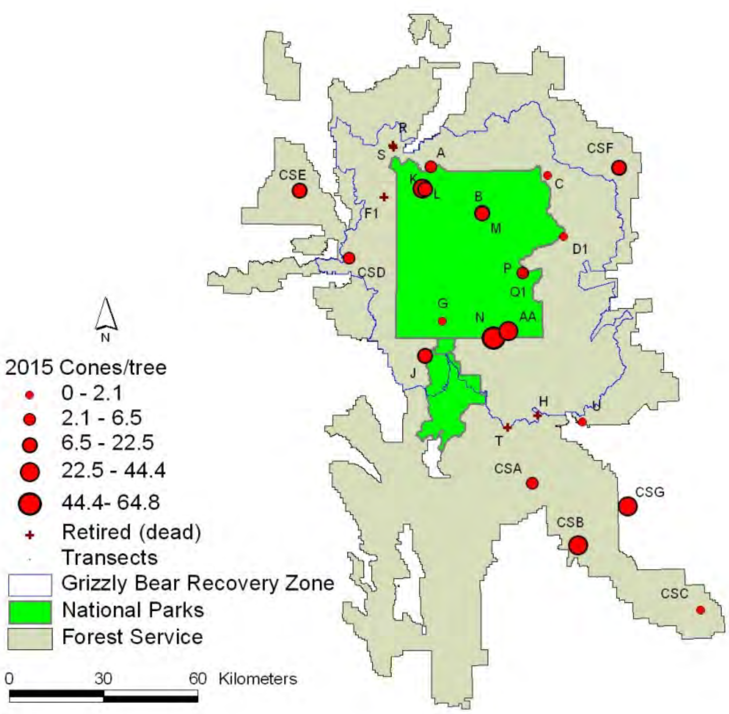

Figure 22. Locations and mean number of cones/tree for 21 whitebark pine cone production transects surveyed in the Greater Yellowstone Ecosystem, 2015.

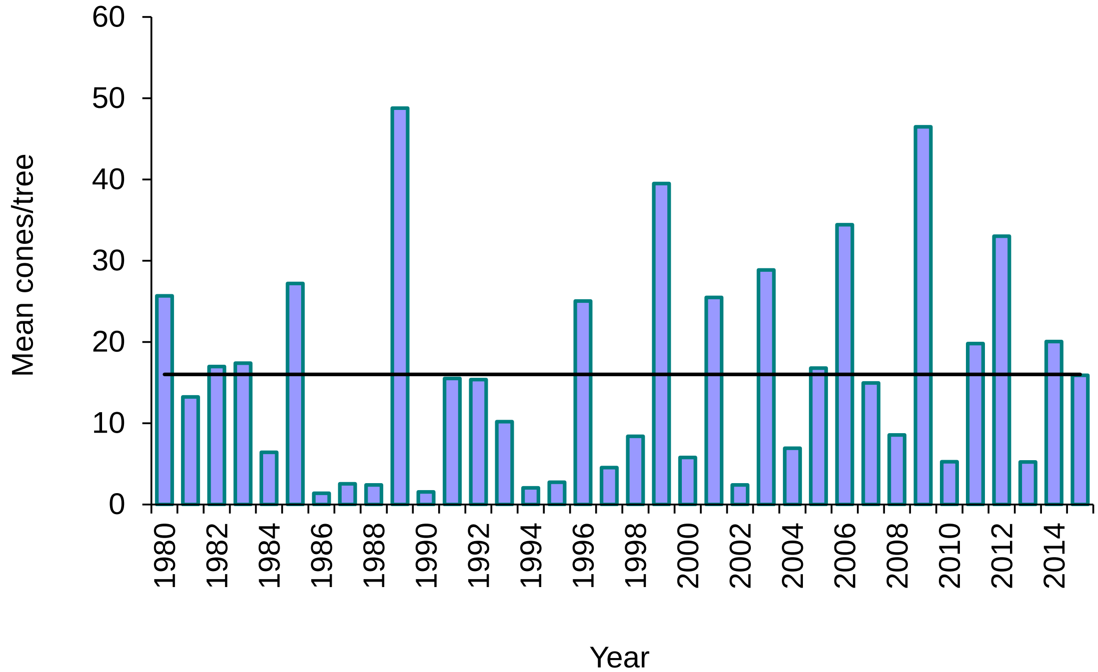

Figure 23. Annual mean cones/tree on whitebark pine cone production transects surveyed in the Greater Yellowstone Ecosystem during 1980–2015. Overall average ($\bar{x}$ = 16.0) shown as solid line.

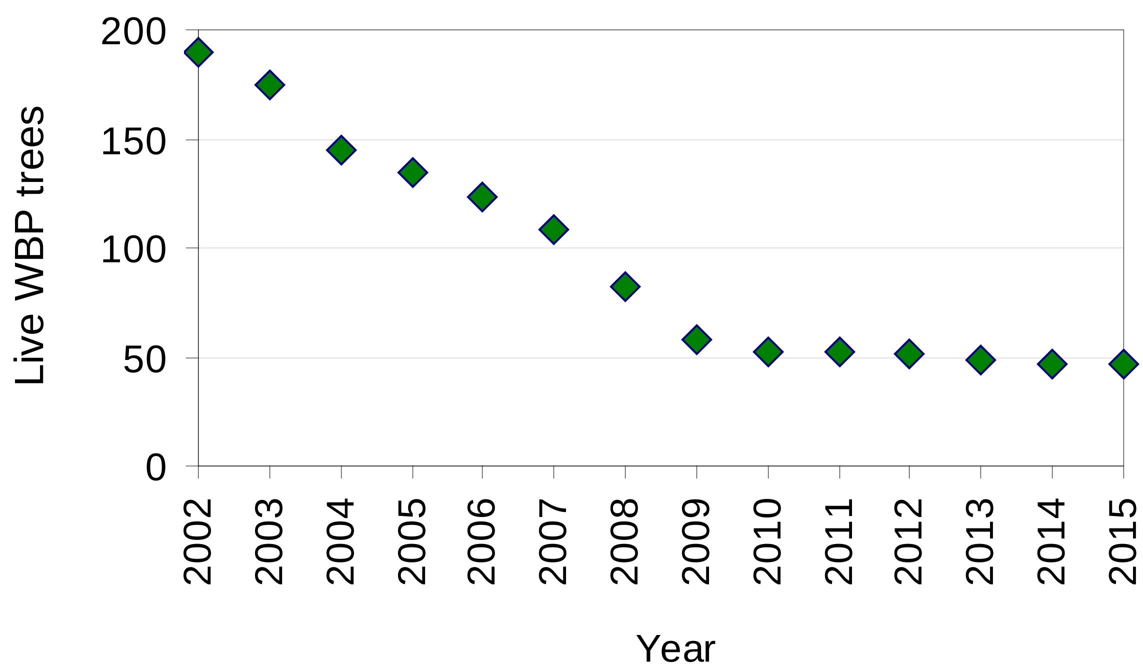

Figure 24. Number of live whitebark pine trees on cone production transects among 190 individual tress monitored since 2002.

Habitat Monitoring

Grand Teton National Park Recreational Use
(Katharine R. Wilmot, Grand Teton National Park)

In 2015, total visitation in Grand Teton National Park was 4,647,885 people, including recreational, commercial (e.g., Jackson Hole Airport), and incidental (e.g., traveling through the Park on U.S. Highway 191 but not recreating) use. Recreational visits alone totaled 3,149,921. Backcountry user nights totaled 33,798. Long and short-term trends of recreational visitation and backcountry user nights are shown in Table 26 and Figure 25.

Table 26. Average annual recreational visitation and average annual backcountry use nights in Grand Teton National Park by decade from 1951 through 2009, and the most recent 10-year average.

Decade	Average annual park-wide visitation[a]	Average annual backcountry use nights
1950s	1,104,357	Data not available
1960s	2,326,584	Data not available
1970s	3,357,718	25,267
1980s	2,659,852	23,420
1990s	2,662,940	20,663
2000s	2,497,847	30,049
2006–2015	2,665,330	29,752

[a] In 1983, a change in the method of calculation for park-wide visitation resulted in decreased numbers, whereas another change in 1992 increased numbers. Thus, park-wide visitation data for the 1980s and 1990s are not strictly comparable.

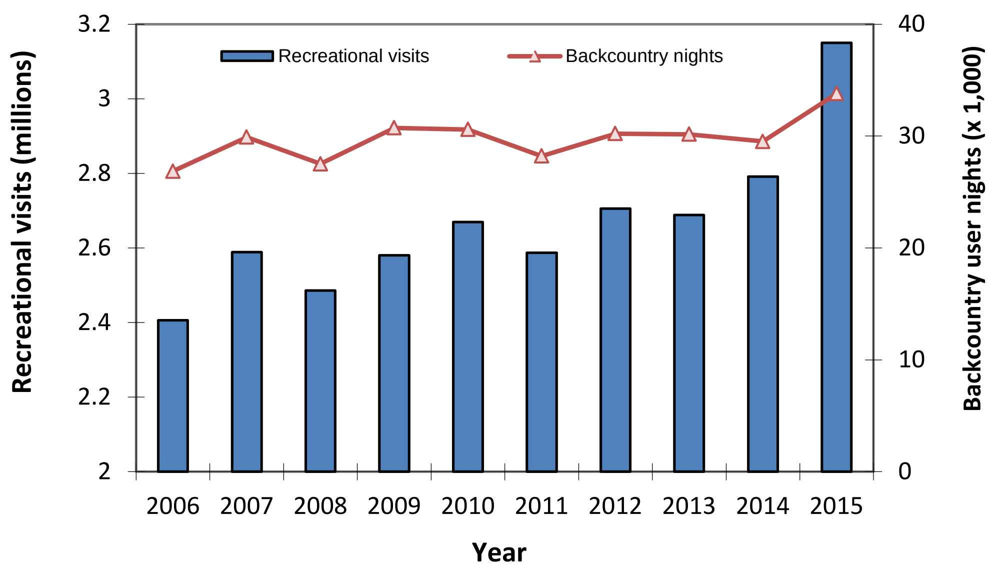

Figure 25. Trends in recreational visitation and backcountry user nights in Grand Teton National Park, 2006–2015 (data available at https://irma.nps.gov/Stats).

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Yellowstone National Park Recreational Use
(Kerry A. Gunther, Yellowstone National Park)

Total visitation to Yellowstone National Park was 5,253,829 visits in 2015 (https://irma.nps.gov/Stats/SSRSReports/Yell/Yellowstone) including recreational and non-recreational (e.g., traveling through the Park on U.S. Highway 191 but not recreating) use. Recreational visits in 2015 totaled 4,097,710, the highest visitation year on record and the 9th straight year that recreational visitation has topped the 3 million mark. Seven of the top 10 visitation years have occurred in the last decade (Table 27). Most of the park's recreational visitation occurred during the 6 month period from May through October. In 2015, there were 3,934,169 recreational visits (96%) during those peak months, an average of 21,381 recreational visits per day. In 2015, visitors spent 770,675 overnight stays in developed area roadside campgrounds, and 44,817 overnight stays in backcountry campsites in Yellowstone Park.

Average annual recreational visitation has increased each decade from an average of 7,378 visitors/year during the late 1890s to 3,012,653 visitors/year in the 1990s (Table 28, Figure 26). Average annual recreational visitation decreased slightly during 2000–2009, to an average of 2,968,037 visitors/year. The decade 2000–2009 was the first in the history of the park that visitation did not increase from the previous decade. However, the decade beginning in 2010 is on pace to set a new park record high for visitation. Five of the 6 highest years of visitation ever recorded in Yellowstone National Park have occurred since 2010. Although total park recreational visitation has increased steadily over time, the average number of overnight stays in backcountry campsites has been relatively stable, ranging from 39,280 to 45,615 overnight stays/year (Table 28, Figure 27). The number of overnight stays in the backcountry is limited by both the number and capacity of designated backcountry campsites in the park. The average number of overnight stays in developed campgrounds in the park has increased considerably since 2010 (Table 28, Figure 28).

Table 27. Ten highest years for visitation to Yellowstone National Park, 1895–2015.

Rank	Year	Visitation
1	2015	4,097,710
2	2010	3,640,184
3	2014	3,513,484
4	2012	3,447,727
5	2011	3,394,321
6	2009	3,295,187
7	2013	3,188,030
8	2007	3,151,343
9	1992	3,144,405
10	1999	3,131,381

Table 28. Average annual recreational visitation, auto campground overnight stays, and backcountry campsite overnight stays in Yellowstone National Park by decade, 1895–2015.

Decade	Average annual number of recreational visits	Auto campground average annual overnight stays	Backcountry campsite average annual overnight stays
1890s	7,378[a]	Data not available	Data not available
1900s	17,110	Data not available	Data not available
1910s	31,746	Data not available	Data not available
1920s	157,676	Data not available	Data not available
1930s	300,564	82,331[b]	Data not available
1940s	552,227	139,659[c]	Data not available
1950s	1,355,559	331,360	Data not available
1960s	1,955,373	681,303[d]	Data not available
1970s	2,240,698	686,594[e]	45,615[f]
1980s	2,344,485	656,093	39,280
1990s	3,012,653	647,083	43,605
2000s	2,968,037	624,450	40,362
2010s	3,546,911[g]	702,595[g]	41,533[g]

[a] Data from 1895 1899. During 1872 1894, visitation was estimated to be not less than 1,000 and no more than 5,000 each year.

[b] Data from 1930 1934

[c] Average does not include data from 1940 and 1942.

[d] Data from 1960 1964.

[e] Data from 1975 1979.

[f] Backcountry use data available for the years 1972 1979.

[g] Data for the years 2010 2015.

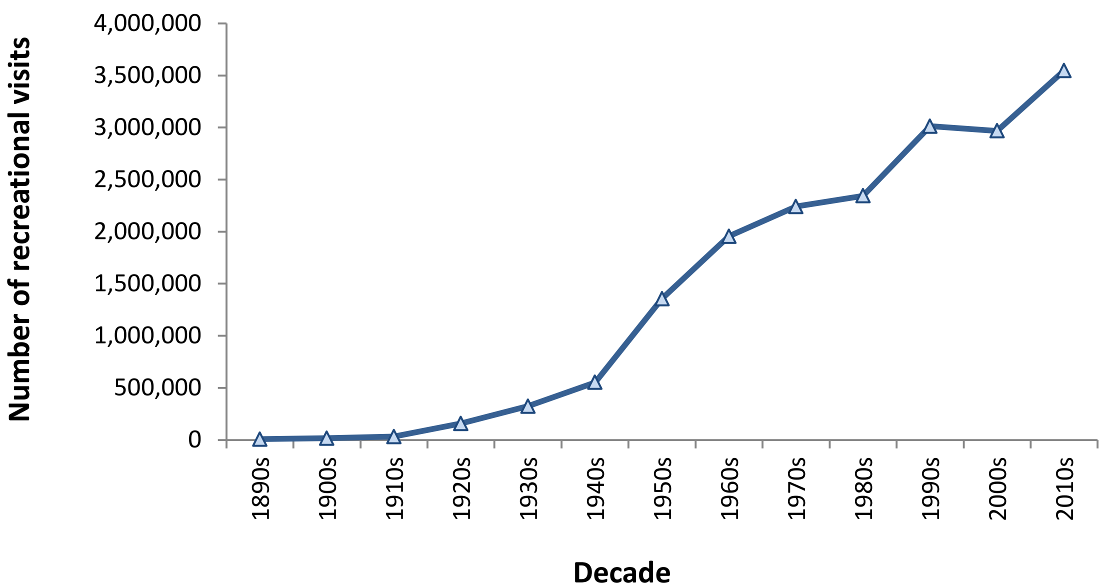

Figure 26. Average annual number of recreational visitors to Yellowstone National Park by decade, 1895 2015.

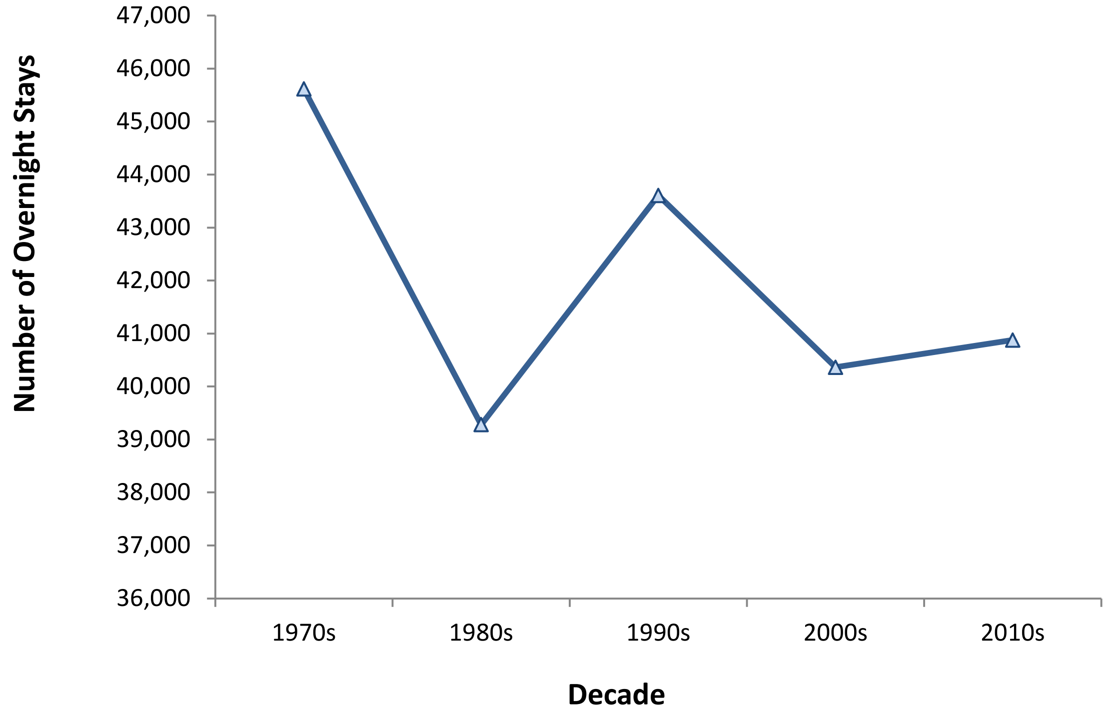

Figure 27. Average annual number of overnight stays in backcountry campsites in Yellowstone National Park by decade, 1972–2015.

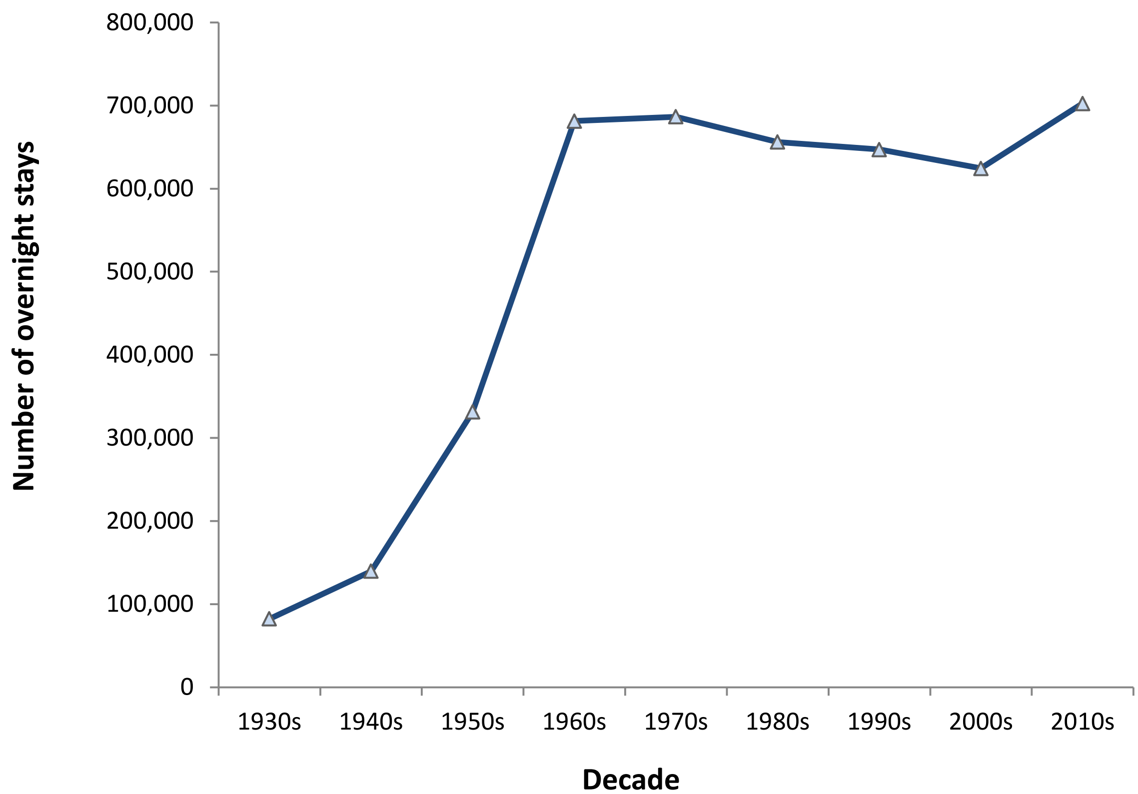

Figure 28. Average annual number of overnight stays in roadside campgrounds in Yellowstone National Park by decade, 1930–2015.

Trends in Elk Hunter Numbers within the Grizzly Bear Recovery Zone Plus the 10-mile Perimeter Area *(Dan D. Bjornlie, Wyoming Game and Fish Department; Kevin L. Frey, Montana Department of Fish, Wildlife and Parks; and Curtis Hendricks, Idaho Department of Fish and Game)*

State wildlife agencies in Idaho, Montana, and Wyoming estimate the number of hunters for each big game species. We used state estimates for the number of elk hunters by hunt area as an index of trend in hunter numbers for the Grizzly Bear Recovery Zone plus a 10-mile perimeter area (defined in the 1993 Recovery Plan as the area for population monitoring). Because some hunt area boundaries do not conform exactly to the Recovery Zone and 10-mile perimeter area, regional biologists familiar with each hunt area were queried to estimate hunter numbers within the Recovery Zone plus the 10-mile perimeter area. Elk hunters were used because they represent the largest cohort of hunters for an individual species. Although there are bighorn sheep, moose, and deer hunters using the Recovery Zone and 10-mile perimeter area, their numbers are relatively small in relation to elk hunter numbers and many hunt these species in conjunction with elk. Elk hunter numbers represent a reasonably accurate index of trend of total hunters within areas occupied by grizzly bears in the GYE.

We generated annual data from all states from 2003 to 2015 (Table 29) with the exception of Montana, where there was no estimate for 2013. Generally, the downward trend in total hunter numbers since 2003 has stabilized over the past few years and shows a slight increase in 2015 from a low of 20,305 estimated hunters in 2012 (Figure 29). This recent change in trend is a result of increased estimates in all three states over the past few years. From a low of 1,763 in 2008, hunter numbers in Idaho have rebounded, increasing to 2,921 in 2015. Hunter numbers in Wyoming also increased from a low of 6,551 in 2011 to 8,100 in 2014, and dropping slightly in 2015. Montana experienced the largest decrease in hunter numbers since 2002, reduced to fewer than 11,000 in 2012. Montana also contributed to the recent trend by increased hunter numbers over 12,000 in 2015. The hunter numbers in respective states bring the total estimate of 23,413 near what was observed in 2007, but remain considerably less than the highest estimate of 31,545 hunters in 2003 (Table 29).

Table 29. Estimated numbers of elk hunters within the Grizzly Bear Recovery Zone plus a 10-mile perimeter in Idaho, Montana, and Wyoming, 2003–2015.

	Year												
State	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Idaho	3,285	3,454	3,619	3,016	2,592	1,763	1,819	1,904	1,860	1,803	1,937	2,771	2,921
Montana	16,489	14,320	12,365	12,211	12,635	12,470	12,382	12,334	12,269	10,936	NA	11,925	12,779
Wyoming	11,771	10,828	9,888	9,346	8,716	8,966	8,444	6,764	6,551	7,566	7,705	8,100	7,713
Total	31,545	28,602	25,872	24,573	23,943	23,025	22,641	20,950	20,542	20,305	NA	22,805	23,413

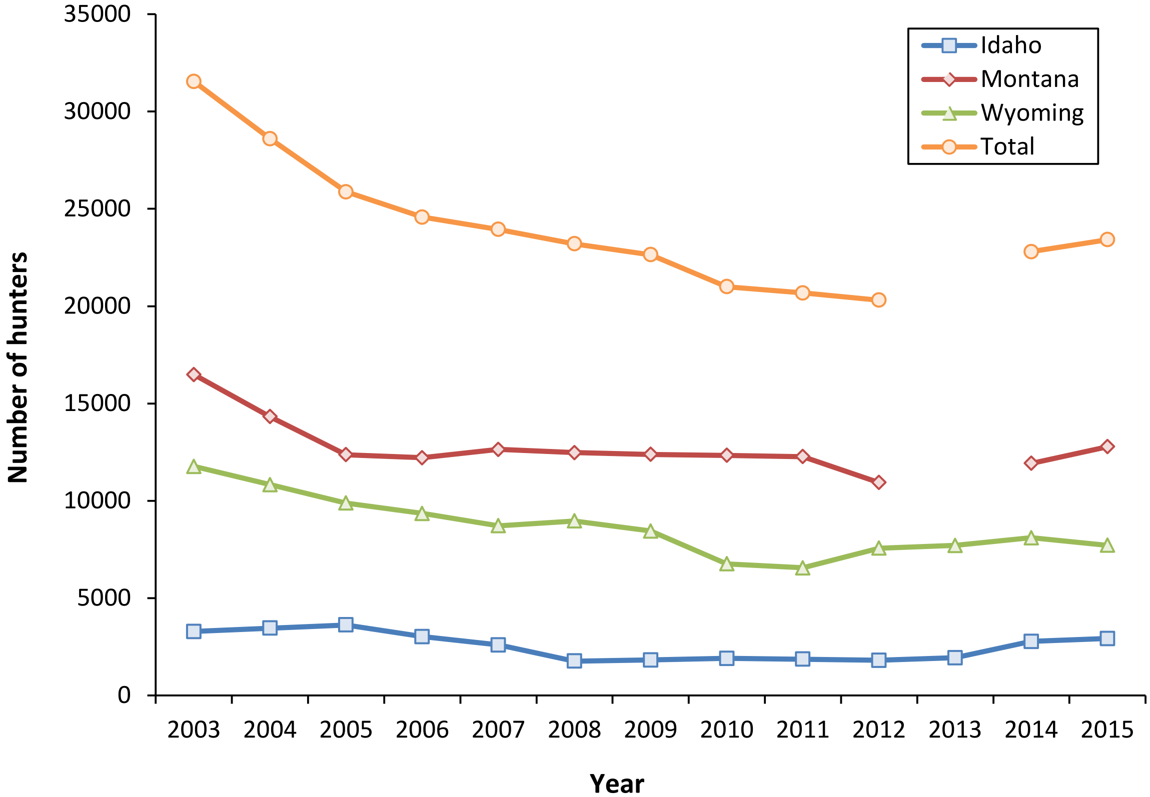

Figure 29. Trend in elk hunter numbers within the Primary Conservation Area plus a 10-mile perimeter in Idaho, Montana, and Wyoming, 2003−2015.

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Human-Grizzly Bear Conflicts in the Greater Yellowstone Ecosystem

Human-Grizzly Bear Conflicts in Grand Teton National Park *(Katharine R. Wilmot, Grand Teton National Park and John D. Rockefeller, Jr. Memorial Parkway)*

No management actions were taken on grizzly bears in Grand Teton National Park in 2015. However, management of nonfood-conditioned, human-habituated bears required considerable effort to prevent conflicts from occurring. Grizzly bears were hazed off of park roads 9 times and out of a developed area once. In addition, 1 bear captured on private land and relocated to the park was hazed upon its release. Grand Teton National Park recorded a minimum of 366 bear jams (84 grizzly, 234 black, 48 species not recorded), created when habituated bears frequented roadsides and the outskirts of other developments and drew crowds of onlookers. Grizzly bear jams peaked in May. Black bear jams remained steady through May, June, and July and peaked in August and September. The park's Wildlife Brigade managed most of these jams, as well as enforcing food storage at campgrounds, picnic areas, and other developments. Wildlife Brigade volunteers contributed 6,639 hours towards this important bear conservation and public education program.

Grand Teton National Park hosted 152 bear safety programs park-wide. These presentations highlighted safety in bear country and concluded with a bear spray (inert) demonstration. The program was well received, with over 4,835 visitors attending over the summer. Grand Teton National Park continued its partnership with the Grand Teton National Park Foundation to cost-share expenses for the purchase and installation of bear-resistant food storage lockers. Fifty-two 30 cubic-foot bear boxes were installed in 2015, bringing the total number of bear boxes in campgrounds and other developed sites to 547[a]. Three of the parks 6 roadside campgrounds, including Jenny Lake, Signal Mountain, and Lizard Creek Campgrounds, now have a food storage locker at each campsite.

[a] Forever Resorts, a permitted concessionaire in Grand Teton National Park, purchased and installed 13 bear boxes in the Lizard Creek campground in 2012, which we failed to report at the time.

Human-Grizzly Bear Conflicts in Yellowstone National Park *(Kerry A. Gunther, Travis Wyman, and Eric Reinertson, Yellowstone National Park)*

To effectively allocate resources for implementing management actions designed to prevent human-grizzly bear conflicts, Yellowstone National Park managers need baseline information as to the types, causes, locations, and recent trends of conflict incidents. To address this need, all reported human-grizzly bear conflicts are recorded annually. Conflicts are grouped into broad categories using standard definitions described by Gunther et al. (2012).

The frequency of human-grizzly bear conflicts is inversely associated with the abundance of natural bear foods (Gunther et al. 2004). When native bear foods are abundant, there tend to be few human-grizzly bear conflicts involving property damage and anthropogenic foods. When native bear foods are scarce, incidents of grizzly bears damaging property and obtaining anthropogenic foods increase, especially during late summer and fall when bears are hyperphagic (Gunther et al. 2004).

In 2015, the availability of high-quality, concentrated bear foods in Yellowstone National Park was below average during the spring, and the estrus and early hyperphagia periods, and average during late hyperphagia. During spring, there were few winter-killed ungulate carcasses on the Northern Ungulate Winter Range and in thermally influenced ungulate winter ranges in the interior of the park (see "***Spring Ungulate Availability and Use by Grizzly Bears in Yellowstone National Park***"). During spring, sign of grizzly bears digging up earthworms, geothermal soils, and food caches of plant roots of pocket gophers were encountered while conducting field work. There were very few spawning cutthroat trout observed in monitored tributary streams of Yellowstone Lake (see "***Spawning Cutthroat Trout***"). However, evidence of grizzly bears fishing for cutthroat trout was observed on 4 streams. Grizzly bear predation on newborn elk calves, grazing succulent graminoids, digging up pocket gopher food caches, and foraging for many species of forbs were common during the estrus season. During early-hyperphagia, grizzly bears foraged for a variety of forbs. During late hyperphagia, grizzly bears foraged for whitebark pine seeds (see "***Whitebark Pine Cone Production***"), false truffles, and mushrooms (primarily *Boletus* spp.).

There was only 1 human-grizzly bear conflict reported in Yellowstone National Park in 2015 (Table 30). On August 6, an adult female grizzly bear accompanied by 2 cubs attacked, killed, and consumed a solo day-hiker on Elephant Back Mountain (Figure 30). The annual number of human-bear conflicts occurring in Yellowstone National Park can vary widely from year to year and is dependent on the availability of natural bear foods, grizzly bear population numbers, park visitation, park staffing levels, and other factors. The number of conflicts have decreased significantly after efforts to prevent bears from obtaining anthropogenic foods were implemented in the late 1960s and early 1970s (Figure 31).

During 2015, there were 3 known grizzly bear mortalities in the Yellowstone National Park portion of the GYE. The adult female grizzly bear and her 2 female cubs involved in the human fatality on Elephant Back Mountain were captured and removed from the park. The adult female grizzly bear was killed and the 2 cubs were sent to the Toledo Zoo in Ohio. Trends in causes of grizzly bear mortality inside Yellowstone National Park have changed significantly over time. From the late 1950s through the 1970s most grizzly mortality in the park was due to human causes (Figure 32), primarily management removals of bears involved in human-bear conflicts. In recent decades (1980–2014) most grizzly mortality in the park is from natural causes, primarily old age and intraspecific strife and predation.

In addition to the capture and removal of the grizzly bear family group involved in the Elephant Back Mountain fatality, considerable management effort was dedicated toward preventing conflicts from occurring (Table 31). In an effort to prevent the need to capture and relocate or remove bears, grizzly bears were hazed out of human use areas 27 times. Grizzly bears were hazed out of park developments 17 times, off of primary roads 8 times, off of a boardwalk trail 1 time, and off of a busy backcountry trail near the trailhead 1 time. In addition, as part of the park's strategy for preventing bears from obtaining human foods, 134 bear-proof food storage boxes were purchased with National Park Service funds and donations raised by the Yellowstone Park Foundation and installed in roadside campgrounds and backcountry campsites. With the installation of 127 bear boxes in roadside campgrounds in 2015, 661 (35%) of the parks 1,898 campground campsites now have bear boxes. Six of the parks 11 campgrounds including Pebble Creek, Slough Creek, Tower Falls, Indian Creek, Norris, and Lewis Lake have bear boxes in 100% of their campsites. As part of the program some bear boxes have also been installed in the Mammoth (42% of sites), Canyon (18% of sites), Bridge Bay (20% of sites), Grant (20% of sites), and Madison (16% of sites) Campgrounds. It is the park's goal to provide park visitors with bear-proof food storage boxes in every roadside campsite. Seven additional bear boxes were installed in backcountry campsites in 2015 to replace broken food poles. All 301 designated backcountry campsites in Yellowstone National Park currently have a food storage device (food hanging pole or bear-proof food storage box).

Although there were few conflicts in Yellowstone National Park, management of non-food conditioned, human-habituated bears required considerable management effort. Habituation is the waning of a bear's response to people (McCullough 1982, Jope 1985, Herrero et al. 2005, Hopkins et al. 2010). Habituation is adaptive and reduces energy costs by reducing irrelevant behavior (McCullough 1982, Smith et al. 2005) such as fleeing from park visitors that are not a threat. Habituation allows bears to access and use habitat in areas with high levels of human activity, thereby increasing habitat effectiveness (Herrero et al. 2005). Habituation most commonly occurs in national parks where there are few human-caused bear mortalities, and exposure to humans is frequent and predictable and does not result in negative consequences for bears. Bears will readily habituate to people, human activities, roads, vehicles, traffic, and buildings. The large areas of non-forested habitat in Yellowstone National Park, combined with habituation of bears to park visitors has created exceptional bear viewing opportunities, resulting in significant growth of bear viewing as a local industry. Bear viewing is now one of the primary activities of visitors to Yellowstone National Park (Taylor et al. 2014, Richardson et al. 2015), and contributes millions of dollars to the economies of gateway communities annually (Richardson et al. 2014). In 2015, 279 roadside traffic-jams caused by visitors stopping to view habituated grizzly bears along roadsides were reported in Yellowstone National Park. Thousands of visitors viewed bears at these bear-jams. Park staff responded to 225 (81%) of the grizzly bear-jams and spent more than 1,160 personnel hours managing habituated bears, the traffic associated with bear-jams, and the visitors that stopped to view and photograph habituated bears. On average, 5.2 hours of park staff time were spent managing each grizzly bear jam.

Visitation to Yellowstone National Park has increased almost every decade (see "***Yellowstone National Park Recreational Use***"). In 2015, a new record high for visitation was recorded. Eight of the all-time top 10 visitation years have occurred in the most recent 10-year period. As visitation increases, park managers should expect an increasing number of bears to become habituated to people and a higher level of habituation among those bears, thereby causing more bear-jams and jams of longer duration (Haroldson and Gunther 2013). As the level of habituation increases, the distance at which bears allow visitors to approach before fleeing will also become smaller. Therefore, concurrent with increasing visitation, park managers should anticipate the need for increased staff time and infrastructure (e.g., housing, vehicles, equipment) dedicated to bear-jam management.

Table 30. Number of incidents of human-grizzly bear conflict reported in Yellowstone National Park, 2015.

Conflict type	Number of conflicts
Property damage – without food reward	0
Property damage – with food reward	0
Human injury	0
Human fatality	1
Total conflict incidents	1

Table 31. Number of grizzly bear incidents where management actions were taken in Yellowstone National Park, 2015.

Management action	Number of incidents
Bear warnings posted	17
Temporary area closures	17
Bear-jam management	225
Management hazing	27
Attempt capture – unsuccessful	0
Capture, mark, and release on-site	0
Capture and relocate	0
Capture and remove	1[a]
Capture for humane reasons	0
Total management actions	287

[a] Three bears were removed in this incident (adult female and 2 cubs)

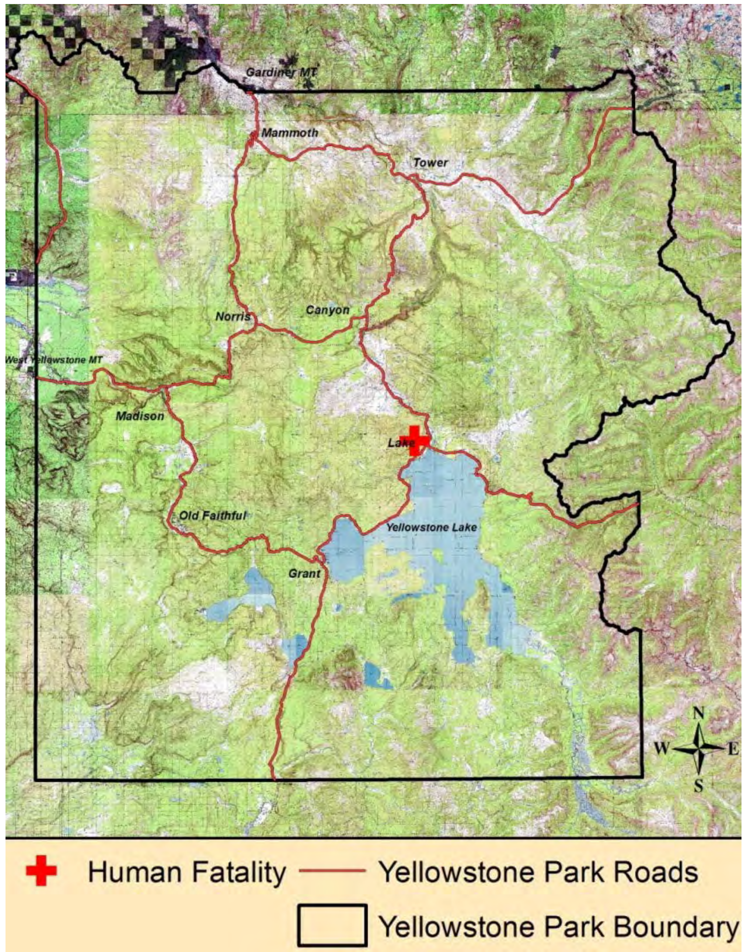


Figure 30. Locations of human-grizzly bear conflicts in Yellowstone National Park, 2015.

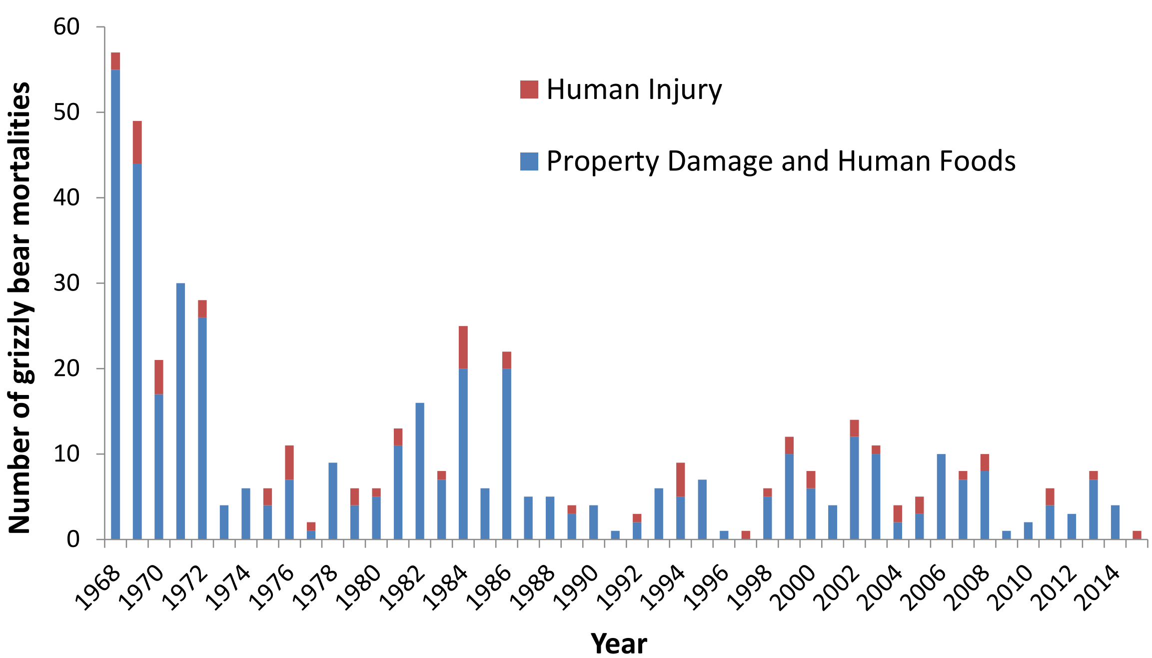


Figure 31. Number of incidents of human-grizzly bear conflict in Yellowstone National Park, 1968–2015.

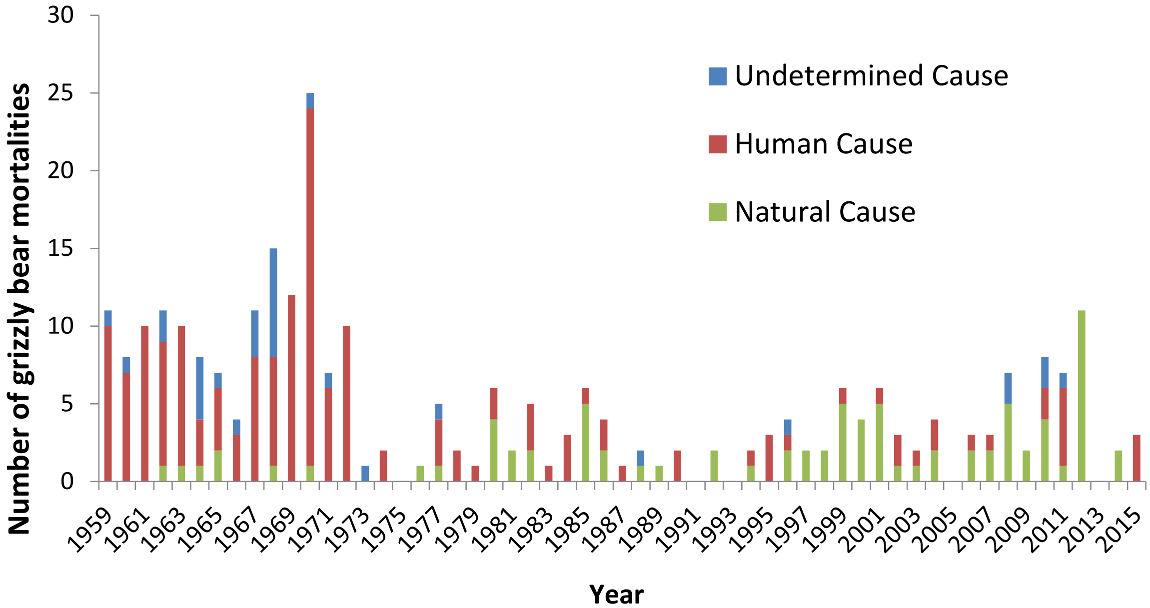


Figure 32. Number of known and probable grizzly bear mortalities in Yellowstone National Park, 1959–2015.

In 2015, 279 roadside traffic-jams were reported in Yellowstone National Park caused by visitors stopping to view habituated grizzly bears along roadsides (photo courtesy of Steve Ard).

Human-Grizzly Bear Conflicts in Idaho *(Curtis Hendricks, Idaho Department of Fish and Game, February 2016)*

Idaho Fish and Game Upper Snake Regional Carnivore Biologist, Wildlife Staff, and Conservation Officers responded to 28 human-grizzly bear conflicts during 2015 (Table 32). Conflicts are incidents where bears injure people, damage property, obtain anthropogenic foods, kill or injure livestock, damage beehives, or obtain vegetables or fruit from gardens and orchards (Gunther et al. 2000). These conflicts vary from a single bear involved in a single incident or the same bear active in multiple incidents to multiple bears involved in multiple incidents. Annual variation occurs in the number and location of conflicts, influenced by natural food abundance, livestock use patterns, availability of unsecured anthropogenic foods and an expanding population (both geographic and numbers) of grizzly bears and black bears as well as humans.

One human injury occurred in Idaho during 2015. This human injury involved an archery elk hunter and occurred on August 31, 2015. The attack was attributed to a female defending young and protecting a food cache. A detailed conflict report has been recorded for this incident.

Grizzly bears frequenting developed areas (e.g., subdivisions, campgrounds) were the most common conflict type in 2015. In these instances, garbage, dog food, and birdfeeders provided a food reward. Public education and a cost-share program for bear resistant garbage containers in southeast Idaho, has reduced the number of incidents in which bears actually obtain human foods. The domestic elk shooting operation that had concentrated bears during the fall in previous years has not been in operation since 2013, thus eliminating that unnatural food source. Reported livestock depredations were low but still present.

There has been a general increasing trend in number of conflicts in the Idaho portion of the Yellowstone Ecosystem since 2005 (Figure 33). This trend would be expected with the overall increase in bear numbers and expansion of occupied range that has occurred in Idaho in recent years.

During 2015, there were 4 known grizzly bear mortalities in Idaho. A grizzly bear was struck by a vehicle on highway 20 near the Idaho/Montana border. An old male grizzly bear was removed because of repeated entry into buildings after hazing and aversive techniques proved futile. A necropsy showed that this old male bear had severely marginalized dentition, which likely increased his dependence on anthropogenic food sources. A third mortality also involved a management removal as a result of repeated livestock depredations by an adult male grizzly in the Henry's Lake Flats area. The grazing allotments in this area have had repeated livestock depredations during the past three years. Finally, a female grizzly was removed because of repeated consumption of anthropogenic foods in Idaho and Wyoming and acclimation to human residences. This female had 2 yearlings, which were fitted with VHF collars and released at an approved release site in Idaho.

Climatic conditions in the Idaho portion of the Yellowstone Ecosystem were not extremely favorable for grizzly bear food production in 2015. Winter snow pack was below average and spring-summer precipitation was insufficient to produce good summer forage, particularly in late summer.

Table 32. Human-grizzly bear conflicts in the GYE portion of Idaho, 2015.		
Conflict type	Number	Land ownership
Human injury	1	USFS
Aggression towards humans	0	
Livestock – cattle	5	Idaho State land, USFS, and private
Livestock – poultry	0	Private
Livestock – swine	0	Private
Elk ranch offal	0	Private
Anthropogenic foods	10	USFS and private
Beehives/orchards	5	Private
Property damage	7	Private
Total	28	

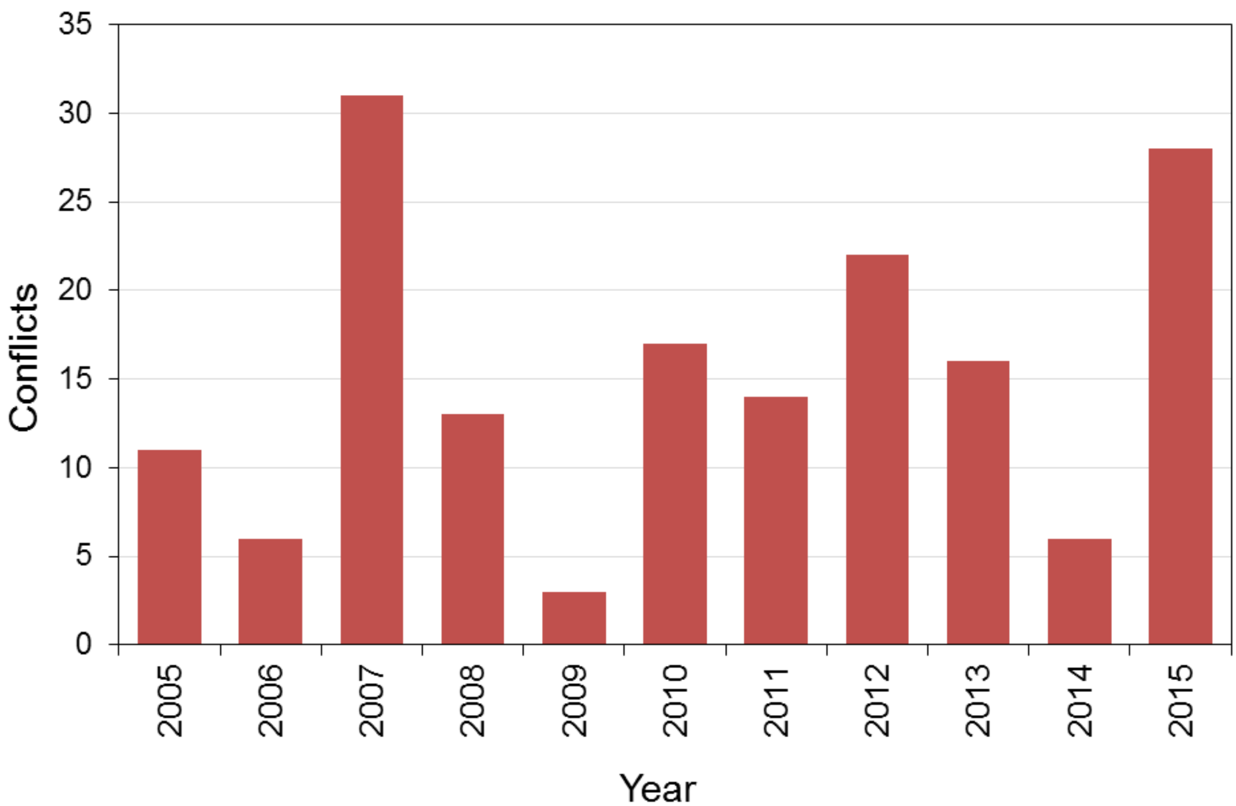


Figure 33. Number of documented human-grizzly bear conflicts in the Idaho portion of the Greater Yellowstone Ecosystem, 2005–2015.

Human-Grizzly Bear Conflicts in Montana *(Kevin L. Frey and Jeremiah Smith, Montana Fish, Wildlife and Parks)*

During 2015, Montana Fish Wildlife and Parks (MFWP) investigated 90 human -grizzly bear conflicts in Montana's portion of the Greater Yellowstone Ecosystem. Incidents in which grizzly bears cause public safety concerns, property damage, livestock depredations, human injuries, obtain anthropogenic foods, or grizzly bear mortalities are considered conflicts that require agency response, which may involve management action. These conflicts usually vary from one bear being involved in a single incident to multiple incidents involving one or more bears over a period of time before the conflicts can be resolved. The mean annual number of conflicts over the previous 10 years is 58. There were a total of 90 reported and investigated human-grizzly bear conflicts in 2015 (Table 33). With an expanding grizzly bear population in geographic distribution and numbers, conflicts are occurring in a larger geographic area on public and private land (Figure 34). Most conflicts occurred on private land (Table 34). Annually, efforts by MFWP continue to reduce conflicts, increase public safety, and reduce mortalities in areas of historic high conflicts, in new geographic areas and at individual sites.

One person was injured during an encounter situation with a grizzly bear in Montana's portion of the GYE, during 2015. Four grizzly bears were killed in backcountry self-defense situations during the fall season. Cattle depredations were the most common conflict type in 2015. The majority of the livestock depredations continued to occur in the greater Red Lodge area. This area had no livestock depredation conflicts until 2011. The area now experiences yearly depredations due to northerly expansion of grizzly bears, mostly from the eastern side of the ecosystem. The majority (80%) of the depredations have been occurring on private ranch lands beyond the Demographic Monitoring Area (DMA), where these and other conflict types are and will remain a management challenge.

Table 33. Human-grizzly bear conflicts in Montana portion of the Greater Yellowstone Ecosystem, 2015.

Conflict type	Number of conflicts
Encounter situations	13 (1 human injury)
Livestock – cattle	50 (50 cattle killed, 2 injured)
Livestock – sheep	0
Livestock – poultry	1
Property damage	6 (3 vehicle related)
Anthropogenic foods	4
Anthropogenic foods w/ property damage	8
Near developed sites- safety concerns	8
Total	90

Table 34. Private and public land grizzly bear conflicts in Montana portion of the Greater Yellowstone Ecosystem, 2015.

Jurisdiction	Number of conflicts
Private	64 (71% of total - mostly livestock related)
State	3
County or local jurisdiction	0
Federal jurisdiction	2
Bureau of Land Management	5
Gallatin National Forest	6
Beaverhead National Forest	10
Custer National Forest	0
USFWS – National Wildlife Refuge	0
Total	90

Historically, unnatural (anthropogenic) food-related conflicts were the most common annual human-bear conflict type, which was also the main cause for bear captures, relocations, and mortalities. For more than twenty years, extensive effort has been made on private and public land to secure attractants and reduce these conflicts. Early in the recovery program this was a primary management emphasis for the Yellowstone grizzly bear population. Bears near developed sites often investigate the possibility of obtaining anthropogenic foods. In Montana and throughout the ecosystem, information and education programs, sanitation efforts, and experience have helped reduce the number of bears obtaining anthropogenic foods, thereby reducing the need for management actions involving capture, relocation, or sometimes removal. These efforts will need to continue to reduce conflicts, reduce mortalities, and maintain social tolerance of grizzly bears.

From 2006 through 2015, there were 684 reported and investigated human-grizzly bear conflicts in Montana, which vary annually (Figure 35). During the time period 1996–2005, there were 466 human-grizzly bear conflicts investigated. Annual conflict numbers have been increasing. This increase is attributed to the increase in grizzly bear population numbers, the expansion of occupied grizzly bear range, and the increase in human population and activity. There has been a 32% increase in conflicts during the most recent 10-year period. However, if taken into consideration the 2011 U.S. Census data of increase in human population (25%), the increase in GYE grizzly bear population (32%) and the increase in overall bear distribution in Montana's portion of the GYE (36%), conflicts have been occurring at a relatively constant rate. Conflict reduction efforts have been successful on public and private lands.

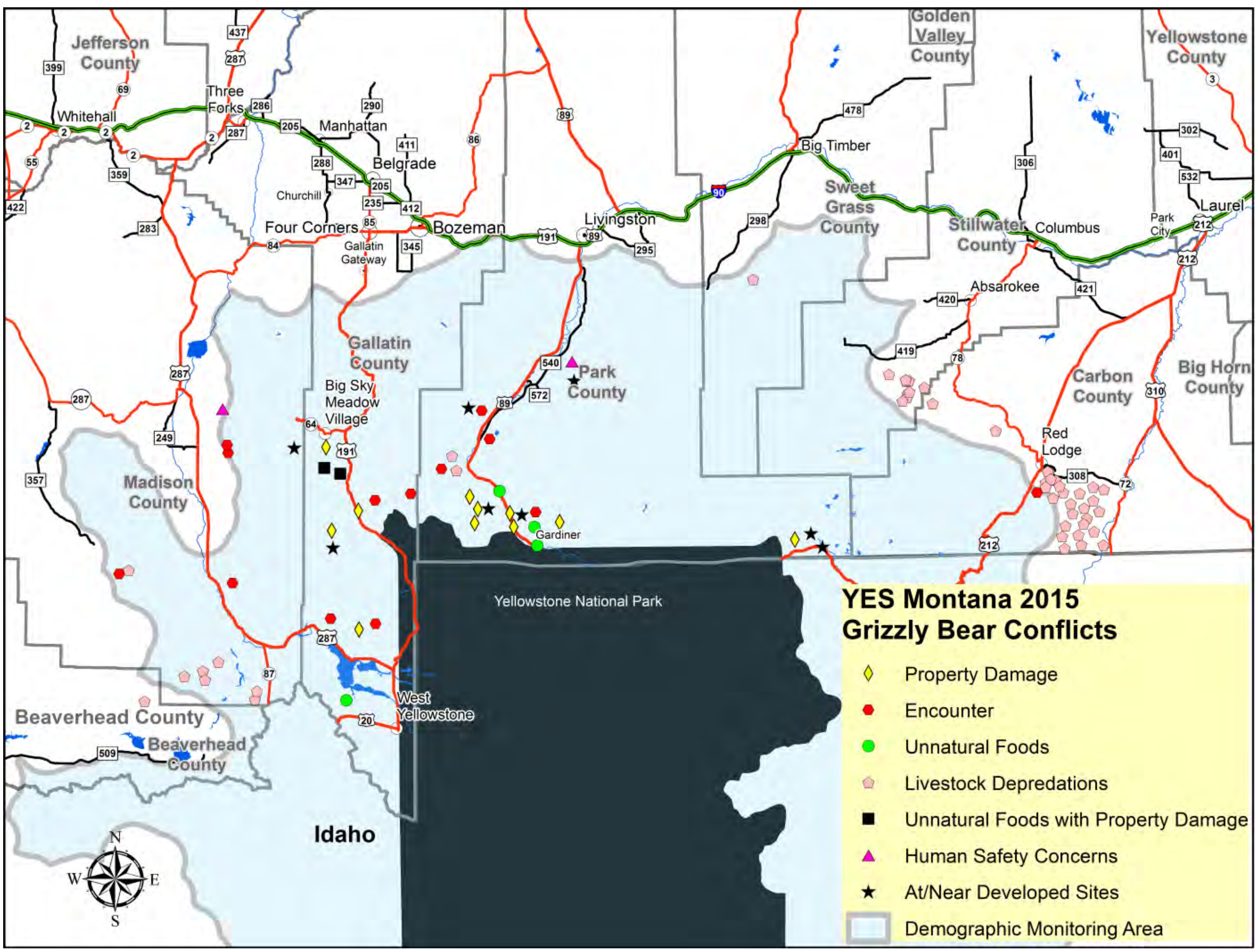


Figure 34. Locations of human-grizzly bear conflicts in the Montana portion of Greater Yellowstone Ecosystem, 2015.

Historically, livestock depredations by grizzly bears have been relatively low in southwest Montana. However, as bears expand their distribution farther away from recognized suitable habitat, livestock depredations are greatly increasing on private and public lands in these areas. During 2015, 78% of the livestock related conflicts occurred on private land outside the DMA, in the northeast area of the ecosystem near Red Lodge. With an increase in grizzly bear density and distribution on the northwest side of the ecosystem, livestock depredations have also become more frequent. During 1996–2005, there were 22 livestock related conflicts investigated in southwest Montana. This conflict type increased to 109 investigated livestock related conflicts during 2006–2015, with 50 occurring in 2015, mostly attributed to one adult female bear.

During 2015, there were 10 management captures of grizzly bears, with 9 of the captures occurring on private land (Figure 36). The long-term average over the previous 20 years is 4 management captures per year. Seven of the 2015 grizzly bear captures were due to livestock (cattle) depredations, which involved 4 adult males, 1 subadult male, and 1adult female with 1 cub. One of these adult male bears was captured on public land within the DMA and was subsequently removed due to numerous cattle depredations. The three other adult males and adult female with 1 cub involved in livestock depredations were on private land outside the DMA. Two of the adult males were removed, one adult male and one subadult male were non-target captures and were released near their capture sites. The adult female bear with 1 male cub were relocated within the DMA. This adult female bear lost her cub (cause unknown) returning to the area of previous livestock conflicts, where she killed numerous cattle on private land and was finally removed during the fall season. An old adult female bear with 2 female cubs were captured in a conflict involving property damage and anthropogenic foods on private land within the DMA. The adult female was subsequently removed due to age and very poor physical condition and the 2 cubs were transferred to a zoo facility.

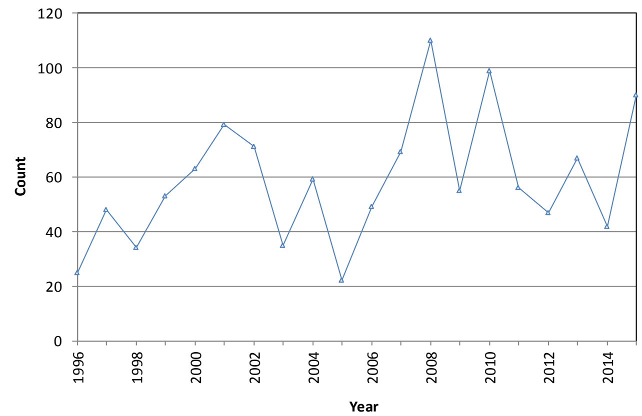


Figure 35. Annual variation in total human-grizzly bear conflicts in the Montana portion of the Greater Yellowstone Ecosystem, 1996–2015.

During 2015, there were 18 known or probable grizzly bear mortalities in the Montana portion of the GYE (Figure 37). This was the highest number of yearly mortalities recorded for Montana's portion of the GYE. Five of the mortalities occurred on private land and 13 occurred on various jurisdictions of public lands. Of those 13 mortalities on public land, 3 adult females and 1 adult male grizzly bear mortalities occurred because of close encounters and defense of life (DL) incidents on public land within the DMA boundary. One of these adult females killed in a DL situation had 3 cubs at her side when killed. Due to backcountry location and winter conditions, it is presumed that the 3 cubs died after the female was killed and are listed as probable mortalities due to an encounter and DL situation (Table 16). All of the DL mortalities (confirmed and probable) are currently under investigation. As previously stated, one adult female bear was removed on state land for multiple cattle depredations. This adult female had also lost her male cub after being translocated. The cause of the cub's death is unknown, but we assume it was influenced by the translocation of the adult female. One subadult male bear was illegally killed on Bureau of Land Management lands. One adult male bear mortality was due to a management removal on national forest land because of livestock conflicts. There was a probable mortality of an adult bear of unknown sex (DNA analysis pending), and 1 known mortality of a subadult male bear on US Highway 89S near Gardiner.

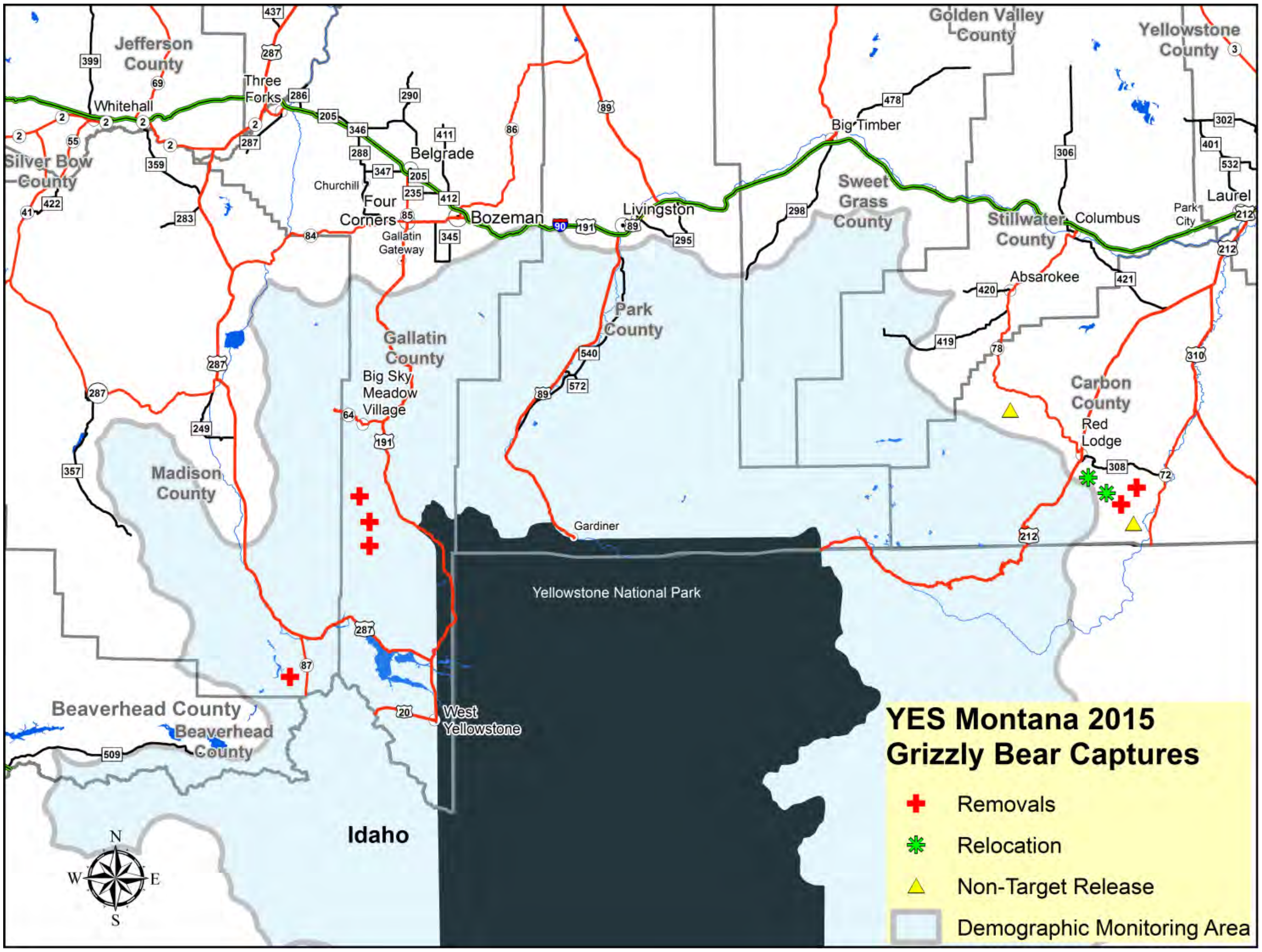


Figure 36. Locations of grizzly bear management captures in the Montana portion of Greater Yellowstone Ecosystem, 2015

Even as the Yellowstone grizzly bear population has been expanding throughout the entire ecosystem, Montana's long-term mortality trend has remained fairly constant since 1992, averaging 4 to 4.5 bear mortalities per year. Comparing time periods of 1994─2004 to 2005─2015, bear mortalities associated with anthropogenic foods have decreased from 50% to 16% of the total annual mortality in Montana, indicating that sanitation and education efforts have been successful. However, grizzly bear encounters resulting in human injuries and DL related bear mortalities has increased from 22% of the average annual bear mortality during 1994─2004 to 35% during 2005─2015. Additionally, management removals because of livestock depredations have increased from 5% to 17% of the average annual mortalities during these same time two periods. The increase in overall mortality and shifts in causes of mortality can be partially attributed to Yellowstone grizzly bear expansion in population numbers and distribution. The trend of grizzly bear mortalities due to management actions compared with all other mortality causes is shown in Figure 38. The expectation is that grizzly bears will continue to expand their range into areas beyond the DMA, potentially resulting in an increase of total conflicts and bear mortalities.

The 2015 summer climatic conditions were similar to 2014, resulting in slightly higher precipitation during the summer months and relatively cooler temperatures compared with 2012 and 2013. A mild late winter allowed for early stage plant growth. However, snow, cold temperatures, and wind persisted into the spring months with ample moisture, but the sporadic cooler temperatures and wind were detrimental to fruit-producing shrubs and trees that were in blossom or setting fruit buds. This likely reduced the availability and longevity of berry fruits persisting for late summer and fall foraging. Because of the early overall start of plant phenology, fruits that were produced ripened before bears normally seek out the food source. Whitebark pine cone production was near average in the GYE during 2015 (see "***Whitebark Pine Cone Production***"). Bears were also feeding on vegetative roots, grazing, and scavenging animal carcasses during the fall months. Grizzly bear conflicts in late summer and fall involving anthropogenic foods and developed sites can be partially related to the availability of natural higher- quality (fats, carbohydrates, proteins, sugars) foods.

Grizzly bear conflict numbers (n = 90) during 2015 were above the long-term (20 years) average (n = 62). The higher number of conflicts did not correlate to food stress for bears overall, but was directly related to a high number (n = 50) of livestock depredations on private land outside the DMA, which were mostly attributed to one adult female bear. Without that individual bear creating conflicts, the annual number of total conflicts would have been near the long-term average. Field investigations indicated grizzly bears were using heavy shaded timber, wet areas, and open areas during the summer months. This feeding strategy likely allowed bears to find adequate vegetative and protein food sources, thereby resulting in fewer human interactions and conflicts during the summer months. Summer vegetative foods were adequate in these shaded and mesic areas, as high-quality fall foods (e.g., roots, seeds, carcasses) were in good quantity. No single factor can be attributed to low or high conflicts in a given year and it is always the combination of multiple factors. Natural food availability, climate conditions, bear numbers, individual bear behavior, previous bear removals, management efforts and human activities all factor into the annual variation in bear-human conflicts.

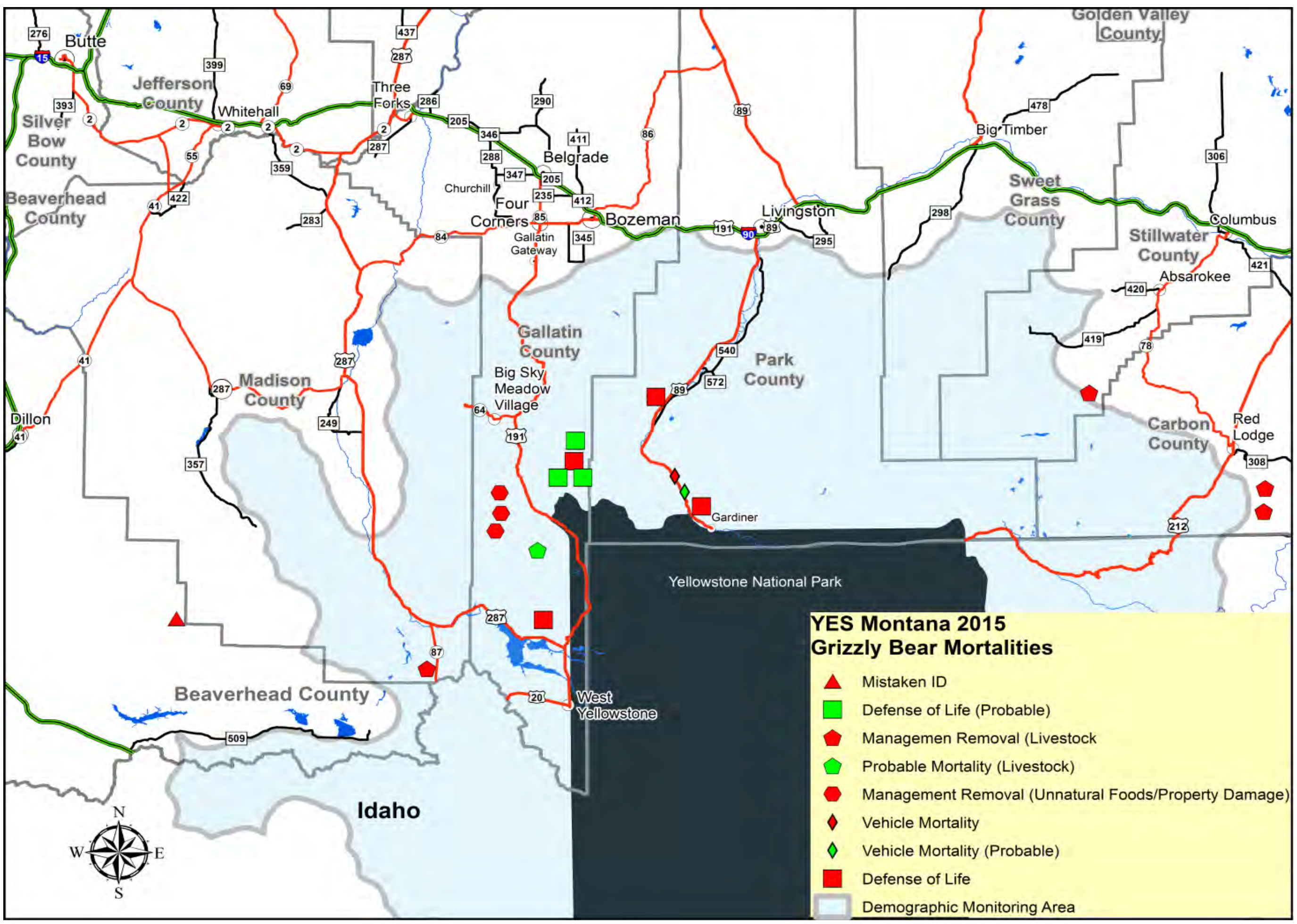


Figure 37. Locations and causes of grizzly bear mortalities in the Montana portion of Greater Yellowstone Ecosystem, 2015

An extensive effort has been made to reduce all types of conflicts and a measured success is being observed in a reduction of sanitation and anthropogenic food related conflicts and associated bear mortalities. During 2015, twelve conflicts were related to garbage with remaining anthropogenic conflicts mostly involving domestic animal feeds.

Conservation Strategy funding from the USFWS provided since the initial delisting of the Yellowstone grizzly bear population has allowed the acquisition of 346 bear-resistant refuse containers for placement on private and public land within the Primary Conservation Area. Since 2006, Montana Fish, Wildlife and Parks and local community efforts have distributed and placed 282 bear-resistant garbage containers in the upper Yellowstone River-Gardiner area, which has greatly reduced garbage related conflicts in the area. Additionally, with the formation of a Bear Aware Council, representing private businesses, community developments, and agencies, Republic Services has distributed over 650 bear-resistant garbage containers in the Big Sky area. This sanitation effort will greatly help reduce black bear and grizzly bear conflicts in this portion of Gallatin and Madison Counties.

The most difficult conflict type to prevent is surprise encounter. Such encounters can lead to human injuries and are currently trending to be the leading cause of grizzly bear mortalities in the Montana portion of the GYE. During 2015, there was one human injury due to a physical encounter with a bear. In this incident, the person sustained bruises and scrapes from being knocked down by a grizzly bear and it was not certain if the person was directly injured by the bear's teeth or claws. The person had been walking with a dog along a river shore which was covered by willows and cedar trees. Montana Fish, Wildlife and Parks continues to distribute bear conflict information to hunters through hunter (archery and rifle) education classes, license holders, postcards, letters, personal contacts, newspapers, websites, and televised news. In general, most of the public is aware of grizzly bear presence and potential encounter situations, but due to the unpredictable and random occurrence of surprise encounters, it is impossible to completely prevent these types of conflicts. The largest future challenge will be to effectively address bear management situations on lands beyond recognized suitable habitat and the DMA.

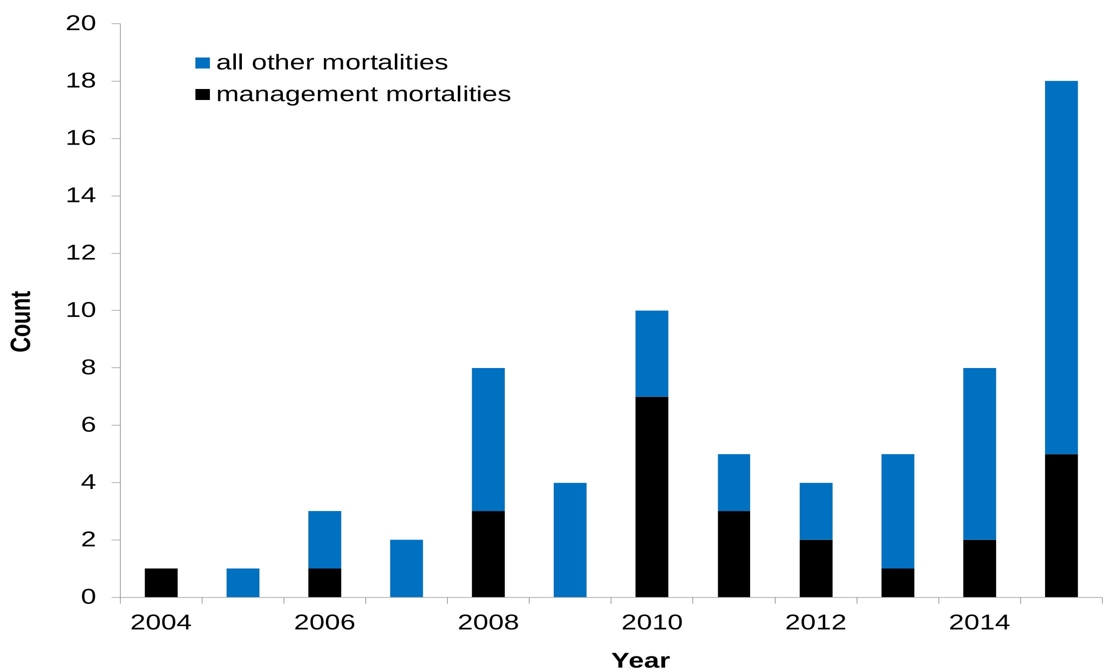


Figure 38. Mortality trend in the Montana portion of Greater Yellowstone Ecosystem, 2004–2015.

Human-Grizzly Bear Conflicts in Wyoming *(Brian DeBolt, Zach Turnbull, Luke Ellsbury, Michael Boyce, Kyle Bales, Sam Stephens, Dustin Lasseter, Carter Nielsen and Dan Thompson; Large Carnivore Section; Wyoming Game and Fish Department)*

Bear-human interactions and conflicts in Wyoming are typically a result of bears seeking unnatural foods in association with people and property, close encounters with humans, or when bears depredate livestock. The number and location of human-bear conflicts is influenced by unsecured unnatural attractants (e.g., human foods, garbage), natural food distribution and abundance, bear density and distribution, and human and livestock use patterns on the landscape.

The preferred approach to resolve human-bear conflicts in Wyoming is through prevention or to secure the attractant. In addition, the Wyoming Game and Fish Department (WGFD) relocates and removes grizzly bears in accordance with state and federal law, regulation, and policy. The management technique of capturing bears in areas where they may come into conflict with people and relocating them to remote locations is a common practice throughout the world. Relocating bears achieves several social and conservation functions: 1) reduces the probability of property damage, livestock damage, or human interactions in areas where the potential for conflict is high; 2) reduces the potential for bears to become food conditioned or human habituated, which often results in destructive and dangerous behaviors; 3) allows bears the opportunity to forage on natural foods and remain wary of people; and 4) may prevent removing bears from the population, which may be beneficial in meeting population management objectives. Removal refers to lethal or live removal (e.g., placement with a zoo or other captive bear facility) from the population.

During 2015, WGFD personnel captured 45 grizzly bears in 51 capture events in an attempt to prevent or resolve conflicts (Figure 39). Most captures were lone grizzly bears of all age classes, but 2 family groups (1 female with 2 cubs and 1 female with 2 yearlings) were also captured. Twenty-four (47%) of the 51 capture events occurred in Park County, 16 (31%) in Sublette County, 7 (14%) in Fremont County, 2 (4%) in Hot Springs County, and 2 (4%) in Teton County (Table 35).

Of the 51 capture events, 22 captures were a result of bears killing livestock (primarily cattle), 6 were captured for getting unsecured garbage and 6 were obtaining pet, livestock food, or foraging on fruit trees. Twelve management captures occurred as preemptive measures for bears exhibiting habituated behavior or being in close proximity to people, as well as 3 non-target captures and 2 captures for property damage. All relocated grizzly bears were released on U.S. Forest Service lands in or adjacent to the Primary Conservation Area (PCA; Figure 40). Of the 34 relocation events, 17 (50%) bears were released in Park County, 16 (47%) were released in Teton County, and 1 (3%) was released in Fremont County (Table 35).

Sixteen of the 51 capture events resulted in the removal of grizzly bears from the population by Department personnel by lethal removal or live placement in a zoo. These bears were removed due to a history of previous conflicts, a known history of close association with humans, or they were deemed unsuitable for release into the wild (e.g. orphaned cubs, poor physical condition, human safety concern).

All relocated grizzly bears of independent age (≥2 years) were fitted with a radio-collar to track their movements after release. Attempts to obtain locations on marked grizzly bears through aerial telemetry were made approximately every 10–14 days as part of standard monitoring techniques throughout the ecosystem. As per Wyoming Statute, within 5 days of releasing a grizzly bear, the County Sheriff was notified by e-mail and a press release was distributed to all local media contacts in the county where the grizzly bear was released. The media release contained information on the location of the grizzly bear release, the number of grizzly bears relocated, the date of the relocation, and the reason the grizzly bear was relocated (Table 35).

Grizzly bear cattle depredation was the most frequent type of conflict documented in Wyoming in 2015 (photo courtesy of Zach Turnbull, Wyoming Game and Fish Department).

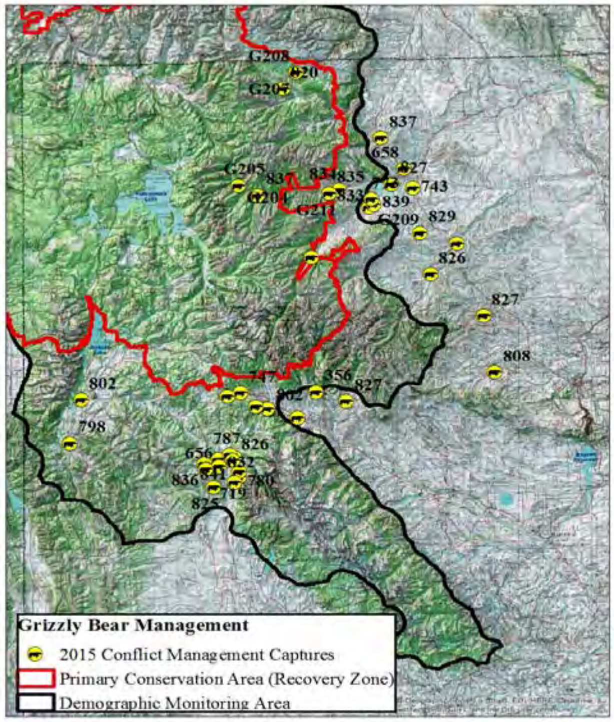


Figure 39. **Management capture locations (*n* = 51) of grizzly bears captured, relocated, released, or removed in Wyoming, 2015. Grizzly bears with "G" in front of their number were ear-marked but not fitted with radio collars upon release, typically because they were too young to be collared. Grizzly bears identified with "NA" were grizzly bears removed from the population without being given an identification number. PCA is the grizzly bear Primary Conservation Area as defined in the 2007 Grizzly Bear Conservation Strategy. The grizzly bear Demographic Monitoring Area is based on IGBST (2012).**

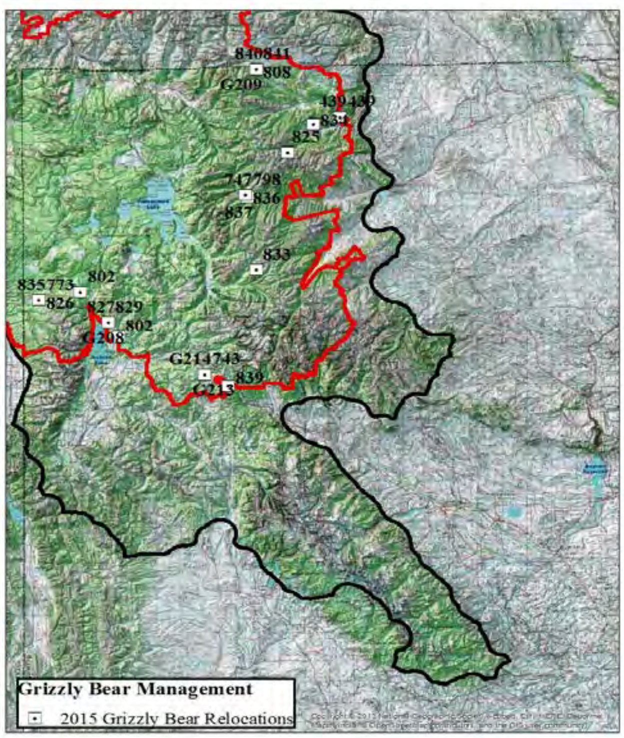


Figure 40. **Release locations (*n* = 34) for grizzly bears captured, relocated, or released on site in conflict management efforts in Wyoming, 2015. Grizzly bears with "G" in front of their number were ear-marked but not fitted with radio collars upon release typically because they were too young to be collared. PCA is the grizzly bear Primary Conservation Area as defined in the 2007 Grizzly Bear Conservation Strategy. The grizzly bear Demographic Monitoring Area is based on IGBST (2012).**

Table 35. Capture date, grizzly bear identification number (ID), capture county, relocation site, release county, and reason for capture for all 2015 grizzly bear conflict management captures ($n = 51$) in Wyoming. Grizzly bears identified with "NA" were grizzly bears removed from the population without being given an identification number.

Date	ID	Capture county	Relocation site	Release county	Reason for capture
4/17/2015	802	Teton	Pilgrim Creek - Bridger-Teton Forest	Teton	Non-target capture
5/14/2015	808	Hot Springs	Fox Creek - Shoshone Forest	Park	Relocated for sheep depredation
5/14/2015	802	Fremont	Glade Creek - JDR Parkway	Teton	Non-target capture
6/11/2015	G204	Park	Squirrel Meadows - Bridger-Teton Forest	Teton	Relocated for frequenting guest lodge
6/11/2015	G205	Park	Squirrel Meadows - Bridger-Teton Forest	Teton	Relocated for frequenting guest lodge
6/26/2015	656	Sublette			Removed for chronic cattle depredations
6/27/2015	NA	Fremont			Removed for chronic garbage conflicts
6/27/2015	G206	Sublette	Five Mile Creek - Shoshone Forest	Park	Relocated for cattle depredations
7/3/2015	356	Fremont			Removed for chronic garbage conflicts
7/12/2015	719	Sublette			Relocated for cattle depredations
7/25/2015	780	Sublette			Relocated for cattle depredations
7/25/2015	G207	Park	Bailey Creek - Bridger-Teton Forest	Teton	Relocated for frequenting developed area
7/25/2015	G208	Park	Bailey Creek - Bridger-Teton Forest	Teton	Relocated for frequenting developed area
8/2/2015	824	Sublette	Mormon Creek - Shoshone Forest	Park	Relocated for cattle depredations
8/3/2015	825	Sublette	Sunlight Creek - Shoshone Forest	Park	Relocated for sheep depredation
8/7/2015	826	Park	Squirrel Meadows - Bridger-Teton Forest	Teton	Relocated for obtaining horse grain
8/8/2015	NA	Fremont			Removed for garbage conflicts
8/8/2015	827	Hot Springs	Bailey Creek - Bridger-Teton Forest	Teton	Relocated for frequenting developed area
8/11/2015	NA	Fremont			Removed for chronic cattle depredations
8/13/2015	658	Park			Removed for obtaining garbage

Table 35. Continued.					
Date	ID	Capture county	Relocation site	Release county	Reason for capture
8/20/2015	826	Sublette			Removed for property damage
8/20/2015	G209	Park	Fox Creek - Shoshone Forest	Park	Removed for obtaining garbage
8/21/2015	829	Park	Bailey Creek - Bridger-Teton Forest	Teton	Relocated for cattle depredations
8/24/2015	NA	Park			Removed for livestock depredation
8/29/2015	832	Sublette	Five Mile Creek - Shoshone Forest	Park	Relocated for cattle depredations
9/1/2015	833	Park	Fox Creek - Shoshone Forest	Park	Relocated for damaging apple trees
9/2/2015	834	Park	East Painter Gulch - Shoshone Forest	Park	Non-target capture, relocated
9/3/2015	835	Park	Squirrel Meadows - Bridger-Teton Forest	Teton	Relocated for damaging apple trees
9/3/2015	G210	Park	Squirrel Meadows - Bridger-Teton Forest	Teton	Relocated for damaging apple trees
9/3/2015	G211	Park	Squirrel Meadows - Bridger-Teton Forest	Teton	Relocated for damaging apple trees
9/6/2015	836	Sublette	Five Mile Creek - Shoshone Forest	Park	Relocated for cattle depredations
9/8/2015	827	Fremont	Mormon Creek - Bridger-Teton Forest	Park	Relocated for pig depredations
9/9/2015	837	Park	Mormon Creek - Bridger-Teton Forest	Park	Relocated pre-emptively from developed site
9/10/2015	439	Sublette	Antelope Butte - Shoshone Forest	Park	Relocated for cattle depredation
9/10/2015	G212	Sublette	Antelope Butte - Shoshone Forest	Park	Relocated for cattle depredations
9/11/2015	NA	Sublette			Captured for cattle depredation, accidental mortality
9/11/2015	798	Teton	Five Mile Creek - Shoshone Forest	Park	Relocated for damaging apple trees
9/13/2015	839	Park	Moccasin Basin - Shoshone Forest	Fremont	Relocated for killing chickens and ducks
9/16/2015	747	Fremont	Five Mile Creek - Shoshone Forest	Park	Relocated for cattle depredations
9/19/2015	832	Sublette			Relocated for cattle depredations
9/21/2015	773	Park	Squirrel Meadows - Bridger-Teton Forest	Teton	Relocated for obtaining garbage
9/23/2015	837	Park			Removed for chronic habituation

Table 35. Continued.

Date	ID	Capture county	Relocation site	Release county	Reason for capture
9/25/2015	787	Sublette			Relocated for cattle depredations
9/25/2015	840	Sublette	Fox Creek - Shoshone Forest	Park	Relocated for cattle depredations
9/26/2015	841	Sublette	Fox Creek - Shoshone Forest	Park	Relocated for cattle depredation
10/6/2015	NA	Park			Removed for chronic habituation
10/17/2015	827	Park			Removed for chronic habituation
10/22/2015	820	Park			Removed for repeated property damage
10/28/2015	743	Park	Squaw Basin - Bridger-Teton Forest	Teton	Relocated from Cody landfill
10/30/2015	G213	Park	Squaw Basin - Bridger-Teton Forest	Teton	Relocated from Cody landfill
10/30/2015	G214	Park	Squaw Basin - Bridger-Teton Forest	Teton	Relocated from Cody landfill

Department personnel investigated and recorded 325 human-grizzly bear conflicts in 2015 (Table 36, Figure 42). As a result of numerous and diligent education and conflict prevention efforts, the general pattern of conflicts is relatively steady within currently occupied habitat (Figure 41). However, as occupied grizzly bear range has expanded, conflicts continue to occur in areas further from the Recovery Zone/Primary Conservation Area and outside the Demographic Monitoring Area, often on private lands. Bears are increasingly coming into conflict with people in areas where grizzly bears have not been present in recent history. Although the joint efforts of the WGFD, U.S. Forest Service, non-governmental organizations, and particularly the public have resulted in reducing conflicts through education and attractant storage in many areas, numbers of grizzly bear conflicts in Wyoming were very high this year. Bears frequented lower elevations and developed areas regularly throughout the active season. Grizzly bear cattle depredation was the most frequent type of conflict documented in 2015. The annual variation in livestock depredation incidents is not easily explained. Although most human-bear conflicts are correlated with natural food abundance, the number of cattle and sheep killed annually do not follow the same pattern. The WGFD continues to explore options to reduce grizzly bear-livestock conflicts.

The majority of conflicts in Wyoming occurred on private lands outside of the Recovery Zone/Primary Conservation Area (Figures 42 and 43). The increasing distribution of grizzly bears is reflected in the annual documentation of conflicts further from the Recovery Zone/Primary Conservation Area and expansion outside the DMA. As bears expand and occupy habitats commonly used by humans, there is a greater potential for conflicts to occur. Education and conflict-prevention efforts are used anywhere bears and people coexist, and management actions will be a function of human values and grizzly bear population effects in those areas.

Conflict Type	Number	Percent (%)
Cattle	141	43.4
Garbage	87	26.8
Pet-Livestock-birdfeeders	37	11.4
Property damage	22	6.8
Sheep	11	3.4
Fruit trees	6	1.8
Unsecured attractants	5	1.5
Animal death	4	1.2
Aggression toward humans	4	1.2
Poultry	3	0.9
Animal injury	2	0.6
Swine	1	0.3
Beehive	1	0.3
Human injury	1	0.3
Total	325	100.0

Table 36. Type and number of human-grizzly bear conflicts in Wyoming, 2015.

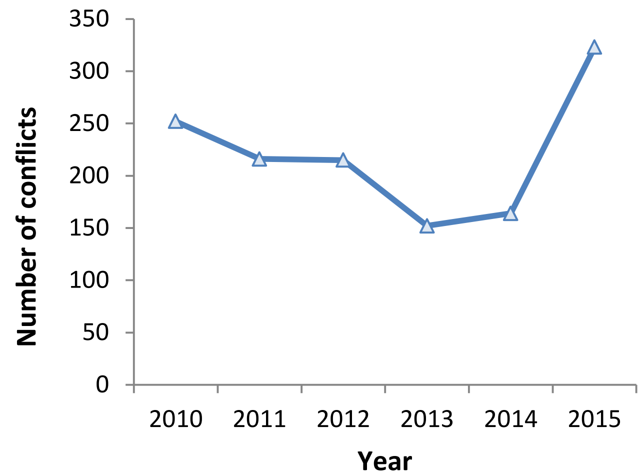


Figure 41. Number of human-grizzly bear conflicts in Wyoming, 2010─2015

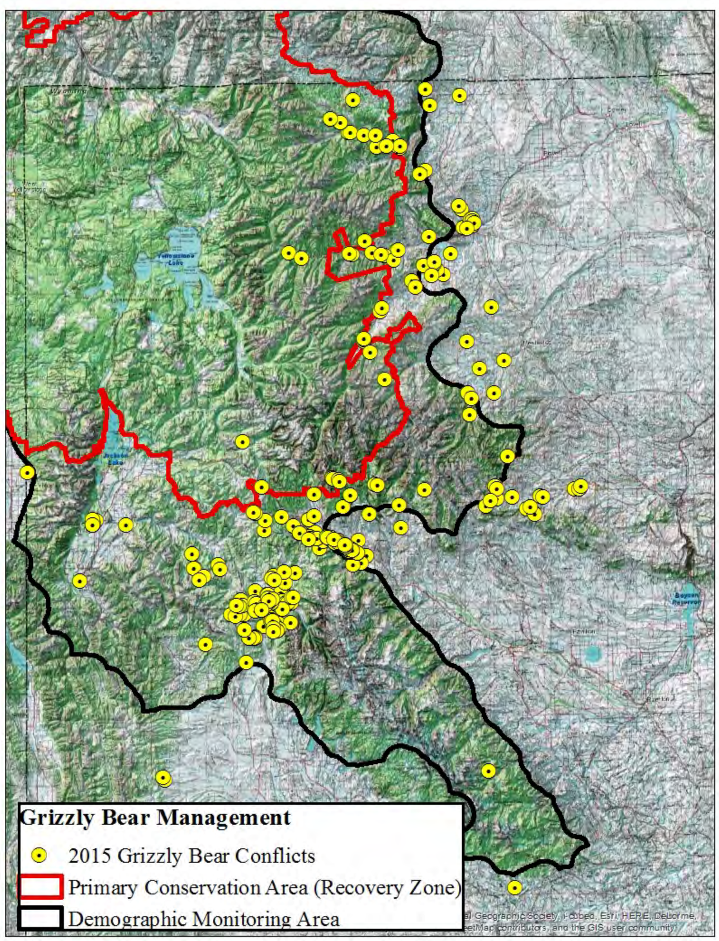


Figure 42. Location of human-grizzly bear conflicts in Wyoming outside of National Parks (*n* = 325) in relation to the Recovery Zone/Primary Conservation Area and the Demographic Monitoring Area, Wyoming, 2015.

Within Wyoming, outside of the National Parks and Wind River Reservation, there were 33 known or probable human-caused mortalities in 2015. Management removals accounted for 16 mortalities in 2015. Of the 16 grizzly bears removed in management actions, 7 were removed due to livestock depredations and 9 due to property damage or human food rewards and exhibiting unnaturally bold behavior in close proximity to humans. In addition to the 16 management removals, 1 died of unknown causes, 1 died after capture, 5 died of natural causes, and 10 mortalities are under investigation by law enforcement.

Most human-grizzly bear conflicts in Wyoming were a result of domestic livestock depredations and food rewards from humans in the form of garbage or pet and livestock feed. Long-term trends in the number of conflicts is likely a result of grizzly bears increasing in numbers and distribution and expanding into areas used by humans, including livestock production, on public and private lands. As the GYE grizzly bear population continues to grow and expand in distribution, bears encounter food sources such as livestock and livestock feed, garbage, and pet food resulting in increased property damage and threats to human safety. Conflict prevention measures such as attractant storage, deterrence, and education are the highest priority for the WGFD. In general, there is an inverse relationship between social tolerance and biological suitability for bear occupancy in areas further from the Recovery Zone due to development, land use patterns, and various forms of recreation. Although prevention is the preferred option to reduce conflicts, each situation is managed on a case-by-case basis with education, securing of attractants, relocation or removal of individual bears, or a combination of methods used for long-term conflict resolution.

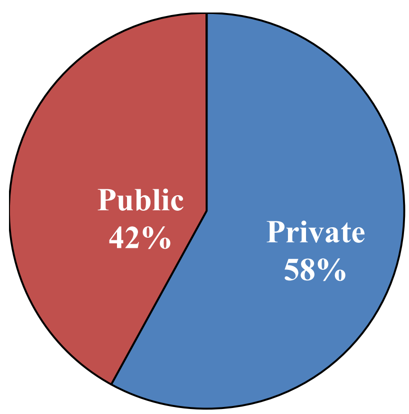


Figure 43. Percent of human-grizzly bear conflicts on private and public lands in Wyoming, 2015.

Human-Grizzly Bear Conflicts on the Wind River Reservation (*Pat Hnilicka, Lander Fish and Wildlife Conservation Office, U.S. Fish and Wildlife Service; and Ben Snyder, Eastern Shoshone and Northern Arapaho Tribal Fish and Game Department*)

No depredations of livestock were reported or documented on Wind River in 2015. No grizzly bears were removed or transported to or from Wind River in 2015 for any purpose, including human conflicts.

In 2015, confirmed observations of grizzly bears continued well beyond the boundary of occupied range. The farthest southeast of these locations, near South Pass at the terminus of the Wind River Range in Wyoming, are closer to the town of Boulder, Colorado than they are to the most northwesterly confirmed grizzly bear location on the opposite side of the Greater Yellowstone Ecosystem (photo IGBST/Frank T. van Manen).

Human-Grizzly Bear Interactions in Yellowstone National Park *(Kerry A. Gunther and Travis Wyman, Yellowstone National Park)*

In an effort to make scientifically based decisions regarding the bear safety recommendations provided to park visitors, Yellowstone National Park managers are interested in the relative risk of grizzly bear attack on the public recreating in the park. To address this need, we recorded information on human-bear interactions occurring in the park. Because the risk of bear attack varies depending on visitor location and activity, we grouped human-bear interactions into 5 broad categories including: 1) front-country developments, 2) road-side corridors, 3) backcountry campsites, 4) backcountry trails, and, 5) off-trail backcountry areas. We considered all encounters where the person believed the grizzly bear was aware of the person's presence as an interaction.

Bear-Human Interactions within Developed Front-country Sites

Bears enter front-country developments in the park for a variety of reasons including travel, foraging for natural foods, avoiding more dominant bears, and seeking human foods or garbage. However, since implementation of a new bear management program in 1970, it is rare for bears to obtain food rewards in park developments. Under the park's Bear Management Plan, front-country developments are managed for people and bears are actively excluded through hazing, capture and relocation, or capture and removal.

Activity of Bears in Front-country Developed Sites

In 2015, there were 33 incidents reported where grizzly bears were known to enter park developments (Table 37). The activity of the bear was reported in all 33 incidents. In 55% (n = 18) of the incidents bears foraged for natural foods within the developments and in 42% (n = 14) it appeared that the bear was just traveling through the development. In 3% (n = 1) of the incidents, bears investigated sources of anthropogenic attractants (human food or garbage). The bear did not damage property or obtain a food reward in this incident.

Reactions of Bears to the Presence of People in Front-country Developments

Grizzly bears were known to have encountered people in 24 of the 33 reported incidents where they entered front-country developments (Table 38). The bears' reaction to the presence of people was reported in all 24 encounters. Bears reacted with a flight response in 58% (n = 14) and in a neutral manner in 42% (n = 10) of the incidents. Bears did not attack or display aggressive behavior in any of the 24 encounters that occurred within developments.

Bear-Human Interactions along Roads

Bears frequent habitat adjacent to roads in the park for traveling, foraging for natural foods, avoiding more dominant bears, seeking human food handouts, and other reasons. In the past (1910–1969) bears commonly panhandled along park roads for food handouts from park visitors (Schullery 1992). Strict enforcement of regulations prohibiting the hand feeding of bears since 1970 has mostly eliminated this behavior in park bears. However, bears are still regularly observed near park roads traveling and foraging for native foods. Unlike park developments that are managed solely for people and bears are actively excluded, under the park's Bear Management Plan, roadside habitats are managed for both human and bear uses. Although bears are not allowed to remain or linger on the paved road, roadside pull-outs, road shoulder, or adjacent drainage ditch, they are tolerated in roadside meadows and are not actively discouraged from using roadside habitats to forage for natural foods.

Bear Activity along Roadsides

In 2015, 279 reports of grizzly bears along park roads were recorded (Table 39). The primary activity of roadside bears was recorded in 277 of these 279 reports. In the majority of these incidents, the roadside bears' primary activity was foraging for natural foods (84%, n = 235). Other activities reported included traveling (12%, n = 34), mating (2%, n = 5), swimming (<1%, n = 2), and sleeping (<1%, n = 1).

Bear Reactions to the Presence of People Along Roadsides

Bears were noticeably aware of the presence of people in 188 of the 279 reports of bear activity along roads. The reaction of bears to people was reported for 184 of these 188 roadside encounters (Table 38) and were classified as neutral in 72% (n = 133), flight response in 26% (n = 47), and as curious in 2% (n = 3) of the incidents. Bears displayed aggressive behavior in <1% (n = 1) of the roadside encounters. There were no people attacked by grizzly bears along roadsides within Yellowstone National Park in 2015.

Bear-Human Interactions in Backcountry Areas

Bears are generally given priority in recreation management decisions where bear and human activities are not compatible in backcountry areas of the park. Yellowstone National Park implements seasonal closures and restrictions on recreational use of backcountry areas during periods when bear activity is concentrated on specific foods in predictable locations. In addition, short-term closures of backcountry trails, campsites, and off-trail areas to recreational use are implemented when human activities conflict with natural bear activities and behaviors.

Activity of Bears in Occupied Backcountry Campsites

Bears occasionally enter designated backcountry campsites while the campsites are occupied by recreational users. In 2015, there were 4 incidents reported where grizzly bears entered occupied backcountry campsites (Table 40). The primary bear activity was reported for 2 of the 4 incidents and included foraging on native foods (n = 1) and walking past the edge of the campsite (n = 1).

Bears Reactions to the Presence of People in Backcountry Campsites

In 3 of the 4 incidents where grizzly bears entered occupied backcountry campsites, the campers believed that the bear knew people were present in the campsite. The bears fled from the presence of people in all 3 of these incidents (Table 38). There were no people attacked by grizzly bears in backcountry campsites in Yellowstone National Park in 2015.

Bears Reactions to Encounters with People on Backcountry Trails

In 2015, there were 31 incidents where people encountered grizzly bears on backcountry trails where the bear was aware of the human presence (Table 38). Reactions of bears to the encounters were reported for all 31 of these incidents. Grizzly bears reacted to encounters with people along backcountry trails with flight behaviors in 52% (n = 16), neutral behaviors in 13% (n = 4), curious behaviors in 13% (n = 4) of the incidents, and stress behaviors in 3% (n = 1) of the encounters. Grizzly bears reacted aggressively (bluff charge) without making contact in 19% (n = 6) of the encounters. No people were attacked by grizzly bears on backcountry trails in the park in 2015.

Bear Reactions to Encounters with People in Off-Trail Backcountry Areas

In 2015, there were 15 incidents where people encountered grizzly bears where the bear was aware the people were present, while traveling off-trail in backcountry areas (Table 38). The reaction of bears to the encounters were reported in 14 of the incidents and included fleeing (71%; n = 10), neutral behavior (7%; n = 1), aggression without contact (14%, n = 2), and attack (7%, n = 1). The attack involved a lone hiker that was killed and partially consumed by a grizzly bear while traveling off-trail on Elephant Back Mountain.

Summary

Grizzly bears instill fear in many Yellowstone National Park visitors and when they attack people in the park, it generates world-wide news further spreading their ferocious reputation. However, grizzly bears rarely reacted aggressively toward people during encounters in Yellowstone National Park in 2015 (Table 41). Results in 2015 are similar to overall results from the entire period bear-human interactions have been monitored in the park (1991–2015, Table 42). In the 5,578 encounters between grizzly bears and people where the bears reaction was reported, bears reacted with neutral behaviors in 57% (n = 3,192), by fleeing in

35% (n = 1,929), curious behaviors in 3% (n = 191), and with stress, bluster, or warning behaviors in 1% (n = 32) of the incidents. Grizzly bears reacted with aggression without contact in 4% (n = 213) of the encounters. Less than 1% (n = 21) of the 5,578 reported encounters between people and grizzly bears in Yellowstone National Park from 1991–2015 resulted in an attack. The frequency of attack was greatest during backcountry off-trail interactions (7 attacks in 381 reported encounters) and on-trail interactions (14 attacks in 1,340 encounters). Bear attacks were less frequent in areas where human presence was consistent and predictable, such as along primary roads (0 attacks in 3,094 encounters), within developments (0 attacks in 581 encounters), and in designated backcountry campsites (0 attacks in 182 encounters).

Table 37. Activity of bears that entered front-country developments in Yellowstone National Park, 2015.

Bears activity while inside development	Number of incidents
Not reported or unknown	0
Travel through	14
Forage natural foods	18
Investigate anthropogenic foods but no food reward and no property damage	1
Investigate and damage property but no food reward	0
Investigate and obtain anthropogenic foods	0
Attack people	0
Other	0
Total	33

Table 38. Reactions of grizzly bears to encounters with people within front-country developments, along roadsides, in backcountry campsites, on trails, and in off-trail areas in Yellowstone National Park, 2015.

Reaction of bear	Development	Along roadside	Backcountry campsite	On trail	Off trail	Total
Not reported/not known	0	4	0	0	1	5
Flight response						
Run away	6	5	0	9	3	23
Walk away	8	42	0	7	7	64
Adult climb tree	0	0	0	0	0	0
Cubs climb tree/adult remain	0	0	0	0	0	0
Flight behavior subtotal	14	47	0	16	10	87
Neutral behaviors						
No overt reaction	10	133	3	4	1	151
Stand up on hind legs	0	0	0	0	0	0
Circle down wind	0	0	0	0	0	0
Neutral behavior subtotal	10	133	3	4	1	151
Curious behaviors						
Walk towards stationary person	0	3	0	4	0	7
Follow mobile person	0	0	0	0	0	0
Investigate vehicle	0	0	0	0	0	0
Curious behavior subtotal	0	3	0	4	0	7
Stress/agitation/warning signals						
Salivate	0	0	0	0	0	0
Sway head side to side	0	0	0	0	0	0
Make huffing noises	0	0	0	0	0	0
Pop jaws/teeth clacking noises	0	0	0	0	0	0
Stood ground watched/stared	0	0	0	0	0	0
Slap ground with paw	0	0	0	1	0	1
Flatten ears/erect spinal hairs	0	0	0	0	0	0
Stiff legged walk/hop	0	0	0	0	0	0
Stress/warning behavior subtotal	0	0	0	1	0	1
Aggressive behaviors						
Growl	0	0	0	0	0	0
Stalk	0	0	0	0	0	0
Run towards/aggressive charge	0	1	0	6	2	9
Aggressive behavior subtotal	0	1	0	6	2	9
Attack behaviors						
Defensive attack	0	0	0	0	0	0
Predatory attack	0	0	0	0	0	0
Attack unknown cause	0	0	0	0	1	1
Attack behavior subtotal	0	0	0	0	1	1
Total	24	188	3	31	15	261

Table 39. Primary activity of grizzly bears along roadsides in Yellowstone National Park, 2015.	
Activity of bear while inside development	Number of incidents
Not reported/unknown	2
Traveling	34
Foraging natural foods	235
Mating	5
Swimming	1
Sleeping	2
Investigating vehicles/seeking anthropogenic foods – no food reward	0
Obtain anthropogenic foods	0
Damage property	0
Attack people	0
Other	0
Total	279

Table 40. Primary activity of grizzly bears that entered occupied backcountry campsites in Yellowstone National Park, 2015.	
Activity of bear	Number of incidents
Not reported/not known	2
Walked past edge of campsite	1
Walked through core camp	0
Forage native foods	1
Investigate tent without damage	0
Investigate food pole	0
Investigate fire ring	0
Attempt to get human foods	0
(not successful)	
Damage property	0
Obtain anthropogenic foods	0
Investigate latrine (buried human feces/toilet paper)	0
Lay down/rest in campsite	0
Aggressive approach/posture towards people in campsite	0
Total	4

Table 41. Grizzly bears reactions to 256 interactions with people that occurred in developments, roadside corridors, backcountry campsites, backcountry trails, and off-trail backcountry areas in Yellowstone National Park, 2015.

	Reaction of bear											
	Flee		Neutral behavior		Curious		Stress/agitation		Aggression without contact		Attack	
Location of encounter	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Park development	14	58	10	42	0	0	0	0	0	0	0	0
Roadside corridor	47	26	133	72	3	2	0	0	1	<1	0	0
Backcountry campsite	0	0	3	100	0	0	0	0	0	0	0	0
Backcountry trail	16	52	4	13	4	13	1	3	6	19	0	0
Backcountry off-trail	10	71	1	7	0	0	0	0	2	14	1	7
Total	87	34	151	59	7	3	1	<1	9	4	1	<1

Table 42. Grizzly bears reactions to people in 5,578 interactions that occurred in developments, roadside corridors, backcountry campsites, backcountry trails, and off-trail backcountry areas in Yellowstone National Park, 1991-2015.

	Reaction of bear											
	Flee		Neutral behavior		Curious		Stress/agitation		Aggression without contact		Attack	
Location of encounter	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Park development	280	48	275	47	16	3	2	<1	8	1	0	0
Roadside corridor	685	22	2,297	74	47	2	9	<1	56	2	0	0
Backcountry campsite	78	43	83	46	15	8	1	1	5	3	0	0
Backcountry trail	675	50	412	31	101	8	19	1	119	9	14	1
Backcountry off-trail	211	55	125	33	12	3	1	<1	25	7	7	2
Total	1,929	35	3,192	57	191	3	32	1	213	4	21	<1

Visitor Compliance with Bear Spray and Hiking Group Size Bear Safety Recommendations in Yellowstone National Park *(Kerry A. Gunther and Eric Reinertson, Yellowstone National Park)*

Large party sizes have been shown to reduce the risk of bear attack (Herrero 2002). In addition, bear spray has proven to be effective at stopping aggressive bear behavior during surprise encounters when the person involved has time to deploy it (Herrero and Higgins 1998, Smith et al. 2008). To reduce the risks of bear attack in Yellowstone National Park, safety information distributed to visitors recommends that backcountry recreationists traveling by foot maintain group sizes of at least 3 people and carry bear spray. To evaluate visitor compliance with these safety recommendations, we conduct annual surveys to determine the proportion of recreationists that hike in groups of 3 or more people and the proportion that carry bear spray or other deterrents, such as bear bells and firearms. Although it is legal to carry firearms inside Yellowstone National Park, it is illegal to discharge them within the park, so they are not considered a legal bear deterrent.

Due to time, budget, and staffing constraints, we conducted surveys of convenience. While working on other bear research, monitoring, and management projects throughout the park, we recorded how many recreationists that we encountered at trailheads and on trails and boardwalks were carrying bear spray or other deterrents. We also recorded information on group size and type of recreational activity. We grouped recreational activity into 6 broad categories: 1) day hikers, 2) overnight backpackers, 3) boardwalk trail users, 4) stock (horse or mule) day-riders, 5) stock overnight-riders, and 6) day-use bicyclist trail riders. Our surveys were conducted visually. We recorded the presence of bear spray and other deterrents that were visible and therefore quickly retrievable. Bear spray or other deterrents stored in backpacks, saddle bags, paniers, or carried under coats would likely not be retrievable fast enough for use during surprise encounters with bears.

In 2015, we surveyed 3,284 people in 1,142 groups at 30 different backcountry trails and 4 boardwalk trails. Our surveys included 1,859 backcountry day hikers, 1,383 people walking on boardwalk trails, 32 overnight backpackers, 7 overnight stock riders, and 3 day-use bicyclists. No stock day-riders were encountered during surveys in 2015.

Day Hikers

Yellowstone National Park contains >1,000 miles of backcountry hiking trails accessible from 92 trailheads located throughout the park (Yellowstone National Park 2014). We surveyed 1,859 day hikers traveling in 622 groups on 27 different trails. Average party size was 3.0 people per group (Table 43). The most common group size (mode) and the median group size were 2 people per party. Fifty-eight percent of day hiking parties had less than the recommended party size of 3 people and 13% hiked alone. Of the 1,859 day hikers, 267 (14%) carried bear spray, 15 (1%) had bear bells, and 1 (<1%) carried a firearm (Table 44). Of the 622 groups of day hikers, 218 (35%) had at least 1 member that carried bear spray, 12 groups (2%) had at least 1 person wearing bear bells, and 1 group (<1%) had one person carrying a firearm.

Overnight Backpackers

Yellowstone National Park has 301 designated backcountry campsites (Yellowstone National Park 2014). We surveyed 32 backpackers in 11 groups on 7 different trails. Average party size was 3.0 people per party (Table 43). Although the median party size was also 3 people per party, the most common party size (mode) was 2 people. Forty-five percent (n = 5) of the backpacking groups had less than the recommended party size of 3 people and 9% (n = 1) hiked alone. Of the 32 backpackers, 16 (50%) carried bear spray and 1 (3%) carried a firearm (Table 44). None of the backpackers surveyed in 2015 had bear bells. All 11 of the backpacking groups (100%) had at least 1 person in the party that carried bear spray. One person in one group (9%) carried a firearm.

Stock Day-Riders

No stock day-riders were encountered while conducting surveys in 2015.

Stock Overnight-Riders

We surveyed 7 people in 1 group that were riding stock and camping overnight on the South Boundary Trail. Of the 7 overnight stock riders, 1

(14%) carried bear spray (Table 44). None of the overnight stock riders carried bear bells or openly carried firearms.

Day Use Bicycle Trail Riders

Yellowstone National Park contains 13 designated bike trails. One of the 13 trails has access to a designated backcountry campsite. We surveyed 3 people in 2 groups riding bicycles on day trips on the Natural Bridge designated bike trail. Of the 3 bicyclists, none carried bear spray, bear bells, or firearms.

Boardwalk Trails

Yellowstone National Park contains approximately 15 miles of boardwalk trails (Yellowstone National Park 2014). Boardwalk trails are short trails found near park roads that contain interpretive signs providing visitors with information about geysers or other natural features. Boardwalks are constructed to provide a stable walking surface with gentle grades or steps to get up and down hills, allowing use by visitors of a wide-range of ages, physical abilities, and backcountry hiking experience. Stock animals and overnight camping are not allowed on boardwalk trails. We surveyed 1,383 people in 506 groups on 4 different boardwalk trails (Mammoth Terrace, Norris Geyser Basin, Old Faithful, and Children's Fire Exhibit trails) in 2015. Average party size was 2.9 people per group (Table 43). The most common group size (mode) and the median group size were both 2. Fifty-seven percent of boardwalk users had less than the recommended party size of 3 people and 18% hiked alone. Approximately 1% ($n = 9$) of the individuals surveyed carried bear spray (Table 44). Two percent of the groups ($n = 9$) surveyed had at least one person in the party that carried bear spray. No individuals observed on boardwalk trails had bear bells; 1 person carried a firearm.

Discussion

In 2015, overnight backpackers had the highest level of compliance with the park's bear spray recommendation; 50% of backpackers carried bear spray. Overnight backpackers have had the highest proportion of individuals that carried bear spray in 4 of the 5 years surveys have been conducted (Table 45) We suspect the high level of compliance by this type of recreationist is due to the methods used to convey bear safety information to overnight backpackers. In Yellowstone National Park, permits are required for camping in the backcountry. During the permit process, backpackers are given face-to-face verbal information about bears and bear spray from the ranger issuing the permit and are also required to watch a safety video containing information on hiking and camping in bear country and how to use bear spray. Backpackers are also given the "Beyond Roads End" safety booklet containing information on bear spray and hiking and camping in bear country. Social surveys indicate that Yellowstone National Park visitors retain verbal information from uniformed park staff better than written information from signs or brochures (Taylor et al. 2014). In addition, we speculate that many backpackers may have a high level of experience in bear country. The most common party size observed (mode) among backpackers was 2 people per party, indicating that many backpackers did not follow the park's recommended group size of 3 people for hiking in bear country. The most common party size (mode) for overnight backpackers has been 2 people per party each year surveys were conducted (Table 46).

Only 14% of day hikers carried bear spray. Less than 20% of day hikers carried bear spray in each of the 5 years surveys have been conducted (Table 45). Permits are not required for day hiking so day hikers may not receive the same level of bear safety information as backpackers, such as the verbal safety information from a park ranger. Visitors day hiking in Yellowstone National Park can seek and obtain bear safety information from the Yellowstone National Park web page, park newspaper, day hike trip planners, safety cards and brochures, and from rangers at visitor centers. However, the only bear safety information day hikers are exposed to if they do not seek it out themselves is from signs posted at trailheads. We also suspect that many day hikers in Yellowstone National Park may have a lower level of experience in bear country than many backpackers have. The most frequently observed group size (mode) among day hikers was 2 people per group indicating that many day hikers did not comply with the recommended group size of 3 for hiking in bear country. Since most grizzly bear attacks in Yellowstone National Park involve day hikers (26 of 40 backcountry attacks since 1970), getting more day hikers to carry bear spray is a priority for park managers.

In 2015, the most common group size encountered on boardwalk trails was 2 people per party and <1% of boardwalk hikers carried bear spray. Recreationists on boardwalk trails have had very low compliance with bear safety recommendations each year surveys were conducted (Tables 45 and 46). However, only 2 grizzly bear attacks have occurred on or near boardwalk trails in the last 46 years, therefore the risk is very low.

Overnight stock riders had a high average group size (7 people per party), however, only 14% carried bear spray in 2015. Although bear spray may not be very useful while in the saddle, as deploying it from horseback may result in the rider being thrown from their horse, it is useful and encouraged for carry by stock groups during rest stops along the trail and while in camp. In general, people riding stock are less likely to be involved in surprise encounters and bear attacks. Horses usually sense a bear's presence before a person does (Herrero 2002), alerting the rider and reducing the chances of surprise encounters at close distances. The large size of horses is also more intimidating to bears. In addition, unlike humans, when charged by bears horses have enough speed and agility to outrun bears providing an added margin of safety as long as the rider can stay in the saddle.

In 2015, none of the bicycle groups we observed on designated bike trails carried bear spray. Bicyclists incur greater risk of surprise encounters because bicycles are fast and relatively quiet.

Although some backcountry recreationists in Yellowstone National Park carry firearms, and it is legal to do so, it is illegal to discharge them within the park, so they are not considered a legal bear deterrent. Firearms were openly carried by <1% of the recreationists we observed in 2015. Backpackers (3%) had the highest frequency of firearms carry. Firearms have been openly carried by only a small proportion of all types of recreationists all 5 years of the survey. Recreationists riding horses often carry firearms for euthanizing injured stock, however if these firearms were carried in saddle bags or panniers they would not have been visible during our surveys and would not have been readily available as a bear deterrent during surprise encounters.

Bear bells were used by <1% of all recreationists in Yellowstone National Park in 2015. Day hikers (1%) had the highest frequency of bear bell use. Although bear bells may provide some benefit in alerting bears to the presence of approaching hikers (Jope 1982), they are generally not considered effective at preventing surprise encounters when hiking in strong winds, near rushing water, or in dense forest (Herrero 2002).

Table 43. Number of people and groups surveyed, and mean, median, and mode group size for different types of recreationalists surveyed in Yellowstone National Park, 2015.

Type of recreational activity	Total people	Total groups	Average group size	Median group size	Mode group size
Boardwalk trail (foot travel walking)	1,383	506	2.7	2	2
Day hiker (day use foot travel-hiker, angler, photographer, etc.)	1,859	622	3	2	2
Overnight backpacker (foot travel camping overnight)	32	11	2.9	3	2
Stock - day use	0	0			
Stock – overnight use	7	1	7	7	7
Day bicycle trip	3	2	1.5	1.5	1 and 2
Totals	3,284	1,142	2.9	2	2

Table 44. Number and percent (%) of people and groups of different types of recreationalists surveyed that carried bear spray, firearms, or bear bells in Yellowstone National Park, 2015.

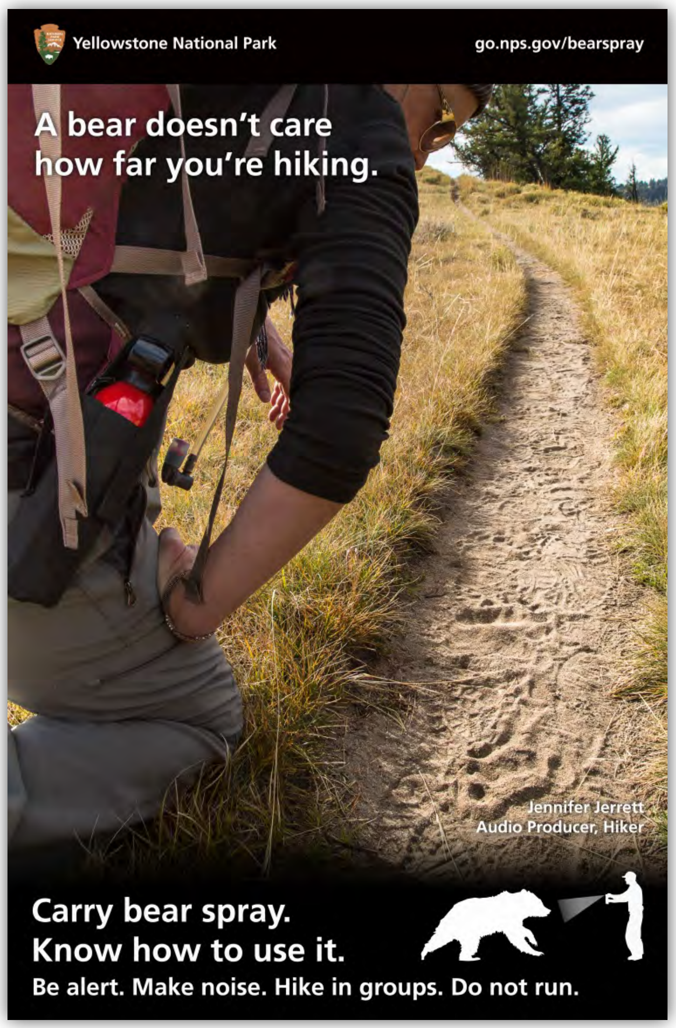
	Type of recreation/mode of travel						
	Boardwalk trail	Day hiker	Day use bicycle	Overnight backpacker	Stock - day use	Stock - overnight use	Totals (all types)
Total people surveyed (# parties)	1,383 (506)	1,859 (622)	3 (2)	32 (11)	0	7 (1)	3,284 (1,142)
Total people with bear spray	9	267	0	16		1	293
Percent of people with bear spray	0.7	14.4	0	50.0		14.3	8.9
Number of parties with bear spray	9	218	0	11		1	239
Percent of parties with bear spray	1.8	35.0	0	100.0		100.0	20.9
Total people with firearms	1	1	0	1		0	3
Percent of people with firearms	0.1	0.1	0	3.1		0	0.1
Number of parties with firearms	1	1	0	1		0	3
Percent of parties with firearms	0.2	0.2	0	9.1		0	0.3
Number of people with bear bells	0	15	0	0		0	15
Percent of people with bear bells	0	0.8	0	0		0	0.5
Number of parties with bear bells	0	12	0	0		0	12
Percent of parties with bear bells	0	1.9	0	0		0	1.2

Table 45. Percent (%) of different types of backcountry recreationalists that carried bear spray in Yellowstone National Park, 2011–2015.

Year	Overnight backpackers	Day hiker	Boardwalk	Stock day-use	Stock-overnight use	Day-use bicycle
2011	53	15	Not surveyed	0	60	Not surveyed
2012	47	11	0	9	44	0
2013	60	16	0	11	22	0
2014	48	13	<1	0	35	33
2015	50	14	<1	Not surveyed	14	0
2011–2015	52	14	<1	7	35	12

Table 46. Number people and groups surveyed, and mean, median, and mode group size for different types of recreationalists surveyed in Yellowstone National Park, 2011–2015.

Type of recreational activity	Total people	Total groups	Average group size	Median group size	Mode group size
Boardwalk	3,238	1,200	2.7	2	2
Day hiker (day foot travel- hiker, angler, photographer, etc.)	7,770	2,669	2.9	2	2
Overnight backpacker (overnight-foot travel)	387	143	2.7	2	2
Horse – day use	59	8	7.4	8	3 and 9
Horse – overnight use	77	15	5.1	5	2,5, and 6
Day bicycle trip	34	15	2.3	2	2
Totals	11,565	4,050	2.9	2	2



Yellowstone National Park embarked on a new campaign called "a bear doesn't care" to increase the number of people carrying bear spray (image courtesy of National Park Service)

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Appendix A

2015 Grizzly Bear Annual Habitat Monitoring Report

Greater Yellowstone Area Grizzly Bear Habitat Modeling Team

April 2016

Background

This report is the collective response from the National Forests and National Parks within the Greater Yellowstone Ecosystem (GYE) to obligations for grizzly bear habitat monitoring and reporting established in the *Final Conservation Strategy for the Grizzly Bear in the Greater Yellowstone Area* (U.S. Fish and Wildlife Service [USFWS] 2007). The Conservation Strategy requires annual reporting to evaluate federal adherence of habitat standards for the Yellowstone grizzly bear population. Habitat standards and monitoring requirements identified in the Conservation Strategy went into effect in 2007 when federal protections under the Endangered Species Act (ESA) were removed for the Yellowstone population. However, the 2007 rule was challenged and overturned in a Montana District Court in 2009. The 2009 ruling was upheld by the 9th Circuit Court of Appeals in 2011, which vacated the 2007 rule and returned the grizzly bear population in the GYE to threatened status under the ESA. Issues raised by the courts were addressed when the Interagency Grizzly Bear Study Team (IGBST) conducted analyses to evaluate responses of Yellowstone grizzly bears to changing conditions of food resources (IGBST 2013; Bjornlie et al. 2014; Costello et al. 2014, 2016; Gunther et al. 2014; Schwartz et al. 2014*a*, *b*; Ebinger et al. 2016; van Manen et al. 2016). The findings of those analyses indicated that the Yellowstone grizzly bear population so far has shown notable resilience in the face of decline of whitebark pine and natural stochasticity of other food resources. In 2016, the USFWS concluded that the GYE population of grizzly bears has recovered and no longer meets the definition of a Threatened population under the ESA. A Proposed Rule to remove the Yellowstone grizzly bear population from the Federal List of Endangered and Threatened Wildlife was published in the Federal Register on March 11, 2016 and has been released for public review (Federal Register 2016). Regardless of the legal status of the Yellowstone grizzly bear, land managers associated with the 5 National Forests and 2 National Parks in the GYE are committed to abiding by habitat standards identified in the Conservation Strategy for the long-term protection and well-being of the grizzly bear population.

Introduction

The intent of habitat standards established in the Conservation Strategy is to preserve adequate secure habitat for grizzly bears and reduce negative impacts of human presence in occupied habitat throughout the core area of the GYE. Three distinct habitat standards were enumerated in the Conservation Strategy pertaining to motorized access, human development, and commercial livestock grazing; all three of which are known to contribute to grizzly bear mortality and displacement in occupied areas across the landscape. The three habitat standards specifically call for no net decrease in secure habitat (a metric for the absence of motorized access), and no net increase in the number of human developed sites and grazing allotments from that which existed in 1998. This 1998 baseline is predicated on evidence that habitat conditions at that time, and for the preceding decade, contributed to the 4 to 7% population growth of the Yellowstone grizzly bear population observed between 1983 and 2001. Habitat standards apply only within the Grizzly Bear Recovery Zone (GBRZ)[1], which is located at the core of the GYE (Figure A1).

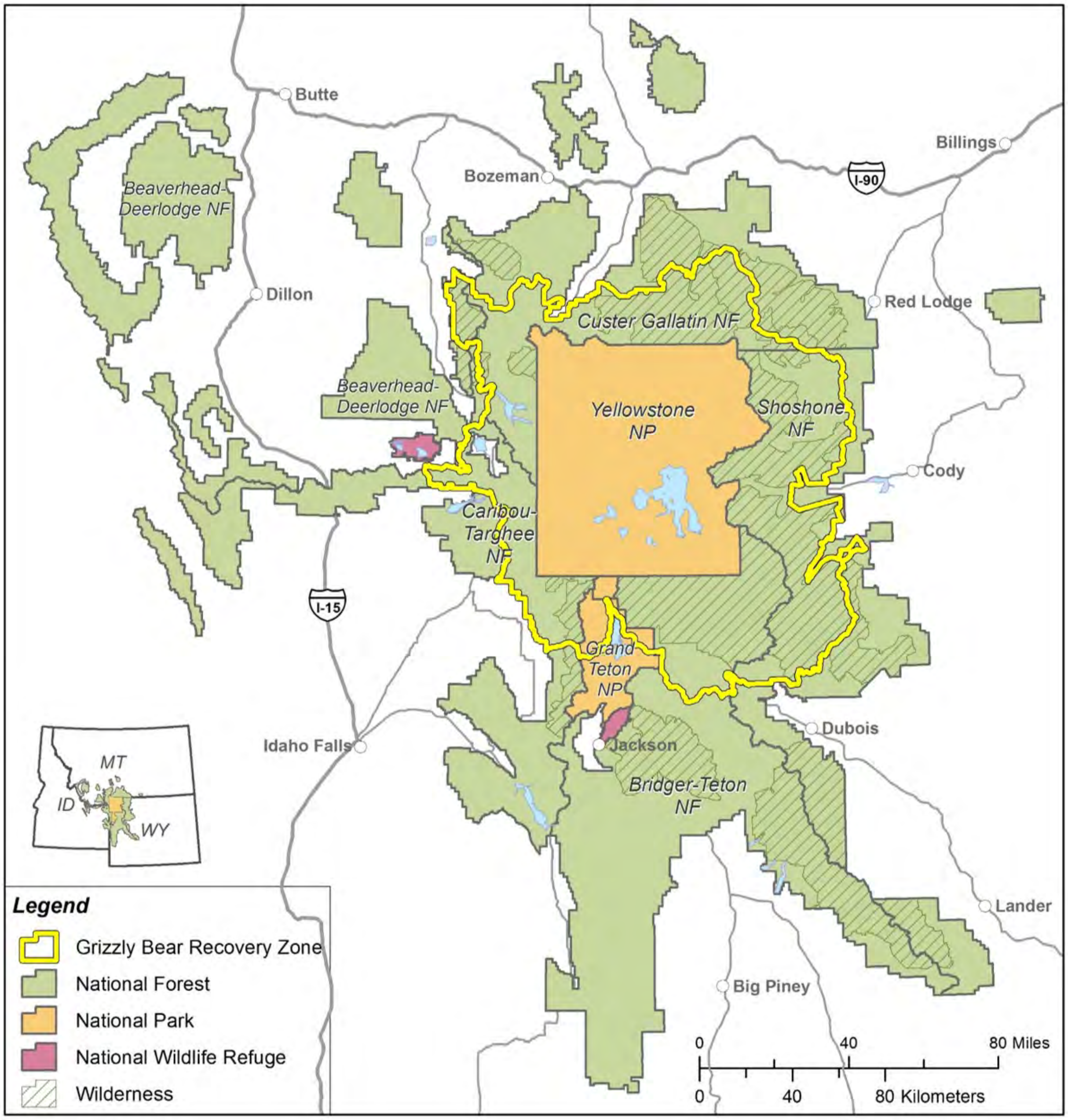

Figure A1. *Federal lands comprising the Greater Yellowstone Ecosystem (GYE) and the Grizzly Bear Recovery Zone (GBRZ).*

Annual Monitoring Requirements (inside the GBRZ)

To comply with annual habitat monitoring requirements, this report summarizes habitat changes incurred inside the GBRZ during the past year and compares current status with that of 1998 for the following monitored parameters: 1) number and acreage of commercial livestock grazing allotments and permitted domestic sheep animal months, 2) number of developed sites, 3) motorized access route densities, and 4) percentage of secure habitat. In addition, all incidental and recurring grizzly bear conflicts associated with livestock allotments

[1] The Grizzly Bear Recovery Zone (GBRZ) is a term used when the Yellowstone grizzly bear is under federal protection. The same area is referred to as the Primary Conservation Area when the bear is removed from federal protection. The GBRZ term is used in this 2014 report to reflect the current legal status of the Yellowstone grizzly bear as a threatened population.

occurring on public land are summarized annually for the ecosystem, both inside and outside the GBRZ. Current status of these four habitat monitoring parameters, except for livestock allotments, are evaluated, summarized, and reported annually for each of the 40 subunits within the 18 Bear Management Units (BMU; Figure A2) and are compared against 1998 levels. The number and status of livestock allotments is reported annually for each National Forest and Park unit (the establishing legislation allowed for grazing in Grand Teton National Park). The 1998 habitat baseline measurements represent the most current and accurate information available documenting habitat conditions inside the GBRZ during 1998. Forest and Park personnel continue to improve the quality of their information to more accurately reflect what was on the landscape in 1998.

Additional habitat monitoring for spring ungulate availability, spawning cutthroat trout, insect aggregation sites, and whitebark pine cone production are reported in the section titled *Monitoring of Grizzly Bear Foods* found in the main body of this annual report.

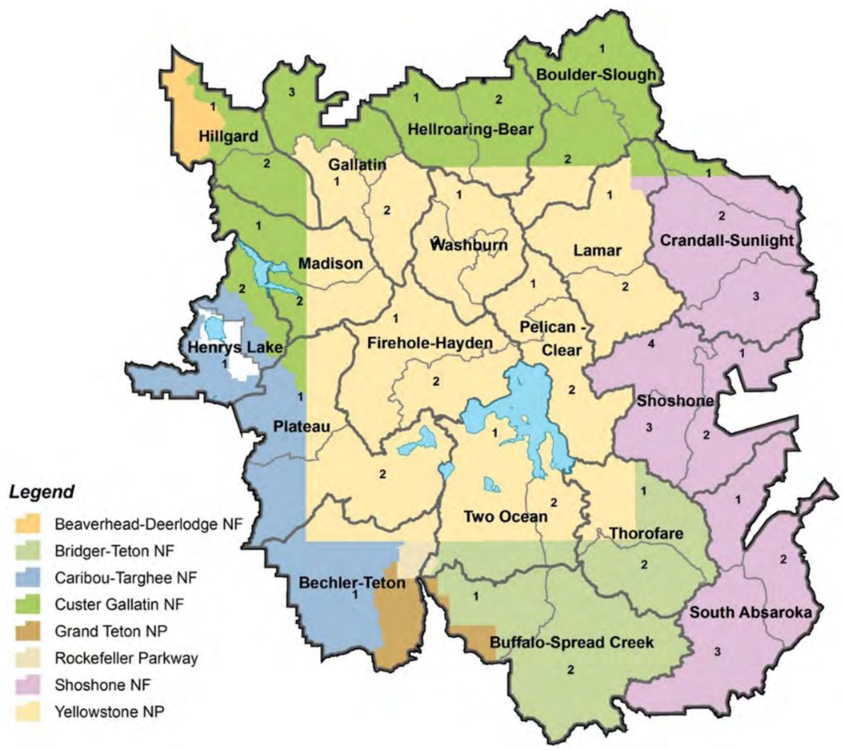

Figure A2. *Bear Management Units (BMUs) and subunits comprising the Grizzly Bear Recovery Zone in the Yellowstone Ecosystem.*

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Monitoring of Livestock Grazing

The habitat standard for livestock allotments established in the Conservation Strategy requires that there be no net increase in the number of commercial livestock grazing allotments or any increase in permitted sheep animal months (AMs) inside the GBRZ from that which existed in 1998. These AMs are derived by multiplying the permitted number of sheep times the months of permitted grazing on a given allotment. Existing sheep allotments are to be phased out as opportunity arises with willing permittees. The change in number of active and vacant livestock allotments cited in this report account for all commercial grazing allotments occurring on National Forest land within the GBRZ. With closure of the last cattle allotment inside Grand Teton National Park in 2011, there are no grazing allotments on National Park land inside the GYE. Livestock grazing on private inholdings and horse grazing associated with recreational use and backcountry outfitters are not covered by the grazing standard and are not included in this report. Operational status of allotments is categorized as *active*, *vacant*, or *closed*. An active allotment is one with a current grazing permit. However, an active allotment can be granted a "no-use" permit on a year-by-year basis when a permittee chooses not to graze livestock or when management seeks a resolution to grazing conflicts. Vacant allotments are those without an active permit, but which may be grazed periodically by other permittees at the discretion of the land management agency. Such reactivation of vacant allotments is typically on a temporary basis to resolve resource issues or other concerns. Vacant allotments can be assumed non-active unless otherwise specified. When chronic conflicts occur on cattle allotments inside the GBRZ and an opportunity exists with a willing permittee, cattle can be moved to a vacant allotment where there is less likelihood of conflict. A closed allotment is one that has been permanently deactivated such that commercial grazing will not be permitted to occur anytime in the future.

Corrections to the 1998 Baseline for livestock allotments

The 1998 baseline for livestock allotments represents the best available measure of the number of grazing allotments that were active or vacant in 1998 on federal lands inside the GBRZ. The baseline continues to evolve as more reliable information is acquired. In 2014, a concerted effort was made by each of the National Forest units within the GYE to review and update the status and number of commercial livestock grazing allotments known to exist inside the GBRZ during 1998. Several errors in the baseline were identified on the Custer Gallatin and Shoshone National Forests and subsequent corrections have been made to the 1998 baseline for grazing allotments. The corrected number and area of baseline allotments are based on the most current information available pertaining to 1998 conditions and are presented in Table A1. The 2014 review of the baseline led to the following *net* increase in the number of livestock allotments known to exist on National Forest land inside the GBRZ during 1998: active cattle/horse (n = +1, Custer Gallatin National Forest), vacant cattle/horse (n = +1, Custer Gallatin National Forest), and vacant sheep (n = +1 Custer Gallatin National Forest, n = +2 Shoshone National Forest). The increase in number of known vacant sheep allotments in 1998 did not represent an increase of sheep grazing activity on the landscape because these vacant allotments had not been grazed since prior to 1998, and were subsequently closed post-1998.

Aside from identified errors of omission or commission, the known spatial configuration of an allotment may also have been initially reported incorrectly. For example, on the Shoshone National Forest, the Crandall cattle/horse allotment had actually been split into two distinct allotments (Crandall II and Reef Creek) managed under a single permit in 1998. This particular example technically accounts for an increase of 1 in the total number of allotments; however, the actual footprint of grazing did not change and was properly accounted for in the 1998 baseline. The present-day status (active, vacant, or closed) of all commercial livestock allotments comprising the 1998 baseline were also reviewed in 2014 for any errors. A number of corrections were made on the Bridger-Teton, Caribou-Targhee, Custer Gallatin, and Shoshone National Forests. To the best of our knowledge, Table A1 represents an accurate comparison of current and 1998 levels of commercial livestock grazing allotments on National Forest land inside the GBRZ.

Change in Cattle allotments since 1998: The number of active commercial cattle grazing allotments on public lands inside the GBRZ has decreased since 1998 when there were 72 active and 13 vacant commercial cattle allotments (Table A1). During 2015 there were 54 active and 13 vacant commercial cattle allotments operating inside the GBRZ. This accounts for a permanent closure of approximately 28% of the total area commercially grazed by cattle in 1998, and an additional 5% that has been vacated and is no longer being actively grazed. Of the total area of vacant cattle grazing land present in 1998, 57% (157 km^2) has been permanently closed, and 43% (118 km^2) remained vacant during 2015.

Sheep allotments since 1998: Domestic sheep allotments inside the GBRZ have mostly been phased out since 1998. In 1998 there were 11 active and 10 vacant sheep allotments inside the GBRZ. During 2015 there was one active and no vacant commercial sheep allotments remaining inside the GBRZ (Table A1). This accounts for a permanent closure of 92% of the total area actively grazed by domestic sheep inside the GBRZ since 1998. Of the 23,090 sheep AMs issued in 1998, only 1,970 (Meyers Creek) were permitted during 2015. The Meyers Creek sheep allotment on the Caribou-Targhee National Forest, the only active sheep allotment currently remaining inside the GBRZ, has been issued a no-use permit since 2008 and consequently, there has been no domestic sheep grazing inside the GBRZ since 2008. Of the 312 km^2 of vacant sheep allotments present in 1998, 100% is now permanently closed to grazing.

Recent Action - Meyers Creek Sheep Allotment: The Meyers Creek sheep allotment, located on the Caribou-Targhee National Forest and administered by the U.S. Forest Service, is the only active sheep allotment currently remaining inside the GBRZ. Historically, the USDA Sheep Experiment Station (USSES), located in the Centennial Mountains of Idaho and Montana, has used the Meyers Creek sheep allotment as a supplemental grazing pasture. When legal protections for the Yellowstone grizzly bear were reinstated under the Endangered Species Act in 2009, the USSES initiated preparation of an Environmental Impact Statement (EIS) to assess effects of historic and ongoing grazing on grizzly bears. In 2010, a directive by the Agricultural Research Service (ARS) halted all sheep grazing on the Meyers Creek allotment and adjacent USSES summer range lands while the USSES prepared the EIS. Meanwhile, ongoing grazing and research activities elsewhere on USSES lands (outside the GBRZ) continued. In November, 2011 the USFWS issued a biological opinion on a subsequent proposal by the ARS to continue sheep grazing in the project area. Five environmental groups filed a lawsuit in 2013 arguing that the USFWS opinion violated the Endangered Species Act and Administrative Procedure Act and asked the federal judge to temporarily shut down the USSES. On June 20, 2014, the U.S. Secretary of Agriculture announced the decision to halt funding on the Sheep Station and redirect those funds to other projects; however, this decision was denied by Congress and funding for the USSES was continued. In September, 2014, non-governmental organizations filed a formal complaint against the ARS and USFWS for violations of the ESA, however, the lawsuit was dropped in March 2015 when a judge ruled that grazing on the Sheep Station's summer pastures would stay closed until the environmental review was completed. Within days of this ruling, the ARS released a draft EIS for public review recommending that the Sheep Station be kept open and summer sheep grazing be allowed. A final decision will be issued by ARS after review of public comment. Meanwhile, there has been no sheep grazing on the Meyers Creek allotment since the 2008 Willow fire.

Changes in Allotments during 2015

Four grazing allotments inside the GBRZ were permanently closed in 2015. All four closures involved cattle allotments on the Custer Gallatin National forest (Red Canyon, Sulphur Springs, Wapiti, and Cache-Eldridge). These closures account for a net reduction of 83 km^2 (20,467 acres) of potential commercial livestock grazing on federal lands inside the GBRZ. No other changes to the number, status, or acreage of commercial livestock allotments were reported to occur on federal lands inside the GBRZ during 2015. See Table A1 for 2015 status of livestock allotments compared with 1998 status.

Table A1. *Number of commercial livestock grazing allotments and sheep animal months (AMs) inside the Grizzly Bear Recovery Zone in 1998 and 2015.*

Administrative Unit	Cattle/Horse Allotments				Sheep Allotments				Sheep Animal Months	
	Active		Vacant		Active		Vacant			
	1998	2015	1998	2015	1998	2015	1998	2015	1998	2015
Beaverhead-Deerlodge NF	3	3	2	0	0	0	0	0	0	0
Bridger-Teton NF	9	5	0	1	0	0	0	0	0	0
Caribou-Targhee NF (1)	11	7	1	1	7	1	4	0	14,163	1,970
Custer Gallatin NF	23	14	10	7	2	0	4	0	3,540	0
Shoshone NF	25	25	0	0	2	0	2	0	5,387	0
Grand Teton NP	1	0	0	0	0	0	0	0	0	0
Total number in GBRZ	**72**	**54**	**13**	**9**	**11**	**1**	**10**	**0**	**23,090**	**1.970**
Total area in GBRZ (km^2)	**2,674**	**1,845**	**275**	**164**	**600**	**14**	**312**	**0**		

(1) The Meyers Creek allotment, the only active sheep grazing unit remaining inside the GBRZ, took a "no use" permit in 2015.

Livestock Conflicts Inside and Outside the GBRZ

Conflicts between grizzly bears and livestock have historically led to the capture and relocation or removal of grizzly bears in the GYE. Grizzly bear conflicts associated with livestock depredation are reported on an annual basis for all sheep and cattle grazing allotments and forage reserves on National Forest land within the GYE. This section summarizes the reported annual incidences of grizzly bear-livestock conflict occurring on commercial grazing allotments on National Forest lands throughout the ecosystem. Livestock conflicts on private or State land are not included in this report.

Livestock Conflicts in 2015

In 2015, a total of 122 grizzly bear-livestock conflicts resulting from cattle and sheep depredation were reported on Forest Service lands within the GYE. These conflicts happened on 13 distinct commercial grazing allotments throughout the ecosystem (Table A2). Three of the 122 livestock-related conflicts occurred inside the GBRZ. Ninety-six percent (n = 117) involved cattle depredation, and 4% (n = 5) involved sheep depredation. During 2015 approximately 117 livestock mortalities resulted from grizzly bear depredations, including: calves or yearlings (n = 101), heifers (n = 3), cows, (n = 5), steers (n = 2), ewes (n = 4), and lambs (n = 2). An additional 5 calves and 1 cow sustained non-fatal injuries. Of the 122 livestock conflicts reported during 2015, 64% (n = 78) occurred on the Upper Green River cattle allotment located outside the GBRZ on the north portion of the Bridger-Teton National Forest. Management actions in direct response to livestock-related conflicts on public land led to the removal of 6 male (5 adults, 1 subadult) grizzly bears. Of the 6 grizzly bear removals, 4 (67%) were due to depredation incidents on the Upper Green River cattle allotment.

Recurring Livestock Conflicts 2011–2015

Allotments with 'recurring' conflicts are those in which grizzly bear-livestock incidents occurred during three or more years of the most recent 5-year period. During the past five years (2011–2015) an estimated 424 livestock-related conflicts occurred on grazing allotments on National Forest land within the GYE (Fig. A3). Approximately 60% (n = 256) of these conflicts occurred on the Upper Green River allotment on the Bridger-

Teton National Forest. During this same time period, 14 distinct allotments sustained recurring conflicts: 5 on the Bridger-Teton National Forest and 9 on the Shoshone National Forest (Table A2). Over the past 5 years, there have been 21 grizzly bear mortalities (4 adult females, 15 adult males, and 2 subadult males) due to livestock-related conflicts on Forest Service land. All 21 mortalities were management-sanctioned removals. Of these grizzly bear mortalities, 17 (81%) were due to cattle depredation on the Upper Green River allotment.

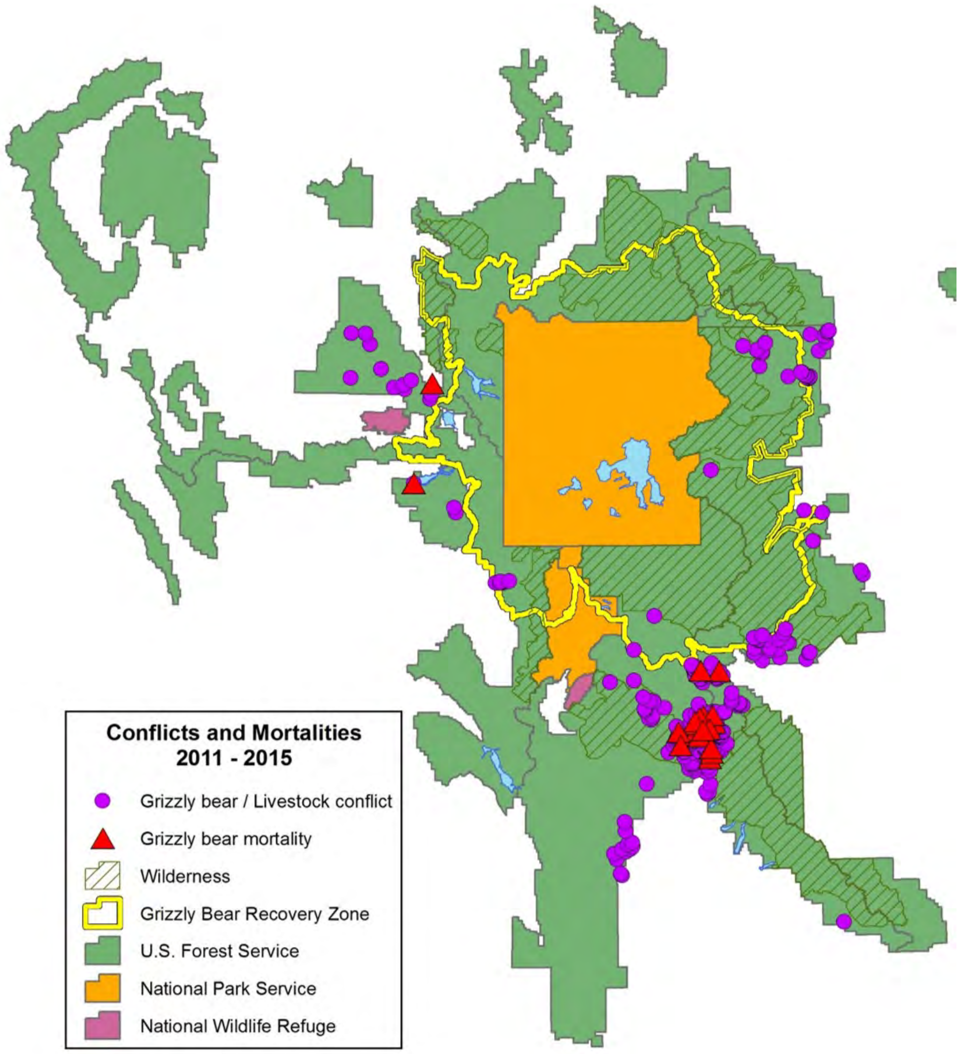

Figure A3. *Grizzly bear conflicts and mortalities related to livestock grazing on Federal lands in the GYE during 2011–2015.*

Table A2. *Commercial livestock allotments with documented grizzly bear conflicts during the past 5 years. Allotments with conflicts in 3 or more of the last 5 years are considered to be recurring conflicts.*

Allotment Name	Total Acres	Conflicts					Total conflicts (2011-2015)	Recurring conflicts
		2011	2012	2013	2014	2015		
Beaverhead-Deerlodge National Forest								
Antelope Basin	4,430	0	0	0	0	2	2	No
Barnett	6,454	0	0	1	0	0	1	No
Bufiox	13,077	1	0	0	0	0	1	No
Clover Meadows	3,081	0	0	0	0	1	1	No
Red Tepee	8,256	0	0	1	0	0	1	No
Upper Ruby	44,395	0	0	1	0	0	1	No

Table A2. Commercial livestock allotments with documented grizzly bear conflicts during the past 5 years. Allotments with conflicts in 3 or more of the last 5 years are considered to be recurring conflicts.

Allotment Name	Total Acres	Conflicts					Total conflicts (2011-2015)	Recurring conflicts
		2011	2012	2013	2014	2015		
West Fork	53,096	0	0	0	0	4	4	No
Bridger-Teton National Forest								
Beaver-Horse	25,359	0	2	0	0	0	2	No
Crows Nest	3,640	1	0	0	0	0	1	No
Elk Ridge	6,365	2	1	0	0	0	3	No
Fish Creek [a]	76,217	2	0	0	0	0	2	No
Green River Drift	1,002	1	0	0	0	0	1	No
Jack Creek	32,387	0	1	0	0	0	1	No
Kinky Creek	22,834	0	1	0	0	0	1	No
Kohl Ranch	483	0	1	0	0	0	1	No
Lime Creek	4,973	0	0	0	0	5	5	No
New Fork-Boulder	10,976	0	0	2	0	0	2	No
Noble Pasture	762	1	0	1	0	1	3	Yes
North Cottonwood	28,177	0	0	1	0	2	3	No
Pot Creek	4,499	0	0	1	0	0	1	No
Prospect Peak	8,917	0	1	0	0	0	1	No
Redmond-Bierer Creek	7,109	0	0	1	0	0	1	No
Roaring Fork	8,416	0	1	0	0	0	1	No
Rock Creek	5,148	0	1	1	2	0	4	Yes
Sherman C and H	8,287	3	1	1	1	0	6	Yes
Tosi Creek	14,090	0	1	0	0	0	1	No
Turpin Meadow	1,493	1	0	0	0	0	1	No
Union Pass [a]	39,497	0	1	0	0	0	1	No
Upper Green River	131,94	31	41	40	66	78	256	Yes
Upper Gros Ventre	67,497	0	5	1	1	5	12	Yes
Wagon Creek	182	0	0	1	0	1	2	No
Caribou-Targhee National Forest								
Davis Lake	28,930	0	0	0	1	0	1	No
Grand View	43,478	0	0	0	0	2	2	No
Squirrel Meadows	28,797	0	7	0	0	0	7	No
Shoshone National Forest								
Basin	73,319	0	0	0	0	1	1	No
Bear Creek	33,672	0	1	1	0	1	3	Yes
Beartooth	30,317	0	0	2	3	1	6	Yes
Beartooth Highway	9,350	0	0	1	0	0	1	No
Bench (Clarks Fork)	28,751	1	0	0	8	3	12	Yes
Crandall	30,089	0	0	1	0	0	1	No
Deep Lake	6,486	0	0	0	1	0	1	No
Dick Creek	9,569	0	0	0	0	1	1	No
Ghost Creek	11,579	0	6	0	0	0	6	No
Horse Creek	29,980	2	1	0	1	0	4	Yes
Lake Creek	21,399	0	0	1	0	0	1	No

Table A2. Commercial livestock allotments with documented grizzly bear conflicts during the past 5 years. Allotments with conflicts in 3 or more of the last 5 years are considered to be recurring conflicts.								
Allotment Name	**Total Acres**	**Conflicts**					**Total conflicts (2011-2015)**	**Recurring conflicts**
		2011	**2012**	**2013**	**2014**	**2015**		
Parque Creek	13,528	0	2	0	2	4	8	Yes
Piney	14,287	1	0	0	0	0	1	No
Ramshorn	16,005	0	0	0	0	1	1	No
Rock Creek	16,833	0	1	0	1	0	2	No
South Absaroka Trans	152,256	0	0	1	0	0	1	No
Sunshine	2,152	0	0	0	0	1	1	No
Union Pass	39,497	1	6	2	0	0	9	Yes
Warm Springs	16,875	3	4	2	1	2	12	Yes
Wiggins Fork	37,653	3	1	0	1	2	7	Yes
Wind River	44,158	4	1	0	3	4	12	Yes
Total conflicts		**58**	**88**	**64**	**92**	**122**	**424**	
[a]Forage reserve.								

Monitoring of Developed Sites

Habitat standards identified in the Conservation Strategy require that the number of developed sites and capacity of human use of developed sites inside the GBRZ be maintained at or below the levels existing in 1998. Administrative site expansions are exempt from mitigation if such developments are deemed necessary for enhancement of public lands and when other viable alternatives are not plausible. A developed site is one on public land that has been developed or improved for human use or resource development and includes, but is not limited to, campgrounds, trailheads, lodges, administrative sites, service stations, summer homes, restaurants, visitor centers, and permitted natural resource development sites such as oil and gas exploratory wells, production wells, mining activities, and work camps. Developments on private land are not counted against this standard.

Corrections to 1998 Developed Sites Baseline

The 1998 developed sites baseline represents a static snapshot in time of human development on public lands inside the GBRZ for the year 1998. However, when legitimate errors are identified, the Conservation Strategy allows for the 1998 baseline to be corrected. Two errors of omission to the 1998 Developed Sites Baseline were identified and corrected in 2014: the Lizard Creek campground in Grand Teton National Park and the Buffalo Horn administrative cabin on the Custer Gallatin National Forest. The Lizard Creek campground located along the north eastern shore of Jackson Lake and just inside the western border of the Buffalo-Spread Creek #1 subunit, was erroneously excluded from the 1998 baseline. According to John Daugherty's 2002 book, *A Place called Jackson Hole*, this campground predates 1998 and existed as early as the 1960s. Also excluded from the baseline is the Buffalo Horn administrative cabin located within the Gallatin #3 subunit. Evidence of the 1998 status of this administrative site is based on a vintage 1999 Forest Service Visitors Map which locates the cabin feature approximately 2.6 km northeast of Grouse Mountain and south of Cow Flats. Both the Lizard Creek campground and the Buffalo Horn administrative cabin remained active sites during 2015 and have been added as corrections to the 1998 baseline. For a complete list of developed sites comprising the 1998 baseline, please refer to Supplemental Table S1 linked to this report (available online only): Table S1 Developed Sites 1998 Baseline-Current Status.

Changes in Developed Sites since 1998

The number of developed sites inside the GBRZ has decreased from 595 known sites in 1998 to 578 in 2015. This net reduction of 17 developed sites affected 11 subunits throughout the GBRZ (Table A3). Only 1 subunit (Hilgard #2) has shown an increase in developed sites since 1998. This increase occurred in 2005 when the Taylor Falls-Lightning trailhead, originally located in subunit #1 of the Hilgard BMU, was moved from one side of a road to the other, placing it in subunit #2 of the Hilgard BMU. In this case, the loss in one subunit resulted in a gain in the other. Although this transfer technically accounted for an increase in developed sites on Hilgard #2, it was determined to have no detrimental effect on grizzly bears and did not violate the intent of the developed site standard. For a complete list of developed sites comprising the 1998 baseline, please refer to Supplemental Table S1 linked to this report (available online only): Table S1 Developed Sites 1998 Baseline-Current Status.

Changes in Developed Sites in 2015

During 2015 there were no changes in the number of developed sites on public lands inside the GBRZ.

Table A3. Number of developed sites in 1998 and 2015 on public lands per bear management subunit in the Greater Yellowstone Ecosystem.

Bear Management Subunit	Admin Unit [1]	Summer Home Complexes		Developed Campgrounds		Trailheads		Major Developed sites & Lodges [2]		Administrative or Maintenance sites		Other Developed sites		Plans of Operation for Minerals Activities [3]		Total number of developed sites	
		1998	2015	1998	2015	1998	2015	1998	2015	1998	2015	1998	2015	1998	2015	1998	2015
Bechler-Teton #1	CTNF	0	0	1	1	5	5	2	2	4	4	16	16	0	0	59	59
	YNP	0	0	0	0	2	2	0	0	2	2	2	2	0	0		
	GTNP	0	0	8	8	3	3	1	1	3	3	10	10	0	0		
Boulder-Slough #1	CGNF	0	0	1	1	7	7	0	0	1	1	3	3	8	2	20	14
Boulder-Slough #2	CGNF	0	0	0	0	0	0	0	0	2	2	0	0	0	0	9	9
	YNP	0	0	1	1	3	3	0	0	2	2	1	1	0	0		
Buffalo-Spread Creek #1	BTNF	0	0	1	1	1	1	0	0	0	0	2	2	0	0	19	19
	GTNP	0	0	1	1	7	7	2	2	2	2	3	3	0	0		
Buffalo-Spread Creek #2	BTNF	1	1	4	2	3	5	3	3	5	5	5	3	1	1	22	20
Crandall-Sunlight #1	SNF	0	0	2	2	5	5	1	1	1	1	5	5	0	0	23	23
	CGNF	0	0	2	2	2	2	0	0	0	0	5	5	0	0		
Crandall-Sunlight #2	SNF	0	0	5	5	4	4	1	1	2	2	5	5	1	1	18	18
	CGNF	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Crandall-Sunlight #3	SNF	0	0	2	2	3	3	0	0	1	1	2	2	0	0	11	11
	WG&F	0	0	2	2	0	0	0	0	1	1	0	0	0	0		
Firehole-Hayden #1	YNP	0	0	1	1	5	5	1	1	6	6	13	13	0	0	26	26
Firehole-Hayden #2	YNP	0	0	1	1	3	3	1	1	2	2	8	8	0	0	15	15
Gallatin #1	YNP	0	0	0	0	3	3	0	0	1	1	0	0	0	0	4	4
Gallatin #2	YNP	0	0	2	2	5	5	1	1	12	12	1	1	0	0	21	21
Gallatin #3	CGNF	0	0	2	2	9	9	0	0	1	1	6	6	0	0	18	18
	YNP	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Hellroaring-Bear #1	CGNF	0	0	5	5	11	11	0	0	3	3	7	7	8	8	36	36
	YNP	0	0	0	0	1	1	0	0	0	0	1	1	0	0		
Hellroaring-Bear #2	CGNF	0	0	0	0	1	1	0	0	1	1	0	0	0	0	4	4
	YNP	0	0	0	0	0	0	0	0	2	2	0	0	0	0		
Henrys Lake #1	CTNF	2	2	3	3	1	1	0	0	3	3	10	10	1	0	20	19
Henrys Lake #2	CTNF	0	0	0	0	1	1	0	0	1	0	1	1	1	1	18	18
	CGNF	5	5	3	3	4	4	0	0	0	0	2	3	0	0		

Table A3. Number of developed sites in 1998 and 2015 on public lands per bear management subunit in the Greater Yellowstone Ecosystem.

Bear Management Subunit	Admin Unit (1)	Summer Home Complexes		Developed Campgrounds		Trailheads		Major Developed sites & Lodges (2)		Administrative or Maintenance sites		Other Developed sites		Plans of Operation for Minerals Activities (3)		Total number of developed sites	
		1998	2015	1998	2015	1998	2015	1998	2015	1998	2015	1998	2015	1998	2015	1998	2015
Hilgard #1	BDNF	0	0	0	0	0	0	0	0	3	1	0	0	0	0	14	11
	CGNF	0	0	0	0	6	5	1	1	2	2	2	2	0	0		
Hilgard #2	CGNF	0	0	0	0	4	5	0	0	1	1	1	1	0	0	9	10
	YNP	0	0	0	0	3	3	0	0	0	0	0	0	0	0		
Lamar #1	YNP	0	0	1	1	5	5	0	0	3	3	2	1	0	0	37	36
	CGNF	0	0	2	2	7	7	0	0	6	6	3	3	8	8		
	SNF	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Lamar #2	YNP	0	0	0	0	0	0	0	0	4	4	0	0	0	0	4	4
Madison #1	CGNF	0	0	1	1	11	11	0	0	1	1	8	7	0	0	21	20
	YNP	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Madison #2	CGNF	8	8	2	2	1	1	1	1	4	4	5	5	0	0	25	25
	YNP	0	0	0	0	1	1	0	0	2	2	1	1	0	0		
Pelican-Clear #1	YNP	0	0	0	0	2	2	0	0	0	0	0	0	0	0	2	2
Pelican-Clear #2	YNP	0	0	1	1	4	4	1	1	4	4	3	3	0	0	13	13
Plateau #1	CTNF	1	1	0	0	0	0	0	0	0	0	1	1	0	0	3	3
	CGNF	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	YNP	0	0	0	0	0	0	0	0	1	1	0	0	0	0		
Plateau #2	CTNF	0	0	0	0	1	1	0	0	1	1	1	1	0	0	7	7
	YNP	0	0	0	0	0	0	0	0	4	4	0	0	0	0		
Shoshone #1	SNF	1	1	2	2	0	0	0	0	0	0	6	5	0	0	9	8
Shoshone #2	SNF	0	0	0	0	1	1	1	1	0	0	0	0	0	0	2	2
Shoshone #3	SNF	2	2	0	0	1	0	1	1	0	0	0	0	0	0	4	3
Shoshone #4	SNF	3	3	3	2	3	3	6	6	0	0	8	9	0	0	23	23
South Absaroka #1	SNF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
South Absaroka #2	SNF	0	0	0	0	0	0	0	0	2	2	0	0	0	0	2	2
South Absaroka #3	SNF	1	1	3	3	4	4	1	1	1	1	5	4	0	0	15	14
Thorofare #1	BTNF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4
	YNP	0	0	0	0	0	0	0	0	4	4	0	0	0	0		

Table A3. Number of developed sites in 1998 and 2015 on public lands per bear management subunit in the Greater Yellowstone Ecosystem.

Bear Management Subunit	Admin Unit [1]	Summer Home Complexes		Developed Campgrounds		Trailheads		Major Developed sites & Lodges [2]		Administrative or Maintenance sites		Other Developed sites		Plans of Operation for Minerals Activities [3]		Total number of developed sites	
		1998	2015	1998	2015	1998	2015	1998	2015	1998	2015	1998	2015	1998	2015	1998	2015
Thorofare #2	BTNF	0	0	0	0	0	0	0	0	2	2	0	0	0	0	2	2
	YNP	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Two Ocean Lake #1	YNP	0	0	2	2	3	3	1	1	3	3	2	2	0	0	15	14
	BTNF	0	0	1	1	0	0	0	0	0	0	0	0	0	0		
	GTNP	0	0	0	0	1	1	0	0	1	1	1	0	0	0		
Two Ocean Lake #2	BTNF	0	0	0	0	0	0	0	0	2	2	0	0	0	0	4	4
	YNP	0	0	0	0	0	0	0	0	1	1	1	1	0	0		
Washburn #1	YNP	0	0	2	2	8	8	2	2	7	7	6	6	0	0	25	25
Washburn #2	YNP	0	0	1	1	6	6	0	0	1	1	4	4	0	0	12	12
Total in GBRZ		**24**	**24**	**68**	**65**	**161**	**162**	**28**	**28**	**118**	**115**	**168**	**163**	**28**	**21**	**595**	**578**

Note: The 1998 baseline values in this table may vary from those tabulated in the 2007 Conservation Strategy since corrections have been made with time. The numbers in this table represent the best estimates currently available for developed sites on public lands inside the Grizzly Bear Recovery Zone of the Greater Yellowstone Ecosystem.

(1) Abbreviations for administrative units: BDNF = Beaverhead-Deerlodge National Forest, BTNF = Bridger-Teton National Forest, CGNF = Custer Gallatin National Forest, CTNF = Caribou-Targhee, GTNP = Grand Teton National Park, SNF = Shoshone National Forest, WG&F = Wyoming Game and Fish, YNP = Yellowstone National Park.

(2) Major developed areas such as Grant, Lake, Fishing Bridge, Old Faithful, Canyon, and Mammoth in YNP and are comprised of a combination of recreation and administrative facilities. All buildings and facilities at a given major developed area are tracked collectively as a single developed site.

(3) A single plan of operation may have multiple mining claims and not all plan sites have active projects.

Monitoring Secure Habitat and Motorized Access

Habitat standards identified in the Conservation Strategy require that grizzly bear secure habitat be maintained at or improved upon levels existing in 1998 for each of the 40 subunits inside the GBRZ. Secure habitat serves as a metric of human activities in grizzly bear habitat and is based entirely on proximity to motorized routes (both roads and trails). Secure habitat is defined as any contiguous area ≥10 acres in size and more than 500 m from an open or gated motorized route. Lakes larger than 1 square mile (2.59 km^2) in size are excluded from habitat calculations.

Monitoring protocol established in the Conservation Strategy and Forest Plan Amendment requires that secure habitat, seasonal open motorized access route density (OMARD), and total motorized access route density (TMARD) be reported annually for each subunit within the 18 BMUs inside the GBRZ. Values for secure habitat are compared against 1998 levels inside the GBRZ to ensure adherence to the secure habitat standard. Gains in secure habitat are achieved primarily through decommissioning of open, motorized access routes. In context to the measurement of grizzly bear secure habitat, a route is considered decommissioned when it has been effectively treated on the ground so that motorized access by the public and administrative personnel is restricted. Road decommissioning can range from complete obliteration of the road prism to physical barriers permanently and effectively blocking all access points to motorized traffic. Any route that is open to public or administrative motorized use during any portion of the non-denning season (March 1 through November 30) detracts from secure habitat. This includes routes that are gated to the public yearlong but which may be accessed by administrative personnel.

The Conservation Strategy and Forest Plan Amendment do not impose any mandatory standards pertaining to motorized route density. However, changes in this parameter are monitored and reported annually. This provision for monitoring route density was incorporated into these two seminal management documents based on evidence indicating that grizzly bears are sensitive to the effects of access management, especially as related to motorized use. Monitoring protocol requires that the following parameters be reported for each BMU subunit on an annual basis: 1) seasonal OMARD > 1 mile/mi^2 (0.62 km/km^2), and 2) TMARD > 2 miles/mi^2 (1.2 km/km^2). Seasonal OMARD is measured for two seasons: season 1 is March 1–July 15 and season 2 is July 16–November 30. Gated routes that prohibit public access for an entire season do not count toward seasonal route density (i.e., season of closure) but do contribute toward TMARD. All motorized routes open to the public and or administrative personnel during any portion of the non-denning season contribute to TMARD. Decommissioned routes that are managed for long-term closure to all motorized use do not contribute to OMARD or TMARD and do not detract from secure grizzly bear habitat.

Permanent Changes in Secure Habitat since 1998

The standard for maintaining secure grizzly bear habitat inside the recovery zone calls for “no net loss” with respect to levels that existed in 1998. Compliance with this habitat standard has been met in all 40 BMU subunits as documented in Table A4. Secure habitat is measured for each subunit as a percentage of the subunit area, excluding major lakes. In each of the 40 subunits, secure habitat has either been maintained or increased with respect to 1998 levels. Improvements in secure habitat range from minor increases of 0.1% demonstrated in a number of subunits, to a more significant gain of 17.2% for the Gallatin #3 subunit. All changes throughout the GBRZ collectively translate to a net gain of approximately 131 mi^2 (339 km^2) of secure habitat since 1998; an increase comparable in size to that of Yellowstone Lake. The greatest improvement in secure habitat is the 17.2 % increase occurring on the Gallatin #3 Bear Management Subunit (BMS) on the Custer Gallatin National Forest. The Gallatin #3 is one of three subunits targeted in the Conservation Strategy and Forest Plan Amendment as in need of improvement above 1998 levels (also targeted were Henrys Lake #2 and Madison #2). For these 3 subunits, a Gallatin Cleanup Amendment proposes to establish the enhanced secure levels resulting from Travel Plan implantation as the new baseline from which change will be measured. Other notable gains in secure habitat, ranging from 3.4% on the Hellroaring-Bear #1 subunit to 13.4% on the Hilgard #1 subunit, are also identified in Table A4. These gains in secure habitat were incurred on the Custer Gallatin

National Forest as a result of systematic decommissioning of unnecessary non-system roads due to Gallatin Travel Plan implementation. Three subunits (Lamar #2, Thorofare #1 and #2, and Two Ocean-Lake #2) are roadless areas that are, and will remain into the foreseeable future, completely secure.

Permanent Changes in Secure Habitat during 2015

Several minor changes in secure habitat occurred on public lands inside the GBRZ during 2015 accounting for a net increase of 3 mi^2 (7.8 km^2) in secure habitat. All of these changes occurred in the Custer Gallatin National Forest as several final Gallatin Travel Plan changes were implemented on the ground, and as errors in the configuration of motorized routes were corrected in the database. Corrections to the database led to slight increases ranging from 0.1% to 0.5% in secure habitat for the Boulder Slough #1, Gallatin #1 and #3, and Hilgard #1 subunits. A slight decrease (0.2%) in secure habitat was identified in the Hellroaring-Bear #1 subunit due to a correction to the motorized access database. This decrease in secure habitat resulted from the addition of approximately 1.6 mi (2.5 km) of the Cedar Creek motorized road that was erroneously omitted during Travel Plan updates. The most current and reliable estimates for secure habitat inside the GBRZ are shown in Table A4.

Table A4. *1998 Baseline and 2015 percentages per subunit of open motorized access route density (OMARD), total motorized access route density (TMARD), and secure habitat for 40 Bear Management Unit subunits in the Grizzly Bear Recovery Zone, Greater Yellowstone Ecosystem.*

BMU subunit Name	OMARD (% > 1 mile / mile²) Season 1 (Mar 1 – Jul 15)			OMARD Season 2 (Jul 16 – Nov 30)			TMARD (% > 2 miles / mile²)			% Secure Habitat			Area (miles²) (excluding lakes) Subunit	Secure Habitat	
	1998	2015	% chg	1998	2015	% chg	1998	2015	% chg	1998	2015	% chg		1998	2015
Bechler/Teton	17.0	17.0	-0.1	17.0	17.0	-0.1	5.8	5.8	0.1	78.1	78.1	0.0	534.3	417.0	417.2
Boulder/Slough #1	3.2	2.8	-0.5	3.2	2.8	-0.5	0.3	0.2	-0.1	96.6	97.1	0.6	281.9	272.2	273.8
Boulder/Slough #2	2.1	2.1	0.0	2.1	2.1	0.0	0.0	0.0	0.0	97.7	97.7	0.0	232.4	227.1	227.1
Buffalo/Spread Creek #1	11.4	11.4	0.0	11.5	11.4	-0.1	5.3	6.1	0.8	88.3	88.6	0.4	219.9	194.1	194.9
Buffalo/Spread Creek #2	14.5	15.0	0.6	15.6	14.5	-1.0	12.7	11.6	-1.1	74.3	74.4	0.1	507.6	377.2	377.5
Crandall/Sunlight #1	13.3	12.4	-0.9	19.3	18.5	-0.8	7.2	6.3	-0.9	81.1	81.9	0.8	129.8	105.2	106.2
Crandall/Sunlight #2	15.6	14.8	-0.8	16.6	16.0	-0.6	11.7	11.2	-0.5	82.3	82.7	0.4	316.2	260.3	261.5
Crandall/Sunlight #3	14.4	14.3	-0.1	19.2	18.8	-0.4	10.6	10.4	-0.2	80.4	81.1	0.7	221.8	178.3	179.9
Firehole/Hayden #1	10.4	10.5	0.1	10.4	10.5	0.1	1.7	1.7	0.0	88.3	88.3	0.0	339.2	299.7	299.6
Firehole/Hayden #2	8.9	8.9	0.0	9.0	9.0	0.0	1.5	1.5	0.0	88.4	88.4	0.0	172.2	152.3	152.3
Gallatin #1	3.6	2.5	-1.0	3.6	2.5	-1.0	0.5	0.1	-0.4	96.3	97.0	0.7	127.7	122.9	123.9
Gallatin #2	9.5	9.1	-0.4	9.5	9.1	-0.4	4.5	4.5	0.0	90.2	90.2	0.0	155.2	139.9	139.9
Gallatin #3	46.0	18.6	-27.4	46.0	27.4	-18.5	22.9	12.5	-10.4	55.3	72.5	17.2	217.6	120.2	157.7
Hellroaring/Bear #1	22.4	18.4	-4.0	23.1	18.4	-4.7	15.8	12.1	-3.7	77.0	80.4	3.4	184.7	142.2	148.5
Hellroaring/Bear #2	0.1	0.0	-0.1	0.1	0.0	-0.1	0.0	0.0	0.0	99.5	99.6	0.1	228.9	227.8	228.0
Henry's Lake #1	49.0	49.2	0.2	49.0	49.2	0.2	31.2	31.1	-0.1	45.4	46.1	0.7	191.2	86.8	88.2
Henry's Lake #2	49.9	41.3	-8.6	49.9	41.3	-8.6	35.2	30.7	-4.5	45.7	51.5	5.8	140.2	64.1	72.2
Hilgard #1	29.0	8.2	-20.8	29.0	13.3	-15.7	15.3	4.4	-10.9	69.8	83.1	13.4	201.2	140.3	167.2
Hilgard #2	21.0	8.8	-12.2	21.0	16.1	-4.9	13.6	4.6	-8.9	71.4	80.2	8.8	140.5	100.4	112.7
Lamar #1	9.9	9.7	-0.1	9.9	9.7	-0.1	3.8	4.0	0.2	89.4	89.9	0.5	299.9	268.1	269.6
Lamar #2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	0.0	180.8	180.8	180.8
Madison #1	29.2	13.2	-16.0	29.5	20.3	-9.2	12.5	7.5	-5.0	71.5	80.7	9.2	227.9	162.9	183.9

Table A4. *1998 Baseline and 2015 percentages per subunit of open motorized access route density (OMARD), total motorized access route density (TMARD), and secure habitat for 40 Bear Management Unit subunits in the Grizzly Bear Recovery Zone, Greater Yellowstone Ecosystem.*

BMU subunit Name	OMARD (% > 1 mile / mile²)						TMARD (% > 2 miles / mile²)			% Secure Habitat			Area (miles²) (excluding lakes)		
	Season 1 (Mar 1 – Jul 15)			Season 2 (Jul 16 – Nov 30)									Subunit	Secure Habitat	
	1998	2015	% chg	1998	2015	% chg	1998	2015	% chg	1998	2015	% chg		1998	2015
Madison #2	33.7	32.0	-1.8	33.7	32.0	-1.7	24.0	21.6	-2.4	66.5	67.5	1.0	149.4	99.4	100.9
Pelican/Clear #1	2.0	2.0	0.0	2.0	2.0	0.0	0.5	0.5	0.0	97.8	97.8	0.0	108.4	106.0	106.0
Pelican/Clear #2	5.4	5.4	0.0	5.4	5.4	0.0	0.4	0.4	0.0	94.1	94.1	0.0	251.6	236.7	236.7
Plateau #1	22.0	16.9	-5.2	22.2	19.0	-3.3	12.9	10.3	-2.7	68.8	70.6	1.8	286.3	197.0	202.1
Plateau #2	8.5	8.5	0.0	8.5	8.5	0.0	3.5	3.2	-0.2	88.7	88.8	0.1	419.9	372.3	372.7
Shoshone #1	1.5	1.5	0.0	1.5	1.5	0.0	1.1	1.0	-0.1	98.5	98.5	0.1	122.2	120.3	120.4
Shoshone #2	1.3	1.1	-0.2	1.3	1.1	-0.2	0.7	0.6	-0.2	98.8	99.0	0.1	132.4	130.9	131.0
Shoshone #3	3.9	2.8	-1.1	3.8	2.8	-1.1	2.1	1.5	-0.6	97.0	97.8	0.8	140.7	136.5	137.6
Shoshone #4	4.5	4.4	0.0	5.3	5.2	0.0	2.9	2.7	-0.2	94.9	94.9	0.0	188.8	179.1	179.1
South Absaroka #1	0.6	0.6	0.0	0.6	0.6	0.0	0.1	0.1	0.0	99.2	99.2	0.0	163.2	161.9	161.9
South Absaroka #2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	99.9	99.9	0.0	190.6	190.3	190.3
South Absaroka #3	2.4	2.4	0.0	2.4	2.4	0.0	2.7	2.7	0.0	96.8	96.8	0.0	348.3	337.1	337.2
Thorofare #1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	0.0	273.4	273.4	273.4
Thorofare #2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	0.0	180.1	180.1	180.1
Two Ocean/Lake #1	3.5	3.6	0.2	3.5	3.6	0.2	0.3	0.5	0.2	96.3	96.3	0.0	371.9	358.3	358.2
Two Ocean/Lake #2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	0.0	124.9	124.9	124.9
Washburn #1	16.1	16.1	0.0	16.1	16.1	0.0	4.2	4.2	0.0	83.0	83.0	0.0	178.3	147.9	147.9
Washburn #2	7.4	7.4	0.0	7.4	7.4	0.0	1.1	1.1	0.0	92.0	92.0	0.0	144.1	132.6	132.6
Total for GBRZ	**12.3**	**9.8**	**-2.5**	**12.7**	**10.9**	**-1.8**	**6.7**	**5.4**	**-1.3**	**85.6**	**87.0**	**1.5**	**9,025**	**7,725**	**7,855**

Temporary Changes to Secure Habitat due to Federal Projects in 2015

Reductions in secure habitat below 1998 baseline levels are allowed on a temporary basis inside the GBRZ when associated with authorized Federal projects. In these cases, adherence to the 1% application rule and other provisions established to consolidate and reduce detrimental effects must be met. The 1% rule states that the total acreage of secure habitat affected by a project within a given BMU must not exceed 1% of the total acreage of the largest subunit within that BMU. Application rules permit only one temporary project to be active in a particular subunit at any given time. During 2015 two projects involving temporary reductions in secure habitat were operational inside the GBRZ. A third project initiated in 2012 was completed in 2015 (Table A5). Below is a brief summary of these three projects.

Grouse Mountain (Bridger-Teton National Forest): The Grouse Mountain Experimental Whitebark Pine Enhancement project was initiated in 2012 on the Bridger-Teton National Forest directly southwest of Grouse Mountain in the Buffalo-Spread Creek subunit #2. Section 7 consultation with USFWS was completed on May 7, 2012 and field activities associated with this project were launched that summer; although initial incursions into secure grizzly bear habitat were not implemented until summer of 2013. Approximately 0.6 mi (0.9 km) of decommissioned route, previously rendered impassable due to downfall, was cleared of debris for access to the project area. All project roads were gated to the public for the duration of project activities. No temporary roads associated with the Grouse Mountain project were open to the public. The project was terminated in 2015 and routes that were reactivated to access whitebark pine treatment stands have been rehabilitated and permanently closed to all motorized traffic.

Beem Gulch/Company Timber Sale (Shoshone National Forest): The *Beem Gulch and Company Timber Sales* were both authorized for the Crandall-Sunlight #3 subunit on the Shoshone National Forest as part of the *Sunlight Vegetation Project* decision. The Beem Gulch and Company timber sales are both within close proximity of each other and are therefore considered part of the same timber project. All project roads associated with the two timber sales are within a 2.2 mile (3.5 km) radius of the center point between projects. Project activities are restricted to an area that stretches along Sunlight Creek from Little Sunlight Campground to the northeast and Sulphur Lake to the southwest.

Groundwork for the Beem Gulch timber sale was initiated in 2012 with the construction of 0.5 mi (0.8 km) of new road which was permanently decommissioned in 2015. Another 1.1 mi (1.8 km) of previously restricted road along the Little Sunlight creek was reactivated for the Beem Gulch timber sale and remained open during 2015 for the sale of salvage firewood. The Company Timber sale, located immediately south of the Beem Gulch sale, involved the construction of 3.0 mi (4.8 km) of new temporary road in 2015. At current status it is calculated that the 4.1 mi (6.6 km) of project roads remaining active for the two timber sales account for a temporary loss of 1.4 mi^2 (3.5 km^2) of secure habitat inside the GBRZ. This temporary reduction in secure habitat is below the maximum of 3.2 mi^2 (8.2 km^2) allowed for the Crandall-Sunlight bear management unit according to the 1% rule imposed for temporary changes in secure habitat.

Upper Wind River Vista Timber Sale (Shoshone National Forest): The *Vista Timber Sale was* initially approved in 2007 for the South Absaroka #3 subunit as part of the *Upper Wind River Vegetation Treatment Project*. Project approval was granted to expedite reduction of hazardous fuel in an at-risk timbered area south of Brooks Lake on the Wind River Ranger District of the Shoshone National Forest. Implemented in 2011, the Vista Timber Sale was broken up into three separate sales: Vista, Brooks Lake Creek, and Pinnacles Heights. During 2011–2014 approximately 0.8 mi (1.3 km) of new temporary project roads were constructed and an additional 2.2 mi (3.5 km) of previously restricted road (1.4 mi (2.2 km) inside and 0.8 mi (1.3 km) outside the GBRZ) were reactivated to gain motorized access to timber units. By the close of 2015, all 0.8 mi of new project roads have been permanently closed to all motorized traffic, however, the total length of reactivated routes (2.2 mi) remain gated and closed to the public but accessible to administrative personnel. Upon project termination, reactivated project roads occurring inside the recovery zone will be closed to all motorized traffic, including administrative use. The remaining 0.8 mi (1.3 km) of reactivated road occurring immediately outside the GBRZ will remain open for administrative purposes indefinitely, but will be gated and closed to the public. At current status, it is calculated that the 1.4 mi of project roads remaining active inside the GBRZ impose a temporary loss of 0.11 mi^2 (0.28 km^2) of secure habitat. This temporary reduction in secure habitat is below the maximum of 3.5 mi^2 (9.1 km^2) allowed for the South Absaroka bear management unit according to the 1% rule imposed for temporary changes in secure habitat.

Table A5. *Temporary projects inside the Grizzly Bear Recovery Zone, 2015.*

Bear Management	Area ($miles^2$) (excluding major lakes)		Project Name and Admin Unit	Secure Habitat ($miles^2$)			Project Status 2015
	Subunit [1]	Maximum change Allowed [2]		2015 without project	2015 with project	Area affected	
Buffalo-Spread Creek #1	219.9	NA	**Grouse Mountain** (Bridger-Teton NF)	194.9	194.9	0.00	Closed
Buffalo-Spread Creek #2	**507.6**	**5.1**		**377.5**	**377.5**	**0.0**	
Crandall-Sunlight #1	129.8	NA	**Beem Gulch / Company** (Shoshone NF)	106.2	106.2	0.00	Active
Crandall-Sunlight #2	316.2	NA		260.5	260.5	0.00	
Crandall-Sunlight #3	**221.8**	**3.2**		**178.9**	**178.5**	**0.4**	
South Absaroka #1	163.2	NA	**Upper Wind River Vista Timber Sale** (Shoshone NF)	161.9	161.9	0.00	Active
South Absaroka 2	190.6	NA		190.3	190.3	0.00	
South Absaroka #3	**348.3**	**3.5**		**337.2**	**337.1**	**0.1**	

(1) Subunits affected by a temporary project are highlighted in gray.
(2) The maximum allowable temporary reduction in secure habitat is 1% of the area of the largest subunit within the BMU.

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Appendix B

National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Monitoring Whitebark Pine in the Greater Yellowstone Ecosystem

2015 Annual Report

Natural Resource Report NPS/GRYN/NRR—2016/1146

Monitoring Whitebark Pine in the Greater Yellowstone Ecosystem

2015 Annual Report

Natural Resource Report NPS/GRYN/NRR—2016/1146

Authors

Greater Yellowstone Whitebark Pine Monitoring Working Group
2327 University Way, Ste. 2
Bozeman, Montana 59715

Prepared by

Erin Shanahan
Greater Yellowstone Inventory and Monitoring Network
National Park Service
2327 University Way, Suite 2
Bozeman, Montana 59715

Editor

Sonya Daw
National Park Service
Inventory and Monitoring Program
Science Writer/Editor
Flagstaff, AZ 86001

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U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Report Series is used to disseminate comprehensive information and analysis about natural resources and related topics concerning lands managed by the National Park Service. The series supports the advancement of science, informed decision-making, and the achievement of the National Park Service mission. The series also provides a forum for presenting more lengthy results that may not be accepted by publications with page limitations.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols. This report received formal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data, and whose background and expertise put them on par technically and scientifically with the authors of the information.

This report is available in digital format from the Greater Yellowstone Network website (http://science.nature.nps.gov/im/units/gryn/index.cfm), and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/nrpm/). To receive this report in a format optimized for screen readers, please email irma@nps.gov.

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Appendix C

Defining and Assessing Trend Using Mark-Resight Estimates for the Number of Female Grizzly Bears with Cubs-of-the-Year in the Greater Yellowstone Ecosystem

Final Report to the Interagency Grizzly Bear Study Team

Christopher P. Peck
Department of Mathematical Sciences
Montana State University

May 11, 2016

Abstract

Population trend analysis is commonplace for researchers tasked with monitoring species and assessing the success of conservation efforts. Though the definition and estimation of a trend are linked, it is not uncommon for trends to go undefined in ecological publications. This in turn can have a deleterious effect on the transparency of statistical results informing management decisions. In an effort to shift this paradigm, we present an overview of methods used to assess trend found within ecological literature and connect them to formally defined trends. The motivating example for this paper concerns the number of female grizzly bears with cubs-of-the-year (FCOY) in the Greater Yellowstone Ecosystem (GYE) based on yearly mark-resight data. Using posterior distributions of unmarked FCOY from a Bayesian latent multinomial model, we assess the ability to detect a true decline using computer simulation under several different definitions of trend. The preliminary results presented in this paper will hopefully serve as a catalyst for further study into the complex objective of detecting declines in the GYE grizzly bear population.

1 Introduction

> A trend is a trend is a trend.
> But the question is, will it bend?
> Will it alter its course
> Through some unforeseen force,
> And come to a premature end?
>
> Sir Alexander Cairncross

Monitoring trends in population size is an essential conservation tool for long-lived, slow-reproducing taxa, which are most susceptible to over-harvest (Garshelis et al., 2006). However, there does not appear to be a consensus regarding the best way to define and assess trends in the field of ecology. This challenge is often further perpetuated by a disconnect between the definition and the method used to assess and estimate a true trend in a population measure. As a result, trends taken to be self-explanatory may inhibit peer assessment of the appropriateness of the definition and/or method of assessment. The implications of monitoring trends are often far-reaching, such as informing decisions to list or delist an animal from the threatened or endangered species list. For this reason, it is important to be as clear and transparent as possible in the definition and assessment of trends so that management decisions can be made on the best available science.

We have two objectives in this paper. First, we present an overview of methods used to assess trend found within ecological literature and connect them to formally defined trends. Second, we motivate an example concerning the number of female grizzly bears with cubs-of-the-year (FCOY) in the Greater Yellowstone Ecosystem (GYE) based on data from aerial sightings and results from yearly mark-resight analyses. Using posterior distributions of unmarked FCOY from a Bayesian latent multinomial model, we assess the ability to detect a true decline using computer simulation under several different definitions of trend.

2 General Strategies for Assessing Trend

Although not exhaustive, we present an overview of some common methods used to assess trends in population size by researchers in the field of ecology. Additionally, we will attempt to highlight each method's strengths, weaknesses, and connection to a defined trend. To avoid potential misunderstanding regarding the meaning of trend, we will hereafter reserve the term trend to mean the true trend that we wish to model/estimate. For example, we may be interested in estimating the linear component of how the population size is changing over time, even though the process is likely more complex than that.

2.1 Linear Model

The simplest of trends, the linear trend, is defined as a constant change in the response variable (e.g., yearly counts of FCOY) for a specified period of time. The linear trend is commonly estimated by the slope parameter of the least-squares line and evidence for non-zero linear trends can be assessed using a t-test if assumptions are adequately met. The method's simplicity and natural interpretation of the estimated slope parameter make it an attractive option for many researchers. Inferential objectives for this method are twofold: (i) assessing evidence for non-zero linear trend and (ii) estimating the magnitude and uncertainty of the linear trend. This method is generally applied to shorter time series (less than 15 years) but application to longer series is not uncommon (e.g., Holmes et al. (2001) investigated 30 year trends of forest birds in New Hampshire using linear regression). One potential drawback of the linear trend is the biologically unrealistic assumption of constant change in the response for the time period considered. However, this assumption may be realistic enough for the beginning years of long-term monitoring programs.

2.2 Exponential Model

The exponential growth trend is defined as a constant multiplicative change in the response variable over a specified period of time (Figure 1). This is equivalent to a so-called log-linear trend, which is defined as a constant additive change in the logarithm of the population size for a specified period of time. This reformulation allows the log-linear trend to be estimated by the slope parameter of the least-squares line after log transformation of the population size. The exponential growth trend is common in ecological literature because it is a standard model used to describe the growth of a single population in the field of population ecology. The exponential growth trend can be defined in terms of the instantaneous growth rate (λ) and this parameter can be estimated by the exponentiated slope coefficient from a log-level model fit to a specified period of time. A benefit of defining trend in terms of λ is many management officials are familiar with the parameter and its connection to population growth. However, because there are several mathematical definitions of λ in this field, it is imperative that any use of λ be accompanied by a formal definition.

The exponential growth trend also makes the potentially unrealistic assumption of constant change but this may be useful in some applications. Furthermore, both linear and exponential growth trends are commonly estimated using methods that assume observations are independent. Time series almost always violate this assumption but methods exist to account for the presence of autocorrelation. For example, Chaloupka et al. (1999) account for autocorrelated errors in the log-level model by including a second order moving average error term in their assessment of a linear trend in humpback whale abundance. By explicitly incorporating the temporal autocorrelation, the authors avoid overstating uncertainty in the estimated

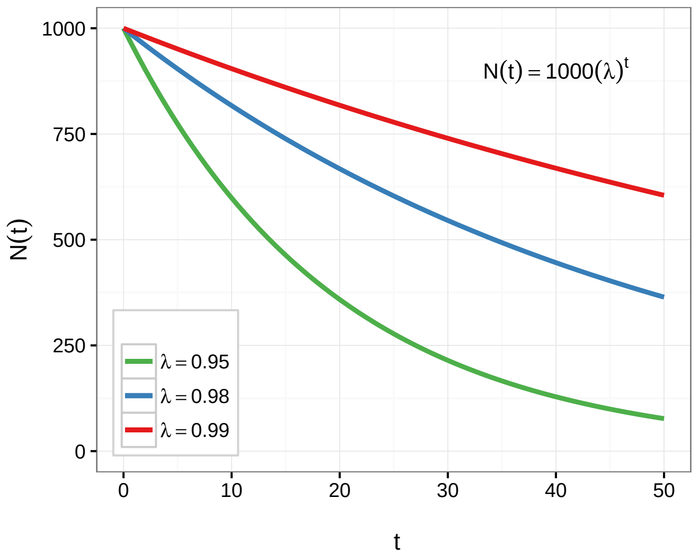

Figure 1: Example of exponential growth trend with $\lambda \in \{0.95, 0.98, 0.99\}$.

log-linear trend due to the presence of negative autocorrelation.

There are several instances of the exponential model applied to the *Ursus* genus: Swedish brown bears (Swenson et al., 1994; Kindberg et al., 2011), North American black bear (Garshelis et al., 2006), and grizzly bears in GYE (Knight et al., 1995).

2.3 Generalized Additive Model

Wood (2006) defines the generalized additive model (GAM) as a generalized linear model with a linear predictor that involves the sum of smoothed functions of covariates. GAMs are often hallowed for their flexibility and ability to avoid, either explicitly or implicitly, making assumptions about the parametric form of the function to be fitted to the time series (Crawley, 2012). That being said, there is no immediately obvious definition of trend in terms of a model parameter that can be estimated by GAMs since parameter estimates are not returned. This could prove problematic if management plans require a definition and method be explicitly stated in monitoring protocols.

Further complications arise when deciding upon the appropriate degree of smoothing. Although cross-validation methods exist to provide 'optimal' smoothness under some criteria (loss function), it is difficult to assess how the degree of smoothness affects the estimates of a defined trend. Furthermore, like all smoothers, GAMs are subject to end effects which is particularly problematic if that is the part of the series we are most interested in. Although GAMs appear to be less than ideal for the purposes of estimating trends, they can be useful as a statistical tool used to explore potential functional relationships in the response. For example, Donner et al. (2008) use a GAM for the purposes of a change point analysis where they identified key points of change in the gradient of fitted values to describe changes in the population of Kirtland's warblers over time.

The recent application of GAMs in ecological literature has primarily been in the field of ornithology: farmland birds in the United Kingdom (Fewster et al., 2000; Freeman et al., 2001), male Kirtland's warblers in Michigan (Donner et al., 2008), and waterbirds in Great Britain and Northern Ireland (Atkinson et al., 2006). Additionally, Balazs et al. (2004) present a Bayesian GAM model to assess trends in Hawaiian green sea turtle nester abundance. All four analyses involve time series at least 25 years long and Atkinson et al. (2006) state the method "relies on extensive counts made over long-periods, a situation of data-richness that is unlikely to exist beyond a few NW European countries."

2.4 Additional Approaches

This section serves to provide a summary of additional modelling approaches found in the ecological literature, particularly those applied to the *Ursus* genus. We do not attempt to review any of these additional methods or connect them to a defined trend at this time. However, they may serve as a convenient starting-point for future efforts aimed at defining and assessing trend.

- Wiener-drift process yielding a lognormal probability distribution of population abundance (Dennis et al., 1991)
- Overview of using both MONITOR and TRENDS power analysis programs (Hatch, 2003) and Poisson regression using TRIM software package (Conrad et al., 2006)
- Kalman-filter framework of structural time-series models (Visser, 2004) and applied use of TrendSpotter software (developed by H. Visser) to waterbird monitoring data (Soldaat et al., 2007)
- Theil's non-parametric test based on log-mean count annual indices (Morrison et al., 1994)
- Pradel models implemented in MARK for DNA mark-recapture data from grizzly bears in Northern Continental Divide Ecosystem (Stetz et al., 2010) and British Columbia (Boulanger et al., 2004)
- Spatial and temporal trends in harbour porpoise using MCMCglmm in R (Peschko et al., 2016)
- Finite rate of increase ($\lambda = N_{t+1}/N_t$) using a revised Lotka equation for grizzly bears in the Swan Mountains, MT (Mace et al., 1998) and Yellowstone (Eberhardt et al., 1994)
- 3-year moving average using Bayesian latent multinomial model (Higgs et al., 2013)

2.5 General Oversights

Regardless of the definition of trend, it is not uncommon for researchers to fail to keep reference to the number of years the trend is defined for. This is particularly important when estimating short-term trends because the number of data points informing the estimate can be influential. When comparing results from several definitions is of interest, failure to maintain this reference may lead to unwarranted or misleading comparisons.

3 Motivating Example

Management and government officials alike are interested in both the growth rate of GYE grizzly bears in the past and how the population is changing now (Harris et al., 2007). Formed in 1973, the Interagency Grizzly Bear Study Team (IGBST) is an interdisciplinary team of researchers responsible for research efforts on GYE grizzly bears. Under the Grizzly Bear Recovery Plan (USFWS, 1993), IGBSTs monitoring program includes both annually estimating the number of FCOY in the GYE population and assessing trend for this segment of the population (IGBST, 2014). FCOY are an easily recognizable cohort and changes in population size for this segment of the population will generally track changes for the population as a whole.

3.1 Current Protocol for Estimating FCOY

IGBST (2014) outlines the protocol for estimating population size from counts of unique FCOY in a given year. First, the number of unique FCOY from ground observations and aerial sightings is estimated using a rule set developed by Knight et al. (1995). This estimate of unique females provides a minimum annual estimate of FCOY in the population (Cherry et al., 2007). Using only FCOY observed within the Demographic Monitoring Area (Figure 2), the Chao2 estimator (Wilson et al., 1992; Keating et al., 2002) is applied to sighting frequencies estimated by the rule set for each unique family. The result is an estimate of the total FCOY present in the population. It should be noted that simulation studies indicate that the rule set of Knight et al. (1995) inherently underestimates known numbers of unique FCOY (Schwartz et al., 2008), which makes sense given that it was meant to estimate a minimum. Furthermore, simulations suggest an additional, but smaller, source of underestimation bias comes from the Chao2 estimator itself (Wilson et al., 1992; Keating et al., 2002; Cherry et al., 2007).

3.2 Mark-Resight Method

In an attempt to obtain more reliable inference for FCOY abundance, Higgs et al. (2013) propose a mark-resight approach utilizing a Bayesian latent multinomial

Figure 2: According to IGBST (2014), only FCOY observed within the Demographic Monitoring Area will be used for population estimation.

model for inference. IGBST has conducted two standardized observation flights within Bear Observation Areas (Figure 2) per year since 1997. Each year, the number of marked FCOY sighted zero, one, and two times, and the total number of sightings of unmarked FCOY are recorded. Using a common sightability model, assuming homogeneity in sighting probabilities over all previous sampling occasions (years), and data obtained from aerial surveys each year, we obtain a yearly posterior distribution for population size of unmarked FCOY.

3.3 Research Question

The IGBST has identified the years 2002-2015 of particular interest. This decision was motivated by demographic analyses which indicated a slowing of population growth due to changes in vital rates during 2002-2011 compared to 1983-2001 (IGBST, 2012). The study team is interested in examining the following question regarding the application of the mark-resight estimator: assuming that the population of unmarked FCOY has been stable for the years of 2002-2015 (the so-called 'plateau phase'), can we detect a decline in the population of {1%, 2.5%, 5%} per year after {5, 10, 15, 20} years time? To address this question, we will begin by providing several potential definitions of trend followed by an assessment of our ability to detect a decline in the number of FCOY in the population using simulation.

3.4 Defining Trend

Before proceeding with any analyses, we will present several definitions of trend and justify the appropriateness of their application to FCOY monitored by the IGBST. Note that all of the following definitions represent different mathematical definitions of change in population size. As introduced in Section 2.2, the exponential growth model is commonly used in ecology to model the growth (and decline) of populations. Furthermore, the instantaneous rate of population change is the parameter of interest in IGBSTs current trend assessment protocol (IGBST, 2014).

> **Definition 1.** instantaneous rate of FCOY population change (λ) assuming exponential growth over a specified number of years

An important facet of this definition to keep in mind, and all remaining definitions, is the explicit number of years for which trend is defined. The exponential growth model can be expressed mathematically as

$$N_{u,t} = N_{u,1} \cdot \lambda^t, \tag{1}$$

where $N_{u,t}$ is equal to the number of unmarked FCOY at time t. Taking the natural logarithm of each side yields

$$\ln(N_{u,t}) = \ln(N_{u,1}) + t \cdot \ln(\lambda). \tag{2}$$

The structural form of Equation 2 indicates that λ may be estimated by the exponentiated slope coefficient from the least-squares regression of $\ln(N_{u,t})$ on t. It should be noted that this is not the only method available for estimating this definition of λ but it is the method that we will proceed with. A direct result of the definition is λ values less than 1 imply the population is experiencing decline. Therefore, we will be interested in computing the posterior probability of $\lambda < 1$ for each time frame considered.

Harris et al. (2006) consider two alternative definitions of the 'population trajectory' summary statistic λ:

> **Definition 2.** the geometric mean of the n ratios of unmarked FCOY in $n+1$ successive years

> **Definition 3.** the arithmetic mean of the n ratios of unmarked FCOY in $n+1$ successive years

Both definitions define the ratio of unmarked FCOY in successive years in terms of the finite rate of increase

$$\lambda_f(t) = \frac{N_{u,t+1}}{N_{u,t}}, \tag{3}$$

which assumes exponential growth for each successive 1 year period. The geometric mean of n ratios of unmarked FCOY in $n+1$ successive years can be computed as

$$\bar{\lambda}_2 = \left(\prod_{i=1}^{n} \frac{N_{u,\,i+1}}{N_{u,\,i}} \right)^{\frac{1}{n}} = \left(\frac{N_{u,\,n+1}}{N_{u,\,1}} \right)^{\frac{1}{n}}. \tag{4}$$

Note that the geometric mean can be alternatively expressed as the exponentiated arithmetic mean of the log-transformed ratios of unmarked FCOY

$$\bar{\lambda}_2 = \exp\left[\frac{1}{n} \sum_{i=1}^{n} \ln\left(\frac{N_{u,\,i+1}}{N_{u,\,i}} \right) \right]. \tag{5}$$

Additionally, the arithmetic mean for n ratios of unmarked FCOY in $n+1$ successive years can be computed as

$$\bar{\lambda}_3 = \frac{1}{n} \sum_{i=1}^{n} \frac{N_{u,\,i+1}}{N_{u,\,i}}. \tag{6}$$

For either estimate, we are interested in computing the posterior probability of $\bar{\lambda} < 1$ for each time frame considered. By taking the geometric or arithmetic mean of the λ_f's, we obtain a measure of average finite rate of increase for the time period under consideration. This can be thought of as an extreme case of smoothing over the specified time period.

Instead of assuming exponential growth, we can alternatively consider the annual linear rate of change in population size.

> **Definition 4.** an annual rate of linear FCOY population change over a specified number of years

We will investigate the annual linear rate of population change as estimated by the least-squares regression slope coefficient (β_1) of $N_{u,\,t}$ on t. Given this definition, we will be interested in the posterior probability of $\beta_1 < 0$ for each time frame considered.

4 Methods

4.1 Simulating FCOY

In order to simulate realizations of FCOY consistent with mark-resight sampling, we will use R (R Core Team, 2016) and the `griz_sim_Fcoy()` function from the `grizzly` package written by Michael Lerch for IGBST. The user must provide the function with the following arguments:

- `unmarked_total`: vector of true number of unmarked FCOY in each year
- `marked_total`: vector of true number of marked FCOY in each year

- `detect_prob`: sighting probabilities $\boldsymbol{\pi} = (\pi_0, \pi_1, \pi_2)$ where π_0, π_1, and π_2 represent the probability that an unmarked FCOY is sighted 0 times, 1 time, and 2 times in a given year.

To define `unmarked_total`, we assume the population of FCOY is not changing from 2002-2015 (i.e., the 'plateau phase') followed by a decrease of (1%, 2.5%, 5%) per year (rounded to nearest integer) for 20 years. The simulated true number of unmarked FCOY during the period of 2002-2015 was set to 70, which seems reasonable given the posterior distributions of unmarked FCOY during the period 2002-2012 (Figure A.1) reported in Table 2 of Higgs et al. (2013). Furthermore, assuming a total of 70 FCOY resulted in simulated numbers of sightings similar to those observed in practice.

To define `marked_total`, we assume that IGBST maintains a constant year-to-year count of marked FCOY. The maximum number of marked FCOY for the entire region (excluding moth aggregation sites) for years 2002-2014 was 10 (Higgs et al., 2013), which we use as a "best-case scenario". Finally, we define `detect_prob` to be equal to the sighting probabilities specified by IGBST: $\boldsymbol{\pi} = (0.70, 0.25, 0.05)$, which approximates the proportion of marked bears observed zero, one, and two times over all years since 1997.

4.1.1 Simulation Assumptions

Given that all results derived from this simulation are dependent on the assumptions made in simulating the hypothetical realizations, we take this opportunity to explicitly summarize and justify the assumptions for the reader.

First, the sighting probabilities $\boldsymbol{\pi}$ are assumed to be constant year-to-year and identical for both marked and unmarked FCOY. In practice, sighting information is pooled across years since the information from any given year is very limited given the relatively small number of marked FCOY and the low sighting probability. Second, the number of marked FCOY remains constant for the entire time period considered. Although a simplifying assumption, we believe it is reasonable since the number of marked females has remained relatively constant over time despite changes in the population size. Third, we simulate a multiplicative decline in unmarked FCOY using the following equation

$$N_{u,t} = 70 \cdot \lambda^t \qquad t = 1, \ldots, 20\,, \tag{7}$$

where $N_{u,t}$ is rounded to the nearest integer and $\lambda \in \{0.99, 0.975, 0.95\}$. Assuming a multiplicative decline in the population of unmarked FCOY is consistent with current IGBST methods of assessing trend in FCOY. However, Equation 7 intrinsically assumes the multiplicative decline is constant across years. While this is not a realistic assumption, it is necessary to assess ability to detect a decline of {1%, 2.5%, 5%} per year after {5, 10, 15, 20} years time.

Typically when considering trend, we are simulating a decline in the population size due to death of individuals. The FCOY trend is not only based on annual survival, but also on annual reproduction rates. Furthermore, female grizzly bears reproduce, on average, every three years. Therefore, a bear who is an FCOY one year may still be alive the following year, but unlikely as an FCOY. To remedy this, we could simulate a decline in the number of female grizzly bears each year through the use of a Markov process with transition probabilities for mortality and reproduction. Sighting probabilities could then be sampled each year from Dirichlet(62.5, 18.5, 1.5) (Higgs et al., 2013) which would be applied to the subset of females that have cubs. Although there are numerous ways to simulate more realistic data, we believe the results presented in this paper represent a useful starting point.

4.2 Estimating FCOY

We used the Gibbs sampler outlined in Section 3.3 of Higgs et al. (2013) to estimate the number of unmarked FCOY using the realizations of simulated FCOY from Section 4.1. An implementation of the Gibbs sampler is available via the `griz_Fcoy_sampler()` function in the `grizzly` package. For each realization, the sampler was run for 100,000 iterations, saving every fifth iteration. Preliminary runs indicated the number of iterations was sufficient to feel comfortable with convergence, as assessed by the Gelman and Rubin Statistic $\widehat{R}$ and visual inspection of the traceplots. The posterior distributions of unmarked FCOY for each year ($N_{u,t}$) are then obtained after removing the first 500 saved draws, for a total of 19,500 used to approximate each posterior distribution.

4.3 Posterior Distribution of Estimated Trend

As stated previously, we obtain posterior distributions of unmarked FCOY for each year of the simulation. Given the posterior distributions for N_u, the posterior distribution for $g(N_u)$ is completely specified (Link et al., 2009). In other words, we can obtain a posterior distribution of the estimated trend so long as it is defined as a function of the posterior distributions for N_u.

Using the ith posterior draw from each independent posterior distribution of unmarked FCOY, we obtain a time series of length 20 years. Using all posterior draws yields 19,500 time series where each individual series can be interpreted as a series of point estimates of yearly unmarked FCOY that could have resulted from the realization of simulated FCOY. To each individual series, a summary measure $g(N_u)$ used to estimate a defined trend will be computed for varying lengths of time (e.g., first five years, first ten years, etc). Saving the estimated parameter from each draw results in a posterior distribution for that parameter for the specified number of years. From this posterior distribution we can compute the posterior probability of interest related to population decline.

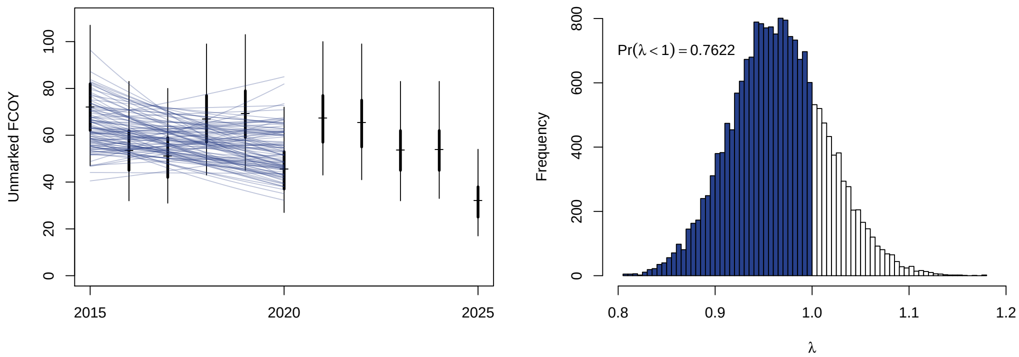

Figure 3: (Left) Posterior distributions of N_u for the first 10 years of data simulated under a 1% yearly reduction in population size beginning with 70 unmarked FCOY. Back-transformed log-level regression lines displayed for a random sample of 100 posterior draws. (Right) Posterior distribution of λ defined for the first 5 years with posterior probability of $\lambda < 1$ displayed.

4.3.1 Posterior of Derived Parameter Example

Here, we outline the steps taken to obtain the posterior distribution of λ for a realization of 20 years of data under a 1% yearly reduction in population size beginning with 70 unmarked FCOY. Figure 3 displays the posterior distributions of N_u from the latent multinomial model for the first 10 simulated years. For this example, we will focus on λ defined for the first 5 years and fit a log-level regression to every 5-year series of posterior draws of N_u. The back-transformed log-level regression lines for a random sample of 100 posterior draws are displayed in Figure 3. For each log-level regression, we compute the derived parameter λ as the exponentiated slope coefficient. Collectively, all 19,500 derived values of λ make up the posterior distribution of λ (Figure 3) from which posterior quantities of interest (e.g., $\Pr(\lambda < 1)$) can be readily computed.

5 Results

5.1 Exponential Rate of Change (λ)

We observe, as expected, our ability to detect the true decline increases both with increasing number of years of decline considered and increasing percent decline per year. From a practical management perspective, IGBST is interested in the ability to detect declines after at most 10 years. There is poor ability to detect declines after 5 years, regardless of the yearly percent decline, as evidenced by the wide range of posterior probabilities (Figure 4). Considering 10 years also indicates poor ability

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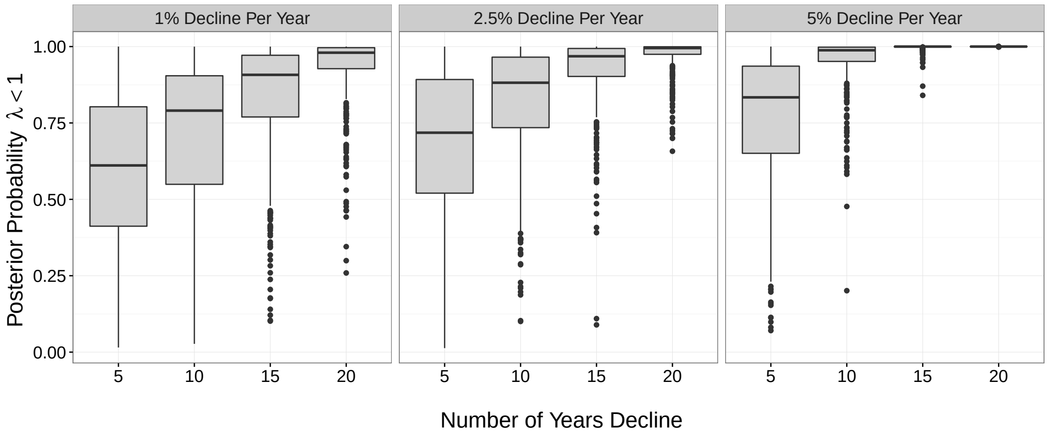

Figure 4: Boxplots of posterior probabilities of $\lambda < 1$ for 500 realizations at each specified percent decline and t years of decline.

to detect declines of 1% and 2.5% per year and moderate ability for a 5% per year decline.

5.2 Geometric Mean ($\bar{\lambda}_2$)

We observe wider ranges of posterior probabilities compared to the posterior probabilities for λ (Figure 4). Ability to detect a true decline after 5 or 10 years is poor, regardless of the percent decline considered.

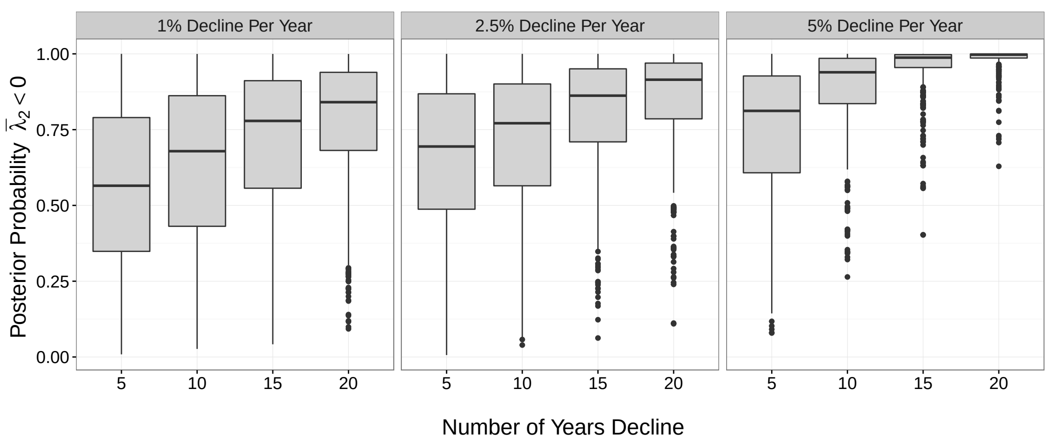

Figure 5: Boxplots of posterior probabilities of $\bar{\lambda}_2 < 1$ for 500 realizations at each specified percent decline and years of decline.

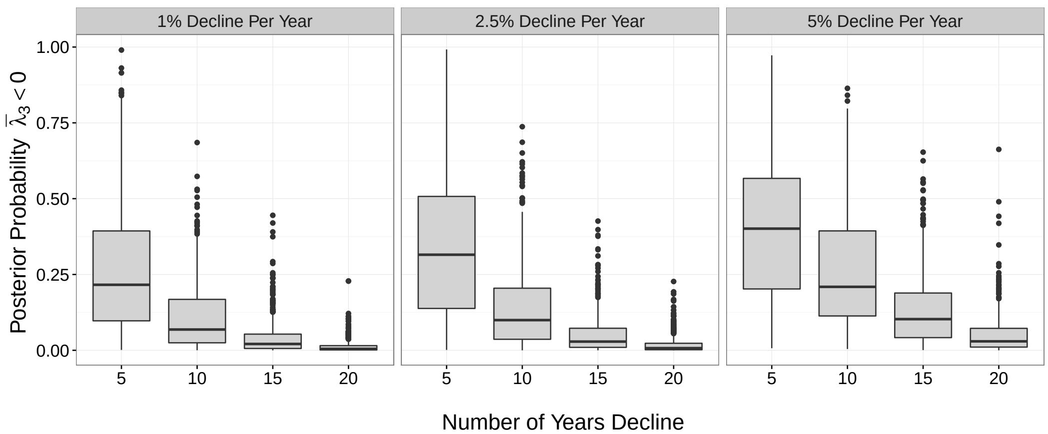

Figure 6: Boxplots of posterior probabilities of $\bar{\lambda}_3 < 1$ for 500 realizations at each specified percent decline and years of decline.

5.3 Arithmetic Mean ($\bar{\lambda}_3$)

It is immediately apparent that the ability of $\bar{\lambda}_3$ to detect a true decline is extremely poor. Additionally, we observe that increasing the number of years considered further decreases the detection accuracy. While seemingly counterintuitive, this result is a product of the year-to-year variability inherent in the posterior distributions. For example, consider the random sample of 20 posterior draws from one simulated realization (Figure A.2). It is clear that some yearly ratios result in values much greater than 1, which in turn inflates $\bar{\lambda}_3$. By considering longer periods of decline, we in turn increase the instances of ratios greater than 1 which lowers our ability to detect decline based on the posterior probability of $\bar{\lambda}_3 < 1$.

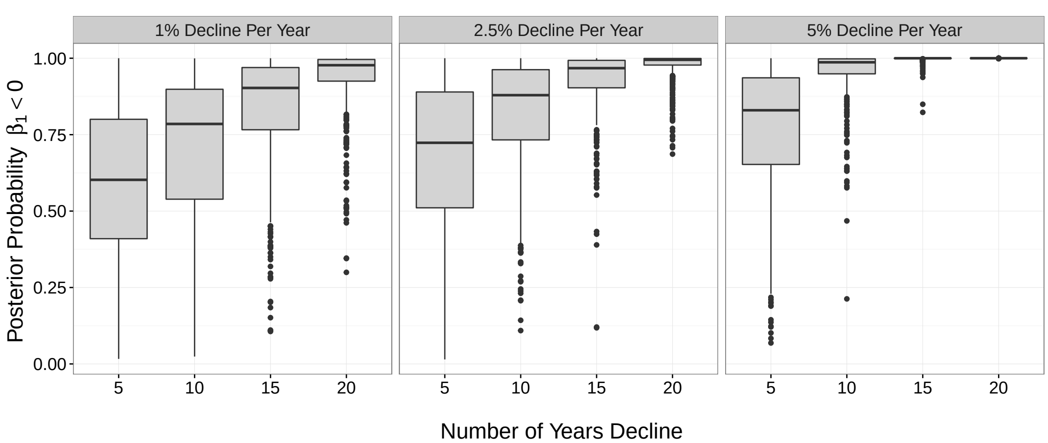

Figure 7: Boxplots of posterior probabilities of $\beta_1 < 0$ for 500 realizations at each specified percent decline and t years of decline.

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5.4 Linear Rate of Change (β_1)

Again, we observe poor ability to detect declines after 5 years, regardless of the yearly percent decline. The 10 year period also indicates poor ability for declines of 1% and 2.5% per year and moderate ability for a 5% per year decline. The exponential trend underlying the simulation is not distinguishable from linear due to the lack of curvature, so both λ and β_1 definitions are nearly identical in their ability to detect the true decline.

5.5 Direct Comparisons

As mentioned previously, the ability to detect declines after 5 or 10 years is practically meaningful from a management perspective. Accordingly, we present a more direct comparison of detection ability among the mathematical definitions of trend considered (Figure 8).

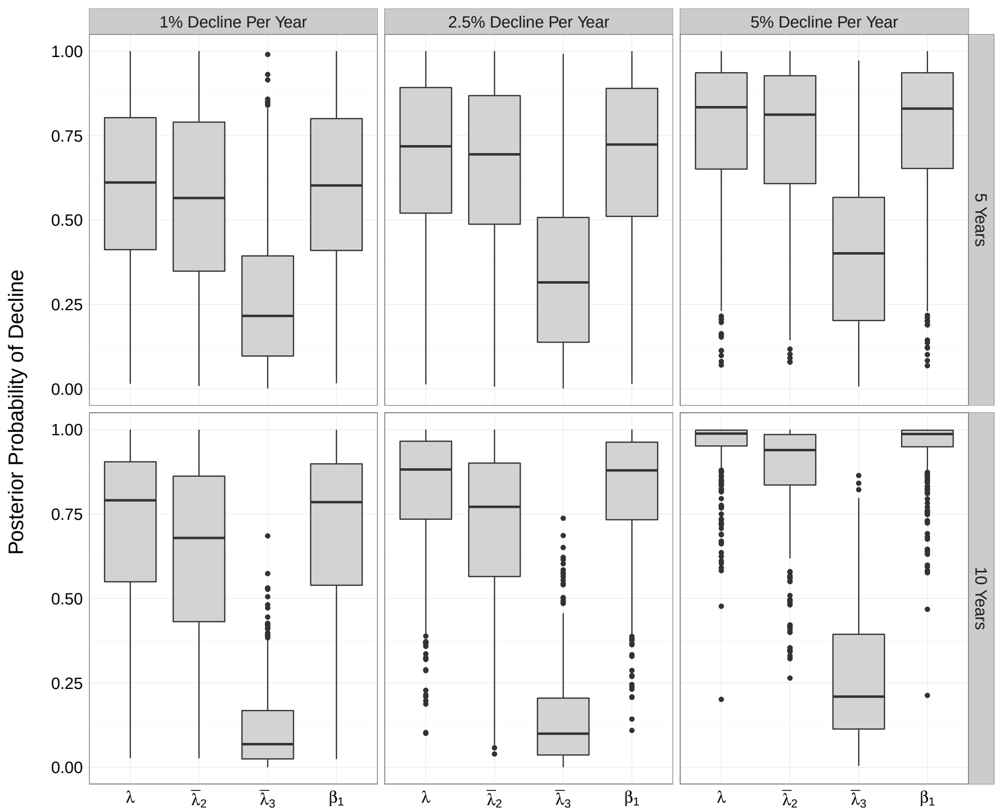

Figure 8: Comparison of posterior probabilities of decline across mathematical definitions of trend. Each boxplot contains 500 realizations at each specified percent decline (columns) and years of decline (rows).

6 Discussion

6.1 Connections to Traditional Power Curves

Had we considered some cutoff value c indicative of ability to capture true decline (e.g., $c = 0.9$), we could compute the number of realizations out of 500 resulting in a posterior probability greater than c. This would result in curves similar to traditional 'power curves' in each of the facets of Figures 4–6. However, we chose not to disseminate the results in this manner for two reasons. First, the choice of the cutoff value c is arbitrary (see Section 6.2 for discussion). Second, by observing the raw posterior probabilities, we can visually assess the variability in our ability to detect trend. For example, consider the posterior probabilities from two hypothetical definitions of trend, each containing 33 realizations (Figure 9). If we consider the cutoff $c = 0.85$, we would conclude that both have similar ability to detect a true decline since both have 11 out of 33 realizations that were above $c = 0.85$. However, it is clearly evident that the left boxplot is inferior in its ability to detect a true decline due to its variability as compared to the right boxplot. For this reason, we decided the raw posterior probabilities are not only more useful in assessing ability to detect trend, but it also better aligns with our belief in transparency. We do, however, recognize that a cutoff may have to be implemented in order to make management decisions.

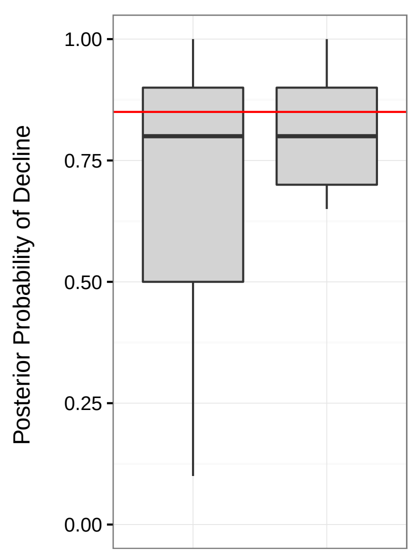

Figure 9: Hypothetical situation in which assessment of ability to detect trend may be less informative if we consider the number of realizations above the cutoff value $c = 0.85$ (red horizontal line) instead of observing the raw posterior probabilities.

6.2 Cutoff Value Considerations

The choice of a cutoff value c is technically arbitrary. However, this does not imply that the selection of a cutoff value should be made without considerable thought concerning its implications from a management perspective. For example, we can think about each posterior draw as a hypothetical mark-resight time series of N_u that could be observed given the observed sighted counts. We can then ask questions such as "what proportion of the 19,500 hypothetical time series would need to indicate a decline for managers to feel comfortable or confident concluding the population is in decline?"

6.3 Autocorrelation

Since the data were simulated in the absence of autocorrelation and the latent multinomial referenced in Section 4.2 obtains results for each year separately, we did not pursue time dependence in our estimation of trend. Additionally, an ACF plot of the observed FCOY counts during 1997–2012 does not indicate strong autocorrelation within the series (Figure A.3).

This naturally begs the question of whether or not incorporating autocorrelation into the estimate of a defined trend is appropriate in this particular application. If positive autocorrelation is expected, then incorporating autocorrelation will improve ability to detect the trend. However, it is important to remember that in these simulations we are introducing an unrealistic process (see Section 4.1.1). Therefore, the combination of not accounting for autocorrelation and having an unrealistic process might balance each other out somehow. Regardless, we encourage a thorough investigation of trend detection sensitivity in the presence of time dependence in future work. In particular, the implications of both positive and negative autocorrelation on more realistic simulations of the underlying process should be explored.

6.4 Additional Considerations

The practicality of the results presented in Section 5 are constrained by the assumptions made in Section 4.1.1. Lack of verity to the true underlying process of female grizzly bear reproduction and large uncertainty in posterior distributions of N_u pose the greatest impediments.

The general lack of ability to detect a true decline can be primarily attributed to the amount of uncertainty present in the posterior distributions of unmarked FCOY. A primary source of uncertainty in the posterior for N_u is the uncertainty in the estimates of the sighting probabilities $\boldsymbol{\pi}$. This is largely due to the low number of marked females in the population. However, increasing the number of marked females is a non-trivial task subject to many logistical and bureaucratic constraints.

7 Conclusion

In this paper, we summarized common methods used to assess trends in population size and connected them to formally defined trends. As a motivating example, we provided an assessment of trend detection ability based on several different definitions using simulated realizations of FCOY consistent with mark-resight sampling. We observed poor ability to detect a true decline within a practically meaningful time frame across all definitions of trend considered. This, however, represents only a preliminary investigation of the ability to detect trends in FCOY within the GYE. We hope this paper serves as a catalyst for further study of this complex research objective.

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A Supplementary Figures

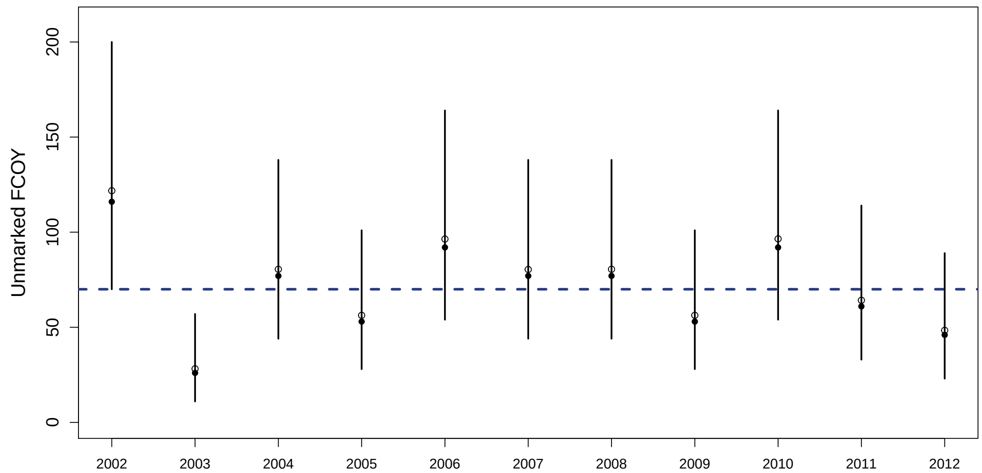


Figure A.1: Posterior means (open circles) and medians (closed circles) for total unmarked FCOY from the latent multinomial model based on data presented in Table 2 of Higgs et al. (2013). Horizontal dashed line set at 70 unmarked FCOY.

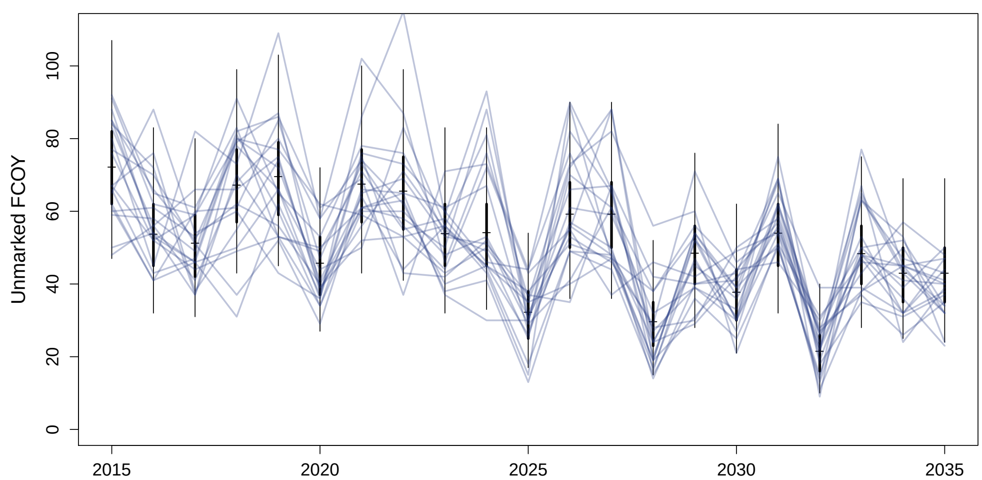


Figure A.2: Traces of 20 random posterior draws for a realization of 20 years of data under a 1% yearly decline in population size beginning with 70 unmarked FCOY. Each trace comprises the ith draw from each posterior distribution connected across the 20 year time period.

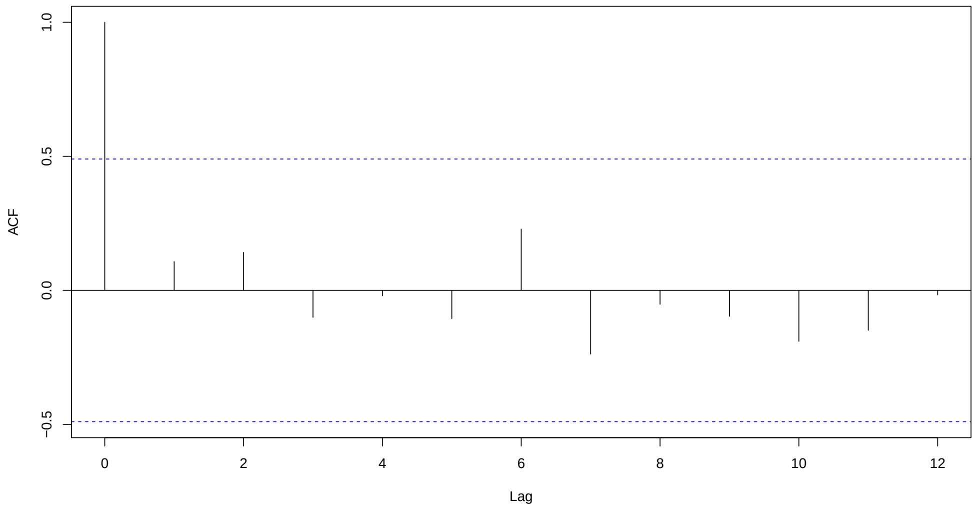


Figure A.3: ACF plot of observed FCOY counts (marked + unmarked) during 1997–2012 as given in Table 1 of Higgs et al. (2013).

Appendix D

2015 Wyoming Bear Wise Project Update

Dusty Lasseter, Bear Wise Community Coordinator, Wyoming Game and Fish Department

Introduction

The Bear Wise Community Program is a proactive initiative that seeks to minimize human-bear (black and grizzly) conflicts, minimize management-related bear mortalities associated with preventable conflicts, and to safeguard human communities in northwest Wyoming. The overall objective of Bear Wise is to promote individual and community ownership of ever-increasing human-bear conflict issues, moving toward creating a social conscience regarding responsible attractant management and behavior in bear habitat. This project seeks to raise awareness and proactively influence local waste management infrastructures with the specific intent of preventing conflicts from recurring. Strategies used to meet the campaign's objectives are: 1) minimize accessibility of unnatural attractants to bears in developed areas; 2) employ a public outreach and education campaign to reduce knowledge gaps about bears and the causes of conflicts; and 3) employ a bear resistant waste management system and promote bear-resistant waste management infrastructure.

This report provides a summary of program accomplishments in 2015. Past accomplishments are reported in the 2006–2014 annual reports of the Interagency Grizzly Bear Study Team (IGBST) and in the 2011–2014 Annual Job Completion Reports of the Wyoming Game and Fish Department (WGFD).

Background

In 2004, a subcommittee of the IGBST conducted an analysis of causes and spatial distribution of grizzly bear mortalities and conflicts in the Greater Yellowstone Area (GYA) for the period of 1994–2003. The analysis identified that the majority of known, human-caused grizzly bear mortalities occurred due to agency management actions in response to conflicts (34%), self-defense killings, primarily by big game hunters (20%), and vandal killings (11%). The report made 33 recommendations to reduce human-grizzly bear conflicts and mortalities with focus on 3 actions that could be positively influenced by agency resources and personnel: 1) reduce conflicts at developed sites; 2) reduce self-defense killings; and 3) reduce vandal killings (Servheen et al. 2004).

To address action number 1, the committee recommended that a demonstration area be established to focus proactive, innovative, and enhanced management strategies where developed site conflicts and agency management actions resulting in relocation or removal of grizzly bears had historically been high. Spatial examination of conflicts identified the Wapiti area in northwest Wyoming as having one of the highest concentrations of black bear and grizzly bear conflicts in the GYA. The North Fork of the Shoshone River west of Cody was then chosen as the first area composed primarily of private land to have a multi-agency, public approach to reducing conflicts at developed sites.

In 2005, the Department began implementation of the Bear Wise Community Program. Although the program's efforts were focused primarily in the Wapiti area, the Department initiated a smaller scale project in Teton County to address the increasing number of black and grizzly bear conflicts in the Jackson, Wyoming area. For the last 9 years, the Bear Wise Community Programs in both Cody and Jackson have deployed a multi-faceted education and outreach campaign in an effort to minimize human-bear conflicts and promote proper attractant management. Although a wide array of challenges remain and vary between communities, many accomplishments have been made and progress is expected to continue as Bear Wise efforts gain momentum. In an effort to broaden the scope of the program, this work was rebranded as the Bear Wise Wyoming Program.

Wapiti Project Update

The Wapiti Bear Wise Community Program continues to use radio, television and print media, mass mailings, and the use of signing on private and public land to convey the educational messages surrounding human-bear conflict prevention. Conflict prevention information is also disseminated through public workshops and presentations and by contact with local community groups, governments, the public school system, and various youth organizations. To compliment educational initiatives, the program uses an extensive outreach campaign that assists the community in obtaining and using bear-resistant products and implementing other practical methods of attractant management. Ongoing efforts and new accomplishments for 2015 are as follows:

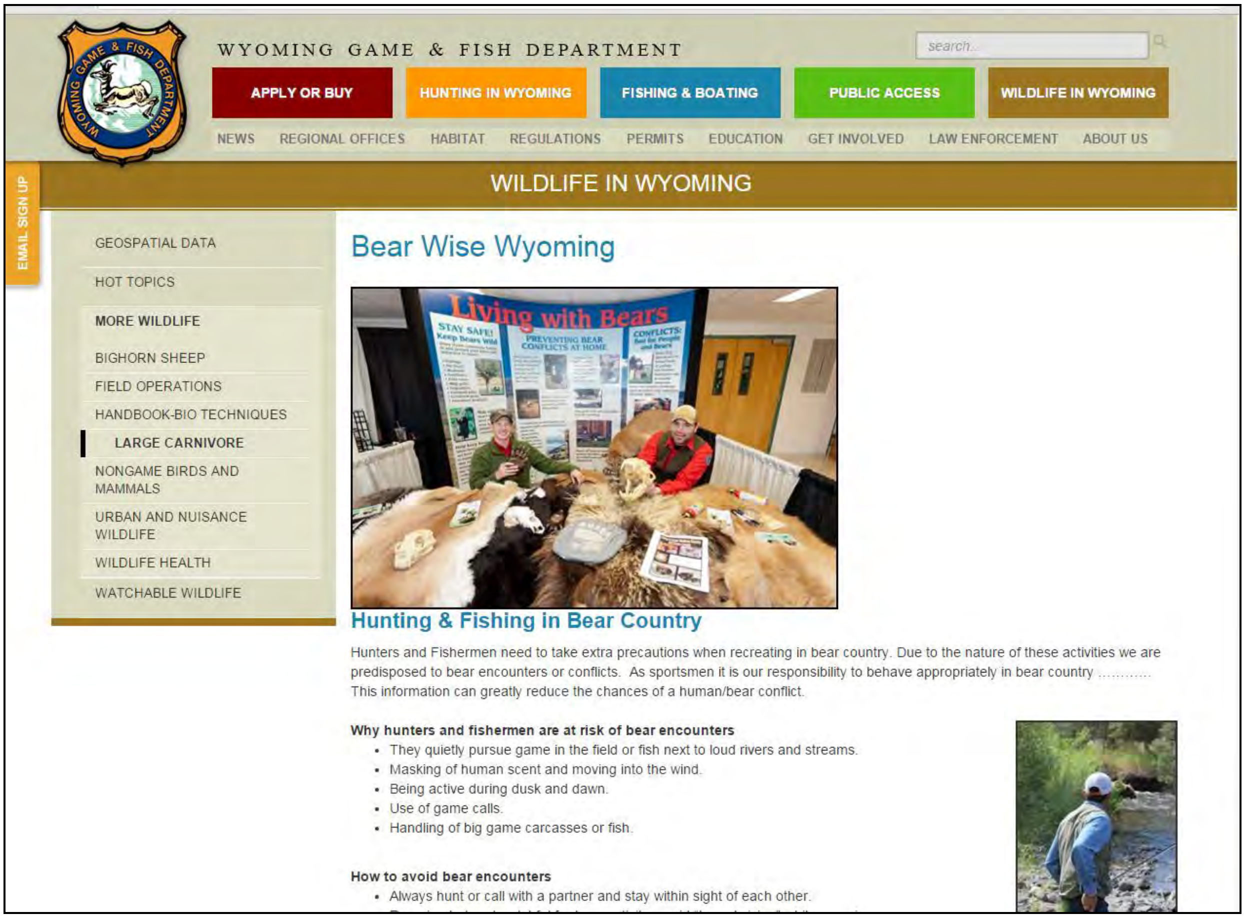
1. The Carcass Management Program continues to provide a domestic livestock carcass removal service for livestock producers located in occupied grizzly bear habitat within Park County, Wyoming. The program has been traditionally funded by the Park County Predator Management District and Wyoming Animal Damage Management Board. In addition to those donors, the program received contributions from Park County Commissioners, Wyoming Outdoorsmen, and the Memorial Bear Fund. The program provides livestock producers and owners with an alternative to the use of on-site carcass dumps, which are a significant bear attractant and indirectly contribute to numerous human-bear conflicts. Since June 2008, 755 domestic livestock carcasses have been removed from private lands. This year an article was published in the *International Bear News*, a publication of the International Association for Bear Research and Management, discussing the efficacy of the program.

2. Recommendations concerning the proper storage of garbage and other attractants are provided to the Park County Planning and Zoning Commission for new developments within the greater Cody area. The Coordinator reviews proposed developments on a case-by-case basis, attends monthly meetings, and contacts applicants directly to discuss conflict prevention measures. To date, these comments have been adopted as either formal recommendations or as a condition of approval for 19 new developments within Park County.

3. This year with grants from the Wyoming Outdoorsmen and Yellowstone Country Bear Hunters Association the Department was able to purchase 100 cans of bear spray to be distributed to sportsmen. The bear spray was handed out at the Cody Wyoming Game and Fish Check Station and was all cans were distributed in under an hour. Sportsmen where asked to voluntarily fill out a short survey to gather a better understanding how the Bear Wise program can better meet constituent needs.

4. The Wyoming Game and Fish partnership with the North Fork Bear Wise Group (NFBWG) continues to grow. The group is comprised of six local Wapiti citizens that meet monthly in order to articulate community needs and assist in the development of educational and outreach initiatives. The group met once a month for six month (during active bear season) and were instrumental in coming up with ideas on how to reduce human-bear conflicts.

5. As WGFD developed a new website for hunters and fishermen we were able to create a Bear Wise Wyoming page to better educate both resident and non-resident sportsmen and recreationists. In the future, this platform will be a key place to direct citizens who have questions about staying safe in bear country. https://wgfd.wyo.gov/Wildlife-in-Wyoming/More-Wildlife/Large-Carnivore/Grizzly-Bear-Management/Bear-Wise-Wyoming



6. Educational black bear/grizzly bear identification materials were distributed to individuals and to local sporting goods stores in the Cody, Pinedale, and Lander areas and mailed to black bear hunters who registered bait sites with the Department in areas surrounding the GYA.

7. Numerous informational presentations were given that focused on human-bear conflict prevention to audiences including the Park, Fremont, Hot Springs, and Big Horn County public school systems, homeowners associations, Boy Scouts, 4-H members, DANO, Paint Rock Hunter Management Program, guest ranches, and college students. Frequent one-on-one contacts were made during the 2015 conflict season in areas where the occurrence of human-bear conflicts has historically been high.

8. A "Working Safely in Bear Country" workshop was conducted for the Park County Weed and Pest District, Bureau of Land Management, Black Hills Energy, and British Broadcasting Corporation.

9. A booth containing information on bear identification, attractant storage, hunting and recreating safely in bear country, and the proper use of bear spray was staffed at the Lander Winter Fair, Cody Arbor Day, Dubois Museum Days, Lander Outdoor Expo, and Wyoming Outdoorsmen Banquet.

10. By utilizing the bear trailer, booths, workshops, and giving 50 presentations upon request, the Bear Wise program directly reached approximately 4,250 people in the Cody Region. Although the level of interaction differed from person to person, the added awareness to bears lessened conflicts.

11. The Department gave two interpretative hikes up the Elk Fork River on the Shoshone National Forest to discuss the ecology, management and conservation of the Yellowstone grizzly bear for the annual Cody Chambers sponsored Spring Into Yellowstone. These tours took approximately 5 hours and a good deal of bear sign was identified on the tour.

12. A public service announcement (PSA) was recorded by WGFD personnel on “Staying Safe in Bear Country” and broadcast over the radio in the spring and fall of 2015 on the Bighorn Basin Radio Network.

13. In the Cody Region, Large Carnivore Section (LCS) personnel erected 19 temporary electric fences around bee apiaries to minimize conflicts. There were also several electric fences temporarily placed around apple orchards to deter bears.

14. In the spring, LCS personnel put on 13 “Living in Large Carnivore Country” workshops across Wyoming. The objective of these workshops is to reach out to the public and give them the opportunity to learn how to live with bears, mountain lions, and wolves. In 2015 we gave presentations and hands on demonstrations to 250 attendees.

Pinedale Area Update

In 2011, a Bear Wise Community effort was initiated targeting residential areas north of Pinedale, Wyoming where the occurrence of human-bear conflict has increased in recent years. Accomplishments for the Pinedale area in 2015 are as follows:

1. The Department hosted “Living in Lion, Bear, and Wolf Country” workshops in Pinedale and Green River. Approximately 60 people attended the workshops.

2. Bear safety presentations were given to the Boy Scouts of America at “Camp Newfork”.

3. The Department secured donated materials to construct bear resistant meat storage poles. The Big Piney Ranger district erected 4 sets of meat poles in 2015 with the donated materials.

4. Hunting in Bear Country presentations were given to hunter safety classes throughout the Region.

5. A bear safety presentation was given to cowboys and sheepherders of two different grazing associations in the Region.

6. A bear safety presentation was given to staff members of the Sublette County Chamber of Commerce and Sublette County Visitor's Center.

7. A bear safety presentation was given to the Pinedale and Big Piney Ranger Districts of the United States Forest Service and the Pinedale office of the Bureau of Land Management.

8. A bear safety presentation was given to Sublette County Weed and pest workers and volunteers.

9. Multiple bear safety presentation were given to staff members of the Red Cliff Bible Camp.

10. The Department hosted a bear safety booth at Pinedale's Rendezvous Days Celebration, contacting hundreds of participants over a 3-day period. Pinedale's Rendezvous Days attracts approximately 10,000 people over the 4-day event and Department employees contact an estimated 1,000 constituents.

11. The Department hosted a bear safety booth at the Cora Rural Fire Department's annual picnic and celebration, contacting dozens of homeowners that live and recreate in occupied grizzly bear habitat.

12. Participated in a WGFD "day in the park" meeting and educating locals and tourists on bear education in the Pinedale Town Park.

Objectives for 2016 include continued expansion of the program into the other areas of the state where human-bear conflicts continue to be a chronic issue and the continuation of current educational and outreach efforts in the Cody area with specific focus on areas that have not adopted proper attractant management methods. The Department is also working to assist the U.S. Forest Service with providing bear proof storage and meatpoles at targeted areas in the Region.

The Wapiti and Pinedale area Bear Wise Community programs face the ongoing challenges of: 1) the absence of ordinances, regulations, or laws prohibiting the feeding of bears; 2) limited educational opportunities and contact with portions of the community due to a large number of summer-only residents and the lack of organized community groups and; 3) decreased public tolerance for grizzly bears due to record numbers of human-bear conflicts and continued federal legal protection. The future success of the Bear Wise program lies in continued community interest and individual participation in proper attractant management.

Jackson Hole Project Update

The Bear Wise Jackson Hole program continues educational and outreach initiatives in an effort to minimize human-bear conflicts within the community of Jackson and surrounding areas. In 2015, the program's public outreach and educational efforts included the use of signage, public workshops and presentations, distribution of informational pamphlets, promoting awareness about bear spray, carcass and fruit tree management, and utilizing our bear education trailer.

1. A bear education trailer was purchased in August 2010 with funding contributions from the Department, Grand Teton National Park, Bridger Teton National Forest, and Jackson Hole Wildlife Foundation. Two bear mounts (1 grizzly bear, 1 black bear) have been placed in the trailer along with other educational materials. The bear mounts were donated to the Department through a partnership with the U.S. Taxidermist Association and the Center for Wildlife Information. The trailer was displayed and staffed at various events and locations including Teton National Park, Jackson Elk Fest, Fourth of July Parade, and the National Elk Refuge Visitor Center.

2. Public service announcements were broadcast on 4 local radio stations in Jackson for a total of 6 weeks throughout the spring, summer, and fall of 2015. The announcements focused on storing attractants so they are unavailable to bears and hunting safely in bear country.

3. Numerous educational talks were presented to various groups including homeowner's associations, guest ranches, youth camps, Jackson residents, tourists, school groups, and Teton County employees.

4. Door flyers with detailed information about attractant storage and bear conflict avoidance were distributed in 2 Teton County residential areas where high levels of human-bear conflicts were occurring.

5. A considerable amount of time was spent removing ungulate and livestock carcasses from residential areas and ranches in the Jackson Region.

6. Recommendations were made to a North Jackson home owner's association about fruit tree management and installing bear resistant infrastructure in their subdivision.

7. Spanish language bear informational pamphlets were distributed to Spanish speaking residents in Teton County with the help of the Teton County Latino Resource Center, Teton Literacy Center, and the Jackson Visitor Center.

8. Refrigerator magnets featuring tips about proper attractant management were distributed to Teton Village homeowners, Aspens Property Management, and Jackson Hole Mountain Resort lodging.

9. Numerous personal contacts were made with private residents in Teton County. This has proven to be a useful way to establish working relationships with residents and maintain an exchange of information about bear activity in the area.

10. A booth containing information on bear identification, attractant storage, hunting and recreating safely in bear country, and the proper use of bear spray was staffed at the Jackson Hole Antler Auction and Kids Fishing Day.

11. Assisted 6 hunting outfitters and with the installation and maintenance of electric fence systems around their field camps and located in the Bridger-Teton National Forest.

12. Assisted Teton County Transfer Station staff with the installation and maintenance of an electric fence enclosure around their dead animal pit.

13. Signage detailing information on hunting safely in bear country, bear identification, recent bear activity, and proper attractant storage were placed at U.S. Forest Service trailheads and in private residential areas throughout Teton County.

14. Consultations were conducted at multiple businesses and residences, where recommendations were made regarding sanitation infrastructure and compliance with the Bear Conflict Mitigation and Prevention LDR.

15. Bear Aware educational materials were distributed to campground hosts in the Caribou-Targhee National Forest, hunters, and numerous residents in Teton County.

16. Several radio and newspaper interviews were conducted regarding conflict prevention in the Jackson area.

17. Educational materials for black bear vs. grizzly bear identification were distributed to black bear hunters who registered bait sites with the Wyoming Game and Fish Department in the Jackson region.

18. Worked with Jackson Sanitation companies on researching and purchasing new bear-resistant trashcans.

19. Worked with the Jackson Hole Wildlife Foundation on designing and installing an educational billboard located near Wilson on Hwy 22.

Objectives for the Bear Wise Jackson Hole program in 2016 will be focused on supporting Teton County and local waste management companies with projects that will help disseminate information and achieve compliance with the recently adopted Teton County Bear Conflict Mitigation and Prevention LDR. In addition, more work will be done to identify areas within the city limits of Jackson and Star Valley communities where better attractant management and sanitation infrastructure is needed.

The recent implementation of the Teton County Bear Conflict Mitigation and Prevention LDR has greatly reduced the amount of available attractants on the landscape and is a tremendous step forward for the Bear Wise Jackson Hole program. The new challenges faced by the Department will be achieving full compliance with this regulation, even in years with low conflict when it may appear that the conflict issues are resolved. The Bear Wise Jackson Hole Program will convey the importance of compliance and strive to maintain public support for the LDR through public outreach and education projects. In order for the Jackson program to be successful, the program must continually identify information and education needs within the community, while being adaptive to changing situations across different geographic areas. This will require the Department to coordinate with other government agencies and local non-government organizations working across multiple jurisdictions to develop a uniform and consistent message. If this level of coordination is achieved, the Department will be more effective in gaining support and building enthusiasm for Bear Wise Jackson Hole, directing resources to priority areas, and reaching all demographics.

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Information and Education

2015 Accomplishments

1) Electronic and Print Media

   a) As per Wyoming Statute, grizzly bear relocation from one county to another must be announced through local media and to the local sheriff of the county into which the bear was relocated. Each announcement is posted in a timely fashion to the web page. In 2015, 19 notifications were distributed and posted on the website.
   b) Personnel issued multiple educational news releases throughout the season informing readers and listeners of bear safety, behavior, conflict avoidance, food storage and natural food availability.

2) Grizzly Bear Management Web Page

   a) The grizzly bear management web page continues to be maintained and updated on a regular basis in order to provide timely information to the public regarding grizzly bear management activities conducted by the department. The web page contents include various interagency annual reports and updates and links to other grizzly bear recovery web sites.
   b) Beginning May 2015, weekly updates of ongoing management activities related to depredations, research, trapping and monitoring, and information and education were posted to the department's website. A total of 24 weekly updates were posted from May 2, 2015 through October 24, 2015.

3) Hunter Education

   a) Every hunter education class in Wyoming is required to discuss how to hunt safely in bear country. To assist instructors, most have been provided inert bear spray canisters for demonstration purposes and DVDs titled "*Staying Safe in Bear Country, A Behavioral Based Approach to Reducing Risk*". A section on bear safety is included in the student manual. Approximately 5,000 students are certified each year.

Publications

The primary link to other publications, annual reports, and peer-reviewed literature for the Yellowstone population of grizzly bears is summarized on the U.S. Geological Service web site at:
www.usgs.gov/norock/igbst

For information specific to the Wyoming Game and Fish Department's grizzly bear management program, including links to publications, reports, updates, and plans visit: https://wgfd.wyo.gov/web2011/wildlife-1000674.aspx

For additional information about the Wyoming Bear Wise Program contact:

Bear Wise Coordinator
Dusty Lasseter
(307) 272-1121
dustin.lasseter@wyo.gov

Appendix E

Project Update: Grizzly Bear Response to Elk Hunting in Grand Teton National Park

Michael R. Ebinger, Mark A. Haroldson, and Frank T. van Manen; U.S. Geological Survey, Interagency Grizzly Bear Study Team; and Dave Gustine, Katharine R. Wilmot, and Steve L. Cain; National Park Service, Grand Teton National Park)

Introduction

Although population growth of grizzly bears (*Ursus arctos*) in the Greater Yellowstone Ecosystem has slowed from 4–7% during the 1980s and 1990s to 0–2% during 2002–2011, expansion of occupied range has continued throughout the last decade. Successful population recovery has coincided with increases in human populations on the periphery of the ecosystem and human visitation to national parks. One particular challenge is the availability of ungulate gut piles and carcasses during fall hunting seasons, a time when bears' caloric demand and intake is greatest (hyperphagia). Areas that exhibit traditional and concentrated ungulate hunter success may become seasonal "ecocenters" for bears. Supporting this concept, Haroldson et al. (2004) found that grizzly bears were 2.4–2.7 and 2.3–4.4 times more likely to be outside Yellowstone National Park's northern and southern boundaries, respectively, following the opening of the September elk season, thus increasing the risk of human-bear conflicts and grizzly bear mortality. Gunther et al. (2004) found that grizzly bears killed in defense of human life or property ($n = 32$) represented the greatest source of human-caused mortality during 1992–2000, including 27 from ungulate hunters.

Under its 1950 establishing legislation, Grand Teton National Park is authorized to conduct a joint Elk Reduction Program (ERP), when deemed necessary, with the State of Wyoming for conservation of the Jackson elk herd, a significant portion of which travels though Grand Teton National Park during annual fall migrations to wintering areas on the National Elk Refuge and 3 nearby state feed grounds. Because the Grand Teton National Park hunting season is open later than those on adjacent lands, the 'ecocenter' effect of a highly attractive grizzly bear food source may exacerbate the potential for bear-hunter conflicts. The fall elk hunting in conjunction with increasing grizzly bear numbers creates a unique and substantial challenge for park managers.

Several national park provisions for mitigating hunter-grizzly bear conflicts are already in place, including requiring hunters to carry bear spray, providing hunt camps with game storage facilities, prohibiting artificial elk calls, and providing hunters with a bear safety education packet. In response to the recent human-bear conflicts, Grand Teton National Park proposed additional measures and revisions to the ERP for 2013. These revisions are currently based on a limited set of regulatory tools, involving changes in hunter densities (e.g., hunters/day, access), closure of areas to hunting (e.g., Snake River bottoms), and changes in hunting regulations to reduce wounding loss (e.g., ammunition limits). However, even with these changes, park managers expect conflicts between elk hunters and grizzly bears to increase. Therefore, park managers are seeking new, science-based information to help reduce conflict potential. The overall goal of this study is to gain a thorough understanding of grizzly bear responses to the ERP in Grand Teton National Park. Our specific objectives are to determine: 1) changes in grizzly bear density and distribution relative to the timing and location of the ERP hunting season, 2) spatial and temporal distribution of elk remains, 3) grizzly bear detection and use of elk remains, and 4) the relative risk of human-bear encounters.

Field Data Collection

During the 2015 field season (June 15th–December 30th) we constructed, monitored, and removed 60 hair-snare corrals distributed across 20 5- × 5-km grid cells during 3 separate 5-week long primary periods (as defined by the "robust design" framework for mark-recapture analysis). Over 300 corral visits were conducted during the 2015 field season (3 primary periods × 5 secondary periods × 20 hair corrals). During the 2014 field season we discovered extensive travel by bears on the powerline right-of-ways and scent marking (rubs) of power poles throughout the study area. During 2015, we continued the use of the powerline network and included these as opportunistic samples for the mark-and-recapture design similar to Kendall et al. (2008). Samples were also collected from natural mortality, hunter gut piles, and wounding-loss elk that were circumscribed with barbed wire and fencing t-posts to make temporary hair corrals. We collected 405 hair samples, where each sample was defined as the group of hairs (1–100 hairs) snagged within the coils of barbed wire. Seventy-six percent of samples originated from the hair corrals, 13% from powerpole rubs, 9% from carcasses or gut piles, and 0% from grizzly bear research trap sites (although DNA was collected from handled bears).

Based on remote camera monitoring, hair corrals were visited and non-food reward scent lure investigated by bison (*Bison bison*), elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), wolves (*Canis lupus*), coyotes (*Canis latrans*), mountain lions (*Puma concolor*), American black bears (*Ursus americanus*), grizzly bears, red fox (*Vulpes vulpes*), American pine martin (*Martes americana*), and red squirrels (*Tamiasciurus hudsonicus*). Black and grizzly bears were the only species observed rubbing on powerpoles. Grizzly bears, coyotes, and red fox were the only species observed at carcass corrals during the active ERP hunting season. Of the 405 hair samples collected during the field season, approximately 89% were assignable to bears based on field personnel expertise and remote camera data. Approximately 9% of the samples could not reliably be assigned to the genus level based on field personnel classification and camera data. The remaining 2% of collected samples consisted of wolf hair. Of the bear samples we collected, approximately 68% were visually identifiable as grizzly bear (silver tips and remote camera confirmation) and 20% as black bear (lacking silver tips and remote camera confirmation). The remaining 12% were likely Ursid hairs, but will require additional analysis (cuticular scale patterns or DNA analysis) for species identification.

Under the guidelines of another Grand Teton National Park permit (GRTE-2015-SCI-0021) 8 grizzly bears were captured, 7 of which were handled during the 2015 season. No females were captured and 7 males were captured and fitted with GPS radio collars. Based on all study bears (including 2014) collared in Grand Teton National Park, we recorded 19,867 telemetry locations (includes locations outside the park) during the 2015 study period (June 15th–December 30th) for a total of 1,297 bear-days. We recorded over 295 human GPS tracks from field personnel, hunters, and outfitters during the 2015 ERP hunting season in hunt areas 75 and 79. We visited 45 grizzly bear GPS clusters during the 2015 ERP season, of which 91% showed some sign of feeding on animal matter. The remaining 9% were daybeds.

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A black bear ‘encourages’ visitors to take the back road, Blacktail Plateau, Yellowstone National Park (photo courtesy of Jeremy Nicholson, National Park Service).