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Hey Rebecca,

Attached are the edits/comments from Mark and myself. I also attached our rebuttal paper, which is a different version than the one you used for the quotes (see my comments in the response section).

Let us know if you have any questions!

Frank

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Re-evaluation of Yellowstone Grizzly Bear Population Dynamics Provides False Insights: Response to Doak & Cutler

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Re-evaluation of Yellowstone Grizzly Bear Population Dynamics Provides False Insights:**Response to Doak & Cutler****Frank T. van Manen***

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For Peer Review

Abstract

Doak & Cutler (2013) critiqued methods used by the Interagency Grizzly Bear Study Team (IGBST) to estimate grizzly bear population size and trend in the Greater Yellowstone Ecosystem. We found major flaws with the premise, implementation, and interpretation of simulations they used to support their arguments. They argued population increases documented by IGBST based on females with cubs-of-the-year were a function of increased search effort. However, their simulations were not reflective of the true observation process nor did results provide statistical support for their conclusion. Doak & Cutler further argued survival and reproductive senescence should be incorporated into population projections but their choice of extreme mortality risk beyond age 20 and incompatible baseline fecundity substantially influenced their simulations, leading to erroneous conclusions. We conclude their critique was unfounded when placed within the context of a thorough understanding of the data, the study system, and previous research findings and publications.

Introduction

Doak & Cutler (2013; hereafter D&C) critiqued methods used to estimate grizzly bear (*Ursus arctos*) population size and trend in the Greater Yellowstone Ecosystem (GYE) by the Interagency Grizzly Bear Study Team (IGBST), a research partnership among federal, state, and tribal agencies formed by the Secretary of the Interior in 1973. Peer review and critique are essential to scientific progress, and the IGBST has a long history of publishing study results, making reports publicly available, presenting background and justification for analysis decisions, and providing careful interpretation of population trend and demographic results. D&C's critique mainly concerns two claims: 1) increase in grizzly bear population estimates from 1983 to 2001 can be attributed to factors other than population size, primarily increased observation effort and sightability of female grizzly bears with cubs-of-the-year (F_{COY}); and 2) estimates of population growth were biased high because survival senescence and reproductive senescence were not properly accounted for in demographic analyses. Here, we discuss both claims and demonstrate the conclusions of D&C are unfounded when placed within the context of a thorough understanding of the data, the study system, and previous research findings and publications.

Population Size and Trend

D&C claim they simulated the “observation process” as a function of number of flight hours and argue, based on simulation results, that increases in bear numbers during the 1983–2001 time period can be explained simply by increases in search effort and sightability.

Search Effort.—We found three major flaws with Doak and Cutler's simulations of the observation process. First, we disagree that D&C's method “explicitly simulates the observation process.” (p. 3). Their approach makes sweeping assumptions about the sampling process and

study system that do not represent reality. They explicitly allow each F_{COY} to be sampled every flight hour, regardless of the spatial location of the flight (see Supporting Information). For this to be realistic, observation flights would have to cover all occupied range in the GYE during each flight hour, which is clearly impossible and why 48 flight observation areas have been established. Even if it were possible, most F_{COY} would be too far away to be seen during most flight hours so their probability of being sighted would be zero for most flight hours. In recent work (Higgs *et al.* 2013), we used a mark-resight estimator based solely on counts of marked (radio collar) and unmarked F_{COY} from the standardized observation flights; this work also addressed the known underestimation bias of the Chao2 estimator (IGBST 2012; see Supplemental Information). For that estimator, we have assumed an individual F_{COY} can only be sighted one time per flight survey and there are only two flights over each observation area per year. This assumption is supported by data on sightings of radio-collared F_{COY} during survey flights without aid of telemetry (Higgs *et al.* 2013). Because D&C assumed that all bears in the entire study area are available to be sighted each flight hour, in their simulations the number of F_{COY} sighted once (f_1) or twice (f_2) quickly stabilize as flight hours increase and are relatively low compared with the number of unique F_{COY} observed (m) because many are sighted more than twice (Fig. 1). The consequence is that the Chao2 estimate for the simulated population of known N is determined essentially by m , rather than the frequency of sightings (f_1 and f_2), which, unsurprisingly, results in a direct correspondence between flight hours and Chao2 estimates (Fig. 1). However, this simplistic relationship to flight hours is the foundation of arguments made by D&C regarding Chao2 estimates and trends.

Second, D&C base their conclusion that the increasing trend in Chao2 was driven by increased search effort on a simple visual comparison of their simulation results with empirical

Chao2 data. IGBST has always carefully compared simulated data characteristics with those of empirical data (e.g., Cherry *et al.* 2007), which D&C did not do. Accordingly, we applied linear regression to each of 1,000 realizations of data produced from D&C's simulation method of the 25-year time series (not 20 years, as D&C described) to obtain a distribution of slope (trend) estimates under their model. We then compared the slope of our empirical estimates of $\ln(\text{Chao2})$ for 1986–2010 ($\hat{\beta} = 0.0404$, $P < 0.001$, $R^2 = 0.61$; Fig. 2A) with the distribution of slopes based on D&C's simulations: 99.9% of D&C's realizations resulted in slopes less than observed from the empirical data (Fig. 2A). Therefore, given the known, constant population of 70 individuals, we found no support for the notion that increase in search effort alone would result in detection of the population trend documented by IGBST based on empirical data, even under the model used by D&C that assumes a much stronger relationship between flight hours and sightings than is realistic for the system.

Finally, D&C's definition of effort as the number of flight hours failed to account for the increase in area surveyed, with their methods assuming each hour is used to survey the same spatial area. IGBST survey efforts have evolved to account for documented range expansion as reported by Blanchard *et al.* (1992), Schwartz *et al.* (2002, 2006c), and Bjornlie *et al.* (2013), who documented a 38% increase in occupied grizzly bear range during 2004–2010 alone. Accordingly, observation areas outside the recovery zone were added in 1989, 1999, and 2007 based on new records of bear presence (e.g., sightings, conflicts). Because dispersal among grizzly bears is substantially male biased (Proctor *et al.* 2004), such expansion initially involved subadult and young adult males. Thus, establishment of F_{COY} occurred subsequent to expansion of observation flight areas. Indeed, only 24 out of 297 initial sightings of F_{COY} were from observation flights outside the recovery zone during 1986–2010, or an average increase of 1

unique F_{COY}/yr . Of course, a larger survey area required additional flight hours (Fig. 3) but we argue that it is search intensity (effort/area surveyed) that matters because the probability of seeing an F_{COY} in these expansion areas was very small, if not zero, prior to expanding the survey area. In other words, it is unrealistic for D&C to assume the population was actually stable or declining but appeared to be increasing because of search effort expanding to new areas. To demonstrate this point, we adjusted annual flight hours based on total area surveyed and repeated the simulations with which D&C generated their Fig. 5. To account for this spatial component of search effort in a way that is tractable under the binomial framework of D&C's simulations, we rescaled the original search hours using the area flown as the adjustment parameter. We used the smallest search area (1988) as the reference category and adjusted flight hours for all other years accordingly (the choice of reference year influences the absolute numbers for flight hours but does not affect relative change in counts across years). Of 1,000 realizations generated by these simulations, all had slopes lower than the Chao2 trend of our empirical data (Fig. 2B).

We conclude that D&C's assertion that estimates of grizzly bear population trend are a direct consequence of search effort is based on substantially flawed simulations of the observation process and is not even consistent with results from their own simulations, particularly after adjusting number of flight hours for increased survey area. Thus, we find no support for their conclusion that "much of the apparent increasing trend in bear numbers during this time period can be parsimoniously explained as a result of increasing search effort." (p. 4). Moreover, we find it remarkable that D&C failed to mention the Chao2 estimator is known to be biased low (Keating *et al.* 2002, Cherry *et al.* 2007) and, as applied to F_{COY} in the GYE, that this bias increases with population size (Schwartz *et al.* 2008).

Sightability.—D&C claim that sightability of F_{COY} has potentially increased over time, which would inflate Chao2 estimates. Indeed, under these assumptions, their simulations show estimates of Chao2 increase with greater mean sightability of individuals. They also show an increase of Chao2 with decreasing coefficient of variation (CV) of sightability (although they incorrectly state that “rising CV in sightabilities results in increased F_{COY} and Chao2 estimates” [D&C Fig. 3 caption]; the relationship is actually opposite because CV *declined* along the horizontal axis). However, details of these relationships were previously reported and published in Keating *et al.* (2002) and Cherry *et al.* (2007). Thus, their argument hinges on the premise that mean sightability of individuals has increased over time, for which D&C provide no quantitative evidence. Instead, they speculate that changes known to be occurring in the ecosystem that affect grizzly bears (e.g., use of army cutworm moth [*Euxoa auxiliaris*] aggregation sites and increased researcher knowledge of those sites; decline of cutthroat trout [*Oncorhynchus clarkii*] and whitebark pine [*Pinus albicaulis*]; reintroduction of wolves [*Canis lupus*]) have led to a progressive increase in mean sightability of grizzly bears. We do not disagree that sightability may increase or decrease due to these factors. However, observations of radio-collared F_{COY} from telemetry flights, which are well distributed throughout the GYE (Schwartz *et al.* 2006d:12), provide no basis for assuming a major shift in sightability (Fig. 4).

Finally, D&C cite Link (2003) and argue that population size is nonidentifiable for estimators using observation frequencies when frequencies are small and variance in sightability is high. Link (2003) was making the point that mark-recapture data cannot identify the true underlying distribution that generated the data. However, Link (2003) did not show that estimators could not approximate true population size. Cherry *et al.* (2007:198) actually

referenced this issue and clearly demonstrated that estimates were close to truth, although still biased low.

Demographic Analyses

Incorporating Survival Senescence in Population Projections.—D&C applied a biologically unrealistic senescence function for independent female survival (see Supporting Information). To examine the influence of survival senescence as modeled by D&C versus empirical data, we used data for 1983–2011 to estimate age-specific survival. Our procedures followed Haroldson *et al.* (2006) but instead of generating a single mean survival rate for the entire period, we estimated age-specific survival of females using age and age² covariates (Fig. 5, solid black line), similar to the analyses of Johnson *et al.* (2004). We used these age-specific, empirical data to repeat the survival senescence population projections of D&C. In contrast to D&C's reduction of 1.1% population growth for both high and low survival scenarios (Tables 1A and 1B), we observed a 0.1% reduction (high survival, Table 1A) and a 0.4% increase of population growth (low survival, Table 1B) compared with projections (Fig. 5, dashed line) using the age-constant survival rates of Harris *et al.* (2006, 2007). These findings suggest little contribution of age-specific survival on population projections and confirm those of Haroldson *et al.* (2006), who found age class did not explain much variation beyond other covariates in the model. We do not dismiss D&C's point that survival senescence may become relevant as this population ages: however, information gained from incorporating age-specific survival should be weighed against increased model complexity and, so far, we found no support for incorporating age-specific survival.

Incorporating Reproductive Senescence in Population Projections.—D&C used an incompatible baseline for fecundity to assess effects of reproductive senescence (see Supporting

Information). To demonstrate the importance of which baseline fecundity is used for comparison, we constrained D&C's combined reproductive and survival senescence simulations to allow for a reproductive senescence-only scenario, which they did not include. A hypothetical population with a compatible baseline of $\bar{m}_{x\ pop*} = 0.2635$ would undergo only a 0.5% (high survival, Table 1A) and 0.5% (low survival, Table 1B) reduction in population growth during 1983–2001 upon inclusion of reproductive senescence, compared with a 2.5% and 2.6% reduction, respectively, using the higher, incompatible baseline of $\bar{m}_{x\ pop} = 0.322$ (Table 1). The lack of a strong reproductive senescence effect confirms findings from our earlier work (see Supporting Information). Clearly, the choice of fecundity baseline changes interpretation regarding impacts of reproductive senescence, which D&C did not acknowledge.

Incorporating Survival and Reproductive Senescence in Population Projections.—

Table 1 shows how D&C's choice of extreme survival senescence and incompatible baseline for reproductive senescence influenced their simulation results. Using the hypothetical fecundity reference data for inference, reductions in population growth due to D&C's combined reproductive and survival senescence are 1.6% (Table 1A) and 1.5% (Table 1B); these reductions are the same as those for survival senescence only (Tables 1A and 1B) because when both senescence functions are combined and an appropriate fecundity reference is used, the extreme survival senescence function of D&C (i.e., almost zero survival past age 20) overrides any reproductive senescence effects. We point this out because D&C implied a strong additive effect from reproductive senescence in their Fig. 6, but this is not possible because their simulations allow no females to survive long enough to reach reproductive senescence age. The additive effect from reproductive senescence was in fact a function of an inappropriate fecundity reference, rather than senescence itself.

Finally, when using the hypothetical reference for fecundity, IGBST estimates of age-specific survival resulted in only a 0.2% reduction (Table 1A) and a 0.2% increase (Table 1B) in population growth with a slightly additive effect when combined with D&C's reproductive senescence (0.4% [Table 1A] and 0% [Table 1B] reduction of population growth, respectively). These changes are not biologically relevant; thus these simulations do not support the importance of incorporating survival and reproductive senescence. We conclude that D&C's choice of an extreme survival senescence function, combined with inappropriate comparison among fecundity schedules to model reproductive senescence, substantially influenced their simulation results, leading to erroneous conclusions.

Discussion

D&C conclude that “we actually know very little about the past trends of this population” and that “with rapidly accelerating impacts, and with Chao2 estimates flattening in the last decade, even as search effort has continued to increase, it is quite likely that the population is now, in fact, declining.” (p. 9). D&C further assert that the comprehensive population studies of IGBST (e.g., Schwartz *et al.* [2006d], Keating *et al.* [2002], Cherry *et al.* [2007], Harris *et al.* [2006, 2007], and IGBST [2006, 2012]) show a “lack of attention to basic issues of wildlife data analysis (accounting for observation effort and realistic treatment of life history patterns)” and “are likely to have resulted in misunderstandings of the data collected, systematic bias in the inferences about the dynamics of this population, and overconfidence in apparent trends.” (p. 9). As we demonstrate here, these statements are not supported by their own analyses, are based on selective and incorrect use of existing data, and fail to recognize the broader context provided by available data and other published information.

We recognize that no two investigators are likely to make the exact choices in dealing with complex data. It can be tempting, from afar, to imbue such choices with intent when it merely results from the inevitable differences in choice made by equally qualified and objective investigators. In fact, this is why IGBST has long favored a team approach. Current and past demographic analyses include about a dozen scientists and methods and results are critically evaluated, often involving intensive debates and exhaustive consideration of alternatives. Moreover, IGBST explicitly evaluates stochasticity in the modeling process whenever possible. When faced with the inevitable uncertainty associated with parameter estimation, the study team evaluated such relationships, chose to avoid overestimation of population size and mortality limits (see Supporting Information), and provided complete transparency of the process (e.g., IGBST 2012:20).

Scientific findings produced by IGBST have played an important role in the management of GYE grizzly bears because of its unique role bridging science and policy (Lynch *et al.* 2008:826). Decisions by federal, state, and tribal land managers regarding Yellowstone grizzly bears are not based on any single data source or analysis but rather on the totality of available data, rigorous analyses, and knowledge of the system by a team of experienced scientists. To that regard, we point out that two independent datasets (Chao2 based on unduplicated counts of F_{COY} and population projections based on demographics analyses of intensive known-fate data) have shown very similar population growth trends (Harris *et al.* 2006, 2007; Haroldson *et al.* 2011). Moreover, our interpretation of a positive population trend during 1983–2001 and diminished growth in the last decade (IGBST 2012) is supported by additional indicators, including: (1) standardized observation flights within the Recovery Zone (excluding army cutworm feeding sites where bears are more observable), where search effort has remained

constant or even declined slightly, show observation rates of bears increased from $<1/\text{hr}$ in the mid-1990s to $\sim 3/\text{hr}$ in late 2000s (Fig. 6); (2) proportion of unmarked bears in the capture sample (i.e., first capture) remained constant and high (50–70%) while total individuals captured/yr increased (Fig. 7); and (3) during the 1970s and into the 1980s, grizzly bear range was likely contained within the recovery zone ($23,828 \text{ km}^2$) but expanded to $34,416 \text{ km}^2$ by the end of the 1990s (Schwartz *et al.* 2002) to $50,280 \text{ km}^2$ in 2010 (Bjornlie *et al.* 2013).

We conclude the critique of D&C is unfounded when placed within the context of a thorough understanding of the data, the study system, and previous research findings and publications. The wealth of papers and publicly available reports by the IGBST and collaborating scientists is testimony to their work on keeping decisions and assumptions transparent and open to peer review. Careful reading of those papers and reports addresses most, if not all, of the claims presented by D&C. Furthermore, we would gladly have discussed their questions with them had we been aware of their work prior to publication. The task of IGBST is to use the best available science to ensure that federal and state agencies have objective and reliable data upon which to base their policy and management decisions (e.g., Schwartz *et al.* 2006). Thorough review is critical to the scientific process and can lead to important new insights. However, based on our examination, the simulations and analyses that formed the foundation of D&C's critique led to erroneous conclusions and false insights.

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Table 1. Population size, mean annual population growth (λ), and percent decline in λ for female grizzly bears in the Greater Yellowstone Ecosystem (GYE) based on simulations of Doak & Cutler (2013). We compared influence of survival senescence as implemented by Doak & Cutler with IGBST estimates of age-specific survival. Doak & Cutler used fecundity (m_x) for 1983–2001 from Harris *et al.* (2007) as their reference. We created a second reference model based on Schwartz *et al.* (2003: model D) to demonstrate the effect of having a compatible reference dataset to assess influence of age-specific fecundity; this model is not representative of the GYE (see text and Supporting Information for further explanation). Population projections are based on survival estimates in which bears with unknown fates were censored (A) or assumed dead (B) (Haroldson *et al.* 2006), which Doak & Cutler refer to as “high” and “low” survival scenarios, respectively. We use Doak & Cutler’s terminology of survival and reproductive senescence but see footnotes for corrections.

Population projection scenarios	m_x in reference model based on Harris <i>et al.</i> (2007) ($\bar{m}_{x\ pop} = 0.322$) ^a			m_x in reference model based on Schwartz <i>et al.</i> (2003) ($\bar{m}_{x\ pop} = 0.2635$) ^b		
	N_{2001} ^c	λ 1983–2001 ^d	% reduction of λ	N_{2001} ^c	λ 1983–2001 ^d	% reduction of λ
A. High survival scenario						
Reference model	219	1.074	0	148	1.052	0
Survival senescence ^e	176	1.062	1.1	110	1.035	1.6
Survival senescence (IGBST data) ^f	216	1.073	0.1	143	1.050	0.2
Reproductive senescence ^{g,h}	136	1.047	2.5	136	1.047	0.5
Survival senescence ^e and reproductive senescence ^h	110	1.035	3.6	110	1.035	1.6
Survival senescence (IGBST data) ^f and reproductive senescence ^h	138	1.048	2.4	138	1.048	0.4
B. Low survival scenario						
Reference model	131	1.046	0	88	1.024	0
Survival senescence ^e	108	1.035	1.1	67	1.009	1.5

Survival senescence (IGBST data) ^f	142	1.050	-0.4 ⁱ	93	1.026	-0.2 ^h
Reproductive senescence ^{g,h}	81	1.019	2.6	81	1.019	0.5
Survival senescence ^e and reproductive senescence ^h	66	1.009	3.5	66	1.009	1.5
Survival senescence (IGBST data) ^f and reproductive senescence ^h	90	1.024	2.1	90	1.024	0

^aAs implemented by Doak & Cutler (2013) in their simulations.

^bAs implemented by authors for additional simulations with different m_x for reference model; based on R code in Doak & Cutler (2013) Supporting Information.

^cPopulation size at end of 19-year time series (2001).

^dMean of annual population growth (N_{t+1}/N_t).

^eSenescence as modeled by Doak & Cutler (2013) based on parameter estimates for age and age² from Johnson *et al.* 's (2004) proportional hazards model (Fig. 5, solid gray line).

^fAge-specific survival based on IGBST empirical data (see Fig. 5 [solid black line] for high survival scenario).

^gNot included in simulation models of Doak & Cutler (2013).

^hReproductive senescence modeled as age-specific fecundity based on Schwartz *et al.* (2003: model D).

ⁱNegative value indicates population increase compared with reference data (due to greater survival among ages 6–18 years; Fig. 5).

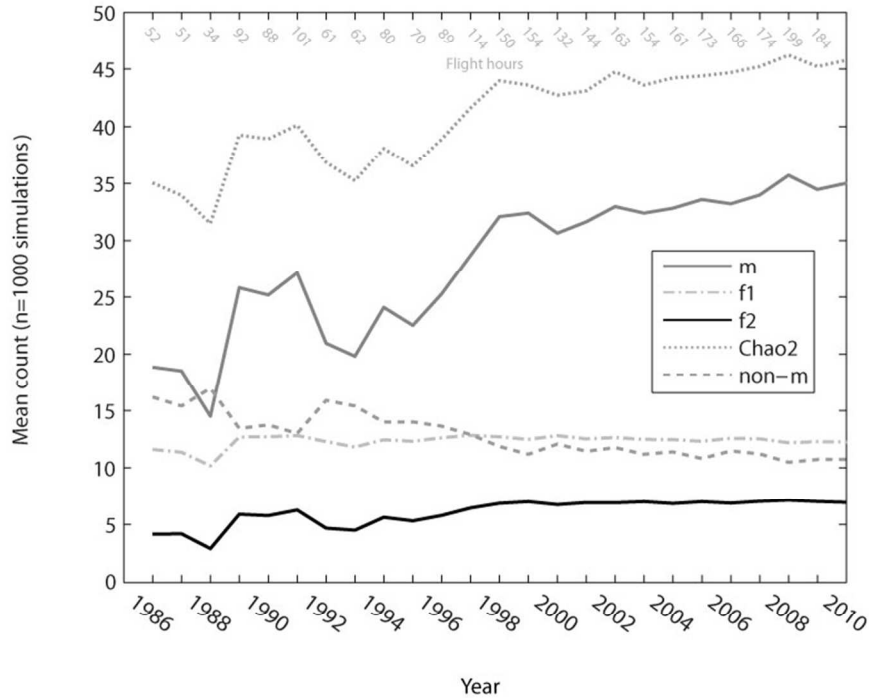


Fig. 1. Mean count of female grizzly bears with cubs-of-the-year (F_{COY}) seen once (f_1), twice (f_2), unique F_{COY} observed (m), Chao2 estimate, and F_{COY} not observed (non- m [Chao2- m]) based on simulations of Doak & Cutler (2013) for a known population of 70 F_{COY} , 1986–2010. Flight hours are shown on top x-axis.

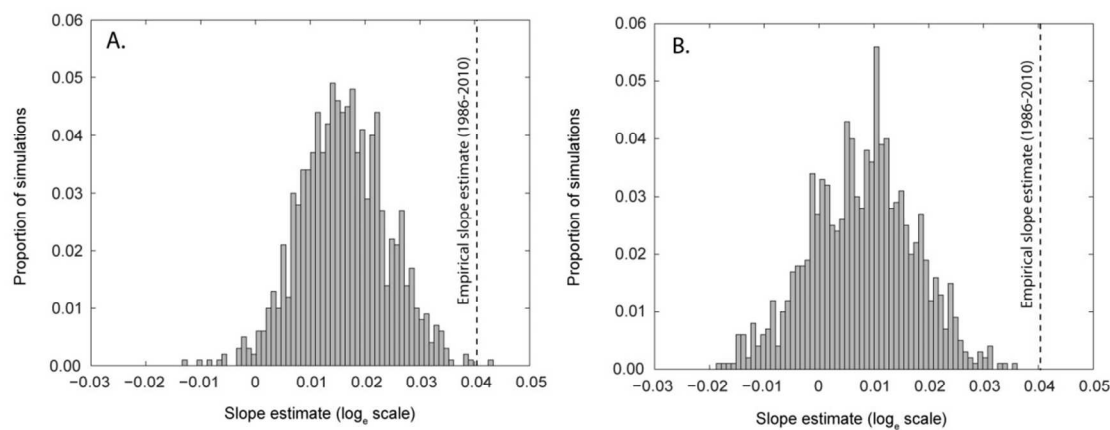


Fig. 2. Distribution of slope estimates obtained from 1,000 simulated realizations of data using linear regression of Chao2 (natural log scale) estimates of female grizzly bears with cubs-of-the-year (F_{COY}) as a function of (A) search effort (number of flight hours; following D&C) and (B) area-adjusted search effort (number of flight hours adjusted for area surveyed, our new analysis) based on 1,000 simulations of 25-year time series. The vertical dashed line shows the analysis value of the actual estimated slope for empirical Chao2 estimates of F_{COY} during 1986–2010 (Haroldson *et al.* 2011).

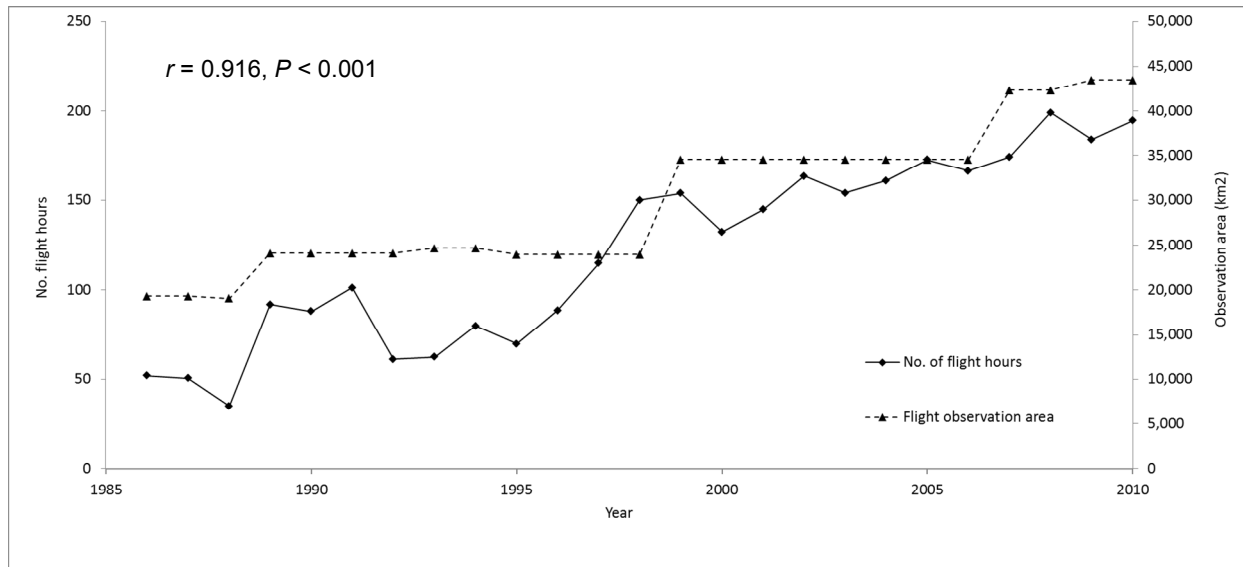


Fig. 3. Number of flight hours increased as flight observation areas for female grizzly bears with cubs-of-the-year were added to accommodate range expansion, Greater Yellowstone Ecosystem, 1986–2010.

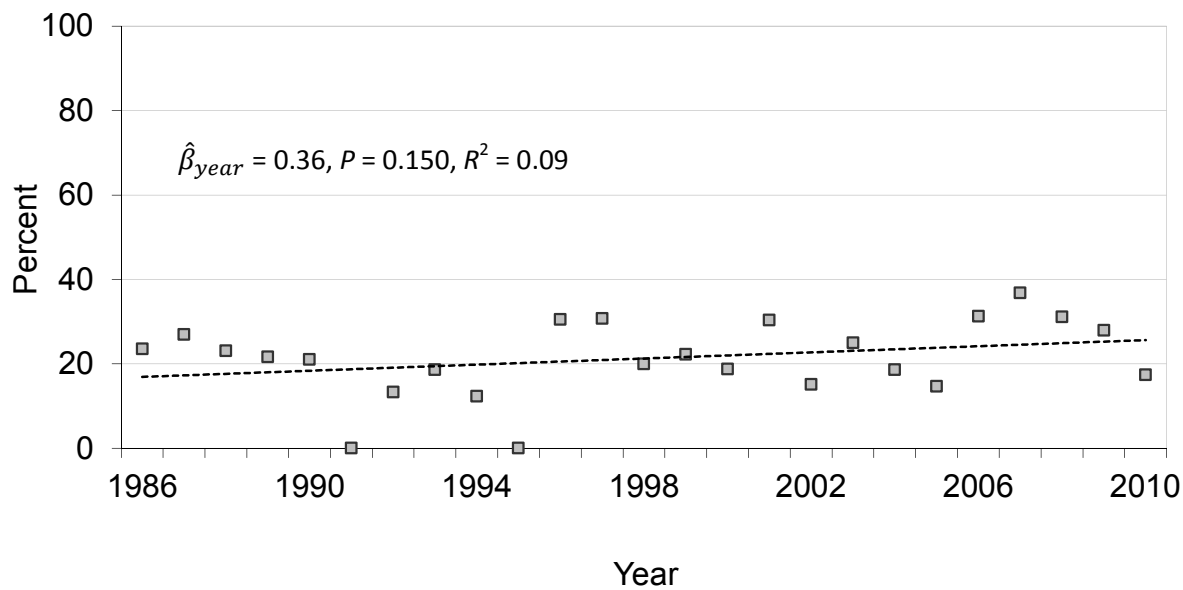


Fig. 4. Percent of locations of radio-marked female grizzly bears with cubs-of-the-year obtained during radio-telemetry flights that resulted in visual observation, Greater Yellowstone Ecosystem, May–August, 1986–2010.

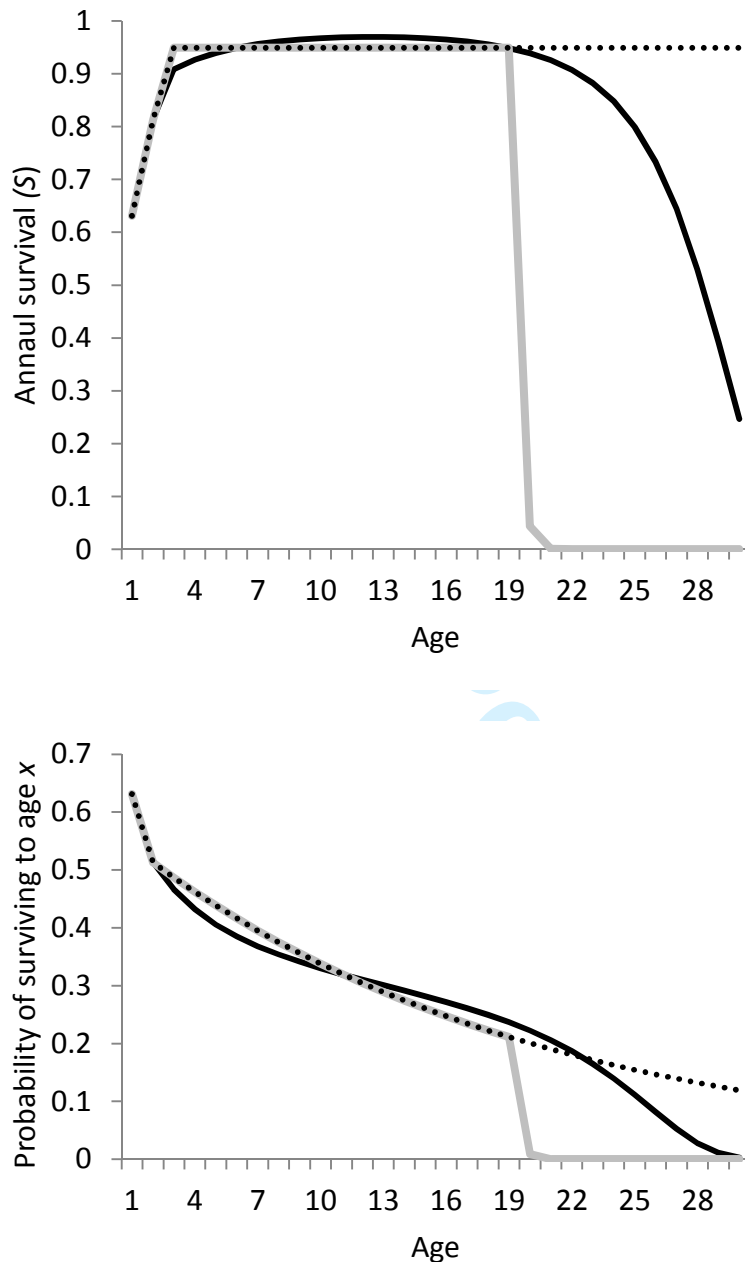


Fig. 5. Age-specific survival (A) and survival probability (B) for female grizzly bears in the Greater Yellowstone Ecosystem, 1986–2010. Dashed line is based on constant independent-aged survival from R code provided by Doak & Cutler (2013) and based on Harris *et al.* (2006, 2007); baseline annual survival ($\bar{S} = 0.949$) was the mean across all years for independent-aged bears (unknown fates censored or high survival scenario) with cub survival of 0.631 and yearling survival of 0.813. Solid gray line incorporates Doak and Cutler’s survival senescence function. Solid black line shows age-specific survival based on empirical data from IGBST for 1983–2011.

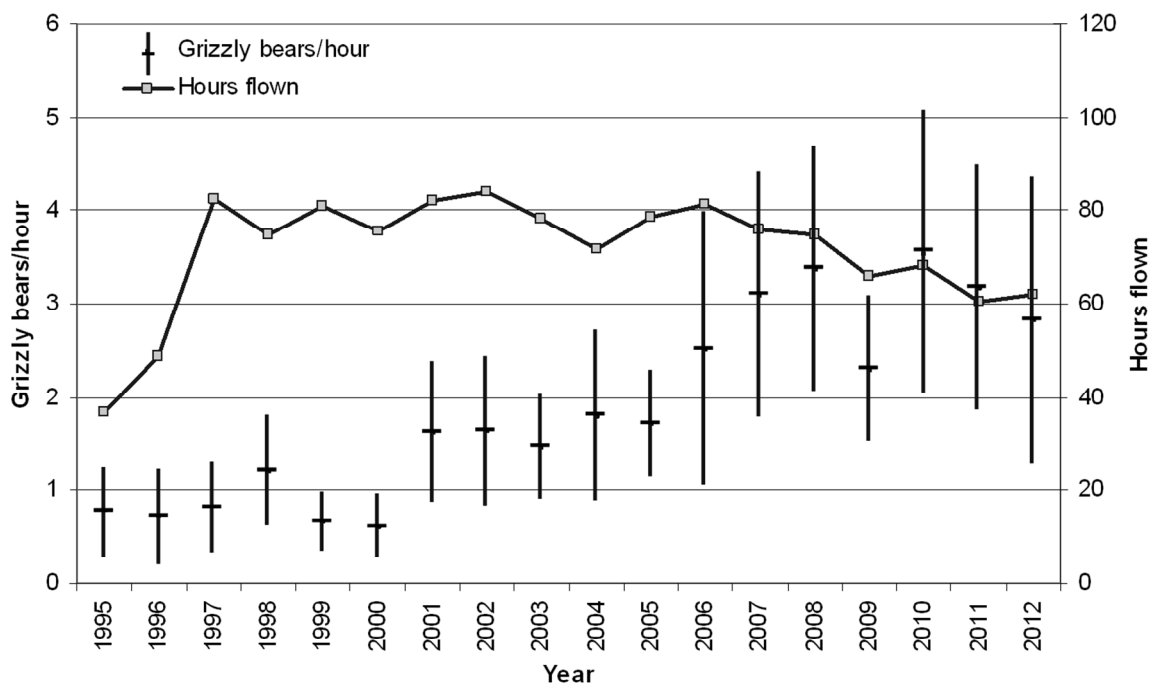


Fig. 6. Mean and 95% confidence intervals for grizzly bears observed per flight hour and total hours flown during 1995–2012 for Recovery Zone Bear Management Units, excluding those that contain army cutworm moth aggregation sites where bears congregate and are more observable.

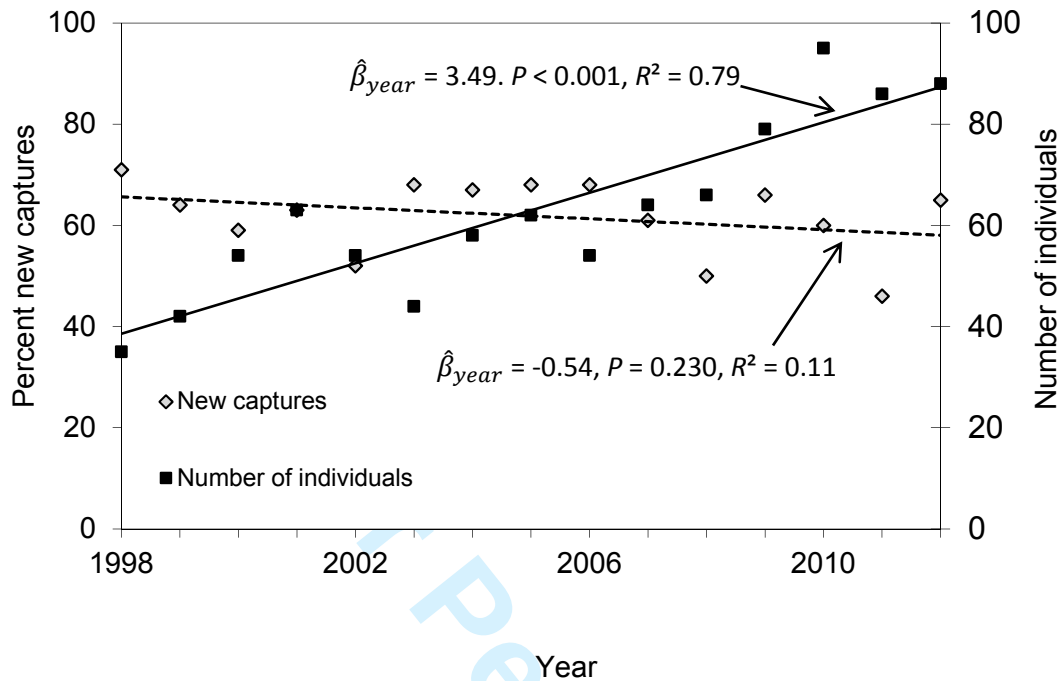


Fig. 7. Number of captures of grizzly bears and proportion of those captures representing new, unmarked individuals, Greater Yellowstone Ecosystem, 1998–2012.

Grizzly Bear Recovery Plan

Supplement: Revised Demographic Recovery Criteria for the Yellowstone Ecosystem

Original Approved: January 29, 1982
Revised Plan Approved: September 10, 1993
Previous Supplement on Demographic Recovery Criteria Approved: March 6, 2007

Prepared by: Dr. Christopher Servheen
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Approved:

Regional Director, U.S. Fish and Wildlife Service

Date

Comment [FTvM1]: GENERAL COMMENT:

I suggest you consistently refer to the proposed count line as the **Demographic Monitoring Area**, rather than just Monitoring Area. The "demographic" part emphasizes that this is where we collect demographic data, the area for which we perform our demographic analyses, establish sustainable mortality limits, etc.

Demographic Recovery Criteria for the Grizzly Bear Population in the Greater Yellowstone Ecosystem

In 2007, we supplemented the 1993 Grizzly Bear Recovery Plan with revised demographic criteria for the Greater Yellowstone Ecosystem (GYE) population (72 FR 11376, March 13, 2007). Since that time, new information relevant to these demographic criteria has become available. Consistent with Task Y11 of the Grizzly Bear Recovery Plan (U.S. Fish and Wildlife Service 1993, p. 44) that directs the Service to “Reevaluate and refine population criteria as new information becomes available,” we are revising the demographic criteria based on updated demographic analyses and the best available science.

The revised demographic recovery criteria in the GYE are:

- **Demographic Recovery Criterion 1**— Within the Monitoring Area, maintain a minimum population size of at least 500 animals and at least 48 females with cubs, as indicated by methods established in published, peer-reviewed scientific literature and calculated by the Interagency Grizzly Bear Study Team (the Study Team) using the most updated Protocol, as posted on their website. The estimate of total population size cannot drop below 500 in two consecutive years or 48 females with cubs in two consecutive years. This estimate will be calculated using data obtained within the Monitoring Area shown in Figure 1. If less than 48 females with cubs per year are reported for more than 2 consecutive years, this criterion will not be met and the Study Team will produce a Biology and Monitoring Review to inform the appropriate management response.
- **Demographic Recovery Criterion 2**— Sixteen of 18 bear management units within the Recovery Zone (Figure 2) must be occupied by females with young, with no 2 adjacent bear management units unoccupied, during a 6-year sum of observations. This criterion is important as it ensures that reproductive females occupy the majority of the Recovery Zone and are not concentrated in one portion of the ecosystem.
- **Demographic Recovery Criterion 3**— Within the Monitoring Area, calculate sustainable mortality limits annually for independent females (at least 2 years old), independent males (at least 2 years old), and dependent young (less than 2 years old) that correspond to a lambda value (i.e., population growth rate) of at least 1.0. This ensures the population does not decline. Annual mortality limits will be calculated

using sustainable mortality rates and the estimated population size for that year, as reported by the Study Team using peer reviewed scientific methods such as known-fate analyses (see Harris et al. 2006). Instead of permanently setting these rates in the criterion as was done in the 2007 Supplement, the Study Team may now adjust these rates in response to changes they detect in population vital rates. For example, the sustainable mortality rate using data from 2002-2011 is 7.6% for independent females while the rates for independent males and dependent young are 15% and 7.6%, respectively. These rates for independent females and dependent young are lower than what was calculated using data from 1983-2002, highlighting the importance of allowing the Study Team to adjust these rates in response to changes they detect in population vital rates. If mortality limits for independent females are exceeded in any 2 consecutive years, this criterion will not be met and the Study Team will produce a Biology and Monitoring Review to inform the appropriate management response. Similarly, if mortality limits for independent males or dependent young are exceeded in any 3 consecutive years, this criterion will not be met and a Biology and Monitoring Review will be completed. Mortalities will be counted and reported annually using data obtained within the Monitoring Area shown in Figure 1.

Background

In 2000, we began a process to reevaluate and update methods to determine the status of the GYE grizzly bear population, estimate population size, and determine the sustainable level of mortality in the GYE. The Wildlife Monograph: "Temporal, Spatial, and Environmental Influences on The Demographics of Grizzly Bears in The Greater Yellowstone Ecosystem" (Schwartz et al. 2006); the report: "Reassessing Methods to Estimate Population Size and Sustainable Mortality Limits for the Yellowstone Grizzly Bear" (Interagency Grizzly Bear Study Team 2005); and the report: "Reassessing Methods to Estimate Population Size and Sustainable Mortality Limits for the Yellowstone Grizzly Bear Workshop Document Supplement 19-21 June, 2006" (Interagency Grizzly Bear Study Team 2006) provided the scientific basis for revising the demographic recovery criteria in the GYE in 2007. Similarly, the revisions we are implementing through this Supplement to the Recovery Plan are based on updated demographic analyses using the same methods as before (Schwartz et al. 2006), as reported in the Interagency Grizzly Bear Study Team's 2012 report: "Updating and Evaluating Approaches to Estimate Population Size and Sustainable Mortality Limits for Grizzly Bears in the Greater Yellowstone Ecosystem." This 2012 Study Team report provides the scientific basis for the changes proposed below.

We changed the first and third criteria because they no longer represent the best scientific data or the best technique to assess recovery of the Yellowstone grizzly bear population. Specifically, these criteria warrant revision because – (1) There are updated demographic analyses for 2002-2011 indicating that the rate of growth seen during the 1983–2001 period has slowed and sex ratios have changed; (2) there is consensus among scientists and statisticians that the area within which we apply mortality limits should be the same area we use to estimate population size; and (3) the need exists to make the demographic criteria dynamic so the Study Team can incorporate results from updated demographic analyses and implement new scientific methods based on peer-reviewed, scientific literature as they become available.

These criteria replace the 2007 Demographic Criteria and are hereby appended to the Yellowstone chapter of the Grizzly Bear Recovery Plan (U.S. Fish and Wildlife Service 1993, p. 44) and the Final Conservation Strategy for the Grizzly Bear in the Greater Yellowstone Area.

More information about Revisions to Demographic Criterion 1:

Because the GYE grizzly bear population is currently isolated from other grizzly bear populations, to adequately mitigate the potential effects of genetic drift and inbreeding depression, Miller and Waits (2003) recommended that the total population size for the GYE grizzly bear population be at least 400 bears. To assure that this goal is met and in order to adopt a conservative approach, the total population will be maintained above 500 grizzly bears in the GYE. The biological intent of this revision is identical to the 2007 criterion. The number 500 is not a population goal nor is there any intention to manage down to 500 bears. The number 500 is a floor that the population cannot go below to assure population health.

While continuing to reflect the demographic goal of maintaining a minimum population size of 500 animals and at least 48 females with cubs, this criterion no longer specifies which scientific method must be used to assess the criterion. We eliminated the criterion's dependence on a specific method (e.g., Chao2) so the Study Team can rapidly implement improved scientific methods as they become available in the peer reviewed literature. Methods used to estimate population size will be available online for review in the Application Protocol posted on the Interagency Grizzly Bear Study Team's website (<http://nrmssc.usgs.gov/research/igbst/research>).

More information about Revisions to Demographic Criterion 3:

Demographic Criterion 3 still ensures sustainable mortality limits (i.e., rates that will avoid population declines) will be calculated each year. However, instead of permanently setting these rates in the criterion as was done in the 2007 Supplement, the Study Team may now adjust those rates in response to changes they detect in population vital rates. The sustainable mortality rates established in the 2007 Demographic Criteria were based on data obtained between 1983 and 2002 from radio-collared bears and the modeling results of Harris et al. (2006). When these Demographic Criteria triggered a demographic review by the Study Team in 2011, they examined more recent data from 2002-2011 and compared the results of these new analyses with those from the previous time period. Between 2002 and 2011, population growth slowed and sex ratios changed, with more independent males in the population than previously documented (Interagency Grizzly Bear Study Team 2012). When sustainable mortality rates were re-calculated with these more recent data, the Study Team found that these rates had changed for some age and sex classes. Specifically, the sustainable mortality rate for independent females from all sources changed from 9.0% to 7.6% and the sustainable mortality rate for dependent young from human causes only also changed from 9.0% to 7.6% (~~Study Team~~[Interagency Grizzly Bear Study Team](#) -2012). Because these rates represent the best available science, we revised Demographic Criterion 3 to reflect these new demographic analyses. The language in Demographic Criterion 3 allows results from demographic analyses to be implemented as they become available and sustainable mortality rates adjusted accordingly to prevent population decline.

While the general biological intent of this proposed revision is identical to the 2007 criterion (i.e., to establish mortality limits that prevent population decline), there is one important difference. The new rates are based on knowing what level of mortality will result in population stability and managing mortalities below that level rather than setting the mortality limit so that 95% of the time the population would increase. Managing at the lower 95% (as was done in the 2007 demographic criteria) is no longer appropriate because of the new demographic analyses. Because the point estimate of lambda for the entire GYE is 1.022 (~~Interagency Grizzly Bear Study Team~~[IGBST](#) 2012), there is no lower 95% CI that results in a stable population.

Because there are several indications the population is at or near carrying capacity and human-caused mortality will always be the limiting factor for this grizzly bear population, managing human-caused mortality at levels that prevent population decline is reasonable. No population can grow forever since the resources it requires are finite.

When a population grows too large for its environment to support continued growth, it is said to be above “carrying capacity.” Carrying capacity in wild species that are habitat generalists like grizzly bears varies from year to year and seasonally. Although carrying capacity varies widely in natural environments, there are several indications that the GYE grizzly bear population is at or near carrying capacity inside suitable habitat (see Schwartz et al. 2006; Interagency Grizzly Bear Study Team 2012). The agencies recognize that this population will soon need to be managed for stability instead of ever increasing growth (Interagency Grizzly Bear Study Team 2012) because the resources to maintain any wildlife population are finite.

Like the methods adopted in 2007, Demographic Criterion 3 continues to count deaths of independent (at least 2 years old) male and female grizzly bears from all sources against annual mortality limits while counting only known and probable human-caused mortalities against annual mortality limits for dependent young (less than 2 years old). For independent females and males, counted mortalities include: (1) known and probable human-caused mortalities; (2) reported deaths due to natural and undetermined causes; and (3) calculated unreported human-caused mortalities. The Study Team will continue to use the methods of Cherry et al. (2002) to estimate unknown/unreported mortalities each year based on the number of known, reported deaths (Cherry et al. 2002, p. 179; Interagency Grizzly Bear Study Team 2005, pp. 39-41).

Annual mortality limits will be assessed within the Monitoring Area shown in Figure 1. The Study Team developed this Monitoring Area using USFWS suitable habitat (see 72 FR 14866, March 29, 2007) as a base layer then adding areas which could serve as mortality sinks (e.g., cities) because these areas could have disproportionate effects on the population generally contained within the suitable habitat zone (Interagency Grizzly Bear Study Team 2012). Mortalities outside of the Monitoring Area will be recorded and reported but do not count against the sustainable mortality limits for that year. Grizzly bear occupancy will not be actively discouraged outside the Monitoring Area and grizzly bears will not be captured just because they are there. However, as is the case within the Monitoring Area boundary, individual bears may be removed from the population or relocated if there are conflicts. On occasion, grizzly bears may also be preemptively relocated to avoid conflicts if there is a demonstrated threat to human safety. However, bears will not be moved just because they are seen. There has to be a clear reason to preemptively move bears. Preemptive moves would not be classified as a conflict for the bear being moved.

To provide the opportunity for grizzly bears, particularly males ~~which~~ that are more likely to disperse long distances, to move between the Yellowstone and Northern Continental Divide ecosystems, discretionary mortality will be minimized in the Tobacco Root and Highland Mountains ranges and intervening valleys even though mortalities would not count against mortality limits. ~~Management emphasis will be on~~ conflict prevention and response. Attractant storage rules are in place on National Forest lands. Grizzly bears will not be captured and removed from this area unless there are conflicts or demonstrated threats to human safety.

Comment [rs2]: update based on language in responses below

Application of the proposed revisions to Demographic Criteria 1 and 3.

The Application Protocol describing the current methods to evaluate and measure these Demographic Recovery Criteria are available at the Study Team's website and will be updated as necessary to assure the use of the best available science.

See: <http://nrmsc.usgs.gov/research/igbst-home.htm>

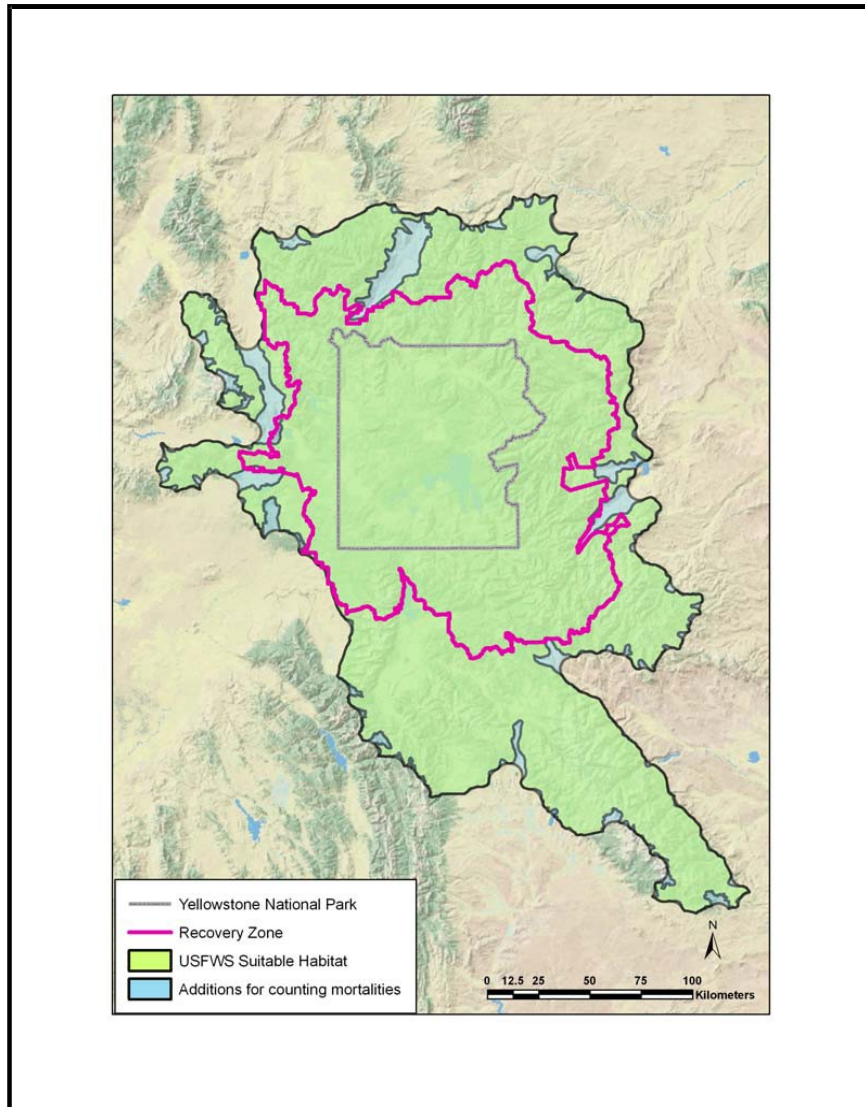


Figure 1. The Demographic Monitoring Area within which all demographic criteria would be assessed.

Comment [rs3]: MARK: We need this map to have I90 & I15 on it & a few cities for reference (Cody, Bozeman) & state boundaries. Also, the Monitoring Area should be 1 polygon, not a combo. of Suitable and Additions; add clarification about where habitat restrictions apply vs. food storage vs. demographic monitoring only

Comment [mah4]: Sent 2 version on 11/13/2013.



Figure 2. Yellowstone grizzly bear recovery zone boundary showing bear management unit (BMU) and subunit boundaries for application of Demographic Criterion 2.

Literature Cited

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- Interagency Grizzly Bear Study Team. 2013. Changes in food supply and health of Yellowstone grizzly bears: A synthesis. Interagency Grizzly Bear Study Team, USGS Northern Rocky Mountain Science Center, Montana State University, Bozeman, Montana, USA.
- Miller, C.R., and L.P. Waits. 2003. The history of effective population size and genetic diversity in the Yellowstone grizzly (*Ursus arctos*): Implications for conservation. *Proceedings of the National Academy of Sciences* 100:4334-4339.
- Schwartz, C.C., M.A. Haroldson, G.C. White, R.B. Harris, S. Cherry, K.A. Keating, D. Moody, and C. Servheen. 2006. Temporal, spatial, and environmental influences on the demographics of grizzly bears in the Greater Yellowstone Ecosystem. *Wildlife Monographs* 161.
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Responses to public comments: Greater Yellowstone Ecosystem grizzly bear demographic criteria changes

We released draft revisions to the demographic recovery criteria for the Greater Yellowstone Ecosystem grizzly bear population for public comment and peer review on March 22, 2013 (78 FR 17708). The 90-day comment period ended June 20, 2013 (see 78 FR 29774, May 21, 2013). During this time, we received approximately 40,000 comments and one solicited peer review. We have made appropriate changes in the Final Supplement to the demographic criteria in response to these comments or, for comments not directly addressed through the final Supplement, comments are summarized below, followed by our response to each.

1. **Comment:** The apparent increase in the number of females with cubs of the year (FCOY) can be explained by factors other than an actual increase in population size. Specifically, Doak and Cutler (2013) said this apparent increase could be explained by increased observer effort, changes in sightability due to changes in food sources, and not including reproductive or survival senescence.

Response: We disagree with Doak and Cutler's (2013, doi: 10.1111/conl.12048) conclusions. They do not raise any new or unaddressed issues. In fact, similar concerns or analyses that question the validity of the Study Team's population demographics analyses due to these very same reasons have been thoroughly disclosed, analyzed, and rebutted in the scientific literature previously (see Cherry et al. 2002; Keating et al. 2002; Interagency Grizzly Bear Study Team 2005, 2006; Haroldson et al. 2006; Schwartz et al. 2006; Cherry et al. 2007; Schwartz et al. 2008; Interagency Grizzly Bear Study Team 2012). Doak and Cutler (2013) is the latest attempt to undermine the scientific credibility of an interagency cooperative research effort that has made the GYE grizzly bear population the most studied grizzly bear population in the world. As in the past, IGBST Doak and Cutler (2013) was systematically rebutted the critique of Doak and Cutler (2013) in a follow-up paper submitted to the same journal (*Conservation Letters*) in August 2013 (van Manen et al., in press review). In that paper, Van van Manen et al. (in press review) demonstrate in detail that Doak and Cutler's conclusion that increases in the number of females with cubs are actually due to increased observer effort and/or increases in sightability due to changes in food resources have no basis in fact or science. Here are relevant comments from the rebuttal paper (van Manen et al. in press review):

They [Doak and Cutler 2013] used simulations to support their claim that IGBST monitoring of population trend based on Chao2 estimates of females

Comment [rs5]: check w/ Frank/Mark to make sure they agree w/ this 1st paragraph

FTvM: I agree with this language, but see Mark's suggestion below to add several references and my note below to use quotes from the attached submission instead.

Comment [mah6]: Should probably include Harris et al. 2006 and 2007, along with Eberhardt and Cherry 2000, which is the response to Pease and Mattson 1999.

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with cubs-of-the-year (F_{COY}) (Keating *et al.* 2002, Cherry *et al.* 2007) is biased because search effort (flight hours) increased over time. Their model assumed that any F_{COY} within ~20,000–45,000 km² of occupied habitat (1986–2001) was potentially observable during any given flight hour, which is clearly unreasonable. We further demonstrate their claim that population trend increased as a direct result of more flight hours was not statistically supported by their own simulations and even less so when we used effort/area surveyed to account for population expansion.

Doak & Cutler further argued that by not accounting for survival and reproductive senescence, IGBST's demographic projection models overestimate population growth. This statement is incorrect because influence of age on survival and fecundity were investigated in detail (Harris *et al.* 2006, 2007; Haroldson 2006) but resulted in negligible changes in population trajectory. Doak & Cutler support their senescence argument with another set of simulations using a baseline model with constant survival and fecundity as implemented by IGBST. The survival senescence function they used, however, was so extreme that female survival decreased from 0.949 at age 19 to essentially no survival for ages ≥ 21 , unsupported by empirical data and unrealistic for any grizzly bear population.

Doak & Cutler's choice of extreme survival and incompatible reproductive senescence functions substantially influenced their simulation results, leading to erroneous conclusions. We conclude their critique is unfounded when placed within the context of a thorough understanding of the data, the study system, and previous research findings and publications.

2. Comment: There should be a criterion about connectivity. There should be identified protected connectivity areas like the draft Northern Continental Divide Ecosystem Grizzly Bear Conservation Strategy proposes.

Response: As stated in the Final Rule (72 FR 14866) and upheld by the Courts, connectivity is not mandatory to ensure genetic isolation will not threaten the GYE grizzly bear population. That being said, allowing the opportunity for animals to move into or out of the GYE is desirable because it increases the ability of the population to respond to changes in environmental conditions and other factors we have no authority or control over, such as private land development or scientific uncertainty. We would expect bears to gradually reoccupy habitat between the GYE and the NCDE in the Highland and Tobacco Root mountain ranges. To

Comment [FTvM7]: These quotes are actually from the first version we submitted, which was limited to 500 words. We were then invited to submit a full-length rebuttal; so these quotes do not match the official submission. I have attached the official submission so you can borrow quotes from that version instead.

Comment [rs8]: have Kevin & LHB review this response

Comment [rs9]: want some input about this. Is this a compelling response to the shallenberger crowd?

FTvM: this makes sense to me from a scientific standpoint.

provide the opportunity for non-nuisance grizzly bears to reoccupy these mountain ranges at low densities, grizzly bears will not be captured and removed unless there are conflicts or demonstrated threats to human safety. As is the case inside the Monitoring Area, management emphasis will be on conflict prevention and response. Attractant storage rules are in place on National Forest lands. Additional habitat protections are not necessary for recovery.

3. Comment: The Centennials, Gravelly's, Snowcrest, Wyoming, and Wind River Mountain ranges should be included in the Monitoring Area.

Response: The Centennial, Gravelly, and Wind River Ranges are already in the monitoring area. The Wyoming Range is not included in the revised Monitoring Area due to the high risk of mortality resulting from grizzly bear/human conflicts in this peripheral area of current grizzly bear distribution. These unsuitable habitat areas do not permit grizzly bear reproduction or survival because bears that repeatedly come into conflict with humans or livestock are usually either relocated or removed from these areas. the density of domestic sheep grazing in the area. The Snowcrest range is not part of the Monitoring Area but discretionary mortalities will be minimized here. Grizzly bears will not be captured and removed from this area unless there are conflicts or demonstrated threats to human safety.

4. Comment: Implementing the plan will only further preclude connectivity with other grizzly bear populations.

Response: We disagree because grizzly bears will not be captured and removed from this area areas between the GYE and NCDE unless there are conflicts or demonstrated threats to human safety.

5. Comment: Some commenters were concerned that the sustainable mortality rate is set at a value that corresponds with a stable population growth rate instead of an increasing one. They say it's unclear if managing for stability is consistent with the ESA. At face value, this means you're managing a threatened species to remain a threatened species.

Response: Wording has been modified so management will assure that the population does not decline and mortalities will be managed below the sustainable mortality rate. Within the Monitoring Area, we are managing GYE grizzly bears to ensure no decline and to improve their status from threatened.

6. Comment: The new methodology is intended to increase, not decrease, the number of bear mortalities, in contravention of the ESA.

Comment [rs10]: talk to Mark about this....i'm having a hard time saying why we included some sinks (cities) but not others (sheep allotments) in the Monitoring Area.

FTVM: It's critical to note that we did NOT use subjective criteria but used a universal method to 'close the inlets'. See Mark's description below.

Comment [mah11]: We used a systematic, quantitative method to smooth the USFWS 2007 Suitable Habitat boundary. We closed inlets based on an annual activity radii of 6 km estimated from female grizzly bears that wore GPS collar and had been track for a minimum of 5 month. We buffered your boundary by 6 km, and then took an inside buffer of 6 km, retaining areas where outside buffer overlapped. Lisa did it an can likely explain it better than I can.

Response: The new methodology is not designed to increase the number of mortalities. Instead it is designed to assure that mortalities do not exceed sustainable mortality levels. Within the Monitoring Area, m~~M~~Mortalities will be managed in a dynamic way so that if the population continues to increase, the sustainable mortality rate will increase. If the population stabilizes the sustainable mortality rate will stabilize and if the population should decrease the sustainable mortality rate will decrease. The new methodology is designed to assure that the mortality limits are known so that management can assure that this mortality does not exceed sustainable mortality.

7. Comment: The ESA requires that public notice and opportunity for public review and comment be provided during recovery plan development and revision.

Response: We agree. As always, changes to criteria contained in a recovery plan will include an opportunity for public review and comment. However, future changes to the methods we use to ~~evaluate-assess~~ recovery plan criteria will not be subject to public review although they always go through both a scientific peer review process and an agency peer review process. _

8. Comment: The revised criteria will allow more bears to die even though their numbers have stabilized. Won't this lead to a decline in numbers if current mortality levels result in a stable population?

Response: The new criteria will assure that the mortality levels do not exceed sustainable mortality levels so the population within the Monitoring Area will not decline. Eventually the population must stabilize as it reaches the carrying capacity of the ecosystem and the proposed management system will assure that mortalities are adjusted so that the population does not decline due to excessive mortality.

9. Comment: The plan to relocate bears from other ecosystems to the GYE to address genetic isolation violates the spirit of the Endangered Species Act and the Service's stated "primary goal" of "restoring a threatened animal to the point where it is again a secure, self-sustaining member of its ecosystem." (as quoted from 78 FR 17708).

Response: Relocation of bears to the GYA as a method of recovering the species has been upheld by a reviewing court (Greater Yellowstone Coalition v. Servheen et al.). While natural connectivity and dispersal between ecosystems on occasion is desirable, manually moving bears between ecosystems is scientifically defensible to mitigate any future genetic threats.

10. Comment: It appears this proposed rapid-response approach would effectively exclude the scientific community from participating in the process of reviewing status and trend methodology outside of the formal peer review process.
Response: This Supplement allows the Study Team to implement new scientific methods to assess demographic recovery criteria as they become available, instead of viewing assessment methods as a revision to the actual criteria. All demographic assessment methods are subject to extensive peer review processes by members of the scientific community. Subjecting methods to scientific peer review and publication processes therefore ensures the scientific community will continue to be the driving force behind grizzly bear management in the GYE. We do not believe it is necessary or appropriate to have the general public vet scientific methods used to assess demographic criteria. That being said, we welcome comments from anyone at any time that provide scientific information, alternative methods, literature or research we may not be aware of, or scientific critiques for our consideration.
11. Comment: Item # 26 in Appendix C of the Yellowstone Conservation Strategy says: "No changes in the population management systems will be made unless these changes are based on the best available science and the changes have been subject to peer review and an open public process."
Response: No changes are being proposed or made to the process described in the Conservation Strategy.
12. Comment: It is not clear as to when or how often new mortality limits would be calculated.
Response: Mortality limits will be calculated every year using the estimate of population size for that year. Mortality rates that these annual limits are based on would be reassessed if demographic monitoring indicates that the sustainable mortality levels have changed.
13. Comment: FWS must explain the Capture-Mark-Recapture (CMR) method better, how to handle moth sites if it were adopted, and how the "very large Confidence Intervals" fit into conservative decision-making.
Response: We agree these 3 issues warrant further evaluation, as stated by the Study Team (2012, p. 30). Further, we will not implement any method until it has been vetted and published in a peer-reviewed professional journal._

14. Comment: There were multiple comments regarding the level of uncertainty surrounding estimates of population growth, population size, and mortality limits. Some requested that we identify and address the uncertainty associated with population and allowable mortality estimates, provide clear criteria for how those estimates and their associated uncertainty are analyzed and addressed, and consider using the standard 95% confidence interval to ensure conservative management. While the Service knows the Knight rule set is biased low, in many steps of the process of calculating population size and mortality rates, the levels of uncertainty are unknown. The peer reviewer thought “Accurate demographic analysis of the GYA grizzly population is precluded by low sample size and wide variance. ...there is substantial uncertainty around estimates of population performance. Thus the demographic criteria will support grizzly bear conservation only as long as embedded system errors are conservative.”

Response: Uncertainty is a fact in all wildlife management decisions. It is unavoidable because it is a by-product of monitoring a population using a sample of individuals instead of every single member. The scientific community generally quantifies uncertainty as a “confidence interval” around a “point estimate.” As the names imply, a confidence interval describes a range of values within which we can be reasonably sure that the true value for the entire population actually lies while the point estimate is the closest approximation of reality based on *that sample*. A 95% confidence interval is often interpreted as indicating a range within which we can be 95% certain that the true value lies. While it is obviously desirable to reduce levels of uncertainty to gain a more accurate picture of reality, uncertainty (as described with confidence intervals) is a scientific fact and scientists are morally obligated to disclose levels of uncertainty surrounding their estimates, if they are known. In other words, uncertainty is part of the scientific method. Science cannot provide unequivocal answers to decision makers and it never will.

Due to the biological traits of grizzly bears (e.g., elusive, intelligent, slow reproducers so they have to be followed several consecutive years, wide-roaming, tendencies to use habitat in rugged mountain terrain far from any access option that would accommodate trapping), estimates of population size and population trend invariably include values that do not allow managers to entirely reject the possibility of a population decline. ~~Obviously~~ Clearly, this decreases confidence in our decisions. But as the peer reviewer acknowledged, “most wildlife is managed with much less information and most maintain stable to increasing populations.” To improve our confidence, we monitor multiple indices of population health (e.g., litter size, reproductive interval, age specific survival, sex ratios, etc.) in addition to

trend and size to be sure all data are pointing in the same direction. This increases ~~the~~ confidence in ~~our~~ our decisions and also in the point estimates of population trend and size. Another way we increase confidence in our decisions is by using different methods to estimate the same parameters and making sure they corroborate. For example, our estimate of trend using radio-collared bears and known fate analyses is approximately the same as our estimate of trend using the Chao2 estimator. The point estimates are the closest approximation of reality and it is therefore reasonable to use them to inform our decisions. As Schwartz et al. (2006, p. 62) noted, “To claim that no decision about what has occurred should be adopted until uncertainty is removed, or to claim that the only acceptable decision adopts some lower confidence limit as truth, is to reject the role of science.”

Managing by the lower 95% confidence interval that results in a stable population (as was done in the 2007 demographic criteria) is no longer appropriate because of the new demographic analyses. Because the point estimate of lambda for the entire GYE is 1.0, there is no lower 95% confidence interval that results in a stable population (~~Study Team~~ Interagency Grizzly Bear Study Team 2012).

15. Comment: The Service fails to sufficiently explain why it is establishing a population goal of 500- and adjusting mortality limits to manage for stability.
Response: As reflected in this Supplement to the Grizzly Bear Recovery Plan, the Service has clarified that 500 is not a “goal” but a lower limit. Stability is no longer the management direction and the wording in Criterion 3 has been changed to emphasize that the goal is to manage mortality below sustainable limits so the population does not decline within the Monitoring Area. It is not the desire or in the interests of any agency in the GYE to attempt to manage at maximum allowable mortality limits every year because this would result in additional work for those agencies when the Study Team (which they are members of) is required to conduct a Biology and Monitoring Review in response to excessive human-caused mortality.

16. Comment: The math behind the estimated proportion of FCOY in the population (0.289) is complex and not necessarily supported by the data (e.g., assuming transition probabilities are an age and time invariant Markovian process). In this case, the peer reviewer was suggesting that the assumption of a stable age distribution may not be met for the Yellowstone grizzly bear population.

Response: The peer reviewer seems to presents 2 concerns here: 1) complexity of calculating proportion of FCOY and 2) assumption of stable age distribution is not supported. The Study Team estimates the proportion of FCOY in the population

Comment [mah12]: Point estimates for the proportion of females in the “with COY” state are simple to calculate and can be done easily in spreadsheet. And they are supported by the data. You use data to generate the estimates. Getting confidence intervals or investigating the influence of covariates is more complicated

Comment [rs13]: MARK/FRANK: is this what you understood Waller’s concern to be?

FTvM: See edits, which includes Mark’s comment.

Comment [rs14]: MARK/FRANK: is this what you understood Waller’s concern to be?

FTvM: See edits

based on the stable state transition probability for females with COY in the population because the technique is unaffected by differences in the probability of capture heterogeneity among reproductive states and is unbiased if the number of 3-year-old females in the sample is representative of the number in the assumption population. Point estimates for the proportion of females in the “with COY” state are simple to calculate (e.g., can easily be calculated in a spreadsheet) and are derived from the monitoring data. Calculating confidence intervals or investigating the influence of covariates is more complicated but this not justify choosing a simpler but biased technique. ~~of a stable age distribution because this technique is not biased by capture heterogeneity. Accounting for these differences in the likelihood of detecting different age and sex classes is an important consideration when using FCOY data. Schwartz and White (2008) provide further details on advantages of using stable state transitions to estimate proportion of FCOY in the population.~~ This technique is indeed based on the assumption that the population has a relatively stable age distribution and that transition probabilities are constant across age and time, but so are any of the alternative (but biased) techniques when data are pooled. As Schwartz and White (2008) indicate, the assumption of a stable age distribution is reasonable for most bear populations, and especially for Yellowstone, where mean female survival rates have been relatively constant since the mid 1980s.

Comment [FTvM15]: I would suggest something like this to indicate why use of our technique is justified.

Comment [rs16]: MARK/FRANK: how's this layman's def. of capture heterogeneity?

17. **Comment:** Supplement the female with cubs population estimate with a DNA-based population estimate. However, this DNA-based estimate “would not have to be as rigorous as the DNA-based population estimate for the NCDE”.

Response: We agree that a DNA-based estimate is of value but the actual cost of applying such an estimate to the 50,000 square kilometers of occupied grizzly habitat in the Yellowstone ecosystem, even if it was a less rigorous sampling than the NCDE estimate, would be millions of additional dollars beyond currently available funding and would be a one-time estimate. If a less rigorous system was implemented, it would undermine the accuracy of the results because sample size would be reduced and variance would increase.

Comment [FTvM17]: Would it be worthwhile pointing out that this would only provide an estimate for a single point in time ?

18. **Comment:** “...evidence suggests that density dependence and whitebark pine declines are causing growth to slow, but that these results are completely confounded.”

Response: We agree that the results are complex. The foods synthesis document (IGBST 2013) includes several analyses that attempt to clarify and tease apart these two similar effects. Regardless of whether these changes are being driven by declines in whitebark pine or are simply an indication of a population reaching carrying capacity, our management response would be the same: to carefully manage human-caused mortality. Managing mortality to assure that the population

does not decline will address population management while other, ongoing studies examine the specific potential causes of any changes observed.

19. Comment: The proposed Monitoring Area is substantially smaller than that proposed in 2007 and “excludes substantial areas of suitable habitat in Wyoming and Montana.”

Response: The suitable habitat area is described and defined in the explanation sheet on suitable habitat provided as part of the proposed changes (available at http://www.fws.gov/mountain-prairie/species/mammals/grizzly/BackgroundOnUSFWS_SuitableHabitatMarch2013.pdf). The previous area within which mortality limits were assessed was substantially larger than the area within which data were collected to estimate population size. The Monitoring Area was much larger in size but the Study Team was not monitoring the entire area for population growth, only mortality. This means we were counting mortalities in areas where we weren’t monitoring for population size or trend. This inevitably leads to underestimating the size of the population which is then used to estimate sustainable mortality limits. The revised Monitoring Area addresses this known bias so that mortalities and population health and size will be monitored in the same area.

20. Comment: The Service should clearly state the differences in size and counts with the new versus the old Monitoring Areas.

Response: Below, we provide an example of the 2012 mortality limits for various age classes in the previous monitoring area (called the “Conservation Strategy Management Area”) and the Monitoring Area contained in this Supplement. Figure 1 shows the spatial pattern of known and probable mortalities from 2007-2012. While the Monitoring Area described in this Supplement is nearly half the size of the previous monitoring area (49,931 sq km instead of 95,225 sq km), only a very small proportion of mortalities occur outside this area. For example, between 2007 and 2012 there were ~~X-253~~ mortalities ~~that would not have been counted toward mortality limits in the Greater Yellowstone area~~. ~~Of of~~ these, ~~Y-5~~ were not counted toward mortality limits under the 2007 demographic criteria because they occurred outside of the previous monitoring area.

	Previous monitoring area	Monitoring Area
Size in sq. km	95,225 sq km	49,931 sq km
Independent female mortalities observed in 2012 (mortality limit)	15 (23)	12 (19)
Independent male mortalities	34 (24)	31 (37)

Comment [rs18]: MARK: wanna fill in the blanks?

Comment [mah19]: Changed the wording some. Did not make sense as it was.

observed in 2012 (mortality limit)		
Dependent young mortalities observed in 2012 (mortality limit)	6 (17)	6 (17)

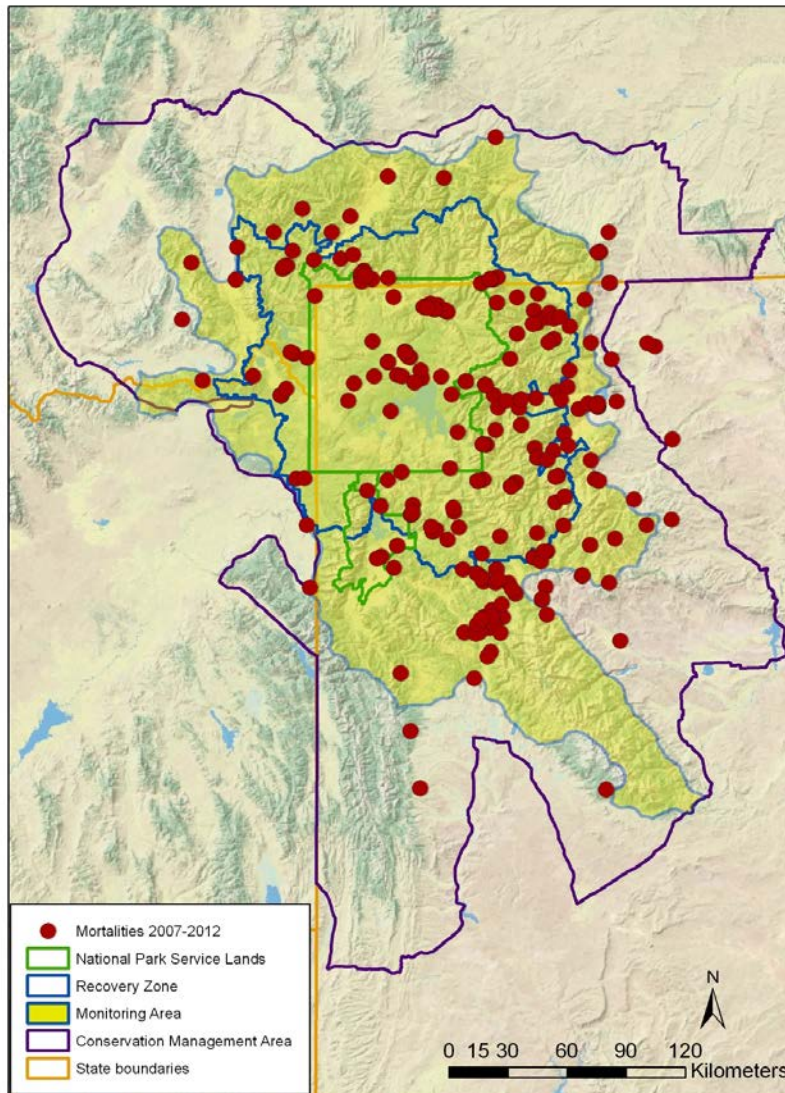


Figure 1. Known and probable grizzly mortalities 2007-2012 inside and outside the Monitoring Area identified in this Supplement.

Appendix A.

Implementation Schedule

The following Implementation Schedule outlines actions and estimated costs for the grizzly bear (*Ursus arctos horribilis*) recovery program over the next 5 years [in the GYE](#). Functioning as a practical guide for meeting the species' recovery goals, this schedule indicates action priorities, action numbers, action descriptions, duration of actions, and estimated costs. In addition, parties with authority, responsibility, or expressed interest in implementing a specific recovery action are identified; however, this neither obligates nor implies a requirement for the identified party to implement the action(s) or secure funding for implementing the action(s). However, parties willing to participate may benefit by being able to show in their own budgets that their funding request is for a recovery action identified in an approved recovery plan and, therefore, is considered a necessary action for the overall coordinated effort to recover the grizzly bear. Also, section 7(a)(1) of the ESA, as amended, directs all Federal agencies to utilize their authorities in furtherance of the purposes of the ESA by carrying out programs for the conservation threatened and endangered species. The following implementation schedule only covers time and cost estimates related to the demographic recovery criteria discussed in this Supplement. However, the total cost for annual implementation of all recovery actions is approximately \$3,773,685. It is not practicable to estimate the total time to recovery as we do not know how long the population will remain listed.

Key to Implementation Schedule Priorities (column 1)

PRIORITY 1 ACTION: An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

PRIORITY 2 ACTION: An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

PRIORITY 3 ACTION: All other actions necessary to provide for full recovery of the species.

Key to responsible parties in column 4:

USFS =	U.S. Forest Service
YNP =	Yellowstone National Park
USGS =	U.S. Geological Survey
MT =	Montana Fish Wildlife and Parks Department
ID =	Idaho Fish and Game Department
WY =	Wyoming Game and Fish Department
GTNP =	Grand Teton National Park

Action Priority	Action Description	Action Duration	Responsible Parties	USFWS Lead	Total (annual) Costs	Comments
3	Monitor the number of females with cubs.	Annual	USGS, MT, WY, ID, YNP, GTNP, USFS	N	\$203,920	Estimate derived from Appendix H of the Final Conservation Strategy for the Grizzly Bear in the Greater Yellowstone Area and adjusted for inflation.
3	Monitor and investigate grizzly bear mortalities	Annual	USGS, MT, WY, ID, YNP, GTNP, USFS, USFWS	N	\$108,235	Estimate derived from Appendix H of the Final Conservation Strategy for the Grizzly Bear in the Greater Yellowstone Area and adjusted for inflation.
3	Monitor distribution of family groups	Annual	USGS, MT, WY, ID, YNP, GTNP, USFS	N	\$78,165	Estimate derived from Appendix H of the Final Conservation Strategy for the Grizzly Bear in the Greater Yellowstone Area and adjusted for inflation.
3	Maintain sample of at least 25 radio-collared females	Annual	USGS, MT, WY, ID, YNP, GTNP, USFS	N	\$462,735	Estimate derived from Appendix H of the Final Conservation Strategy for the Grizzly Bear in the Greater Yellowstone Area and adjusted for inflation.
3	Management of grizzly bear/human conflicts	Annual	USGS, MT, WY, ID, YNP, GTNP, USFS	N	\$2,230,435	Estimate derived from Appendix H of the Final Conservation Strategy for the Grizzly Bear in the Greater Yellowstone Area and adjusted for inflation.
3	Conflict prevention via outreach and education	Annual	USGS, MT, WY, ID, YNP, GTNP, USFS	N	\$210,630	Estimate derived from Appendix H of the Final Conservation Strategy for the Grizzly Bear in the Greater Yellowstone Area and adjusted for inflation.
3	Report writing, data analyses, literature publication	Annual	USGS, MT, WY, ID, YNP, GTNP, USFS	N	\$25,000	Estimate derived from Appendix H of the Final Conservation Strategy for the Grizzly Bear in the Greater Yellowstone Area and adjusted for inflation.

Note: It is anticipated that these annual costs will continue in perpetuity, regardless of listed status, or until cheaper methods to obtain the same quality of information are developed