

Chapter 1 Population Standards and Monitoring

[JF1]

Introduction

To maintain a healthy (recovered) grizzly bear population in the Yellowstone Ecosystem, it is necessary to have adequate numbers of bears that are widely distributed with a balance between reproduction and mortality. This section details the demographic criteria in the *1993 Recovery Plan* that were necessary to achieve recovery, and the criteria necessary to maintain it in the *Recovery Plan Supplement*. *1993 Recovery Plan* criteria focused on the PCA and a 10-mile perimeter, whereas criteria in the Strategy, the *2016 Recovery Plan Supplement: Revised Demographic Criteria for the Yellowstone Ecosystem*, and the appended state plans encompass the Demographic Monitoring Area (DMA) of the Yellowstone Ecosystem. Because grizzly bears are a difficult species to monitor and manage, multiple criteria are identified to provide sufficient information upon which to base management decisions.

The IGBST has generated extensive information useful to determine the status of the Yellowstone Ecosystem grizzly bear population. Few populations have benefited from the amount of effort in data collection, as has the Yellowstone population. Agencies responsible for management will continue their commitment to data collection so population status can be determined and all designated standards maintained.

Under this Conservation Strategy and the *2016 Recovery Plan Supplement: Revised Demographic Criteria for the Yellowstone Ecosystem*, all mortalities and all reports of unduplicated females with cubs will be monitored within the DMA in Figure 3. This will result in the management and monitoring of the grizzly bear population in the entire Yellowstone Ecosystem area as a single population, as opposed to the system in the *1993 Recovery Plan*, which managed and monitored only the population inside the recovery zone and 10 miles outside the recovery zone. This is more stringent than the system under the *1993 Recovery Plan* and allows management of the entire population, like management of most other wildlife species. None of the standards in the Strategy are associated with the 10-mile area. Conservation Strategy standards and the standards in the state plans are tied to either the PCA or the DMA, shown in Figure 3. The criteria and objectives of the existing *1993 Recovery Plan* have been included or modified, as the *1993 Recovery Plan* will no longer apply.

Population Monitoring

Primary monitoring protocols for this population will focus on being able to assess whether the demographic standards described. Additional monitoring or research may be conducted as determined by the IGBST.

Demographic Recovery Criteria from the *2016 Recovery Plan Supplement: Revised Demographic Criteria for the Yellowstone Ecosystem*

[JF2]

The *1993 Recovery Plan* defined a recovered grizzly bear population as one that could sustain a defined level of mortality and is well distributed throughout the recovery zone. The *1993 Recovery Plan* outlined a monitoring scheme that employed three demographic sub-goals to measure and monitor recovery of the Yellowstone grizzly bear population. The second criterion

pertaining to the distribution of female with offspring remains unchanged. However, the first and third criteria pertaining to the minimum allowable number of females with cubs of the year and sustainable mortality limits are hereby revised and updated to reflect current methods based on the best available science. The current demographic recovery criteria in the 2016 Recovery Plan Supplement are::

- Maintain a minimum of 15 unduplicated females with cubs-of-the-year (COY) over a six-year average both inside the recovery zone and within a 10-mile area immediately surrounding the recovery zone (14,497 square miles).
- Maintain a minimum of 48 females with cubs of the year in the Yellowstone Ecosystem DMA (Figure 3), which is equivalent to a population of approximately 500 total individuals. The number of females with cubs of the year cannot drop below 48 for any 2 consecutive years. For genetic reasons (Miller and Waits 2003) it is desirable that the total population of grizzly bears in the Yellowstone Ecosystem be maintained above 400 bears. To assure that this goal is met and in order to adopt a conservative approach, the total population will be maintained at or above 500 grizzly bears in the Yellowstone Ecosystem. The estimate of 48 adult females with cubs of the year will be calculated by the IGBST based on model averaging as described in the *Reassessing Methods to Estimate Population Size and Sustainable Mortality Limits for the Yellowstone Grizzly Bear: Workshop document supplement on 19-21 June 2006* (IGBST 2006, Appendix O_{JF31}).
- Sixteen of 18 Bear Management Units (BMUs) within the PCA must be occupied by females with young, including COY, yearlings, or two-year olds, as confirmed by the IGBST from a six-year sum of observations. No two adjacent BMUs may be unoccupied during the same six-year period. This is equivalent to verified evidence of at least one female grizzly bear with young at least once in each BMU over a six-year period.
- For independent females (at least 2 years old), the current annual mortality limit, not to be exceeded in 2 consecutive years and including all sources of mortality, is 7.6 percent of the total number of independent females. For independent males (at least 2 years old), the current annual mortality limit not to be exceeded in 3 consecutive years and including all sources of mortality, is 15 percent of the total number of independent males. For dependent young (less than 2 years old), the current annual mortality limit, not to be exceeded in 3 consecutive years and including only known and probable human-caused mortalities, is 7.6 percent of the total number of dependent young. The Study Team will conduct a management review every 5 years to assess the population numbers and trend against the management objective based on all available scientific data. Vital rates such as age/sex-specific survival and reproductive rates will also be reevaluated using the most recent data to adjust sustainable mortality levels as necessary.
- The running six-year average for total known, human-caused mortality as confirmed by the IGBST is not to exceed 4% of the minimum population estimate. The running six-year average annual known, human-caused female grizzly bear mortality is not to exceed 30% of the 4% total mortality limit over the most recent three-year period. These mortality limits cannot be exceeded in any two consecutive years. Beginning in 2000, probable mortalities were included in the calculation of mortality thresholds, and COY orphaned as a result of human causes will be designated as probable mortalities. Sex of probable mortalities for young is randomly assigned as described in the Monitoring Protocol for Mortality section of the Strategy.

Conservation Strategy Population Standards

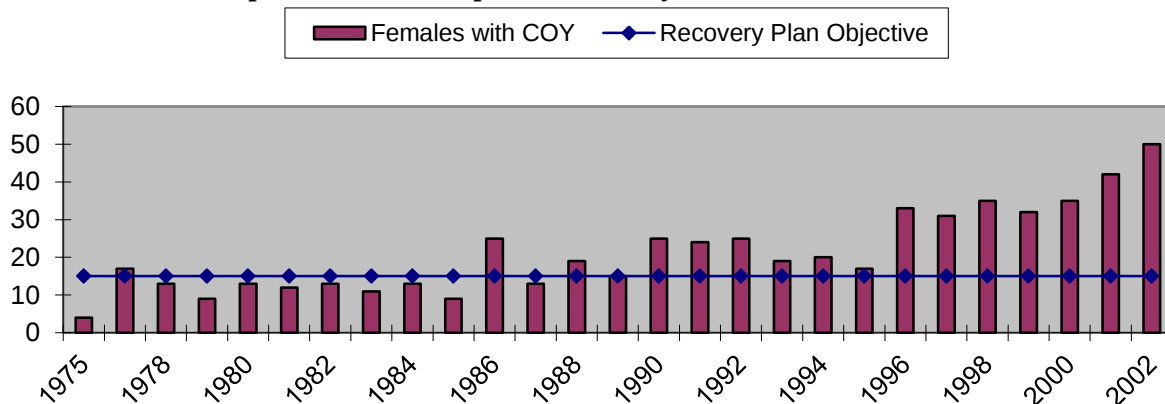
This Conservation Strategy and the state management plans set an objective of maintaining a recovered grizzly bear population in the Yellowstone area sufficient to meet management objectives inside and outside the PCA in biologically suitable and socially acceptable habitats. The demographic standards in this Conservation Strategy are designed to meet these goals. The Yellowstone Ecosystem grizzly bear population exceeds 500 total bears as of 2006 (Appendix O). The intent of the Conservation Strategy is to allow grizzly bears to expand their range and numbers and reoccupy all biologically suitable and socially acceptable habitats. It is the goal of the agencies of the YGCC implementing this Conservation Strategy to stabilize the Yellowstone grizzly bear DMA population at the 2002-2014 average Chao2 population estimate of 674 individuals. This Conservation Strategy requires continued monitoring of the standards originally prescribed by the *1993 Recovery Plan* and some additional standards. Specific population standards, will be applied to the DMA.

Unduplicated Females with Cubs-of-the-Year^[JF4]

Background

Females with COY also occupy all of the existing bear management units within the PCA as well as areas outside the PCA (Figure 5).

Figure 1. The number of unduplicated females with cubs-of-the-year within the Primary Conservation Area and the 10-mile perimeter area, as per the Recovery Plan, 1975–2002.



Monitoring Protocol

Monitoring unduplicated females with COY will provide information to demonstrate adequate reproduction and to estimate *total* population size. *Total* population size will be estimated, as described in [Appendices B, C, N, and O \[JF5\]](#) using the sightings and resightings of unduplicated females with cubs from all areas where grizzly bears occur in Figure 3. This is a departure from the way the population estimate was done per the *1993 Recovery Plan*. In the *1993 Recovery Plan*, a *minimum* population estimate was made based on the most recent three years of sightings of unduplicated females with cubs, using only unduplicated sights from the recovery zone and 10 miles outside the recovery zone. The revised and improved methodology used in this document allows an estimate of the *total* rather than the *minimum* population size. This allows the calculation of mortality limits based on the total population size of each age and sex class (i.e., independent females, independent males, and dependent young) within the entire area in Figure 3 occupied by the Yellowstone Ecosystem grizzly bear population. This method allows mortality management and population monitoring of the Yellowstone Ecosystem grizzly bear DMA population, as opposed to the method used in the *Recovery Plan*, which focused mortality management and population monitoring on only a portion of the Yellowstone grizzly bear population. The number of females with COY can also be used to demonstrate that a sufficient number of adult females are alive within the population to reproduce and offset existing levels of human-caused mortality. These data for the PCA will be evaluated concerning established population management standards. The most recent year of unduplicated sightings and resightings of females with cubs of the year will be reported by the IGBST. Using these data, the IGBST will produce the model-averaged Chao2 estimate of the total number of independent females in the population which will then be used to estimate the total population size. This total population estimate will be used to calculate biologically sustainable mortality limits for both independent females (> 2 years old) and independent males (> 2 years old) from all causes as well as sustainable mortality limits for dependent young (≤ 2 years old) from human-caused mortality. For a more detailed description of this methodology, see Appendix C.

Sightings and resightings of females with COY will be obtained from numerous sources, including radio tracking flights, confirmed sightings, and observation flights. Observation flights are primarily designed to survey all existing BMUs to obtain these data. The number of flights conducted in each BMU is standardized to ensure equal effort in obtaining data. The IGBST will verify the reliability of all sightings. The IGBST will plot all sightings and summarize data for unduplicated females and numbers of cubs seen for the entire population. Methodology developed by Knight et al. (1995) will be used to separate duplicated from unduplicated sightings.

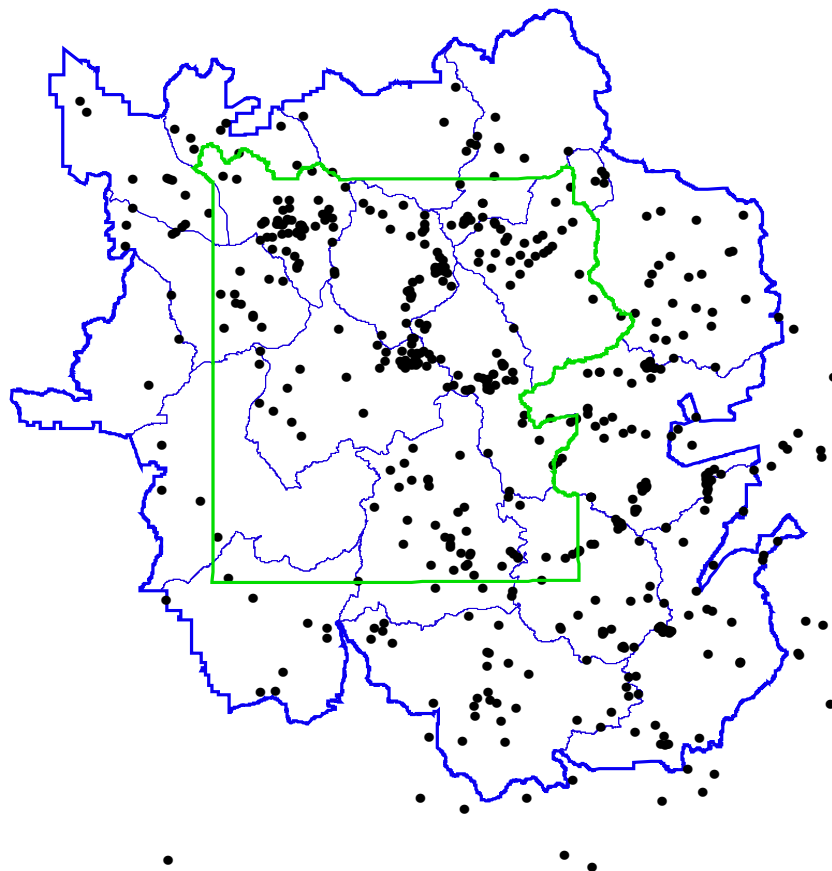


Figure 2. Initial sightings of unduplicated females with cubs-of-the-year in the Yellowstone Ecosystem, 1985–2001 (IGBST Data).

Distribution of Females with Young

Background

The distribution of females with young, based on the most recent six years of observations in the ecosystem, is presented in Figure 6. The recovery criterion of having 16 of 18 BMUs occupied with no two adjacent units vacant has been met. This criterion is important as it ensures that females occupy the majority of the PCA and that successful reproductive females are not concentrated in one portion of the ecosystem.

Figure 3. Bear Management Units occupied by females with young based on verified reports, 2009–2014.

Bear Management Unit	2009	2010	2011	2012	2013	2014	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	X	5
Totals	18	18	16	15	18	18	

Monitoring Protocol

This effort will provide information to assess distribution of the reproductive cohort in all occupied habitats, although specific standards will apply only to the PCA. A recovered population should be well distributed throughout grizzly bear range. Successful reproduction is one indicator of habitat sufficiency, thus distribution of family groups is one indicator of suitable habitat in areas where such sightings occur. Since sub-adult females usually establish home ranges adjacent to that of their mothers, the distribution of family groups is also an indication of future occupancy of these areas by grizzly bears.

Radio tracking flights, observation flights, agency personnel sightings, and verified reports from other individuals will be the primary methods employed to collect female distribution data. The IGBST will verify all reports and keep a record of locations. Data will be maintained by the IGBST.

The number of BMUs occupied by females with young will be reported for the last six years. Females with young outside the PCA will also be reported, but only those females with young within the PCA will be used to document achievement of this distribution standard.

Mortality^[JF6]

(Portions of this section are superseded by the methodology in Appendix C.)

Background

Agencies have placed significant effort toward limiting human-caused deaths for grizzly bears. To date, these efforts have been very successful at limiting mortality, allowing the population to increase since it was listed in 1975.

Although there was no legal hunter harvest from 1991 to 2001, 110 known and probable human-caused grizzly bear mortalities have been documented in the Yellowstone Ecosystem. Female grizzly bears accounted for 41 of these mortalities (37%) (Figure 9). Annual total human-caused mortality has not exceeded 22, while human-caused known and probable mortalities of females has not exceeded eight for the 1991–2001 period (Figure 9). Based on population criteria described in Appendix C, the threshold mortality limits for independent females, independent males, and dependent young have not been exceeded in any 2 consecutive years (Figures 1, 2, and 3 in Appendix C). As can be seen in Figure 7, the distribution of known and probable bear mortalities has occurred throughout the grizzly bear's documented range. As the population continues to expand, the percentage of known and probable mortalities occurring outside the PCA is increasing.

Monitoring Protocol

The management of human-caused mortality of grizzly bears is key to successful maintenance of the grizzly bear population in the Yellowstone Ecosystem. Mortality limits are a necessary tool for managers in regulating impacts to any wildlife population, including grizzly bears. Managing mortality is necessary to avoid the unregulated killing that occurred as the Yellowstone area was settled and to build support for long-term survival of the population. A higher rate of mortality is expected as the grizzly bear population expands, particularly in peripheral areas on the edge of the range when bears move on to private lands or in areas with higher levels of human development. Mortality management will recognize the need for some bears to be removed to meet management needs for nuisance bears, human safety issues, etc. Regulated harvest may be utilized as a management tool when and where appropriate, and all known and probable mortalities due to regulated harvest will be limited by the overall ecosystem mortality limit. Mortality limits will be monitored and evaluated annually and applied to the entire population to ensure mortality is not jeopardizing the survival of the population.

Harris (1986) reported that grizzly bear populations having the characteristics of those in the interior Rocky Mountains could sustain 6.5% human-caused mortality without population decline when no more than 30% of the known and probable mortalities are females. The 6.5% level suggested by Harris (1986) was reduced to a conservative 4% limit of known, human-caused mortality to:

- Facilitate continuing recovery and population expansion into desirable areas
- Use a conservative approach
- Ensure that unknown, unreported human-caused mortality, when added to the known mortality level, is not likely to exceed 6.5% of the population estimate. (The current ratio of

known and probable to unknown mortalities is 2:1; therefore, an upper limit of 4% documented mortality allows for an actual mortality limit of 6%.)

Figure 4. Distribution of 307 known and probable human-caused mortalities in the Yellowstone Ecosystem, 1975–2001 (IGBST Data).

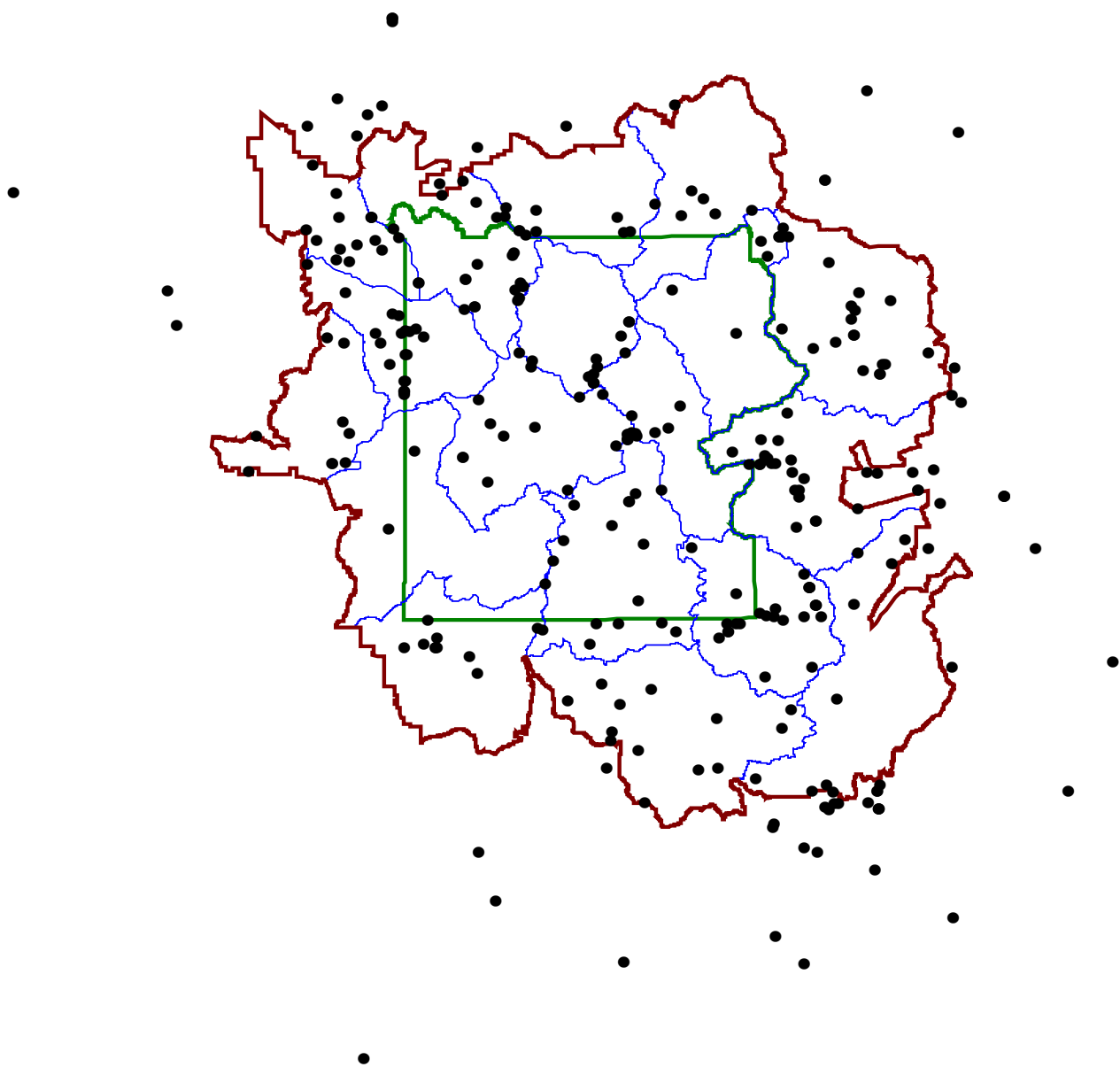


Figure 5. Example of the 2001 minimum and total population estimates within the Greater Yellowstone Area and 4% and 30% female mortality limits.

	Minimum Population Estimate	Total Estimate
	365	531
4%	14.6	21.2
30% females	4.4	6.4

The mortality thresholds established in the *Recovery Plan* of 4% or less of the minimum population provided population growth and expansion. The mortality limit established in the Strategy of no more than 4% of the total population is also conservative and should allow these trends to continue (Figure 8).

A mortality threshold for the Yellowstone Ecosystem DMA, rather than just the recovery zone and 10 miles beyond the recovery zone, will be managed so that known and probable human-caused mortality will not exceed 4% of the total population estimate. No more than 30% of the 4% total allowable mortality should be females. This equates to human-caused female known and probable mortalities being no more than 1.2% of the total population estimate. Protecting females, especially adult female bears, is an important part of mortality management.

Mortality limits of 4% of the total population in the GYA will be calculated on a six-year running average. The total population estimate will be based on the sum of the most recent three years of females with COY sightings and resightings using the approach in Appendix B. Calculating mortality limits on a six-year running average covers two breeding cycles and provides a conservative estimate of allowable mortality. The annual allowable take of bears may be updated as new information becomes available through additional analysis.

Known and probable human-caused mortalities are defined as follows:

Known. Carcass recovered or evidence to indicate known status due to radio telemetry. Known deaths require a carcass, management removal, or a cut radio collar. Found collars having the appearance of being cut should receive additional forensic review for definitive proof.

Probable. Strong evidence to indicate mortality, reported by highly reliable sources, no carcass recovered. Probable deaths include those cases where there is supportive evidence that a bear was wounded. Circumstances of each reported instance should be considered. Probable includes those cases where evidence of blood, hair, or other tissues clearly indicates wounding serious enough to result in death. The literature is unclear on the probability of survival for orphaned cubs. Any cub orphaned during its first year of life because of a known adult female mortality is considered a probable mortality.

Because probable mortalities will be counted against the mortality quota, and because there is a female quota, each probable mortality must be assigned a sex. Sex will be assigned in the following manner:

- Probable deaths of adult bears where cubs-of-the-year are reported present will be classified as sex = female.
- Lone bears classified as probable deaths will be assigned sex based upon statistics available from known deaths in the ecosystem. The percentage of known male and female deaths in the Yellowstone Ecosystem between 1975 and 1998 is 59% and 41% respectively. These estimates exclude natural mortalities, management removals, and females with young.

Therefore, sex will be assigned to probable adult mortalities in the Yellowstone Ecosystem at a ratio of 59:41, male:female.

- Cubs-of-the-year that are orphaned and counted as mortalities will be assigned sex based a 50:50 sex ratio at birth (Eberhardt et al. 1994). For each cub, a random number will be drawn between 1 and 100. If the number is 1 through 50, the sex will be assigned as male; if the number is 51 to 100, the sex will be assigned as female.

It is recognized that established mortality limits might be exceeded in any given year. Any mortality threshold will not affect the immediate management of nuisance grizzly bears. This document describes agency responsibilities and actions to reduce mortality should this occur. State plans provide for the take of nuisance bears regardless of the current mortality quota upon consultation among all involved agencies. ~~A running six year average for mortality gives agencies flexibility to deal with years of high bear conflicts due to environmental factors, while ensuring the long term viability of the population. In short, it is acceptable to exceed the allowable mortality in one year because mortality limits will be calculated on a running six year average.~~

~~The 4% total allowable mortality limit and 30% allowable take of female bears will be applied to the entire GYA.~~ Mortality will be monitored by reports from all sources. Each state wildlife agency and national park will provide mortality information to the IGBST, who will annually summarize all mortality information as to location, type, date, sex, and age for the Yellowstone Ecosystem.

The established outer boundary for grizzly bear occupancy in Wyoming encompasses most of the area within the Wyoming portion of the Yellowstone Ecosystem, shown in Figure 3 as the gray area in Wyoming, and in Figure 12 in the Wyoming State Management Plan (Appendix L). Grizzly bears that occur outside this boundary will be dealt with on an individual basis, utilizing the Wyoming Game and Fish Department's full array of management practices. If necessary, bears outside this area will be removed from the population, and those removals will not count against the mortality threshold.

Once population and distribution goals have been met, the mortality standards will be reviewed and revised as necessary using the best available information and science to meet these population goals. All management of and information on mortality management will be open to full public review.

Population Trend

Background

The most current information indicates that this population of grizzly bears was increasing at approximately 4% to 7% annually between 1983 and 2001 (Eberhardt et al. 1994, Boyce 1995, Boyce et al. 2001, Harris et al. 2006). While there is some debate related to the actual level of increase since the bear was listed in 1975, all of the current information, number of unduplicated females (Figure 9), distribution of reproducing females, distribution of bears, informal sightings by agency personnel, and areas where nuisance bears are being managed indicate this population has increased in both numbers of bears (Figure 9) and the geographic area they occupy (Schwartz et al. 2002).

Monitoring Protocol

This Strategy recognizes that any one factor cannot provide the needed information to assess population size and trend. Ultimately, assessments will require multiple sources of information. One technique that provides insight into trend is the application of the Lotka equation. Population trend, using the Lotka equation as calculated from survivorship and reproductive rate data for the appropriate period (Eberhardt et al. 1994, Eberhardt and Knight 1996), will be used as supportive information to evaluate population trend. This method will be applied to the entire population.

Estimates of population trend using critical population parameters can yield the rate of change in a population and proximate causes for the change. Using the statistical method called bootstrapping and the Lotka equation as described in Eberhardt et al. (1994) and Eberhardt (1995), it is now possible (given sufficient data) to estimate the population trajectory of a grizzly bear population with confidence limits. To use this method, female survivorship and reproductive rate must be monitored.

The agencies will strive to maintain a minimum of 25 adult female grizzly bears fitted with mortality-sensing radio collars and monitored at all times. To adequately sample survival, these 25 females will be spatially distributed throughout the ecosystem. The target distribution of these 25 radio-collared adult females will be determined by the IGBST; the expected distribution of collared females by agency will be assigned. Each female will be monitored using aerial telemetry flights during the non-denning period. These data will be collected in conjunction with other regularly scheduled relocation flights. When a radio collar indicates that a bear may have died, a field crew will evaluate the actual status of the female and determine cause of death. The IGBST will coordinate field crew collection of mortality data on each bear.

Data to calculate reproduction and survival are collected annually in all areas occupied by grizzly bears throughout the Yellowstone Ecosystem. These data sets will be maintained by the IGBST and used periodically to evaluate population trend.

Figure 6. Annual count of unduplicated females with cubs-of-the-year (COY), and known and probable^a human-caused grizzly bear mortalities within the Yellowstone Ecosystem, 2004-2014.

									1993 Recovery Plan Mortality Thresholds			
Years	Unduplicated females with COY			Human-caused mortality				Total population estimate	Total human- caused mortality		Total female mortality	
	Annual minimum count	Annual total count ^c	6-year Average ^b	Annual		6-year Average			4% of total population	Year Result	30% of total mortality	Year result
				Total	Female	Total	Female					
1991	24	35	20	0	0	4.7	2.5	287	11.5		3.4	
1992	25	48	20	4	1	3.8	1.8	377	15.1		4.5	
1993	20	24	22	3	2	3.8	1.8	374	15	Under	4.5	Under
1994	20	26	22	11	4	4.8	2.2	341	13.6	Under	4.1	Under
1995	17	55	22	17	7	7.3	3.3	364	14.6	Under	4.4	Under
1996	33	41	23	10	4	7.5	3	425	17	Under	5.1	Under
1997	31	41	24	10	4	9.2	3.7	480	19.2	Under	5.8	Under
1998	35	41	26	3	1	9	3.7	427	17.1	Under	5.1	Under
1999	33	37	28	10	3	10.2	3.8	407	16.3	Under	4.9	Under
2000	37	63	31	22	7	12	4.3	484	19.3	Under	5.8	Under
2001	42	55	35	20	8	12.5	4.5	531	21.2	Under	6.4	Under

	Unduplicated females with COY			Human-caused mortality				Total population estimate	Total human-caused mortality ^a		Total female mortality ^a	
Year	Annual minimum count	Annual total count ^c	6-year average	Annual		6-year average		Total	4% of total population	Year result	30% of total mortality	Year result
				Total	Female	Total	Female					
2004	49											
2005	31											
2006	47											
2007	50											
2008	44											
2009	42											
2010	51											
2011	39											
2012	49											
2013	58											
2014	50											

^a 1993 Recovery Plan Mortality Thresholds

^c Total numbers calculated using methods of Keating et al. 2002 (Appendix B)