

Peer Review of proposed changes to the Greater Yellowstone Area grizzly bear recovery plan demographic criteria

Reviewer: Dr. John S. Waller

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Charge to Reviewers:

The US Fish and Wildlife Service (USFWS) and Interagency Grizzly Bear Study Team (IGBST) sought peer review on two interrelated documents: (1) Proposed Revisions to the Demographic Recovery Criteria for the Grizzly Bear Population in the Greater Yellowstone Area (GYA); and (2) Application Protocol for these Proposed Revisions. These proposed revisions were the result of a scientific report produced by the IGBST in 2012 titled: "Updating and Evaluating Approaches to Estimate Population Size and Sustainable Mortality Limits for Grizzly Bears in the Greater Yellowstone Ecosystem." Reviewers were asked to decide if, in their judgment, this report provided appropriate scientific support for the proposed revisions. The purpose of seeking independent peer review was to ensure that the best biological and scientific data were being used in the revision process, as well as to ensure that reviews and input by recognized experts were incorporated into the final Demographic Recovery Criteria.

Reviewers were asked to consider, but not limit responses, to the following questions and provide any other relevant comments, criticisms, or ideas:

1. Are assumptions and sources of uncertainties clearly identified and quantified in the Study Team (2012) Workshop report?
2. Given known (and unknown) levels of uncertainty, are the revised demographic criteria likely to support long-term conservation of grizzly bears in the GYA?
3. Would additional analyses or research reduce sources of uncertainty and to what extent? If so, what analyses/research would be most helpful?
4. Do you believe that managing for stability (instead of an increasing or decreasing population) an appropriate approach for this population of grizzly bears?
5. Is assessment of demographic criteria exclusively within the Monitoring Area identified a reasonable biological and statistical approach?

6. Do the proposed revisions and supporting documents provide all the necessary and pertinent literature to support our assumptions and conclusions?

Reviewers were also asked to provide a brief written report evaluating the documents. This report would include the reviewer's organizational affiliation and credentials before responding to the questions above and presenting findings and conclusions. Reviewers were not expected to provide advice on the specific decision but rather ensure that scientific uncertainties were clearly identified and whether more research was likely to decrease key uncertainties and, if so, to what extent. The reviewers name and report would be available to the public.

Review of Updating and evaluating approaches to estimate population size and sustainable mortality limits for grizzly bears in the Greater Yellowstone Ecosystem, IGBST 2012.

The methods described in this document are complex, having many steps to estimate numerous population parameters. The document falls short in a number of places in describing the steps in sufficient detail. Estimating the population size of females in the ecosystem is the heart of the current system. Simply speaking, the Chao2 estimator is used to estimate the total number of females with cubs-of-the-year (F_{coy}) present in the ecosystem based on the observed count frequencies of F_{coy} seen during aerial surveys. This number is then divided by the estimated proportion of F_{coy} in the population (0.289) to arrive at the total number of adult females in the population. This is an estimate divided by an estimate. The derivation of the later estimate is not described in the document, but requires study of preceding reports and publications. The mathematics behind estimating the proportions are complex with numerous assumptions that are not necessarily supported by the data (for example assuming transition probabilities are an age and time invariant Markovian process). The resulting quotient is then divided by the estimated proportion of adult females in the population (0.77699) to arrive at the total number of independent females (≥ 2 years old) in the population. We now have an estimate divided by an estimate divided by an estimate.

Sustainable mortality is estimated at 9% based on simulations of survival and fecundity that result in population growth rates (λ) ≥ 1.0 . This estimate is then multiplied by the estimates derived above. Thus sustainable mortality is: estimate(estimate/estimate/estimate). The IGBST expressed the need to dampen variability in mortality limits in order to provide managers with inter-annual stability in mortality thresholds. They do not elaborate on why this is important or desired, nor could I find prior documentation of how or why this was considered necessary. The authors smooth F_{coy} estimates by fitting linear and quadratic models to previous years data (but which years are not identified), then averaging the results and using this mean as the first estimate described in 2.2.1.1. So now we have estimate(mean estimate/estimate/estimate).

Unknown and unreported mortality are estimated using the method described by Cherry et al. (2002), but not described in this document. How the estimate is used is also not described, however I assume it is subtracted from the total allowable mortality of 9%. So the allowable mortality can now be expressed as {estimate(mean estimate/estimate/estimate)}-estimate.

The authors switch to using the model-averaged number of F_{coy} in the population to estimate the number of cubs by multiplying by the mean litter size. Number of yearlings is estimated by multiplying the number of cubs in the previous year by their estimated survival rate. Thus the number of cubs and yearlings can be expressed as (mean estimate*mean litter size) estimated survival. The sustainable mortality limit for dependent young was set at 9% and includes only known and probable human caused mortalities. The rationale is explained in IGBST 2005 (p. 36), and is based on a number of assumptions, but also appears to contain an error. The estimated total mortality rate of dependent young (0.48) is multiplied by the percent of known human-caused mortality (0.297). This product (0.143) is reported as the percent of mortalities that are human caused, but is actually the percent of all young lost to human-causes. This product is then erroneously doubled in order to approximate the observed human caused mortality rate (0.297). The product was doubled to account for sex even though the previous rates included both sexes. However, the consequence is that the mortality limit (9%) is only 64% of the observed human caused mortality (14%) during a period of population growth and thus is very conservative, although there is no mechanism to estimate unknown and unreported mortality of dependent young.

The population of independent males is based on the estimate of independent females and the modeled sex ratio from the stable age distribution. Readers are referred to Harris et al. (2006) for details, but identifying the method within that paper is difficult and time consuming. The sustainable mortality limit for independent males was set at 15% because that level appeared to sustain an increasing population 1983-2001. This is a departure from the demographic rationale used for other cohorts.

The authors discuss uncertainty in section 2.2.5. and state that there are valid measures of sampling error in most (but not all) of the steps involved in their protocol. Unfortunately, it is nearly impossible for the reader to determine exactly which steps have valid errors, even after reviewing much of the supporting documentation. The authors acknowledge that the errors are not accumulated through the protocol so that final estimates have unknown errors associated with them. This assertion lends support to adopting methods where uncertainty can be quantified.

An objective of this document is to describe efforts to improve current approaches to population estimation. The authors acknowledge that the Knight et al. (1995) rule set has 2 problematic flaws; there is no way to quantify uncertainty and estimates are biased low with magnitude increasing with true population size. The document reviews 2 proposed alternatives in detail, the ancillary data resampling method (ADR) and mark-resight method (CMR). The ADR method was rejected by the authors due to computational complexity and because results are strongly influenced by the spatial distribution of F_{coy} across the region. They preferred using CMR to estimate F_{coy} from standardized aerial surveys. They acknowledged that there is better quantification of uncertainty, but that estimates are still imprecise. The method also requires large samples of radio-marked females. The authors noted that additional work to be done included refining and updating the geographic area to be excluded due to moth sites (stratification), exploring models beyond linear and quadratic as smoothing functions, performing power analyses to evaluate trade-off between sample size and precision and for trend detection under different population scenarios, and possibly improving the precision of CMR estimates by expanding to all females with dependent young. Other alternative approaches to population

estimation that were briefly considered were statistical population reconstruction and DNA-based CMR. Interestingly, the latter was deemed too expensive due to budgetary constraints, but there was no elaboration on that statement. Although the authors had direct experience with the method, they did not seem aware of the potential for DNA-based techniques to solve some of the problems that currently confound them.

In section 4, the authors present some preliminary analyses to update our understanding of grizzly bear vital rates from telemetry data. This is work in progress on 2002-2011 data. Subadult, yearling, and cub survival rates appear to have declined from those observed 1983-2001, and fecundity may also have declined. Adult male survival appears to be slightly higher. Population growth appears to have ceased ($\lambda = 1.0$), a decline from the previous period. Evidence for the existence of differential growth rates in geographic zones is 'weak', but suggested higher growth inside the recovery zone and park than outside the recovery zone. In section 5, the authors present their preliminary efforts to understand these changes using the information theoretic approaches available in program MARK. Although results are not available for this report, evidence suggests that density dependence and whitebark pine declines are causing growth to slow, but that these results are completely confounded. The authors observe that the GYA grizzly population grew from 4-7% annually during the 1980's and 1990's up until 2002, "after which density-dependent effects would be expected to manifest themselves." They do not explain why they think this may be occurring.

Section 6 presents recommended revisions to sustainable mortality limits. These arguments are used to support the proposed changes to the demographic recovery criteria. The rationale is difficult to follow, partly due to references to a conceptual shift in how survival rates are calculated. They imply that Harris et al. (2006) did not use deterministic models, which is not the case. The authors recommend decreasing mortality limits to 7.6 from 9% because population growth has declined. The rationale for applying the same rate (7.6%) to dependent young and independent males is unchanged – still poorly explained in this document. Noted in Figure 6.1, but not discussed, is an increase in mean litter size from 2.04 to 2.49.

In section 6.2, the authors discuss revision of the area within which mortality limits apply. Although it makes sense that the mortality monitoring and population estimation areas should coincide, the document doesn't give much detail as to why the 'suitable habitat' map was developed and why this wasn't considered in the conservation strategy (CS; USFWS 2007b). The proposed suitable habitat area is perhaps half the size of the area indicated in the CS, so it would behoove the authors to show the consequences of this adjustment. As written, it does not support the proposed change to the demographic criteria.

Review of proposed changes to GYA grizzly bear demographic criteria numbers 1 and 3:

The USFWS and IGBST propose 4 changes to the demographic recovery criteria specified in the 2007 supplement (USFWS 2007a):

1. Language is added to criterion 1 stating the demographic goal of maintaining a minimum population size of 500 individuals and 48 females with cubs.

General comments: It isn't clear how this goal would be achieved, or how to measure attainment. Currently, estimates of population size are based on estimates of proportions of sex and age classes based on transition probabilities within a population assumed to have a stable age distribution. Variances around these estimates are only roughly approximated via the delta method and are not tracked through the process. Thus, current estimates of population size have no error associated with them. There is also no discussion of how sampling and process errors may be propagated through the system. The desired 500 individuals came from an arbitrary inflation of a minimum number suggested by Miller and Waits (2003). Based on work by Waples and Yokota (2007), and a recent review by Luikart et al. (2010), this recommendation may not be as conservative as we think. There is no discussion of where the goal of 500 bears should apply. Early documents state that the target area for the 500 bears was the GYA, but the current proposal is to half that area. Should the same minimum population goal apply? There is no discussion of this topic in IGBST (2012).

2. In criterion 1, references to the Chao2 estimator are eliminated so that new methods can be implemented rapidly.

General comments: The existing language requires the IGBST to use the Chao2 estimator to estimate numbers of females with cubs for the purposes of estimating population size and formulating mortality limits. The IGBST is free to use whatever other additional methods they choose to estimate numbers of females with cubs. Eliminating reference to a specific method would allow the IGBST to apply new methods without the delay caused by navigating a public review process. The downside is that it could muddy interpretation of the estimates. Imagine a scenario where a different method was applied every year. It could be difficult to relate changes in actual population size to changes in methodology. I assume that the IGBST wishes to adopt a CMR estimator. There are many different CMR methods that could be applied and all would give different estimates. How will you choose – AIC? What if a different method is used each year? How will you calculate trend then? Then pros and cons are not well presented in the documentation. IGBST (2012) provides adequate justification for use of alternative methodologies.

3. In criterion 1, eliminate reference to the GYA as the area of application for the demographic criteria and establish a mortality monitoring area that mirrors the monitoring area.

General comments: The supplement and protocol do not clearly describe that the revised monitoring area would decrease the monitored area by perhaps 50%. I had to go back to the previous supplement (USFWS 2007a) to find a map of the GYA. I then had to draw with pencil on the proposed suitable habitat map what this might look like. It's also confusing to relate the CS (USFWS 2007b) to the recovery plan. Since the CS was tabled by the courts, the recovery plan has been changed to reflect actions in the CS. In 2007, the recovery plan was modified to require population monitoring in the GYA, as opposed to the 1993 plan which specified monitoring in the recovery zone plus a 10 mile buffer. An annotated flow chart showing the changes in controlling documents might be helpful. There was limited but pointed justification in the CS for expanding monitoring to the GYA from the buffered recovery area. There is much less justification for reducing this area now. If grizzly bears were delisted would the area expand back out to include the entire GYA? From the CS:

The standards described here may vary from those in the *Recovery Plan*. For example, the *Recovery Plan* criterion related to the number of unduplicated females referred to the recovery area plus a 10-mile area surrounding it. However, under this Conservation Strategy, all mortalities and all reports of unduplicated females with cubs will be monitored in all areas where grizzly bears occur in Figure 3. This will result in the management and monitoring of the grizzly bear population in the entire Yellowstone area as a single population, as opposed to the system in the *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 *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 all areas within the Grizzly Bear Management Areas shown in Figure 3. The criteria and objectives of the existing *Recovery Plan* have been included or modified, as the *Recovery Plan* will no longer apply.

Furthermore, if the monitoring area is 50% smaller than the GYA, is it reasonable to leave the minimum population goal unchanged? Maybe it is if few bears live on the periphery of the GYA. Neither this document nor the 2012 IGBST report provide strong justification for changing the monitoring areas.

4. In criterion 3, the 'hard' mortality limits (9% for females and young, 15% for independent males) are changed to a 'soft' target of maintaining a stable population by limiting human caused mortality to levels that will sustain the population without allowing for population declines.

General comments: Not clear as to over what interval new limits would be calculated, but I assume annually. One of the big points for smoothing is to limit inter-annual variability in mortality limits. If these are recalculated annually, what happens to management? It also isn't clear if 'managing for stability' is consistent with ESA listing. Technically, grizzlies are still considered threatened. This implies that we plan to manage for continued threatened status. Stability would be a reasonable goal if the bear was delisted and the CS was the controlling document.

Review of Proposed Application Protocol for Yellowstone Grizzly Bear Demographic Recovery Criteria, March 2013

This short document itemizes the specific steps that the IGBST will take to: A) estimate total population size, B) document distribution of females with young, and C) establish sustainable mortality rates and count grizzly bear mortalities.

General comments: The relationship between the protocol document and the demographic criteria are not clear. For example, the demographic criteria leaves out specific methods but the application protocol includes them, e.g., the Chao2 estimator.

Specific comments:

A. 1. a. Lists methods used (Knight et al. 1995, Keating et al. 2002) but perhaps should explicitly say “not limited to”.

A. 2. The use of model averaging to detect change is not well described.

A. 7. The use of 1.000 as the ratio of independent males:females is not clearly explained in the supporting literature and is a dramatic departure from the ratio used in previous application protocols (0.635).

Responses to specific questions in the charge to peer reviewers:

1. Are assumptions and sources of uncertainties clearly identified and quantified in the Study Team (2012) Workshop report?

Generally yes, with a few lapses here and there. See detailed review above.

2. Given known (and unknown) levels of uncertainty, are the revised demographic criteria likely to support long-term conservation of grizzly bears in the GYA?

Grizzly bears in the GYA have made a dramatic comeback since their listing under the ESA in the 1970's. Very few wildlife species receive the attention, concern, scrutiny, and scientific study given GYA grizzly bears. Most wildlife, including those managed for commercial and sport harvest, is managed with much less information and most maintain stable to increasing populations. Accurate demographic analysis of the GYA grizzly population is precluded by low sample size and wide variance, when variance can be calculated at all. Currently, size and trend measurements of the GYA grizzly population are fundamentally based on two metrics; counts of unduplicated females with cubs and performance of radio-marked females. Inspection of Table 3.1 in the IGBST workshop report (2012) shows that available sample sizes for females with cubs are very small and likely yield detection probabilities less than 20% across the board. Estimation of vital rates is much better - with over 285 bear years of data available, confidence intervals of demographic parameter estimates were generally less than 55% of the estimate

(Harris et al. 2007, Table1). Nevertheless, there is still 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. In some cases we know that the errors are conservative, such as the known bias in the Knight et al. (1995) protocol. In other cases it may not be as conservative as previously thought (as in the Miller and Waits (2003) estimate of effective population size). Ultimately, the actions that will support grizzly bear conservation are not metrics but continuation of the actions that abated the causes of excessive human-caused mortality: human-bear conflicts, habitat destruction, and illegal killing.

3. Would additional analyses or research reduce sources of uncertainty and to what extent? If so, what analyses/research would be most helpful?

DNA-based sampling programs have become a common technique for monitoring populations. These methods appear to have been dismissed by using the cost of Kendall et al. (2009) as a comparable. However, dollar for dollar replication of this study design is probably not necessary to obtain useful results. While telemetry information provides valuable information on population vital rates, DNA based methods generally provide much larger sample sizes. Recent refinements that capitalize on behavior (rub trees) offer the possibility of obtaining large samples at significantly reduced cost (Stetz et al. 2010). New research shows that combining data types increases precision (Boulanger et al. 2008, Abadi et al. 2010), thus implementing a DNA sampling program concurrent with radio telemetry could greatly increase precision of population estimates.

4. Do you believe that managing for stability (instead of an increasing or decreasing population) an appropriate approach for this population of grizzly bears?

‘Managing for stability’ is a value-laden concept and personal beliefs regarding the appropriateness of the concept to the GYA population may not be relevant in a peer review. The question is how managing for stability contributes to attaining our goals and objectives. In the context of this review, the implication is that the population will be managed to not change from current levels. The IGBST estimates that population growth during 2002-2011 has decelerated from that observed during 1983-2001. They hypothesize that the population is approaching carrying capacity. As they note, carrying capacity is not static, so if carrying capacity is declining, then it may not be possible to manage for stability unless extraordinary efforts are made, e.g., artificial feeding. Since the 1990’s, grizzly bears have expanded their occupied range in the GYA. This expansion required a certain level of population pressure to cause dispersing animals to move into areas that were previously unoccupied and inhospitable. Expansion of the GYA population will eventually create demographic connectivity with other ecosystems (NCDE, Bitterroot), a desired condition. If ‘managing for stability’ means increasing allowable human caused mortality to the point where dispersal does not, or cannot, occur, then inter-ecosystem connectivity may not be attainable to the detriment of grizzly bear conservation. It’s also unclear if management for stability is consistent with ESA threatened status.

5. Is assessment of demographic criteria exclusively within the Monitoring Area identified a reasonable biological and statistical approach?

It is reasonable, statistically, to have identical population and mortality monitoring areas. Biologically, it may not always make sense to exclude mortalities that occur outside the population monitoring area. For example, a bear killed while making a short-term foray outside the monitoring area and outside its normal home range, would not be counted against the mortality threshold when it probably should be. The new proposed monitoring area is substantially smaller than that adopted in 2007, and excludes substantial areas of suitable habitat in Wyoming and Montana. These areas are likely to be recolonized in the coming years. More rationale and justification is needed to explain the implications of this major change.

Findings and Conclusions

Of the four proposed changes to the GYA demographic criteria, I find that only change number 2, eliminating the references to the Chao2 estimator, is sufficiently justified in the supporting documentation. I recommend that additional clarification be made as to how multiple methods would be employed, yet maintain coherence in population estimates.

Justification for change 1, establishing a goal of minimum population size of 500 grizzly bears, is insufficient. The supporting documentation needs greater clarification as to why 500 is an appropriate number, and how, why, and where attainment can be met and measured.

Justification for change 3, adopting the USFWS Suitable Habitat Map for the population and monitoring area, is insufficient. There may be good reasons for this change, but they are not presented in the supporting documentation. There is no way to easily compare the map of the proposed area to the current map, and no accounting of the change in area. Impacts of the change to potential future ecosystem connectivity are not discussed. The relationships between decisions made in the Conservation Strategy to those proposed for the recovery plan are unclear.

Justification for change 4, adjusting mortality limits to maintain population stability, is insufficient. It is unclear as to why a listed species should not be allowed to grow and expand into new habitats. If carrying capacity, social tolerance, or density-dependent regulatory processes are at work, then these need to be more carefully presented. Conversely, if habitat changes have, or will, reduce carrying capacity, then it might not be possible to manage for stability by managing human-caused mortality limits.

Review of the proposed changes was not straight forward. It required extensive review of prior documents to understand how the current situation developed. Many of these documents presented advanced applications of demographic mathematics that were difficult to digest. In some cases, I could never find what I was looking for, for example an accounting of variance calculations for the numerous steps in the protocol. In other cases, prior documents contained either typographical errors or outright errors in application that further complicated interpretation. If the objective is to maintain a transparent chain of decisions, then I recommend that the authors create a more comprehensible document that addresses as many concepts as possible, as simply as possible. The 2005 report is a good jumping off point.

In conclusion, I applaud the authors for providing the GYA population of grizzly bears an unprecedented level of attention and care, and for attempting to apply a transparent and informed management process. I fully appreciate the difficulty of their mandate and the limitations they face. I hope this review provides useful insights into how to improve this process.

/s/ John S. Waller

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