List of Appendices

Appendix A. Chronological List of the Grizzly Bear Recovery Process for the Greater Yellowstone Ecosystem

I.   Grizzly Bear Recovery Plan revision (1993)

II.   Workshop on habitat-based recovery criteria (1997)

III.   Achievement of recovery targets in the Recovery Plan for demographic values and for habitat criteria specified for that grizzly bear population (1999)

IV.   Conservation Strategy development for the Yellowstone area, including habitat-based recovery criteria, and release of draft Conservation Strategy for review (2000)

V.   Publication of Proposed Rule in the Federal Register (2005). Proposed Rule documents the status of the population according to the five factors in ESA Section 4(a)(1) including population and habitat status, and references Conservation Strategy for documentation of the existence of adequate regulatory mechanisms and consideration of DPS policy.

VI.   Public comment period with public hearings

VII.   Consideration and incorporation of public comments and any new information developed as a result of the comment period

VIII.   Publication of Final Rule in the Federal Register of status change or continuation of listed status in conjunction with release of the final Conservation Strategy, final Habitat Criteria, and final DPS analysis (2007).

IX.   Relisting of the Yellowstone grizzly bear population (2010) in compliance with an order from the District Court of Montana that overturned the final rule (2009).

X.   Concurrent publication in the Federal Register of the draft 2016 Conservation Strategy, draft Recovery Plan Supplement: Demographic Criteria, and Proposed Rule. Proposed Rule documents the status of the population according to the five factors in ESA Section 4(a)(1) including population and habitat status, and references Conservation Strategy for documentation of the existence of adequate regulatory mechanisms and consideration of DPS policy.

XI.   Public comment period with public hearings

XII.   Peer review

XIII.   Consideration and incorporation of public comments, peer review, and any new information developed as a result of the comment period

XIV.   MOU to implement the Conservation Strategy signed by all agencies

XV.   Publication of Final Rule in the Federal Register of status change or continuation of listed status in conjunction with release of the final 2016 Conservation Strategy and final Recovery Plan Supplement: Demographic Criteria.

Appendix B. Estimating Numbers of Females with Cubs-of-the-Year in the Yellowstone Grizzly Bear Population

ESTIMATING NUMBERS OF FEMALES WITH CUBS-OF-THE-YEAR IN THE YELLOWSTONE GRIZZLY BEAR POPULATION

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Abstract: For grizzly bears (*Ursus arctos horribilis*) in the Greater Yellowstone Ecosystem (GYE), minimum population size and allowable numbers of human-caused mortalities have been calculated as a function of the number of unique females with cubs-of-the-year (F_{CUB}) seen during a 3-year period. This approach underestimates the total number of F_{CUB}, thereby biasing estimates of population size and sustainable mortality. Also, it does not permit calculation of valid confidence bounds. Many statistical methods can resolve or mitigate these problems, but there is no universal best method. Instead, relative performances of different methods can vary with population size, sample size, and degree of heterogeneity among sighting probabilities for individual animals. We compared 7 nonparametric estimators, using Monte Carlo techniques to assess performances over the range of sampling conditions deemed plausible for the Yellowstone population. Our goal was to estimate the number of F_{CUB} present in the population each year. Our evaluation differed from previous comparisons of such estimators by including sample coverage methods and by treating individual sightings, rather than sample periods, as the sample unit. Consequently, our conclusions also differ from earlier studies. Recommendations regarding estimators and necessary sample sizes are presented, together with estimates of annual numbers of F_{CUB} in the Yellowstone population with bootstrap confidence bounds.

Criteria for recovering the grizzly bear in the lower United States include annual limits on mortalities (U.S. Fish and Wildlife Service 1993). Since 1993, these limits have been calculated as a function of the number of F_{CUB} present in the population, as estimated during 6-year running periods. Currently, the number of F_{CUB} present each year (*N*) is estimated as the number of such animals actually observed ($\hat{N}_{Obs}$). To the extent that criteria for distinguishing family groups are conservative (see Knight et al. 1995), and because it is highly unlikely that all such animals are seen, $\hat{N}_{Obs}$ almost certainly underestimates *N*. This helps ensure that mortality limits are conservative, but precludes calculation of valid confidence bounds. Moreover, use of a biased estimator like $\hat{N}_{Obs}$ effectively removes decisions regarding the appropriate degree of conservatism from the purview of managers. This is not a trivial issue because the magnitudes of biases and uncertainties inherent in $\hat{N}_{Obs}$ may be biologically and managerially significant.

Efforts to calculate statistically sound estimates of *N* have focused on parametric approaches. Eberhardt and Knight (1996) applied the Peterson-type estimators of Chapman and Bailey (Seber 1982), and Boyce et al. (M.S. Boyce, D. MacKenzie, B.F.J. Manly, M.A. Haroldson, and D. Moody, 1999, Cumulative counts of unique individuals for estimating population size, U.S. Fish and Wildlife Service, Missoula, Montana, USA) recommended the maximum likelihood method of Lewontin and Prout (1956). These methods assume that each family group

has an equal probability of being sighted. Because this assumption is untenable for the Yellowstone data (K.A. Keating, M.A. Haroldson, D. Moody, and C.C. Schwartz, 1999, Estimating the number of females with cubs-of-the-year in the Yellowstone grizzly bear population: are maximum-likelihood estimates that assume equal sightability conservative? U.S. Fish and Wildlife Service, Missoula, Montana, USA) estimates based on these methods will be negatively biased. Seeking a more robust approach, Boyce et al. (2001) recommended joint estimation of *N* over all years using an estimator derived from the zero-truncated negative binomial distribution. This estimator can be traced to Greenwood and Yule (1920), with early applications to wildlife population estimation by Tanton (1965, 1969) and Taylor (1966). The sampling model assumed by the negative binomial estimator allows for heterogeneous sighting probabilities among individuals and, thus, is equivalent to model M_h of Otis et al. (1978). Unfortunately, Boyce et al. (2001) found that the negative binomial estimator gave reasonable results only when the coefficient of variation among individual sighting probabilities (CV) was assumed to be constant over time. This assumption is difficult to justify for grizzly bears in Yellowstone, where year-to-year differences in distributions and abundances of foods affect bear movement patterns and, in turn, the likelihood of seeing particular bears (Picton et al. 1986). Such differences almost certainly affect heterogeneity among individual sighting probabilities, implying that CV varies among years. Also, because

the size, distribution, and behavior of bear populations may interact in ways that affect sightability (Keating 1986), CV likely changes with N. The claim of an increased bear population in Yellowstone (Boyce et al. 2001), therefore, is inconsistent with the assumption of a constant CV. The joint estimation procedure recommended by Boyce et al. (2001) suffers other drawbacks as well. Most seriously, estimates of N from previous years may change retrospectively as new data are added — a property that is justifiable only if CV is truly constant over time. Overall, problems with the parametric methods used to date argue for considering other alternatives.

Many nonparametric estimators might apply to this problem (e.g., Otis et al. 1978, Bunge and Fitzpatrick 1993, Lee and Chao 1994). Indeed, when estimating N under model M_h, many studies have favored non-parametric methods such as the jackknife (Burnham and Overton 1978, 1979), Chao (Chao 1984, 1989), and sample coverage estimators (Chao and Lee 1992, Lee and Chao 1994). Among the nonparametric methods available, however, there is no universal best choice, as relative performances can vary with N, CV, or sample size (Burnham and Overton 1979, Smith and van Belle 1984, Chao 1988). What we require is an estimator that is reasonably robust to variations in these parameters over the range of values experienced when sampling the Yellowstone grizzly bear population. To identify such an estimator, we used Monte Carlo methods to compare performances of 7 nonparametric methods when sampling from a range of conditions that encompassed those deemed plausible for observations of F_{CUB} in the GYE.

METHODS

General Problem and Notation

The sampling model we used approximates the true sampling scheme, in which reports of F_{CUB} come from observers using various sampling methods (ground-based observation, trapping, systematic fixed-wing observations, or fixed-wing observations made incidental to other work). Because the sampling period associated with each of these methods varies considerably (or, in some cases, is undefined) we used the sighting of an individual F_{CUB} as the sample unit. The problem of estimating population size from repeated sightings of unique individuals may then be phrased as a special case of the more general model in which multiple individuals may be sighted during a given sampling period (e.g., Otis et al. 1978).

Suppose that, during a given year, after recording n independent random sightings of individuals from a closed population of size N (where N is unknown), we observe m unique animals. The average probability that any par-

ticular sighting will be of the ith individual is p_i, and probabilities for all N individuals are given by $\mathbf{p} = (p_1, p_2, ..., p_N)$ where

$$\sum_{i=1}^{N} p_i = 1$$

Because the model allows for heterogeneous p_i values, temporal or spatial differences in habitat use or sampling effort are incorporated into $\mathbf{p}$, as are differences in probabilities of reporting and recording sightings of particular animals. We assume all individuals are correctly identified (consequences of misidentification are considered below). In our sample, individuals were observed with frequency $\mathbf{n} = (n_1, n_2, ..., n_N)$, which is multinomially distributed with cell probabilities $(p_1, p_2, ..., p_N)$. However, we do not know the identities of the $N - m$ animals for which $n_i = 0$. The number of different individuals observed exactly j times was f_j, and $\mathbf{f} = (f_0, f_1, f_2, ..., f_n)$ is fully observable except for f_0, the number of bears not observed in our sample. Important relationships include

$$n = \sum_{i=1}^{N} n_i = \sum_{j=1}^{N} jf_j$$

$$m = \sum_{j=1}^{N} f_j$$

and $N - m = f_0$. The problem is to estimate N (or, equivalently, f_0) using only the observable information in $\mathbf{f}$ and n.

In this idealized model, all information about population size is obtained from the n randomly sighted individuals. For the Yellowstone grizzly bear population, observations of radiomarked F_{CUB} made during radiorelocation flights provide additional information from non-randomly sighted individuals. In particular, observations of otherwise unobserved F_{CUB} may be added to m to improve the estimate of minimum population size, yielding $\hat{N}_{Obs} \geq m$. $\hat{N}_{Obs}$ provides a natural lower bound for estimating N and is the estimator that has been used previously to set annual mortality limits. Overall, we seek an estimator that improves upon $\hat{N}_{Obs}$ while minimizing the risk of overestimating N.

The Estimators

In addition to m and $\hat{N}_{Obs}$, which we included in our analyses for comparative purposes, we evaluated 7 nonparametric estimators (see Table 1 for example calculations). The first 5 methods we considered estimate N as $\hat{N} = m + \hat{f_0}$, where $\hat{f_0}$ is an estimate of the number of unobserved individuals.

We first examined Chao's (1984) estimator,

$$\hat{N}_{Chao1} = m + \frac{f_1^2}{2f_2} \tag{1}$$

In Eq. (1), $\hat{f_0} = f_1^2/(2f_2)$. Using $\hat{N}_{Chao1}$, the statistical expec-

Table 1. Example calculations for the 7 non-parametric estimators compared in this study, using 1997 grizzly bear sighting data from the Greater Yellowstone Ecosystem. For 1997, n = 65 sightings of females with cubs-of-the-year (F_{cub}) were made via means other than radiotelemetry. Distinguishing individuals as per Knight et al. (1995), m = 29 unique animals were seen; 13 were seen once (f_1 = 13), 7 were seen twice (f_2 = 7), 4 were seen 3 times (f_3 = 4), 1 was seen 4 times (f_4 = 1), 3 were seen 5 times (f_5 = 3), and 1 was seen 7 times (f_7 = 1). Two additional and otherwise unobserved F_{cub} were seen only as a result of using radiotelemetry. Because all calculations were carried out in double precision, rounding errors are evident in some of the examples.

Estimator	Example calculation
Unique F_{cub} observed via random sightings	$m = 29$
Unique F_{cub} observed via random sightings and radiotelemetry	$\hat{N}_{Obs} = 29 + 2 = 31$
Chao	$\hat{N}_{Chao1} = m + \dfrac{f_1^2}{2f_2} = 29 + \dfrac{13^2}{2(7)} \approx 41.1$
Bias-corrected Chao	$\hat{N}_{Chao2} = m + \dfrac{f_1^2 - f_1}{2(f_2 + 1)} = 29 + \dfrac{13^2 - 13}{2(7+1)} \approx 38.8$
First-order jackknife	$\hat{N}_{J1} = m + \left(\dfrac{n-1}{n}\right)f_1 = 29 + \left(\dfrac{65-1}{65}\right)13 = 41.8$
Second-order jackknife	$\hat{N}_{J2} = m + \left(\dfrac{2n-3}{n}\right)f_1 - \left(\dfrac{(n-2)^2}{n(n-1)}\right)f_2 = 29 + \left(\dfrac{2(65)-3}{65}\right)13 - \left(\dfrac{(65-2)^2}{65(65-1)}\right)7 \approx 47.7$
Best-order jackknife	$\hat{N}_{Jk1} = \hat{N}_{J1} = 41.8$ was selected because $T_1 = \dfrac{\hat{N}_{J2} - \hat{N}_{J1}}{[\hat{var}(\hat{N}_{J2} - \hat{N}_{J1} \mid m)]^{1/2}} \approx \dfrac{47.7 - 41.8}{[17.996]^{1/2}} \approx 1.396 < 1.960$, where $$\hat{var}(\hat{N}_{J2} - \hat{N}_{J1} \mid m) = \dfrac{m}{m-1}\left[\sum_{j=1}^{2}(b_j)^2 f_j - \dfrac{(\hat{N}_{J2} - \hat{N}_{J1})^2}{m}\right]$$ $$\approx \dfrac{29}{29-1}\left[\left(\dfrac{2(65)-3}{65} - \dfrac{65-1}{65}\right)^2 13 + \left(\dfrac{(65-2)^2}{65(65-1)}\right)^2 7 - \dfrac{(47.7 - 41.8)^2}{29}\right] \approx 17.996$$
First-order sample coverage	$\hat{N}_{SC1} = \dfrac{m + f_1\hat{\gamma}^2}{\hat{C}_1} = \dfrac{29 + 13(0.325)}{0.800} \approx 41.5,$ where $\hat{C}_1 = 1 - \dfrac{f_1}{n} = 1 - \dfrac{13}{65} = 0.800$ and $\hat{\gamma}^2 = \max\left\{\dfrac{m}{\hat{C}_1}\sum_{j=1}^{n}\dfrac{j(j-1)f_j}{n(n-1)} - 1,\ 0\right\} = \max\left\{\dfrac{29}{0.800}\left(\dfrac{2(7)+6(4)+12(1)+20(3)+42(1)}{65(65-1)}\right) - 1,\ 0\right\} \approx 0.325$
Second-order sample coverage	$\hat{N}_{SC2} = \dfrac{m + f_1\hat{\gamma}^2}{\hat{C}_2} = \dfrac{29 + 13(0.319)}{0.803} \approx 41.3,$ where $\hat{C}_2 = 1 - \dfrac{f_1 - 2f_2/(n-1)}{n} = 1 - \dfrac{13 - 2(7)/(65-1)}{65} \approx 0.803$ and $\hat{\gamma}^2 = \max\left\{\dfrac{m}{\hat{C}_2}\sum_{j=1}^{n}\dfrac{j(j-1)f_j}{n(n-1)} - 1,\ 0\right\} = \max\left\{\dfrac{29}{0.803}\left(\dfrac{2(7)+6(4)+12(1)+20(3)+42(1)}{65(65-1)}\right) - 1,\ 0\right\} \approx 0.319$

tation for the estimate, $E(\hat{N})$, equals N only when sighting probabilities are the same for all animals; i.e., when CV= 0. Theoretically, when CV > 0, $E(\hat{N}) < N$ (Chao 1984). This does not ensure $\hat{N}_{Chao1} \leq N$ in all cases, but does suggest that $\hat{N}_{Chao1}$ might provide an inherently conservative approach to estimating N. We also considered a similar bias-corrected form of this estimator, developed by Chao (1989). Where the sample unit is the individual animal, Chao's (1989) estimator is given by (Wilson and Collins 1992),

$$\hat{N}_{Chao2} = m + \frac{f_1^2 - f_1}{2(f_2 + 1)}$$

Here, $\hat{f}_0 = (f_1^2 - f_1)/[2(f_2 + 1)]$. Unlike $\hat{N}_{Chao1}$, $\hat{N}_{Chao2}$ will yield an estimate even when $f_2 = 0$.

Burnham and Overton (1978, 1979) devised a jackknife estimator $(\hat{N}_{Jk})$ of the general form

$$\hat{N}_{Jk} = m + \sum_{j=1}^{k} \alpha_{jk} f_j$$

where α_{jk} is a coefficient in terms of n, and $\alpha_{jk} = 0$ when $j > k$ (see Table 2). Here, f_0 is estimated as the series

$$\sum_{j=1}^{k} \alpha_{jk} f_j$$

Theoretically, jackknife estimates of order $k = 1$ to n could

be calculated, but variance increases rapidly with k so that, in practice, k is small (Burnham and Overton 1979). We considered the first- and second-order jackknife estimators ($\hat{N}_{J1}$ and $\hat{N}_{J2}$, respectively; Table 2), as well as a best kth-order jackknife estimator. Burnham and Overton (1979) suggested 2 methods for choosing a best value for k for a particular study. Because previous work showed little difference between them (K.A. Keating unpublished data), we considered only their first method, which evaluates estimates of order $k = 1$ to 5 (Table 2). The method is as follows. Beginning with $k = 1$ and proceeding to subsequently higher values of k, test the null hypothesis that $E(\hat{N}_{J, k+1} - \hat{N}_{Jk}) = 0$ versus the alternative hypothesis that $E(\hat{N}_{J, k+1} - \hat{N}_{Jk}) \neq 0$. If the observed difference is not significant, testing ends and $\hat{N}_{Jk}$ is taken as the best jackknife estimate. We reference the resulting kth-order estimate as $\hat{N}_{Jkl}$. The test is based on the statistic

$$T_k = \frac{\hat{N}_{J,k+1} - \hat{N}_{Jk}}{[\hat{v}ar(\hat{N}_{J,k+1} - \hat{N}_{Jk} \mid m)]^{1/2}}$$

where

$$\hat{v}ar(\hat{N}_{J,k+1} - \hat{N}_{Jk} \mid m) = \frac{m}{m-1}\left[\sum_{j=1}^{n}(b_j)^2 f_j - \frac{(\hat{N}_{J,k+1} - \hat{N}_{Jk})^2}{m}\right]$$

Table 2. Jackknife estimators of population size, $\hat{N}_{Jk}$, for order $k = 1$-5, where m is the number of unique individuals observed after n samples and f_i is the number of individuals observed exactly i times (after Burnham and Overton 1979).

$$\hat{N}_{J1} = m + \left(\frac{n-1}{n}\right) f_1$$

$$\hat{N}_{J2} = m + \left(\frac{2n-3}{n}\right) f_1 - \left(\frac{(n-2)^2}{n(n-1)}\right) f_2$$

$$\hat{N}_{J3} = m + \left(\frac{3n-6}{n}\right) f_1 - \left(\frac{3n^2 - 15n + 19}{n(n-1)}\right) f_2 + \left(\frac{(n-3)^3}{n(n-1)(n-2)}\right) f_3$$

$$\hat{N}_{J4} = m + \left(\frac{4n-10}{n}\right) f_1 - \left(\frac{6n^2 - 36n + 55}{n(n-1)}\right) f_2 + \left(\frac{4n^3 - 42n^2 + 148n - 175}{n(n-1)(n-2)}\right) f_3$$

$$- \left(\frac{(n-4)^4}{n(n-1)(n-2)(n-3)}\right) f_4$$

$$\hat{N}_{J5} = m + \left(\frac{5n-15}{n}\right) f_1 - \left(\frac{10n^2 - 70n + 125}{n(n-1)}\right) f_2 + \left(\frac{10n^3 - 120n^2 + 485n - 660}{n(n-1)(n-2)}\right) f_3$$

$$- \left(\frac{(n-4)^5 - (n-5)^5}{n(n-1)(n-2)(n-3)}\right) f_4 + \left(\frac{(n-5)^5}{n(n-1)(n-2)(n-3)(n-4)}\right) f_5$$

and $b_j = \alpha_{j,k+1} - \alpha_{jk}$. T_k was evaluated at $\alpha = 0.05$ using P values determined from the standard normal distribution.

Chao and Lee (1992) proposed an estimator based on sample coverage (C), where C is the sum of the p_i values for the m individuals actually observed in the sample. Lee and Chao (1994) offered 2 estimators of C that, in the notation of our sampling model, are given by

$$\hat{C}_1 = 1 - \frac{f_1}{n} \qquad (2)$$

and

$$\hat{C}_2 = 1 - \frac{f_1 - 2f_2/(n-1)}{n} \qquad (3)$$

In Eqs. (2) and (3), the quantities f_1/n and $[f_1 - 2f_2/(n-1)]/n$, respectively, estimate the sum of the p_i values for the f_0 unobserved animals. For our model (equivalent to model M_h of Otis et al. [1978]), Lee and Chao (1994) then estimated N as

$$\hat{N}_{SCj} = \frac{m}{\hat{C}_j} + \frac{f_1}{\hat{C}_j}\hat{\gamma}^2$$

$$= \frac{m + f_1\hat{\gamma}^2}{\hat{C}_j} \qquad (4)$$

where $j = 1$ or 2, and γ is a measure of the coefficient of variation of the p_i's . Essentially, Eq. (4) begins with a Peterson-type estimator $(m/\hat{C})$ that assumes equal sightability (i.e., all $p_i = 1/N$; Darroch and Ratcliff 1980), then adds a bias correction term $(f_1\hat{\gamma}^2/\hat{C}_j)$ that increases with heterogeneity, as estimated by $\hat{\gamma}^2$. Put another way, the quantity $f_1\hat{\gamma}^2$ estimates the number of additional individuals that would have been observed if p had, in fact, been homogeneous. Adding this to m then dividing by the estimated coverage estimates N. Where the sample unit is the sighting of an individual animal, $\hat{\gamma}^2$ is calculated as (Chao and Lee 1992),

$$\hat{\gamma}^2 = \max\left\{\hat{N}\sum_{j=1}^{n}\frac{j(j-1)f_j}{n(n-1)} - 1, \ 0\right\} \qquad (5)$$

Calculation of $\hat{\gamma}^2$ requires an initial estimate of N. Following Chao and Lee (1992), we used $\hat{N} = m/\hat{C}_j$. We considered but did not use the partitioned sample coverage estimator of Chao et al. (1993, 2000) because pre-

liminary Monte Carlo results showed the method offered no advantage over $\hat{N}_{SCj}$ when applied to our field data.

Monte Carlo Comparisons

Estimator performances were compared using Monte Carlo methods. Parameters for the Monte Carlo sampling were chosen to encompass the range of values deemed plausible when sampling F_{CUB} in the GYE. Overall, we simulated 15 populations, including all combinations of $N = 20, 40$, and 60 animals, where the coefficient of variation among the p_i values was set to CV = 0.0, 0.25, 0.50, 0.75, or 1.0. We calculated p_i as the integral of a standard beta distribution over the interval $(i - 1)/N$ to i/N; i.e.,

$$p_i = I_{i/N}(a,b) - I_{(i-1)/N}(a,b), \qquad (6)$$

where $I_x(a,b)$ is the incomplete beta function ratio with parameters a and b (Johnson et al. 1995). We used a downhill simplex (Press et al. 1992) to select values for a and b (Table 3) that gave the desired CV among the p_i values. We then sampled each population, with replacement, by generating n pseudorandom numbers from the specified beta distribution and tallying each as a sighting of the ith animal if it fell within the interval $(i - 1)/N$ to i/N. We chose n so that the number of sightings per individual in the population (n/N) was equal to 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, or 4.0. After each sampling bout, we estimated N using each of the estimators described above. This process was repeated 1,000 times for each parameterization of the model. For each parameterization and estimator, performance was summarized as the bias and root mean square error (RMSE) of the estimator, where

$$\text{RMSE} = \sqrt{\text{bias}^2 + \text{SD}^2}$$

In addition, 2 estimators $(\hat{N}_{SC1}$ and $\hat{N}_{SC2})$ yielded explicit estimates of CV, in the form of $\hat{\gamma}$ (Eq. 5).

Following the above analyses, the most promising estimator was selected. Confidence bounds for estimates based on the best method were calculated using the method of Boyce et al. (2001), in which bootstrap samples were drawn from the distribution of individual sighting frequencies implied by $\hat{N}$ (i.e., from the estimate of the vector **n**). Details are as follows. A model population with $\hat{N}$ indi-

Table 3. Values of the parameters (a, b) of the standard beta distributions used to model $\mathbf{p} = (p_1, p_2, ...p_N)$, where p_i is the probability that a particular sighting will be of the ith animal. Values are listed by size (N) of the model population and the coefficient of variation (CV) among the p_i values.

N	(a, b)				
	CV = 0.00	CV = 0.25	CV = 0.50	CV = 0.75	CV = 1.00
20	(1.000, 1.000)	(0.955, 1.270)	(0.791, 1.380)	(0.664, 1.446)	(0.589, 1.600)
40	(1.000, 1.000)	(1.084, 1.398)	(0.797, 1.382)	(0.686, 1.477)	(0.593, 1.512)
60	(1.000, 1.000)	(1.173, 1.449)	(0.794, 1.369)	(0.688, 1.462)	(0.611, 1.559)

viduals was constructed and the first m individuals were assigned sighting frequencies $\mathbf{n}^* = (n_1^*, n_2^*, ..., n_m^*)$, corresponding to the actual sighting frequencies (n_i values) for the m animals observed in the original sample. The remaining $\hat{N}$ - m individuals were assigned sighting frequencies of 0. A bootstrap sample of $\hat{N}$ (rounded to the nearest integer) individual sighting frequencies (n_i^* values) was then randomly drawn with replacement from $\mathbf{n}^*$. The number of samples for which $n_i^* = j$ was tabulated as f_j^*, giving the bootstrap sighting frequency vector $\mathbf{f} = (f_1^*, f_2^*, ..., f_n^*)$, and the bootstrap number of sightings

$$n^* = \sum_{j=1}^{n} j f_j^*$$

The estimate was then recalculated using the information in $\mathbf{f}^*$ and n^*. This procedure was repeated 1,000 times for each estimate. Confidence bounds were calculated using both the percentile and bias-corrected-and-accelerated (BCA) methods (Efron and Tibshirani 1993). We assessed performances of the 2 methods by comparing observed versus nominal coverages.

Although 90 or 95% confidence bounds are normal for scientific hypothesis testing, managers may appropriately choose a higher level of risk. Thus, we compared coverages for lower, 1-tailed 70, 80, 90, and 95% confidence bounds. Earlier studies reported 2-tailed confidence bounds (e.g., Eberhardt and Knight 1996, Boyce et al. 2001). However, we believe 2-tailed bounds are inappropriate for this problem because managers charged with recovering the Yellowstone grizzly bear population are concerned with possible overharvest, not underharvest. Thus, they seek assurance that the true population size is greater than or equal to the estimated size. It follows that lower, 1-tailed confidence bounds provide the appropriate measure of uncertainty.

Field Data

Sightings of F_{CUB} were examined for 1986–2001. We considered only sightings from within the grizzly bear recovery zone and the surrounding 10-mile buffer area because calculated mortality limits only apply to human-caused mortalities within this area. Boyce et al. (2001) considered sightings throughout the GYE. Consequently, sample sizes (n values) and numbers of unique, randomly observed F_{CUB} (m values) reported herein differ slightly from values reported by Boyce et al. (2001).

For each year, unique family groups were distinguished as per Knight et al. (1995). Observations of radiocollared animals made during radiolocation flights were included when calculating the minimum number of F_{CUB} known to exist in the population each year ($\hat{N}_{\text{Obs}}$), but were excluded from statistical estimates of N because such sightings were non-random. Sightings were summarized by year as the number of unique family groups seen once, twice, etc. Total numbers of F_{CUB} for each year were then estimated using the method selected following our Monte Carlo comparisons. Lower, 1-tailed confidence bounds were calculated using the selected bootstrap procedure.

RESULTS

Monte Carlo Comparisons

Patterns of estimator performance varied little with population size. For brevity, therefore, we discuss only results for model populations with $N = 40$ individuals.

Population Estimates.—All estimates tended to converge toward N as relative sample size (n/N) increased, but rate of convergence and direction of bias at small to moderate sample sizes varied considerably among estimators and with CV (Fig. 1). Contrary to expectations, Chao's (1984) estimator, $\hat{N}_{\text{Chao1}}$, was postively biased when CV was small. This bias was especially pronounced when n/N also was small. However, $\hat{N}_{\text{Chao1}}$ was among the least biased estimators when CV was large, regardless of sample size. As predicted by theory (Chao 1989), $\hat{N}_{\text{Chao1}}$ was nearly unbiased when CV = 0, but became increasingly and negatively biased as CV increased. The jackknife estimators ($\hat{N}_{\text{J1}}$, $\hat{N}_{\text{J2}}$, and $\hat{N}_{\text{Jk1}}$) were all negatively biased when $n/N < 1.0$, but tended to overestimate N at sample sizes where $1.0 < n/N \leq 3.0$, particularly when CV was small. The jackknife estimators also did not converge toward N as quickly as other estimators as sample size increased. Patterns for the 2 sample coverage estimators were similar: both tended to overestimate N when n/N and CV were small, but converged relatively quickly toward N as n/N exceeded 1.0, particularly when $0.25 \leq CV \leq 0.75$.

With some methods, it was not always possible to estimate N. Over the full range of conditions modeled, $\hat{N}_{\text{Chao1}}$, $\hat{N}_{\text{Jk1}}$, $\hat{N}_{\text{SC1}}$, and $\hat{N}_{\text{SC2}}$ failed to yield estimates in 0.2% of the cases (range = 0.0–29.0% for $\hat{N}_{\text{Chao1}}$; range = 0.0–6.6% for $\hat{N}_{\text{Jk1}}$, $\hat{N}_{\text{SC1}}$, and $\hat{N}_{\text{SC2}}$). Reasons for failures varied. For $\hat{N}_{\text{Chao1}}$, no estimate is possible when $f_2 = 0$ because this leads to division by zero (Eq. 1). For $\hat{N}_{\text{Jk1}}$, the selection process was aborted if a best jackknife estimate was not selected from the estimates $\hat{N}_{\text{J1}}$- $\hat{N}_{\text{J5}}$. Using $\hat{N}_{\text{Jk1}}$, Burnham and Overton (1979) similarly failed to identify a best estimate in 3.7% of their trials. For $\hat{N}_{\text{SC1}}$ and $\hat{N}_{\text{SC2}}$ no population estimate is possible if the estimated sample coverage is zero, as this also leads to division by zero (Eq. 4). This occurs when individuals in the sample are seen only once each, so that $f_1 = n$ and $f_2 = 0$ (Eqs. 2 and 3). For all of these methods, failure rates declined as sample size and, hence, information content increased.
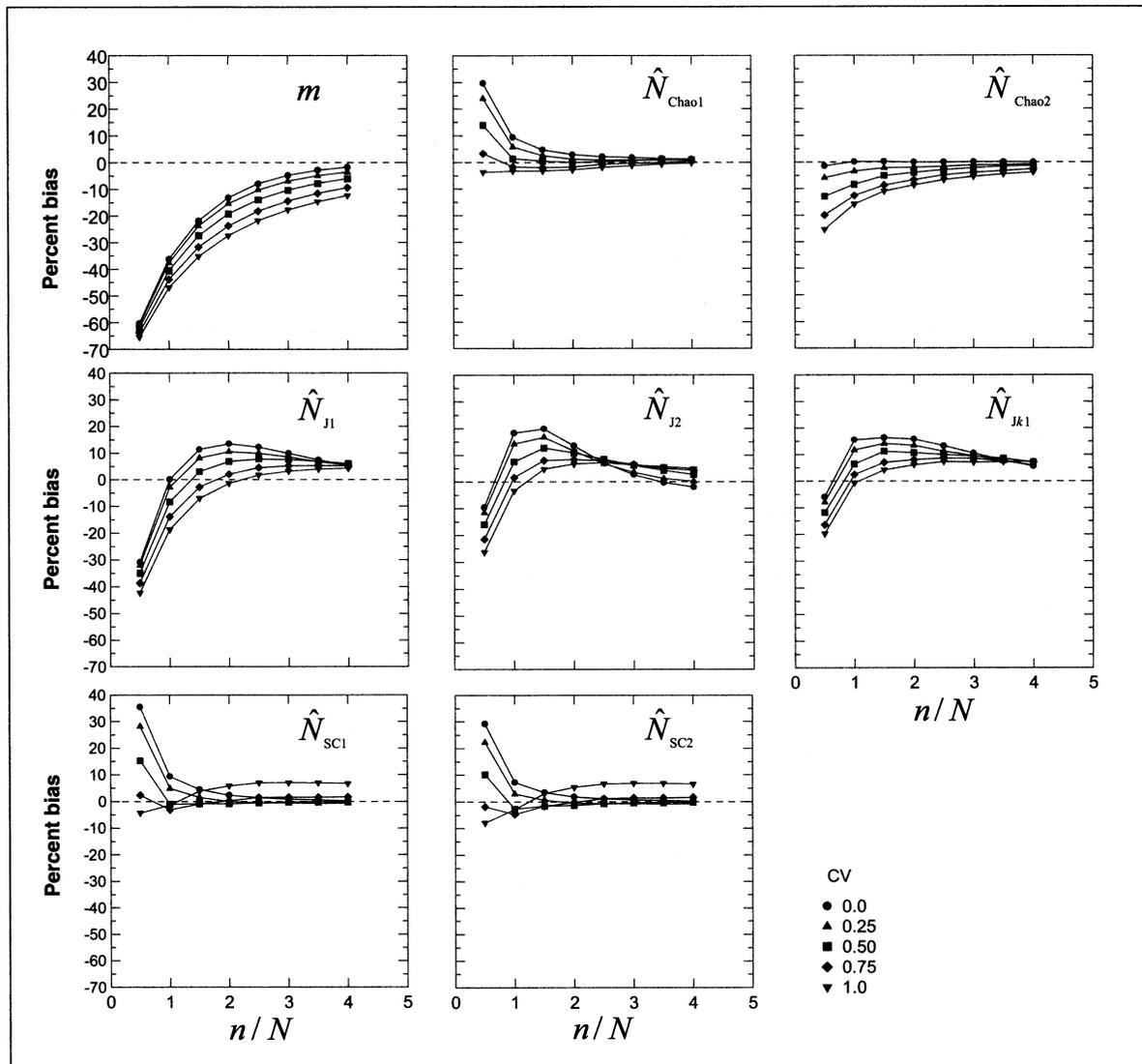
Fig. 1. Percent bias of population estimates calculated using the Chao ($\hat{N}_{Chao1}$), bias-corrected Chao($\hat{N}_{Chao2}$), first-order jackknife ($\hat{N}_{J1}$), second-order jackknife ($\hat{N}_{J2}$), best-order jackknife ($\hat{N}_{Jk1}$), first-order sample coverage ($\hat{N}_{SC1}$), and second-order sample coverage ($\hat{N}_{SC2}$) estimators. Number of unique individuals observed (*m*) is shown for comparison. Each point represents the mean of 1,000 Monte Carlo replicates; in each, calculations were based on *n* random sightings drawn from a model population with *N* = 40 individuals. CV gives the coefficient of variation among sighting probabilities for the 40 individuals. CV = 0.0 indicates equal sightability.

For $\hat{N}_{Chao1}$, $\hat{N}_{Chao2}$, $\hat{N}_{SC1}$, and $\hat{N}_{SC2}$, RMSE declined monotonically toward zero as *n/N* increased (Fig. 2). Patterns of decline were indistinguishable for $\hat{N}_{SC1}$ and $\hat{N}_{SC2}$, and RMSE converged more quickly toward zero for these estimators than for $\hat{N}_{Chao1}$ or $\hat{N}_{Chao1}$. Also for these 4 estimators, RMSE increased with CV when *n/N* ≥ 1. When *n/N* was small, $\hat{N}_{J1}$, $\hat{N}_{J2}$, and $\hat{N}_{Jk1}$ exhibited the lowest RMSEs of the estimators we evaluated. However, rate of convergence toward zero as sample size increased was slow compared to other methods; indeed, RMSE for the jackknife estimators often increased with sample size when 0.5 ≤ *n/N* ≤ 2.0. Also, relatively low RMSEs, especially

for $\hat{N}_{J1}$, often were due to low standard deviations overcompensating for high bias. This suggested that $\hat{N}_{J1}$ may yield narrow confidence bounds, but that those bounds will be centered around highly biased estimates, likely resulting in poor coverage.

Of the methods we compared, our overall choice was the second-order sample coverage estimator, $\hat{N}_{SC2}$ (see Discussion). Comparing observed versus nominal lower, 1-tailed confidence bounds for $\hat{N}_{SC2}$ showed that coverage was affected by *n/N* and CV, and by the method used to calculate confidence bounds (Figs. 3 and 4). Disparities between observed and nominal coverages generally
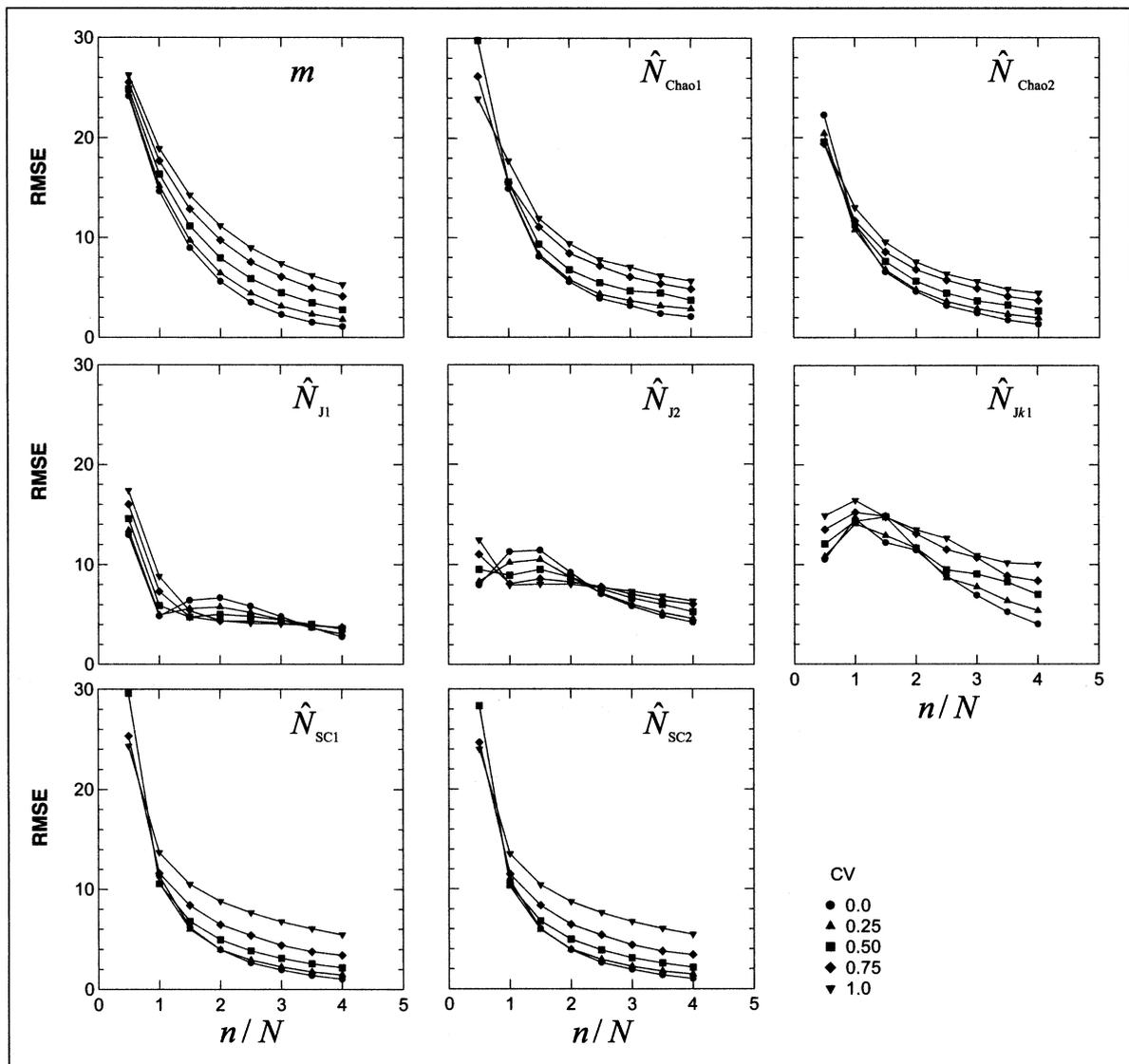
Fig. 2. Root mean square error (RMSE) of population estimates calculated using the Chao ($\hat{N}_{Chao1}$), bias-corrected Chao ($\hat{N}_{Chao2}$), first-order jackknife ($\hat{N}_{J1}$), second-order jackknife ($\hat{N}_{J2}$), best-order jackknife ($\hat{N}_{Jk1}$), first-order sample coverage ($\hat{N}_{SC1}$), and second-order sample coverage ($\hat{N}_{SC2}$) estimators. Number of unique individuals observed (m) is shown for comparison. Each data point represents the mean of 1,000 Monte Carlo replicates; in each, calculations were based on n random sightings drawn from a model population with $N = 40$ individuals. CV gives the coefficient of variation among sighting probabilities for the 40 individuals. CV = 0.0 indicates equal sightability.

increased with CV, but declined as the nominal confidence level increased. Results varied most noticeably with n/N when CV ≥ 0.75. Using the percentile bootstrap method, nominal values sometimes overstated the true coverage when CV = 0.0, but tended to either closely approximate or understate true coverage when $0.25 \leq CV \leq 1.0$ (Fig. 3). Using the BCA bootstrap method, nominal values more closely approximated observed coverages when CV = 0.0, and tended to either approximate or understate true coverage when $0.25 \leq CV \leq 0.75$. For CV = 1.0, however, nominal values tended to overstate true coverage by a large margin when $n/N \geq 2.0$. Overall, we chose the

percentile bootstrap method for calculating confidence bounds because, with CV = 0.0 unlikely in natural populations, we believe that it better minimizes the risk of overestimating N.

Estimates of n/N *and CV.*—In our Monte Carlo study, n/N and CV were important determinants of performance for our estimator of choice, $\hat{N}_{SC2}$. Estimates of these values are given by $n/\hat{N}_{SC2}$ and $\hat{\gamma}$ (Eq. 5), respectively. Presumably, such estimates might be used to ask whether actual values of n/N and CV in our field studies were within the range of values in which $\hat{N}_{SC2}$ performed well. First, however, it is prudent to ask whether $n/\hat{N}_{SC2}$ and $\hat{\gamma}$ themselves provide
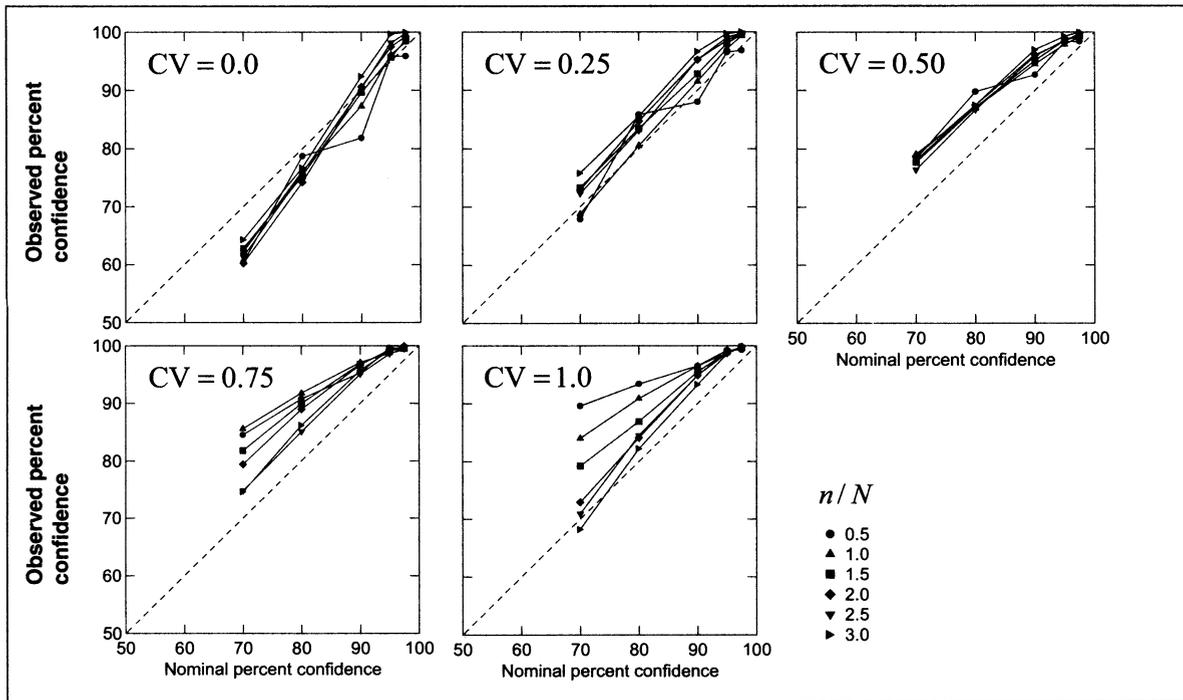
Fig. 3. Observed versus nominal coverages of lower, 1-tailed confidence bounds for second-order sample coverage estimates (N_{sc2}), calculated using the percentile bootstrap method (Efron and Tibshirani 1993). Points above the dashed line indicate that mean observed coverage was greater than nominal coverage, so confidence bounds tended to be conservative. Each data point represents the mean of 1,000 Monte Carlo replicates; in each, calculations were based on n random sightings drawn from a model population with N = 40 individuals. CV gives the coefficient of variation among sighting probabilities for the 40 individuals. CV = 0.0 indicates equal sightability.
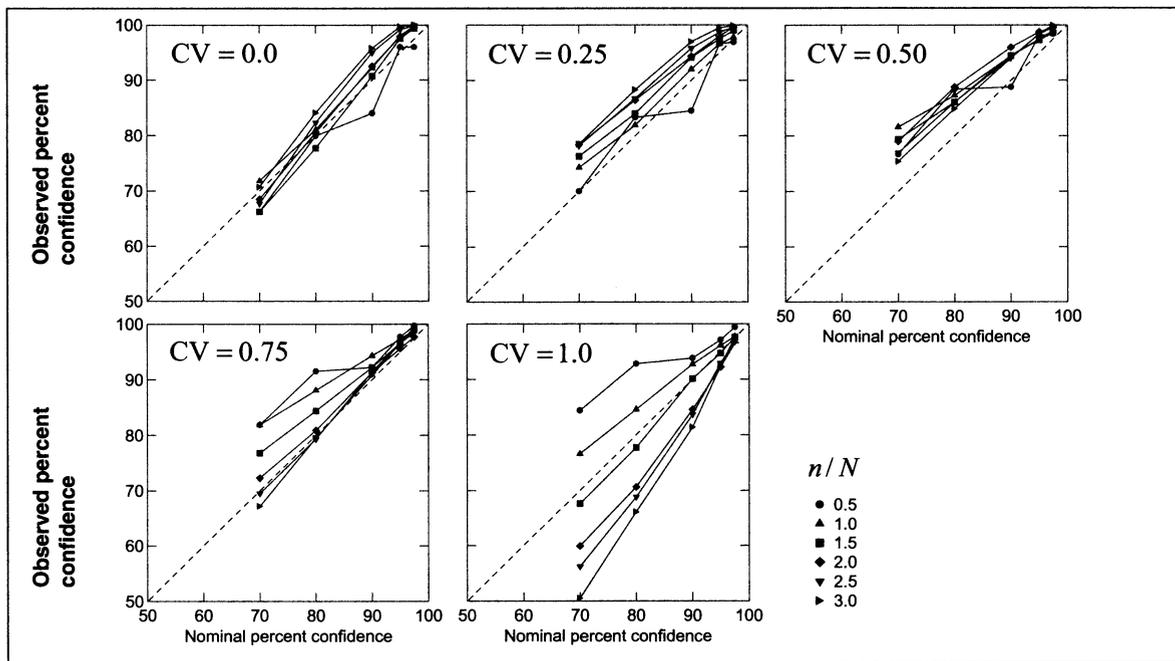
Fig. 4. Observed versus nominal coverages of lower, 1-tailed confidence bounds for second-order sample coverage estimates (N_{sc2}), calculated using the bias corrected and accelerated bootstrap method (Efron and Tibshirani 1993). Points above the dashed line indicate that mean observed coverage was greater than nominal coverage, so that confidence bounds tended to be conservative. Each data point represents the mean of 1,000 Monte Carlo replicates; in each, calculations were based on n random sightings drawn from a model population with N = 40 individuals. CV gives the coefficient of variation among sighting probabilities for the 40 individuals. CV = 0.0 indicates equal sightability.

good estimates. Comparisons showed that $n/\hat{N}_{SC2}$ provided nearly unbiased estimates of n/N throughout the range of conditions we modeled (Fig. 5a). However, $\hat{\gamma}$ was a biased estimator of CV, overestimating the true value when CV = 0.0 and underestimating in all other cases (Fig. 5b). The degree to which $\hat{\gamma}$ underestimated CV when CV $\geq$ 0.25 was influenced by relative sample size. When n/N = 3.0, $\hat{\gamma}$ tended to underestimate CV by about 0.07–0.14. When n/N = 0.5, $\hat{\gamma}$ tended to underestimate CV by about 0.10–0.59.

Field Data

Observation frequencies for F_{CUB} in Yellowstone's grizzly bear recovery area and the surrounding 10-mile buffer zone were tabulated for 1986–2001 (Table 4). Sample sizes ranged from 20 observations in 1987 to 94 in 1999. Using $\hat{N}_{SC2}$ and rounding to the nearest integer, estimated numbers of F_{CUB} in the Yellowstone population ranged from 20 animals in 1987 and 1989 to 60 in 2000 (Table 5). Estimated relative sample size $(n/\hat{N}_{SC2})$ averaged 1.5 and ranged from 0.5 in 1995 to 2.6 in 1986 and 1999, with $n/\hat{N}_{SC2} \geq 1.0$ for 14 of the 16 years examined (Table 5). The estimated coefficient of variation among individual sighting probabilities $(\hat{\gamma})$ averaged 0.46 and ranged from 0.0 in 1990, 1993, and 1994 to 0.90 in 2000 (Table 5).

The total number of unique F_{CUB} actually observed $(\hat{N}_{Obs})$ ranged from 13 in 1987 to 42 in 2001 (Table 5). This included animals that would not have been detected without radiotelemetry. The number of unique F_{CUB} detected through random sightings alone (m) ranged from 12 in 1987 to 39 in 2001 (Table 5). On average, additional information provided by radiotelemetry increased

the number of unique F_{CUB} observed by 2.1 animals/year (range = 0–5 animals). For every year, $\hat{N}_{SC2}$ exceeded $\hat{N}_{Obs}$ (Table 5). However, when rounded to the nearest integer, the lower, 1-tailed 95 and 90% confidence bounds for $\hat{N}_{SC2}$ were less than $\hat{N}_{Obs}$ for 10 and 5 of the years, respectively (Table 5). Lower, 1-tailed 70 and 80% confidence bounds were $\geq \hat{N}_{Obs}$ for all years except 1990 (Table 5).

DISCUSSION

Whether Yellowstone's grizzly bears are removed from the threatened species list depends, in part, on whether human-caused mortalities are within calculated limits. Because mortality limits are computed as a function of the number of F_{CUB} present in the population, statistically sound estimates of annual numbers of F_{CUB} (N) are needed. Parametric methods proposed by Eberhardt and Knight (1996) and Boyce et al. (2001; unpublished report,1999) improved on the practice of basing mortality limits on a minimum estimate for N, determined as the number of unique F_{CUB} observed in a given year $(\hat{N}_{Obs})$. However, these methods require untenable assumptions about the form and constancy of distributions of individual sighting probabilities. At best, these assumptions leave unnecessary room for dispute, potentially undermining the credibility of results and diverting attention from other important issues. At worst, they can cause serious biases.

Nonparametric approaches are free of assumptions about distributions of sighting probabilities, but have not previously been applied to this problem. Nor should they be applied uncritically, as both absolute and relative performances of different estimators can vary with sampling conditions. In this study, we sought a nonparametric
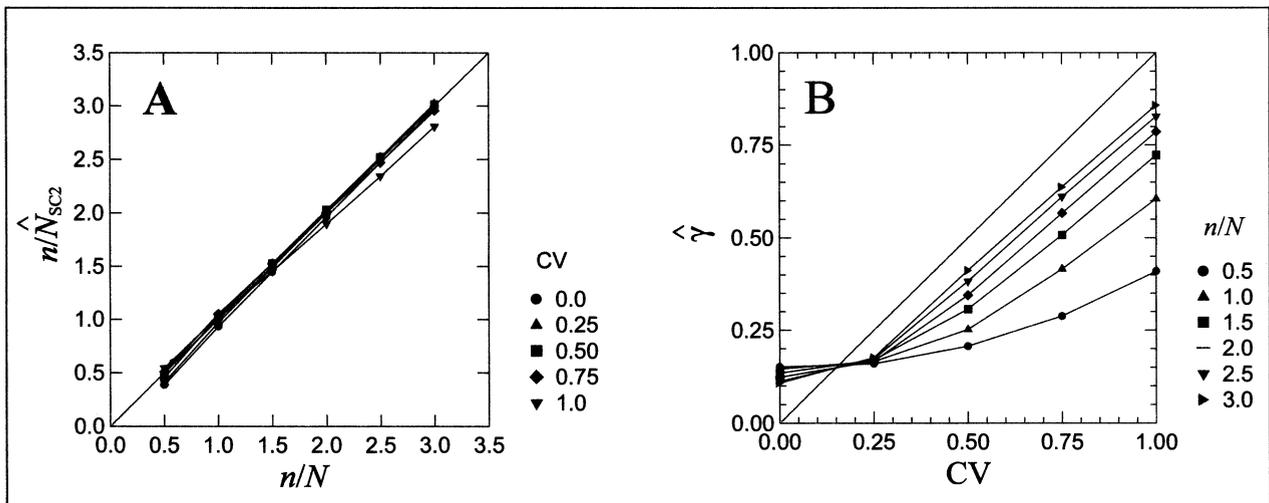
Fig. 5. Estimated $(n/\hat{N}_{SC2})$ versus observed (n/N) relative sample sizes (A), and estimated $(\hat{\gamma})$ versus observed (CV) values for the coefficient of variation among individual sighting probabilities (B). In both (A) and (B), each point represents the mean value, based on 1,000 Monte Carlo replicates; in each, calculations were based on n random sightings drawn from a model population with N = 40 individuals.

Table 4. Observation frequency (f_j) by year, where f_j is the number of unique females with cubs-of-the-year (F_{CUB}) that were seen exactly j times during that year. Total number of observations is given by $n = \sum_{j=1}^{\ } jf_j$. Only observations made without the benefit of radiotelemetry and within or <10 miles of the designated grizzly bear recovery zone were included.

Year	n	f_1	f_2	f_3	f_4	f_5	f_6	f_7	f_8	f_9	f_{10}	f_{11}	f_{12}	f_{13}	f_{14}	f_{15}
1986	82	7	5	6	1	1	0	1	2	0	0	0	0	0	0	1
1987	20	7	3	1	1	0	0	0	0	0	0	0	0	0	0	0
1988	36	7	4	4	1	1	0	0	0	0	0	0	0	0	0	0
1989	27	6	5	0	1	0	0	1	0	0	0	0	0	0	0	0
1990	49	7	6	7	1	1	0	0	0	0	0	0	0	0	0	0
1991	62	11	3	3	3	1	2	1	0	0	0	0	0	0	0	0
1992	37	15	5	1	1	1	0	0	0	0	0	0	0	0	0	0
1993	29	7	8	2	0	0	0	0	0	0	0	0	0	0	0	0
1994	29	9	7	2	0	0	0	0	0	0	0	0	0	0	0	0
1995	25	13	2	1	0	1	0	0	0	0	0	0	0	0	0	0
1996	45	15	10	2	1	0	0	0	0	0	0	0	0	0	0	0
1997	65	13	7	4	1	3	0	1	0	0	0	0	0	0	0	0
1998	75	11	13	5	1	1	0	2	0	0	0	0	0	0	0	0
1999	94	9	4	6	2	4	2	0	1	0	0	1	0	0	0	0
2000	72	17	8	1	2	1	0	2	0	1	0	0	0	0	0	0
2001	84	16	12	8	0	1	1	0	0	1	0	0	0	0	0	0

Table 5. Estimates of annual numbers ($\hat{N}_{Obs}$) of females with cubs-of-the-year (F_{CUB}) in the Yellowstone grizzly bear population, 1986–2001. $\hat{N}_{Obs}$ gives the number of unique F_{CUB} actually observed, including those located using radiotelemetry; m gives the number of unique F_{CUB} observed using random sightings only; and $\hat{N}_{SC2}$ gives the second-order sample coverage estimates, per Lee and Chao (1994; Eqs. 3–5). Lower, 1-tailed confidence bounds are for $\hat{N}_{SC2}$ and were calculated using Efron and Tibshirani's (1993) percentile bootstrap method. Also included are annual estimates of relative sample size ($n/\hat{N}_{SC2}$, where n is the total number of observations of F_{CUB}) and of the coefficient of variation among sighting probabilities for individual animals ($\hat{\gamma}$, Eq. 5).

Year	$\hat{N}_{Obs}$	m	$\hat{N}_{SC2}$	Lower 1-tailed confidence bounds				$n/\hat{N}_{SC2}$	$\hat{\gamma}$
				70%	80%	90%	95%		
1986	25	24	31.9	28.4	27.0	25.1	23.5	2.6	0.86
1987	13	12	19.5	16.8	15.2	13.3	11.7	1.0	0.37
1988	19	17	21.5	20.1	19.1	17.7	16.7	1.7	0.25
1989	15	13	20.2	16.9	15.3	13.7	12.3	1.3	0.71
1990	25	22	25.5	24.4	23.5	22.2	21.3	1.9	0.00
1991	24	24	34.5	31.1	29.3	27.0	25.2	1.8	0.63
1992	25	23	47.6	40.0	36.4	32.1	28.9	0.8	0.61
1993	19	17	21.8	20.1	19.0	17.9	16.3	1.3	0.00
1994	20	18	25.5	23.4	21.8	19.9	18.8	1.1	0.00
1995	17	17	54.9	41.2	35.9	28.8	24.7	0.5	0.86
1996	33	28	41.4	38.7	36.6	34.0	31.8	1.1	0.00
1997	31	29	41.3	37.5	35.5	33.0	31.1	1.6	0.57
1998	35	33	40.9	38.4	37.1	35.1	33.7	1.8	0.44
1999	32	29	35.7	33.3	32.1	30.4	29.0	2.6	0.61
2000	35	32	59.7	51.8	48.2	43.8	40.3	1.2	0.90
2001	42	39	54.6	49.5	47.3	44.6	42.2	1.5	0.58

method that performs well over the range of sampling conditions deemed plausible for sightings of F_{CUB} in the GYE. Comparing 7 variations of the Chao (Chao 1984, 1989), jackknife (Burnham and Overton 1978, 1979), and sample coverage (Chao and Lee 1992, Lee and Chao 1994) methods, our provisional choice for estimating numbers of F_{CUB} in the Yellowstone population was the second-order sample coverage estimator, $\hat{N}_{SC2}$. Differences between $\hat{N}_{SC2}$ and the first-order sample coverage estimator, $\hat{N}_{SC1}$, were minor, with both methods converging more rapidly toward N as sample size increased than did other estimators. For both estimators, however, the coefficient of variation among individual sighting probabilities (CV) affected performance. Over all CV values, $\hat{N}_{SC2}$ exhibited a slightly better balance than $\hat{N}_{SC1}$ between tendencies to overestimate and underestimate when relative sample size (n/N) was in the range of $1.0 < n/N \le 2.0$ (Fig. 1). Performance under these conditions was seen as particularly important because estimates of n/N for our field study were within this range most years (Table 5).

Chao's (1984) estimator ($\hat{N}_{Chao1}$) showed a greater tendency toward positive bias and exhibited somewhat larger RMSEs than $\hat{N}_{SC2}$ (Figs. 1, 2), but otherwise performed well. Because the most serious biases were associated

with model populations where CV = 0 (an unlikely situation in nature), $\hat{N}_{Chao1}$ may be a suitable alternative to the sample coverage estimators. However, we cannot recommend the other methods we compared. Over all CV values, RMSEs for $\hat{N}_{Chao2}$ were lower than for $\hat{N}_{SC2}$ (Fig. 2), but $\hat{N}_{Chao2}$ became increasingly and negatively biased as CV increased (Fig. 1). Because individual animals clearly are not equally sightable, use of such an estimator would introduce a chronic, negative bias into estimates of population size and sustainable mortality. Jackknife estimates oscillated, being negatively biased when n/N was small, positively biased at moderate values of n/N, and converging toward N only as n/N increased beyond values observed in our field study (Fig. 1). Neither bias nor RMSE declined monotonically with sample size for any of the jackknife estimators. This suggested that, relative to the other methods examined, larger sample sizes would be needed to achieve comparably accurate estimates and that increased sample size might actually lead to increased bias in some situations. The latter problem was particularly pronounced in the range of $1.0 < n/N \leq 2.0$ (Figs. 1, 2).

In a similar analysis, Mowat and Strobeck (2000) evaluated nonparametric estimators available in the program CAPTURE (Otis et al. 1978, White et al. 1982, Rexstad and Burnham 1991). They selected Burnham and Overton's (1979) best-order jackknife method ($\hat{N}_{Jk1}$) for estimating numbers of grizzly bears in 2 Canadian populations that showed evidence of "relatively weak heterogeneity" among individual capture probabilities (Mowat and Strobeck 2000:191). Our study differed in important respects. First, all else being equal, the underlying distribution of sighting probabilities should be more heterogeneous in our study (i.e., CV should be larger) because our sample unit consisted of a single sighting rather than a sample period. Second, because our sampling universe included only F_{CUB}, population size appeared to be smaller than the 74 and 262 animals estimated by Mowat and Strobeck (2000). Although population size was not a major determinant of estimator performance in our study, we considered only a narrow range of values ($N = 20, 40$, and 60 animals). Over a larger range, N might emerge as a more important factor. Third, we considered sample coverage estimators (Chao and Lee 1992, Lee and Chao 1994) not available in CAPTURE. Fourth, Mowat and Strobeck (2000), apparently, did not vary sampling effort in a way that would have revealed the oscillatory pattern we observed for the jackknife estimators.

Like all estimators we examined, performance of $\hat{N}_{SC2}$ varied with n/N. As expected, the largest biases and RMSEs were associated with the smallest relative sample size, $n/N = 0.5$. Performance improved dramatically, however, with even modest increases in n/N, leading us to

recommend a minimum sample size of $n/N = 1$. A nearly unbiased estimate of n/N was $n/\hat{N}_{SC2}$ (Fig. 5a). Observed values for $n/\hat{N}_{C2}$ met or exceeded our recommended minimum for all but 2 years during 1986–2001 (Table 5). This suggested that observed sample sizes were large enough in most years to support fairly good estimates of N (Fig. 1). At this minimal level of sampling effort, however, confidence bounds were sometimes undesirably broad (Table 5). To narrow confidence bounds, we suggest that $n/N = 2$ is a reasonable and achievable goal. Based on estimates of N for 1996–2001 (Table 5), such a goal would translate into target sample sizes of about 80–120 independent random sightings of F_{CUB} per year. This compares with observed sample sizes of 45–94 sightings/year during that same period and indicates a need for increased support for this aspect of the Yellowstone grizzly bear monitoring effort.

Performance of $\hat{N}_{SC2}$ also varied with the degree of heterogeneity among individual sighting probabilities, as measured by CV. However, such variation was dramatic only when $n/N = 0.5$. When $n/N \geq 1$, $\hat{N}_{SC2}$ was fairly robust to variations in CV, especially in the range of $0.0 \leq CV \leq 0.75$ (Fig. 1). Even when CV = 1.0, bias was <10%, regardless of n/N (Fig. 1). An advantage of $\hat{N}_{SC2}$ is that CV is estimated ($\hat{\gamma}$, Eq. 5) as part of the calculation. For 1986–2001, $\hat{\gamma}$ averaged 0.46 and ranged from 0.0–0.9, suggesting that actual CVs were within the range of values in which $\hat{N}_{SC2}$ performs well. Our Monte Carlo study demonstrated, however, that $\hat{\gamma}$ was negatively biased when CV ≥ 0.25, particularly when n/N is small (Fig. 5). Using calculated values for $n/\hat{N}_{SC2}$ and $\hat{\gamma}$ (Table 5), rough corrections for such biases can be inferred from Fig. 5. For example, when $n/N = 1.0$ and CV = 0.4, $\hat{\gamma}$ tended to underestimate CV by about 0.2 (Fig. 5). Given $n/\hat{N}_{SC2} = 1.5$ and $\hat{\gamma} = 0.58$ for 2001 (Table 5), this suggests an unbiased estimate for CV of about 0.85 for that year. Similar inferences for other years yielded a maximum estimated CV of around 1.3 in 2000, but suggested that, overall, CV rarely was much greater than 1. Thus, we believe that actual CVs for sighting probabilities of F_{CUB} in the Yellowstone population typically are within the range of values in which $\hat{N}_{SC2}$ performs well.

Regardless of method, there is an inherent risk of overestimating N that, in turn, could lead to setting mortality limits at unsustainably high levels. To minimize this risk, we believe it is prudent to base management on some lower, 1-tailed confidence bound. This would provide a specified level of assurance that the population of F_{CUB} is at least as large as estimated. For example, calculated confidence bounds indicated that we can be 95% certain there were at least 42 F_{CUB} in the Yellowstone grizzly bear population in 2001, and 80% certain there were at least 47 (Table 5). To determine whether such bounds accu-

rately depict the risk of overestimating N, we compared nominal versus observed sample coverages using both the BCA and percentile bootstrap methods (Efron and Tibshirani 1993). The BCA method, theoretically, is superior to the percentile method (Efron and Tibshirani 1993). Nonetheless, we recommend the percentile method for this application because the BCA method substantially overstated true coverage under conditions that might reasonably occur in field studies; i.e., when $CV = 1.0$ and $n/N \geq 2.0$ (see Table 5). Such an error would cause us to understate the true risk of overestimating N. Although the percentile method overstated true coverage when $CV = 0.0$ and nomimal coverage was 70 or 80%, we view this as less serious because it is not reasonable to expect that $CV = 0.0$ for natural populations.

In general, we believe $\hat{N}_{SC2}$ is superior to $\hat{N}_{Obs}$ as a basis for calculating mortality limits for Yellowstone's grizzly bears, particularly if lower, 1-tailed confidence bounds are used to minimize the risk of overestimation. In some years, however, depending on the confidence level that is chosen, $\hat{N}_{Obs}$ may be the better alternative. For example, $\hat{N}_{Obs}$ equaled or exceeded the lower, 1-tailed 90% confidence bound for $\hat{N}_{SC2}$ (rounded to the nearest integer) in 8 of the 16 years examined (1986–90, 1993, 1994, 1998, and 1999; Table 5), yet is unburdened by the same risk of overestimation. Thus, it offers a superior estimate of a lower bound for N for those years. This situation occurs largely because $\hat{N}_{Obs}$ incorporates additional information from non-random sightings of radiocollared animals; information that cannot legitimately be used when calculating $\hat{N}_{SC2}$ or its confidence bounds.

Overall, we sought a reliable statistical method for estimating numbers of F_{CUB} because such estimates are essential for setting mortality limits for grizzly bears in the GYE. Given recommended sample sizes, we believe $\hat{N}_{SC2}$ is a reasonable choice for this purpose and that it improves on earlier approaches. We emphasize, however, that knowledge of the number of F_{CUB} is not, by itself, sufficient for setting mortality limits. Other calculations and assumptions are involved that merit additional and comparable scrutiny. Thus, we have refrained from using estimates generated in this study to project total population size or infer acceptable levels of mortality, believing that the remaining issues should be addressed first. An important issue is the assumption that every sighting was correctly identified to individual. Misidentifications undoubtedly occurred, leading to errors of Type I (sightings of the same animal mistakenly classified as sightings of different animals) or Type II (sightings of different animals mistakenly classified as sightings of the same animal). Our experience in applying the rule set of Knight et al. (1995) suggests that Type II errors are much more likely. Such a bias would cause a tendency to undercount the number of unique animals actually seen (m), while also inflating sighting frequencies (n_i values) for the $\hat{m}$ animals estimated to have been seen. In turn, this would lead to estimates of N that are more negatively biased than depicted in our Monte Carlo results, regardless of the estimator that is used. Such a bias, although undesirable, is not by itself inconsistent with our goal of improving on $\hat{N}_{Obs}$ while minimizing the risk of overestimating N. Effects of misidentification on precision are less clear, however. Misidentification introduces uncertainty in sighting frequencies and, thus, would increase uncertainty in estimates based on those frequencies. Our lower, 1-tailed confidence bounds did not incorporate this additional uncertainty and, thus, were probably higher than they would have been if effects of misidentification had been fully accounted for. The tendency toward positive bias in the lower confidence bound would have been countered to some degree by 2 factors. First, any negative bias in N resulting from misidentification would necessarily have been accompanied by a similar bias in the confidence bounds surrounding $\hat{N}$. Second, our lower, 1-tailed confidence bounds already were biased low within the range of conditions most often experienced in this study (Fig. 3). Overall, effects of misidentifications on precision would be mitigated, but to an unknown degree. Additional work to better define the nature, magnitude, and consequences of identification errors is needed and has been undertaken. In the meantime, we offer this work as the first in what we hope will be a series of refinements that better ensure reliable estimates of allowable mortality, while minimizing the risk of error.

ACKNOWLEDGMENTS

LITERATURE CITED

Boyce, M.S., D. MacKenzie, B.F.J. Manly, M.A. Haroldson, and D. Moody. 2001. Negative binomial models for abundance estimation of multiple closed populations. Journal of Wildlife Management 65:498–509.

Bunge, J., and M. Fitzpatrick. 1993. Estimating the number of species: a review. Journal of the American Statistical Association 88:364–373.

Burnham, K.P., and W.S. Overton. 1978. Estimation of the size of a closed population when capture probabilities vary among animals. Biometrika 65:625–633.

———, and ———. 1979. Robust estimation of population size when capture probabilities vary among animals. Ecology 60:927–936.

Chao, A. 1984. Nonparametric estimation of the number of classes in a population. Scandinavian Journal of Statistics 11:265–270.

———. 1988. Estimating animal abundance with capture frequency data. Journal of Wildlife Management 52:295–300.

———. 1989. Estimating population size for sparse data in capture–recapture experiments. Biometrics 45:427–438.

———, W.-H. Hwang, Y.-C. Chen, and C.-Y. Kuo. 2000. Estimating the number of shared species in two communities. Statistica Sinica 10:227–246.

———, and S.-M. Lee. 1992. Estimating the number of classes via sample coverage. Journal of the American Statistical Association 87:210–217.

———, M.-C. Ma, and M.C.K. Yang. 1993. Stopping rules and estimation for recapture debugging with unequal failure rates. Biometrika 80:193–201.

Darroch, J.N., and D. Ratcliff. 1980. A note on capture–recapture estimation. Biometrics 36:149–153.

Eberhardt, L.L., and R.R. Knight. 1996. How many grizzlies in Yellowstone? Journal of Wildlife Management 60:416–421.

Efron, B., and R.J. Tibshirani. 1993. An introduction to the bootstrap. Chapman and Hall, New York, New York, USA.

Greenwood, M., and G.U. Yule. 1920. An inquiry into the nature of frequency distributions representative of multiple happenings with particular reference to the occurrence of multiple attacks of disease or of repeated accidents. Journal of the Royal Statistical Society, Series A 83:255–279.

Johnson, N.L., S. Kotz, and N. Balakrishnan. 1995. Continuous univariate distributions. Volume 2. Second edition. John Wiley and Sons, New York, New York, USA.

Keating, K.A. 1986. Historical grizzly bears population trends in Glacier National Park, Montana. Wildlife Society Bulletin 14:83–87.

Knight, R.R., B.M. Blanchard, and L.L. Eberhardt. 1995. Appraising status of the Yellowstone grizzly bear population by counting females with cubs-of-the-year. Wildlife Society Bulletin 23:245–248.

Lee, S.-M., and A. Chao. 1994. Estimating population size via sample coverage for closed capture–recapture models. Biometrics 50:88–97.

Lewontin, R.C., and T. Prout. 1956. Estimation of the number of different classes in a population. Biometrics 12:211–223.

Mowat, G., and C. Strobeck. 2000. Estimating population size of grizzly bears using hair capture, DNA profiling, and mark–recapture analysis. Journal of Wildlife Management 64:183–193.

Otis, D.L., K.P. Burnham, G.C. White, and D.R. Anderson. 1978. Statistical inference from capture data on closed animal populations. Wildlife Monographs 62.

Picton, H.L., D.M. Mattson, B.M. Blanchard, and R.R. Knight. 1986. Climate, carrying capacity, and the Yellowstone grizzly bear. Pages 129–135 in G. Contreras and K. Evans, compilers. Proceedings of the grizzly bear habitat symposium. U.S. Forest Service General Technical Report INT-207.

Press, W.H., S.A. Teukolsky, W.T. Vetterling, and B.P. Flannery. 1992. Numerical recipes in FORTRAN, the art of scientific computing. Second edition. Cambridge University Press, New York, New York, USA.

Rexstad, E., and K. Burnham. 1991. User's guide for interactive program CAPTURE. Colorado Cooperative Fish and Wildlife Research Unit, Fort Collins, Colorado, USA.

Seber, G.A.F. 1982. The estimation of animal abundance. Macmillan, New York, New York, USA.

Smith, E.P., and G. van Belle. 1984. Nonparametric estimation of species richness. Biometrics 40:119–129.

Tanton, M.T. 1965. Problems of live-trapping and population estimation for the wood mouse, Apodemus sylvaticus (L.). Journal of Animal Ecology 34:1–22.

———. 1969. The estimation and biology of populations of the bank vole and wood mouse. Journal of Animal Ecology 38:511–529.

Taylor, S.M. 1966. Recent quantitative work on British bird populations: a review. The Statistician 16:119–170.

U.S. Fish and Wildlife Service. 1993. Grizzly bear recovery plan. U.S. Fish and Wildlife Service, Missoula, Montana, USA.

White, G.C., D.R. Anderson, K.P. Burnham, and D.L. Otis. 1982. Capture–recapture and removal methods for sampling closed populations. Los Alamos National Laboratory LA-8787-NERP, Los Alamos, New Mexico, USA.

Wilson, R.M., and M.F. Collins. 1992. Capture–recapture estimation with samples of size one using frequency data. Biometrika 79:543–553.

Appendix C. Calculation of Total Population Size and Mortality Limits

Efforts to improve the population size estimation and management methods and to reevaluate the sustainable mortality limits in the Greater Yellowstone Ecosystem (GYE) have continued with the Interagency Grizzly Bear Study Team (IGBST) leading these efforts. Notably, several special reports have been produced including: "Reassessing Methods to Estimate Population Size and Sustainable Mortality Limits for the Yellowstone Grizzly Bear" (hereafter referred to as the Reassessing Methods Document, IGBST 2005, Appendix L), which was released for public comment and peer review. In response to comments received during this process, a second document, "Reassessing Methods To Estimate Population Size And Sustainable Mortality Limits For The Yellowstone Grizzly Bear: Workshop document supplement on 19–21 June 2006" (hereafter referred to as the Supplement to the Reassessing Methods Document, IGBST 2006, Appendix M) was produced after further peer review. Most recently, a third document "Updating and Evaluating Approaches to Estimate Population Size and Sustainable Mortality Limits for Grizzly Bears in the Greater Yellowstone Ecosystem" (hereafter referred to as the Updated Demographics document, IGBST 2012) was prepared in response to updated information and changes in population trajectory related to grizzly bear demographics. This 2012 document is attached to this 2016 Conservation Strategy as Appendix N.

The goals of these IGBST workshops were to assemble internal and external experts to review and enhance existing methods and, to the extent feasible, use existing data to develop new population estimation methods in order and ensure that population estimation and mortality management methods for the GYE grizzly bear population are based on the best available science. This effort was undertaken as per the commitment in the Conservation Strategy of all management agencies to employ adaptive management using the best available science to manage the GYE grizzly bear population.

The IGBST will use the protocol described in this Appendix to annually estimate population size within the Demographic Monitoring Area (DMA), and then set mortality limits inside the DMA for the following year based on the sliding scale in Table 1. Methods used in this protocol are described in the Reassessing Methods Document (IGBST 2005), summarized in the Supplement

to the Reassessing Methods Document (IGBST 2006), and revised in the Updated Demographics Rates Document (IGBST 2012). Any change in the methods described below would be considered a change to the Conservation Strategy and would be revised through the Yellowstone Grizzly Bear Coordinating Committee process with the requirement that any proposed changes: 1) be based upon the best available science; and 2) go through public review before they are accepted, as per p. 99 of this Conservation Strategy.

The population goal is set for the average population size 2002–2014 inside the DMA. The current and approved method to estimate population size in the DMA uses the model-averaged Chao2 estimator. If another population estimator was adopted as per the Conservation Strategy procedures described above, this new population estimator will be applied to the 2002–2014 data to estimate the average population size 2002–2014. The new population estimate results would be inserted in Table 1 to reset the population size numbers with the same sliding scale, with the intent to maintain the population goal of the average population size 2002–2014. If a review of the vital rate data by the IGBST (similar to that in the 2012 report) resulted in new mortality rate for a sustainable population at the 2002–2014 average population size, then the new sustainable mortality rate for the average 2002–2014 population size would replace the 7.6% for independent females and dependent young in Table 1. Any such change would be considered a change to the Conservation Strategy and would be revised through the Yellowstone Grizzly Bear Coordinating Committee process, which requires that any proposed changes: 1) be based upon the best available science; and 2) go through public review before they are accepted, as per p. 99 of this Conservation Strategy.

The following procedures detail how population size and mortality thresholds would be calculated:

1. Observations of sightings of females with cubs-of-the-year[1] will be separated into an estimate of unique females with cubs-of-the-year and repeat observations of the same female using the methods of Knight *et al*. (1995).

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1 Adult female grizzly bears accompanied by cubs that are less than one year old.

2. Only sightings of unique females with cubs-of-the-year from within the DMA will be used for subsequent estimates.

3. The Chao2 estimator (Keating *et al*. 2002) will be applied to sighting frequencies of unique females with cubs-of-the-year to estimate the total number of females with cubs of the year in the population.

4. The number of unique females with cubs-of-the-year obtained from the Chao2 estimator each year will be added to the long-term dataset to conduct the model-averaging process described in the Supplement to the Reassessing Methods Document (IGBST 2006). This process involves fitting a linear and quadratic trend model, followed by averaging model parameters based on the respective Akaike's Information Criterion (AIC_c) weights of the linear and quadratic models. These model-averaged parameters are then used to estimate the number of females with cubs-of-the-year.

5. The estimated number of females with cubs-of-the-year obtained through the model averaging will be used as the best estimate of the total number of independent females with cub-of-the-year in the DMA for that year.

6. The purpose of fitting the trend model is to obtain the best estimate of the current number of females with cubs-of-the-year by using information from past estimates, recognizing that with each iteration, some change is expected. Retrospectively adjusting estimates from previous years will not occur.

7. The estimated number of females with cubs-of-the-year will be divided by the proportion of females ≥4 years old estimated to be accompanied by cubs-of-the-year (transition probability = 0.2965) observed during 2002–2011. The resulting value represents the best estimate of the total number of females in the population ≥4 years old.

8. The number of females ≥4 years old will be divided by the estimated proportion of females ≥4 years old in the population of females ≥2 years old (proportion = 0.844) observed during 2002–2011. The resulting value is the best estimate of the number of independent females (≥2 years old) in the population that year.

9. The sustainable mortality limit for independent females is dependent on the population estimate of independent females (Table 1).

10. Unknown and unreported mortality will be estimated based on the methods of Cherry *et al*. (2002) as described in the Reassessing Methods Document (IGBST 2005).

11. The number of independent males in the population will be based on the estimated ratio of independent males to independent females (ratio = 1:1) observed during 2002–2011 and derived via stochastic modeling described in the Supplement to the Reassessing Methods Document (IGBST 2006). The number of independent females in the population will thus be multiplied by 1.0 and the resulting value represents the best estimate of the number of independent males that year.

12. The sustainable mortality limit for independent males is dependent on the population estimate of independent males (Table 1).

13. The number of cubs-of-the-year in the annual population estimate will be calculated directly from the model-averaged estimate of females with cubs-of-the-year (IGBST 2006). The number of cubs will be estimated by multiplying the model-averaged estimate of females with cubs-of-the-year by the mean litter size (litter size = 2.49; mortality adjusted estimate) observed during 2002–2011.

14. The number of yearlings will be estimated by multiplying the estimated number of cubs from the previous year by the mean survival rate for cubs (cub survival = 0.553) observed during 2002–2011.

15. The sustainable mortality limit for dependent young (cubs and yearlings) is dependent on the population estimate of dependent young (Table 1). Only human-caused deaths (reported known and probable) will be tallied against the threshold for dependent young.

16. Unknown and unreported mortality will not be estimated for dependent young.

17. Sustainable mortality limits will be established annually based on the data collected in that year and the calculations described here. These mortality limits will then apply the following year. Because model-averaged estimates are used, annual variability among estimates is explicitly addressed. Consequently, annual limits based on a 3-year running average, as proposed in the Reassessing Methods Document (IGBST 2005), are not used. Instead, annual sustainable mortality limits for any year will be based on the data and calculations for the previous year (as described in this protocol and the Updated Demographic Rates Document, IGBST 2012, Appendix N).

18. Estimates of uncertainty about the number of independent females, independent males, dependent young, and total population size will be derived following methods detailed in the

Supplement to the Reassessing Methods Document (IGBST 2006) using updated vital rates as documented in IGBST (2012, Appendix N).

19. The objective of 48^{2} females with cubs-of-the-year as estimated with Chao2 will be evaluated based on the model-averaged estimate of females with cubs-of-the-year (IGBST 2012).

20. A biology and monitoring review by the IGBST will occur should the model-averaged Chao2 estimate decline below 48 females with cubs-of-the-year for any 2 consecutive years.

21. Agencies will implement management to attempt to limit female mortality model-averaged Chao2 estimate decline below 48 females with cub-of-the-year in any given year.

22. In modeling the rate of change (trend) of females with cubs-of-the-year as described in the Supplement to the Reassessing Methods Document (IGBST 2006), if the AIC_c weight favors the quadratic term and corresponding $\Delta AIC_c \geq 2.0$ compared with the linear model for 3 consecutive years, a full review of the population's demographics will be undertaken to better understand its status. Given evidence of a population nearing carrying capacity and a population fluctuating around a long-term mean, this approach allows timely detection of a sustained increasing or decreasing trend (van Manen *et al.* 2015).

23. If dead bears are reported in years subsequent to actual year of mortality, they will be tallied against year of death and total mortality will be recalculated. If mortality exceeds the threshold for that year, the difference (total mortality minus threshold) will be counted against the current years' threshold.

24. For bears that are estimated to be independent of age, if sex cannot be determined, sex will be assigned randomly using ratio of 59:41 male:female as recommended in Appendix A of Schwartz and Haroldson (2001).

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[2] 48 independent females with cubs of the year in the DMA is approximately equivalent to a population of 600 bears.

Table 1. Annual sustainable mortality limits by sex and age cohorts[3] of grizzly bears in the Greater Yellowstone Ecosystem under the protocol to manage for a population at the average annual population estimate for the period 2002–2014 in the Demographic Monitoring Area (DMA) (using the Chao2 estimator this average number is 674).

Maximum mortality rate for:	Population estimate inside the DMA using the model-averaged Chao2 method.			
	<674	674	675-747	>747
% of independent **FEMALES**	<7.6%	7.6%	9%	10%
% of independent **MALES**	15%	15%	20%	22%
% of **DEPENDENT YOUNG**	<7.6%	7.6%	9%	10%

Literature Cited

Cherry, S., M.A. Haroldson, J. Robison-Cox, and C.C. Schwartz. 2002. Estimating total human-caused mortality from reported mortality using data from radio-instrumented grizzly bears. Ursus 13:175–184.

Interagency Grizzly Bear Study Team. 2005. Reassessing methods to estimate population size and sustainable mortality limits for the Greater Yellowstone Ecosystem grizzly bear. Interagency Grizzly Bear Study Team, USGS Northern Rocky Mountain Science Center, Montana State University, Bozeman, Montana, USA. 60 pp.

Interagency Grizzly Bear Study Team. 2006. Reassessing methods to estimate population size and sustainable mortality limits for the Greater Yellowstone Ecosystem grizzly bear workshop document supplement 19–21 June 2006. Interagency Grizzly Bear Study Team, USGS Northern Rocky Mountain Science Center, Montana State University, Bozeman, Montana, USA. 21 pp.

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[3] Sustainable mortality estimates are based on the sustainable mortality percentage of the respective population segment relative to the population estimates.

Interagency Grizzly Bear Study Team. 2012. Updating and evaluating approaches to estimate
population size and sustainable mortality limits for grizzly bears in the Greater
Yellowstone Ecosystem. Interagency Grizzly Bear Study Team, U.S. Geological Survey,
Bozeman, Montana, USA. 66 pp.

Keating, K.A., C.C. Schwartz, M.A. Haroldson, and D. Moody. 2002. Estimating numbers of
females with cubs-of-the-year in the Yellowstone grizzly bear population. Ursus 13: 161–
174.

Knight, R.R., B.M. Blanchard, and L.L. Eberhardt. 1995. Appraising status of the Yellowstone
grizzly bear population by counting females with cubs-of-the-year. Wildlife Society
Bulletin 23: 245–248.

Schwartz, C.C. and M.A. Haroldson. 2001. Appendix A. Pages 119–121 *in* Yellowstone grizzly
bear investigations: annual report of the Interagency Grizzly Bear Sutdy Team, 2000.
U.S. Geological Survey, Bozeman, Montana, USA.

Van Manen, F.T., M.A. Haroldson, D.D. Bjornlie, M.R. Ebinger, D.J. Thompson, C.M. Costello,
and G.C. White. 2015. Density dependence, whitebark pine decline, and changing vital
rates of Yellowstone grizzly bears. Journal of Wildlife Management. doi:
10.1002/jwmg.1005.

Appendix D. Existing Bear Foods and Related Monitoring Programs

Winter-killed Ungulate Carcass and Associated Bear Use Survey

During April and May of each year, YNP and IGBST personnel conduct ungulate carcass surveys along 126.5 miles of survey routes on the Northern Winter Range, 82.5 miles of survey routes in the Firehole River drainage, 17 miles of survey routes in the Norris Geyser Basin, and 27 miles of survey routes in the Heart Lake area. Survey routes are hiked, snowshoed, or skied by teams of two people. All ungulate carcasses as well as bears and bear sign (tracks, scat, feeding sign) observed from the survey routes are recorded. Data collected include species, sex, and age class of ungulate carcasses found, estimated date and cause of death, scavenging by bears, species of bear using the carcass, use of carcass by other scavengers, and UTM location.

Cutthroat Trout Spawning Stream And Associated Bear Use Surveys

Beginning 1 May each year, 8 front country streams (Lodge Cr., Hotel Cr., Hatchery Cr., Incinerator Cr., Wells Cr., Bridge Cr., Weasel Cr., and Sand Point Cr.) within or near the Lake Developed area, and 5 front country streams (Sandy Cr., Sewer Cr. Little Thumb Cr., Arnica Cr., and 1167 Cr.) within or near the Grant Village development are checked daily to detect the presence of adult cutthroat trout (Andrascik 1992, Olliff 1992). Once adult trout are found (i.e., onset of spawning), weekly surveys of cutthroat trout on these streams and on an additional 8 backcountry streams (Cub Cr., Clear Cr., Columbine, Flat Mountain Arm Cr., Delusion Lake Outlet, Trail Cr., and 1150 Cr.) are conducted. In each stream on each sample day, two people walk upstream from the stream mouth and record the number of adult trout observed. Sampling continues one day per week until most adult trout return to the lake (i.e., end of spawning). Counts are used to estimate the peak periods, relative magnitude and duration of spawning runs (Reinhart 1990). While making fish counts, observers record bear sign (e.g., bear sightings, fish parts, hair, scats, and tracks) and collect hair from DNA hair collection corrals. Track measurements and DNA from collected hair are used to determine the number, species, and association of family groups of bears.

Cutthroat Trout Population Monitoring Programs

Since the discovery of lake trout in Yellowstone Lake in 1994, park biologists have been developing and refining control techniques for lake trout removal and for assessing potential impacts to native Yellowstone cutthroat trout. The cutthroat trout population is monitored using four methods including fish traps, spawning stream surveys, largemesh gillnetting, and hydroacoustic technology.

Fish Trap Surveys

 Information on the numbers of upstream and downstream migrants, and the size and age class of the cutthroat trout spawning migration are collected annually from weirs with fish traps erected each spring at the mouths of Clear Creek, Arnica Creek, and Bridge Creek, three tributaries to Yellowstone Lake (Koel 2001). The fish traps are generally installed during the month of May, the exact date depending on winter snow accumulation, weather conditions and spring snow melt. Fish passage, enumeration, and sampling occur through dip-netting trout that enter the upstream and downstream trap boxes and/or visually counting trout as they swim through wooden chutes attached to the traps. An electronic fish counter is also periodically used. Other data collected include weights, lengths, sex and ages (based on collected scales) of captured fish. Daily instream flows and water temperatures are also collected. Continued operation of the Clear Creek, Arnica Creek, and Bridge Creek fish traps may be used for long term monitoring of the potential impacts of lake trout on the Yellowstone Lake cutthroat trout population.

Spawning Stream Surveys

Beginning 1 May each year, 8 frontcountry streams (Lodge Cr., Hotel Cr., Hatchery Cr., Incinerator Cr., Wells Cr., Bridge Cr., Weasel Cr., and Sand Point Cr.) within or near the Lake Village developed area, and 5 frontcountry streams (Sandy Cr., Sewer Cr. Little Thumb Cr., Arnica Cr., and 1167 Cr.) within or near the Grant Village development are checked daily to detect the presence of adult cutthroat trout (Andrascik 1992, Olliff 1992). Once adult trout are found (i.e., onset of spawning), weekly surveys of cutthroat trout on these streams are conducted.

In each stream on each sample day, two people walk upstream from the stream mouth and record the number of adult trout observed. Sampling continues one day per week until most adult trout return to the lake (i.e., end of spawning). Counts are used to estimate the peak periods, relative magnitude and duration of spawning runs (Reinhart 1990). While making fish counts, observers record bear sign (e.g., bear sightings, fish parts, hair, scats, and tracks). Track measurements are used to estimate the number, species, and association of family groups of bears frequenting spawning streams.

Largemesh Gillnetting Surveys

A largemesh gillnetting program is also used to monitor the population structure of cutthroat trout in Yellowstone Lake. At each of 11 sampling sites around Yellowstone Lake, 5 38.1 x 1.8 m monofilament gillnets spaced 100m apart, are set overnight in 2 - 6 m of water (Koel 2001). Length, weight, sex, stage of maturity, and scales for aging are collected for each captured fish. Continuation of this gillnetting operation may be used for long term monitoring of the potential impacts of lake trout on the Yellowstone Lake cutthroat trout population.

Hydroacoustic Surveys

Cutthroat trout density data will be gathered lakewide on Yellowstone Lake using hydroacoustic survey techniques (Koel 2001). One survey requires approximately 4 field days for a 2-person crew. Data analysis would require an additional 4 to 10 days of a trained biologists time for each survey. Approximately three surveys will be conducted annually.

Whitebark Pine Surveys

Twenty-one whitebark pine transects are currently visited annually. Each transect contains 10 marked trees. Cones are counted on each marked tree between July 15 and August 15 depending on annual phenology. The objective is to count cones after maturation, but before cones and seeds have been collected by red squirrels (*Tamiasciurus hudsonicus*) and Clark's nutcrackers (*Nucifraga columbiana*). Data is recorded on standard field forms and sent to the IGBST. The

IGBST maintains the official ecosystem database. The presence or absence of blister rust and beetle infestations as well as grizzly bear, black bear, red squirrel, and Clark's nutcracker activity are noted for each transect.

Army Cutworm Moths

IGBST Monitoring Program. The IGBST and Wyoming Game and Fish Department currently monitor bear use of moth aggregation sites during radio tracking and annual grizzly bear observation flights. When army cutworm moths are present on the high elevation talus slopes, concentrations of grizzly bears are observed at the moth aggregation sites during these flights. The presence of bears at the aggregation sites is used as an indirect measure of the presence or absence of moths during a given year. This monitoring program does not provide direct information on the relative abundance of moths.

State of Montana Monitoring Program. Army cutworm moth larvae are agricultural pests which eat a wide range of host plants including small grains, alfalfa and sugar beets (Blodgett 1997). Moth outbreaks occur sporadically, when insect population potential is high and environmental factors are favorable to the insects' survival (Blodgett 1997). Because army cutworm moths are an agricultural pest, the State of Montana has a cutworm moth monitoring and forecasting program. The forecasting method employed by county extension agents entails trapping for army cutworm moths in agricultural areas between August and October. Extension agents set two army cutworm pheromone traps per county (G. Johnson, Montana State University, pers. commun.). Trap sites are located in agricultural areas often where soil has been tilled to seed winter wheat in the fall as moth larvae prefer such soft soils (G. Johnson, MSU, pers. commun.). Extension faculty find the amount of fall moth activity can be indicative of moth egg lay (Blodgett 1997). When trap catches exceed 800 moths during the August through October trapping period, extension agents forecast potentially damaging larvae populations may appear the following spring (G. Johnson, MSU, pers. commun.).

Many factors can affect moth larval development. Abundant precipitation from May through July is harmful for the worms and can reduce local cutworm populations (Blodgett, MSU, pers.

commun.). Army cutworm moth outbreaks have been noted in warm and dry years when rainfall from 1 May through 31 July was less than 4 inches (Blodgett 1997). If serious cutworm problems are suspected, agents see crop damage by the first of April. Fewer adult moths are trapped after warm and dry weather patterns with mild winters when there is a lack of early spring snow cover to insulate and protect larvae from freezing (G. Johnson, MSU, pers. commun.). Dry weather in the fall also contributes to the mortality of moth eggs and larvae (G. Johnson, MSU, pers. commun.). Pesticides also affect larval recruitment. Warrior, a synthetic pyrethroid, is an EPA registered army cutworm moth pesticide for use on wheat crops. Currently, pesticide companies are in the process of registering this pesticide for use on barley crops as well (G. Johnson, MSU, pers. commun.).

Since 1992, a statewide army cutworm moth pheromone trapping program has been conducted in Montana. Twenty counties in Montana participated in the program in 1997 (Blodgett 19970). In fall 1998, MSU extension agents plan to coordinate with extension agents at universities in Wyoming, Colorado and Nebraska to expand the moth trapping program to include county trapping efforts in their respective States. In addition to trapping for moths, extension agents plan to gather daily weather and temperature data to improve their forecasting technique (G. Johnson, MSU, pers. commun.). The IGBST, WGF, and YNP are currently evaluating methods for incorporating State army cutworm moth monitoring programs into existing grizzly bear foods monitoring programs.

Literature Cited

Blodgett, S. 1997. Pheromone traps help forecast cutworm moth activity. Montana Crop Health Report (WWW version) 10:7–9.

Andrascik, R. 1992. Lake area-Bridge Bay spawning survey. Pages 29–35 *in* R. Andrascik, D.G. Carty, R.D. Jones, L.R. Keading, B.M. Kelly, D.L. Mahoney, and T. Olliff. Annual project report for 1991, Fishery and Aquatic Management Program, Yellowstone National Park. U.S. Fish and Wildlife Service, Fisheries Assistance Office, Yellowstone National Park, Wyoming, USA.

Koel, T.M. 2001. Yellowstone Center for Resources, Fisheries and Aquatic Sciences Section Work plan FY2002. Yellowstone Center for Resources, Fisheries and Aquatic Sciences Section, Yellowstone National Park, WY, USA.

Olliff, S.T. 1992. Grant Village spawning survey. Pages 36–43 *in* R. Andrascik, D.G. Carty, R.D. Jones, L.R. Keading, B.M. Kelly, D.L. Mahoney, and S.T. Olliff. Annual project report for 1991, Fishery and Aquatic Management Program, Yellowstone National Park. U.S. Fish and Wildlife Service, Fisheries Assistance Office, Yellowstone National Park, Wyoming, USA.

Reinhart, D.P. 1990. Grizzly bear habitat use on cutthroat trout spawning streams in tributaries of Yellowstone Lake. Masters Thesis, Montana State University, Bozeman, Montana, USA.

Appendix E. Habitat Standards and Monitoring Protocol

Introduction

The 1998 baseline reflects the best available habitat measures representing ground conditions inside the Primary Conservation Area (PCA) as of 1998. Habitat standards identified in the Conservation Strategy pertain to secure habitat, developed sites, and livestock grazing allotments. The standards demand that all three of these habitat parameters are to be maintained at or improved upon conditions that existed in 1998. The 1998 baseline represents the best estimate of what was known to be on the ground at the time and establishes a benchmark against which future improvements and/or impacts can be assessed. It also provides a clear standard for agency managers to follow when considering project effect analysis. This appendix documents estimates for baseline values so that current and future habitat conditions throughout the PCA can be evaluated for compliance with habitat standards as formalized in the Conservation Strategy. In theory, the 1998 baseline should be a static measurement bound to a single point in time. In reality, this baseline continues to evolve as more reliable information is acquired; errors in the baseline are identified and corrected; and as new geoprocessing tools are developed to more accurately model secure habitat and estimate road densities. Since the release of the 2007 Conservation Strategy, new information has become available and some errors in the 1998 baseline have been identified. Consequently, baseline values have been adjusted where necessary to more accurately reflect 1998 ground conditions. The 1998 baseline database will continue to be improved upon when and if legitimate errors are identified. Features found to be erroneously excluded from the 1998 baseline will be reviewed as to their actual status in 1998. If reliable information is made available to substantiate the existence of these features in 1998 then corrections to the baseline will be made. All corrections made to the baseline will be documented, tracked, and reported in the Interagency Grizzly Bear Study Team (IGBST) annual reports. Baseline values presented in this appendix represent the best available information at this time and will serve as a basis for monitoring and evaluating improvements in habitat conditions and identifying any need for mitigation measures in the future.

Secure Habitat and Motorized Access Route Density

Maintaining or improving secure habitat at or above 1998 levels inside the PCA is a required habitat standard. To monitor compliance with this standard, secure habitat is annually measured and compared against 1998 levels for each bear management subunit. There are no mandatory standards for motorized route density, however, monitoring protocol requires that open motorized access route density (OMARD) and total motorized access route density (TMARD) inside the PCA be measured, monitored, and compared against 1998 levels annually.

Secure habitat is any contiguous area greater than 10 acres in size and more than 500 meters (m) from an open or gated motorized route. OMARD measures the density of all motorized routes (roads and trails) that are open to the public for one or more days during the non-dennning portion of the year when grizzly bears are active (March 1 – November 30). TMARD measures the density of motorized routes open to the public and/or administrative personnel for one or more days during the non-denning season. Hence, routes that are gated to the public year-round and accessible only to administrative staff contribute to TMARD but do not count toward OMARD. OMARD is reported at levels > 1.6 kilometer (km) per square kilometer (sq km) (> 1 mile (mi) per square mile (sq mi)) while TMARD is reported at levels > 3.2 km per sq km (> 2 mi per sq mi. State, county, and private roads occurring on federal lands are included in these calculations; however, roads occurring on private inholdings reflect 1998 conditions and are not updated in the motorized access database through time.

Calculations for percentage of secure habitat, OMARD, and TMARD are generated using the Motorized Access Model, a suite of customized geoprocessing tools compatible with ArcGIS software. Algorithms built into the model generate a 500 meter buffer around all relevant motorized features. Areas larger than 10 acres in size that fall outside this buffer are designated secure habitat. Methods for measuring route density have greatly improved with advancements in geoprocessing tools since earlier versions of the Conservation Strategy were released. Starting in 2009 a more accurate method for measuring line density was implemented into the ArcGIS software, which led to improved estimates for the 1998 baseline values of motorized route density. The new baseline measurements provide a more accurate and realistic estimate of road densities and do not reflect changes in the configuration of 1998 motorized routes. Instead, only

the method from which road density is calculated has changed. Route density values are stored in a 30 m raster format and cell values correspond to densities within a 1.6 sq km (1 sq mi) moving window. In previous methods, the total length of motorized routes within the moving window was based on a simple absence or presence of motorized routes within a given cell. Cells containing one or more route segments were summed and then multiplied by 30 m (length of single cell) to get the total length of motorized routes within the moving window. This method tended to under-estimate route density in some cases, and over-estimate in others. The current algorithm instead accounts for all route segments within a cell and accurately measures the total length of routes intersecting the 1.6 sq km (1 sq mi) moving window based on actual line geometry (Figure 1).
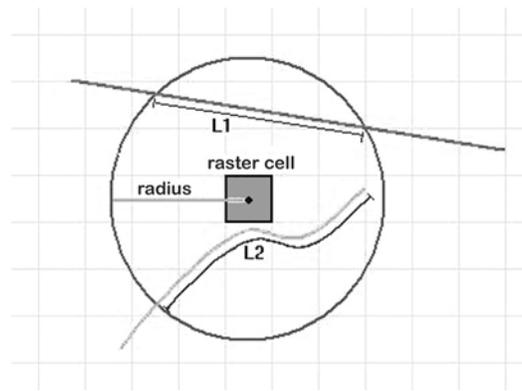
Figure 1 Measurement of route density based on total length of routes within 1.6 sq km (1 sq mi) moving window.

The most current values for 1998 baseline levels of secure habitat, OMARD, and TMARD are presented in Table 1. These values, which are based on the best methods available, supersede those presented in the 2007 Conservation Strategy and comprise the benchmark against which all future change is to be measured.

Exceptions to the 1998 Baseline for Secure Habitat

Three subunits, Gallatin #3, Henrys Lake #2, and Madison #2, were targeted in previous versions of the Conservation Strategy as needing improvement in secure habitat with respect to 1998 levels. The specific areas with potential for improvement identified in these three subunits fall

within the Gallatin National Forest boundary and hence, the quantity and timing of improvements was to be determined by the Gallatin National Forest Travel Management Plan (TMP). A primary factor contributing to impoverished secure habitat levels in these three subunits was motorized access on private land inholdings. Since 1998, the Gallatin National Forest conducted several land exchanges under the *Gallatin Range Consolidation and Protection Act* in areas inside and outside the PCA. These land exchanges resulted in the acquisition of formerly private parcels which are now administered as part of the Gallatin National Forest. With implementation of the 2006 Gallatin TMP, many roads inherited from these exchanges have been permanently decommissioned. Non-system routes that are not maintained by the Forest Service have subsequently been closed, with a high priority given to road decommissions in the three subunits identified as in need of improvement. With full implementation of the Gallatin TMP very near completion, measurable increases in secure habitat with respect to 1998 baseline levels have been realized in the three targeted subunits. Consequently, the Gallatin National Forest has proposed via a Travel Plan Amendment that the improved levels of secure habitat resulting from full implementation of the TMP constitute new baseline levels for these 3 subunits. This amendment effectively raises the bar for baseline conditions in the 3 identified subunits. These enhanced levels of secure habitat for the 3 targeted subunits will constitute new measures against which future change will be made (Table 1).

Protocol for measuring Open Motorized Road Density (OMARD)

Previous to this version of the Conservation Strategy, OMARD was measured for two distinct non-denning grizzly bear seasons; Season 1 (March 1 – July 15) and Season 2 (July 16 – November 30). However, the timing of seasonal route closures on National Forest lands throughout the ecosystem does not typically correspond with grizzly bear seasons. Technically, if a motorized route is open to the public for even one day in a given season, the road contributes to that seasonal measurement of OMARD. For most motorized routes on Forest land, the period open to public motorized use overlaps some portion of both seasons, and hence, there is very little measurable difference between seasonal route densities. For this reason, seasonal differences in OMARD are no longer tracked and reported. Instead, a single measurement of

OMARD for the entire non-denning season of the year (March 1 – November 30) is to be measured, monitored, and reported annually per bear management subunit.

Cumulative Effects Model

With previous versions of the Conservation Strategy, the Cumulative Effects Model (CEM) was the requisite tool for estimating effectiveness and quality of habitat when evaluating project impacts. With this version of the Conservation Strategy the CEM will no longer serve as the requisite tool for evaluating impacts of competing project scenarios. Instead, the current tool for conducting project impact analyses is the Motorized Access Model which was established concurrent with the CEM.

The CEM was a computerized model designed in stages during the 1980s and 1990s as a tool for evaluating relative change in grizzly bear habitat quality due to human activities. The model led to construction of useful spatial data layers reflecting various habitat components and delineating management boundaries relevant for monitoring secure habitat. Some of these layers were subsequently incorporated into the Motorized Access Model. The CEM was considered the best available science at the time; however, the utility of the CEM has since been questioned and is no longer the endorsed protocol for reporting habitat metrics. The rationale for this change in protocol is many-fold, least not is the inability to verify or ground truth in a statistically defendable manner the validity of numerous numerical coefficients residing at the core of the model (Boyce *et al*. 2001, Borkowski 2006). Furthermore, the process for developing vegetation coefficients described by Mattson *et al*. (2004) proves to be highly technical and complex, making it difficult to interpret and implement. Therefore, updating the vast array of coefficients with any reasonable degree of reliability poses a daunting challenge as the grizzly bear population expands, broad landscape changes occur, or new information becomes available. In addition, many of the CEM geospatial datasets are approaching three decades in age and there is no operative mechanism in place to systematically update all existing data layers to reflect current conditions. Collectively, neither the vegetation spatial data nor the multitude of coefficients have proven accurate enough for site-specific project analyses, as past modeling efforts have shown (Dixon 1997). Finally, the format of GIS datasets designed to interface with the CEM are now obsolete and the program code would need to be completely re-vamped to

accommodate current geospatial data formats. This is especially problematic since few members of the CEM technical modeling team remain employed in the GYE and there is no technical documentation of the underlying source code for the CEM algorithms (Dixon 1997). In short, the CEM is a high maintenance operation that is difficult to execute and interpret. The Motorized Access Model will instead continue to be used to calculate and monitor secure habitat and motorized route density inside and outside the PCA.

Developed Sites on Public Lands

Developed sites include all sites on public land developed or improved for human use or resource development. Examples of developed sites include, but are not limited to, campgrounds, trailheads, lodges, administrative sites, service stations, summer homes, restaurants, visitor's centers, and permitted resource development sites such as oil and gas exploratory wells, production wells, plans of operation for minerals activities, work camps, etc. Developed sites on public lands inside the PCA are currently inventoried and tracked in existing GIS databases. Table 2 displays the number of developed sites for each administrative unit by bear management unit (BMU) subunit as of 1998.

Activities based in statutory rights, such as oil and gas leases and mining plans of operation under the *1872 General Mining Law* are also tracked as part of the developed site monitoring effort. Mining claims and or oil and gas leases do not in and of themselves constitute a site development, but have the potential to be developed sometime in the future. It is important to note that one mining claim does not necessarily mean a potential for one operating plan. In 1998, approximately 1,354 mining claims associated with 28 plans of operation had been filed throughout nine BMU subunits; however, no oil and gas leases existed inside the PCA. Claims are often staked around known mineral deposits to protect the original claim and a single operating plan can sometimes encompass hundreds of claims. Furthermore, a number of filed claims, upon detailed exploration, do not have enough mineralization to be economically developed and consequently are never acted upon. Approved operating plans associated with mining claims or claim groups are included as a separate category in the developed site baseline

(Table 2). A detailed itemized list of all developed sites (names and types) compromising the 1998 baseline is documented in Table 3.

Livestock Grazing

The livestock allotment standard established in the Conservation Strategy requires that there be no net increase in the number or acreage of active commercial livestock grazing allotments or in permitted sheep animal months (AMs) inside the PCA from that which existed in 1998. Existing sheep allotments will be monitored, evaluated, and phased out as the opportunity arises with willing permittees. Sheep animal months (AMs) are calculated by multiplying the permitted number of sheep times the months of permitted use.

In 1998 there were 101 active or vacant commercial livestock grazing allotments and 23,900 permitted sheep animal months (AMs) inside the PCA (Table 4). Of these, 83 were cattle and/or horse allotments and the remaining 18 were for sheep. Operational status of allotments is categorized as active, vacant, or closed. An active allotment is one with a current grazing permit, although a "no-use" permit can be granted on a year-by-year basis when a permittee chooses not to graze livestock. Vacant allotments are those without an active permit but may be used periodically by other permittees at the discretion of the land management agency to resolve resource issues or other concerns. Reissuance of permits for vacant cattle allotments may result in an increase in the number of permitted cattle but the number and acreage of active allotments inside the PCA must remain at or below 1998 baseline levels. Combining or dividing existing allotments is allowed as long as net acreage in active allotments does not increase above 1998 levels. Any such use of vacant cattle allotments resulting in an increase in cattle numbers will only be allowed after an analysis to evaluate impacts on grizzly bears. Where chronic conflicts occur on cattle allotments inside the PCA, and an opportunity exists with a willing permittee, one alternative for resolving the conflict may be to phase out cattle grazing or to move the cattle to a currently vacant allotment where there is less likelihood of conflict.

Table 1. 1998 Baseline values (and exceptions) for percentage of open motorized access route density (OMARD), total motorized access route density (TMARD), and secure habitat for all 40 bear management unit (BMU) subunits in the Primary Conservation Area.

BMU subunit name	1998 % OMARD (> 1 mi / mi^2)	1998 % TMARD (> 2 mi / mi^2)	% 1998 Secure Habitat	Subunit area (mi^2) (excluding lakes)
Bechler/Teton	17.0	5.8	78.1	534.3
Boulder/Slough #1	3.2	0.3	96.6	281.9
Boulder/Slough #2	2.1	0.0	97.7	232.4
Buffalo/Spread Creek #1	11.5	5.3	88.3	219.9
Buffalo/Spread Creek #2	15.6	12.7	74.3	507.6
Crandall/Sunlight #1	19.3	7.2	81.1	129.8
Crandall/Sunlight #2	16.6	11.7	82.3	316.2
Crandall/Sunlight #3	19.2	10.6	80.4	221.8
Firehole/Hayden #1	10.4	1.7	88.3	339.2
Firehole/Hayden #2	9.0	1.5	88.4	172.2
Gallatin #1	3.6	0.5	96.3	127.7
Gallatin #2	9.5	4.5	90.2	155.2
Gallatin #3*	46.0*	22.9*	55.3*	217.6
Hellroaring/Bear #1	23.1	15.8	77.0	184.7
Hellroaring/Bear #2	0.1	0.0	99.5	228.9
Henry's Lake #1	49.0	31.2	45.4	191.2
Henry's Lake #2*	49.9*	35.2*	45.7*	140.2
Hilgard #1	29.0	15.3	69.8	201.2
Hilgard #2	21.0	13.6	71.4	140.5
Lamar #1	9.9	3.8	89.4	299.9
Lamar #2	0.0	0.0	100.0	180.8
Madison #1	29.5	12.5	71.5	227.9
Madison #2*	33.7*	24.0*	66.5*	149.4
Pelican/Clear #1	2.0	0.5	97.8	108.4
Pelican/Clear #2	5.4	0.4	94.1	251.6
Plateau #1	22.2	12.9	68.8	286.3
Plateau #2	8.5	3.5	88.7	419.9
Shoshone #1	1.5	1.1	98.5	122.2
Shoshone #2	1.3	0.7	98.8	132.4
Shoshone #3	3.9	2.1	97.0	140.7
Shoshone #4	5.3	2.9	94.9	188.8
South Absaroka #1	0.6	0.1	99.2	163.2
South Absaroka #2	0.0	0.0	99.9	190.6
South Absaroka #3	2.4	2.7	96.8	348.3
Thorofare #1	0.0	0.0	100.0	273.4
Thorofare #2	0.0	0.0	100.0	180.1
Two Ocean/Lake #1	3.5	0.3	96.3	371.9

BMU subunit name	1998 % OMARD (> 1 mi / mi^2)	1998 % TMARD (> 2 mi / mi^2)	% 1998 Secure Habitat	Subunit area (mi^2) (excluding lakes)
Two Ocean/Lake #2	0.0	0.0	100.0	124.9
Washburn #1	16.1	4.2	83.0	178.3
Washburn #2	7.4	1.1	92.0	144.1
Mean for PCA/Total sq. miles	**12.7**	**6.7**	**85.6**	**9025.4**

* *Baseline values for the three subunits identified as in need of improvement (Gallatin #3, Henrys Lake #2, and Madison #2) will no longer be based on 1998 levels, but rather on improved levels based on full implementation of 2006 Travel Management Plan. See appended table below.*

Exceptions to 1998 Baseline (baseline values based on 2006 Gallatin National Forest Travel Management Plan levels)				
BMU subunit name	% OMARD (> 1 mi / mi^2)	% TMARD (> 2 mi / mi^2)	% Secure Habitat	Subunit area (mi^2) (excluding lakes)
Gallatin #3	28.6	12.7	70.7	217.6
Henrys Lake #2	41.5	30.6	51.7	140.2
Madison #2	32.0	21.6	67.5	149.4

Table 2. The 1998 baseline for numbers of developed sites on public lands in each bear management subunit in the GYE[1].

Subunit	Administrative units[2]	Summer home complexes[3]	Developed campgrounds[4]	Trailheads	Major developed sites and lodges	Administrative or maintenance	Other[5]	Plans of operation[5]	Total sites per subunit
Bechler/Teton	CTNF YNP GTNP	0 0 0	1 0 8	5 2 3	2 0 1	4 2 4	16 2 10	0 0 0	60
Boulder/Slough #1	CGNF	0	1	7	0	1	3	8	20
Boulder/Slough #2	CGNF YNP	0 0	0 1	0 3	0 0	2 2	0 0	0 1	9
Buffalo/Spread Creek #1	B-TNF GTNP	0 0	1 0	1 7	0 2	0 2	2 3	0 0	18
Buffalo/Spread Creek #2	BTNF	1	4	3	3	5	5	1	22
Crandall/Sunlight #1	SNF CGNF	0 0	2 2	5 2	1 0	1 0	5 5	0 0	23
Crandall/Sunlight #2	SNF CGNF	0 0	5 0	4 0	1 0	2 0	5 0	1 0	18
Crandall/Sunlight #3	SNF WG&F	0 0	2 2	3 0	0 0	1 1	2 0	0 0	11
Firehole/Hayden #1	YNP	0	1	5	1	6	13	0	26
Firehole/Hayden #2	YNP	0	1	3	1	2	8	0	15
Gallatin #1	YNP	0	0	3	0	1	0	0	4
Gallatin #2	YNP	0	2	5	1	12	1	0	21
Gallatin #3	CGNF YNP	0 0	2 0	9 0	0 0	0 0	6 0	0 0	17
Hellroaring/Bear #1	CGNF YNP	0 0	5 0	11 1	0 0	3 0	7 1	8 0	36
Hellroaring/Bear #2	CGNF YNP	0 0	0 0	1 0	0 0	1 2	0 0	0 0	4
Henrys Lake #1	CTNF	2	3	1	0	3	10	1	20
Henrys Lake #2	CTNF CGNF	0 5	0 3	1 4	0 0	1 0	1 2	1 0	18
Hilgard #1	BDNF CGNF	0 0	0 0	0 6	0 1	3 2	0 2	0 0	14

Subunit	Administrative units[2]	Summer home complexes[3]	Developed campgrounds[4]	Trailheads	Major developed sites and lodges	Administrative or maintenance	Other[5]	Plans of operation[5]	Total sites per subunit
Hilgard #2	CGNF YNP	0 0	0 0	4 3	0 0	1 0	1 0	0 0	9
Lamar #1	YNP CGNF SNF	0 0 0	1 2 0	5 7 0	0 0 0	3 6 0	2 3 0	0 8 0	37
Lamar #2	YNP	0	0	0	0	4	0	0	4
Madison #1	CGNF YNP	0 0	1 0	11 0	0 0	1 0	8 0	0 0	21
Madison #2	CGNF YNP	8 0	2 0	1 1	1 0	4 2	5 1	0 0	25
Pelican/Clear #1	YNP	0	0	2	0	0	0	0	2
Pelican/Clear #2	YNP	0	1	4	1	4	3	0	13
Plateau #1	CTNF CGNF YNP	1 0 0	0 0 0	0 0 0	0 0 0	0 0 1	1 0 0	0 0 0	3
Plateau #2	CTNF YNP	0 0	0 0	1 0	0 0	1 4	1 0	0 0	7
Shoshone #1	SNF	1	2	0	0	0	6	0	9
Shoshone #2	SNF	0	0	1	1	0	0	0	2
Shoshone #3	SNF	2	0	1	1	0	0	0	4
Shoshone #4	SNF	3	3	3	6	0	8	0	23
South Absaroka #1	SNF	0	0	0	0	0	0	0	0
South Absaroka #2	SNF	0	0	0	0	2	0	0	2
South Absaroka #3	SNF	1	3	4	1	1	5	0	15
Thorofare #1	BTNF YNP	0 0	0 0	0 0	0 0	0 4	0 0	0 0	4
Thorofare #2	BTNF YNP	0 0	0 0	0 0	0 0	2 0	0 0	0 0	2
Two Ocean/Lake #1	YNP B-TNF GTNF	0 0 0	2 1 0	3 0 1	1 0 0	3 0 0	2 0 1	0 0 0	14

Subunit	Administrative units[2]	Summer home complexes[3]	Developed campgrounds[4]	Trailheads	Major developed sites and lodges	Administrative or maintenance	Other[5]	Plans of operation[5]	Total sites per subunit
Two Ocean/Lake #2	YNP BTNF	0 0	0 0	0 0	0 0	2 1	0 1	0 0	4
Washburn #1	YNP	0	2	8	2	7	6	0	25
Washburn #2	YNP	0	1	6	0	1	4	0	12
Primary Conservation Area	**All**	**24**	**67**	**161**	**28**	**117**	**168**	**28**	**593**

[1]Note, figures in this table represent the most current information available on the number of developed sites for each administrative unit as of 1998. This table replaces Figure125 in Appendix A of the USDA Forest Service, Forest Plan Amendment for Grizzly Bear Habitat Conservation for The Greater Yellowstone Area National Forests, Final Environmental Impact Statement (USDA Forest Service 2006) and Table 4 in Appendix F of the 2007 Final Conservation Strategy for the Grizzly Bear in the Greater Yellowstone Area (U.S. Fish and Wildlife Service 2007).

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

[3]Single permitted recreation residences are classified as other developed sites in this table.

[4] Campgrounds with trailheads are sometimes combined and treated as single developed sites.

[5] Includes developed recreation sites, as well as community infrastructure sites, dams, and other miscellaneous facilities.

[6]Includes mining claims with plans of operation. Currently, not all sites have active projects.

Table 3. Developed sites (type and name) comprising the 1998 baseline per Bear Management Subunit inside the PCA.

Bear Management subunit	Admin Unit	Name and type of developed sites
Bechler/Teton #1	CTNF	**Developed Campgrounds:** Cave Falls. **Trailheads:** Coyote Meadows, Hominy Peak, S. Boone Creek, Fish Lake, Cascade Creek. **Major Developed Sites:** Loll Scout Camp, Idaho Youth Services Camp. **Administrative or Maintenance Sites:** Squirrel Meadows Guard Station/Cabin, Porcupine Guard Station, Badger Creek Seismograph Site, Squirrel Meadows GS/WY Game & Fish Cabin. **Other Developed Sites:** Grassy Lake Dam, Tillery Lake Dam, Indian Lake Dam, Bergman Res. Dam, Loon Lake Disperse sites, Horseshoe Lake Disperse sites, Porcupine Creek Disperse sites, Gravel Pit/Target Range, Boone Creek Disperse Sites, Tillery Lake O&G Camp, Calf Creek O&G Camp, Bergman O&G Camp, Granite Creek Cow Camp, Poacher's TH, Indian Meadows TH, McRenolds Res. TH/Wildlife Viewing Area/Dam.
	YNP	**Trailheads**: 9K1 and Cave Falls. **Administrative or Maintenance Sites:** South Entrance, Bechler Ranger Stations. **Other Developed Sites:** Union Falls, Snake River picnic areas.
	GTNP	**Developed Campgrounds:** Grassy Lake Road campsites (8 individual car camping sites). **Trailheads**: Glade Creek, Lower Berry Creek, Flagg Canyon. **Major Developed Sites:** Flagg Ranch (lodge, cabins and campground including remote cistern and sewage treatment plant sites). **Administrative or Maintenance Sites:** Flagg Ranch Ranger Station, employee housing, maintenance yard, Snake River pit road construction staging area. **Other Developed Sites:** 3 Backcountry cabins (Upper Berry, Lower Berry, and Moose Basin), 5 Backcountry campsites {Berry Designated Horse Camp, 4 Jackson Lake designated campsites (1 group and 3 individual)}, 2 boat launches (Flagg Ranch and Yellowstone South Entrance).
Boulder/Slough #1	CGNF	**Developed Campgrounds:** Hicks Park. **Trailheads**: Goose Lake/Grasshopper Glacier, Upsidedown Creek, Independence, Sheep Creek, Copper Creek, Bridge Creek, Box Canyon. **Administrative or Maintenance Sites:** Box Canyon. **Other Developed Sites**: 2 recreation residences (Rasnick and Mandeville), Independence Mine Site (no plan of operations). **Plans of Operation:** Carolyn, Cray, East Iron Mtn Beartooth Plateau 1, East Iron Mtn Beartooth Plateau 2, Iron Mountain Idaho Construction Metal, Crescent Creek Pan Palladium, Crescent Creek Chromium Corp America, Crescent Creek Beartooth Platinum.
Boulder/Slough #2	CGNF	**Administrative or Maintenance Sites:** Slough Creek, Buffalo Fork Cabins.
	YNP	**Developed Campgrounds:** Slough Creek. **Trailheads:** Specimen ridge, Slough Creek, Lamar Ford. **Administrative or Maintenance Sites:** Elk Tongue, Lower Slough patrol cabins. **Other Developed Sites:** Yellowstone River picnic area.
Buffalo/Spread Creek #1	BTNF	**Developed Campgrounds:** Pacific Creek CG/TH**. Trailheads:** Colter Dump. **Other Developed Sites:** Teton Horseback Adventures, Shoal Creek Outfitters Base Camp.
	GTNP	**Trailheads:** Grand View Point, Two Ocean Lake, Christian Pond, Arizona Creek #1, Pilgrim Creek, Arizona Lake, Arizona Creek #2. **Major Developed Sites:** Moran Entrance Station housing, Jackson Lake housing. **Administrative or Maintenance Sites:** Moran Entrance Ranger Station**,** Jackson Lake Ranger Station. **Other Developed Sites:** Moran Post Office, Moran School, Colter Bay storage/staging area.

Bear Management subunit	Admin Unit	Name and type of developed sites
Buffalo/Spread Creek #2	BTNF	**Summer Home Complex**: Turpin Meadows. **Developed Campgrounds**: Box Creek CG/TH, Hatchet, Turpin Meadows, Angles CG/TH. Trailheads: Turpin Meadows, Lava Creek, Clear Creek. Major Developed Sites: Heart Six Ranch, Turpin Meadows Ranch, Togwotee Lodge. **Administrative or Maintenance Sites:** Buffalo Ranger District Office, Buffalo Ranger District Compound (Includes a gravel pit), Enos Lake Patrol Cabin, Nowlin Meadows Patrol Cabin, Hatchet administrative site. **Other Developed Sites:** UW Forestry Walk VIS, Four Mile Picnic Area, Lost Lake Info Station, Togwotee Overlook, Historic ranger station. **Plans of Operation:** 1 gravel pit
Crandall/Sunlight #1	SNF	**Developed Campgrounds:** Beartooth, Island Lake. **Trailheads:** Beartooth Lake, Island Lake, Clay Butte, Muddy Creek, Morrison Jeep. **Major Developed Sites:** Top of the World Store complex. **Administrative or Maintenance Sites:** YNP highway maintenance site (includes 2 summer residences). **Other Developed Sites:** Island Lake Boat Ramp, Beartooth Lake Boat Ramp, Clay Butte Lookout, Pilot/Index Overlook, Beartooth Lake Picnic Area.
	CGNF	**Developed Campgrounds:** Chief Joseph, Ovis Lake Road Camp. **Trailheads:** Broadwater, Clarks Fork Foot Trailhead. **Other Developed Sites:** Arbor Day Watchable Wildlife site, Kersey Lake rental cabin and boat dock, Round Lake rental cabin/warming hut, Clarks Fork fishing platform and interpretive exhibit, 1 recreation residence (summer home).
Crandall/Sunlight #2	SNF	**Developed Campgrounds:** Fox Creek, Lake Creek, Hunter Peak, Crazy Creek, Lily Lake Campsites. **Trailheads:** Pilot Creek, Clarks Fork, North Crandall, Crazy Creek. **Major Developed Sites:** K-Z Lodge. **Administrative or Maintenance Sites:** Crandall admin site (2 residences, office, shop and bunkhouse), Crandall Game and Fish Cabin. **Other Developed Sites:** Crandall waste transfer site, Clarks Fork Overlook, Lily Lake Boat ramp, Swamp Lake Boat Ramp, Reef Creek Picnic Area. **Plan of Operations**: Commercial sale gravel pit at Ghost Creek for Beartooth Hwy Construction.
	CGNF	**No Developed Sites.**
Crandall/Sunlight #3	SNF	**Developed Campgrounds:** Dead Indian, Little Sunlight. **Trailheads:** Little Sunlight trailhead and corrals, Dead Indian, Hoodoo Basin/Lamar. **Administrative or Maintenance Sites:** Sunlight Ranger Station. **Other Developed Sites:** Sunlight Picnic Area, Sunlight Bridge Overlook.
	WG&F	**Developed Campgrounds:** Sunlight Unit Campground #1, Sunlight Unit Campground #2. **Administrative or Maintenance Sites:** Sunlight Unit Complex.
Firehole/Hayden #1	YNP	**Developed Campgrounds:** Madison Junction. **Trailheads:** Nez Perce Cr, 7-Mile Bridge, Fountain freight road, Lone Star, OK5. **Major Developed Sites:** Old Faithful. **Administrative or Maintenance Sites:** Norris employee/gov't area, Norris hot mix plant, Madison employee/gov't site, Mesa Pit site, Mary Lake patrol cabin, Nez Perce patrol cabin. **Other Developed Sites:** Norris, Gibbon Meadows, Tuft Cliffs, Gibbon Falls, Madison, Buffalo Ford, Cascade, Firehole Canyon, Nez Perce, Feather Lake, Goose Lake, Excelsior picnic areas, Norris Geyser Basin Museum.
Firehole/Hayden #2	YNP	**Developed Campgrounds:** Bridge Bay. **Trailheads:** Divide, Beach Lake, DeLacy Creek. **Major Developed Sites:** Lake. **Administrative or Maintenance Sites:** Lake gov't area, Bridge Bay Marina. **Other Developed Sites:** Gull Point, Sand Point picnic areas with 6 additional lakeshore picnic areas.
Gallatin #1	YNP	**Trailheads:** WK2, WK3, and WK6. **Administrative or Maintenance Sites:** Daly Creek patrol cabin.

Bear Management subunit	Admin Unit	Name and type of developed sites
Gallatin #2	YNP	**Developed Campgrounds:** Mammoth, Indian Creek. **Trailheads:** Rescue Creek, Lava Creek, Golden Gate, Bunsen Peak, Fawn Pass. **Major Developed Sites:** Mammoth. **Administrative or Maintenance Sites:** Stephens Creek area, Gardiner gravel crusher/asphalt site, Xanterra headquarters site in Gardiner, Lower Mammoth employee housing area, YCC employee housing area, Indian Creek pit site, Deaf Jim patrol cabin, North Entrance Ranger Station, Fawn Pass patrol cabin, Winter Creek patrol cabin, Bunsen Peak radio repeater site, Mt Holmes fire lookout. **Other Developed Sites:** Sheepeater picnic area.
Gallatin #3	CGNF	**Developed Campgrounds:** Tom Miner, Red Cliff. **Trailheads:** Buffalo Horn, Sphinx Creek, Elkhorn, Wilson Draw, Tom Miner, Tom Miner Horse Facilities, Sunlight, Twin Cabin, Tepee Creek. **Other Developed Sites:** Corwin Spring fishing and boat access, Yankee Jim fishing access and boat ramp, Elkhorn River Ford (horse access), Windy Pass rental cabin, Yankee Jim picnic area, Porcupine Creek recreation residence.
	YNP	**No Developed Sites.**
Hellroaring/Bear #1	CGNF	**Developed Campgrounds:** Eagle Creek campground, Eagle Creek horse facility, Bear Creek, Timber Camp, Canyon. **Trailheads:** Cedar Creek, LaDuke, Little Trail Creek, Pine Creek, Palmer Mt. (3 trailheads), North Fork of Bear Creek, Joe Brown, Bear Creek, Sixmile. **Administrative or Maintenance Sites:** OTO Ranch, Blanding Station house and barn (horse facility), Hayes/McPherson property. **Other Developed Sites:** LaDuke picnic area, LaDuke bighorn sheep watchable wildlife site, 1 recreation cabin, Lonesome Pond camping area, McConnell fishing and boat access, Watchable Wildlife-Big Game Winter Range, Watchable Wildlife Site-fish. **Plans of Operation:** Counts (1), Mineral Hill Mine (3), and (2), Independence (1), Livingston (1).
	YNP	**Trailheads:** Crevice. **Other Developed Sites:** Crevice Cabin.
Hellroaring/Bear #2	CGNF	**Trailheads:** West Fork Mill Creek. **Administrative or Maintenance Sites:** Hellroaring cabin and tack shed.
	YNP	**Administrative or Maintenance Sites:** Buffalo Plateau and Hellroaring patrol cabins.
Henrys Lake #1	CTNF	**Summer Home Complexes:** Big Springs SHA North, Big Springs SHA South. **Developed Campgrounds:** Big Springs, Flat Rock, Upper Coffee Pot. **Trailheads:** Howard Creek. **Administrative or Maintenance Sites:** Sawtelle Peak Electronics Site, Keg Springs Seismograph Site, Big Springs Fire Tower. **Other Developed Sites:** Big Springs Interpretive Trail, Big Springs Bridge Fish Viewing, Johnny Sack Cabin, Big Springs Boat Ramp, Big Springs Snow Park/Warming Hut, Macks Inn Water Treatment Plant, Macks Inn Substation, County/State Sheds Complex, FAA Maintenance Sheds, Cold Springs Substation. **Plans of Operation:** Willow Creek Mining Site.
Henrys Lake #2	CTNF	**Trailheads:** Targhee Creek. **Administrative or Maintenance Sites:** Defosses Cabin. **Other Developed Sites:** Howard Springs Family Picnic/Wayside Area. **Plans of Operation:** Turquoise Mountain Mine.
	CGNF	**Summer Home Complexes:** Clark Springs (8 lots), Rumbaugh Ridge (5), Romsett (9), Lonsomehurst A, Lonsomehurst B. **Developed Campgrounds:** Lonesomehurst, Cherry Creek, Spring Creek. **Trailheads:** Basin, Watkins Creek, Targhee Pass, West Denny Creek. **Other Developed Sites:** Basin rental cabin, Lonsomehurst boat ramp, Reas Pass day use site.
Hilgard #1	BDNF	**Administrative or Maintenance Sites:** McAtee Cabin, Indian Creek Cow Camp, Shedhorn Cow Camp.
	CGNF	**Trailheads:** Upper Buck Ridge, Cinnamon, Meadow Creek Cutoff, Cache Creek, Lower Buck Ridge, Taylor Falls/Lightning Creek. **Major Developed Sites:** Covered Wagon Ranch. **Administrative or Maintenance Sites:** Cinnamon Cabin, Cinnamon Mountain Lookout. **Other Developed Sites:** Yellow Mule Rental Cabin, Buck Creek Recreation Residence.

Bear Management subunit	Admin Unit	Name and type of developed sites
Hilgard #2	CGNF	**Trailheads:** Eldridge, Wapiti, Lower Wapiti/Albino Lake, Sage/Elkhorn. **Administrative or Maintenance Sites:** Eldridge Cabin. **Other Developed Sites:** Wapiti rental cabin.
	YNP	**Trailheads:** WK1, WK5, WK4.
Lamar #1	YNP	**Developed Campgrounds:** Pebble Creek. **Trailheads:** 3K1, 3K3, 3K4, Trout Lake, Lamar. **Administrative or Maintenance Sites:** Northeast Entrance Ranger Station and supporting gov't operation, Lamar Buffalo Ranch Ranger Station/Institute, Cache Creek patrol cabin. **Other Developed Sites:** Warm Creek picnic area, Buffalo Ranch/Lamar River picnic area.
	CGNF	**Developed Campgrounds:** Soda Butte, Colter. **Trailheads:** Republic Creek, Lower Lady of Lake with parking lot, Lady of Lake 1, Woody Pass, Daisy Pass, Lost Wolverine, Abundance Lake/upper Stillwater . **Administrative or Maintenance Sites:** Cooke City guard station and warehouse, 2nd Forest Service warehouse, Highway borrow pit, mine tailings repository, old mine buildings at Woody Pass trailhead, mine reclamation pond. **Other Developed Sites**: Cooke City dump (SUP), Beartooth Highway Interpretive site (near Silver Gate), Cooke City burn pile. **Plans of Operation**: 7 distinct New World Mine plans, Cray Placer.
	SNF	**No Developed Sites.**
Lamar #2	YNP	**Administrative or Maintenance Sites:** Calfee Creek, Upper Miller Creek, Cold Creek, and Lamar Mountain patrol cabins.
Madison #1	CGNF	**Campgrounds:** Cabin Creek. **Trailheads**: Potamogeton, West Fork Beaver Creek, Whit's Lake, Johnson Lake, Tepee Creek (Hebgen RD), Red Canyon, Kirkwood, Cub Creek, Fir Ridge, Hebgen Mountain, Cabin Creek. **Administrative or Maintenance Sites:** Building Destruction Site. **Other Developed Sites:** gravel pit, Tepee Creek snowmobile parking area, Watchable Wildlife Site at Beaver Creek, Beaver Creek rental cabin, Cabin Creek rental cabin, Hebgen Dam fishing access and admin site, Yellowstone Holiday picnic area, North Shore picnic area.
	YNP	**No Developed Sites.**
Madison #2	CGNF	**Summer Home Complexes:** California (2 lots), Lakeshore A (6), Lakeshore B (8), Lakeshore C (3), Lakeshore E (19), Baker's Hole (3), Railroad (3), Horse Butte (2). **Developed Campgrounds:** Rainbow Point, Baker's Hole (includes watchable wildlife site). **Trailheads:** Rendezvous Ski Trail (includes 2 cabins and a biathlon range). **Major Developed Sites:** Madison Arm Resort. **Administrative or Maintenance Sites:** West Yellowstone Ranger Station, WY Interagency Fire Center (Includes crew quarters IAFCC, fire control center and mixing site), Bison capture facility (SUP), Game Warden Residence. **Other Developed Sites:** Solid Waste Transfer Station (SUP), Madison picnic area/boat ramp, Rainbow Point picnic area/boat ramp, Horse Butte Lookout/Picnic Site, South Plateau shooting range.
	YNP	**Trailhead:** Cable Car. **Administrative or Maintenance Sites:** West Entrance Ranger Station/housing complex, Cougar Cr patrol cabin. **Other Developed Sites:** Madison River picnic area.
Pelican/Clear #1	YNP	**Trailheads:** Lower Falls, Sour Creek.
Pelican/Clear #2	YNP	**Developed Campgrounds:** Fishing Bridge RV Park. **Trailheads:** Pelican Valley, 9-mile, Clear Creek, Avalanche Peak. **Major Developed Sites:** Fishing Bridge store/gas station/employee housing/museum. **Administrative or Maintenance Sites:** East Gate Ranger Station/housing complex, Fern Lake patrol cabin, Pelican Cone patrol cabin, Pelican Springs patrol cabins. **Other Developed Sites:** Steamboat Point, Lake Butte, Sylvan Lake picnic areas.

Bear Management subunit	Admin Unit	Name and type of developed sites
Plateau #1	CTNF	**Summer Home Complexes:** Moose Creek SHA**. Other Developed Sites:** Lucky Dog Lodge/TNC/SUP
	CGNF	**No Developed Sites.**
	YNP	**Administrative or Maintenance Sites:** South Riverside patrol cabin.
Plateau #2	CTNF	**Developed Campgrounds:** None. **Trailheads:** Moose Creek/Trail Canyon. **Administrative or Maintenance Sites:** Warm River Springs GS/Cabin. **Other Developed Sites:** Snow Creek Pond Disperse sites.
	YNP	**Administrative or Maintenance Sites:** Cove, Outlet, Three Rivers, and Buffalo Lake patrol cabins.
Shoshone #1	SNF	**Summer Home Complexes:** Moss Creek (7 lots). **Developed Campgrounds:** Newton Creek and Rex Hale. **Other Developed Sites:** One summer home across from Newton Creek Campground (isolated lot E), Fire Memorial, Robbers Roost Cabin (Cow Camp), Newton Springs Picnic Area, Blackwater Pond Picnic/Fishing Area, Palisades Interpretive Site**.**
Shoshone #2	SNF	**Trailheads:** Blackwater. **Major Developed Sites:** Blackwater Lodge.
Shoshone #3	SNF	**Summer Home Complexes:** Eagle Creek (8 lots), Kitty Creek (14 lots). **Trailheads:** Kitty Creek**. Major Developed Sites:** Buffalo Bill Boy Scout Camp.
Shoshone #4	SNF	**Summer Home Complexes:** Grinnell Creek (2lots), Pahaska (2 lots), Mormon Creek (13 lots). **Developed Campgrounds:** Eagle Creek, Three Mile, Sleeping Giant. **Trailheads:** Fishhawk North, Eagle Creek, Pahaska. **Major Developed Sites:** Elephant Head Lodge, Absaroka Mountain Lodge, Shoshone Lodge, Cross Sabers Lodge, Goff Creek Lodge, Pahaska Tepee. **Other Developed Sites:** Sleeping Giant ski area, Wyoming Game and Fish cabin, Wayfarers Chapel, 1 summer home near Game and Fish cabin (50 Mile, isolated lot C), summer home lot A, summer home lot B (both lots are across from Eagle Creek summer home complex), West Gateway Interpretive Site, Cody Peak Interpretive Site.
South Absaroka #1	SNF	**No Developed Sites.**
South Absaroka #2	SNF	**Administrative or Maintenance Sites:** Venus Creek Cabin, Needle Creek Administrative site (includes 2 cabins).
South Absaroka #3	SNF	**Summer Home Complexes:** Pinnacles (20 lots). **Developed Campgrounds:** Brooks Lake, Pinnacles, dispersed campground near Brooks Lake Campground. **Trailheads:** Long Creek/Dunoir, Brooks Lake, Pinnacles Trailhead, Bonneville. **Major Developed Sites:** Brooks Lake Lodge. **Administrative or Maintenance Sites:** Wolf Creek. **Other Developed Sites:** Brooks Lake boat ramp, transfer corral/Bud Betts, Transfer Corral/Paul Gilroy, Transfer Corral/Bridger Teton Outfitter on Brooks Lake Creek, Winter Cabin/warming hut.
Thorofare #1	BTNF	**No Developed Sites.**
	YNP	**Administrative or Maintenance Sites:** Cabin Creek, Howell Creek, Trail Creek, and Thorofare patrol cabins.
Thorofare #2	BTNF	**Administrative or Maintenance Sites:** Hawk's Rest patrol cabin, ***WY G&F patrol cabin.***
	YNP	**No Developed Sites.**
Two Ocean/Lake #1	YNP	**Developed Campgrounds:** Lewis Lake, Grant Village. **Trailheads:** Shoshone Lake, Heart Lake, Riddle Lake. **Major Developed Sites:** Grant Village. **Administrative or Maintenance Sites:** Heart Lake patrol cabin, Harebell patrol cabin, Mt Sheridan fire lookout. **Other Developed Sites:** West Thumb warming hut, Frank Island picnic area.
	BTNF	**Developed Campgrounds:** Sheffield Creek Campground/Trailhead.
	GTNP	**Trailheads:** Sheffield Creek. **Other Developed Sites:** Snake River Picnic Area.
Two Ocean/Lake #2	YNP	**Administrative or Maintenance Sites:** Peale Island and Fox Creek patrol cabins.

Bear Management subunit	Admin Unit	Name and type of developed sites
	BTNF	**Administrative or Maintenance Sites:** Fox Park Patrol Cabin. **Other Developed Sites:** Huckleberry Lookout Historic Site on edge of Two Ocean Lake #2 and Buffalo/Spread Creek #1.
Washburn #1	YNP	**Developed Campgrounds:** Tower and Canyon Village. **Trailheads:** Lower Blacktail, Upper Blacktail, Blacktail Plateau Rd/ski trail, Hellroaring, Wraith Falls, Mount Washburn, Dunraven Pass, Howard Eaton. **Major Developed Sites:** Canyon Village complex, Roosevelt Lodge complex. **Administrative or Maintenance Sites:** Frog Rock pit, Grebe Lake pit, Tower Ranger Station (Includes maintenance building and employee housing), Upper Blacktail, Lower Blacktail, and Observation Park patrol cabins; Mount Washburn fire lookout. **Other Developed Sites:** the Lava Creek, Antelope Creek, Dunraven Pass, Dunraven, and Howard Eaton picnic areas; Yancey's Hole cookout site.
Washburn #2	YNP	**Developed Campgrounds:** Norris. **Trailheads:** Bighorn Pass, Winter Creek, Solfatara Creek, Grizzly, Grebe, Ice Lakes. **Administrative or Maintenance Sites:** Ice Lake gravel pit. **Other Developed Sites:** Apollinaris Springs, Beaver Lake, Norris Junction, and Virginia Meadows picnic areas.

Table 5. Number and acreage of commercial livestock grazing allotments and number of sheep animal months inside the Yellowstone Primary Conservation Area (PCA) in 1998.

Administrative unit	Cattle Allotments		Sheep Allotments		Sheep AMs
	Active	Vacant	Active	Vacant	
Beaverhead-Deerlodge NF	3	2	0	0	0
Bridger-Teton NF	9	0	0	0	0
Caribou-Targhee NF	11	1	7	4	14,163
Custer-Gallatin NF	23	10	2	4	3,540
Shoshone NF	25	0	2	2	5,387
Grand Teton NP	1	0	0	0	0
Total number in PCA	72	13	11	10	23,090
Total area in PCA (acres)	**660,845**	**67,893**	**148,368**	**77,665**	**NA**
Total area in PCA (km^2)	**2,674**	**275**	**600**	**312**	**NA**

Literature Cited

Borkowski, J.J. 2006. Assessment of a cumulative effects model to monitor habitat quality of grizzly bears in the Greater Yellowstone Ecosystem. Final report to the Interagency Grizzly Bear Study Team. Montana State University, Bozeman, Montana, USA. 93 pp.

Boyce, M.S., B.M. Blanchard, R.R. Knight, and C. Servheen. 2001. Population viability for grizzly bears: a critical review. International Association for Bear Research and Management Monograph Series Number 4. 45 pp.

Dixon, B.G. 1997. Cumulative effects modeling for grizzly bears in the Greater Yellowstone
    Ecosystem. Master's thesis. Montana State University, Bozeman, Montana, USA. 192 pp.

Mattson, D.J., K. Barber, R. Maw, and R. Renkin. 2004. Coefficients of productivity for
    Yellowstone's grizzly bear habitat. U.S. Geological Survey. Biological Resources
    Division Information and Technology Report. USGS/BRD/BSR-2002-2007. 76 pp.

Appendix F. Annual Cost Estimates by Agency for Implementing this Conservation Strategy

Task	YNP	USGS - IGBST	Wyoming	Montana	Idaho	USFS	GTNP	TOTAL
Annual GIS layer updates and GIS analysis for habitat monitoring[1]	-	22,500	-	-	-	80,000	2,000	104,500
Monitor developed sites and livestock grazing	-	-	-	-	-	2,000	-	2,000
Monitor hunter numbers	-	-	1,000	2,500	1,000	-	-	4,500
Cutthroat trout spawners (Kokanee – Idaho)	11,520	10,000	-	-	1,000	-	-	22,520
Spring carcass surveys	16,704	12,000	-	2,000	-	4,000	-	34,704
Whitebark cone transects	6,336	65,600	1,550	2,500	-	2,000	45,000	122,986
Moth presence	-	59,400	1,500	2,000	-	-	-	62,900
Private land status	-	-	1,500	10,000	2,000	-	-	13,500
Monitoring unduplicated females w/cubs	18,000	147,000	44,000[2]	35,000[3]	14,000[4,5]	-	4,000	262,000
Mortality	3,000	72,400	20,000[2]	23,000	1,000	-	1,000	120,400
Distribution of family groups	12,000	66,600	30,000[2]	7,500	6,500[4]	-	2,000	124,600
Maintaining a radio-monitored sample of the population for known-fate monitoring, including at least 25 adult females per year	15,000	431,200	195,000[2]	20,000	32,000[5]	-	10,000	703,200
Human/bear conflict mgt.	672,800	-	735,000[2]	246,000[6]	32,000[5]	650,000[7]	537,000[6]	2,872,800

1 These are new costs to manage habitat but are already required as per the Recovery Plan.

2 Currently the Wyoming Game and Fish Department (WGFD) uses Conservation Strategy funds for additional implementation of said category. The Annual federal monies acquired through Conservation Strategy funding (~$40,000 - $50,000) represent < 5% of funds currently spent to monitor and manage grizzly bears in Wyoming outside of the National Park System and Wind River Reservation. The total amount of money listed herein used toward grizzly bear management is not all-inclusive. There are additional funds related to other WGFD personnel assisting with grizzly bear management and recovery.

3 75% of this expenditure is provided through a USFWs Conservation Strategy funding contract.

4 Approximately $10,000 of the monitoring females with cubs and distribution of family groups comes from Section 6 Funding.

5 $50,000 of conflict management, maintaining adult females with radios, and monitoring females with cubs comes from USFWS funding.

6 21% of this expenditure is provided through a USFWs Conservation Strategy funding contract.

7 30% currently funded; 70% currently needed but unfunded and are currently necessary to minimize bear-human conflicts as per the Recovery Plan.

Task	YNP	USGS - IGBST	Wyoming	Montana	Idaho	USFS	GTNP	TOTAL
Outreach and education	121,717	40,000	75,000[2]	30,000[8]	27,300	60,000	67,000	421,017
Monitor genetic variation	-	35,700	20,000	2,500	-	-	-	58,200
Miscellaneous	-	-	50,000[2]	-	9,000	-	55,000	114,000
Total per agency per year	877,077	962,400[9]	1,174,550	383,000[10]	125,800	798,000	723,000	-
GYE TOTAL COST PER YEAR								**5,043,827**

8 40% of this expenditure is provided through a USFWS Conservation Strategy funding contract.

9 Much of this cost is in current IGBST operations, annual costs covered by FWS: $185,000.

10 24% of expenditure is provided through a USFWS Conservation Strategy funding contract.

Appendix G. Lead Agencies for Actions under this Conservation Strategy

AGENCY LEADS AND PARTICIPANT AGENCIES HABITAT AND POPULATION MONITORING				
TASK	**LEAD AGENCY**	**PARTICIPANT AGENCIES**	**TASK LEADER**	**ANNUAL REPORT LEADER**
Habitat Effectiveness (GIS run and database updates)	USFS	YNP, GTNP	USFS	USFS
Secure Habitat/OMARD and TMARD (GIS runs and database updates)	USFS	YNP, GTNP	USFS	USFS
Cutthroat trout spawners	YNP	IGBST	YNP	YNP
Spring carcass surveys	YNP	IGBST	YNP	YNP
Whitebark cone transects	IGBST	YNP, USFS	IGBST	IGBST
Moth presence	WY	YNP, GTNP, IGBST	IGBST/WY	IGBST/WY
Mortality reduction	WY, MT, ID, NPS, USFS, FWS/LE	WY, MT, ID, NPS, USFS, FWS/LE	Cooperative	Cooperative
Developed Sites and Livestock Grazing	USFS	NPS	USFS	IGBST
Hunter Numbers	WY, ID, MT	WY, ID, MT	WY	IGBST
Private land status	Private conservation groups in cooperation with states	WY, ID, MT	To be selected	To be selected

AGENCY LEADS AND PARTICIPANT AGENCIES HABITAT AND POPULATION MONITORING				
TASK	**LEAD AGENCY**	**PARTICIPANT AGENCIES**	**TASK LEADER**	**ANNUAL REPORT LEADER**
Unduplicated females w/cubs	IGBST	WY, YNP, MT, ID, GTNP	IGBST	IGBST
Mortality	IGBST	MT, WY, ID, YNP, GTNP, FWS/LE	IGBST	IGBST
Distribution	IGBST	WY, YNP, MT, ID, GTNP	IGBST	IGBST
Maintaining 25 adult females with collars	IGBST	WY, YNP, MT, ID, GTNP	IGBST	IGBST
Monitoring genetic diversity	IGBST	IGBST, USFWS	IGBST	IGBST
Control action and conflict reporting	YNP	WY, YNP, MT, ID, GTNP	YNP	YNP/IGBST
Public outreach and information	All	WY, YNP, MT, ID, GTNP, USFS, FWS/LE	To be selected	To be selected

Appendix H. The Relationship Between the Five Factors in Section 4(a)(1) of the ESA and the Existing Laws and Authorities

The relationship between the five factors in Section 4(a)(1) of the Endangered Species Act and the existing State and Federal laws and regulations is important to assure that the existing laws and authorities can address all the factors necessary to assure recovery under the Endangered Species Act. This table presents the State and Federal laws and authorities and which of the five factors are addressed by that law or authority.

Sec. 4. (A) General. - (1) The Secretary shall by regulation promulgated in accordance with subsection (b) determine whether any species is an endangered species or a threatened species because of any of the following factors:

    A. the present or threatened destruction, modification, or curtailment of its habitat or
        range;
    B. overutilization for commercial, recreational, scientific, or educational purposes;
    C. disease or predation;
    D. the inadequacy of existing regulatory mechanisms;
    E. other natural or manmade factors affecting its continued existence.

FEDERAL AND STATE LAWS AND REGULATIONS	Five Factors				
	A	**B**	**C**	**D**	**E**
The Act of Congress March 1, 1872 - Set Yellowstone National Park as a Public Park	X	X		X	X
National Park Service Organic Act of 1916, 16 U.S.C. 1, 39 Stat. 535	X	X		X	X
Lacey Act of 1900, as amended, 16 U.S.C. 701, 702; 31 Stat. 187, 32 Stat. 285; Criminal Code Provisions, as amended, 18 U.S.C. 42-44, 62 Stat. 87				X	
Fish & Wildlife Coordination Act of 1934, as amended, 16 U.S.C. 661-666c; 48 Stat.401	X	X		X	X
The Act of Congress September 14, 1950 - Expansion of Grand Teton National Park to include Jackson Hole National Monument	X			X	
Sikes Act, 1960, as amended, 16U.S.C. 670a-670o; 74 Stat. 1052, Pub. L. 86-797	X	X			X
Multiple-Use Sustained-Yield Act of 1960, 16 U.S.C. 528-531, 74 Stat. 215, P.L. 86-517	X	X			X
National Environmental Policy Act of 1969, as amended, 42 U.S.C. 4321, 83 Stat. 852, Pub. L. 91-190	X	X			X
The Act of Congress August 25, 1972 - Establish John D. Rockefeller, Jr. Memorial Parkway	X	X			
Endangered Species Act of 1973, as amended, 16 U.S.C. 1531-1543; 87 Stat. 884	X	X	X	X	X
Forest and Rangeland Renewable Resources Planning Act, 1974, Pub. L. 93-378	X	X		X	X
National Forest Management Act of 1976, U.S.C. 1600 et. seq., Pub. L. 94-588	X	X			X
Federal Land Policy and Management Act of 1976, as amended,43 U.S.C. 1701 et. seq., Pub. L. 94-579, 90 Stat. 2744		X			X
Fish & Wildlife Improvement Act of 1978, 16 U.S.C. 742 l, 92 Stat. 3110				X	
Fish and Wildlife Conservation Act of 1980, 16 U.S.C. 2901-2904; 2905-2911; 94 Stat. 1322, Pub. L. 96-366	X	X		X	X
36 CFR 1.5 (a)(1)		X		X	
36 CFR 1.7(b) and 2.10(d)				X	X
36 CFR 1.7(b) and 7.13 (l)		X		X	X
36 CFR 2.2		X		X	X
36 CFR 2.10				X	X
36 CFR 219		X			X
36 CFR 219.19	X			X	

FEDERAL AND STATE LAWS AND REGULATIONS	Five Factors				
	A	**B**	**C**	**D**	**E**
36 CFR 219.27 (a)(6)	X			X	X
36 CFR 261.50 (a), (b) and (c)				X	X
36 CFR 261.53 (a) and (e)				X	X
36 CFR 261.58 (e), (s) and (cc)				X	X
WYOMING STATE STATUTES					
23-1-101 (a)(xii)				X	
23-1-103		X		X	
23-1-302 (a)(ii)		X		X	
23-1-901					X
23-2-101 (e)				X	X
23-2-303 (d)				X	X
23-3-102 (b)		X		X	
23-3-103 (a) & (b)		X		X	X
23-3-106				X	X
23-3-107		X		X	X
23-3-109		X		X	X
23-3-112		X		X	X
23-3-301				X	X
WYOMING GAME AND FISH COMMISSION REGULATIONS					
Chapter XLIII		X		X	X
Chapter XXVIII		X		X	X
Chapter III		X		X	X
IDAHO STATE STATUTES					
36-103 (a)		X		X	X
36-103 (b)				X	X
36-201				X	X
36-716		X		X	X
IDAHO FISH AND GAME COMMISSION REGULATIONS					

FEDERAL AND STATE LAWS AND REGULATIONS	Five Factors				
	A	B	C	D	E
IDAPA 13 G 1.9		X		X	X
IDAPA 13 G 2.2				X	
MONTANA STATE STATUTES					
Section 87-1-301	X	X		X	X
Section 87-5-301	X	X		X	X
Section 87-5-302		X		X	
Section 87-2-101		X		X	X
ADMINISTRATIVE RULES OF MONTANA					
MCA 12.9.103 Grizzly Bear Policy (1)	X	X	X	X	X
MONTANA DEPARTMENT OF STATE LANDS					
Title 75, Chapter 1 MCA - Montana Environmental Policy Act	X				
Title 76, Chapter 14, MCA - Montana Rangeland Resource Act	X				
Title 77, Chapter 1 MCA - Administration of State Lands	X				X
Title 87, Chapter 5, MCA - Nongame and Endangered Species Conservation Act	X			X	X
Montana Constitution. Article IX - Environment and Natural Resources. Section 1 - Protection and Improvement	X				
Montana Constitution. Article X - Education and Public Lands. Section 4 - Board of Land Commissioners.	X				
FEDERAL PLANS AND GUIDELINES - NATIONAL PARK SERVICE					
NPS-77, Natural Resource Management Guidelines, May 16, 1991		X			X
Final Environmental Impact Statement, Grizzly Bear Management Program, Yellowstone National Park, July, 1983	X	X	X	X	X
Yellowstone National Park Annual Bear Management Plan		X			X
Grand Teton National Park Human/bear Management Plan, 1989	X	X	X	X	X
U.S. FOREST SERVICE (Regions 1,2, and 4)				X	
Beaverhead NF Plan (1986) Deerlodge NF Plan (1987)	X			X	X
Bridger-Teton NF Land and Resource Management Plan (1989)	X		X	X	X
Custer NF and Grasslands Land Resource Management Plan (1987)	X		X		
Gallatin NF Plan (1987)	X		X	X	X

FEDERAL AND STATE LAWS AND REGULATIONS	Five Factors				
	A	**B**	**C**	**D**	**E**
Shoshone NF Land and Resource Management Plan (1986)	X		X	X	
1997 Revised Forest Plan - Targhee National Forest	X		X	X	X
OTHER GUIDANCE					
Grizzly Bear Compendium. National Wildlife Federation, Washington, D.C. 1987					X
Interagency Grizzly Bear Committee Taskforce Report, Grizzly Bear/Motorized Access Management. 1994. Revised 1998.				X	
Yellowstone Grizzly Bear Investigations				X	X
Public Information and Involvement Strategy for IGBC.				X	X

Appendix I. Grizzly Bear Management Plan for Southwestern Montana

GRIZZLY BEAR

Management Plan for Southwestern Montana

2002-2012

FINAL PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

Prepared by:
Montana Fish,
Wildlife & Parks

With Input From The
Montana Grizzly Bear Working Group
and other interested parties

October 2002

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INTRODUCTION

Process for Plan Development

Montana Fish, Wildlife & Parks (FWP) developed this plan and programmatic environmental impact statement (PEIS) through a series of meetings with affected agencies, governments, interested persons, and groups. FWP initiated the scoping processes with discussion of potential issues and alternatives with biologists, wardens, and representatives from Idaho and Wyoming during the summer of 2000. Following those preliminary efforts, FWP held a series of 13 public scoping meetings in southwestern Montana during September and October 2000 (Livingston, Bozeman, Missoula, Big Sky, Big Timber, Dillon, Ennis, Butte, West Yellowstone, Billings, Columbus, Gardiner, and Red Lodge). FWP solicited written comments throughout Fall 2000 through news releases, press interviews, and personal contacts. During these meetings, FWP sought to identify issues likely to involve significant impacts and those issues not likely to involve significant impacts, as well as to identify possible alternatives for grizzly bear management. To further develop issues and ideas for possible alternatives, FWP held a meeting in Bozeman consisting of the Governors' Roundtable members, and other invited interest groups and individuals, on December 4-5, 2000. FWP invited the participation of those individuals and groups that had expressed interest in additional participation as well as other affected agencies. Following this meeting, a draft management plan was produced and resubmitted to a broader group of interested parties including those who attended the December meeting. An additional facilitated meeting was held in Bozeman April 30-May 1, 2001 to review and discuss approaches presented in the preliminary draft plan with the purpose of fine tuning a draft. A meeting was held on October 22, 2001, to further review the draft plan for release and formal public hearings. All of the meetings were open to the public. A draft plan was released for public comment April 5, 2002. Formal public hearings were conducted through the same area of southwestern Montana as previous scoping sessions (13 total). Public comment was also accepted in writing for 90 days through July 5, 2002. All comments were used to assist in preparing the final plan. A summary of comments and FWP response to them is available in Appendix AA.

Montana Fish, Wildlife & Parks (FWP) Goals For The Grizzly Bear

FWP has statewide goals for wildlife resources. This plan more specifically deals with grizzly bear resources in southwestern Montana. These goals are:

1.   To provide the people of Montana and visitors with optimum outdoor recreational opportunities emphasizing the tangible and intangible values of wildlife and natural and cultural resources of aesthetic, scenic, historic, scientific, and archaeological significance in a manner that:
   a.   Is consistent with the capabilities and requirements of the resources
   b.   Recognizes present and future human needs and desires, and
   c.   Ensures maintenance and enhancement of the quality of the environment

2. Wildlife Program Goal -- To protect, perpetuate, enhance, and regulate the wise use of wildlife resources for public benefit now and in the future.

3. Grizzly Bear Management Goal -- To manage for a recovered grizzly bear population in southwestern Montana and to provide for a continuing expansion of that population into areas that are biologically suitable and socially acceptable. This should allow FWP to achieve and maintain population levels that support managing the bear as a game animal along with other species of native wildlife and provide some regulated hunting when and where appropriate.

These goals will be achieved by addressing the following issues identified early in the planning process: human safety, habitat, population monitoring, future distribution, trails programs, livestock conflicts, property damage, nuisance guidelines, hunting, enforcement concerns, education, and funding. The success of grizzly bear management in Montana will be contingent upon FWP's ability to address these issues in a way that builds social support for grizzlies.

President Theodore Roosevelt stated: "The nation behaves well if it treats the natural resources as assets which it must turn over to the next generation increased and not impaired in value". It is FWP's hope that this plan will allow the next generation of Montanans to manage a grizzly bear population that has increased in both numbers and distribution in southwestern Montana.

Development of this plan is further guided by recommendations of a group of citizens referred to as the Governors' Roundtable. This group was appointed by the governors of Montana, Wyoming, and Idaho and was composed of five representatives from each of the three states. These citizens were selected to represent a cross section of the people interested in grizzly bears in the greater Yellowstone area, and their purpose was to review the draft Conservation Strategy for grizzlies prepared by the Interagency Grizzly Bear Committee (IGBC). The Roundtable was able to reach unanimous agreement on all 26 of its recommendations (Appendix A).

Among the key recommendations was support for continued management of the proposed Primary Conservation Area (PCA) as a secure "core" area for grizzly bears within the Yellowstone Ecosystem (Fig. 1). The group also recommended that the three states develop management plans for the areas outside the PCA to:

1. Ensure the long-term viability of bears and avoid the need to relist the species under the Endangered Species Act.

2. Support expansion of grizzly bears beyond the PCA in areas that are biologically suitable and socially acceptable.

3. Manage the grizzly bear as a game animal including allowing regulated hunting when and where appropriate.

Purpose and Need

The need for this plan was precipitated by changes in bear management in the Yellowstone Ecosystem during the 1980-90s, resulting in increasing numbers and expanding distribution of grizzly bears in this area. Current approaches to land management, wildlife management, and recreation within the PCA appear to be providing the conditions needed to establish a population of bears outside the PCA. It is FWP's objective to maintain existing renewable resource management and recreational use where possible and to develop a process where FWP, working with local publics, can respond to demonstrated problems with appropriate management changes. By maintaining existing uses, which allows people to continue their lifestyles, economies, and
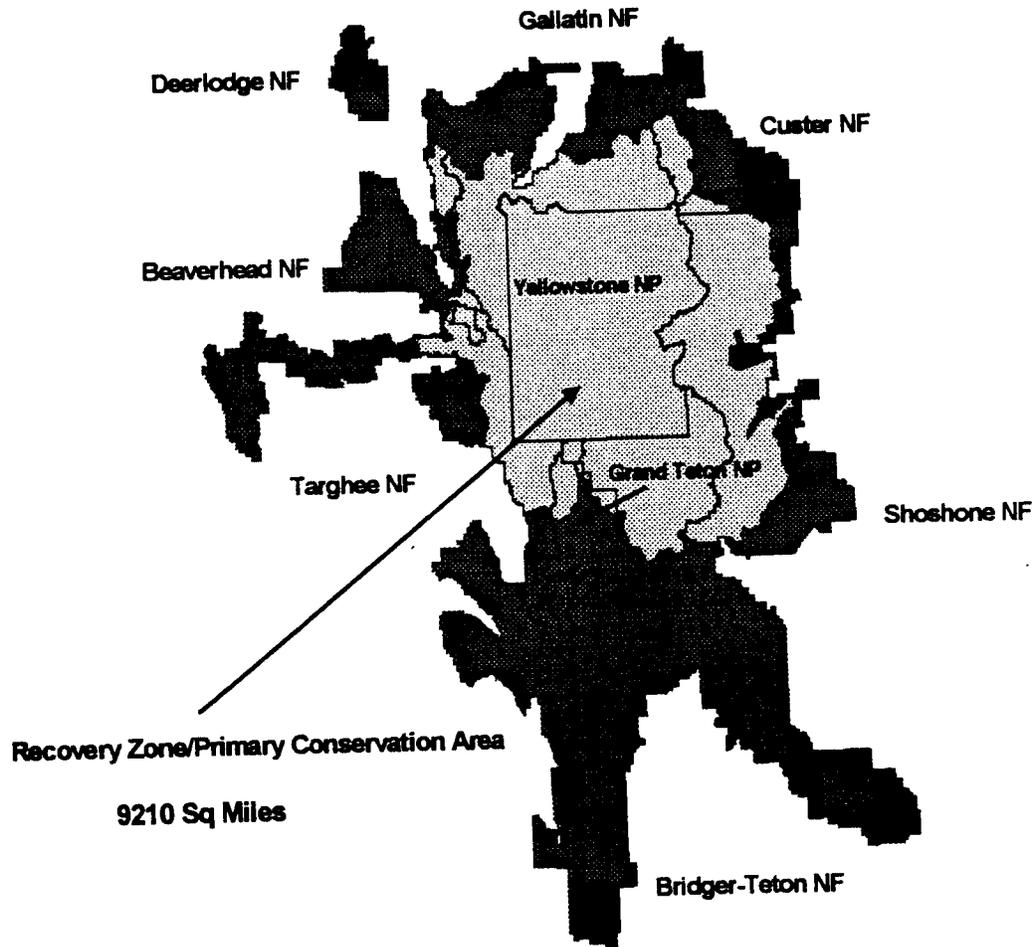
Figure 1. Location of the recovery zone/primary conservation area within Greater Yellowstone Ecosystem.

feelings of well being, this approach builds support and increases tolerance for an expanding grizzly bear population.

Along these same lines, the Governors' Roundtable produced a recommendation to allow grizzly bears to inhabit areas that are "biologically suitable and socially acceptable." The level of social acceptance of grizzlies in historic habitat is alterable, based on how the issues are approached, and how much faith people have in managers. To maximize the area of Montana that is "socially acceptable" grizzly bear range, the state planning and management effort will employ an adaptive learning process to develop innovative, on-the-ground management. By demonstrating that grizzly bear conservation can be integrated with broad social goals, public faith in management can be enhanced and human tolerance of grizzly bears increased. This approach already has demonstrated success in northwestern Montana along the Rocky Mountain Front, where bear populations have increased and bears have reoccupied habitats from which they had been absent for decades.

Under such an approach, this document should be a strategy for initiating, implementing, and learning from a set of localized efforts. What FWP learns from these localized efforts, changed programs, and adapted approaches will become part of the State Grizzly Bear Management Plan.

This process will entail developing a set of plans on the relatively small scale of Ranger Districts, Conservation Districts, or valleys. FWP, other agencies, local citizens, and wildlife organizations would cooperatively design local strategies tailored to local conditions. These strategies would include monitoring provisions that would require management adaptations as conditions dictate or change. Ultimately, together we would learn from these localized efforts, and develop a basis of knowledge for replicating efforts elsewhere, incorporating successes in the statewide management of this and other species. The underlying basis for this approach is that as bears reoccupy areas from which they have been absent for decades, there are many issues that can't be anticipated or predicted with accuracy. Consequently, this approach allows FWP to adjust the program as necessary.

Localized efforts have many advantages:

1.   They tend to generate productive, focused solutions.
2.   They provide low-conflict settings for trying out innovative ideas.
3.   They have tremendous local importance that can help increase political support (e.g., showing that ranchers can and do get along with grizzlies builds support for the agricultural community and for the benefits they provide to the rest of society).

The adaptive learning approach is ongoing and produces tangible results. In fact, innovative grizzly conservation efforts are already underway in Montana, so we can make use of the lessons already available. This approach will be described in more detail in the local management section. Ultimately this plan and approach will be re-evaluated in 10 years to provide for a complete review of its successes and/or failures.

History of Bears and Bear Biology in the Greater Yellowstone Area

The Eurasian brown bear and the North American grizzly are considered the same species (*Ursus arctos*). Current theory holds that this species developed its large size, aggressive temperament, flexible feeding habits, and adaptive nature in response to habitats created by intermittent glaciation. It is believed that ancestors of the grizzly bear migrated to North America from Siberia across a land bridge at the Bering Strait at least 50,000 years ago. As the continental ice sheet receded about 10,000 years ago, the species began to work its way south over post glacial North America.

European explorers found grizzlies throughout most of the American West, including northern Mexico. It is not known exactly how many grizzlies lived in the U.S. before

1700, but based on historical sightings and modern-day densities, it is estimated that around 50,000-100,000 bears lived in parts of 17 states.

Prior to 1800, grizzly bears were undoubtedly common in the Yellowstone area. With newly acquired access to firearms by indigenous people and westward expansion of settlers, bears began to be impacted. With no mechanisms to provide protection or management, almost without exception, bear numbers declined where man and bear came together for any length of time. The decline of the grizzly bear took less than 60 years, from the end of the trapping era in 1840 to the turn of the century. The decline was due to a number of factors including: a reduction of prey because of market hunting associated with gold exploration and mining; subsistence hunting associated with gold exploration and mining; construction of railroads, homesteading, and predator control; and loss of habitat related to ranching, farming, and human settlement. Much of the killing was based on the fact that the grizzly bear posed a threat to people and livestock.

Grizzly bears were gone from West Coast beaches by the 1870s, and gone from prairie river bottoms in the 1880s. By the turn of the century, they had disappeared from most broad, open mountain valleys. Fifteen years later, most foothill country lacked grizzlies.

Grizzlies were never eliminated from Montana, but their numbers probably reached their lowest levels in the 1920s. At that time, changes were made out of concern for the future of the species including designating grizzlies a "game animal" in 1923, the first such designation of the species in the lower 48 states. This change, along with the early prohibitions on the use of dogs to hunt bears, outlawing baiting (both in 1921), closing seasons, etc., had the effect of allowing grizzlies to survive in portions of western Montana.

The degree of protection and the sophistication of management practices has grown steadily. In the 1940s, the importance of protecting fish and wildlife habitat began to emerge as a key public issue in wildlife management. Through all of the previous years, wildlife conservation was the goal, and was sought through the restriction and regulation of hunters and anglers. Although partially effective, the regulations and laws failed to address a more fundamental issue: the protection of fish and wildlife habitat.

Habitat protection under state authority began with winter game range acquisitions in the 1940s and stream preservation in the early 1960s. Generally, concern for and protection of habitat appeared in state laws dealing with controlling natural resource development. These laws usually addressed specific resource issues such as surface mining and siting of major industrial facilities. An exception to this specific approach was the Montana Environmental Policy Act (MEPA) adopted in 1971. Montana MEPA law mirrored in large part the National Environmental Policy Act (NEPA) adopted by Congress in 1969.

The Montana Fish and Game Commission (MFGC) adopted rules for implementing MEPA. These rules provide for the preparation and distribution of an environmental analysis evaluating a series of actions, programs or policies that affect the quality of the

human environment. Grizzly bear management in Montana is being addressed within the framework of MEPA and its regulations. This plan and programmatic environmental impact statement deals directly with that portion of Montana known as the "Greater Yellowstone Ecosystem" (GYE) and adjacent lands in southwestern Montana and includes our management programs within the PCA. The GYE has been defined in many different ways by different people depending on their purposes. For the purpose of this plan, the GYE is defined very broadly for southwestern Montana to include lands that may be accessed by grizzly bears in the near future (Fig. 2).

The people of Montana's early concern is evidenced in the fact that the state contains all or portions of four of the six areas in the lower 48 states identified by the U.S. Fish and Wildlife Service's plan for grizzly recovery. This concern continues as demonstrated by the fact that the species is Montana's "State Animal," and there is specific policy directing management of the species. Grizzly bear populations are currently increasing in the Yellowstone and portions of the Northern Continental Divide area. A small population of grizzly bears in the Cabinet-Yaak area of Montana appears to be slowly increasing. There are currently no documented grizzlies in the Bitterroot ecosystem.

It is important to recognize that the presence of a viable grizzly bear population is very important to many people in Montana as well as nationally. This species is one of the things that makes Montana such a special place to live, work, and recreate. Many people travel to Montana with the hope of seeing a bear, and the stories of such encounters are retold many times. There are also clear economic benefits from tourism, recreation, and potential harvest from the presence of grizzlies. While FWP is fully aware that there are also costs and potential risks associated with the species, this plan should allow FWP to manage these in a way that meets the needs of the public. In light of this, the State of Montana has adopted the following policy for this species:

Montana Fish, Wildlife & Parks Commission Policy

The Montana Fish, Wildlife & Parks Commission (MFWPC) is the policy making arm of Montana's fish, wildlife, and parks programs. Section 87-1-301(1), Montana Codes Annotated (MCA) requires the Commission to "set policies for the protection, preservation, and propagation of the wildlife, fish, game, furbearers, waterfowl, nongame species, and endangered species of the state for the fulfillment of all other responsibilities of FWP as provided by law."

The legislature has given specific policy direction to the Commission on the issue of grizzly bears. Section 87-5-301, MCA, states:

"It is hereby declared the policy of the State of Montana to protect, conserve, and manage grizzly bears as a rare species of Montana wildlife."

Section 87-5-302 describes the FWP Commission's power regarding grizzly bears.

Within this legal framework, the FWP Commission developed a grizzly bear policy in Section 12.9.103, ARM (Appendix B). That policy addresses the need to protect grizzly bear habitat, the need to pursue grizzly bear research, the role of regulated hunting in grizzly bear management, depredations and the appropriate FWP response to depredations, and requires compliance with federal regulations relating to grizzly bears. It is within this framework, and that described by the Endangered Species Act (16 U.S.C. Sec. 1531, et seq.), that specific FWP goals for the grizzly bear were developed. Because of high mortality rates resulting from sudden closure of open dumps in Yellowstone National Park, concern over the status of the grizzly population in

Figure 2. Location of Carbon, Stillwater, Sweet Grass, Park, Gallatin, Madison, and Beaverhead Counties.

the greater Yellowstone area rapidly increased during the late 1960s and early 1970s. This population, along with other grizzly populations in the lower 48 states, was listed as threatened under the Endangered Species Act in 1975. As a result of this listing, many management changes were made to benefit grizzlies. A recovery plan was prepared and approved in 1982 and revised in 1993. The success of recovery efforts is evident in the estimates of bear numbers in the area, increasing from approximately 230 in the late 1960s to a minimum of over 361 bears today. This has set the stage for a possible delisting of the species and a return of this species to state management, which is predicated on a state management plan.

DESCRIPTION OF GRIZZLY BEAR MANAGEMENT AREA
FOR SOUTHWESTERN MONTANA

Grizzly bears currently -- or could in the near future -- occupy suitable habitats in the seven southwestern and south-central Montana counties adjacent to or near Yellowstone National Park (Carbon, Stillwater, Sweet Grass, Park, Gallatin, Madison, and Beaverhead Counties, Fig. 2). The proposed action of this document is to create and adapt a management plan for this area. The following section briefly describes the geographic and human environment of this seven-county area with respect to general description, size, human population, land ownership, special management areas, agricultural interests, and recreation. Not all portions of these counties are suitable grizzly bear habitat. However, some of the above attributes of these counties may affect the distribution and survival of grizzly bears. Given enough time and adequate management programs, grizzly bear distribution may extend beyond this seven-county area. For purposes of this plan, expansion in grizzly bear distribution during the next 10 years is most likely to occur within this seven-county area. It is anticipated that the programs outlined in this plan would apply should grizzlies extend their distribution beyond these counties sooner than anticipated.   In addition, the success of our program rests on coordinating and cooperating with the surrounding states and federal agencies. We will continue to work with them so that the needs of the bear population as a whole are met.

General Description

Each county is characterized by one or more major river valleys divided by rugged mountain ranges. Elevations range from 12,799 ft. at Granite Peak (Montana's highest point) to about 3,330 ft. on the Yellowstone River near Park City. Major river drainages include the Clark's Fork of the Yellowstone, Stillwater, Boulder, Shields, Yellowstone, Gallatin, Madison, Red Rock, Ruby, Bighole, Wise, Beaverhead, and Jefferson rivers. Several rivers in the western portion of this area flow together to form the Upper Missouri River, beginning at Three Forks. Lower elevation habitats (below 6,000 ft.) vary greatly, including large areas of short-grass/sagebrush prairie, mountain foothills, intensively cultivated areas (grain and hay field agriculture), natural wetlands/lakes, riparian plant communities ranging from narrow stream bank zones to extensive cottonwood river bottoms, man-made reservoirs, small communities, and sizeable cities.

The mountainous portion of this seven-county area (above 6,000 ft.) contain all or portions of 18 mountain ranges including the Beartooth, Absaroka, Crazy, Bridger, Gallatin, Spanish Peaks, Madison, Henry Lake, Centennial, Gravelly, Snowcrest, Ruby, Tobacco Root, Highland, East Pioneer, West Pioneer, Tendoy, Beaverhead, and Anaconda-Pintler. Mountainous habitats are dominated by coniferous forest (Douglas fir, lodgepole pine, Engleman spruce, whitebark pine, limber pine, ponderosa pine, juniper), and rocky subalpine/alpine communities found above timberline.

Size and Human Population

The seven-county area encompasses approximately 12,865,088 acres or 20,102 square miles of southwestern and south-central Montana (Table 1). This represents about 13.3% of Montana's

Table 1. Selected size, population, and agricultural attributes of the seven counties in the grizzly bear conservation area.

County	Pop.[1]	Size (Sq. Mi.)	People/Sq. Mile	# Cattle[2]	# Sheep[3]	Acres Harvested[4]
Carbon	9,543	2,062	4.6	60,000	7,500	84,850
Stillwater	8,328	1,804	4.6	57,000	10,700	116,155
Sweet Grass	3,584	1,861	1.9	49,000	11,100	48,110
Park	15,982	2,667	6.0	44,000	3,100	69,200
Gallatin	63,881	2,533	25.2	57,000	6,400	163,250
Madison	6,927	3,603	1.9	78,000	7,500	92,900
Beaverhead	8,790	5,572	1.6	157,000	17,500	123,810
Totals	**117,035**	**20,102**	**5.8**	**502,000**	**63,800**	**698,275**

[1]Based on July 1999 population estimate from Montana Census Bureau.
[2]Based on inventory estimates of all cattle and calves for year 2000, from Montana Agricultural Statistics, October 2000.
[3]Based on inventory estimates of all sheep and lambs for year 2000, from Montana Agricultural Statistics, October 2000,
[4]Based on estimates of irrigated and non-irrigated acres harvested in 1999, from Montana Agriculture Statistics, October 2000.

human population. County population size ranges from Gallatin (pop. 63,881) to Sweet Grass (pop. 3,584). Population density for the entire area is 5.8 people/sq. mile, compared to 6.0 people/sq. mile for the entire state. The most densely populated county is Gallatin (25.2 people/sq. mile) and the least densely populated county is Beaverhead (1.6 people/sq. mile). Major population centers include Bozeman (30,723), Livingston (7,626), Belgrade (5,195), Dillon (4,342), Red Lodge (2,278), Big Timber (1,796), Three Forks (1,513), West Yellowstone (1,222), and Big Sky (1,221). Within the seven-county area, only these eight cities exceed a population of 1,000 people.

According to census figures, the population in this area has increased by 19,853 people (20.4%) from 1990-1999. During this same period the population of the entire state increased by 83,714 people or 10.5%. Gallatin County was the fastest growing county, increasing by 13,397 people (26.5%) from 1990-1999, while Beaverhead County grew by only 366 people (4.3%) in the last 10 years.

Land Ownership

The majority of the mountainous habitat (above 6,000 ft.) is within publicly owned National Forests. All or portions of the Custer, Gallatin, and Beaverhead-Deerlodge National Forests occur within this seven-county area. A small portion of mountainous habitat is in Montana Department of Natural Resources and Conservation (DNRC), FWP, Bureau of Land Management (BLM), and private ownership, including private subdivisions, ranches, ski resorts and timber company lands.

Low-elevation river valleys (below 6,000 ft.) are largely privately owned with only a small percentage in state (DNRC, FWP) and federal (BLM, USFS, and U.S. National Wildlife Refuges) public ownership. By far the largest amount of low-elevation land lies within privately owned ranches and farms. Small, medium and large-sized communities also occupy several thousand acres of low-elevation river-valley habitat.

Special Management Areas

Several federal and state special management areas are located in the seven-county area. In large part, these areas are protected from human development and provide long-term habitat for a variety of wildlife species, including grizzly bears. Five National Wilderness Areas lie within mountain ranges in the seven-county area: the Absaroka-Beartooth Wilderness (936,000 acres) in the Custer and Gallatin national forests, the Lee Metcalf Wilderness (261,000 acres) in the Gallatin and Beaverhead-Deerlodge national forests; Bear Trap Canyon Wilderness (5,600 acres), Bureau of Land Management; and approximately half of the Anaconda-Pintler Wilderness (159,000 acres) in the Beaverhead-Deerlodge National Forest. National forest Wilderness Areas have the greatest restrictions on human use and development resulting in the least disturbed habitats available and are important in ensuring long-term grizzly bear survival.

Other special management areas include Red Rock Lakes National Wildlife Refuge (32,000 acres) located in the Centennial Valley in Beaverhead County and eight FWP Wildlife Management Areas (approximately 86,000 acres) in Carbon, Park, Gallatin, Madison and Beaverhead counties.

Agricultural Interests

The seven-county area supports a large agricultural economy. In 1997, there were 3,472 farms and ranches in the seven-county area. By far the most common activity of these farms and ranches is raising beef cattle and growing forage (hay) for cattle. In some areas, small grain crops (wheat, oats, barley) are intensively grown. Horses, sheep, hogs and dairy cattle are also raised in smaller numbers on ranches and farms in southwestern and south-central Montana. Beef cattle and sheep are grazed on privately owned grassland and on publicly owned (USFS, BLM, DNRC) grazing allotments. Some of these allotments occur in higher elevation habitats occupied by

grizzly bears. Livestock depredation by grizzly bears is an issue that will continue to affect grizzly bear numbers, management and distribution.

Based on Montana agricultural statistics for 2000, there were an estimated 502,000 head of cattle (all cattle and calves) in the seven-county area (Table 1). Beaverhead County had the most cattle (157,000 head) while Park County had the lowest number (44,000 head). In terms of cattle production, Beaverhead and Madison counties ranked 1st and 7th, respectively, out of Montana's 56 counties. Since 1940, total cattle numbers statewide have increased from 1.2 million to 2.6 million head with a peak of over 3.2 million head in the mid-1970s.

In 2000, there were an estimated 63,800 sheep (adults and lambs) in the seven-county area (Table 1). Beaverhead County had the largest number of sheep (17,500) while Park County had the fewest sheep (3,100). In terms of sheep production, Beaverhead and Sweet Grass counties ranked 5th and 6th, respectively, statewide in sheep production. Statewide, since 1940 sheep production has steadily declined from over 4.2 million to about 370,000 head.

In 1999, an estimated 698,275 acres of irrigated and non-irrigated crops were harvested in the seven-county area (Table 1). Crop harvest ranged from 163,250 acres in Gallatin County to 48,110 acres in Sweetgrass County.

Recreational Opportunities

Outdoor recreation and tourism is a major component of the economy in this seven-county area. Southwestern and south-central Montana is nationally known for its high quality fishing, hunting, camping, hiking, river floating, skiing, snowmobiling, wildlife viewing and sightseeing opportunities. Nearby, Yellowstone National Park attracts large numbers of people to the area every year. Many of these outdoor activities are made possible by public ownership of large tracts of mountainous habitat and additional access provided by many private landowners. Recreationists have largely unhampered access to millions of acres of undeveloped land. Some of this land is currently, or, based on documented trends of increasing distribution, will be occupied by grizzly bears. As bear numbers and distribution increase, contact and interaction with people engaged in outdoor activities is likely to increase.

SUMMARY OF GRIZZLY BEAR BIOLOGY
(modified from Mincher, B. J., 2000 and Schwartz et al., 2001)

Grizzly bears in this area come in many sizes and colors. The most prevalent color has medium to dark brown underfur, brown legs, hump, and underparts, light to medium grizzling on the head and part of the back, and a light-colored girth band or patch behind the forelegs. Other patterns include (1) an overall gold or silver appearance and brown underparts, with an occasional dark back stripe, (2) no distinct silver tipping giving a general black or brown appearance, or (3) medium to dark brown underfur, rump, legs, and hump, with medium to heavily grizzled forequarters and face. Subadults often appear multicolored with various shadings of red, blond, brown, and great variation in silver tipping. Light-colored "yolks" on the chest and dark stripes on the back are common. These patterns fade as the bear matures into one of the four patterns described in adults.

The size of male and female grizzly bears will vary substantially with males about 1.2-2.2 times larger than females. Differences in body mass between males and females are influenced by age at sexual maturity, samples from within the population, season of sampling, reproductive status, and differential mortality.

Body mass is dynamic in brown bears. During late summer and fall, brown bears gain weight rapidly, primarily as fat when they feed intensively prior to denning. Because bears rely solely on their stored energy reserves during hibernation, this predenning weight gain is essential for reproduction and survival. Peak body mass generally occurs in fall just prior to hibernation. Bears metabolize fat and muscle during the denning period.

Habitat

Brown bears are extremely adaptable and exploit a wide variety of habitats and foods throughout their range indicating relatively broad environmental limits. Individual bears may exhibit individual preferences and tolerances. Most key grizzly foods in the GYE occur seasonally and somewhat unreliably. However, grizzly adaptability often compensates for the lack of some forage thought to be critical. Such a generalized approach to survival necessitates a solitary and mobile lifestyle. Individual grizzlies forage over vast areas and have large spatial requirements. Because the active season for grizzlies is compressed to 5-7 months, during which bears must gain sufficient weight to supply their energetic needs for the next denning cycle, they tend to concentrate their activity seasonally in the most productive habitats available.

In general, GYE home ranges are larger than those of other brown bear populations. This larger range possibly indicates low environmental productivity in the GYE and increased foraging requirements to meet their nutritional needs or it may be caused more by the wide distribution of favorite foods at different times of the year. Individual ranges of both sexes overlap, but do not appear to be defended, even for adult males.

Subadult bears, especially males, disperse from their natal ranges to establish new home ranges, and these spatial requirements probably limit ultimate population density.

As with other bear species and populations, male grizzly home ranges in the GYE are usually larger than female ranges. The Interagency Grizzly Bear Study Team (IGBST) reported mean range sizes from 1975-1987 of 874 km^2 for adult males and 281 km^2 for adult females. Females with new cubs used slightly less area, and those with yearlings used more.

As a group, bear species deviate from most other meat-eating members of the Carnivora by the volume and variety of vegetative foods in their diets. Comparing the three North American bear species, feeding habits of brown bears fall somewhere between those of the largely herbivorous black bear and the primarily carnivorous polar bears. Brown bears are opportunistic omnivores; few taxa, from insects to vertebrates and fungi to angiosperms, are overlooked as potential foods. Evolutionarily, brown bears have developed several adaptations for herbivory, including expansion of molar chewing surfaces and longer claws for digging. Nevertheless, they have maintained an unspecialized digestive system capable of digesting protein with efficiency equal to obligate carnivores.

In the GYE, the pattern of seasonal elevation use is similar to that found for other populations occupying interior western mountains. Grizzlies utilized carrion and rodents prior to spring green-up, and foraged extensively on grasses, sedges and herbs in season, and berries, nuts and fish in the post-growing season. The most widely used foods were grasses and sedges, which constituted more than half of the diet.

Long-term study of Yellowstone grizzly bear food habits revealed large year-to-year variations in diet as grizzlies exploited foods that were only infrequently available. Examples of specialty foods included ants, pondweed and sweet cicely. The early season diet was dominated by ungulates, both scavenged and as neonate prey, notably elk calves, mid-season by grasses and sedges, and late-season by pine seeds. The annual percentage of energy obtained from the ungulate meat is considerably higher in the GYE than for other interior populations although herbaceous foods remain important because they are more predictable. Grizzly bears at high densities and in some circumstances can impact the ungulate prey base. However, in this area the ungulate prey base is largely impacted by other factors such as winter severity. Also in this area, an estimated 30-50 grizzly bears forage annually on spawning cutthroat trout in tributary streams of Yellowstone Lake, a food source that may be jeopardized by the introduction of non-native lake trout in the lake. Bear density in Yellowstone may be limited by lack of fleshy fruits such as berries, making them more dependent than many other bear populations on unreliable crops such as moths, pines seeds, and meat.

Yellowstone area grizzlies preferred open grasslands adjacent to cover for most of their feeding activities. While grizzlies depend on fertile grasslands for their predictable supply of forage, seasonally abundant foods were exploited as available. These foods include whitebark pine seeds and carrion.

Pine seeds are especially important because they are available during the hyperphagic period prior to denning. Many bears feed on pine seed exclusively at that time. Large amounts of cones are obtained by raiding squirrel caches, which the bears exhume. After good production years, seeds that survive the winter are also used the following spring. Whitebark pine seed is so important that there is currently a relationship between the number of bears destroyed in control actions and the success of the annual crop. During good years, bears stay in high-elevation, whitebark pine habitats. But in poor years, they are found foraging near roads and settlements where they are more likely to encounter humans and become objects of control actions. Many whitebark pine stands in the northwest have been infected and killed by whitebark pine blister rust. Whitebark in the GYE has been infected by this disease, and the IGBST monitors the extent of infection.

A second, high-fat food source for grizzlies during the hyperphagic period is the army cutworm moth. Moths collect under rocks in alpine areas in late summer and fall. The importance of moth aggregation sites to grizzly nutrition has only gained appreciation in the last decade. This relationship is an area of current interest as new seasonal gathering sites are being discovered.

Anthropogenic foods (i.e. garbage, livestock feed, pet food, bird seed, human foods, garden crops, honey) are used by brown bears wherever humans and bears coexist. Open garbage dumps can be a source of highly nutritious foods when available. Use of dumps can lead to food conditioning, habituation, and increases in property damage and human-caused bear mortality. In the GYE, considerable effort has gone into eliminating availability of anthropogenic foods. These efforts have been largely successful in reducing incidents of bear-human conflicts. Here, and in other regions where bears and people live in close proximity to one another, most conflicts occur during years when important natural foods fail.

Due to reliance on sporadic food sources, grizzly home ranges may be seasonally dependent. Ranges vary to include seasonal food aggregations, which may cause many individual ranges to overlap. Yet, not all bears rely on all food sources, and individual variation is the norm.

In summary, grizzlies are opportunistic and omnivorous foragers able to take advantage of a wide variety of locally important foods. Home range size seems determined by food abundance, and many individuals are able to abandon, or overlap, their ranges to exploit concentrated food aggregations such as pine seeds, moths, fishes, carrion or garbage. Much of this behavior seems influenced by experience and habit. This adaptability has obvious survival advantages, but also results in large spatial requirements that complicate grizzly management. Currently, designated Wilderness areas as well as roadless areas which may be given Wilderness status at some future point are important to meeting these spatial needs in major parts of this area. Monitoring of key foods is performed systematically by state and federal agencies both within and outside the PCA.

Habitat for Denning

Yellowstone grizzlies spend up to seven months a year in dens. In general, bears den by mid-November, although pregnant females den somewhat earlier. Their emergence from wintering dens occurs from mid-February to late March for males, followed by single females and lastly by females with new cubs, as late as mid-April. The exact timing for this event may be climate dependent.

Site selection for dens occurs on steep slopes and at high elevation ($\geq$6500 feet) and in all cover types in the GYE. Dens are usually excavated, although natural shelters such as caves and hollow trees are also used. The availability of denning habitat is not thought to be limiting for the GYE.

Security at den sites appears to be an important management consideration, especially if human disturbance occurs near the time of den entry. There has been some concern of the possible effects of snowmobiles on denning bears. A study in northwestern Montana did not observe any overt effects of snowmobiles within 2 km of dens. The greatest potential impact on bears was during spring when females with cubs were still confined to the vicinity of the den, and also after bears had moved to gentler terrain more suitable to use by snow machines. Predictable denning chronology and the behavioral plasticity bears exhibit toward den and den site characteristics suggest potential human impacts to denning brown bears may be mitigated by careful consideration when implementing strategies for human activity.

Habitat for Security

All current grizzly bear habitat in the continental United States is characterized by extensive timber cover, and most day beds are found in timber. This implies that visual security is an important habitat component, possibly as a function of social pressure from other bears or possibly in response to human pressure.

It has long been speculated that female grizzlies with cubs avoid adult males due to their aggressive and occasionally cannibalistic nature. The idea that males do not cannibalize their own young has not been tested.

In the GYE, the only indication of sexual segregation through habitat use is in years of poor pine seed production where females were found more often near roads and areas used by humans.

The IGBC considers the presence of even lightly used roads to cause a loss in useful bear habitat. Roads are incorporated in cumulative effects models (CEM) of habitat quality. Probably the most significant effect of roads in grizzly habitat is that of increased access by humans. Some researchers have concluded that grizzly bears habituate to roads and human presence as required to meet their caloric energy needs. However, this is a disadvantage for hunted populations. Human presence can lead to

grizzly bear moralities, whether due to legal hunting, if allowed, to poaching, or to kills by humans for self-defense.

In summary, grizzly habitat requirements are determined by large spatial needs for omnivorous foraging, winter denning, aggressive behavior and security cover. Large roadless areas are ideal as year round grizzly habitat. However, grizzly bears can and do survive in roaded areas if tolerance for their presence is high. Home ranges must include a number of habitat types. Habitat needs vary for individual bears depending on their age and sex. These requirements may also vary annually with seasonal changes in foraging needs.

Population Dynamics

Grizzly bears are long-lived animals that range over large geographic areas. This trait makes it difficult to census and assess population levels. Capture and marking of grizzlies is expensive and dangerous for both researchers and bears. In conjunction, these issues result in limited sample sizes for statistical analyses. Thus, population estimates and dynamics calculations are often contested. Generally, researchers do not contest the facts that grizzlies have low reproductive rates and that grizzly populations are very susceptible to human impacts. Also recognized is that bear numbers are very sensitive to changes in female survival rates. For grizzlies in the Yellowstone area, breeding occurs in late spring with cubs born in the den the following winter. The average litter size is two cubs (range 1-4) and females produce cubs every third year. Age at first reproduction is generally 5.5 for females (range 4-7 years). Offspring remain with the female 2-4 years before weaning. Brown bears are promiscuous. Females mate with multiple males and may have a litter with offspring sired by different males. Males can sire litters with multiple females in a breeding season. Male bears are sexually mature around 5.5 years of age.

Rates of population change within the PCA are calculated using the Lotka equation. The solution to the equation relies on accurate measurements of parameters such as survival rates for various demographic classes of bears, age at first reproduction, rate of reproduction (a factor of litter size and frequency of litters), and life expectancy. The calculation of these parameters requires long-term monitoring of a representative subset of the population.

For the GYE, these parameters have been measured by the Craighead team for the pre-1970 population and by the IGBST after 1975. Thus, vital measurements are available for the same population before and after a significant decrease following the dump closures. Current information indicates the population in the PCA is increasing at 4+% per year.

As with all other bear population in the world, it is not possible to determine definitively the actual numbers of bears in the GYE. Therefore, any figure will be a result of some form of estimation. Estimated values have always been a matter of contention and many different estimates are found in the literature. Using garbage dump census data

collected by the Craighead team, and a census efficiency determined by ratios of collared to uncollared mortalities inside and outside Yellowstone National Park, the pre-dump closure bear population was estimated at 312 animals. This value is now the widely accepted figure for the population for this period. Taken in conjunction with the Craighead demographic data of 43.6% adults and 53.7% females, an adult female population of 73 may be determined for that same time period. Dump census data indicated that this population was growing at an annual average rate of 2.4%.

The population probably decreased by a factor of two, following closure of the dumps beginning in 1969. A minimum of 158 grizzly mortalities was recorded during and immediately after dump closures, between 1969 and 1972. The majority were killed in control actions, as bears were forced to exploit new sources of forage. The grizzly was listed as threatened under the ESA in 1975.

An apparent decline in this bear population continued through the 1980s. Researchers modeled continuing declines based on a downward trend in females with cubs-of-year (COY). They calculated a population decline of 1.8% per year and also concluded that age of first reproduction had increased from 5 to 6 years, and that average litter size had declined since dump closure. These changes were attributed to decreases in available food.

The tally of unduplicated females with COY is now accepted by the IGBC as the method to monitor population trend in the PCA. Females with COY are readily visible and uniquely identifiable. However, the tally is influenced by counting effort, seasonal cover, and the total number of animals. A standardized and conservative counting approach has been adopted to avoid duplication of females counted. These records have been maintained by the IGBST since 1973. Given a three-year breeding interval, a minimum adult female population is determined by summing three successive counts, which produces a three-year moving average. The average count for females with cubs observed during the period 1973-1982 was 12. This count suggests an average of 36 adult females in the population during that time.

Fortunately, the pessimistic predictions of the 1980s were unrealized. The models may have been based on assumptions that were too conservative. Management strategies designed to protect female grizzlies were largely successful which may have contributed to a reverse in the population decline. Researchers became cautiously optimistic that a population increase was occurring by 1987. Researchers calculated a rate of increase of 4.6% per year.

The female with COY count has been steadily increasing since the late 1980s. For the 2001 field season, a count of 42 was reported. This figure suggests an adult female population of over 100. For the year 2001, the IGBST reported a minimum population estimate of 361. Mean litter size appears to have returned to the same level as that for the pre-dump closure (2.0 cubs/litter).

The female COY tally for Yellowstone National Park has actually remained stable while the increase recorded is due to improved counting efforts in the GYE outside of the park. However, the data suggest a GYE total population increase and the whole ecosystem population figure is the key recovery parameter. A minimum population of 361 is greater than the pre-dump closure population suggested as down-listing target in the initial recovery plan in 1982. The current minimum estimate is also very conservative, and actual bear numbers are significantly higher. The USFWS 1993 Recovery Plan established additional demographic criteria for recovery, including females with cubs of the year, mortality limits, and occupancy requirements. Current information on these parameters and their relationship to recovery plan goals are shown in Tables 2 and 3. All of the regional demographic criteria are currently being met for this population.

Table 2. Annual count of unduplicated females with cubs-of-the-year (COY), and known and probable[a] human-caused grizzly bear mortalities within the Recovery Zone and the 10-mile perimeter, 1991-2001. Calculations of mortality thresholds do not include mortalities or unduplicated females with COY documented outside the 10-mile perimeter.

| | | | Human-caused mortality | | | Human-caused mortality 6-Year Running Averages | | | | U.S. Fish and Wildlife service Grizzly Bear Recovery Plan mortality thresholds | | | | |
| | | 6-Year Running Average Females with COY[b] | | | | | | | Minimum Population Estimate | Total human-caused mortality | | Total female mortality | |
Years	Unduplicated females with COY		Total	Female	Adult Female	Total	Female	Adult Female		4% of minimum population	Year Result	30% of total mortality	Year Result
1991	24	20	0	0	0	1.0	2.2	1.2	219	8.8		2.6	
1992	25	20	4	1	0	3.8	1.8	1.0	255	10.2		3.1	
1993	19	21	3	2	2	3.8	1.8	1.0	241	9.6	Under	2.9	Under
1994	20	21	10	3	3	4.7	2.0	1.5	215	8.6	Under	2.6	Under
1995	17	22	17	7	3	7.2	3.2	2.0	175	7.0	Exceeded	2.1	Exceeded
1996	33	23	10	4	3	7.3	2.8	1.8	223	8.9	Under	2.7	Exceeded
1997	31	24	7	3	2	8.5	3.3	2.2	266	10.7	Under	3.2	Exceeded
1998	35	26	1	1	1	8.0	3.3	2.3	339	13.6	Under	4.1	Under
1999	32	28	5	1	1	8.3	3.2	2.2	343	13.7	Under	4.1	Under
2000	37	31	16	6	3	9.3	3.7	2.2	354	14.2	Under	4.2	Under
2001	42	35	19	8	6	9.7	3.8	2.7	361	14.5	Under	4.3	Under

[a]Beginning in 2000, probable human-caused mortalities are used in calculation of annual mortality thresholds.
[b]Recovery Plan target 15 females

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Table 3. Bear Management Units in the Greater Yellowstone Ecosystem occupied by females with young (cubs-of-the-year, yearling, 2-year olds, or young of unknown age), as determined by verified reports, 1996-2001) (IGBST 2001)

Bear Management Unit	1996	1997	1998	1999	2000	2001	Years Occupied
1) Hilgard		X		X	X	X	4
2) Gallatin	X	X	X	X	X	X	6
3) Hellroaring/Bear		X		X	X	X	4
4) Boulder/Slough	X	X		X	X	X	5
5) Lamar	X	X	X	X	X	X	6
6) Crandall/Sunlight		X	X	X	X	X	5
7) Shoshone	X	X	X	X	X	X	6
8) Pelican/Clear	X	X	X	X	X	X	6
9) Washburn	X	X	X	X	X	X	6
10) Firehole/Hayden	X	X	X	X	X	X	6
11) Madison		X	X	X	X	X	5
12) Henry's Lake		X	X		X	X	4
13) Plateau				X	X	X	3
14) Two Ocean/Lake	X	X	X	X	X	X	6
15) Thorofare	X	X	X	X	X	X	6
16) South absaroka	X	X	X	X	X	X	6
17) Buffalo/Spread Creek	X	X	X	X	X	X	6
18) Bechler/Teton	X	X	X	X	X	X	6
Totals	12	17	14	17	18	18	Recovery Target Currently Met

Recovery plan target "16 of the 18 BMUs occupied by females with young from a running 6-year sum of verified sightings and evidence," and "no 2 adjacent BMUs shall be unoccupied." (USFWS 1993).

ISSUES AND ALTERNATIVES IDENTIFIED AND CONSIDERED

The following section presents the discussion of the issues identified from the scoping process, and follow-up meetings, described earlier. Within each section the issue is discussed along with FWP's preferred approach (identified by the statements preceded by a & at the head of each section) and any anticipated impacts and alternatives considered. Some issues presented here do not warrant specific actions. For those issues, no preferred or alternative approaches will be offered, and there will be no impacts described. This section concludes with a brief discussion of anticipated secondary and cumulative impacts of the program along with a discussion of irreversible/irretrievable commitments of resources.

FWP considered a "No Action" alternative beyond continuing existing programs and approaches to grizzly bear management, but a No Action alternative was rejected because the bear population will continue to expand under existing programs. Failure to modify the program would result in unnecessary conflicts and elevated risks to grizzly bears and to the people of Montana and its visitors, and would reduce the opportunity for future bear population increases.

While FWP recognizes that this approach deviates from formats used in many environmental impact statements, it is the wildlife agency's belief that the chosen format makes the document more useful to the public and those interested in grizzly bear conservation.

Before discussing the different issues and alternatives this plan addresses, it is important to keep the following overall perspectives in mind.
- Public support and tolerance for grizzlies is the key to their long-term recovery and re-occupancy of suitable habitats, and this support is contingent on local involvement and active local participation in plan development and implementation.
- All of the biological and social issues are interrelated, and no one part of the plan can function effectively without the others. For example, people intentionally feeding bears create enforcement problems, unnecessary bear mortalities, risk to human safety, property damage, and more.
- This plan does not presuppose habitat problems exist with bear reoccupancy, but instead approaches the issues with the perspective of making sure local people are involved and given sufficient tools to respond to management changes as need arises.
- The key to a broader recovery lies in bears utilizing lands that are not managed solely for them but in which their needs are adequately considered along with other uses. The plan also recognizes the pivotal role private-landowner support will play in a broader recovery.
- Preventative measures are much better than simply responding to problems; however, a great deal is unknown about how bears will utilize some of the available habitats.
- The plan must respond as changes occur and be open to public scrutiny and input.

Human Safety

➢ Bears that kill people will be removed from the population.
➢ Bears displaying unacceptable aggression, or that are considered to be a threat to human safety, will be removed from the population as quickly as possible.
➢ The major emphasis of the program will be on educating people about safety measures and preventing conflicts with people. An early warning system will be developed for use in years when natural foods may be limited and when the potential for conflicts are higher than normal.
➢ Information on safety in bear country will be provided in all big game hunting regulations.
➢ FWP will seek statewide expansion and enforcement of food-storage ordinances.

➢ FWP will work with county governments to require bear-proof garbage containers for homeowners in bear country.

Grizzly bears are large, powerful animals and, on rare occasions, can threaten human safety and life. To be successful in grizzly bear management, threats to human safety must be minimized to the extent possible. Threats to human safety, however, cannot be eliminated totally. Unfortunately, people make mistakes, which in turn can lead to conflicts with bears and increase risks to human safety. For example, by one individual failing to secure human foods from bears, it can start a chain of events that leads to a bear becoming ever more familiar with people and their dwellings. This elevates risks unnecessarily. Also, as time goes by without conflict, people can become complacent, and individual bears can alter their behavior for reasons known or unknown and cause injury or death to people. It is through awareness of the risk, and by responding accordingly, that support can be built for grizzlies in Montana and minimize the risks. If wildlife officials fail to respond adequately to concerns for human safety, there will not be local support for maintaining this species.

As grizzly bears in the GYE expand into new habitats outside the PCA, they will be expanding into habitats, which in large part are already occupied by people living, working, and recreating. With this expansion, the number of bear/human encounters will increase. These encounters could lead to injuries or death for both humans and bears.

Under Montana Statute 87-3-130, a citizen may legally kill a grizzly bear while acting in self-defense if the bear "… is molesting, assaulting, killing, or threatening to kill a person…" In the GYE during the period 1990-99, 22 grizzly bears were killed by individuals acting in self-defense. With the potential for increasing human/bear encounters, safety for both humans and bears becomes an important issue.

One purpose of this management plan is to minimize the potential for human-grizzly conflicts that could lead to injury or loss of human life, or human-caused grizzly mortality while maintaining traditional residential, recreational and commercial uses of the areas into which the grizzly is expanding. There is a possibility that certain types of human use may require modification, restriction, or prohibition to protect people, individual bears, reduce conflicts, or manage critical habitats. This is the same program FWP uses for other potentially dangerous species such as mountain lions or black bears.

Although there are a variety of situations that can result in a human-grizzly conflict, the primary categories are: 1) Food related -- improper food storage or sanitation in either a backcountry (hunter camp, hiker or other backcountry recreationist), rural (farm/ranch, cabin, church camp, etc.) or urban setting (subdivision, town); 2) surprise encounters -- females defending cubs, bears defending a kill/carcass, bears surprised in close quarters and acting defensively, etc.; 3) human encroaching on a bear's space -- photographer, tourist, etc., approaching a bear close enough to elicit a defensive reaction; 4) bears responding to a noise attractant -- bears attracted to a hunter

attempting to bugle or cow-call an elk, bears associating gunshots with a food source (carcass or gut pile), etc.

In summary, this plan recommends that any bears that have killed a human be removed from the population if they can be reasonably identified. FWP will use all available evidence from the incident to identify the bear(s) involved before removal. However, there are times where it may not be possible to determine this absolutely before management actions occur. Some people suggest that if evidence exists that the person precipitated the attack, for example by approaching and poking the bear, that the bear not be removed. Although this is considered an alternative, in FWP's judgment, allowing bears that have been known to kill someone to remain in the population will jeopardize local support. With effective management programs there will hopefully be very few of these incidents.

Strategies preferred to minimize or resolve human-grizzly conflicts include:
1. Inform and educate the public
2. Enforce food storage rules/regulation
3. Use of deterrents and/or aversive conditioning methods
4. Access management if needed
5. Management control
6. Hunting

Inform and Educate

People living, working and recreating in the PCA have been exposed to grizzly bears for decades. However, outside the PCA most individuals have less experience with grizzly bears. People in these peripheral areas will initially have a much lower comfort level relative to grizzly bears. In the past, bear safety information has often been based on fear of the bear. It is apparent that some people do fear the grizzly bear. Some of the concerns are based on worries that the presence of bears in new areas would reduce people's freedoms and safety while they are recreating and conducting economic activities.

Ideally, fear of the bear should largely be replaced by awareness or informed respect. Respecting bears and learning proper behavior around them will help keep bear encounters positive for both people and bears, and reduce the likelihood of negative encounters. Education is the key. Bear safety information should be based on the biology and behavior of the bear, on how to interpret bear behavior, and on how to prevent encounters. Information should address situations that cause the majority of human-bear conflicts: bear habituation to humans, bear use of human food sources, and close encounters. Bear safety information should be of a positive, non-alarmist nature and should target specific audiences -- hunters, hikers/recreationists, rural homeowners, livestock operators, rural communities, commercial interests (loggers, miners, resort operators), and others. Community involvement is also important in developing bear safety programs. FWP will work in partnership with communities located in bear habitat to develop/promote programs that prevent human-grizzly

conflicts. Some examples of the types of information available are found in the packet on the back cover of this document.

FWP will implement an early warning system to alert people who live, work, and/or recreate in bear habitat when natural foods are scarce and risk of conflicts may be correspondingly high. During years of drought and poor whitebark pine seed production, many grizzlies are forced out of secure habitat to lower elevations where they are more likely to come into conflict with people, livestock, and property. (During such times, human-caused grizzly deaths are more than four times higher than in good food years.) Special consideration should be given during poor food years to avoid conflicts and excessive mortalities, especially to females. FWP and other cooperators are currently implementing, and will continue to refine, a system to alert the public of higher risk of encounters during poor food years, and to redouble efforts to inform livestock operators, outfitters, and others of the need for careful conduct, including securing bear attractants to avoid problems.

Information will be delivered at FWP regional headquarters and license agents in Regions 2, 3, and 5 in a variety of ways including brochures, pamphlets, and guides made available to the public via media presentations (newspaper articles, TV spots, "Montana Outdoors" magazine, etc.). Public displays and presentations (slide shows/talks presented to schools, communities, sportsmen groups, sportsmen shows, etc.) will be presented by regional information officers, grizzly bear management specialists, and other FWP staff as requested or needed to address problems which may develop. Much of this information will also be made available through the Internet via the FWP website (**www.fwp.state.mt.us**). The International Association for Bear Research and Management (IBA) has produced a 50-minute bear safety video. This state-of-the-art video (*Staying Safe in Bear Country*) was written by bear biologists and is available to the public and for agency use from FWP.

Enforcement of Food Storage Rules and Regulations

Within the PCA the Forest Service has implemented food storage regulations designed to minimize bear-human conflicts (Appendix C). These regulations should be applied to all public lands statewide where bears may occur and should apply to anyone using these areas (loggers, miners and livestock operators as well as recreationists). FWP will seek to establish an MOU, or other appropriate agreement with the Forest Service and BLM, to expand the food storage order. FWP will work with the appropriate federal processes (NEPA, forest plan revisions, etc.) to accomplish this. It is also imperative that local interests are involved in expanding food storage orders to build necessary support and incorporate local knowledge and concerns.

On private land and in communities, church camps, resorts, and the like, people should be encouraged to use only bear-proof garbage containers. In British Columbia, some communities have revised waste laws making bear-proof garbage bins mandatory for residences and bear-proof container enclosures mandatory for all businesses. As recommended in this plan, local groups are the appropriate avenue for addressing

these concerns and developing necessary solutions. Communities will need to remain vigilant when dealing with food storage/waste storage problems. In our experience, these efforts are very successful. However, as time passes people can revert to behaviors that create problems. FWP will seek support from the Fish, Wildlife & Parks Foundation, as well as other foundations, to assist with these long-term programs.

Bear Repellents and Deterrents

Over the past decade considerable effort has been directed toward the development of non-lethal techniques for dealing with problem bears. Two promising techniques are repellents and deterrents. A repellent is activated by humans and should immediately turn a bear away during a close approach or attack. The most promising repellent is a capsaicin spray ("pepper spray"). Several brands have been developed which have been used successfully to repel attacking bears. These products are for defensive purposes only, and, to be effective must be sprayed at the bear's face (the eye area). People working and recreating in bear habitat should be encouraged to carry pepper spray. Information will be available as to what repellent products are available and how to use them properly. In addition, FWP will work with various private interests to make these more readily available (i.e. cost share, etc.) and provide training on proper use.

A deterrent should prevent undesirable behaviors by turning bears away before a conflict occurs. Where removal of an attractant isn't possible, electric fencing is an effective deterrent to prevent bears from accessing human food sources (garbage, food storage areas, livestock boneyards, etc.). Rubber bullets and hard plastic slugs are used to educate bears to avoid a particular area, usually when a bear is attracted to a human food source or when a bear becomes habituated to human activities. Dogs are used to deter bears from livestock and from backcountry work camps.

Aversive Conditioning

Aversive conditioning is non-lethal bear control used as an alternative to killing or relocating bears that become too closely associated with people. Aversive conditioning should modify previously established undesirable behavior through the use of repellents or deterrents. This conditioning must be repeated until avoidance of people or their property is firmly established. The primary goal of aversive conditioning is to train bears to avoid people and their activities. In recent years, the Wind River Bear Institute has developed the Partners in Life Program with a goal of providing for coexistence of humans and bears by preventing and reducing conflicts. The program uses highly trained Karelian bear dogs in combination with other deterrents (rubber bullets, cracker shell, etc.) to teach bears to change their undesirable behaviors. Problem bears are taught to behave properly and the public is educated to behave in a manner that prevents bear problems and their reoccurrence. The program has been used successfully on both black and grizzly bears in Glacier National Park, Yosemite National Park, several Canadian parks, and on private and public land in northwestern Montana and southwestern Alberta. FWP preferred approach will be to expand this program into southwestern Montana. It is also a flagship program for the FWP Foundation which

provides opportunities for general public support of these efforts. It should be noted that aversive conditioning is not always successful, and some individual bears will still occasionally need to be removed.

Management Control

Bears may become "habituated" to human activities (ignore nearby human activity) or become "food-conditioned" (consume human food or garbage). These bears may lose their fear of humans and no longer avoid people. Habituated, and especially food-conditioned bears, are most often involved in injury or death to humans. To deal with these issues, FWP preferred approaches are as follows: 1) If the bear is already habituated and/or food conditioned and is viewed as a threat to human safety, that bear would be removed (euthanized or relocated to a research facility/zoo). 2) Any bear causing human injury or death while acting in a predaceous manner, will be destroyed. 3) A bear displaying aggressive, but non-predaceous, behavior will not necessarily be removed, depending on the circumstances of the encounter and the sex, age and reproductive status of the bear.

Nuisance bears that have not yet become habituated or food conditioned may be candidates for either: 1) trapping and on-site release accompanied by aversive conditioning, 2) on-site aversive conditioning without trapping, or 3) trapping and relocation. Relocation is the least desirable option. Relocated bears often return or cause problems in another area and ultimately have to be destroyed.

Hunting To Address Human Safety Concerns

FWP believes hunting can play a role in addressing human safety issues. FWP therefore prefers to include this tool in the management program. Properly conducted hunting programs can impact the behavior of the hunted population, making them wary of people. This occurs by changing the hunted animals' behavior making them avoid people. Over time it also provides a selective pressure, at low levels, on animals that exhibit behaviors such as a lack of wariness that makes individuals vulnerable to hunters. This results in a more wary population over time. It also promotes survival and acceptance of potentially dangerous animals by those directly impacted by the presence of grizzly bears. The avoidance behaviors hunted animals exhibit may be unfamiliar to some people, but FWP's experience with managing wildlife indicates they are real. One example is to notice how easily elk are approached in Yellowstone National Park and how difficult it is to get as close to them where they are hunted. These avoidance behaviors include fleeing, hiding, or being active when people are not, all of which will promote better acceptance of grizzlies. Other reasons for hunting as part of the program are discussed later in the plan.

Habitat/Habitat Monitoring/Management of Human Use of Bear Habitat

This management plan recommends coordinated monitoring of major grizzly bear food sources and consulting with land management agencies on issues related to grizzly

bear habitat protection, disturbance, and mitigation. It is important to note that these efforts benefit many species in addition to bears.

➢ FWP will continue to cooperate with other members of the IGBST in a coordinated effort to collect and analyze habitat data.
➢ FWP will work with land management agencies to monitor habitat changes in a manner consistent with its overall approaches for all other managed species.
➢ FWP will continue to use statewide habitat programs to conserve key wildlife habitats in southwestern Montana.
➢ FWP will identify and monitor whitebark pine, moth aggregation sites if identified, and other key foods such as ungulate population levels.
➢ FWP will recommend that land-management agencies manage for an open-road density of one mile or less per square mile of habitat consistent with FWP's statewide Elk Management Plan guidelines.
➢ FWP will support keeping existing inventoried roadless areas in a roadless state and work with local groups and land managers to identify areas where roads could be reclaimed.
➢ FWP will work with the Department of Transportation to address wildlife crossing needs on their projects. An MOU or other agreement may be developed to provide guidelines to enhance the ability of bears and other wildlife to cross roads.
➢ FWP will monitor coal bed methane activities, and other oil and gas projects, and address grizzly bear needs in these permitting processes.
➢ FWP will work with local groups to identify and promote habitat characteristics that benefit bears such as maintaining core areas or working with county planners in important habitat areas.

Because grizzly bears are omnivorous and opportunistic they are often able to survive in a variety of habitats and utilize a variety of foods. Grizzly bear expansion and population increase is expected to be focused initially on areas in the GYE during the timeframe of this plan (10 years). Therefore, FWP will focus its grizzly bear habitat management activities in areas that are adjacent to, and being reoccupied from, the PCA within the GYE. FWP will also begin to evaluate other areas that may be occupied with the ongoing expansion of the grizzly bear population and evaluate them for needed habitat programs.

Four major food sources used by bears inhabiting the GYE are whitebark pine (*Pinus albicaulis*) seeds, army cutworm moths (*Euxoa auxiliaris*), winter-killed large ungulates (elk and bison), and spawning cutthroat trout (*Oncorhynchus clarki*). While the existence and abundance of these food sources has been well documented inside the PCA, there is less documentation for the areas outside the PCA. Existing data indicates that winter-killed large ungulates and spawning cutthroat trout are less available to grizzly bears outside the PCA. However, neonate ungulates may be more available in these areas. Therefore, FWP will direct monitoring of major grizzly bear foods toward whitebark pine and army cutworm moths if any are identified. Ungulate populations and cutthroat trout will be monitored using data collected during FWP annual fish and

ungulate population and trend surveys. If it appears that bear use of these or other food sources is important, monitoring protocols will be implemented.

FWP, in cooperation with the appropriate federal agencies, will survey selected whitebark pine stands and identify any army cutworm moth aggregation sites using existing methodology implemented by the IGBST within the PCA. Whitebark pine stands will be identified and monitored for seed production, tree health (evidence of blister rust, *Cornartium ribicola*), and evidence of bear use. Any identified moth aggregation sites will be monitored for use by bears. Bear activity at moth aggregation sites is an indirect indicator of presence or absence of moths during a given year.

Security cover, the ability of an environment to protect against threats and disturbances, is another important component of habitat. Grizzly bear habitat can be impacted by a reduction of security cover as the direct or indirect result of various human activities, land management practices, and natural phenomenon including recreational development and primary roads, restricted roads and motorized trails, human use, oil and gas development, logging practices, and forest fires.

FWP recognizes the need to minimize negative impacts. Other than on FWP's own wildlife management areas, FWP is not the decision maker on federal or State School Trust lands. However, FWP works closely with these land management agencies to minimize negative impacts on fish and wildlife. Additionally, FWP is considering grizzly bears in comments and discussions regarding land management activity in occupied grizzly bear habitat, whether inside or well outside the PCA.

FWP has strong private land habitat initiatives. Most are funded through earmarked accounts and include Montana's Migratory Bird Stamp (dollars directed toward wetland riparian areas), Upland Game Bird Habitat Enhancement Program (dollars go primarily towards enhancing via good management shrub/grassland communities) and Habitat Montana. Specifically, Habitat Montana allows FWP to conserve habitat on private lands via lease, conservation easements (purchased) or fee title acquisition. This program is not directed at specific species but rather at conserving Montana's most threatened habitats, i.e. wetlands/riparian areas, shrub/grasslands, and intermountain foothills. Habitat Montana funds have been used to conserve habitat in the Yellowstone system via the Northern Range acquisition, Gallatin Lands Consolidation Program, and three conservation easements along the west face of the Madison Mountain Range in the Madison Valley. All of FWP's habitat conservation projects in the GYE have included components of important grizzly bear habitat. Because of the subdivision threats, efforts to conserve habitat in this portion of Montana will continue to be a FWP priority.

The intermountain valleys between major mountain ranges of southwestern Montana are primarily private land. These private lands are vital to the area's agricultural economy and provide important habitat for a variety of fish and wildlife. As agricultural land, they also provide a wide range of opportunities for wildlife to live and travel between mountain ranges. Major highways bisect most of the intermountain valleys.

FWP reviews subdivisions, applies land conservation programs like Habitat Montana, and works with Montana Department of Transportation on mitigating barriers to crossing transportation routes to build tolerances in finding ways for wildlife, including grizzly bears, to "fit" on private land.

This approach, currently used for other species, is very effective.

Specific Habitat Guidelines

A general statement of the approach FWP pursues when dealing with habitat issues is as follows: FWP seeks to manage all fish and wildlife habitat on public land, whether roaded or unroaded, as valuable and unique lands that will remain open to hunters, anglers, and other public users. Accessibility to public lands will be balanced with the year-round requirements of fish and wildlife (habitat, clean water, food, shelter, open space, and disturbance management), while maintaining a functioning road system, including keeping inventoried roadless areas roadless (with science-based exceptions made for forest health, restoration, and other national needs). By implementing this program we can maintain grizzly bears while still providing for other appropriate uses. Reasons for the decline of brown/grizzly bears in North America are excessive human-caused mortality and habitat loss. Habitat loss results from conversion of native vegetation to agriculture, depletion of preferred food resources (i.e. salmon and whitebark pine), disturbance, displacement from human developments and activities (roads, mines, subdivisions), and fragmentation of habitat into increasingly smaller blocks inadequate to maintain viable populations and connectivity.

Management

Radio telemetry studies have identified roads as significant factors in habitat deterioration and increased mortality of brown/grizzly bears. Areas of adult female displacement by roads and development totaled about 16% of available habitat in Yellowstone National Park. The percentage of habitat loss as a consequence of behavioral displacement from roads is a function of road density. The percentage is higher in areas having higher road density regardless of the distance at which roads affect bear behavior.

The distance at which bears appear to be displaced by roads varies in different areas and seasons. Correspondingly, the impact of roads on displacement from preferred habitats is greatest in spring. During fall, bears tend to move to higher elevations to forage. At this time they select habitats that are typically more distant from existing roads. Consequently, the importance of disturbance displacement by roads is less evident during fall than during spring. Level of traffic also appears to influence degree of bear avoidance of roads.

Bears living near roads have higher probability of human-caused mortality as a consequence of illegal shooting, control actions influenced by attraction to unnatural food sources, or by being mistakenly identified as a black bear by hunters.

FWP will seek to maintain road densities of 1 mile or less per square mile of habitat as the preferred approach. This is the goal of our statewide elk plan (including the southwestern Montana areas covered by this plan). The goal seeks to meet the needs of a variety of wildlife while maintaining reasonable public access. If additional management is needed based on knowledge gained as bears reoccupy areas, it should be developed and implemented by local groups as suggested in this plan.

The following general management guidelines are applicable coordination measures. They should be considered when evaluating the effects of existing and proposed human activities in identified seasonally important habitats for a variety of wildlife species including grizzlies on federal and State lands.

1. Identify and evaluate, for each project proposal, the cumulative effects of all activities, including existing uses and other planned projects. Potential site-specific effects of the project being analyzed are a part of the cumulative effects evaluation which will apply to all lands within a designated "biological unit". A biological unit is an area of land which is ecologically similar and includes all of the year-long habitat requirements for a sub-population of one or more selected wildlife species.
2. Avoid human activities, or combinations of activities, on seasonally important wildlife habitats that may result in an adverse impact on the species or reduce the long-term habitat effectiveness.
3. Base road construction proposals on a completed transportation plan which considers important wildlife habitat components and seasonal-use areas in relation to road location, construction period, road standards, seasons of heavy vehicle use, road management requirements, and more.
4. Use minimum road- and site-construction specifications based on projected transportation needs. Schedule construction times to avoid seasonal-use periods for wildlife as designated in species-specific guidelines.
5. Locate roads, drill sites, landing zones, etc., to avoid important wildlife habitat components based on a site-specific evaluation.
6. Roads that are not compatible with area management objectives, and are no longer needed for the purpose for which they were built, will be closed and reclaimed. Native plant species will be used whenever possible to provide proper watershed protection on disturbed areas. Wildlife forage and/or cover species will be used in rehabilitation projects where appropriate.
7. Impose seasonal closures and/or vehicle restrictions based on wildlife, or other resource needs, on roads that remain open and enforce and prosecute illegal use by off-road vehicles if given authority. FWP will actively work to secure authority through the appropriate process and identify funding to support enforcement efforts.
8. FWP supports the U.S. Forest Service and BLM restrictions banning all motorized off-road/trail use.
9. Efforts will be directed towards improving the quality of habitat in site specific areas of habitually high human-caused bear mortality. Increased sanitation measures, seasonal road closures, etc., could be applied.

One alternative suggested was to expand the current higher level of habitat restrictions and programs in place in the PCA to bear-occupied areas outside the PCA. It is FWP's judgment that this approach would not generate social acceptance for the bear and its further recovery. Incorporating the grizzly as another component of FWP's ongoing programs for all wildlife is a more productive approach. In addition, the approach outlined in this plan does allow FWP to modify the program, if necessary, and adapt the program in the future as more is learned.

FWP recognizes that habitat changes in the PCA (loss of whitebark pine, etc.) could result in increased importance of habitats outside and will respond to those changes if they occur.

Population Monitoring

- For grizzly bears, like most species, density (number/unit area) is a key population parameter, and FWP will estimate densities using the best available data from research, distribution changes, DNA samples, and more.
- FWP will monitor unduplicated females with cubs in the PCA and outside.
- FWP will monitor mortality including timing and causes and gather survivorship data in cooperation with the IGBST.
- FWP will use verified sightings to document changes in bear distribution. They would include DNA samples, photographs, sightings by reliable observers, tracks, and more.
- FWP will conduct research in cooperation with other entities to obtain more detailed population information where needed.
- Monitoring will be coordinated with other states and information collected within the PCA by the IGBST as part of a cooperative effort and presented in annual reports.
- This effort will be conducted by, and coordinated between, FWP's wildlife biologists and bear management specialist, with assistance from IGBST.
- Population trend, in combination with habitat conditions, demographics, human/bear conflicts, social tolerance, and research findings, will be FWP's guide to decisions regarding population management.

The bear management units (BMU's) established for the PCA are used for more intensive management of those areas. Analysis units will be established outside the PCA. These units will be used to collect and analyze demographic and occupancy data on grizzly bears by geographic area. FWP anticipates these units will be mountain ranges or groups of ranges similar to those currently used for black bear management. However, if information from bears outside the PCA indicates a change is required, the units will be modified as needed. These units will be created solely for the collection of demographic data and will not of themselves generate any new habitat restrictions.

In order to maintain consistency in data collection and compare grizzly bear population parameters inside and outside of the PCA, monitoring protocols will be similar, but the sampling may vary depending on the survey area. Monitoring of unduplicated females with young may be used as an index to assess population trend or abundance over

time. The data are currently used to estimate a known minimum and total population size for the PCA. The number of unduplicated females are summed over a 3-year period and divided by the known percentage of females (27.4%) in the population to achieve a minimum population estimate. It should be noted that this is a very conservative approach to assessing this population parameter. This minimum population estimate has been used to set mortality thresholds for all human-caused mortalities. The data can also be used to generate a total population estimate. The IGBST has evaluated different statistical approaches and monitoring techniques that will allow agencies to estimate total population size for this population of bears. FWP will continue to review this information and use it and other data in the ongoing management programs.

Radio-marking techniques to estimate population size are not broadly applied outside of Alaska because of the expense associated with capturing bears within heavily forested habitats where bears can't often be spotted from an aircraft. Many researchers in Canada and the United States are focusing on "hair-snaring" techniques to estimate number and density of grizzly bears. With this procedure, bears are attracted to sampling stations with a scent lure. At each sampling station, barbed wire is strung between trees and when the bear passes under the wire, a small tuft of hair is snagged. The follicles from these hair samples contain DNA, which can be used to identify individual animals. This technique is conceptually similar to techniques developed to identify bears based on photos taken when bears trip cameras. Advantages of the DNA and camera techniques include reduced need to mark bears or see them from aircraft. However, these techniques are labor-intensive, expense, and typically have problems identifying the area inhabited by the estimated population. This closure problem creates difficulties in estimating density. So far, the DNA and camera techniques are not standardized for design or data analysis, hence results from different areas may not be comparable. In Glacier National Park, U.S. Geological Survey researcher Kate Kendall has conducted the most extensive effort to estimate grizzly bear abundance using hair-snaring and DNA analysis. Although her research is in progress, she has identified a minimum number of different individuals (>200) in Glacier National Park and vicinity that is larger than previously suspected.

Estimates of density frequently have problems associated with differential inclusion of age or sex groups. Because newborn cubs have high mortality rates, estimates made early in the year will be larger than estimates made later in the year for the same population. Closure problems may result in overestimation of males, the more mobile sex, in a density estimation area. FWP, when attempting to estimate bear density, will be aware of these sources of potential bias and specify which sex and age groups occur in density estimates. With DNA hair-snaring techniques, efforts are made to exclude cubs by setting the barbed wire too high to snag their hair. Regardless, some cubs leave hair samples behind, and some bears less than 1 year old may be able to go under the barbed wire without leaving hair. The age of a bear is not revealed by DNA analyses. The Alaska capture-mark-resight technique avoids most of these problems, but is useful only in areas where bears may be readily seen and may be difficult to apply in habitats with a forest overstory.

Management/research trapping and radio collaring provide necessary data on grizzly distribution, movements, and home ranges. Data collected will include estimation of seasonal, annual, and lifetime home ranges, identification of important seasonal habitats and foods, potential travel or linkage corridors, extent of occupation, and denning sites. Distribution of bears will be determined by using any or all of the following methods: hair corrals, observation flights, telemetry flights, nuisance activities, and verified sightings.

Survivorship data will also be obtained, if funding is available, via aerial and ground telemetry of radio-collared bears. These data are used to determine average life expectancy by sex and age class, causes of mortality, etc., for bears that inhabit different portions of the ecosystem. All suspected human-caused mortality will be investigated by FWP personnel to determine cause of death. These mortalities will be recorded and the information used, along with other mortality data, in the management of the population. This survivorship information will be fundamental to addressing the issue of the potential differences in survivorship of grizzly bears in the PCA, where there are extensive habitat protections, versus bears that live on multiple use areas outside the PCA. In addition, we recognize that no one factor can provide the needed information to assess population size and trend. Ultimately any assessments will result in some level of estimation and extrapolation for management purposes. This is the same approach FWP has used successfully for many other species of wildlife. To assure that our assessments of population size and trend are adequate, we will review the following in making our judgements.

1. Federal laws and regulations may have major influence on the bear population. For example, changes are currently being developed in travel plans/forest plans that will affect bear conservation.
2. A systematic method to survey public and professional sectors and their perceptions of population trends may be developed.
3. Public opinions and perceptions from annual tentative season meetings will be solicited and evaluated.
4. Results of population and habitat research will be consulted. Specific changes in age structure, unreported mortality from marked bears, population densities, habitat use, and habitat quality will be considered.
5. Major changes in human use of management areas will be evaluated. Because Montana's grizzly bears are linked to those in Wyoming and Idaho, land use changes in those states will be monitored as well.
6. Changes in the population status in Yellowstone National Park and Grand Teton National Park will be gathered through discussions with the appropriate management agency.
7. Changes in state and federal road closure policies will be evaluated because they influence the number of grizzly bears susceptible to mortality.
8. The realized or perceived changes in the price of grizzly bear parts will be evaluated. Such changes may affect the level of profiteering.

9.	An attempt will be made to document grizzly bear range expansions or contractions through data gathering. This data will help evaluate changes in the population status.
10.	Based on all available evidence, changes in management areas or management unit boundaries will be evaluated.
11.	The number of control actions will be determined annually. If a trend is apparent in four or five years of analysis, then the program will be re-evaluated and adjustments made to ensure the population is not being excessively impacted. The number of transplants from, or into, the ecosystems will be documented.
12.	Grizzly bear management policies in Wyoming and Idaho will be evaluated in relation to FWP policies. If excessive mortality is occurring in a neighboring state, the FWP program will be adjusted to ensure survival of the population, and FWP will work with that state to reduce mortality.
13.	Evaluation of mortality statistics will be conducted. It is recognized that not all bear deaths are detected and recorded. FWP will, however, try to be as complete as possible. The following mortality statistics are of particular importance:
	a.	Male/female sex ratio.
	b.	Median age of harvest should any occur: median ages should be calculated separately for males and females.
	c.	Determine total mortality: trends in total number of bears should be evaluated in conjunction with other population estimates and/or statistics to determine if changes in mortality quotas are needed. It is anticipated that human caused mortality quotas will be very conservative at 4% or less of the total population on a 6 year running average with no more than 30% females to allow for continued increased populations. This recommendation is based on past experience with grizzly bear management in northwestern Montana as reported in the Programmatic EIS for that area and subsequent updates.
	d.	A summary of mortality from 1992-2001 is presented in Table 4.
14.	Annually monitor, record, and evaluate litter sizes throughout the ecosystems.
15.	Evaluate hunter effort if a hunt occurs. Changes in hunter effort, location of hunt, etc., will substantially aid interpretation of population statistics.

Table 4. Grizzly bear mortalities in southwest Montana, 1992-2001.

CAUSE:	YEAR										Total	% of Total
	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01		
Natural	1	0	0	0	0	1	0	1	0	0	3	8
Livestock Depredation	0	0	0	0	0	0	2	0	0	0	2	5
Unknown	0	1	0	0	1	0	0	0	1	0	3	8
Illegal	1	0	2	1	0	2	0	0	0	0	6	15
Self-Defense/Hunting	0	1	1	2	1	2	0	0	2	0	9	22
Unnatural Food	1	0	3	5	4	0	0	0	1	3	17	42
Total	3	2	6	8	6	5	2	1	4	3	40	100

As an alternative, FWP has considered the collection of population data in a manner that would provide statistically precise population estimates. For a slowly reproducing species like grizzly bears in which even a maximum lambda will always be close to 1.0 (meaning the populations don't fluctuate greatly on an annual basis), it will seldom be possible to have a 95% confidence interval that does not overlap 1.0. However, in FWP's judgment, using the weight of evidence collected in different ways and multiple sources is a more practical and meaningful approach for assessing population trend. Population trend will be FWP's guide to management decisions.

Future Distribution

➢ FWP expects grizzly bear distribution to continue to increase.
➢ FWP views linkage as providing opportunities for bears to naturally reoccupy suitable, but unoccupied habitat, and will continue to work with Idaho, Wyoming, and the IGBC to address this issue.
➢ Areas of potential focus to address problems with movement of bears are the Madison and Paradise valleys, Gallatin Canyon, Bozeman Pass, Centennial Valley/Range west to Monida Pass, Upper Madison/Raynold's Pass area.

Current information demonstrates that the distribution of bears in the GYE is increasing. The most recent review of the distribution of grizzly bears in the GYE by the IGBST demonstrated occupancy well beyond the original recovery zone (PCA) (Fig. 3.) A comparison of the current distribution from the 1990s to previously published distribution maps showed an approximate increase in occupied habitat of 48% and 34% from the 1970s and 1980s, respectively. This expanded distribution has also been noted by others (Fig. 4). It should be noted that these boundaries should be interpreted as a fuzzy approximation, and additional supportive evidence should be considered when making judgments about occupied habitat near the edge.   Based on current programs, both within and outside of the PCA, it is expected this trend will continue during the

period covered by this plan. Data from the composite home range of all marked bears in the GYE for 1980 and 1999 also demonstrate this trend and can be used to estimate potential future changes in distribution (Fig. 5). FWP recognize that distribution changes beyond the PCA and its immediate environs may occur at a somewhat slower pace. It is FWP's intent, however, to implement this management plan in a way that future expansion in distribution is allowed to continue. If the expected increase in distribution does not occur, FWP will evaluate, in conjunction with local work groups, the opportunity for translocation of surplus non-nuisance animals into suitable habitats to support distribution increases. This approach is consistent with that used for all of the species FWP manages. Because distribution is currently increasing without translocation, FWP does not anticipate that this would occur in this planning cycle.

Finally, there has been and continues to be debate on the potential for linking the various segments of the grizzly bear populations in Montana. The potential for this to occur is demonstrated by various assessments of habitat, which are ongoing and, evidenced by the information our agency provides the public on areas, where even today there is the possibility of encountering a grizzly bear (Fig. 6).
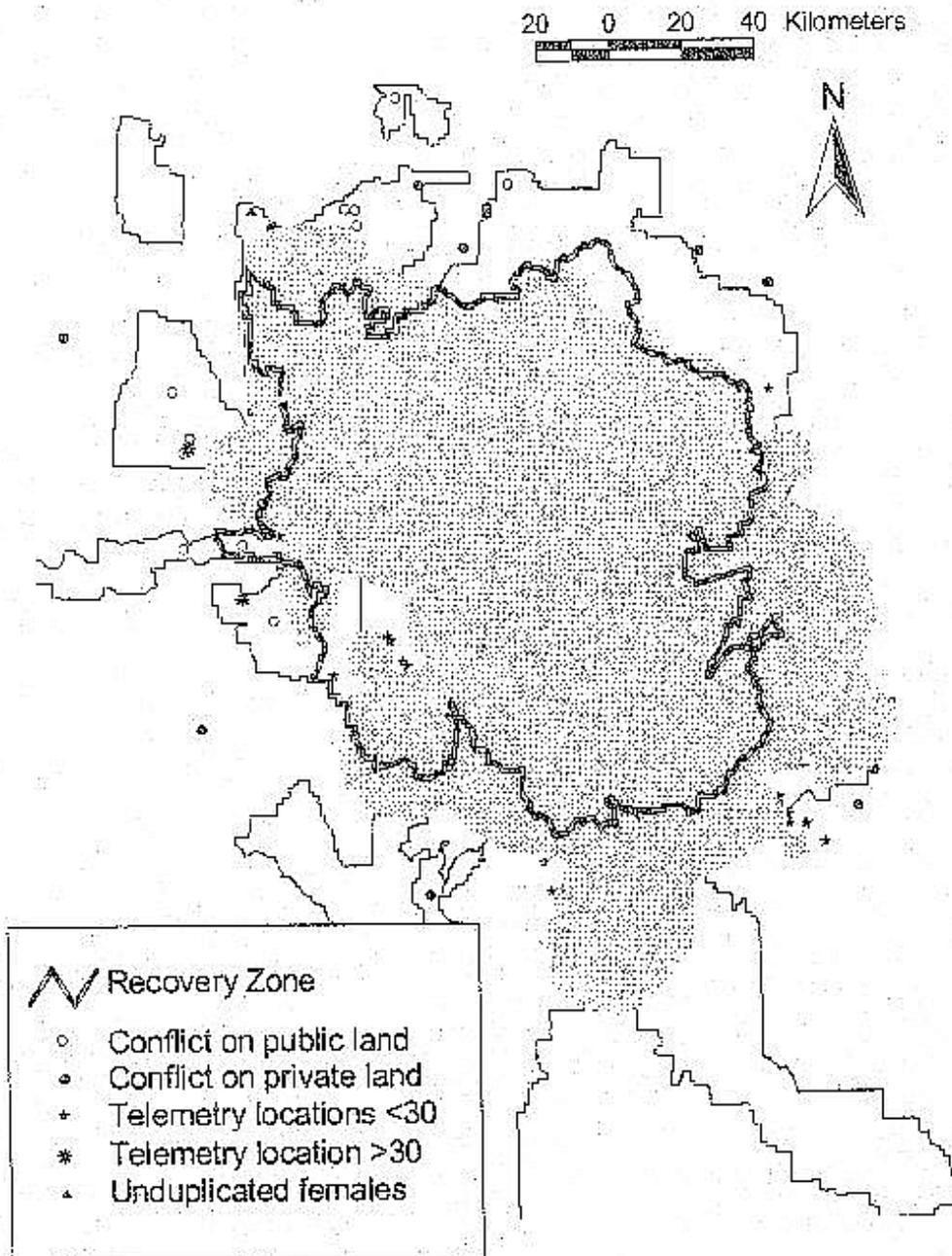
Figure 3. Grizzly bear distribution in the Greater Yellowstone Ecosystem, 1990-2000. Map represents the outer edge of a composite polygon constructed by overlaying fixed kernel ranges constructed from (1) observations of unique unduplicated females with cubs of the year, (2) relocations of radio-collared bears, (3) locations of grizzly bear-human conflicts, confrontations, and mortalities. Points represent data not contained within this coverage.
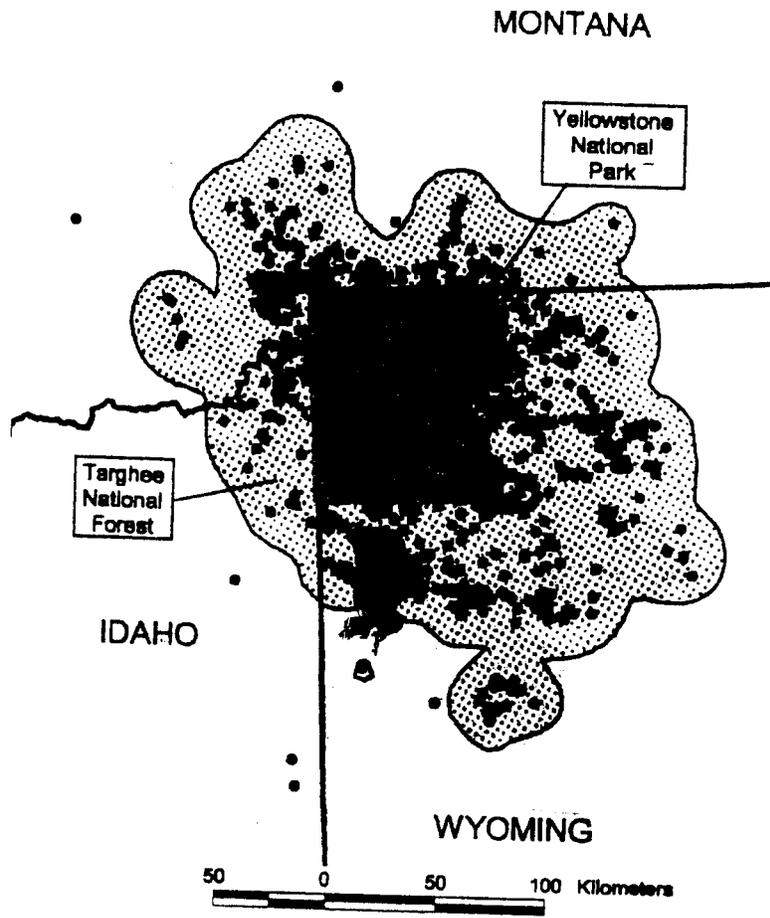
Figure 4. Grizzly bear distribution in the GYE from Bader, M. Northwest Science, Vol. 74, No. 4, 2000.
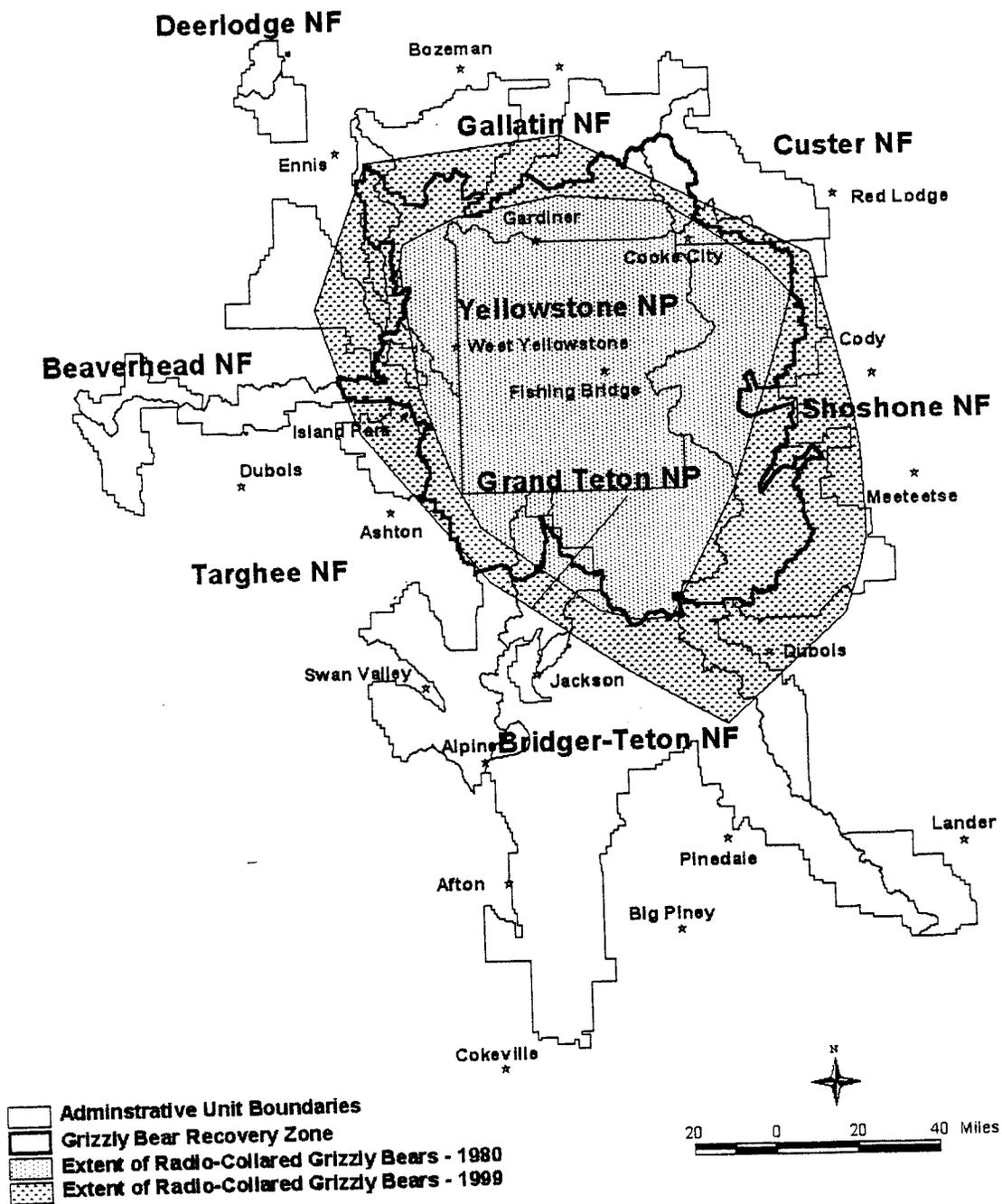
Figure 5. Grizzly bear distribution from information on radio-collared animals.

Figure 6. Light gray = areas occupied by black bears. Dark gray = areas with the potential to encounter grizzly or black bears in Montana.

There is currently a great deal of discussion and work aimed at addressing and defining "population linkage." The IGBC is currently creating two linkage-zone working groups to further address this issue. Generally, a linkage zone is an area between two areas of habitat where animals can live at certain seasons and where they can find the security they need to move between these areas. Linkage zones are broad areas of seasonal habitat where animals can find food, shelter, and security. The long-term health of populations of carnivores will benefit from linkage and population interaction at broader levels. These linkage areas can likely serve multiple carnivore species as well as other wildlife species such as ungulates. Dramatic changes are currently occurring in the remaining possible linkage areas due to ongoing human development and the time to maintain connection opportunities is growing short due to development of some of these lands. A linkage zone, however, is not a "corridor". A corridor implies an area just used for travel, however movement between ecosystems by carnivores rarely if ever occurs this way. For carnivores to get between ecosystems they require habitats that can support their feeding and behavioral needs in these intervening areas. As such, linkage zones are areas that will support low-density carnivore population often as seasonal residents. There are several models which attempt to address this issue, notably by

American Wildlands "Corridors of Life" and Craighead Environmental Research Institute as well as by the U.S. Fish and Wildlife Service (the Yellowstone Area model is not yet complete). These models use Global Imaging Systems (GIS) to predict the broad areas of highest potential for linkage between habitat units for various carnivores. Each model has different assumptions. The main assumption is that human activities determine wildlife distribution in disturbed areas. Models generally look at road density, human developed sites (i.e. houses, campgrounds) and the influence zone around them, presence or lack of vegetative hiding cover, and presence of riparian zones. Linkage zone models are used to predict where grizzly bears and other wildlife species, particularly large carnivores, are most likely to cross between large blocks of public land in the northern Rocky Mountains. These predictions are based on the assumption that movement is most likely to be successful where human activity is least. This does not mean that grizzly bears and other species will not try and cross other areas. The linkage zone concept is based on maintaining and enhancing movement possibilities in areas where such movement is most likely to be successful. The most critical element of these reviews is the pivotal role that private landowners will play in maintaining these areas. Clearly, FWP must meet their needs to engage them in these programs.

It is FWP's long-term goal to allow the populations in western Montana to reconnect by occupying currently unoccupied habitats. FWP anticipates that successful implementation of this plan, along with adequate local involvement, can allow this to occur. In the near term, FWP needs to address those land-use patterns that promote or hinder bear movement. Focus areas currently are the Bozeman Pass area, the Gallatin Canyon, and Madison and Paradise valleys. FWP currently uses habitat programs in these areas to provide for wildlife needs and anticipates additional efforts with the Department of Transportation to address issues of wildlife movement across roads (especially Interstates 90 and 15; and Highways 287, 191, 89, and 20). FWP will also work with landowners and private interests to promote programs that provide for wildlife access to private lands. In summary, FWP's goal is to expand recovery in southwestern Montana.

An alternative considered was limiting grizzly bear distribution to just the PCA. However, in FWP's judgment this approach is logistically impossible and biologically undesirable. In order to maintain resiliency in the population to changes in habitat, tolerance levels and other factors, bears need to be allowed to occupy a broader landscape. Also, bears cannot be confined to the PCA because there are no barriers to contain them, and it is impossible to know the location of every animal all the time.

Trails

➢ FWP will gather information on trail use both within and outside the PCA. In the absence of good data, management programs trend toward extreme solutions. For example, if trail use creates problems only at specific times, it may be possible to accommodate use at other times. Conversely, without season and intensity of use information, FWP will be unable to make such determinations.

➢ All FWP trails projects will be reviewed by area biologists and grizzly bear concerns addressed.
➢ Federal trails programs are currently being adjusted, and FWP is participating in and supporting those efforts. FWP will seek Forest Service and BLM support of its programs/data gathering.
➢ Adjustments to trail access and uses should be developed through local citizen involvement using the best available science.
➢ FWP will evaluate snowmobile programs to ensure they avoid impacting grizzly bears during denning periods, including den entrance and emergence.

Major changes are currently underway to address the issue of trails, trail management, off-road vehicle use, and how they affect wildlife, including bears. Many people, including sportspersons, have recognized the need for change. Working with other management agencies; trails, including snowmobile trails, could be rerouted, seasonally closed, or closed entirely if impacts prove significant.

Effective July 1, 2001, motorized, wheeled cross-country travel is prohibited on National Forest lands yearlong. The purpose of this restriction is to protect riparian areas, wetlands, crucial wildlife habitat, threatened or endangered species, soils and vegetation, aquatic resources, and/or to reduce user conflicts. The policy affects any motorized, wheeled vehicle, but not snowmobiles. Under the new policy, motorcycles may use a single-track trail or road if it is open to motorized vehicles, but ATVs and other four-wheeled vehicles cannot use that single-track road or trail. Several exceptions will apply. Cross-country travel will continue to be allowed for military needs, fire suppression, search and rescue, or law enforcement vehicles in emergencies. Forest users can also drive cross-country to campsites within 300 feet of existing roads or trails, after locating their campsite in a non-motorized fashion. As part of the decision, national forests will identify areas where more detailed local travel plans should be developed. FWP, local groups, and other interested parties should be active participants in such plans.

FWP has developed an Environmental Impact Statement on the trails program. This document recommends that all trail activities be coordinated with a biologist to avoid unacceptable impacts to wildlife. These processes are underway because changes in technology of off-road vehicles including snowmobiles has dramatically changed use patterns on public lands. These issues are being addressed, and it is FWP's intention that the needed changes to programs will also be developed and implemented with involvement of local citizens.

An alternative considered was to deal with bear specific trail restrictions prior to reoccupancy. However, in our judgement, this approach would result in unnecessarily impacting user groups without clear evidence of a problem. FWP's efforts on this issue are intended to build higher levels of social acceptance across user groups while still providing the necessary mechanisms to respond should problems occur.

Livestock Conflicts

- Wildlife Services will continue to be the lead agency dealing with livestock depredation (MOU Appendices D and E).
- FWP focus will be on preventive programs to minimize livestock conflicts with priority toward those areas with a history of conflict or currently occupied by bears.
- FWP will work with beekeepers to provide electric fences for all apiaries accessible to bears, and FWP will re-evaluate the guidelines for bear depredation to beehives and modify if needed.
- FWP will encourage private funding for compensation of livestock loss.
- FWP will respond to conflicts within 12 hours with at least an initial contact by telephone or in person if possible and in cooperation with Wildlife Services.

Livestock operators provide many benefits to the long-term conservation of grizzly bears, not the least of which is the maintenance of open space and habitats that support a wide variety of wildlife, including grizzlies. At the same time, they can suffer significant losses from bears. These losses tend to be directed at sheep and young cattle. In addition, honey bees are classified as livestock in Montana, and apiaries can be significantly damaged by bears. Our ability to deal with this issue will, in large part, determine the overall success of our grizzly management efforts. Currently, issues of livestock depredation are dealt with by Wildlife Services, and FWP anticipates this will continue. It is FWP's intent, however, to try and focus future programs and efforts on prevention of conflicts where possible. The agency envisions programs where landowners can contact FWP's grizzly bear management specialist for assistance with assessments of risks from bears and possible preventative approaches to minimize those risks. FWP will work to provide landowners and beekeepers with the appropriate tools (ex. electric fencing, aversive conditioning, guard dogs, etc.) to minimize conflicts. In addition, FWP will work to develop programs that provide private livestock operations with additional benefits if they implement preventive approaches and maintain opportunities for wildlife, including bears, on their private lands and their public-land allotments. Working with other agencies and interests, the possibility of transferring grazing leases from areas of high conflicts to other areas with willing landowners/operators is another option. In this way, the program and its benefits are focused on operators who make an effort to address the concerns and issues that result from the presence of grizzlies. Also, as a long-term goal FWP will seek to enclose all bee yards in areas accessible to bears with electric fencing. Electric fencing is very effective at deterring both black and grizzly bears, and use of this technique can significantly reduce problems and the need to remove bears. FWP will work with the livestock industry to identify sources of funding to accomplish this. Additional efforts will be made to identify possible funding that could be used to support staff whose sole responsibility would be to develop/implement preventative programs. These personnel should also be available to any livestock operation when requested to assess potential depredation risks and identify possible solutions prior to any depredations.

Devices to protect apiaries, corralled livestock, chicken and turkey coops, and stored feeds may be provided by FWP to property owners for protection of agricultural

products. Protective supplies include electric fencing, audible and visual deterrent devices, and aversive conditioning devices. FWP may form partnerships with livestock operators and land management agencies to promote livestock management techniques that reduce bear depredations. For example, some people request that dead livestock be removed from grizzly bear areas. While there may be times this is appropriate, there are cases in Montana where livestock that died due to poison plants, lightening, or other causes provided food for bears in areas away from potential conflict sites. Recognizing this, FWP has a program to redistribute livestock carcasses on the Rocky Mountain Front so that they remain available to bears but in areas that minimize the potential for conflict. By assisting livestock operators and removing carcasses from areas around buildings or calving/lambing areas, potential conflicts with bears can be minimized. These types of programs will be evaluated for use within the GYE. Conflict management will emphasize long-term, non-lethal solutions, but relocating or removing offending animals will be necessary to resolve some problems. FWP will continue to promote the development of new techniques and devices that can be used to protect agricultural products from bear damage.

At the present time, private conservation groups in Montana assist in developing preventative approaches, and FWP will cooperate with them to address this issue. Defenders of Wildlife has already cost shared the purchase of electric fence to protect sheep and bee yards through their Proactive Carnivore Conservation Fund. They have also purchased dogs and made them available for hazing bears away from houses and humans. These programs will be a key component of any long-term solutions to these issues.

One of the issues that frequently comes up regarding livestock damage is that of compensation of livestock operators for their losses to bears. While FWP encourages private groups (notably Defenders of Wildlife through the Bailey Grizzly Compensation Trust) to continue compensating operators, the agency prefers to take the approach of providing flexibility to operators as a long-term solution. Giving operators the opportunity to develop proactive problem-solving plans to respond to a potential problem before it develops can build support for the long-term program of increasing bear numbers and distribution. Compensation relies on verification that is not easily accomplished in Montana's multi-predator environment. It also requires assessment of value, which can vary greatly between individual animals (for example, not every cow has the same value), and it requires ongoing funding sources. Fundamentally, however, it deals with a problem after it has occurred. If Montana can implement a program that provides landowners flexibility within reason and with some constraints, FWP believes it will build broader public support. Groups interested in conservation of the bear will need assurances that the flexibility provided will not jeopardize long-term survival or ongoing recovery prospects. These needs can be met, and the State Legislature has adjusted statutes to assure that this is the case (Senate Bill 163). This statute will allow FWP to adjust the flexibility afforded to landowners if needed due to excessive mortality.

An alternative suggested and considered was to force livestock operators to absorb losses that occurred on public lands no matter what the cost. However, in FWP's judgement, this approach fails to recognize the significant contribution of private lands, which provide important bear conservation benefits. In fact, in many portions of the GYE these same private lands are critical to the survival of the bear and to accommodating an expanded distribution of the population. If a permittee could not manage depredation risks on public lands, the converse is allowing them to eliminate risks (meaning bears) on their private lands. This either/or approach is not a productive solution to these problems. Additionally, this approach actually significantly conflicts with the FWP objective of building public support necessary for expansion and long-term survival of bear populations.

Property Damage

➢ FWP will focus on preventive measures, including the elimination of attractants, and better sanitation measures; the agency's bear management specialist will work on these issues on public and private lands.
➢ FWP will seek funding to continue the grizzly bear management specialist position currently stationed in Bozeman and evaluate the need for an additional position stationed in Region 5.
➢ FWP will respond to conflicts within 12 hours by phone or in person if possible.
➢ FWP will summarize efforts annually.

Bears can and will on occasion damage personal property other than livestock. They can enter buildings, chew on snowmobile seats, tear down fruit trees, and so on. Bears are highly attracted to almost any potential food source. Processed human food, gardens, garbage, livestock and pet feeds, livestock carcasses, and septic treatment systems are particularly attractive to bears near camps and residential areas, and are often the cause of human-bear conflicts.

FWP will work to identify potential sources of attractants and will work with private property owners, recreationists, and government agencies to reduce the source of attractant with long-term resolution being emphasized and making attractants inaccessible to bears. When the attractant cannot be eliminated, FWP will provide technical assistance to protect the property and to reduce the potential for human-bear conflicts. Techniques to prevent damage may include aversive conditioning, physical protection (i.e., electric fencing), relocating or removing offending animals, and deterrent devices. FWP will continue to encourage the development of effective non-lethal damage management techniques and equipment. FWP will cooperate with city, county, state, and federal governments to develop model systems of managing attractants, provide incentives for property attractant management, and pursue penalties that result in compliance with food storage regulations.

In FWP's judgment, the key to dealing with this issue is the same as all nuisance situations in that prevention is better than responding after damage has occurred. Teaching people how to avoid problems is key to this approach along with rapid

response if damage does occur. FWP will work to keep bears from obtaining unnatural foods or becoming habituated to humans. In general, the nuisance guidelines from the PCA will be followed. FWP response to property damage will also include those techniques currently employed through the Partners for Life program including the use of Karelian bear dogs and on-site aversive conditioning.

FWP will use program such as "Living With Wildlife" to further these goals. Living With Wildlife is a grant program developed by FWP and funded by the Montana Legislature to promote the successful coexistence of people and wildlife in urban and suburban settings. Living With Wildlife will fund projects that emphasize local involvement, partnerships, cost sharing, innovation, prevention, and proactive solutions to human/wildlife conflicts. Although FWP administers Living With Wildlife, other agencies, local governments, non-governmental organizations, and private citizens will develop and implement most funded projects.

An alternative considered was to keep bears and people apart. However, in FWP's judgement, this approach will fail because bear distribution and densities would have to be so low that it would preclude the objective of maintaining a healthy bear population.

Nuisance Guidelines

➢ FWP will focus immediate action in areas already occupied by grizzly bears, i.e., Absaroka/Beartooth, Gallatin, Madison, and Gravelly Mountain ranges.
➢ FWP will attempt to minimize the number of bears removed from the population. This will also be the case even if this population is delisted.
➢ Develop a cost-sharing program to do preventative work, thus encouraging a variety of interest groups to work together with FWP to minimize problems and increase tolerance for bears.
➢ FWP will review and adjust the guidelines for dealing with damage to beehives (Appendix E).
➢ FWP will consider the actions and potential impacts of programs in Wyoming and Idaho when determining our response.
➢ Determination of nuisance status and response is described in Appendix F.

A summary of conflicts with humans and grizzlies in southwestern Montana is presented in Figs. 7 and 8. A review of these figures indicates that conflicts are currently increasing as the bear population continues to increase in numbers and distribution although they can vary greatly on an annual basis. Considering how many people live, work, and recreate in southwestern Montana, it is important to note there have been minimal conflicts overall. However, nuisance or "problem" bears that are not managed successfully may threaten the entire grizzly bear program. When bear problems are not adequately addressed, there are negative consequences for the individual bear, the public, and the reputation of grizzlies in general is damaged. The primary goal is to maximize human safety and minimize losses to property while maintaining viable populations of grizzly bears. Strategies that address nuisance bears should be timely and informed. Successful co-existence and social acceptance of grizzly bears is largely

dependent on prevention and mitigation of human-bear conflicts. The cause, severity, and appropriate response to human-bear conflicts often varies considerably from one incident to another, making a broad range of management applications desirable to wildlife managers. Outside of the PCA, greater consideration will be given to humans when bears and people come into conflict, provided problems are not the result of intentional human actions. Agency management of nuisance bears will be based on risk management protocols that consider the impacts to humans as well as the impacts to the bear population, and will range from no action to lethal control. FWP will use an effective "rapid response" system for nuisance bear determination and control, and will employ any technique that is legal, effective, and appropriate to manage the conflict (Appendix F).

No Action: FWP may take no action when the circumstances of the conflict do not warrant control or the opportunity for control is low.

Aversive Conditioning, Deterrence, or Protection: FWP may employ various options that deter or preclude the bear from additional depredation activities (i.e., electrical fencing, bear proofing buildings or containers, etc.).
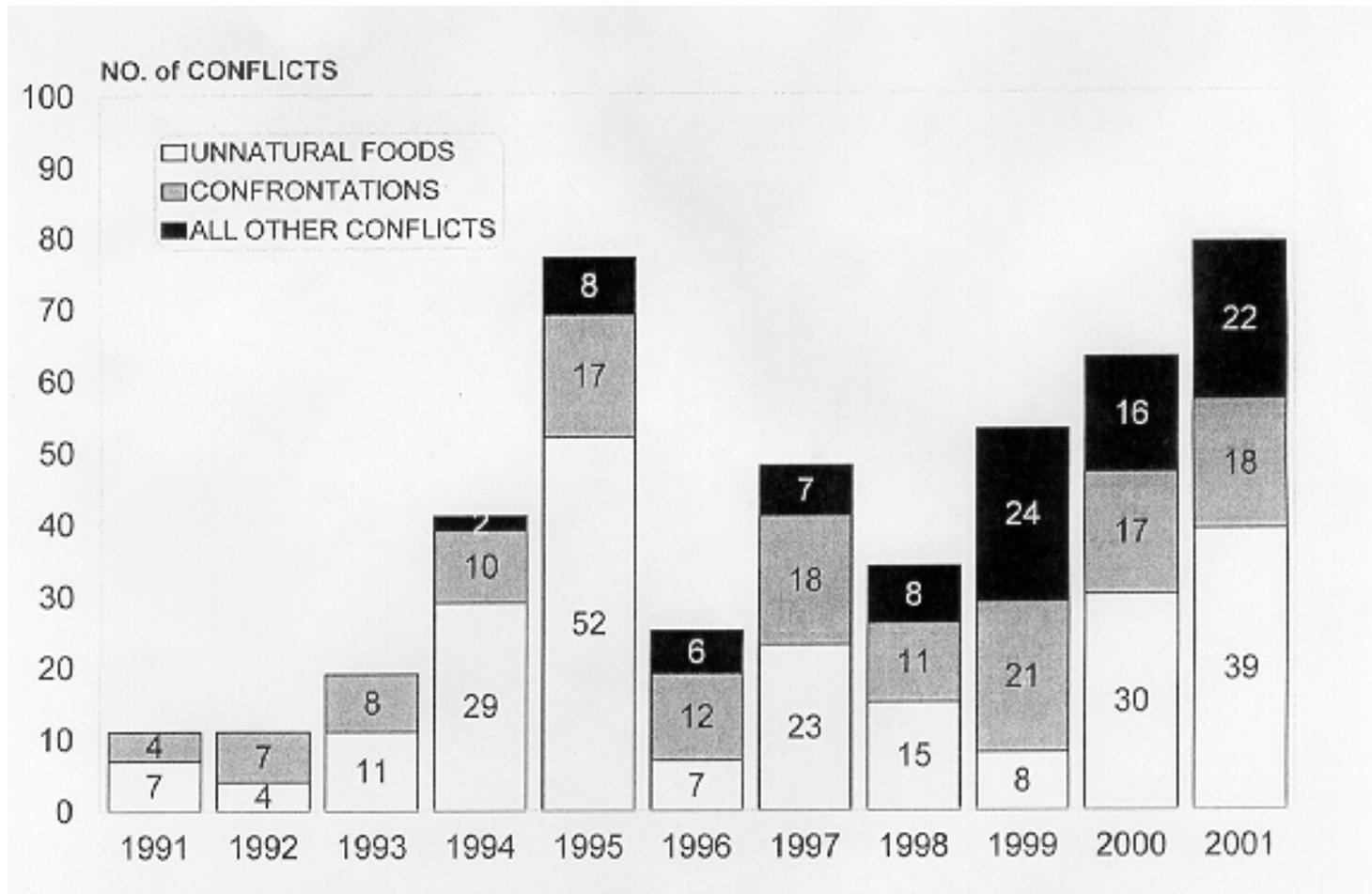
Figure 7. Grizzly bear/human conflicts in Southwest Montana, 1991-2001. Unnatural foods include garbage, bird seed, livestock feed, apple orchards, gardens, etc. Confrontations include approaching/threatening or close range encounters with people. All other conflicts include bears damaging cabins and other property damage.
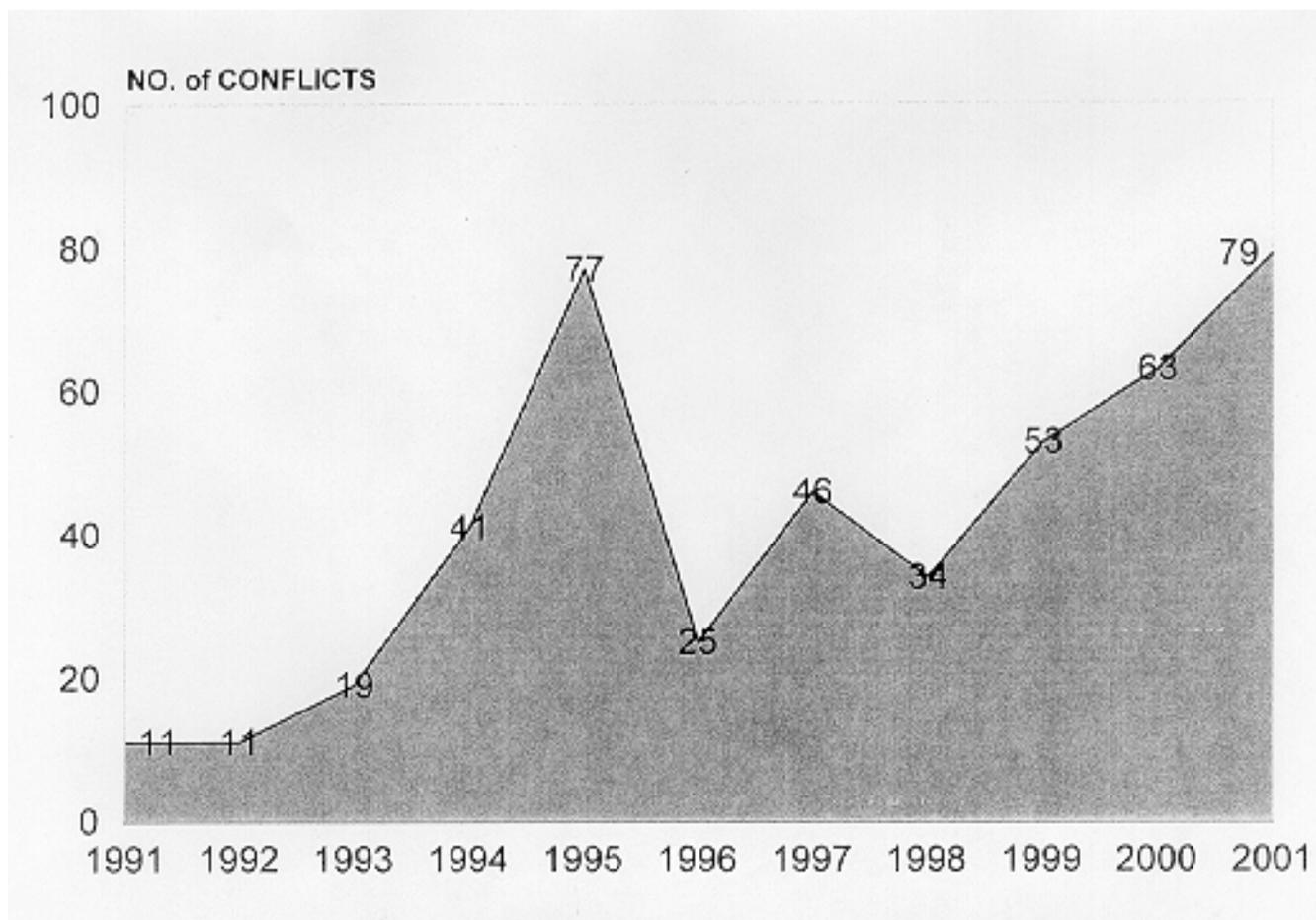
Figure 8. Grizzly bear conflicts in Southwest Montana, 1991-2001.

Capture: FWP will initiate capture operations when other options are not applicable or where human safety is a concern. Capture efforts will be initiated when they are practical, and in a timely manner. Management agencies often resort to translocation to reduce human-caused mortality associated with problem bears. Relocating grizzly bears from human-bear conflict situations is often times a short-term solution to an immediate crisis because many bears return to the conflict site or continue problem behaviors where relocated. Survival of translocated bears is largely affected by whether the bear returned to the capture site; return rates were most affected by distance transported, and age and sex of the bear. Return rates decreased at distances $\geq$75 km, and subadult females returned the least. Because of low survival and high return rates, transporting grizzly bears should be considered a final action to eliminate a conflict situation. However, transporting females must be considered a viable technique because some translocated females have contributed to the population through successful reproduction.

Removal: Lethal control techniques will be employed when other options are not practical and a reasonable opportunity for removal exists.

Bear-Human Interaction Risk Management Protocols

1.   Provide conflict-avoidance information and education to people living, working, and recreating in grizzly bear habitat.
2.   Provide timely information to the public and land management agencies about current bear distribution, including relocations, food conditions, activity, potential and current conflicts, and behaviors (news releases, etc.). Land management agencies will be encouraged to contact their permittees with information that will help them avoid conflicts.
3.   Monitor situations where the activities or behaviors of bears inhabiting areas increase the likelihood of conflicts.
4.   Cooperate with livestock operators and land managers to develop strategies that minimize the potential for bear damage.
5.   Cooperate with property owners, recreationists, and land managers to identify and resolve potential conflicts.
6.   Pre-emptively relocate, aversively condition, deter, or remove bears when potential for conflict is high and other techniques are not applicable.
7.   Relocate, adversely condition, deter, or remove bears involved in conflicts with humans, or property when other techniques are not applicable.
8.   Design occupancy and population objectives that reduce the potential for conflicts in specific grizzly management units.

Rapid Response Protocols

1.   Within each appropriate FWP region (in this case Regions 3 and 5), personnel will be trained and equipped to handle conflicts.
2.   Conflict reporting procedures will be made available to the public through personal contacts and a variety of media channels.

3. Appropriate state and federal agency personnel will be trained and equipped to manage conflicts under circumstances predetermined by FWP and consistent with their jurisdiction.
4. Property owners may be provided deterrent or aversive conditioning supplies when appropriate for management of specific conflicts.
5. Livestock depredation information and evaluation training will be available to livestock producers and their employees.
6. Timely response by FWP for property destruction will be implemented. Management actions will be determined based on the situation.

In the future, FWP will evaluate the potential for a limited-harvest hunting season in areas where a reduction in grizzly bear numbers or densities would likely result in a decrease in chronic conflicts with humans and their property. FWP will integrate nuisance bear considerations into management objectives for each management unit. When applicable, killing of nuisance bears by affected property owners will be allowed through special authorization from FWP. However, any such mortality will be constrained by mortality limits established for the population (initially 4% or less of the total population). FWP would direct the disposition of any bear killed under special authorization.

In situations where bears occupy areas where the potential for conflicts are high (i.e., subdivisions), FWP will pre-emptively and actively manage grizzly bears to prevent damage and provide for human safety.

Development and implementation of a comprehensive information and education program designed for people who live, work, and recreate in grizzly bear habitat is essential to conflict prevention. A technical assistance program, including information on preventative and aversive techniques will be available to property owners, outfitters, and land managers, and will promote successful co-existence and bear conservation. Specific information and education recommendations are addressed in the Information and Education Section.

Guidelines for Nuisance Bear Determination and Control

The focus and intent of nuisance grizzly bear management outside the PCA will be predicated on strategies and actions to prevent human/bear conflicts. It is recognized that active management aimed at individual nuisance bears will be required as part of the management program. Management actions outside the PCA will be implemented according to this management plan. Any management will be conservative and will continue to provide the female segment of the population with additional protections.

General Criteria

Nuisance grizzly bears will be controlled in a practical, timely, and effective manner. Location, cause of incident, severity of incident, history of bear, health/age/sex of bear,

and demographic characteristics of animals involved will all be considered in any management action.

Definitions

Nuisance bear: Any grizzly bear involved in bear/human conflicts resulting in agency management activities.

Unacceptable Aggression: Grizzly bear behavior that includes human injury or death when unprovoked by surprise, food, etc., approaching humans or human use areas, such as camps, in an aggressive way, or aggressive behavior when the bear is also unprovoked by self-defense, defense of cubs, defense of foods, or in a surprise encounter.

Natural Aggression: Defense of young, food, during a surprise encounter, or self-defense.

Food-Conditioned: A bear that has received a significant reward of non-natural foods such as garbage, camp food, pet food, or processed livestock food and persistently seeks those foods.

Habituated: When a bear does not display avoidance behavior around humans or in human use areas such as camps, residential areas, or along roads.

Relocation: The capture and movement of a bear involved in a conflict with humans or their property by management authorities to a remote area away from the conflict site.

Repeat Offense: The involvement of a bear that has been previously relocated in a nuisance situation or continues to repeat a behavior that constituted a human/bear conflict.

Removal: The capture and placement of a bear in an authorized public zoological or research facility or destruction of the bear. Removal can also involve killing the bear through active measures in the wild when it is not otherwise possible to capture the bear.

Depredation: Damage to any property including agricultural products.

Criteria for Nuisance Grizzly Bear Determination and Control Outside the PCA

1.   FWP, or its authorized representative, will investigate reported human-grizzly bear conflicts as soon as practical. FWP will initiate consultation with the affected parties, or their representatives, within 12 hours of the initial investigation either by telephone or in person, if possible. Property owners will be advised of the process to secure compensation if provided by private interests. FWP will also

attempt to notify potentially affected neighbors, livestock producers, permittees, etc., of the nuisance and any ongoing risks if possible.

2. Bears displaying unacceptable aggression or considered a threat to human safety, will be removed from the population as quickly as possible.

3. Bears displaying natural defensive behavior will be removed when, in the judgment of FWP, circumstances warrant removal and non-lethal methods are not feasible or practical.

4. Bears displaying food-conditioned, or habituated behaviors, or damaging property may be relocated, aversively conditioned, or removed based on specific details of the incident. Management authorities will make this judgment after considering the cause, location, and severity of the incident or incidents. FWP will inform the affected people of the desired management direction.

5. Bears may be preemptively moved when they are in areas where they are likely to come into conflicts with humans or their property. Conversely, people may be temporarily excluded from an area if the situation has a high risk to the public, e.g. a carcass on a trail being fed on by grizzlies.

6. Bears may be relocated as many times as FWP determines is appropriate, especially in years where mortality may be excessive in other areas.

7. Bears involved in chronic, significant, or, in the opinion of FWP, have a high probability to cause significant or chronic depredations, will be removed when it is practical and in a timely manner.

8. Bears relocated because of nuisance activities will be released in a location where the probability to cause additional damage is low. Authorities have and will continue to cooperate to provide adequate and available sites for relocations. Bears not suitable for relocation or release will be removed.

9. All grizzly bears captured in management actions that are to be released into the wild will be permanently marked with a unique identifying tattoo and radio collared as necessary to follow their movements.

An alternative we considered was to provide unfettered flexibility to livestock operators and property owners to deal with conflict situations. However, in FWP's judgment, this approach will fail to provide the necessary assurances for long-term conservation. No other FWP programs for a managed species allows for flexibility without constraints.

Disposition Criteria for Bears Removed in Management Actions

Captured grizzly bears identified for removal may be given to public research institutions or public zoological parks for appropriate non-release educational or scientific purposes as per state laws and regulations. Grizzly bears not suitable for these purposes will be killed. FWP will direct the disposition of all parts of a bear killed for any purpose.

Hunting

➢ Regulated harvest will be a part of Montana's long-term conservation program.

- Any hunting program will be justified and open to public review, similar to the processes used for all other managed species in Montana, and coordinated with surrounding states to avoid excessive mortality.
- The female segment of the population will be given additional protections in any proposed hunting program. For example, the killing of females accompanied by young will be prohibited.
- The purpose for a hunt will be to manage "for the species," and garnering additional public support and ownership to ensure its long-term survival and reoccupancy of habitats.
- FWP will encourage hunters and other recreationists to carry pepper spray in bear habitat.
- FWP is committed to supporting recovery in other areas by using all or a portion of any harvestable surplus by live removal and relocation of bears within or outside Montana if such opportunities should arise.

Regulated harvest of wildlife is one of the major tools that allows the recovery and maintenance of predators and prey populations in Montana and elsewhere. Persons who participate in that harvest are pivotal to recovery of prey and the predators that depend on it. In addition, regulated harvest of predators builds tolerance by those most negatively impacted by their presence. It is therefore intended that regulated harvest of grizzly bears will be a part of Montana's program and commitment to grizzlies, when and where appropriate. By managing grizzly bears as a game species they are provided recognition as a valuable wildlife species, protected from illegal harvest, afforded population monitoring and research, and all of the other benefits managed species receive.

Regulated hunting as a management tool for grizzly bears has a long successful history in Montana. Regulated hunting allows FWP to select against unwary bears or bears that associate and habituate to people. This approach was also recognized in the 1975 USFWS rule listing the grizzly, which stated that isolated taking of nuisance bears is not sufficient by itself to prevent numerous depredations, threats to human safety, or selection for wary bears. In contrast, a regulated hunt does select against unwary bears and creates a behavioral response in bears causing them to avoid people in time and/or space in a manner different than unhunted populations. This instills wariness in individual bears and the population, potentially keeping them from becoming problem animals and promotes the long-term survival of the bear population and of people who come into contact with bears. Without benefit of a regulated hunt, FWP response to some conflict situations can only occur after they have developed.

Because wildlife populations produce surplus animals, some can be removed, and the population can still increase. Population estimates and trend data for the GYE as well as other data indicate this is the case. It is important to make the distinction between regulated removals as we now know it and the unregulated mortalities that occurred in the past. Current highly managed and regulated hunting programs can promote population increases and recovery. At the turn of the century, the situation was unregulated. Bears were persecuted and killed without provocation, license, limit, or

season and in excessive numbers.

The State of Montana's grizzly bear management program uses hunting as only one tool among many to promote the long-term conservation of the grizzly bear. The regulated public hunt must therefore be evaluated in the context of an overall bear management program and its efforts to promote management and ongoing recovery of this species. Hunting programs or recommendations will be conservatively applied.

Because of this, hunting pressure exerted on this population should be too limited to result in loss of access by bears to substantial portions of their habitat. Hunting may alter the timing and nature of use of some habitats for short periods of time, but any negative impacts to the population are negligible when considering the size of the ecosystem and the limited amount of hunting anticipated.

Another specific purpose of the regulated hunt is to remove some nuisance animals. Information from the Northern Continental Divide demonstrated that this was the case in many years. For example, during the last legal hunt in Montana in 1991, two of the three bears taken were known problem bears.

Finally, since some hunting mortalities occur in relatively remote areas, removal of bears in a regulated hunt could allow opportunities for young and subadult bears to establish home ranges in areas away from people, further reducing bear-human conflicts. Also, harvest is usually directed at the male segment so the sex ratio in harvested populations tends to be skewed towards females. This in turn could assist with long-term distribution increase by allowing more females to survive.

Hunting impacts population composition in different ways, and regulations can impact the composition of harvests. Because bears are promiscuous, regulations that direct harvests toward males and away from adult females permit higher hunter quotas. In early spring, hunters kill primarily males because they are the first to emerge from dens. Females accompanied by newborn cubs are the last to emerge from dens. Similarly, males are the last to enter dens in the fall, so late fall seasons have higher proportions of males. Regardless of regulations, male bears are more vulnerable to hunters than female bears because they range more widely and are more likely to encounter areas frequented by hunters. In central Alaska, females constituted 18% of the spring season hunter kill prior to May 1, but more than 40% of the harvest after the third week in May. In the fall, females represented 53% of the kill during the first week of September, but less than 43% of the kill during October. In Alaska and Canada, regulations prohibit shooting females accompanied by cub-of-year or yearling offspring, which also contributes to a male bias in hunter harvests. In the Yukon, a point system is used that provides incentives for outfitters to avoid harvesting females. For hunters to distinguish between males and female , the female is usually accompanied by offspring or the male is exceptionally large. In Montana, by using season timing and protective regulations for females with young, FWP was similarly able to focus harvests on males during its legal hunt.

In summary, FWP recommends a regulated hunting season be a part of the overall program for the following reasons:

1. Legal harvest can be managed so as to have minimal impact on the population as a whole.
2. Hunters have legally harvested problem bears and bear/human conflicts could be reduced through such harvest.
3. Hunting reduces the need for agency control of problem bears.
4. Hunting selects against unwary bears and causes bears to be wary of humans. This promotes long-term survival of the bear population in areas they share with humans. Hunting promotes better acceptance of this large and potentially life threatening animal by the local public who are asked to live with grizzlies, and this <u>acceptance</u> is a key to long-term survival of the bear. If the local publics feel threatened by grizzlies, or the management program, they will defend themselves as necessary. This in turn can have detrimental effects on existing grizzly populations and clearly limits opportunities for expanded recovery efforts due to local resistance.
5. Hunting grizzlies may alter cub survival and recruitment providing for population increase. While there is currently some scientific disagreement on this possibility, there is no question that initial harvest levels in the GYE will be so low that any effect of regulated take on increasing cub survival and recruitment would be impossible to measure.
6. Hunters have been and continue to be one of the strongest supporters of long-term conservation efforts. Hunters have purchased more habitat than any other group in the GYE and returned it to wildlife use including grizzly bears. This strong connection between hunters and habitat is critical to continued successes at restoring wildlife including grizzly bears. Hunting gives direct ownership for the welfare of this species by some of the most ardent supporters of wildlife in Montana.
7. Hunting allows the grizzly to be a social asset instead of being considered by some groups as a liability. Hunting provides revenues from license fees on hunted species and excise taxes on equipment to governmental entities for enforcement of wildlife management regulations as well as alleviating potential costs and risks associated with problem animals. Without a regulated hunt, these costs must be paid by the government, and the positive effects of grizzly hunting are lost to society.
8. The presence of licensed hunters can reduce illegal activities. Every year ethical hunters in Montana report people who have violated laws protecting wildlife. More "eyes and ears" in the field can deter illegal activities.

Regulated hunting has been used as only one tool among many to provide for the long-term recovery and survival of grizzly bears. A regulated public hunt must therefore be evaluated in the context of an overall bear management program. There are also many statutes and regulations in Montana that would affect any proposed hunt. In addition, the State of Montana can anticipate some specific constraints on any hunt as summarized below:

1. Hunting will not be proposed immediately upon delisting. It is clear that the public will want some assurance that the other components of the grizzly bear

management program are being adequately implemented prior to a regulated hunt.

2. There are areas that won't be hunted. There are currently areas outside the PCA and within that are closed to hunting and will continue to be.

3. The justification for any proposed hunt will be available to public scrutiny and comment prior to any decision or possible implementation.

4. Regulations have been and will be established to protect the female segment of the population as much as possible. For example, if a hunt were to occur, FWP Commission regulations make it illegal to kill females accompanied by cubs or young.

5. After March 27, 1987, a state statute was implemented which only allows someone to kill one grizzly bear in that person's lifetime (87-2-702).

6. The FWP Commission has the authority to close seasons at any time if mortality was excessive, i.e. occurring at levels which would have long-term negative impacts on the population due to unforeseen circumstances.

7. FWP management experience has shown that while a general managed hunt can reduce some conflict situations; a "damage hunt" targeting individual problem bears has demonstrated this approach is of limited value in the management program. Therefore, we do not intend to use this approach for the following reasons:

   a. Damage hunts characterize the species as a "problem" instead of the valuable wildlife resource they represent.

   b. Response time is critical in damage situations and locating a hunter can delay response time.

   c. There are ethical problems with using technology, for example radio collars, to locate and kill problem animals.

   d. Many nuisance animals are unaccessible to hunting during daylight hours.

   e. There are ethical problems associated with FWP "guiding" a hunter toward an individual bear.

8. No baiting or use of dogs to hunt grizzlies is permitted.

9. Any bear taken must be used for food. It is illegal to waste bear meat or leave it in the field. Also, bears will be hunted when their fur is in good condition to allow complete use of animals harvested.

10. It is illegal to buy or sell grizzly bear parts unless they have been registered with FWP.

Montana's hunting season setting process is an open and dynamic process, although it may be unfamiliar to nonhunters. The following is a synopsis of the process: A proposal is generated by a staff biologist or a group of biologists. The proposal is accompanied by a justification relying heavily on biological data including: population objectives, trends, habitat, weather trends, and often include social constraints. The proposal is next reviewed internally and if found adequate is sent to the FWP Commission. After reviewing the proposal and justification, the Commission at its December meeting either adopts, modifies, or rejects it as a tentative. If adopted as a tentative, it is then released for public review and comment. The public review process occurs annually in January and February. During this period, biologists around the state

conduct public meetings and formal hearings in nearly all of the major cities and towns across the state as well as with any groups or organizations that request them. Additionally, the tentatives are published and otherwise made available to any who wish to review and comment on them. At the end of the comment period, all of the comments received during the meetings and any written or other verbal comments received during the comment period are summarized and sent on to the Commission for its review. In early March, the Commission then formally either accepts, modifies, or rejects the proposals based on the biological justification and the social concerns expressed during the review period. Additionally, the public can also make proposals to the Commission in the form of a tentative at the December meeting. This process is repeated on an annual basis.

An alternative FWP considered was to eliminate hunting as a part of its grizzly bear management program. However, in FWP's judgment, this approach would eliminate a key local and national constituent group with demonstrated commitment to the species and its habitat. Additionally, this would greatly hinder FWP's ability to develop increased tolerance for the species. Success of this tool for other wildlife--and for bears--in Montana and in other places confirms its usefulness.

It was also suggested that FWP make pepper spray mandatory for hunters. While FWP is currently prepared to assist in notifying people of the benefits of pepper spray and encouraging recreationists to carry it, it is premature to make it mandatory at this time. Mandatory carrying of pepper spray may be appropriate at certain times or places and FWP will evaluate this option as appropriate. However, there are currently significant liability and enforcement issues around a "mandatory" approach. In addition, carrying spray can give people a false sense of security and replace common sense and careful backcountry practices. Pepper spray can be ineffective in windy areas, and individual bears can have very different responses to the spray. Also, in some situations people would be better to assume a defensive posture (on the ground with no movement) than to be actively fumbling for a spray can. Also, the spray comes in many brands, with many pepper concoctions, with many shelf-life constraints and propellant systems. It is no doubt a valuable tool, but it is only one of many and cannot replace common sense or other recommendations of appropriate behavior. However, to provide an example for the public, FWP will make pepper spray available to all field personnel operating in bear country and encourage employees to carry it during the non-denning season when bears are active.

Enforcement

➢ FWP will seek authority by developing an MOU with federal agencies to enforce food storage regulations on federal lands.
➢ FWP will implement statutory authority to address intentional feeding of both black and grizzly bears to eliminate the problem.
➢ FWP will seek additional funding and authority to enforce travel management plans, including off-road vehicle use.

FWP enforcement efforts concerning grizzly bears are focused in three areas: patrols of both wilderness and non-wilderness areas, damage control, and poaching investigations.

Wilderness and non-wilderness areas are patrolled during the general hunting season and at other times. Hunter camps are checked for harvested game and compliance with outfitter regulations.

Response to nuisance bear complaints can involve many FWP personnel in some capacity, although enforcement division personnel are frequently the first on the scene.

FWP enforcement personnel investigate and prosecute all violations involving illegal mortality. Cases are processed through the county attorney's office or turned over to the U.S. Fish and Wildlife Service when they appear to involve interstate movement of grizzly bear parts. FWP also coordinates with federal officials in undercover operations. Current state fines for illegally killing a grizzly bear are $2,000 restitution plus $500 to $2000 more, and imprisonment in the county detention center for not more than 6 months or both. In addition, that person, upon conviction or forfeiture of bond or bail, shall forfeit any current hunting, fishing, recreation use, or trapping license issued by this state and the privilege to hunt, fish, or trap in this state for 30 months from the date of conviction or forfeiture, unless the court imposes a longer forfeiture period. Fines for the interstate movement of illegally killed or possessed animals can be much higher.

The U.S. Forest Service manages food storage restrictions on Forest Service lands and some counties have county ordinances on food storage, which are enforced by the county sheriffs.

The FWP enforcement personnel do not currently enforce federal travel restrictions except for hunters and anglers conducting those activities under FWP Commission Rules and Regulations.

There are currently Memorandums of Understanding between U.S. Fish and Wildlife Service and FWP. These MOUs outline joint responsibilities for violations of federal and state laws. They also address responsibilities and guidelines for joint investigations by Montana game wardens and USFWS special agents, as well as between Wildlife Services and FWP outlining joint investigations of grizzly bear depredations (Appendix G).

Discussions to date indicate two areas where statutes and/or regulations need to be changed to support the full implementation of this plan. Earlier drafts of this plan recommended that statutes must be passed to make it illegal to intentionally feed or attract bears. Such legislation was in fact passed in 2001 (MCA 87-3-103, Appendix H). People who intentionally feed or attract bears to their residence create problems that impact their neighbors, jeopardize human safety, and result in problem situations. These actions are now illegal. Secondly, FWP wardens have no enforcement authority to enforce food storage regulations on Forest Service lands. Measures should be taken

to establish this authority. This will be increasingly important as the bear population expands and, hopefully, food storage regulations are required on additional national forest lands. FWP wardens spend a great deal of time in backcountry areas checking people on national forest lands, and their ability to enforce these rules would ultimately result in greater compliance and fewer bear/human conflicts.

Finally, the enforcement aspects are critical enough to program success that additional resources should be made available to implement new responsibilities. These would include sufficient funds for equipment and necessary overtime required to operate in remote areas and, ultimately, additional staffing. The USFS and BLM will be approached to try and identify additional funding to support FWP in these efforts due to increased responsibilities enforcing food storage and travel plan regulations if that authority is developed.

An alternative FWP considered was to not seek additional authority either through MOUs and statutes to expand state enforcement authority in dealing with preventive measures relating to human/bear conflicts. However, FWP enforcement personnel are in the most effective position to address these problems.

Education/Public Outreach

➢ FWP will include lessons on human safety while hunting in bear habitat in each hunter education class.
➢ FWP will continue to expand its efforts to assist hunters with identification of black versus grizzly bears. In 2002, FWP began mandatory training for people interested in hunting black bears.
➢ FWP will develop ways to target education efforts towards "new" Montana residents regarding human/bear issues as well as long-term residents.
➢ FWP will encourage the Board of Outfitters to require all outfitters and guides operating in bear habitat to be certified in human/bear safety.
➢ FWP will continue to work with private organizations and interest groups, as well as the media, to include safety tips on recreating in bear habitat including proper use of pepper spray.
➢ Education and public outreach will be integrated with enforcement on sanitation, etc., to effectively minimize human activities that can lead to human/bear safety issues.
➢ FWP will work with local planning entities to address the needs of grizzly bears in new developments and new residential areas.

Management strategies are unlikely to succeed without useful, state-of-the-art public information and education programs. A partnership information and education approach involving FWP, as well as other agencies, local communities, and private interests, can result in minimizing human/bear tragedies as well as develop a stronger sense of agreement among Montana residents about the state's goals and management programs related to the bear.

Human safety is of utmost concern when hunting in grizzly bear country. In order to teach young, old and first-time hunters the proper techniques for hunting in grizzly country, FWP will incorporate a lesson on human safety while hunting in bear habitat in each hunter education class. In Montana, no person between the ages of 12-17 may apply for and receive any hunting license unless the person possesses a hunter safety certificate. Current records show that approximately 7,000 students are certified each year through FWP's hunter education program.

The FWP Commission adopted in 2001 a program to require mandatory bear identification testing to be completed by black bear hunters in Montana prior to the purchase of a black bear license.

The program is being offered because Montana's grizzly bear population is increasing in both number and in range. Today, grizzly bear encounters are on the rise, and black bear hunters must be aware that they are likely to encounter grizzly bears in areas they may not have inhabited just a few years ago. Black bear hunters must sharpen their ability to tell the difference between black bears and grizzly bears to prevent and avoid mistaken identity killings of grizzly bears.

The FWP Commission is concerned about the impact that mistaken identity killings could have on maintaining a recovered grizzly bear population or on recovery in areas that are still below objectives. The commission believes a solution can be found in directly informing and educating all black bear hunters. Some consider the solution to the problem to be elimination of the black bear hunting season in Montana. That action would minimize FWP's ability to manage bears and create a myriad of other problems essentially lessening the support for management and expanded distribution of grizzlies.

Following is a summary of the bear identification requirements the FWP Commission approved:

- The requirement applies to everyone purchasing a bear license.
- Testing is required before purchase of a license.
- A minimum score of 80% is needed to pass the test. One can retake the test until a passing grade is obtained.
- Recertification is not required.
- The test is available on line at www.fwp.state.mt.us, by mail, or at regional headquarters in Regions 1-5.

Limited quota big game hunting seasons exist in many areas occupied by grizzly bears. Limited quota licenses require a special application and license issuance process. A brochure on bear country safety should be mailed to each successful applicant when their license is issued; this includes both resident and non-resident hunters.

FWP will encourage federal land management and wildlife agencies to continue to play a vital role in grizzly bear education. FWP will continue to encourage and coordinate

with these agencies to provide bear safety literature at their respective trailheads and offices in occupied bear areas. Often this is already happening. The Forest Service should be encouraged to assess the appropriate number and location of bear resistant food storage containers (bear boxes), meat poles, and bear resistant garbage containers (at all campsites) in occupied areas in order to protect bears while assuring wilderness values.

FWP will promote the grizzly bear as a valuable state resource through public school and community presentations, community-based workshops, news releases, magazine articles, and radio and television spots.

The Board of Outfitters will be encouraged to require that all outfitters and guides that provide services within areas occupied by bears be certified in human safety in bear country. The outfitting industry has voluntarily developed a bear education course in partnership with the U.S. Fish and Wildlife Service, U.S. Forest Service, National Park Service, the Wyoming Game and Fish, and the Professional Guides Institution. This course would serve as the model for training in Montana.

A bear safety video has been purchased and made available by FWP.

Examples of current FWP programs are as follows:

- FWP presentations to schools, colleges, civic and sportsmen's groups.
- Interviews with newspaper, radio, and TV reporters.
- Statewide newspaper features.
- News releases, some with other interested cooperators.
- Radio reports.
- FWP Web site devoted to bear identification.
- Public Information Plan designed by Conservation/Education Division in reaching public.
- Video entitled "Bears and Bees," advising beekeepers about avoiding conflicts with bears.
- Information on electric fencing to keep bears out of orchards, garbage, grain storage, bee yards.
- Meetings with homeowner groups on sanitation, bear-proof containers at Big Sky, bear-proof enclosure fence for garbage containment at Corwin Springs.
- Adoption of the South Gallatin County Ordinance to address sanitation in upper Gallatin Canyon.
- Cooperative efforts with Defenders of Wildlife and Yellowstone National Park in producing an informational book on bears for the "gateway communities" in the north and west portions of the Yellowstone ecosystem.
- Day-to-day public contacts by FWP personnel during conflict situations with bears.
- "Living with Grizzlies" brochure.
- "Who's Who? Know Your Bear" brochure.
- "Bears" brochure.

- "Be Bear Aware" children's handout.
- "BEAR HUNTERS—Know Your Target!" wallet card
- Internal education and training

An alternative FWP considered was to not expand these efforts. However, in our judgment, expanded efforts are essential to the objective to allow for expanded bear distribution and long-term survival of the species. It was also suggested that the mandatory bear ID test for black bear hunters be modified to require "in person" testing and that recertification be required. Because this is a new program, it will be monitored to determine its success at reducing mistaken identity mortalities. If adjustments such as those suggested or others become necessary, they may be implemented in the future.

Future Research

Research is an ongoing process, and FWP's program is formatted so knowledge of the species and their needs are always improving. Humans have the greatest influence on brown/grizzly bear distribution and abundance in North America. Today's research techniques are expensive and labor intensive. Also, some population estimation techniques are subjective, have no estimate of precision, and cannot be replicated in a systematic manner. Some techniques require radio-marking large numbers of individuals, which may not be feasible in some environments. These techniques also typically provide density estimates in only small portions of the area inhabited by the entire population, and they are currently expensive and have problems with demographic and geographic closure, potential capture biases, and standardization of experimental design. Design issues include grid size and scent lure rotation frequency, sample collection frequency, and mathematical techniques for data analysis. Techniques based on visual observations of unduplicated adult females accompanied by newborn cubs have been used to estimate minimum population size and establish mortality quotas for bears in the Yellowstone area, but extrapolation to a total population number or population density are viewed with skepticism by some. Observational techniques using double-count procedures are under investigation in Alaska.

Continued improvement on assessing potential impacts of hunting are helpful because brown/grizzly bears have one of the lowest reproductive rates among North American mammals. Without such techniques, appropriate hunting opportunities may be needlessly curtailed or populations may be overharvested. Ongoing assessments such as this are part of other wildlife management programs and will be for grizzly bears.

Montana needs a better means of assessing the biological carrying capacity of actual or potential grizzly bear habitats. Such assessments are important to ensure that restoration efforts for grizzly bears are successful in areas where they are currently expanding or to adapt management policy to environmental change to ensure long-term persistence.

Further research is also needed on the importance of anthropogenic impacts on bear habitats. As documented elsewhere, roads, commercial activities (mining, logging), livestock grazing, suburban sprawl, and recreational uses (i.e. snowmachining, off road vehicles) may impact the ability of bear populations to persist in an area. More intensive research is needed on threshold levels at which these impacts become significant and possible ways to mitigate adverse human impacts on brown/grizzly bear populations. Similarly, it is important to find ways to identify threshold levels of tolerance for adverse impacts of grizzly bears on humans. Additional research on genetic conservation, deterrent/repellants, and conflict management would also be helpful.

Efforts to restore grizzly bears also require better information on economic and ecological costs and benefits of bears and social attitudes towards bears. Among other reasons, such information is needed to demonstrate the value of preserving wildlife movement and access to habitats.

Costs and Funding

➢ The majority of funding for these programs will be borne by the sportspersons of Montana through license fees as well as federal Pittman-Robertson funds from excise taxes on firearms and ammunition currently in place.
➢ FWP will seek significant additional federal funding for the five-year post-delisting monitoring period and develop on MOU with federal agencies to contribute funding support and involvement with habitat and population monitoring within the PCA and on federal lands outside the PCA.
➢ FWP will explore avenues to allow tourists to participate in program funding.
➢ FWP will continue to work to find ways for national interests in this species to be reflected in long-term funding commitments, i.e., a national endowment, Congressional act, or other vehicles.
➢ While cost of the program will initially increase over current levels, these costs should stabilize or even decrease over time as the species is managed as one component of our overall wildlife program.
➢ FWP will explore development of a grizzly bear specialty license plate as an additional source of funding.

Sportspersons in Montana have been and continue to be the proper source of funding for state efforts to manage grizzly bears. Each year FWP spends more than $350,000 in direct costs to manage grizzly bears. These funds are used to monitor and manage population status, distribution, nuisance, and mortality within the state.

As grizzly numbers and the area occupied increase, management costs will also rise. Certain management data will need to be collected to assess population status and to manage nuisance activities. Total costs are difficult to determine at this point in time, especially considering that expansion may not be limited in the near future. The costs associated with data collection and nuisance management will certainly exceed funds currently available. As a result, the grizzly program will not be self-sufficient and will

likely always rely on existing funding sources to a large extent. This is not unusual as the costs associated with managing most big and small game, as well as fisheries, programs exceed revenues from license sales. Adequate management of grizzly bears should take place wherever they are allowed to reoccupy, just like any other managed species in the state.

The grizzly bear is a species of national interest. As such, FWP will continue to pursue some form of a national endowment with funds generated from Congress. Interest from the endowment would be used to offset the costs of managing the grizzly bear in the Greater Yellowstone Ecosystem. This would truly empower all state and federal agencies with the ability to more effectively manage this species.

FWP will also seek implementation of expanded funding sources such as those appropriated for State Wildlife Grants in 2001 that are once again being considered in Congress this year. The key, however, is long-term funding.

An alternative FWP considered was that this program be solely contingent on increases in federal funding. However, our experience indicates that a solid state-funding base is key to long-term success. The estimated cost for implementing this plan are presented below (Table 5). This is not intended to be a detailed description of program costs, but it does provide an idea of current and anticipated expenses. Annual budgets are impacted by both federal and state processes, and these can impact funding and priorities.

Table 5. FWP Southwest Montana Grizzly Bear Management Plan expenses (Yellowstone ecosystem).

Expense	Current Expenditures	Additional $$ Needs
Human/Bear Conflict (includes wildlife specialists, bear dog contract, preventative measures, wardens, biologists, and staff time)	158,000	68,000
Monitoring (Females with cubs, radio tracking, DNA work, FWP Laboratory expenses)	25,000	75,000
Outreach (Cons Education news releases, etc.)	40,000	25,000
Admin (statewide program admin. Costs)	20,000	20,000
Grand Total	243,000	188,000

Expanded Local Involvement

➢ On approval of this plan, FWP will conduct town meetings in southwestern Montana explaining the programs and cultivating local interests.
➢ FWP will explore opportunities to form local work groups in Big Sky, Red Lodge, Ennis, Dillon, Alder/Virginia City, Emigrant/Gardiner, Bozeman, and Livingston. Additional groups may be formed as needed or existing groups with interests in

these issues could be identified and contacted. If groups are formed, the local area biologist will coordinate and conduct at least one meeting annually to address grizzly bear management concerns and to share with local residents current grizzly bear science, information, status, etc.

➢ These local meetings will not only react to problems after they happen, it is FWP's hope they will anticipate conflicts, prepare for them, and try to prevent them. The goal of adaptive management will be promoted by regular monitoring and making policy changes when needed with the input of local residents and other interests.

It is Montana's intent through these efforts to increase local participation in program development and long-term local ownership of bear conservation programs.

- Sanitation in rural communities that lie within occupied bear habitat is an ongoing major issue. Efforts have been ongoing in Cooke City, Gardiner, and West Yellowstone. Sanitation efforts at Big Sky are just starting. These efforts require strong citizen involvement. For example, Big Sky straddles two counties. The Gallatin County portion has a bear proof garbage ordinance while the Madison County portion does not. FWP envisions a cooperative effort between FWP, Big Sky citizens, county commissioners, private interest groups and garbage haulers to solve that sanitation problem, and some of this is already occurring.
- Local work groups in Bozeman, Livingston, Red Lodge, Ennis, Dillon, Big Sky, Alder/Virginia City, and Emigrant/Gardiner if formed would act in an advisory role, and partner with FWP. The purpose is to share information, generate citizen recommendations for resolving bear/human conflicts, and increase tolerance for bears. These work groups should have agriculture, sportsmen, conservationists, land management agency, and community business representation and should coordinate across state boundaries where appropriate.
- FWP will seek to develop an MOU between counties and cities with bear proof garbage ordinance so as to enhance enforcement effectiveness at the state, county, and community level.
- FWP recognizes that there is a national interest in the long-term conservation of this species. As such, Montana anticipates providing opportunities for those representing that interest to be involved as this program is developed and implemented. Any local meetings will be open to the public and opportunities will be provided for others to share their perspectives and contributions to program success. Interested parties can and do also participate in the national processes which affect federal lands and programs.

Secondary and Cumulative Impacts

Successful implementation of the program will have some secondary and cumulative impacts on other programs and some individuals.

Implementing the habitat measures, and the preventative management programs, will undoubtedly benefit other species of wildlife in Montana, especially black bears. Black bear issues parallel those surrounding grizzlies, and the programs recommended

should assist FWP with their management as well. Also, when habitats are managed in a way that allows occupancy and expansion of the grizzly bear population, many other species benefit. For example, areas where road accesses are adequately managed benefit elk and other species as well as bears. There will also be economic benefits to Montana from an expanded bear population. Many people travel to, and relocate to, Montana because of the state's diverse and abundant wildlife resources. In addition, the value of many properties in Montana are enhanced by the presence of wildlife and the opportunities for associated recreation and potential harvests.

There is the potential that population levels of black bears could be somewhat reduced due to the presence of grizzly bears in currently unoccupied habitats. Based on the current status of black bears in and adjacent to areas currently occupied by grizzlies in Montana, impacts are not anticipated to be significant.

Other agencies that manage lands in southwestern Montana could see increased costs due to expanded food storage rules, habitat management changes, and so on. Most of these changes are already occurring in the areas that could be occupied by grizzly bears in the near term, and the public has clearly indicated support for these efforts. Also, because grizzly bears have always had and will always have a high public profile, public pressure could result in FWP and other agencies reprioritizing programs to focus more effort on grizzly bear management. It is FWP's hope that by managing grizzlies as one more component of our wildlife programs such reprioritization would have minimal affect on other programs.

While there are many benefits to expanded grizzly bear populations, there is no denying that there will be impacts to livestock producers and property owners due to conflicts with grizzly bears as the population expands. Implementing the programs recommended in this document will minimize those impacts through prevention, where possible, and adequate management if conflicts occur. Implementing the road density standards as recommended is already occurring for elk management and is allowing for some expansion in the bear population. Future adjustments may be necessary. However, many of these issues are currently being addressed to meet other resource needs (erosion control, water quality, etc.), and those changes are not related to bear concerns.

Irreversible/Irretrievable Resource Commitment

The programs recommended in this document should not result in any irreversible/irretrievable commitment of resources with few exceptions. If expansion of bears proves untenable in some areas, FWP has demonstrated the ability to remove bears. Likewise, habitat programs, access management, and so on can all be reversed or revised if needed. The level of recommended mortality will not result in any irreversible commitment of the grizzly bear resource and should allow it to flourish. Because these levels of removal can be regulated or eliminated on an annual basis, or even short time basis (should data indicate that to be prudent), the management program poses no threat to the species, and should benefit it.

Conversely, because the grizzly bear and other Montana wildlife serve as a major component of our quality of life in Montana and this is attracting new residents and an expanding human population, the state is seeing some irretrievable commitment of resources. Subdivisions, energy development, and other "land development" programs are slowly but steadily altering grizzly habitat. While Montana officials can moderate this loss to a degree by allowing the bear population to expand into currently unoccupied habitats and by managing occupied habitats to meet their needs, we as a people will ultimately have to forego some things to allow grizzlies to survive at viable levels. These issues will be decided by the citizens of Montana and the nation through the appropriate political and social processes.

Finally, grizzly bears are large and potentially dangerous animals. By their presence, they pose some risk to the human inhabitants of the state and to visitors. Current information shows that this risk is very real, but at a surprisingly low level. When one considers all of the people and activities that currently occur in grizzly habitat, and how few injuries or deaths happen, it demonstrates this low level of risk. In addition, the programs outlined in this plan should allow for management and further minimization of the risks of living with grizzlies.

No environment is totally risk free for people. Through education, understanding, and science-based wildlife management, we the people of Montana and this nation can minimize the risks of injury and/or death from grizzlies.

GLOSSARY

ARM -- Administrative Rules of Montana
ATV -- All terrain vehicle
BLM -- Bureau of Land Management
CARA -- Conservation and Reinvestment Act
CEM -- Cumulative Effects Model
COY -- Cubs of the Year
DNA -- Deoxyribonuleic acid -- the molecule that encodes genetic information
DNRC -- Department of Natural Resources and Conservation
EIS -- Environmental Impact Statement
FWP -- Montana Fish, Wildlife & Parks.
GIS -- Geographic Information Ssytem
GYE -- Greater Yellowstone Ecosystem. This area includes all lands in or adjacent to Yellowstone National Park.
IBA -- International Association for Bear Research and Management
IGBC -- Interagency Grizzly Bear Committee.
IGBST -- Interagency Grizzly Bear Study Team. A multi-state, multi-agency group studying grizzlies in the greater Yellowstone area.
MCA -- Montana Codes Annotated
MDOT -- Montana Dept. of Transportation
MEPA -- Montana Environmental Policy Act
MFGC -- Montana Fish and Game Commission
MFWPC -- Montana Fish, Wildlife & Parks Commission
MFWPC -- Montana Fish, Wildlife & Parks Commission
MOU -- Memorandum of Understanding.
NEPA -- National Environmental Policy Act
PCA -- Primary conservation area or the designated recovery zone. This area will receive more intensive management which favors the needs of grizzly bears.
PEIS -- Programmatic Environmental Impact Statement
USC -- United States Congress
USFS -- United States Forest Service
USFWS -- United States Fish & Wildlife Service

LITERATURE USED TO ASSIST IN PREPARATION OF THIS PLAN

Albert, D.M., T.R. Bowzer, and S.D. Miller. 2001. Effort and success of brown bear hunters in Alaska. Wildlife Society Bulletin 28(2): 501-508.

Bader, M. 2000c. Spatial needs of grizzly bears in the U.S. Northern Rockies. Alliance for the Wild Rockies Special Report No. 10, Missoula MT. 28 p.

Bader, M. 2000. Distribution of grizzly bears in the U.S. Northern Rockies. Northwest Science, vol. 74, No. 4. 325-334.

Berger, J., J.E. Swenson, and I. Persson. 2001. Recolonizing carnivores and naïve prey: conservation lessons from Pleistocene extinctions. Science 291:1036-1039.

Caughley, G. 1994. Directions in conservation biology. Journal of Animal Ecology 63:215-244.

Clevenger, A. P., B. Chumszyz, and K. E. Gunson. 2001. Highway mitigation fencing reduces wildlife-vehicle collisions. Wildlife Society Bulletin 29(2):646-653.

Conover, M. R. 2001. Effect of hunting and trapping on wildlife damage. Wildlife Society Bulletin 29(2):521-532.

Conover, M.R., and D. V. Conover. 2001. For whom do we manage wildlife: the resource, society, or future generations. Wildlife Society Bulletin 29(2) 675-679.

Craighead, F.L., M.E. Gilpin, and E.R. Vyse. 1999. Genetic considerations for carnivore conservation in the Greater Yellowstone Ecosystem. Pages 285-321 in T.W. Clark, A.P. Curlee, S.C. Minta, and P.M. Kareiva, editors, Carnivores in Ecosystems: The Yellowstone Experience. Yale U. Press.

Craighead, L. 2000. Regional corridors. A comparison of the Walker-Craighead reserve model with the Merrill-Mattson CERI reserve model. Craighead Environmental Research Institute. Bozeman, MT.

Davitt, K. 2001. Grizzly bear habitat connectivity. Pers. Comm.

Davradou, M., and G. Namkoong. 2001. Science, ethical arguments, and management in the preservation of land for grizzly bear conservation. Conservation Biologist, 15(3), 570-577.

Dobson, A. et al. 1999. Corridors: reconnecting fragmented landscapes. Pages 129-170 in M.E. Soule and J. Terborgh, editors, Continental Conservation: Scientific Foundations of Regional Reserve Networks. Island Press.

Dood, A.R., R. B. Brannon, and R.D. Mace. 1986. Final programmatic environmental impact statement, the grizzly bear in northwestern Montana. Montana Fish, Wildlife & Parks. 287 pp.

Dood, A.R., and H. I. Pac. 1993. Five year update of the programmatic environmental impact statement, the grizzly bear in northwestern Montana 1986-1990. Montana Fish, Wildlife & Parks. 228 pp.

Eberhardt., L. L., and R. R. Knight. 1996. How many grizzlies in Yellowstone? Journal of Wildlife Management 60(2):416-421.

Frey, K. 1999. Grizzly bear management of the Yellowstone Ecosystem in Montana. Montana Fish, Wildlife & Parks Final report. 17 pp.

Grizzly bears in British Columbia, the real story. 2000. Guide Outfitter Association of British Columbia. 17 pp.

Gunther, K.A., et al. 1999. Grizzly bear-human conflicts, confrontations, and management actions in the Yellowstone Ecosystem. Interagency Grizzly Bear Committee. 62 pp.

Henry, G. V., and Muchash. May 2000. Red wolf reintroduction lessons regarding species restoration. Red wolf management series technical report no. 12. 17 pp.

Hood, G. A., and K. L. Parker. 2001. Impact of human activities on grizzly bear habitat in Jasper National Park. Wildlife Society Bulletin 28(2): 624-638.

Infield, M. 2001. Cultural Values: a forgotten strategy for building community support for protected areas in Africa. Conservation Biology 15(3), 800-802.

Interagency Conservation Strategy Team. 2000. Draft conservation strategy for the grizzly bear in the Yellowstone area. 138 pp.

Johnson, S. 2000. Building a species recovery program on trust. Conservation biology in Practices pg 35-37.

Keating, K., C. C. Schwartz, M.A. Haroldson, and D. Moody. 2001. Estimating numbers of females with cubs-of-the-year in the Yellowstone grizzly bear population. In Press. Ursus.

Lacy, R.C. 1997. Importance of genetic variation to the viability of mammalian populations. Journal of Mammalogy 78(2):320-335.

Lande, R. 1993. Risks of population extinction from demographic and environmental stochasticity and random catastrophes. The American Naturalist 142(6):911-927.

Lenton, S.M., E. F. John, and J. Perez Del Val. 2000. A single non-parametric GIS model for predicting species distribution: endemic birds in Bioko Island West Africa. Biodiversity and Conservation 9:869-885.

Linnell, J.D.C., J. E. Swenson, and R. Andersen. 2000. Conservation of biodiversity in Scandinavian boreal forests: large carnivores as flagships, umbrellas, indicators, or keystones? Biodiversity and Conservation 9:857-868.

McLellan, B. N., and F. W. Harvey. 2001. Habitats selected by grizzly bears in a multiple use landscape. Journal of Wildlife Management 65(1):92-99.

Mech, D. L. 2001. Managing Minnesota's recovered wolves. Wildlife Society Bulletin 29(1):70-77.

Messmer, T.A., D. Reiter, and B.C. West. 2001. Enhancing wildlife sciences' linkage to public policy: lessons from the predator-control pendulum. Wildlife Society Bulletin 2001, 29(4):1253-1259.

Miller, C., and L. waits. 2002. Genetic management of Yellowstone grizzly bears. In press.

Miller, S. D. 2001. Rates of brown bear, *Ursus arctos*, cub survivorship in hunted and unhunted portions of Alaska (in press).

Miller, S.D., G.C. White, R.A. Sellers, H.V. Reynolds, J.W. Schoen, K. Titus, V.G. Barnes, Jr., R.B. Smith, R.R. Nelson, W.B. Ballard, and C. C. Schwartz. 1997. Brown and black bear density estimation in Alaska using radiotelemetry and replicated mark-resight techniques. Wildl. Monogr. 133. 55 pp.

Miller, S.D. 1990. Population management of bears in North America. Int. Conf. Bear Res. and Manage. 8:357-373.

Miller, S.D. 1993. Brown bears in Alaska: A statewide management report. Alaska Dept. Fish and Game Wildl. Tech. Bull. 11. 40 pp.

Miller, S.D. Impact of increased bear hunting on survivorship of young bears. Wildl. Soc. Bull. 18:462-467.

Miller, S.D. 1990. Denning ecology of brown bears in southcentral Alaska and comparisons with a sympatric black bear population. Int. Conf. Bear Res. And Manage. 8:279-298.

Mincher, B. J. 2000. Issues affecting grizzly bear management in the Greater Yellowstone Ecosystem. 17 pp.

Noss, R. F., H.B. Quigley, M.G. Hornocker, T. Merrill, and P.C. Paquet. 1996. Conservation biology and carnivore conservation in the Rocky Mountains. Conservation Biology 10(4):939-963.

Pac, H.I., and A.R. Dood. Five-year update of the programmatic environmental impact statement, the grizzly bear in northwestern Montana, 1991-1995. Montana Fish, Wildlife & Parks. 53 pp.

Schwartz, C., S. Miller, and M. Haroldson. 2001. Grizzly/brown bear in Wild Mammals of North America (in prep.)

Schwartz, C.C., and M.A. Haroldson, editors. 2001. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 2000. U.S. Geological Survey, Bozeman, MT. 126 pp.

Schwartz, C.C., M.A. Haroldson, K.A. Gunter, and D. Moody. 2001. Distribution of grizzly bears in the greater Yellowstone Ecosystem, 1990-2000. Interagency Grizzly Bear Study Team, Bozeman, MT. In press.

Schwartzman, S., A. Moreira, and D. Nepstad. 2000. Rethinking tropical forest conservation: perils in parks. Conservation Biology 14(5) 1351-1357.

Servheen, C, J. S. Waller, and P. Sandstrom. 2001. Identification and management of linkage zones for grizzly bears between the large blocks of public land in the Northern Rocky Mountains. U.S. Fish and Wildlife Service. 87 pp.

Stritthold, J.R., and D. A. Dellasala. 2001. Importance of roadless areas in biodiversity conservation in forested ecosystems: case study of the Klamath-Siskiyou Ecoregion of the United States. Conservation Biology 15(6):1742-1754.

Teddy Roosevelt Conservation Alliance. Square Deal Initiative #1. The Square Dealer Vol. 1, Issue 2.

Turback., G. 2000. Food for thought, what does the future hold for Yellowstone's grizzlies? National Wildlife Federation Oct.-Nov. P. 43-48.

Willcox, L., and D. Ellenburger. 2000. The bear essentials for recovery. An alternative strategy for long-term restoration of Yellowstone's great bears. Sierra Club grizzly bear ecosystems project. 25 pp.

Yaffee, S.L., and J. M. Wondolleck. 2000. Making collaboration work! Conservation Biologist in Practice p. 17-25.

APPENDIX A

DRAFT
FINAL REPORT OF THE GOVERNORS' ROUNDTABLE ON THE
DRAFT CONSERVATION STRATEGY FOR THE GRIZZLY BEAR IN THE
YELLOWSTONE AREA

May 30, 2000

Executive Summary

The Yellowstone Ecosystem Subcommittee (YES) of the Interagency Grizzly Bear
Committee (IGBC) produced a draft Conservation Strategy for the Grizzly Bear in the
Yellowstone Area. This document outlines a cooperative management strategy to be
implemented by state and federal agencies upon delisting of this population of grizzly
bears. The U.S. Fish and Wildlife Service (FWS) determined that completion of, and a
commitment to implement, such a plan is a necessary prerequisite to delisting. The FWS
took the lead in drafting the document, with assistance from technical staff from other
agencies in the YES.

At the request of the state members of the IGBC, the Governors of Idaho, Montana and
Wyoming agreed to appoint a 15 member citizen roundtable to review the draft
conservation strategy. The role of the roundtable was to develop consensus
recommendations the Governors could use in formulating the states' responses to the
draft.

The roundtable met three times in the spring of 2000 to discuss the draft conservation
strategy. A neutral party facilitated meetings. Staff from the three state wildlife
agencies, the FWS and the U.S. Forest Service provided technical advice to the
roundtable during and between meetings. All meetings were open to the public.

Given the limited time available and the technical nature of much of the document, the
roundtable took a policy level view of the draft conservation strategy. They identified a
number of issues and generated the following set of recommendations. The roundtable
reached complete consensus on all of these items.

The roundtable affirmed the conceptual approach of maintaining a Primary Conservation
Area (PCA) managed conservatively to protect a core of secure habitat and bear numbers.
They endorsed the proposed size and management of the PCA, which corresponds to the
current Recovery Zone.

The most significant concern that surfaced during the roundtable discussions was
uncertainty regarding management of bears and habitat outside the PCA. Environmental
and sportsmen interests fear that bears will be forever limited to the PCA, while
commodity interests fear that severe restrictions on land use could expand with the bear.

All interests recognized the key to moving forward is development of state management plans for area outside the PCA. State plans should be developed concurrent with revision of the Conservation Strategy and should seek to:

1. Insure the long-term viability of grizzly bears and preclude re-listing.
2. Support expansion of grizzly bears beyond the PCA in areas that are biologically suitable and socially acceptable.
3. Manage grizzly bears as a game animal, including allowing regulated hunting when and where appropriate.

In the short term, state should continue funding essential grizzly bear recovery efforts. In the long term, better funding mechanisms are needed to distribute the cost equitably between the national interests that support grizzly conservation. The governors and congressional delegations from Idaho, Montana and Wyoming should pursue additional federal funding.

The proposed Yellowstone Grizzly Management Committee should be expanded to include 3 non-voting members from each state appointed by the governor. to add citizen perspectives to management.

The agencies should establish a joint agency-citizen education committee to promote better understanding and awareness of grizzly conservation needs. Key messages should include realistic information on bear management, how to live with grizzlies and how to hunt in grizzly country without encountering problems.

Complete text of all 26 unanimous recommendations begins on page 11.

Background

The U. S. Fish and Wildlife Service (FWS) listed the grizzly bear in the coterminous states as "Threatened" under the Endangered Species Act in 1975. Shortly after that, the state and federal agencies involved in efforts to recover the grizzly bear formed the Interagency Grizzly Bear Committee (IGBC) to help coordinate conservation efforts. The Yellowstone Ecosystem Subcommittee (YES) was assigned lead responsibility for recovery efforts in the Yellowstone ecosystem.

The FWS's listing decision identified a number of threats to the long term viability of grizzly bears in the Yellowstone area. Among the factors considered were lack of habitat security and inadequate regulatory mechanisms to control grizzly bear mortality to acceptable levels. The FWS Recovery Plan outlined a number of steps necessary to address these problems. One task in the Recovery Plan was development of a Conservation Strategy by the state and federal agencies in the Yellowstone area that identified how bears and their habitat would be managed after the bear was delisted. The goal of the Conservation Strategy is to ensure the recovered population remains sufficiently healthy that protection under the Endangered Species Act is not necessary.

A technical team composed of staff from state and federal agencies in the YES collaborated on drafting a Conservation Strategy during 1998 and 1999. The FWS Grizzly Bear Recovery Coordinator led the process and was the primary author. Although the technical team sought consensus on content of the strategy, some aspects of the draft strategy were not fully acceptable to all members.

The YES recognized the need for public review of the draft strategy to develop understanding and acceptance of the strategy. The YES was also open to suggestions for change to make the strategy more effective. The YES proposed to submit the draft for public review during the spring of 2000. The FWS agreed to facilitate the review through publication, notice in the Federal Register and compilation of public comment.

Given the state's lead role in management of grizzlies after delisting and the significant costs the states will incur, the IGBC identified the need for understanding of, and commitment to, the Conservation Strategy at the highest levels in state government. Accordingly, as part of the public review process, the IGBC invited the governors of Idaho, Montana and Wyoming to appoint a citizen roundtable to review the draft conservation strategy to help formulate the states' recommendations on the draft.

Governors' Roundtable Members and Process

Governor Kempthorne (ID), Governor Racicot (MT) and Governor Geringer (WY) signed a Memorandum of Understanding in December, 1999, agreeing to appoint a 15 member citizen roundtable to review the draft Conservation Strategy for the grizzly Bear in the Yellowstone Area. The governors' goal was to coordinate the states' review and provide a meaningful role for state residents in defining the future of grizzly bear

conservation in the Yellowstone area. The governors agreed to appoint members from a broad range of interests, to provide support to the roundtable process and to meet jointly to consider the recommendations of the roundtable.

Roundtable members were:

Idaho	Montana	Wyoming
Ms. Jan Brown	Sen. Lorents Grosfield	Mr. Dennis Oden
Sen. Golden Linford	Mr. Tom France	Ms. Jill Siggings
Mr. Roy Moulton	Mr. Tim Mulligan	Mr. Albert Sommers
Mr. Brent Robson	Mr. Randy Newberg	Mr. Steve Thomas
Mrs. Cindy Siddoway	Mr. Gary Ullman	Mr. Harold Turner

Interests represented included conservation and environmental groups, sportsmen, livestock owners, oil and gas industry, local business, county government, state fish and wildlife commissions and state legislatures.

Mrs. Virginia Tribe of Missoula, Montana facilitated the roundtable process. As a neutral party, her role was to keep the group on task and ensure all interests had a fair opportunity to influence the outcome.

The roundtable met March 16 in Bozeman, Montana, April 20 in Idaho Falls and May 17 and 18 in Jackson, Wyoming. All meetings were open to the public.

Staff from the governors' offices, the state wildlife agencies, the FWS and U.S. Forest Service attended the roundtable meetings, and was available between meetings, to provide technical advice to the members.

Given the limited time available and the technical nature of the draft conservation strategy, the roundtable took a policy level view of the document. At their initial meeting, they agreed to accept the science in the strategy as the best available at the time. They agreed to seek consensus on recommendations that:
- can be used collectively by the three Governors to develop their formal comments on the Conservation Strategy;
- acknowledge the importance of flexibility as the situation changes;
- are within the context of states (Idaho, Montana and Wyoming);
- encourage successful partnerships; and
- address states' issues so that states are willing and have the capabilities to accept responsibilities that result from de-listing.

The roundtable organized their discussion and analysis around a number of issues that arose from their individual perspectives. They used the following criteria for evaluating and determining priority issues:
- Is there a legal mandate?
- Will it have significant effect on long-term Grizzly Bear viability?

- How well does it meet the expectations of the MOU?
- Is it an area where all three States have a problem with the proposal? Is it an area where all three States will have to agree?
- To what degree do local, state, and federal agencies agree/disagree?
- Is the issue considered high priority by a large number of Roundtable members or all the Roundtable members of a particular state or interest group?
- Do the States consider it feasible to implement in its present form?
- Can the States afford it?

At their second meeting, the roundtable reached agreement on a list of the most important issues to address. They formulated a statement that outlined key elements of the issue and agreed on guiding principles for resolution of the issue. They identified what interests were affected by the issue and what the affected interests needed to be satisfied with resolution. They developed potential recommendations related to the issue and agreed to network within their states during the interim between their second and final meeting.

Issues

Clarity of the plan; management of the process (roles; decision authorities; citizen involvement in the management process/committee; peer review; guidance for nuisance bears).

Issue Statement

This proposal is based on the assumption that the grizzly bear has been de-listed and that federal and state agencies will fulfill and fund the Conservation Strategy responsibilities assigned to them. Idaho, Montana and Wyoming are deemed to have management plans in place that are satisfactory to carry out the Conservation Strategy. The issue is: How do we develop and implement a state management plan that:
- Utilizes existing state processes and is adapted to reflect issues related to grizzly bears;
- Integrates with the federal Conservation Strategy;
- Coordinates with other agencies and jurisdictions (federal and all 3 states);

Guiding Principles
- The likelihood of success is increased by involvement of local citizenry.
- It is critical to recognize realistic budget constraints.
- The plans must be flexible to respond to biological, social and political change.

Interests/Needs

- It is in the interest of those signing the Conservation Strategy to coordinate their efforts.
- It is in the interest of the environmental community to have assurance that state agencies listen to more than just hunters.
- It is in the interest of private property owners to be satisfied that their property rights have been adequately considered.
- It is in the interest of the hunting community to have state agency funding augmented from sources other than traditional license dollars until hunting is an active component of state management plans.
- It is in the interest of local communities and businesses to have assurance that state plans are responsive to their economic future.

Initial Ideas Toward Recommendations

- Utilize existing state agency processes to reflect the interest of all concerned parties.
- Clarify accountability and responsibility among agencies.
- Establish clear protocol for nuisance bear problems.
- Integrate the plans of all 3 states through the YGMC.
- Expand the YGMC to include citizen members from each state.
- Consider compensation for depredation.
- Identify suitable grizzly bear habitat outside the PCA and manage populations in those areas while mitigating adverse social and economic consequences (in the same way state manage for other major species).
- Consider hunting as a reasonable and anticipated management tool.
- To the extent possible, incorporate state management plans into federal land and resource management decisions.
- Incorporate education programs to reduce nuisance bear problems.

Primary Conservation Area boundaries and habitat requirements.

Issue Statement

This issues related to a number of questions regarding the size of the Primary Conservation Area (PCA), including:

- Do the proposed guidelines exceed or underestimate habitat requirements?
- Are the geographic boundaries within the Conservation Strategy appropriate?
- Is the 10 mile buffer zone adjusting for habitat realities; should there be better criteria for determining the buffer zone?
- Will other species (listed, petitioned and/or otherwise) in the PCA have their habitat needs met?

- Are the PCA and buffer zone boundaries based on biological habitat and science?
- Will Bear Management Units (BMUs) as currently drawn meet "adjacent unit" criteria or are they set up to fail as proposed in the draft?
- Is there a better way (i.e., larger PCA; less restrictions, BMU boundaries, etc.)?
- Can the BMUs be better configured to delete poor habitat?
- Should boundaries be expanded?

Guiding Principles
- Use this process to support bear recovery and not to advance agendas unrelated to bear recovery.
- Seek solutions that constitute a balance among competing interests.
- Seek to maximize benefits to the bear for the money and time invested.
- Meet minimum legal requirements for bear recovery.
- Seek local wisdom and perspective in order to achieve "buy in" with boundaries and habitat objectives.

Interests/Needs
- It is in the interest of counties, communities and businesses in grizzly bear country to have reasonable certainty in their lives.
- It is in the interest of the states have management discretion.
- It is in the interest of federal agencies to have local support rather than continued controversy on boundaries.
- It is in the interest of the US Fish & Wildlife Service to have an area large enough to assure recovery and fulfill the de-listing goal.

Initial Ideas Toward Recommendations
- Modify the monitoring zone boundary to reflect habitat realities (arbitrary 10 miles).
- Accept the current boundary as a reasonable compromise based on assumed science.
- Eliminate portions of BMUs of dubious habitat quality (i.e., some private lands). Consider combining units that have not reached goals due to habitat limitations.
- Consider adding those areas outside the current boundary with high habitat and bears.
- Consider the inclusion of restricted lands (wilderness areas) that have decent habitat.
- Draw a boundary that reflects where the bears want to be and under what conditions.
- Get rid of one circle with BMUs. Look at core federal lands, secondary zones under state responsibility and linkages. In these zones, develop management strategies that consider multiple species including humans.

- Boundaries that are biologically based with social considerations.
- Reconfigure the core area to encompass the highest quality habitat and bear occupation (primarily federal land).
- Develop a "new" secondary (qualitative) habitat category that considers human activities and co-existence, other species, linkages, current management designations, etc. with state primacy in these areas.
- Pool resources and responsibilities for long-term monitoring among federal, state and local (universities) and multi-state entities.

Human use restrictions - Clarity, flexibility, tolerance, and monitoring.

Issue Statement

Concern over human use restrictions exist within three distinct zones: (1) Inside the PCA; (2) Outside the PCA but inside the 10 mile buffer; (3) Outside the 10 mile buffer. Uses being restricted include commercial use, recreational use, and uses on private property.

Guiding Principles
- Maintain a sustainable, recovered grizzly bear population.
- Meet the needs of affected partners.
- Meet the needs of local communities.

Interests/Needs
- It is in the interest of local communities and counties in grizzly bear country to have healthy social/economic situations and maintain and/or increase their tax base.
- It is in the interest of users to have roads available to support their activities.
- It is in the interest of recreationists to have access to recreation areas and sites and to have hunting and fishing opportunities.
- It is in the interest of local ranchers to be able to continue livestock grazing, be viable economically, and continue their way of life and culture.
- It is in the interest of outfitters to have areas that appeal to their clientele.
- It is in the interest of the timber industry to have areas available for timber harvest.
- It is in the interest of oil and gas developers to have areas available for exploration.
- It is in the interest of private property owners to be able to protect their property values and have flexibility in managing their land.
- It is in the interest of the general public, local publics and involved agencies to meet the ESA requirements for de-listing the grizzly bear.

- It is in the interest of involved states to optimize their authority and flexibility to manage human use restrictions.
- It is in the interest of grizzly bears to have adequate habitat and to be managed for their long-term sustainability.

Initial Ideas Toward Recommendations
- Inside the PCA, management flexibility should be provided for people living, working and recreating while still satisfying the recovery objectives for grizzly bear populations and habitat. Monitoring is critical to reducing the level of restriction.
- Outside the PCA, human uses would best be served by management guidelines developed by the states. Grizzly moralities should only be counted inside the PCA.

Cost, budget and funding

Issue Statement

It is critical to determine how the Conservation Strategy will be funded both in the short and long term.

Guiding Principles
- This should/cannot be an unfunded mandate, but rather a shared responsibility.
- The funding burden should not fall unfairly on licensed/permitted users (hunters/anglers, landowners, commercial interests, local communities) of public lands.
- The level of federal funding should be determined based on the part grizzly bear management plays in the whole ESA program.
- Entities who pay for grizzly bear management should have some involvement in decisions related to management strategies.

Interests/Needs
- It is in the interest of commercial users to not bear the financial burden of grizzly bear management.
- It is in the interest of communities and counties to not bear the financial burden of grizzly bear management nor have other economic elements affected negatively.
- It is in the interest of conservation groups to have adequate funding available to support long term sustainability of the grizzly bear, particularly if it is de-listed.
- It is in the interest of the general public to have grizzly bear management funded for the long term sustainability of the grizzly bear.

Initial Ideas Toward Recommendations
- Total federal funding.

- Total state funding.
- Total private funding.
- Combination of all or part of the above.
- Short term - Continued funding by federal and state governments.
- Long term - Creation of an Endowment Fund seeded by the federal government. Interest from the corpus will be used to fund the majority of costs. (Current proposal being forwarded by the Wyoming Game and Fish Department)

The need for comprehensive, ongoing education to help people understand management strategies and increase tolerance for the bear.

Issue Statement

Education is critical to the success of the recovery strategy in order to increase tolerance of the bear and reduce bear mortality; move toward a less restrictive strategy; and promote human safety. The desired end results include safety and the ability to share public lands with bears and long-term survivability of grizzly bears. Educational materials should use accurate, current science, be based on educational curriculum design, and be easily understood. Materials should also help people understand the social and economic factors involved in managing for grizzly bears. The responsibility should be appropriately shared among federal, state, local and citizen interest groups with materials develop to reach a variety of audiences and users including local governments, hunters/outfitters, those who use the land for grazing, recreationists, commodity extractors, Homeowners, school children and visitors from out of the area.

Guiding Principles
- Maximize human safety.
- Minimize bear mortality.
- Use current, accurate, science-based educational curriculums.
- Assure user-friendly materials and programs.
- Identify and prioritize target groups.

Interests/Needs
- In areas managed for grizzly bear, it is in the interest of homeowners, the local public, public land recreationists and commodity users, and out-of-the area visitors:
  - To be adequately informed so they understand safety measures.
  - To understand the social and economic factors related to managing grizzly bears.
  - To understand "nuisance bear" guidelines.
- It is in the interest of advocacy groups to have public tolerance of grizzly bears and to have people understand management strategies.

- It is in the interest of commodity users and recreationists to understand the rationale supporting grizzly bear management strategies so that their actions on the land may eventually lead to less restrictive approaches.
- It is in the interest of local, state and federal governments to have citizenry that are informed about grizzly bears, roles and responsibilities, and authorities in their areas.
- It is in the general public interest to have sustainable populations of grizzly bears and grizzly bear habitat.
- It is in the interest of the US Fish & Wildlife Service to have ongoing management strategies that sustain viable populations of the grizzly bear.

Initial Ideas Toward Recommendations
- Form a committee of state, federal and local government and citizens to develop an education program or programs to meet the needs of the general public and certain target groups.
- Identify tools being used today and find out what's happening currently and by whom.
- Use success stories in educational materials.
- Think "marketing".
- Create "bear country" support groups in and around communities where grizzly bears live.

Final Recommendations

At their third meeting, the roundtable refined their recommendations until agreement was reached on language for each item. Caucusing among similar interests, divergent interests and state representatives was used to expedite discussion. The following lists the final recommendations of the roundtable.

Unanimous Recommendations Related to the Conservation Strategy and the Primary Conservation Area (PCA)

The PCA boundary should be adopted as presented in the draft Conservation Strategy. The Round Table affirms the proposed management within the PCA, including the approach of allowing minimum, temporary reductions in grizzly bear secure areas, only for the purpose of overall grizzly bear habitat improvement.

The Conservation Strategy should include and explain the concept of adaptive management in understandable terms, explain how adaptive management will be applied, and explain how the Conservation Strategy may be amended in the future. (For example, the document should explain how management changes in the Targhee National Forest that may affect habitat in the Plateau and Henry's lake Bear Management Units will be evaluated in relation to occupancy and re-listing criteria, and what changes in the Conservation Strategy might result.)

When data demonstrate that bear populations are healthy and robust outside the PCA according to state plan goals, more flexible management may be considered within the PCA, provided the basic objectives for the PCA are maintained.

Eliminate references to monitoring population parameters and mortality in the 10 mile area surrounding the PCA in relation to management decisions in the Conservation Strategy. (i.e. Eliminate the 10 mile "buffer.") Monitoring and management outside the PCA should be governed by state management plans to be developed as outlined below. Decisions in the Conservation Strategy should be limited to results of monitoring within the PCA unless monitoring under state plans outside the PCA indicates the need for management review and action either inside or outside the PCA.

Continue centralized coordination of ecosystem-wide population monitoring to insure data integrity and to provide a database available to the 3 states and other appropriate entities. The Round Table recommends that the Conservation Strategy include a data validation process for the purpose of eliciting and sustaining confidence in the data.

Unanimous Recommendations Related to State Plans

Assuming adoption of the above recommendations on the Conservation Strategy, the three states should initiate development of state grizzly bear management plans for areas outside the PCA. These plans should be developed concurrent with revision of the draft Conservation Strategy.

State and federal agencies should develop and communicate a process agreement that outlines and harmonizes state and federal planning as well as de-listing.

State plans should be developed through a public process and should seek to:
- Insure long-term viability of grizzly bears and preclude re-listing.
- Support expansion of grizzly bears beyond the PCA in areas that are biologically suitable and socially acceptable.
- Manage grizzly bears as a game animal, including allowing regulated hunting when and where appropriate.

Unanimous Recommendations Related to Funding

Short Term
- Continue funding state efforts and make funding for state plans a priority.
- Re-evaluate state costs, including local government needs (information and education, planning, etc.), so that budgets are realistic.
- Continue federal dollars to support management within the PCA.

Long Term
- Develop mechanisms to assure long term funding. Options include establishment of an Endowment for Grizzly Bear management, Conservation And Reinvestment Act dollars, or other national appropriations through Congress.

- Involve the Governors' Offices and the states' delegations in lobbying for federal dollars.
- Develop funding for livestock depredation compensation.

Unanimous Recommendation Related to Citizen Involvement

Add 3 non-voting citizen members per state to the Yellowstone Grizzly Management Committee (YGMC). In making these citizen appointments, the Governors should strive for a balanced representation. The YGMC should encourage their active participation in each meeting through establishment of Committee ground rules and clarification of roles and authorities. After three years, evaluate the structure and based on the evaluation, make appropriate changes.

Unanimous Recommendations Related to Education

Establish and fund an interagency education working group and include citizen members from each state appointed by the three Governors in a manner that reflects balanced representation.

Produce education materials based on the following criteria and messages:
- Honest and realistic messages about bears and bear management
- The need for nuisance protocol and removal of problem bears
- No jargon
- Safety and sanitation
- The need for and achievement of informed hunters
- Resident and non-resident messages
- Living with bears/bear country communities
- The importance of networks and communication
- Responsibility of local government
- Develop signage appropriate to "bear country"

Think about tools in "bear country" within the PCA that might encourage human safety, survival of the bear, and increased capacity for local governments, managers and private landowners (i.e., habitat-oriented and open space tax incentives; development restrictions and responsibilities; zoning and subdivision regulation).

Tools in "bear country" outside the PCA should be developed in coordination with state management plans.

Unanimous Recommendations Related to Plan and Process Clarity

Make a strong effort to provide citizens with a clear, understandable version of the plan and process.

Find avenues through the IGBC to start communication among states and federal entities about interrelationships among threatened and endangered species in the Yellowstone area and encourage language to this effect in the Conservation Strategy.

Unanimous Recommendations Related to the Montana Legislature

Once the Grizzly Bear is de-listed, add it to the list of animals in 87-1-115 that provides enhanced protection and significant fines under Montana law.

Revise Montana law with regard to taking Grizzlies for potential livestock depredation in a manner that eliminates this barrier to de-listing.

Unanimous Recommendations Related to Nuisance Bear Policy

Nuisance bear policy in the Conservation Strategy should be clarified and defined to increase public understanding and decrease misconceptions.

The Roundtable affirms that management authority for nuisance bears outside Nation Park boundaries lies with state agencies and that clear, effective protocols, including sensitivity to the placement of nuisance bears, need to be part of the Conservation Strategy as well as state plans.

APPENDIX B

Grizzly Bear Policy MCA 12.9.103

<u>MCA 12.9.103 GRIZZLY BEAR POLICY</u> (1) Whereas, the Montana Fish and Game Commission has management authority for the grizzly bear, a resident wildlife species, and is dedicated to the preservation of grizzly bear populations within the state of Montana; and

Whereas the secure habitat for the grizzly has been greatly reduced as a result of the human development and population growth from 1850 through 1950 in the bear's traditional range in all western states; and

Whereas, a significant portion of the remaining grizzly bear habitat and population is located in Montana and these Montana populations occur in wildlands such as wilderness, primitive areas, de facto wilderness areas, national forests, national parks, Indian reservations, and seasonally, on adjacent private lands.

Now, therefore, in order to promote the preservation of the grizzly bear in its native habitat, the commission establishes the following policy guidelines for the Montana Department of Fish, Wildlife and Parks action when dealing with grizzly bear.

(a)   Habitat. The department shall work to perpetuate and manage grizzly bear in suitable habitats of this state for the welfare of the bear and the enjoyment of the people of Montana and the nation. In performing this work the department should consider the following:

(i)   the commission has the responsibility for the welfare of the grizzly and advocates the protection of the bear's habitat;

(ii)   management of Montana's wildlands, including the grizzly bear habitat, is predominately, but not exclusively, a responsibility of various federal agencies and private landowners;

(iii)   land use decisions made by these agencies and individuals affect grizzly bear habitat, thus cooperative programs with these agencies and individuals are essential to the management of this species;

(iv)   preservation of wildlands is critical to the protection of this species and the commission advocates wildland preservation in occupied grizzly bear habitat; and

(v)   while some logging may not be detrimental to grizzly habitat, each logging sale in areas inhabited by grizzly bear should be carefully reviewed and evaluated.

(b)   Research. It is recognized by the commission that research on the habitat requirements and population characteristics of the grizzly bear is essential for the welfare of the species. Departmental research programs and proposals directed at defining those habitat requirements are encouraged and supported.

(c)   Hunting and recreational use. The commission recognizes its responsibility to consider and provide for recreational opportunities as part of a grizzly bear management program. These opportunities shall include sport hunting, recreational experiences, aesthetics of natural ecosystems, and other uses consistent with the overall welfare of the species.

(i)   the department should consider the variability of values between individuals, groups, organizations, and agencies when management programs for various grizzly bear populations are developed.

(ii)   sport hunting is considered the most desirable method of balancing grizzly bear numbers with their available habitat, minimizing depredations against private property within or adjacent to grizzly bear habitat, and minimizing grizzly bear attacks on humans.

(d)   Depredations. Contacts between grizzly bear and humans, or property of humans, require delicate handling and careful consideration. When these contacts reach the stage for definite action, the following actions should be carried out:

(i)   grizzly bear, in the process of threatening or endangering human life, shall be captured or dispatched immediately.

(ii)   where no immediate threat to human life exists, individual bear encounters with humans shall be evaluated on a case-by-case basis and when the attack is abnormal or apparently unprovoked, the individual bear involved shall be captured or dispatched.

(iii)   when the attack is normal (e.g. a female defending her cubs, any bear defending its food, or any bear defending itself) but the situation leads itself to no reasonable possibility of leaving the bear in place, then the bear should be removed.

(iv)   grizzly bear committing depredations that do not directly endanger human life but that are causing property losses shall be evaluated on an individual case basis.

(v)   where removal is determined to be the best resolution to the problem, depredating or nuisance bear shall be trapped, and if determined to be suitable for transplanting, shall be marked and released in suitable habitat previously approved with appropriate land management agencies.

(vi)   reasonable efforts shall be made to inform the public of the transplant program, fully explaining the reasons for the capturing and locations of the release area.

(vii)   upon request by an authorized scientific investigative agency or public zoological institution, a captured bear may be given to that agency or institution, for appropriate nonrelease research purposes. A reasonable charge may be required to cover costs of handling.

(e)   Depredating grizzly bear that are not suitable for release or research because of old age, acquired behavior, disease, or crippling, shall be killed and sent to the department's research facilities for investigation. The public shall be fully informed when these actions are taken and the reasons for these actions shall be fully explained.

(f)   Coordination.   The department shall consult with appropriate federal agencies and comply with applicable federal rules and regulations in implementation of this policy.   (History: Sec. 87-1-301 MCA, IMP, 87-1-201, 87-1-301 MCA; Eff. 12/31/72; AMD, 1977 MAR p. 257, Eff. 8/26/77.)

APPENDIX C

SPECIAL ORDER IN THE
NORTHERN REGION - GALLATIN, BEAVERHEAD, AND CUSTER NATIONAL FORESTS
ROCKY MOUNTAIN REGION - SHOSHONE NATIONAL FOREST
INTERMOUNTAIN REGION - BRIDGER-TETON AND TARGHEE NATIONAL FORESTS

This order is implemented under the authority of 36 CFR 261.50 (a) and (b) with a primary goal of minimizing grizzly/human encounters and thereby providing for user safety and protection of this nationally threatened species.

Definitions

1. "Bear resistant container" means a securable container constructed of solid non-pliable material capable of withstanding 200 foot-pounds of energy (using the approved bear-resistant container impact testing machine). When secured and under stress the container will not have any cracks, openings, or hinges that would allow a bear to gain entry by biting or pulling with its claws. Wood containers are not considered bear-resistant unless they are reinforced with metal.

2. "Food" means any nourishing substance, solid or liquid (excluding baled hay or water) or refuse thereof, that is not native to the immediate area, which is or may be eaten or otherwise taken into the body to sustain life, provide energy, or promote growth of any person or animal.

3. "Grizzly bear use area" means those area(s) delineated by a Forest Supervisor on maps identified as part of this order (Exhibit A).

4. "Animal carcass" means the dead body or parts thereof, of any mammal, bird, or fish, including domestic livestock.

5. "Acceptable storage" means:

    a. stored in a bear resistant container or;

    b. stored in a closed vehicle constructed of solid, nonpliable material or;

    c. suspended at least 10 feet clear of the ground at all points and 4 feet horizontally from any supporting tree or pole.

Prohibitions
The following acts are prohibited while occupying or using the grizzly bear use areas shown in Exhibit A of this Order.

1. Possessing or leaving unattended any animal carcass (36 CFR 261.58 (s)) unless the carcass is:

    (a) at least 1/2 mile from any sleeping area, trail, or recreation site or

    (b) at least 100 yards from any sleeping area, trail, or recreation site and acceptably stored, or

    (c) being eaten, being prepared for eating, or being transported.

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2. Possessing or leaving unattended any food during the daytime period 1 hour before sunrise until 1/2 hour after sunset (36 CFR 261.58 (cc)) unless it is:

    (a) acceptably stored or

    (b) being eaten, being prepared for eating, or being transporte: or

    (c) being attended and acceptable storage methods are present a· can be shown to a Federal, State, or local law enforcement officer.

3. Possessing or leaving unattended any food during the nighttime perio 1/2 hour after sunset until 1/2 hour before sunrise (36 CFR 261.58 (cc)) unless food is:

    (a) acceptably stored or

    (b) being eaten, being prepared for eating, or being transporte

4. Camping within 1/2 mile of any animal carcass or within 100 yards of any acceptably stored animal carcass except when such carcass is bei eaten, being prepared for eating, or being transported (36 CFR 261.5 (e)).

Exceptions

1. Prohibitions 1, 2, 3, or 4 do not apply to any person with a permit issued by the Beaverhead, Custer, Gallatin, Shoshone, Bridger-Teton, Targhee National Forest Supervisors or District Rangers authorizing otherwise prohibited act.

2. Any Federal, State, or local law enforcement officers of other emergency personnel are exempt from these prohibitions only when suc prohibited actions are necessary and/or essential for performance of their official duties.

GRIZZLY BEAR RECOVERY AREA
GALLATIN NATIONAL FOREST

Map: Grizzly Bear Recovery Area, Gallatin National Forest

Legend:
- grizzly bear recovery area
- Forest Boundary
- Ranger District Office

SCALE
0 5 10 15 20 MILES
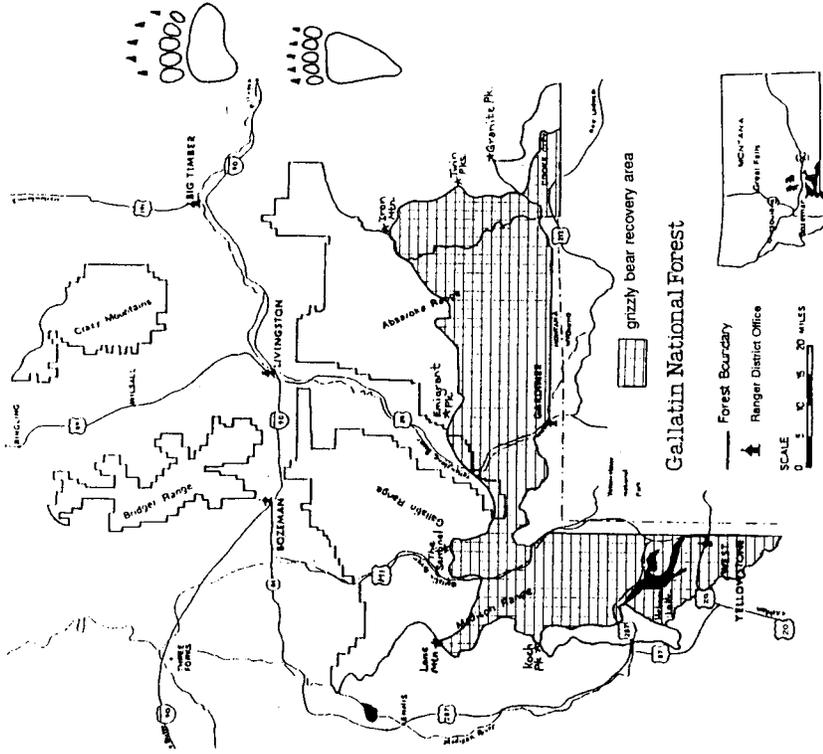
NOTE: This map is intended to give an idea of where grizzly bears are known to range. This does not mean that grizzlies are never seen outside the recovery area, or that visitors are certain to see them within the shaded area. The recovery area shown includes that portion of the Gallatin National Forest that is known to be frequented by grizzly bears, and which contains the habitat components necessary for recovery of the species.

Black bears are found throughout the forest and should be treated with equal respect.

SPECIAL ORDER FOR FOOD STORAGE WITHIN GRIZZLY BEAR RECOVERY AREA

To provide for public safety and protection of the grizzly bear, a threatened species, regulations as summarized below have been issued under the authority of 36 CFR 261.50 (a) and (b).

Within the grizzly bear recovery area shown at right, the following requirements must be met:

a) Human food and beverages, horse feeds, dog food, etc. either in possession or left unattended must be kept unavailable* to grizzly bears unless being consumed, prepared for consumption, or transported.

b) Fish and wildlife carcasses must be kept unavailable to grizzly bears and at least 100 yards from any tent or sleeping area, trailhead, or recreation site, unless being eaten, prepared for eating, or transported.

c) Fish and wildlife carcasses must be kept unavailable to grizzly bears except at locations more than 1/2 mile from campsites, trailheads, and recreation areas.

d) When departing the area, all food and refuse is removed from any bear resistant containers left in the area.

* Items are considered unavailable if they are:

1) stored in a closed, bear resistant container,

2) enclosed within a vehicle constructed of solid, nonpliable material, or

3) suspended at least 10 feet clear of the ground at all points and 4 feet horizontally from any supporting tree or pole.

Violation of this special order is punishable by a fine of not more than $500.00 or imprisonment for not more than six months, or both.

For more detailed information, contact the local Ranger District Office

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APPENDIX D

MEMORANDUM OF UNDERSTANDING
BETWEEN
MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS (FWP)
AND
UNITED STATES DEPARTMENT OF AGRICULTURE
ANIMAL AND PLANT HEALTH INSPECTION SERVICE
ANIMAL DAMAGE CONTROL (ADC)

COOPERATIVE ANIMAL DAMAGE CONTROL PROGRAM IN THE STATE OF MONTANA

ARTICLE 1

The purpose of this Memorandum of Understanding (MOU) is to initiate a cooperative relationship between FWP and ADC for planning, coordinating, and implementing animal damage control programs developed to prevent or minimize damage caused by wild animal species, including threatened and endangered species, to agriculture, animal husbandry, forestry, wildlife, and public health and safety.

ARTICLE 2

FWP is authorized to control wildlife damaging livestock or property or for public health and safety by Montana Codes Annotated, Sections 87-1-201 Powers and duties of the department and 87-1-225 Regulation of wild animal damaging property.

ADC is authorized by the Animal Damage Control Act of March 2, 1931 (7 U.S.C. 426-426b), and the Rural Development, Agriculture, and Related Agencies Appropriations Act, 1988 (P.L. 100-202) to cooperate with States, local jurisdictions, individuals, and public and private agencies, organizations and institutions.

ARTICLE 3

FWP and ADC agree that:

A.   Both parties will cooperate by providing facilities, equipment, personnel and funds to conduct a joint program in the state of Montana which will prevent or minimize the economic effects of depredations caused by wild animals.

B.   ADC will be responsible for capture of grizzly bears, black bears and mountain lions which are involved in livestock depredation, including bees and beehives. Upon notification of a livestock depredation where grizzly bear may be involved, the receiving party will contact the other party and a joint investigation will be conducted.

C. Grizzly bear control activities will follow the action procedures for determining grizzly bear nuisance status and for controlling nuisance grizzly bear in the Interagency Grizzly Bear Guidelines (attached) and 50 CFR 17.40 (b), whereby FWP will be responsible for the disposition of the animal.

D. Grizzly/livestock depredation reports will be prepared by FWP for submittal to the Great Bear Foundation. In cases where there remains a question on whether it was a grizzly involved, all information obtained during the investigation will be provided to Dr. Bart O'Gara for review and assessment.

E. FWP will be responsible for responding to non-livestock complaints involving grizzly bears, black bears and mountain lions. All non-livestock complaints will be referred to FWP.

F. Control activities and field investigations conducted pursuant to this MOU will emphasize sound management practices and due regard for the protection of domestic animals, nontarget wildlife, endangered species and the environment.

G. At the written request of FWP Regional Supervisor and/or the ADC District Supervisor, notification will be provided in these regions when nuisance or livestock depredation control actions are initiated for black bear and mountain lion. All depredation complaints will be responded to within (48) hours. Assistance may be requested of either party when necessary.

H. Both parties will consult as often as necessary to review the number of depredation complaints received and the actions taken to resolve the complaints. Contacts should be made at the local level. FWP Regional Supervisors will coordinate with ADC District Supervisors.

I. ADC will submit an annual report of activities conducted. In addition, ADC will continue to provide the FWP a copy of all Bear and Lion Justification Reports.

J. Salvaging of animals will be reported on the ADC Bear and Lion Justification Report. Carcasses and/or parts will be turned over to FWP. In cases where it is impractical to turn in carcasses or all parts, those parts that remain salvageable will be turned in.

K. Both parties agree to identify areas and notify the other party where preventative measures may be taken to minimize or prevent animal damage. Cooperative preventative efforts will be undertaken whenever possible.

L. Both parties will encourage joint participation at training sessions involving animal damage control.

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M. The Field Services Services Division for FWP will provide for statewide liasion with the Montana Director of ADC regarding activities related to this MOU.

ARTICLE 4

All animal damage control activities will be conducted in accordance with the applicable Federal, State, and local laws and regulations.

ARTICLE 5

This agreement and any continuation thereof shall be contingent upon the availability of funds appropriated by the Congress of the United States and the State of Montana. It is understood and agreed that any monies allocated for the purpose of this agreement shall be expended in accordance with its terms and in the manner prescribed by the fiscal regulations and/or administrative policies of the agency making the funds available.

ARTICLE 6

Pursuant to Section 22, Title 41, United States Code, no member of or delegate to Congress shall be admitted to any share or part of this MOU or to any benefit to arise therefrom.

ARTICLE 7

This MOU shall supersede all existing memorandums of understanding and supplements thereto relating to the conduct of animal damage control programs with FWP. All cooperative animal damage control programs now in progress shall be incorporated and continued under this MOU for the purpose of being consistent.

ARTICLE 8

This MOU shall become effective upon date of final signature and shall continue indefinitely. This MOU may be amended at any time by mutual agreement of the parties in writing. It may be terminated by either party upon 60 days written notice to the other party.

MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS
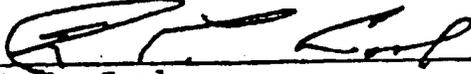
K. L. Cool
Director

Date August 17, 1990

USDA
Animal and Plant Health Inspection Service
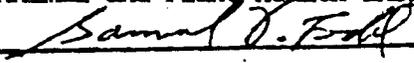
Acting Administrator

SEP 2 0 1990

Date

APPENDIX E

GUIDELINES FOR
BEAR DEPREDATION OF BEEHIVES

Bear depredation to beehives is considered a specialized depredation problem. Consequently, the following guidelines are considered a supplement to the existing, more extensive game damage guidelines dated September 30, 1985. Existing statutes and rules classify bees as livestock. Bees must, therefore, be included with other livestock in statutes which address predation and other problems related to livestock (87-3-127 and 87-3-130). These statutes allow livestock owners to shoot, trap or chase with dogs any bears that have destroyed, or are threatening to destroy beehives. These statutes do not supercede private property rights. Landowners may prevent bears from being killed by both beekeepers and Department personnel by preventing access to their property.

1. All bear depredation complaints to the Department will be investigated within 48 hours (87-1-225). Complaints by beekeepers should be made to local ADC agents or Department of Fish, Wildlife and Parks' personnel. "First contact" individuals or procedures may vary locally. Coordination with ADC relative to bear-bee issues will be accommodated at regional level by Regional Supervisor.

2. All bears known by the Department to have destroyed beehives will be killed in compliance with Department policy. When the Department responds to a verified beeyard damage complaint where bees have been killed by the bear, killing the bear is the only alternative. Beekeepers must have permission of the landowner to kill depredating bears on property other than their own.

3. Beekeepers may shoot, trap, snare or chase with dogs, any bears that have destroyed, or are threatening to destroy beehives (87-3-127; 87-3-130). Beekeepers must have reasonable evidence that bears killed have caused damage and avoid the killing of "innocent" bears. Any bears killed by landowners or beekeepers shall be reported to the Department as soon as practical and no later than 72 hours (87-3-130). After report of a bear kill, FWP personnel will complete the depredation report and the necessary parts and data will be obtained (e.g. tooth, claws, skull).

4. Trapping or snaring of bears by beekeepers must occur within 50 feet of beehives. Snares should only be used after damage has occurred. All traps and snares must be checked at least every 12 hours (87-3-127).

5. Beekeepers using a beehive within 50 feet of an active, occupied registered beeyard, for the purpose of trapping, snaring or shooting depredating black bears, are not baiting as defined under state law (87-3-101).

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6. Bears caught by agency personnel in culvert or live traps in the general vicinity of beeyards, but not known to have actually caused damage, will be held up to 12 hours in the trap so that stools may be inspected for evidence of having caused damage to beehives.

7. Live-trapped bears showing evidence of having caused depredation on beehives will be killed.

8. Live-trapped bears that do not display evidence of having caused beehive damage, and have no history of other nuisance problems, may be relocated under the following circumstances and in compliance with 87-1-231 to 234.

    A. All relocated nuisance black bears will be marked with special "nuisance bear" eartags; records of marked bears will be kept at the regional level; proper distribution of "nuisance bear" eartags will be the responsibility of the Regional Supervisor.

    B. Grizzly bear relocation will follow the IGBC Nuisance Bear Guidelines;

    C. Release sites of nuisance black bears will preferably be at least 50 miles away, in a different mountain range, in an area of low bear density and not in an area of known chronic bear problems. It is recognized that it may not always be possible to meet all of these criteria. Selection of areas for relocations will be the responsibility of the Regional Supervisor.

9. When possible, hunters will be utilized in removing known damage-causing bears during open bear hunting season. A hunter roster for damage hunts will be considered on a region by region basis and will be the responsibility of the Regional Supervisor.

10. The Department will work towards refining of techniques for the protection of beeyards from depredating bears. As new technology becomes available, information will be passed on to beekeepers. New techniques may be pilot tested with cooperating beekeepers.

11. The Department will consider cost-sharing protective structures in certain situations. In "chronic" bear problem areas, the Department will provide a charger to beekeepers who wish to protect their beeyards with electrified fences and who are willing to purchase the materials and erect and maintain such a fence.

12. Other options, such as moving beeyards, should be considered when trying to reduce chronic bear problems. Beekeepers will be encouraged to prevent bear depredation problems whenever possible.

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13. The Field Services Division will be responsible to maintain an active liaison with the Beekeepers Association to mutually seek preventative measures to protect beehives and discourage bears from damaging hives.

Contact individuals relative to these guidelines are Glenn Erickson, 444-2612; Gene Allen, 444-2602; Bob Bird, 444-2452.

GA/ph
508/27

Appendix F. Proposed Montana Nuisance Grizzly Bear Management.
**This outline is intended to give a review of the general approach
and not as a guide to the solution of every potential nuisance situation.**

FWP receives report of grizzly bear problem

Yes

Was there human injury or fatality? → Yes → Human fatality? → Yes → Was this the result of the grizzly bear acting defensively? → Yes → Situation reviewed by MFWP -- removal conducted by MFWP

No

No

No

Was there significant property damage?

Did the grizzly bear act defensively and pose no additional threat? → No → Has the offending grizzly bear been identified?

Yes

No

Yes

Yes

Has the offending grizzly bear been identified?

Yes

Was the grizzly bear in suitable habitat?

Grizzly bear is removed by FWP

No

Yes

Yes

FWP determines the importance of the grizzly bear (females given more chances than subadult males)

No action taken against the grizzly bear other than non-lethal approaches

Significant property damage defined by established dollar amount and/or number of AUMs lost to verified grizzly bear activity.

Property owners not to receive any financial benefit from removing a grizzly bear under special authorization from the FWP. FWP will determine the disposition of the carcass.

Grizzly bears removed by FWP action or authorization will be utilized for scientific or educational purposes.

Grizzly bears recommended for relocation as a result of nuisance activity to be placed in suitable habitats which are adjacent and contiguous to the PCA, or to BMUs within the PCA.

Modified from plan developed by Dennis Oden

Sex of Bear

Removed by FWP

Male

Female with multiple offenses

Female

Relocate to other suitable habitat

Could be removed

FWP to utilize grizzly bear management control options

Removed by private party under special permit authorization

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MEMORANDUM OF UNDERSTANDING
BETWEEN THE
MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS
AND THE
U.S. FISH AND WILDLIFE SERVICE

WHEREAS, the U.S. Fish and Wildlife Service (FWS) has been delegated the authority of the Secretary of the Interior for the administration and enforcement of laws pertaining to fish, wildlife and plants; and

WHEREAS, The Montana Department of Fish, Wildlife and Parks (MFWP) has been delegated the authority for the administration and enforcement of laws pertaining to fish and wildlife in the State of Montana; and

WHEREAS, the Montana Department of Fish, Wildlife and Parks and the U.S. Fish and Wildlife Service have law enforcement personnel located in the State of Montana, these people having the necessary training, qualifications, and experience to enforce all of these laws; and

WHEREAS, the Secretary of the Interior has delegated law enforcement authority to the Director of the U. S. Fish and Wildlife Service and given the Director responsibility for cooperative assistance in enforcing these acts in accord with any cooperative agreement;

NOW, THEREFORE, the Assistant Regional Director for Law Enforcement of the U. S. Fish and Wildlife Service, Region 6, and the Director of the Montana Department of Fish, Wildlife and Parks do hereby agree as follows:

1. Special Agents of the FWS and Law Enforcement Officers of the MFWP are expected to recognize possible violations of State and Federal laws, develop intelligence, collect evidence, and report their activities to the officer responsible for case coordination.

2. Specific requests for investigative assistance by the State of Montana Coordinating Officer will be handled on an individual basis through the nearest Resident Special Agent in Montana.

3. When Special Agents of the FWS provide investigative assistance to the MFWP, the following guidelines shall apply:

    a. Both FWS and MFWP shall each designate a Case Agent who will be responsible for directing the operation and case reporting.

b.   Supervision will follow the routine of the parent agency.

c.   Decisions relating to investigative direction shall be initially decided by the designated Case Agents and confirmed by the appropriate level(s) of supervision in the respective agency.

d.   When operating within the respective investigation, the most restrictive legal policy shall apply (search and seizure, rules of evidence, laws of arrest, etc.).

e.   The State of Montana may supply up to $100,000 per annum on any State/Federal cooperative investigation. The FWS shall supply that funding needed to complete a mutually agreed upon operation. All administrative reporting requirements shall be met as procedurally required by each parent agency.

f.   The MFWP and the FWS, within each agencies administrative guidelines and upon mutual agreement, may assist each other in the payment of expenses necessary to the administration or routine operation on cooperative operations.

g.   All funding initially provided by the MFWP will remain in an interest bearing account and any initial funding issued will require the signature of one person from the law enforcement unit.

h.   Decisions to allocate **any** funds to further the operation will be cleared, in advance, through the appropriate level of supervision in each agency and in accordance with agency administrative policy.

i.   All expenditures are to be documented if at all possible except when case officer safety is an issue. In those cases documentation is not mandated except as can be noted on monthly report forms. MFWP expenditures will be recorded in the checking ledger or covert/business books and the FWS will provide monthly accounting of funding expended to MFWP, office of the chief.

j.   Documentation on all expenditures will be available for audit only when the specific investigation is completed or upon advice of the United States Attorney or Attorney General for the State of Montana.

k. The MFWP and FWS will request that the prosecuting agency(s) seek reimbursement through the courts of any identified expended funds for return to the MFWP fund for re-use within the parameters of agency policy.

l. Operational closedown dates, charges to be filed, courts to be utilized and prosecution direction will be decided by the Case Agents and the appropriate level(s) of supervision.

m. All news releases will be coordinated with the appropriate State/Federal attorneys' offices and the appropriate level(s) of supervision. There will be no release of case information without concurrence of all the above listed parties. The Public Affairs Office(s) to assume the lead in information dissemination will be determined by the parties prior to closedown.

n. All seized property will be disposed of, by the courts and/or mutual State/Federal agreement.

o. Equipment may be loaned by one party to the other on an individual basis. Such equipment becomes the responsibility of the borrower and will be returned in the same condition as when received, normal wear and tear excepted. Damage in excess of normal wear and tear will be repaired by the user. Lost or stolen property will be replaced or reimbursed.

p. Emphasis will be placed on the long term operation, with the goal of apprehending all major targeted violators. However, the length of time an operation will run will be dependent upon the mutual decision of the Case Agents and the State/Federal attorneys.

q. Intelligence relative to joint operations will be centrally located and shared among the parties involved. Arrangements for intelligence centralization will be determined prior to initiation of operations.

r. All property lawfully acquired under color of the covert operation will be disposed of in accordance with agency requirements/regulations.

s. Business contracts may be entered into by either or both parties with cooperating private individuals in accordance with agency policy(s) to further covert operations. Both parties represented by this MOU must consent however to such 3rd party contracts.

This Memorandum of Understanding will become effective when signed by the Director of Fish, Wildlife and Parks for the State of Montana and the Assistant Regional Director for Law Enforcement, U.S. Fish and Wildlife Service. Either of the aforementioned parties may cancel this Memorandum of Understanding upon (30) days written notice to the other party member.

Director
Montana Department of Fish,
  Wildlife and Parks

9-28-98
Date

Assistant Regional Director
U. S. Fish and Wildlife Service
Region 6

10/22/98
Date

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APPENDIX H

87-3-130. Taking of wildlife to protect persons or livestock. (1) This chapter may not be construed to impose, by implication or otherwise, criminal liability for the taking of wildlife protected by this title if the wildlife is attacking, killing, or threatening to kill a person or livestock, except that, for purposes of protecting livestock, a person may not kill or attempt to kill a grizzly bear unless the grizzly bear is in the act of attacking or killing livestock. In addition, a person may kill or attempt to kill a wolf or mountain lion that is in the act of attacking or killing a domestic dog. A person who, under this subsection, takes wildlife protected by this title shall, within 72 hours, notify the department and surrender or arrange to surrender the wildlife to the department.

(2) A person may not provide supplemental feed attractants to game animals by:

(a) purposely or knowingly attracting bears with supplemental feed attractants;

(b) after having received a previous warning, negligently failing to properly store supplemental feed attractants and allowing bears access to the supplemental feed attractants; or

(c) purposely or knowingly providing supplemental feed attractants in a manner that results in an artificial concentration of game animals that may potentially contribute to the transmission of disease or that constitutes a threat to public safety.

(3) A person who is engaged in the normal feeding of livestock, in a normal agricultural practice, in cultivation of a lawn or garden, or in the commercial processing of garbage is not subject to civil or criminal liability under this section.

(4) A person who violates subsection (2) is guilty of a misdemeanor and is subject to the penalty provided in 87-1-102(1). This section does not apply to supplemental feeding activities conducted by the department for disease control purposes.

(5) As used in this section:

(a) "livestock" includes ostriches, rheas, and emus; and

(b) "supplemental feed attractant" means any food, garbage, or other attractant for game animals.

History: En. Sec. 1, Ch. 306, L. 1981; amd. Sec. 13, Ch. 206, L. 1995; amd. Sec. 3, Ch. 540, L. 1995; amd. Sec. 3, Ch. 275, L. 2001; amd. Sec. 6, Ch. 316, L. 2001.

Compiler's Comments

2001 Amendments — Composite Section: Chapter 275 in (1) in first and third sentences after "protected by this" substituted "title" for "chapter" and in third sentence at end inserted "and surrender or arrange to surrender the wildlife to the department"; in (2) in introductory clause after "A person may not" deleted "intentionally" and after "supplemental feed" inserted "attractants"; inserted (2)(a) prohibiting attracting bears; inserted (2)(b) regarding failure to properly store supplemental feed attractants; in (2)(c) at beginning inserted "purposely or knowingly providing supplemental feed attractants" and at end after "transmission of disease" inserted "or that constitutes a threat to public safety"; inserted (3) concerning person engaged in feeding of livestock; inserted (5)(b) defining supplemental feed attractant; and made minor changes in style. Amendment effective April 20, 2001.

Chapter 316 in (1) in first sentence substituted "if the wildlife is attacking" for "if the wildlife is molesting, assaulting" and at end inserted exceptions for grizzly bear attacking or killing livestock and inserted second sentence concerning wolves and mountain lions attacking or killing a domestic dog; and made minor changes in style. Amendment effective April 21, 2001.

Appendix AA

MONTANA FISH, WILDLIFE & PARKS
GRIZZLY BEAR MANAGEMENT PLAN FOR SOUTHWESTERN MONTANA
DRAFT PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT
SEPTEMBER 18, 2002

Summary of Public Comments

The Grizzly Bear Management Plan for Southwestern Montana Draft Programmatic Environmental Impact Statement was released for public comment on April 5, 2002. Montana Fish, Wildlife & Parks solicited public comment through a series of formal public hearings held during May and June in Bozeman, Missoula, Big Sky, Ennis, Dillon, Big Timber, Columbus, Red Lodge, Billings, Gardiner, Livingston, West Yellowstone, and Butte. Oral comments were received and recorded at these hearings. In addition, written comment was accepted for 90 days through July 5, 2002.

One hundred seventy-one people attended the public hearings, and 32 offered oral testimony. Written comments were received from approximately 7300 people, 846 of whom were Montana residents. FWP also received three petitions with approximately 100 signatures. Some of the signatures were from kindergarten classes, and it was difficult to tell how many individuals signed.

Comments were used to improve the final plan.

Major comments and issues and our response are as follows:

Values: Many people commented on the value of maintaining a viable grizzly bear population in southwest Montana and on their own personal values associated with this species. People in Montana as well as people nationally and internationally view this species as very important and associate many differing personal values with it. Comments stated that the grizzly bear is a symbol of freedom, the United States, strength, serenity, fear, motherhood, peace, power, courage, wildness, wilderness, the West, the balance of nature, diversity, a sacred animal, one of God's creatures, a valuable game species, environmentalist meddling, and many more as varied as the individuals commenting.

As suggested in the wide array of comments, people also value the grizzly bear for its role in the ecosystem. This plan, by addressing the needs of those who live, work, and recreate in this area, should allow the bear to expand into those areas that are biologically suitable and socially acceptable. This will result in grizzly bears expanding their ecological role into additional habitats in southwestern Montana.

FWP recognizes these personal and ecological values associated with this species. Montana's program will provide for a secure grizzly population and allow people to pursue their individual values, whatever they may be. The constraint on these pursuits

is that collectively they should support the long-term conservation and maintenance of a healthy grizzly population.

Perceptions: Comments received were based on the perception that the grizzly bear population in southwestern Montana was declining. As the current data shows, this is not the case. Because of this perception, however, some felt that the bear should be "protected" to a higher degree. It is also apparent that people who don't live in close proximity to grizzly bears are generally happy to have them left alone or "unmanaged". Yet because the concerns of those who live with grizzlies must be addressed to build support for the bear, as well as for its population expansion, an active management program as described in this plan will be required.

There are and will continue to be places in this area where management is at a minimum (wilderness areas, national parks), but our experience indicates there are areas where active ongoing management will be required to provide for occupancy by bears.

Early Warning System for Bad Food Years: People suggested that FWP implement an early warning system for years when natural food supplies are low and the potential for bear conflicts grow higher. While it is not always possible to predict how bears will respond to changing environmental conditions, we agree that such a system is important to implement when there is reasonable expectation that such conditions could exist. Language was added to the Human Safety Section to reflect such an approach.

Habitat Issue: Many comments were related to habitat management and the needs of grizzly bears. Some people felt stronger habitat programs needed to be developed both within and outside the Primary Conservation Area (PCA). The plan recognizes that habitat management constraints are more detailed within the PCA as defined in the Conservation Strategy developed in cooperation with the U.S. Fish and Wildlife Service. However, there are specific recommendations for areas outside the PCA, and it is FWP's intent to continue to refine necessary programs as grizzly bears expand. Hopefully, FWP's knowledge of grizzly bear needs will increase as understanding of the needs of those living with grizzlies grows. Together these should allow Montana to build a successful program. This plan should assist FWP in reaching its goal to further restore the grizzly bear as a valuable wildlife resource and re-establish them as part of ongoing wildlife management programs in Montana. While FWP feels the needs of the bear must be addressed, it is also important to address the grizzly bear's needs in the context of the communities and processes in place in southwestern Montana. There are certainly significant issues affecting bears and other wildlife habitats both within and outside the PCA. Ongoing increases in development and human populations will add to these challenges. However, there are also large areas of currently unoccupied habitat or habitat occupied at low levels, where FWP hopes to promote occupancy, as indicated in the plan that will provide additional long-term security of the bear population. Clearly, a linchpin of our State Plan is to find ways to integrate bears into the currently unoccupied habitat without radically displacing or disrupting traditional human uses. We believe this approach will build tolerance or even support for the grizzly bear, and provide for a healthy bear population in Montana. This will be possible in spite of some

site-specific problems. In other words, FWP is aware of the threats that exist to currently occupied habitats, and FWP intends to monitor and respond to those threats as indicated in the plan. FWP also recognizes the opportunities that are, and will be. achieved with bears occupying currently unoccupied areas. FWP also believes the conservative approaches applied in the PCA will allow bears to continue to utilize and survive in that area into the foreseeable future.

Some comments suggested that FWP needs to have some ability to change and/or obtain authority over federal programs/projects on federal lands. FWP does not anticipate such authority will be given to Montana. FWP will continue to work with established processes to input the needs of the bears and other wildlife through federal forest plan revisions, NEPA, and other federal processes. FWP will continue to encourage public involvement in these processes.

Finally, there were suggestions that FWP identify certain "triggers" for response to potential habitat changes. In FWP's judgment, such specifics are not possible due to the nature of the bear (an opportunistic omnivore), and the many variables that affect, or potentially affect, its habitat. FWP will monitor the population and habitat as indicated in the plan and respond, where possible, to ensure the survival of the bear as it responds to problems that affect all other wildlife species it manages.

In conclusion, FWP will work with other agencies, interests, and private landowners to ensure grizzly bear habitat needs are addressed both within and outside the PCA. In fact, this is already ongoing in many areas in southwestern Montana with regard to Forest Plan revisions, county planning, subdivision review, and individual work with ranchers and ranchland groups.

Roads: Comments requested that the criteria for road density inside the PCA be applied outside or that the elk-road standards outside were inadequate to meet the needs of bears. Concern was also expressed by some that road issues would be addressed in such a way as to "lock" people out of the forest.

The major federal landowners (U.S. Forest Service and BLM) are currently reviewing and adjusting their travel plans for southwestern Montana. These agencies are working with local and other interests to modify travel plans. FWP supports these efforts. In addition, the plan recommends following our elk standards outside the PCA. These standards recommend one mile of road or less per square mile of land. FWP felt at this time that the standard will allow us to meet the needs of the bear outside the PCA. There are some areas where this standard may be too high, and access will need to be modified, and others where more flexibility can be promoted. This will vary depending on habitat type, conflicts with people or property, etc. Utilizing the adaptive management approach outlined in this plan, FWP expects to be able to respond as it gains knowledge and experience in these newly occupied areas.

There was also a lot of concern over off-road vehicle issues. These issues are also currently being addressed through the forest planning process and others. FWP will work with those agencies to ensure that adequate monitoring programs are developed, both within and outside the PCA, and enforcement programs are also implemented.

Clearly the advances in ORV technology have created the need for better management programs to address this issue. We intend to work with various interests including the local groups identified in the plan to address these issues.

Delisting: There were comments received either in support or opposition to delisting the grizzly bear in this area from the Federal Endangered Species Act. The issue of delisting is not addressed in this plan because the listing or delisting of species is a separate federal process overseen by the U.S. Fish and Wildlife Service. FWP developed this plan to address how our bear management program would look should the species be delisted in this area. USFWS will have to address many other issues in addition to this plan in any proposal to delist this population. The delisting process is an open public process, and there will be opportunities for public input should a change in status be prepared.

Genetic Concerns: Comments indicated that some people were concerned about the genetic status of the population due to its isolation from other grizzly bear populations. There was concern this population is or could suffer from potential in-breeding. The current science around this issue is the subject of some debate. Current information indicates that a population of 400 or more individuals would be necessary to minimize possible genetic problems with this population. FWP will work with other states and agencies to maintain a minimum of more than 400 bears in the greater Yellowstone area. Current total population estimates are already above this level. Also, because this plan seeks to provide for expansion and potential linkage of this population to others in the long term, the genetic concerns could greatly diminish in the future. FWP will monitor the genetic status of the population with the Interagency Grizzly Bear Study Team (IGBST) so that a timely response could be implemented should it become necessary.

Remove Sheep Allotments or other Livestock from Occupied Grizzly Bear Habitat: The conservation strategy that covers the PCA specifically addresses phasing out sheep allotments as opportunities arise. However, as bears have and will continue to expand well beyond the PCA, they will encounter additional sheep allotments. It is counter productive to efforts of building tolerance for bear expansion, to single out the sheep industry for elimination in areas of expanded bear occupancy.   A more productive approach to nurturing tolerance for expanded bear occupancy is to work with individual producers to develop specific management practices that allow for coexistence. If woolgrowers are specifically targeted for elimination in areas bears are expanding into, Montana will meet a zone of no tolerance which will translate directly into artificially limiting future bear expansion. FWP feels programs that implement management techniques such as guard dogs, sanitation, etc., in combination with removing livestock-killing bears, will be a more productive approach in building tolerance for expanded bear distribution. However, in situations where it is mutually agreeable by the producer and FWP, FWP will also work toward allotment retirement, relocation, or buyout where it is determined to be necessary for maintenance of a healthy grizzly bear population. These three options will only be pursued under mutual agreement between FWP and the producers or other interests.

Linkages/Corridor: Typically, southwestern and west central Montana mountain ranges are linked by relatively large intermountain valleys that are primarily in private ownership. Land use on the private lands is dominated by agriculture (both ranching and farming). These private lands provide significant and high quality winter and year round habitat for a large proportion of southwest and west central deer, elk, and antelope populations. They also provide high quality riparian and wetland habitat as well as key upland habitat for a wide variety of native nongame species found in Montana. Although these same habitats are important in providing connections between primarily federally owned mountain ranges for bears, their greatest value lies in the habitat they provide for many other wildlife species. In short, our habitat programs are designed to conserve these habitats and in so doing preserve connectivity for bears between mountain ranges. Of all the western states, only Montana has an aggressive lands program, which includes acquiring via purchase, conservation easements on private lands determined to be important habitat that is seriously threatened. This program, by statute, requires our habitat dollars to be spent across the state. In southwestern and west central Montana, all of "Habitat Montana" dollars are spent conserving intermountain foothill habitat, which is vital in conserving habitat for wildlife -- including bears -- and in maintaining connectivity between mountain ranges.

We will continue to work with private non-profit land trusts in their effort to secure easements, primarily donated easements, from landowners occupying these intermountain valleys.

Montana FWP has and will continue to place an emphasis on conserving private lands adjacent to highway corridors that have been identified as key wildlife crossing areas. FWP's emphasis with the Montana Department of Transportation will continue to influence the use of highway mitigation dollars to secure adjacent private lands from additional development. Secondary emphasis will continue to be placed on "engineered structures" that facilitate wildlife crossings. However, during site-specific highway reconstruction projects FWP will support fence and highway structure placements that facilitate wildlife movement.

Coordination Between Wyoming, Idaho, and Montana: Reviewers recommended that all aspects of the management program be coordinated between the three states and/or federal agencies in the greater Yellowstone area. FWP intends to continue the existing coordination that is occurring under the IGBC under a newly formed committee if the grizzly bear were to be delisted. Obviously, programs in the states are intertwined and many aspects of the management plan cannot be implemented without participating in the appropriate federal processes.

Results of all coordinated monitoring of habitat, population, conflicts, etc., will be reported annually and made available to the public. In addition, any meeting will be open to the public as specified in Montana's statues.

Population status/estimation: FWP received comments questioning the status of the population. Some noted significant increases and others noted population declines. The current status of the population is discussed in the plan. The best available data indicates a population increasing in both numbers and distribution at the present time.

This creates some misunderstanding among those who believe the population is in decline and therefore seek additional "protections," while others who note grizzly bear increases seek more management flexibility. Population estimation is, and always will be, an area of controversy in grizzly bear management. The plan uses a variety of widely accepted approaches used in other areas, with other species, and with grizzlies in other parts of the world. The plan recognizes that using a variety of information from many sources is the best approach to ensure reasonable estimates. Any estimates used will be explained in full and will be open to public scrutiny and discussion.

Public Information/Education: There was widespread support for these efforts as described in the plan, and FWP will continue to implement them and look at new partnerships and programs to make this aspect of the program even more effective.

Hunting: Comments were received that supported hunting as part of the management program, opposed hunting or a hunt, and suggested that any possibility of hunting be delayed until some future date. FWP recognizes that many people hold strong personal values on either side of the issue of hunting this species. Those who support a hunt view the bears as a valuable wildlife species and game animal. Those who oppose hunting also view bears as a valuable wildlife species, but feel it is in appropriate to hunt predators or wildlife in general. Many who suggested that any hunt be delayed until a future date felt that this population needed to be more secure in both numbers and distribution before any hunt was proposed.

It is important that the public understand this plan only recommends that hunting be a part of the long-term management program. It does not recommend a hunt at this time. If a hunt were to be proposed, it would be through the processes discussed in the plan. The rationale for a hunt would be justified and open to public scrutiny. As discussed in the plan, FWP believes the option of using hunting, as a management tool in the future is important. Hunting has been successfully used as a management tool for many species in Montana (including grizzlies) and for grizzlies in other areas. In addition, Montana consistently has one of the highest levels of participation in hunting of any state in the nation. This constituency has also demonstrated significant long-term support for grizzly bears and their habitat. Some commenters also pointed out that a hunt could help build the political support needed to create statutory changes and/or to obtain funding to maintain ongoing expansion of the bear population.

There were suggestions specific to how to conduct a hunt (spring or fall), and how to sell licenses. These will be more appropriately discussed if and when a specific hunt is proposed.

FWP recognizes a need for ongoing education to reduce the potential for mistaken identification mortality and for enforcement to minimize any illegal mortalities. Any mortality due to a hunt would be considered in total mortality management programs and coordinated with Idaho and Wyoming.

Finally, there was a recommendation that all black bear hunting be closed in grizzly bear areas. FWP believes this approach would eliminate or alienate a group of people

who support bear programs and would limit opportunities for future expansion of the grizzly bear population.

Some opposed to any hunt stated that females with cubs would be killed, that there will be bear baiting, and that there will be various other abuses. These types of situations are illegal and will be enforced with existing and any future statutory authority. It also should be noted that there are portions of southwestern Montana that will never be hunted both within and outside the PCA. However, to promote a broader recovery and expanded local support FWP will need to have this management tool option in some situations and over time. This approach has proven its success with other wildlife species including other large predatory species in Montana.

Some of those opposed to hunting also indicated that they feel the FWP Commissioners are biased, and are reluctant to work with them on their issues. The FWP Commission has been granted authority to establish hunting seasons by the State Legislature. The procedures utilized provide for public comment and scrutiny before decisions are made.

Expansion of Food Storage Orders in Bear Habitat: Many people commented favorably on this aspect of the plan. Most recommended that FWP actively pursue expansion of food storage regulations to all bear habitats (both black and grizzly) in Montana. In addition, there was widespread support for having FWP assist with enforcing those regulations. These types of regulations can be controversial if developed and implemented without active local involvement and responsiveness to local concerns. This is an area where the local work groups identified in the plan could actively participate and build support. We recognize that in order to implement these food storage guidelines, we will have to work with other state and federal agencies and through their processes as well.

Implementation Schedule: Some comments recommend a clearly defined implementation schedule. This is somewhat problematic because the plan is intended to describe a management program for a post-delisted population of grizzly bears in southwestern Montana. No one knows, however, if or when delisting will occur. In addition, some parts of the plan are already implemented while others may or may not be implemented regardless of the population's federal status. The chart below provides a general outline of some of these.

	Ongoing	Post Delisting
Human Safety Programs	X	X
Inform and educate	An information and education plan will be developed by 2003	
Food storage Enforcement/Implementation	FWP is currently seeking the necessary authority and funding	X
Aversive conditioning	X	X
Management Control	X	X
Hunting		Possibly

Habitat/Habitat Monitoring Within PCA Outside PCA	X X Some, with more planned as bear population expands	X X More monitoring as population expands
Habitat Guidelines Within PCA Outside	Being implemented through forest plan revisions (by 2005) Being implemented through forest plan revisions (by 2005)	X X
Population Monitoring	Coordinated by IGBST	Coordinated by IGBST for a minimum of 5 years
Trails Monitoring	Current efforts are to intensify this program -- will be part of forest plan revisions (2005)	X
Livestock conflict management	Identify preventative approaches staff and funding by 2005`	X
Property Damage	New staff in Red Lodge if funding can be found	X
Research	X	With more emphasis outside PCA
Information and education	X	X
Funding	There is a clear need to identify additional funding opportunities	Will seek additional Federal funding to assist with mandated post-delist monitoring for 5 years minimum
Local Involvement	X	Expanded local involvement as bear population increases

Funding: Some commented that FWP would need to secure funding to replace Sec. 6 funding (from the Endangered Species Act) that would be lost if the bear was delisted. Sec. 6 funding for bear management in southwestern Montana has been minor in terms of the overall program cost (Sec. 6 is generally less than $20,000 while the current program costs $243,000 per year). While all funding is important, FWP anticipates and will actively pursue other opportunities from other programs to make up these dollars (such as what was proposed in the Conservation and Reinvestment Act).

Specific targets: Comments indicate some people want more specificity and certain targets which will precipitate certain management responses. FWP would petition to

relist the species if the population were to fall below 300 bears within the Greater Yellowstone Area. In addition, mortality management would become more conservative than recommended if the population fell below 400 individuals (the level necessary to address genetic concerns). Generally, however, bear populations, like all other wildlife, change in response to many environmental factors. FWP will use ongoing information to adapt programs. These programs will be more conservative if populations drop and more flexible at higher levels. As always, any changes in management will be open to public review.

FWP acknowledges that the plan contains a lack of specificity on some issues. Reasons for this are that grizzly bear management programs, and other programs, which potentially affect bears, are continually being adjusted as we gain new information and experience. In addition, as bears reoccupy habitats FWP will have to learn about how the bears use different food sources, adjust movement patterns, create conflicts, and more.   FWP will need to adjust programs accordingly. Also, some aspects of management need to remain flexible. The narrative provided in the plan provides a picture of FWP's intent in these cases. FWP will continue to follow a comprehensive, collaborative process in the future to add specificity on things such as population monitoring, trend, mortality management, and more as the plan is implemented.

Value of Grizzly Bears to the Tourism Industry: Commenters expressed the view that grizzly bears are very important to Montana's tourism industry. Grizzly bears are used in Montana advertising and promotions which results in many visitors arriving with the hopes of viewing a bear. We recognize they grizzly bear's value to tourism, and the plan should allow these benefits to continue and even expand by providing for a healthy bear population.

Nuisance Bears/Reporting Damage: There was a concern expressed by some that some of the definitions and/or approaches to dealing with these issues were too vague or left open to too much interpretation. It is very difficult to anticipate every potential type of conflict that could occur. A review of FWP's current approaches to grizzly-bear related problems in Montana indicates conflicts are very conservatively addressed. FWP makes every effort to avoid unnecessarily removing bears from the population. The plan recommends that these types of approaches continue. However, with expanding numbers and distribution of bears, some animals will have to be removed when conflicts develop.

Other Issues Raised:

Concern over SB163: We received comment that suggested that Senate Bill 163 (SB163) would require the elimination of grizzly bears by the state. This is not the case. The statute and the legislative record of the bill indicate it is intended to deal with <u>individual</u> animals that prey on livestock. These animals would be subject to control as specified in the plan. The USFWS and Interior Department Solicitor's Office reviewed this language and found it adequate for long-term management of the species.

Game Status Animal: There is opposition to having the grizzly bear's status changed to a "game species". The grizzly bear is currently listed as a game species in Montana. This would not change based on the program developed.

Grizzly Bears in Other Ecosystems: Some commenters discussed the status of grizzly bears in other ecosystems or recommended programs outside southwestern Montana. Other documents and processes cover programs in these areas.

Keep People Out of Bear Habitat: There were suggestions that FWP work to keep people out of bear habitats. This is not possible and, in fact, bears are expanding their distribution into previously unoccupied areas. Trying to remove people as grizzlies expand is unworkable and would limit future expansion of the population. A program to manage both people and bears is a more productive approach to long-term conservation. This is the only implementable course of action.

Feed the Bears: It was suggested that FWP consider feeding bears during bad food years and in response to declines in natural foods. FWP believes this is unworkable at the ecosystem scale. While we do consider programs such as redistribution of livestock carcasses to minimize conflicts while still allowing bear use of this food source, we do not see large-scale feeding as workable or desirable. A better approach is to promote an increased distribution of bears to access a variety of areas and habitats to accommodate environmental change.

FWP Should be Responsible for Grizzly Bear/Livestock Conflict Management -- Not Wildlife Services: Some people stated that they would prefer FWP to handle livestock/bear conflicts. They felt that federal Wildlife Services failed to emphasize non-lethal or preventative control programs. Because Wildlife Services is often the first agency called on to address a bear-livestock conflict, FWP will continue to involve Wildlife Services. The two agencies have a current cooperative agreement and both agencies expect the cooperation to continue. Hopefully, as Montana gains more experience with the ongoing implementation of the plan, we will come to expect better prevention and non-lethal management of conflicts. FWP will continue to work with Wildlife Services in these efforts.

Wildlife Over Livestock or Commercial Use on Public Lands: Some say that public wildlife should always take precedence over livestock or commercial use on public lands in southwestern Montana. Wildlife, however, needs private lands as well as public lands to survive. A cooperative program that blends the needs of wildlife with those of private landowners through ongoing management is described in the plan as a more productive approach.

Impacts of Snowmobiles: Commenters suggested that FWP address the impacts or potential impacts of snowmobiles on grizzlies. There is some potential for snowmobiles to directly affect bears through disturbance at some times. It was suggested that snowmobiles might also indirectly affect bears by redistributing ungulates, which could lead to less carrion available for bears.

There is no question that advances in snowmobile technology have changed the potential for impacts to bears. Newer machines are able to access areas today that were not possible a decade ago.

There is very little data available on these issues. The plan allows FWP and others to monitor the situation. FWP will address the needs of the bear if future information indicates that such action is warranted.

Mandatory Pepper Spray Use: It was suggested that FWP mandate the carrying of pepper spray. While the plan as proposed supports the carrying of pepper spray and use information and education to encourage its use, we do not feel mandatory rules are necessary at this time. FWP expects to establish criteria, in conjunction with the USFWS by December 31, 2002 which will be used to determine when a recommendation for mandatory use of pepper spray will be made to the FWP Commission.

Human Safety and Nuisance Guidelines: There was some concern that any bear damaging property would be killed or removed, or that the guidelines are too open to interpretation and too many bears would be removed. A review of our current approaches to these situations shows this is not the case in practice. Each incident is evaluated based on the particular circumstances and guidelines are conservatively applied. The proposed plan continues this approach.

ORV Monitoring: It was suggested that the plan monitor ORV impacts outside the PCA as well as within. Language was added to the plan to reflect this change.

Purchase Corridors: It was suggested FWP purchase corridors between ecosystems. FWP doesn't have sufficient resources to purchase all of these areas. A cooperative program with agencies, private non-profit land trusts, and private landowners is more effective. For additional response, see the section on "linkage".

Bus Tours: It was suggested that FWP promote bus tours in Yellowstone instead of personal vehicles to cut down on noise and/or pollution. This issue is outside the scope of this plan, and authority for this rests with the National Park Service.

Protection of Female Bears: It was suggested that the plan provide additional protections for female grizzly bears. The plan does so in terms of nuisance guidelines and mortality quotas which are structured to provide additional protection for female bears.

Area Closures: Some comments indicated support for area closures to protect bears and also expressed concerns that any such closures be temporary. With active management as proposed, FWP does not feel that permanent closure of areas to people will be necessary. There may be times and/or places where seasonal closures are appropriate (for example, FWP closes elk winter ranges during certain months) or a closure may be necessary due to concerns over human safety (a bear is feeding on a carcass next to an active trail). Any closures will be site specific.

Response Time to Conflicts: People suggested that 12 hours may be too long to respond to some conflicts, and others stated that a response within 12 hours was unworkable in some cases. FWP acknowledges both concerns and recognizes that both situations can occur. The most rapid response possible is always in the best interest of the management program and is the goal of the plan.

Relocation of Problem Bears: It was requested that the plan provide information on where problem bears would be relocated. Because these decisions require information such as age/sex of the bear, current land uses, and understanding human activities, etc. this type of detail is not possible in the plan.

Coal Bed Methane: FWP acknowledges that this type of land management can affect grizzly bears. FWP will seek to have the needs of the bear placed and considered in every appropriate planning and permitting process as outlined in the management plan.

Funding: It was requested that FWP document all funding and have in place all commitments for ongoing funding needs. This is not possible because FWP and others operate on annual budget cycles sensitive to changing needs and priorities. A review of past funding indicates that the types of programs recommended in the plan receive funding support. Some commenters suggested using a gas tax, or a portion of the bed tax, to allow Americans to help support these efforts. FWP encourages those interested in these programs to pursue additional funding opportunities with their state and/or federal representatives.

Local Control: Local control is viewed by some as an excuse to do "bad things" to habitat and bears. This is not the intent of this plan. While FWP has acknowledged the national interest in the species and feels it provides long-term security of the population to meet that need, those living and working in these areas need to be active participants in all phases of plan development, implementation, and evaluation for it to be a success.

Damage to Bee Hives: There was support for re-evaluating the guidelines for damage to beehives as recommend in the plan.

Females with Cubs Monitoring: It was stated that the use of this monitoring parameter was inappropriate. Current and ongoing research demonstrates that there is value in using this parameter. However, it should be noted that our program does not rely on it solely but will use a wide variety of information and data sources in program implementation and evaluation.

Definition of Socially Acceptable: The plan as developed provides for bear expansion into areas that are biologically suitable and socially acceptable. Some commenters wanted additional definition for this. There are some areas where the presence of grizzly bears is unacceptable due to risks to people and/or bears (urban areas). However, in many areas of southwestern Montana the presence of the bear is acceptable if appropriate programs are in place. That is the intent and direction of this plan.

Opposition to "planting bears": The plan provides for relocations of bears within the ecosystem for management purposes and for potential future relocations if projected distribution increases do not occur. It also provides for live removal and relocation of bears to other ecosystems or states if such opportunities become available. No relocations to increase distribution or to other ecosystems or states will occur without completing the appropriate public processes and extensive local involvement.

Risks/Liability from Bears: There was a question raised on who is liable if a bear mauls or kills a person or for any damage done by bears. Grizzly bears inhabit southwestern Montana. As such, the risks associated with them already exist. It is FWP's intent that the programs recommended will keep any risks at manageable levels. If and when court cases are pursued as a result of conflicts with bears the liability, if any, will be determined by the courts.

Hunting Endangers Lives of Humans as Well as Bears: People who would knowingly choose to hunt grizzlies assume those risks voluntarily. For other people in the field, FWP has many programs -- such as its hunter safety classes -- to minimize risks to other humans through understanding and awareness education. Hunting as conducted in Montana is a safe activity, and FWP continues its years of work to make it more so.

Need Fewer Bears in Montana Because There are People Here and Their Needs are Increasing: Based on current information as presented in the plan, Montana can expect numbers of both people and bears to continue to increase into the foreseeable future. This makes a management program necessary in assuring coexistence.

Appendix J. Wyoming Grizzly Bear Management Plan

Wyoming Grizzly Bear Management Plan
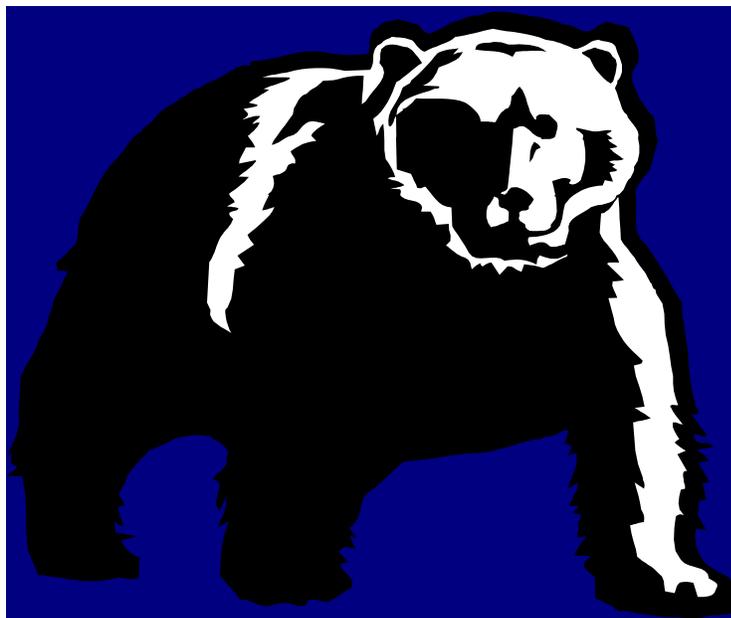
Prepared By

David S. Moody, Dennie Hammer, Mark Bruscino,

Dan Bjornlie, Ron Grogan and Brian Debolt

February, 2002

Wyoming Game and Fish Department

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OVERVIEW

The Yellowstone Ecosystem Subcommittee of the Interagency Grizzly Bear Committee produced a *Draft Conservation Strategy* for the Grizzly Bear in the Yellowstone Ecosystem. This document outlines a cooperative management strategy to be implemented by state and federal agencies upon delisting of this population of grizzly bears. The U.S. Fish and Wildlife Service determined that completion of such a plan, and a commitment to implement such a plan, are necessary prior to delisting.

During the spring of 2000, at the request of the state members of the Interagency Grizzly Bear Committee, the governors of Idaho, Montana, and Wyoming appointed a 15-member citizen roundtable to review the *Draft Conservation Strategy*. The roundtable was requested to provide recommendations the governors could use to develop a response to the *Draft Conservation Strategy*. The roundtable met three times. The roundtable reached complete consensus on 26 of its recommendations. The group also recommended that the three states develop management plans for areas outside the Primary Conservation Area to:

> a. Ensure the long-term viability of grizzly bears and preclude re-listing;
> b. Support expansion of grizzly bears beyond the Primary Conservation area, in areas that are biologically suitable and socially acceptable; and
> c. Manage grizzly bears as a game animal - including allowing regulated hunting when and where appropriate.

Public comment on the *Draft Conservation Strategy* was received and analyzed in 2001. The Yellowstone Ecosystem Subcommittee will use this input to revise the *Draft Conservation Strategy* and create a final document, which will then be approved by the U. S. Fish and Wildlife Service.

Wyoming submitted its draft management plan for public review during the summer of 2001. Over 8,000 written comments were received on the draft plan. In addition, the Wyoming Game and Fish Department (Department) contracted with an independent research firm to conduct a public attitude survey of Wyoming residents (Special Report, WGFD 2001). Over 1,000 residents were surveyed to obtain their attitudes related to grizzly bear management and nuisance issues. The results of both of these activities were used to modify the draft into this final version. Both of these documents can be obtained through the Department's Office of the Director in Cheyenne.

It is the objective of the Department and the Game and Fish Commission (Commission) to maintain existing renewable resource management and recreational use where possible and to develop a process where local publics can provide input to demonstrated problems. Human safety is a high priority within this plan. This approach allows for existing uses to continue, which should build support and increased tolerance for an expanding grizzly bear population. Therefore, Wyoming's Grizzly Bear Management Plan will employ an adaptive management approach.

The Department strongly maintains that it is the appropriate agency to assume management of the grizzly bear once it is delisted and it is a role the agency wants to assume. This management plan will remain in effect until changes (i.e. better population and nuisance techniques or localized input) warrant modification of the plan.

INTRODUCTION

The grizzly bear (*Ursus arctos horribilis*) is considered by many to express the quality and depth of wild places. The species holds aesthetic value for much of the public. In the Greater Yellowstone Ecosystem of Wyoming, the grizzly bear also presents the challenge of balancing the needs of humans and wildlife to the advantage of both. The grizzly bear population in Wyoming is currently listed as "threatened" under the federal Endangered Species Act.   Figure 1 delineates the Recovery Zone/Primary Conservation Area within the Greater Yellowstone Ecosystem.
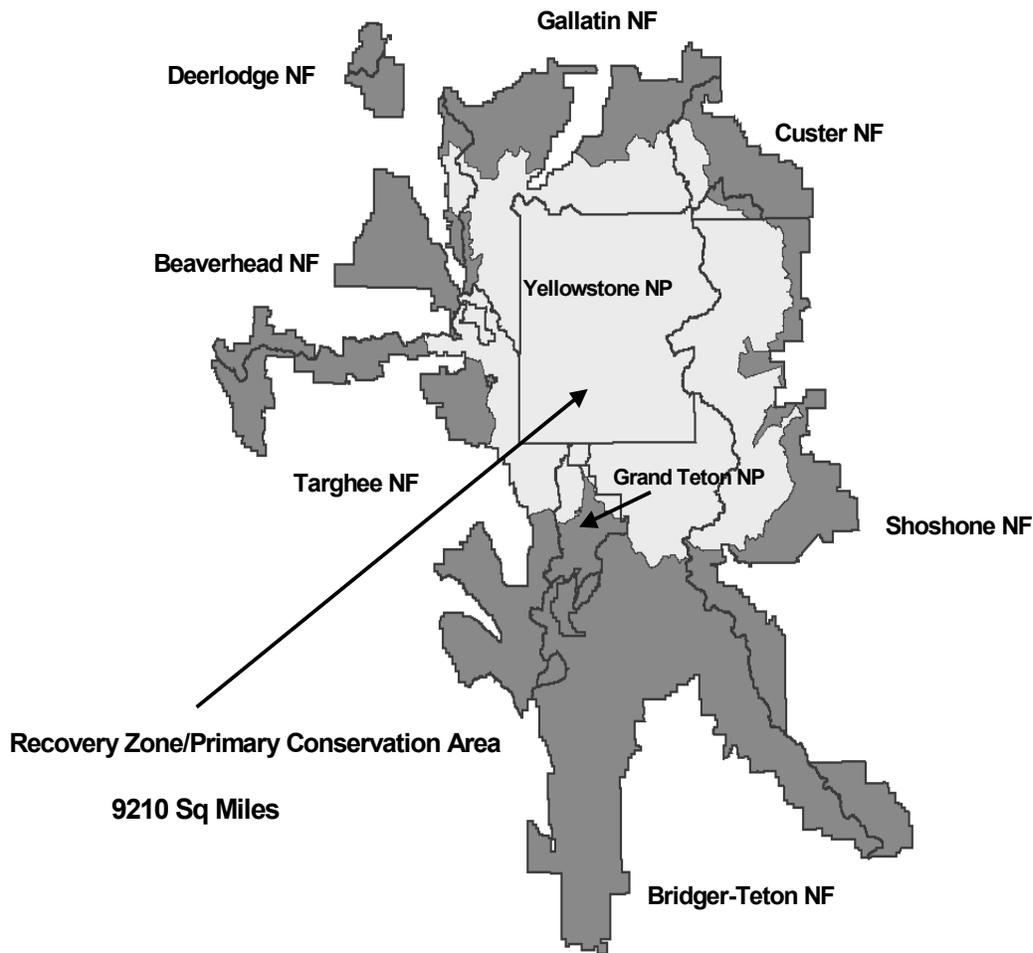
Figure 1. Recovery Zone/Primary Conservation Area within the Greater Yellowstone Ecosystem

With the listing of the grizzly bear as "threatened" under the Endangered Species Act in 1975 (Fed. Reg. 40:145,31734-31736), management goals within Wyoming have been largely defined by the United States Department of the Interior, U.S. Fish and Wildlife Service. Management goals and techniques are listed within the *Grizzly Bear Recovery Plan* (1993) and *Interagency Grizzly Bear Guidelines* (1986). Department currently has no grizzly bear management plan, since a state plan would be superceded by the federal *Recovery Plan* for this species.

However, some management objectives of the state are discussed in the Department publication "A Strategic Plan" (1990). The management objectives to be met by 1995 were:

1) To meet parameters identified in the revised *Grizzly Bear Recovery Plan* for the Yellowstone ecosystem.
2) To maintain at least 7,229 square miles of occupied grizzly bear habitat.
3) To obtain the informed consent of all potentially affected interests in structuring the population objectives, management strategies and regulations.

Wyoming's brief strategic plan is no longer adequate because it does not address management of the grizzly bear following delisting. This state management plan will do that.

The *Recovery Plan* identified specific criteria that must be accomplished prior to a change in status for the grizzly bear. Along with specific population criteria that have been met, habitat-based recovery criteria would be developed and a *Conservation Strategy* would be prepared. Amendments to the *Recovery Plan* and the *Draft Conservation Strategy* were submitted to the public for review in the spring of 2000. The habitat-based recovery criteria will be finalized and appended to the *Recovery Plan*. The *Draft Conservation Strategy*, created by an interagency technical team under the direction of the Interagency Grizzly Bear Committee, describes agency interactions, regulatory mechanisms, population management, population monitoring, habitat monitoring, and habitat management that will be in effect after delisting. The *Conservation Strategy* only applies to the existing Recovery Zone or Primary Conservation Area and a 10-mile buffer. While the final *Conservation Strategy* is in effect, there will be goals for population size and habitat status. If these goals are not met, the grizzly bear could be relisted. It is the intent that all participating federal and state agencies sign the *Conservation Strategy* and agree to its provisions prior to delisting.

Preparation of a state management plan is a necessary component for managing grizzly bears. When grizzly bears within Wyoming are delisted, management of the grizzly bear within the Primary Conservation Area and the 10-mile buffer must meet the requirements of the *Conservation Strategy*. When approved, and while in effect, the *Conservation Strategy* will become part of the Grizzly Bear Management Plan for Wyoming. As long as all population management criteria defined in the *Conservation Strategy* are met, the Department will have full management authority inside and outside the Primary

Conservation Area, with the exception of Yellowstone National Park, Grand Teton National Park, and Tribal managed lands of the Wind River Indian Reservation. The state's grizzly bear management plan will provide the structure for management of grizzly bears and the avenue for public input into grizzly bear management outside Yellowstone National Park, Grand Teton National Park, and Tribal managed lands of the Wind River Indian Reservation.

There has been considerable coordination between the states of Idaho, Montana, and Wyoming during the development of this state plan. Montana and Idaho are also developing state management plans, which should be completed sometime during 2002. The states realize there must be continued coordination after delisting to assure consistency in managing this population of grizzly bears.

RECOVERY CRITERIA

Currently, the *Recovery Plan*, *Grizzly Bear Management Guidelines*, and the *Draft Conservation Strategy* define criteria and methods for monitoring grizzly bear populations. Monitoring does not include estimating specific numbers of grizzly bears. Instead, monitoring measures indicators of population status. Three basic parameters are monitored: (1) sufficient reproduction to offset human-caused mortality; (2) adequate distribution of breeding females throughout the area; and (3) a limit on female and total human-caused mortality to ensure population viability that is related to the previous two parameters.
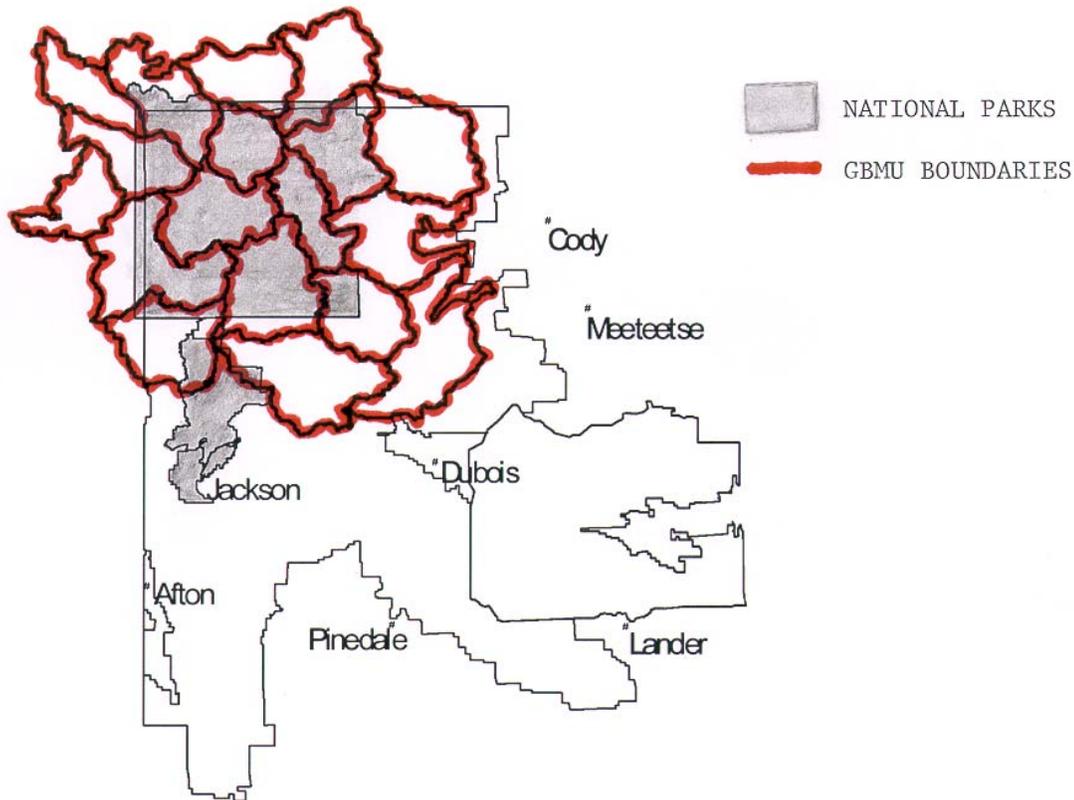
Figure 2. Current Grizzly Bear Management Units within the Primary Conservation Area in relation to the Greater Yellowstone Ecosystem.

These parameters are measured by: (1) the number of unduplicated females with cubs of the year recorded annually; (2) the distribution of females with young or family groups within defined Grizzly Bear Management Units throughout the ecosystem; and (3) the annual number of known female and total human-caused mortalities. These three measures are used to judge the status of the grizzly bear population in the Recovery Zone (Figure 1). The rationale for monitoring these three parameters is discussed in the *Recovery Plan* (1993:20-21) and the *Draft Conservation Strategy* (2000, IGBC). The area to be monitored under the *Draft Conservation Strategy* is geographically identical to the Recovery Zone, but has been renamed the Primary Conservation Area. The area to be monitored under the *Draft Conservation Strategy* is limited to the Primary Conservation Area and a 10-mile area immediately surrounding the Primary Conservation Area.

The population and distribution demographic goals contained in the *Draft Conservation Strategy* for the Primary Conservation Area are: (1) a running six year average of 15 females with cubs-of-the-year within the Primary Conservation Area and 10-mile buffer; (2) a six year average of 16 of 18 Grizzly Bear Management Units (Figures 2 and 3) occupied by females with young with no two adjacent units unoccupied; (3) known human-caused mortality will not exceed, four percent of the population estimate with no more than 30 percent of the total human caused mortality being females - these mortality limits cannot be exceeded during two

consecutive years inside the Primary Conservation Area and 10-mile buffer; and (4) a stable or increasing population trend. The methodology and calculation of numbers are discussed within the *Recovery Plan* (1993:41-46) and the *Draft Conservation Strategy*.

Mean size = 511 square miles
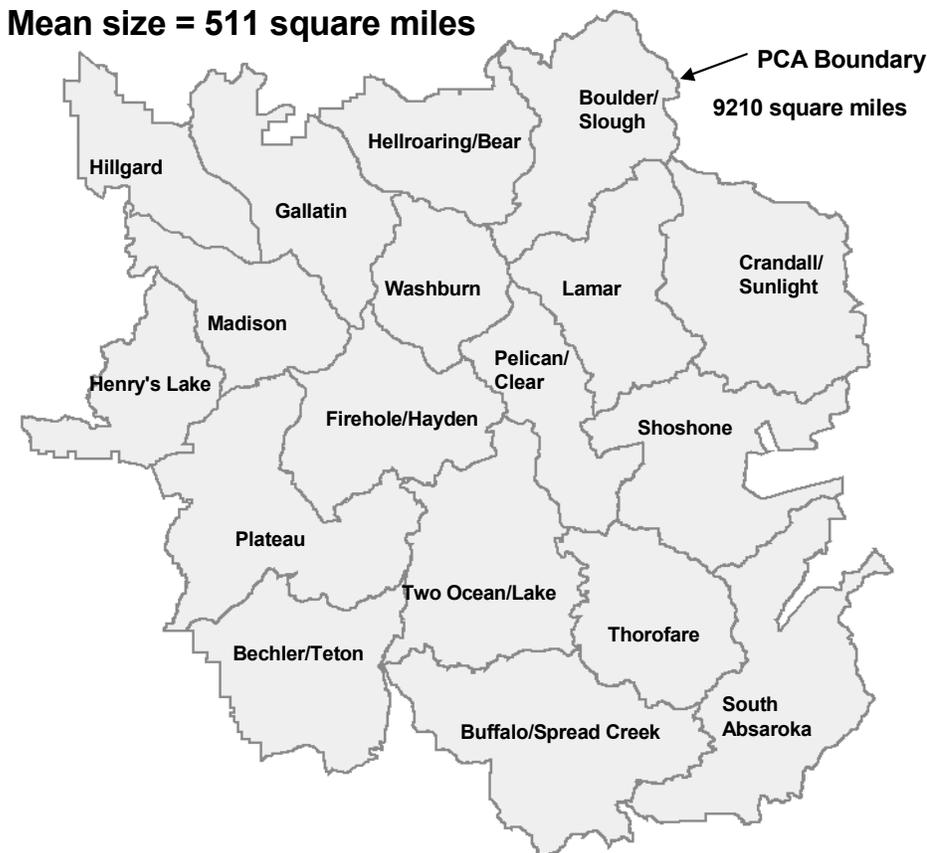
Figure 3. Eighteen Grizzly Bear Management Units within the Primary Conservation Area.

The recovery criteria previously referenced only address population goals. The *Recovery Plan* also directed federal agencies to develop habitat-based recovery goals for the Yellowstone population of grizzly bears. Draft goals were developed and submitted for public review in the fall of 1999. The draft goals will be reviewed and modified by the agencies, and final goals were taken to the public for review and comment in 2002. The U.S. Fish and Wildlife Service must approve these habitat goals before the Yellowstone grizzly bear population can be delisted.

As long as the population objectives in the final *Conservation Strategy* are maintained, the Department may implement additional management options, including regulated hunting.

POPULATION STATUS

Unduplicated Females and Distribution of Those Females

By 1999, all of the demographic goals in the *Recovery Plan* had been reached. The six- year average for occupancy was 18 of 18 Grizzly Bear Management Units (Figure 4). The number of unduplicated females with cubs has been 15 or higher since 1988. Numbers have exceeded 30 females with cubs since 1996 (Figure 5).

Department efforts to meet the population objectives have been very successful in increasing both grizzly bear numbers and the geographic area they occupy. Wyoming intends to continue to meet the population objectives for the Primary Conservation Area in the final *Conservation Strategy*. These demographic criteria have to be maintained in the Primary Conservation Area and the 10-mile area adjacent to the Primary Conservation Area. Wyoming has the option of creating other management criteria or objectives, as long as these existing population objectives are met.
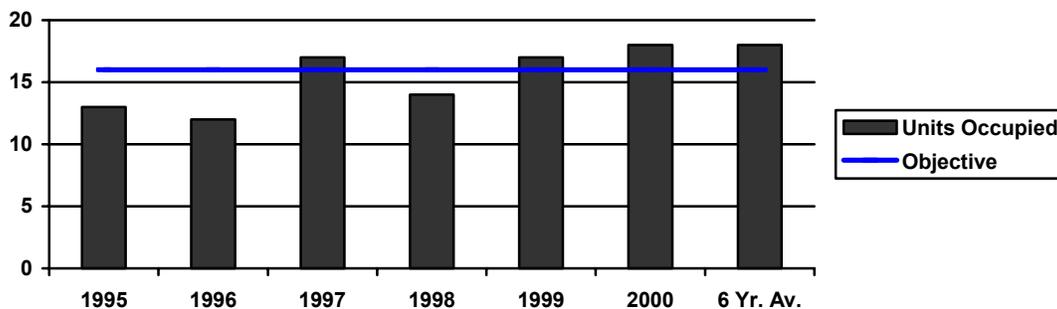
Figure 4. Number of Grizzly Bear Management Units occupied by females with young, 1995-2000 (IGBST, 2000).
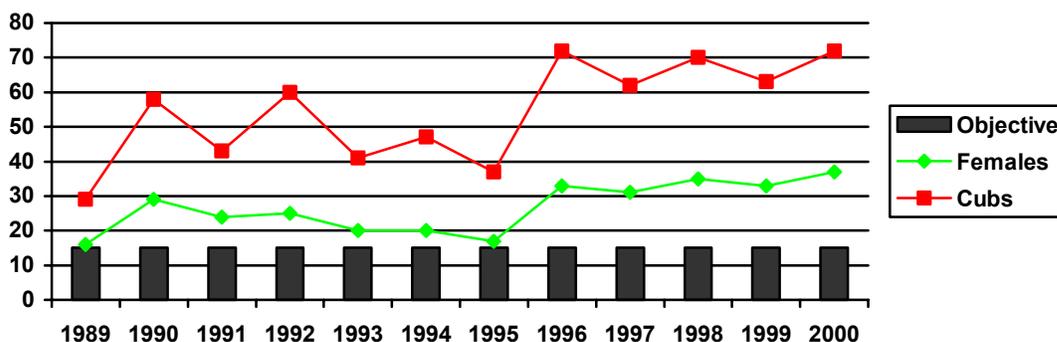
Figure 5. Number of unduplicated females and cubs-of-the-year from 1989-2000.

Hunting Mortality

Harvest of grizzly bears within Wyoming occurred before 1968, and from 1970 to 1974. Before 1968, there were no restrictions on the harvest of grizzly bears. From 1970 to 1974, a limited number of licenses were issued in Park and Teton counties following creation of a special license for the take of grizzly bears. The state's management of grizzly bears was affected by the federal listing of the Yellowstone grizzly bear population in Wyoming on July 28, 1975. When federal listing occurred, the Commission had already suspended the hunting of grizzly bears. This was considered a temporary closure, as reflected in "A Strategic Plan" (WGFD 1990), where an objective of five grizzly bears is still inferred as a harvest objective.

Before 1969, there was no mandatory hunter reporting of harvested grizzly bears, so data on annual harvest is incomplete. After 1970, when mandatory reporting was instituted, records are more accurate. Known harvest during 1970-1974 ranged from three to eight animals (Table 1). The number of permits issued decreased from a high of 30 in 1970 to a low of 12 in 1974.

Year	Harvest
1970	8
1971	6
1972	4
1973	3
1974	7
Total	28

Table 1. Annual grizzly bear harvest in Wyoming, 1970 - 1974.

Man-caused Mortality Within the Primary Conservation Area and 10-Mile Buffer

Although there was no legal sport harvest from 1975 to 2000, 194 known and probable human-caused grizzly bear mortalities were documented in the Yellowstone ecosystem. Female grizzly bears accounted for 29 percent (57) of the total known mortality. Annual human-caused mortality has not exceeded 17 since 1975, while and human-caused mortalities of females has never exceeded 6 for the same time period (Figure 6).
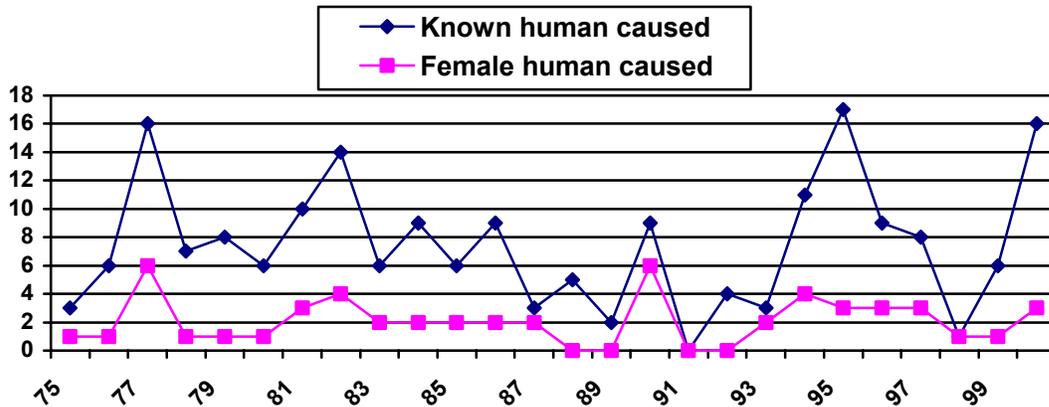
Figure 6. Known and probable human-caused mortality of grizzly bears in and within 10 miles of the Primary Conservation Area, 1975-2000 (IGBST, 2000).

From 1995 through 2000, the threshold for total mortalities of grizzly bears has not been exceeded (Figure 7). During the same period, the threshold for female mortality was exceeded only in 1995 (Figure 8). These mortality thresholds are based on a 6-year average compared against minimum population estimates, not total population estimates.
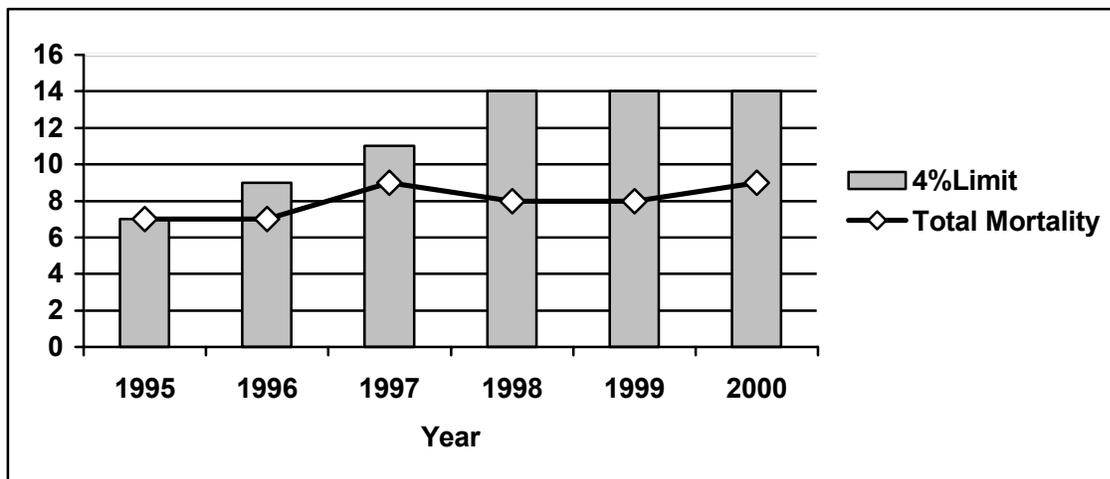
Figure 7. Human-caused total mortality versus threshold, 1995-2000.
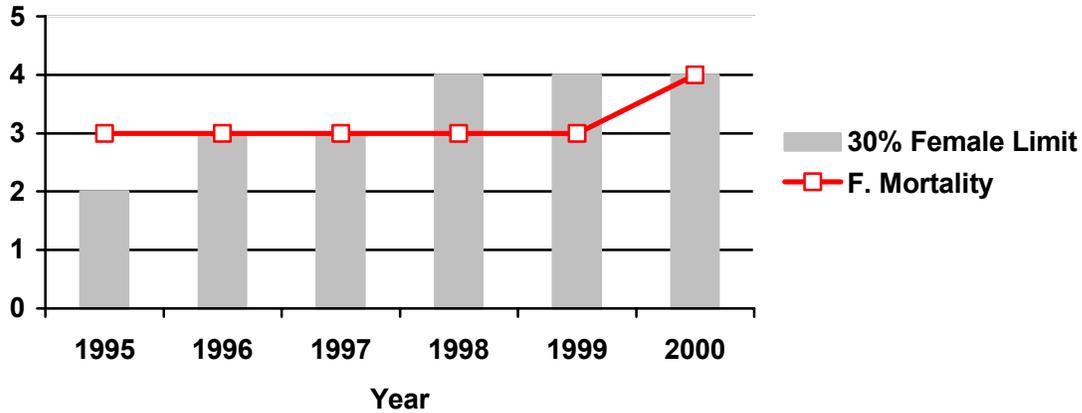
Figure 8. Human-caused female mortality versus mortality thresholds, 1995-2000.

Grizzly Bear Mortalities in Wyoming

Since grizzly bears have been listed as threatened under the Endangered Species Act, federal law has allowed legal take of any grizzly that was an immediate threat to human safety. Authorized state or federal agency personnel have also taken grizzly bears for chronic livestock depredations, property damage, or threat to public safety. These are classified as management removals. On average, 2.6 grizzly bears have been taken by the public in self-defense situations per year since 1990. Management removals and illegal losses have averaged 1.0 grizzly bear per year, respectively, during the same time period (Figure 9).
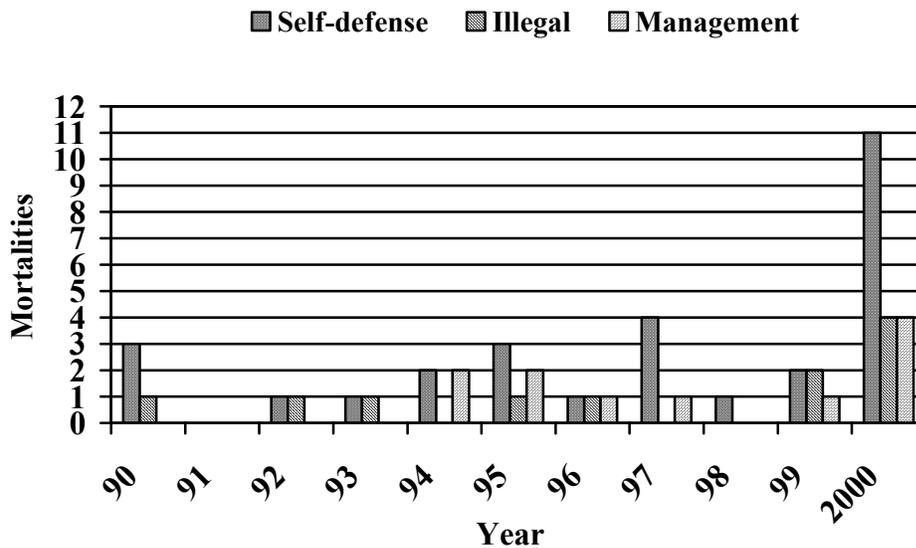
Figure 9. Self -defense, illegal, and management removals of grizzly bears in Wyoming, 1990-2000 (IGBST, 2000).

14

REGULATIONS

History

Management of grizzly bears did not receive much attention within Wyoming during the early part of the 20th century. The 1899 *Game and Fish Laws of Wyoming* made no mention of grizzly bears or their management. The 1903 *State Game Warden Report* simply stated it to be a misdemeanor to hunt, kill or trap grizzly bears upon any of the National Forest Reserves in the state, except during the open game (ungulate) seasons. In 1937, black and grizzly bears were classified as game animals on most national forests and in the Black Hills, and as predators in the remainder of the state. Game animals could not be trapped nor hunted with dogs without the approval of the Chief Game Warden or local game warden. Predatory animals could be taken at any time and by most means. Except where otherwise indicated, hunting seasons for black and grizzly bears corresponded with elk or deer hunting season. A resident or non-resident elk and/or deer license holder could kill one bear of either species.

Current Statutes and Regulations

Currently, the grizzly bear is classified as a "trophy game animal" in Wyoming. This places management of the grizzly under authority of the Commission and empowers that body to fix hunting seasons and bag limits for grizzly bears. By state statute, all wildlife in Wyoming is property of the state. It is the policy of the state to provide an adequate and flexible system for control, propagation, management, protection, and regulation of all Wyoming wildlife. Federal law currently supercedes state laws and regulations that apply to management of grizzly bears.

The Commission has authority to establish zones and areas in which trophy game animals may be taken, in the same manner as predatory animals without a license. Statutes prohibit use of dogs in taking bears, except when authorized by the Chief Game Warden, for animals causing damage to private property. Regulations prohibit placement of baits to hunt black bears in most habitats occupied by grizzly bears and provide penalties for violations of these regulations. Statutes and regulations forbid importation or sale of any living bear, except as permitted by the Commission. The private ownership of grizzly bears is also prohibited. Statutes allow taking of grizzly bears as trophy game animals with a proper license and prohibit wanton destruction. Currently, state regulation prohibits hunting of grizzly bears.

Several Wyoming state statutes and a Commission regulation address procedures for reporting, claiming, and filing for compensation for damage caused by grizzly bears (Appendix I).

MANAGEMENT STRATEGIES

1. OCCUPANCY

Grizzly bears will be managed in currently occupied habitat (Figure 10) and in newly occupied habitat within the Greater Yellowstone Ecosystem during the term of this management plan. The current extent of the grizzly bear's range in Wyoming is not known precisely, but monitoring radio-collared bears from 1975 to 1999 has documented the general area in Wyoming occupied by grizzlies (Figure 10). This area includes all of Yellowstone and Grand Teton national parks, as well as portions of adjacent National Forest and private lands to the south and east of Yellowstone, extending to the eastern edge of the Absaroka Mountains, the western portion of the Owl Creek Mountains, south in the Gros Ventre Range to the Pinnacle Peak area, and south in the Wind River Range to the Green River Lakes area.
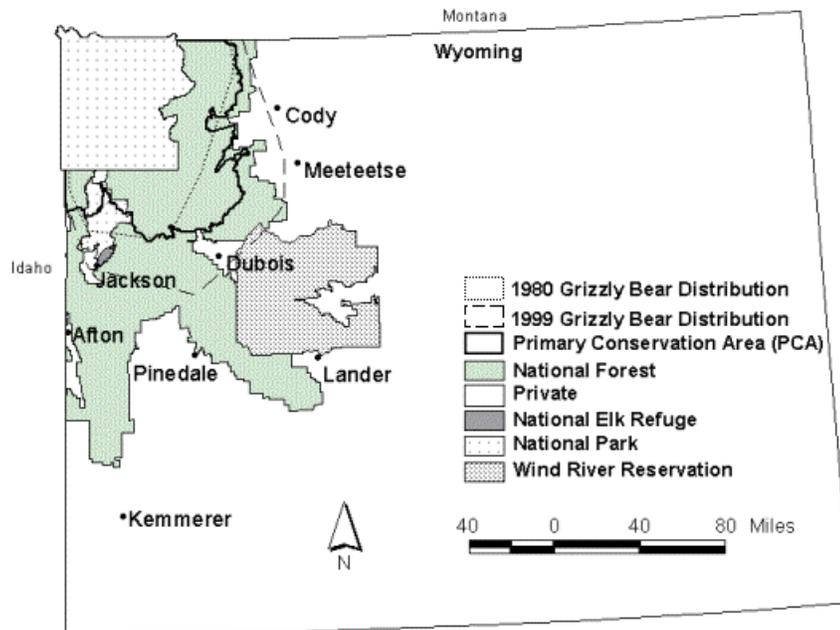
Figure 10. Comparison of grizzly bear distribution in Wyoming, 1975-1980 and 1975-1999, based on radio collared grizzly bears.

The most suitable grizzly bear habitat, both biologically and socially, is in the northwestern portion of Wyoming, in areas with large tracts of undisturbed habitat and minimal human disturbance. This geographic area is commonly referred to as the Greater Yellowstone Ecosystem. The Wyoming portion of the Greater Yellowstone Ecosystem includes portions of Park, Hot Springs, Fremont, Teton, Sublette and Lincoln counties. It includes all lands within the Shoshone, Bridger-Teton, and Targhee national forests, Yellowstone and Grand Teton national parks, the National Elk Refuge, and the western portion of the Wind River Indian Reservation. It also incorporates private, state and federal lands within and adjacent to the above mentioned national forests (Figure 11).

Prior to determining the geographic area in Wyoming where grizzly bears will be allowed to occupy, factors such as the amount of suitable habitat, amount and distribution of important seasonal foods, and human use levels (i. e. potential for conflicts) were thoroughly evaluated by the Department. This method of predicting the area grizzly bears may reoccupy is consistent with other research into this issue (Merrill and Mattson, 2001).

The established outer boundary for grizzly bear occupancy (by natural dispersal) encompasses most of the area within the Wyoming portion of the Greater Yellowstone Ecosystem. Specifically, it includes an area with an outer boundary beginning at the intersection of Wyoming Highway 120 and the Montana border; southerly along said highway through Cody and Meeteetse to U.S. Highway 20 in Thermopolis; southerly along said highway to Wyoming Highway 789 in Shoshoni; southwesterly along said highway to Wyoming Highway 134; westerly along said highway to Wyoming Highway 132; southerly along said highway to U.S. Highway 287; southeasterly along said highway to Wyoming Highway 28 approximately eight miles south of Lander; southerly along said highway to U.S. Highway 191 in Farson; northerly along said highway through Pinedale to U.S. Highway 189; southerly along said highway to U.S. Highway 30 in Kemmerer; west along said highway to the Utah border (Figure 12).

It is the Department's intent to limit grizzly bears to the above-described geographic area. Grizzly bears that occur outside this boundary will be dealt with on an individual basis, utilizing the Department's full array of management practices.

The Department will not allow grizzly bears to reoccupy other areas outside the Greater Yellowstone Ecosystem, including mountain ranges such as the Bighorns, Sierra Madres, Snowy Range, Laramie Peak, and the Black Hills. These mountain ranges are relatively small compared to the Greater Yellowstone Ecosystem, and, as such, do not provide suitable habitats in sufficient quantities to permit realistic populations of grizzly bears to re-establish. All are spatially separated from the Greater Yellowstone Ecosystem by large expanses of high desert habitats that are not conducive to grizzly bear occupancy, and all present an extraordinarily high potential for conflicts. It is also recognized that due to similar concerns about habitat and/or conflicts, select portions within the allowable occupied area may need to be managed for low grizzly bear densities.
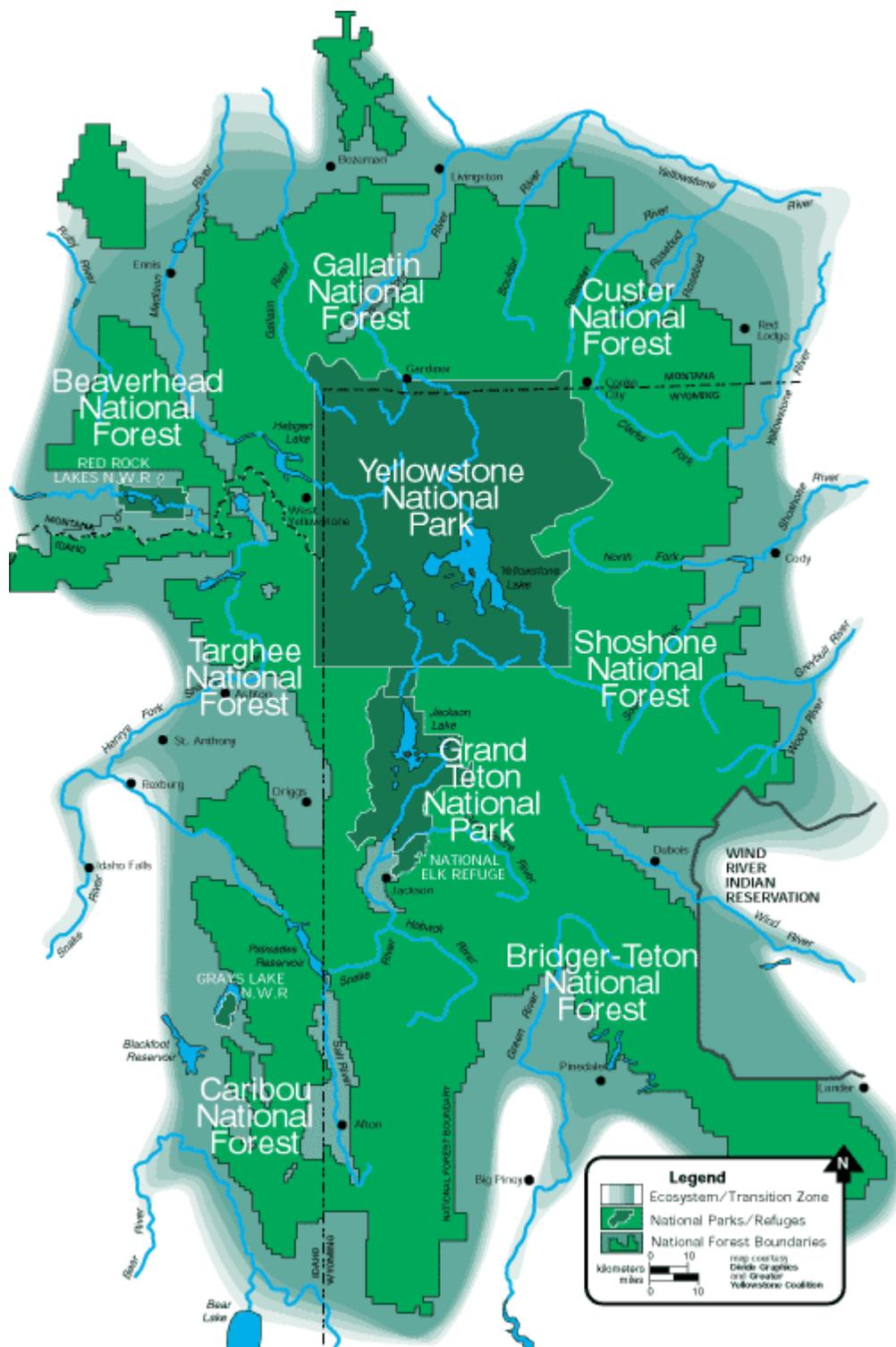
Figure 11. The Greater Yellowstone Ecosystem and ecosystem transition zone.
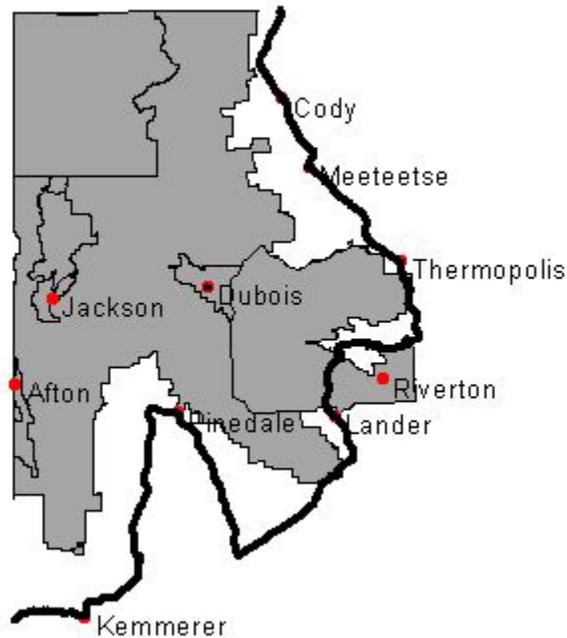
Figure 12. Proposed outer boundary of grizzly bear occupancy within Wyoming.

2. POPULATION MONITORING AND MANAGEMENT

Effective population management requires the collection of data to determine the status of the population and whether objectives are being met. Work is underway to refine population estimators that should be completed by the end of 2002. These protocols should result in a more precise population estimate that will assist in the development of strategic population management objectives to assure a sustainable population of grizzly bears in the Greater Yellowstone Ecosystem. Data collection protocols and analysis techniques will be updated and modified as new information becomes available.

Grizzly bears within the Primary Conservation Area will be managed to meet the population objectives established in the final *Conservation Strategy* to assure a long-term viable population. Grizzly bears outside the Primary Conservation Area may be managed for lower numbers in specific management units, especially in those areas with high potential for human/grizzly bear conflicts.

Population Monitoring

Grizzly Bear Management Units will be established outside the Primary Conservation Area. These units will be used to collect and analyze demographic and distribution data on grizzly bears by area. These units will be established based upon geographic features such as mountain ranges or drainages, as is done with analysis units for other wildlife species in the state. As changes occur in grizzly bear distribution and density, new units

may be created and/or old units may be modified to accommodate these changes. Analysis units will be created for the collection of demographic, distribution and other data.

To maintain consistency in data collection and compare grizzly bear population parameters inside and outside of the Primary Conservation Area, monitoring protocols should be similar to those inside the Primary Conservation Area. However, sampling effort may vary depending on the survey area and available funding. Monitoring of unduplicated females with cubs-of-the-year may be used as an index to assess population trend or abundance over time. This data is currently used to estimate a known <u>minimum</u> population size for the area within the Primary Conservation Area and the 10-mile buffer. The number of known individual females with cubs-of-the-year observed in the past three years are summed and divided by the estimated percentage of females with cubs-of-the-year (27.4%) in the population to achieve a minimum population estimate (Knight et al. 1988). This minimum population estimate is used to set mortality thresholds for all human-caused mortalities inside the Primary Conservation Area and 10-mile buffer. However, this method tends to underestimate the population size due to inherent biases in sampling techniques (IGBC 2000). The Interagency Grizzly Bear Study Team is currently evaluating different statistical approaches that will produce an estimate of the number of females with cubs-of-the-year with confidence intervals around that estimate (Keating et al. in review). The goal of this research is to provide a tool to allow agencies to estimate <u>total</u> population size for this population of grizzly bears.

Another population estimation technique is mark-resight sampling protocol. Mark-resight involves surveying the extent of occupied habitat and counting the number of marked an unmarked grizzly bears. Marked bears that were not observed on the initial survey are then located. The comparison of marked versus unmarked sighting is then used to estimate total population size. Radio marking and resighting techniques for population estimation of grizzly bears similar to those used in northern Canada and Alaska are much less effective in heavily forested habitats, such as those found in the Greater Yellowstone Ecosystem. The effectiveness of the resight observation flights is also greatly impacted by the season in which they are conducted.

Many researchers are now focusing on DNA hair snares as a technique to estimate populations and distribution. In this method, grizzly bears are attracted with scents to a station surrounded by a strand of barbed wire. The wire snags a tuft of hair as the bear passes under it. The follicles of the hair sample are analyzed for DNA and used to identify individual grizzly bears. This technique has been used in Yellowstone and Glacier national parks to identify a minimum number of individuals that was larger than had been previously thought to exist in those areas. Although hair snares can be effective in some cases, it is labor intensive and costly to implement for large areas. There are also problems with a lack of population closure (i.e. no movement in or out) in large areas that can result in population overestimation, especially for adult males.

The Department will monitor the progress in solving the problems in both mark-resight and hair snares and may implement one or both of these techniques if they are deemed feasible.

While management/research trapping and radio-collared grizzly bears may not provide efficient means of population estimation in the Greater Yellowstone Ecosystem, it does provide crucial data on distribution, movements, mortality, habitat use, and home ranges. Data results in estimation of seasonal, annual, and lifetime home ranges, identification of important seasonal habitats and foods, potential travel or linkage corridors, activity patterns, extent of occupation, and denning sites. Radio collars also provide data necessary for the calculation of the rate of change in the population estimate. The formula for this rate of change requires accurate, long-term measurements of survival rates for various demographic classes, age at first reproduction, rate of reproduction, and life expectancy from a representative subset of the population.

The Department will utilize data, such as reproduction, distribution, average life expectancy by sex and age class, and causes of mortality for grizzly bears in various areas of their range, to set annual mortality quotas. The Department will also document all human-caused mortality. All mortality data, as well as reproductive information, will be used in the management of the population. The Department anticipates using an approach similar to the one currently used in the Primary Conservation Area to manage human caused mortalities. Harris (1986) reported that total human-caused mortality in excess of 6.5 percent decreases the long-term stability of grizzly bear populations. The current human-caused mortality threshold within the Primary Conservation Area is 4 percent of the <u>minimum</u> population estimate, and only 30 percent of that number can be female mortality.

Eventually grizzly bears will occupy all areas within the Greater Yellowstone Ecosystem that are biologically suitable and socially acceptable. When that occurs, a stable population of grizzly bears will be the management objective, with mortality equaling recruitment over the long term. Human-caused mortalities may increase in specific areas in some years due to shortages of natural food sources and resulting conflicts with humans, especially in newly occupied areas where the Department can't predict what level of nuisance activity and mortality may occur. The Department will manage grizzly bear mortalities in relation to population objectives and status within the Greater Yellowstone Ecosystem.

Hunting

Throughout recent history, regulated hunting has played an instrumental role in the recovery and continued health of wildlife populations. Hunting is not only useful in keeping populations at desired levels, it is also an important method for maintaining public support and ownership, as well as tolerance, of certain species, especially large predators. Even with the extremely low reproductive rates of grizzly bears, they will ultimately exceed desired objectives in some areas, and the population will require regulation. Any hunting seasons authorized by the Commission will be designed to meet Department management objectives.

Regulated hunting will be part of the Department's overall grizzly bear management program. Grizzly bear hunts may not necessarily begin immediately upon delisting,

however, they will occur when grizzly bears are at a population level able to sustain limited harvest. The timing of implementation and level of harvest may vary. Areas where grizzly bear numbers or human/grizzly bear conflicts are high will likely begin regulated harvest before areas of lower densities or conflicts. These areas may also have higher harvest quotas than areas of lower grizzly bear densities. Hunting seasons may also be established in the Primary Conservation Area, consistent with demographic guidelines established in the *Conservation Strategy*. Regulated hunting, along with other tools, will be utilized to ensure the long-term conservation of grizzly bears in Wyoming.

Human/grizzly bear conflicts cause problems with individuals directly affected by the grizzly bear. These conflicts also erode overall support for grizzly bears statewide. Hunting may be a useful method in reducing the number of nuisance grizzly bear incidents, thus reducing the need for agency control. Nuisance grizzly bears are often the most visible in the population and thus more apt to be encountered by hunters.

Grizzly bear hunting seasons in Wyoming will be established in the same manner as seasons for other species in the state. In general, the process will begin when wildlife managers propose a season. This season will be justified based upon biological data such as population objectives, population trends, habitat, and social constraints. This proposal will then be reviewed internally by biologists, game wardens, supervisors, and administrators. The proposed season will next be made available for public comment in accordance with provisions found in the Wyoming Administrative Procedures Act. Public meetings will be held to gather input. At the end of this public comment period, comments received from meetings and other written or verbal comments will be provided to the Commission. The Commission will ultimately decide on the proposal based on biological data and social concerns expressed in the public comments.

Regulations will be put in place to protect female grizzly bears. Females with young at side will be protected from harvest, by Commission regulation. The timing of hunting seasons may also be set in order to protect females. Early spring and late fall hunts tend to focus hunting pressure on males, because females with young are in their dens. Males are more vulnerable to harvest than females because they range more widely and are more likely to be encountered by hunters.

Baiting of grizzly bears will continue to be illegal within the Primary Conservation Area, throughout the life of the *Conservation Strategy*. Outside the Primary Conservation Area, the policy of baiting black bears will be evaluated in areas occupied by grizzly bears. If grizzly bear mortalities occur over black bear bait sites, black bear baiting may be discontinued in those areas. It is the policy of the Department to prevent the conditioning of grizzly bears to human foods. Human food conditioning has been shown to increase incidents of human/bear conflicts (Herrero, 1985).

Research Recommendations

With an expanding grizzly bear population, continued research on population estimation techniques is a priority. Currently, research is underway that may more accurately estimate the Greater Yellowstone grizzly bear population using a modeling technique to account for different detection probabilities with individual grizzly bears (Boyce et al. 2001). Work is also being conducted on improved estimation of unknown and unreported human-caused grizzly bear mortalities (Cherry et al. in review). In addition, new abundance estimation techniques utilizing hair snares and DNA analysis (Woods et al. 1996, 1999; Mowat and Strobeck 2000) are being tested. However, these techniques have limited application because of concerns about cost, demographic and geographic closure, potential capture biases, and a need for standardization of experimental design.

Much of the land within the Primary Conservation Area has extensive habitat protection, whereas, much of the land outside of the Primary Conservation Area is managed for multiple use. With the diversity of land management strategies outside the Primary Conservation Area, differences in grizzly bear population parameters and habitat utilization may emerge. Differences in survivorship, home range size, human caused mortality, food habits, travel patterns, seasonal use of habitat, and denning sites may all occur due to differing land management practices. Monitoring of these parameters is important to the successful management of grizzly bears outside the Primary Conservation Area. The Department and federal land management agencies need to identify these differences outside of the Primary Conservation Area to create effective management strategies.

3. HABITAT AND LAND MANAGEMENT

Management of grizzly bear habitat in Wyoming, outside the Primary Conservation Area, is complicated. Important habitats need to be identified and managed where grizzly bears exist. Most currently occupied grizzly bear habitat in the state is on U. S. Forest Service land, although grizzly bears do use other federal, state and private lands. The Department's authority over land use decisions is limited to Department-owned lands, yet the Department is responsible for management of grizzly bears on all lands except Yellowstone National Park, Grand Teton National Park, and Tribal managed lands of the Wind River Indian Reservation. The Department will seek to influence management decisions on all fish and wildlife habitat on public land, whether roaded or unroaded, as valuable and unique lands that will remain open to hunters, anglers and other public users. Access to public lands should be balanced with the year-round requirements of fish and wildlife – that is, habitat, clean water, food, shelter, open space and disturbance management. It includes maintaining a functioning road system. Roadless areas should be kept intact with science-based exceptions made for forest health, restoration, and other state and national needs. Coordination among state and federal agencies and private landowners will be crucial. The Department recognizes the need to minimize negative impacts. The Department will continue to closely coordinate with these land management agencies to minimize negative impacts on fish and wildlife. Additionally, the Department has considered, and will continue to consider, grizzly bears in comments and input regarding land management activity in all occupied grizzly bear habitat.

Grizzly bears are omnivorous and very opportunistic. They are able to survive in a variety of habitats (Craighead 1998) and utilize a variety of foods (Craighead and Mitchell 1982). Four major food sources utilized by grizzly bears inhabiting the Greater Yellowstone Ecosystem are whitebark pine (*Pinus albicaulis*) seeds, army cutworm moths (*Euxoa auxiliaris*), large ungulates (newly born young and winter kills), and spawning cutthroat trout (*Oncorhynchus clarki*) (Mattson et al. 1991). Not all grizzly bears utilize all of these food sources. The proportion of the population that utilizes any one of these foods varies annually. A major segment of the population also utilizes gut piles of elk and moose that are killed by hunters. It is estimated that approximately 370 tons of edible biomass are available to grizzly bears and other scavengers annually (Servheen et al. 1986). This represents a vital food source for grizzly bears, especially during years of poor white bark pinecone production. Grizzly bears also use a wide variety of vegetative matter varying from grass to berries.

While the existence and utilization of these food sources has been well documented inside the Primary Conservation Area, there is less documentation for areas outside the Primary Conservation Area. Existing data indicates that spawning cutthroat trout are less available to grizzly bears outside the Primary Conservation Area. While the use of ungulates by grizzly bears is important, extensive monitoring of this food source does not appear to be warranted at this time. Therefore, the Department will direct its monitoring of major grizzly bear foods toward whitebark pine and army cutworm moths. Ungulate populations and cutthroat trout will be monitored using existing Department practices and policies. Other important food sources may be monitored as they are identified.

This management plan recommends coordinated monitoring of major grizzly bear food sources and continued consultation with land management agencies and private land owners on issues related to grizzly bear habitat protection, disturbance, enhancement and mitigation. The Department, in cooperation with the U. S. Forest Service, will survey selected whitebark pine stands and army cutworm moth aggregation sites using existing methodology implemented by the Interagency Grizzly Bear Study Team within the Primary Conservation Area (IGBC 2000). Whitebark pine stands will be identified and monitored for seed production, tree health (i.e. evidence of blister rust, *Cornartium ribicola*), and evidence of grizzly bear use. Existing, as well as newly identified, moth aggregation sites will be monitored for use by grizzly bears. Grizzly bear activity at moth aggregation sites is an indirect measure of presence or absence of moths during a given year.

One of the key reasons for the decline of brown/grizzly bears in North America is increased mortality due to habitat loss. Habitat loss results from conversion of native vegetation, depletion of preferred food resources (i.e. salmon and whitebark pine), disturbance, displacement from human developments and activities (i.e. roads, mines, subdivisions), and fragmentation of habitat into increasingly smaller blocks inadequate to maintain viable populations.

Radio telemetry studies have identified roads as a significant factor in habitat deterioration and increased mortality of brown/grizzly bears. For example, adult females have been displaced from approximately 16 percent of the total available

habitat in Yellowstone National Park by roads and development (Mattson, et al. 1987). The percentage of habitat loss as a consequence of behavioral displacement from roads is a function of road density. Female displacement is higher in areas having higher road density, regardless of the distance at which roads affect grizzly bear behavior. The distance at which grizzly bears appear to be displaced by roads varies in different areas and seasons. Correspondingly, the impact of roads on displacement from preferred habitats is greatest in spring. During the fall, grizzly bears tend to move to higher elevations to forage. At this time, they select habitats that are typically more distant from existing roads. Consequently, the importance of disturbance displacement by roads is less evident during fall than during spring. Traffic levels appear to influence the degree of grizzly bear avoidance of roads. Grizzly bears living near roads have a higher probability of human-caused mortality as a consequence of illegal shooting, control actions influenced by attraction to unnatural food sources, and vehicle collisions. The Department will seek to influence federal land management agencies to maintain average road densities of one mile per square mile of habitat or less. This is the goal the Department advocates for all occupied elk habitat in northwestern Wyoming. This goal has been demonstrated to meet the needs of a variety of wildlife, while maintaining reasonable public access. If different road management is warranted, based on knowledge gained as grizzly bears reoccupy areas, it should be developed and implemented by land management agencies.

Security cover, the ability of an environment to protect against threats and disturbances, is another important component of habitat. Grizzly bear habitat can be impacted by a reduction of security cover as the direct or indirect result of various human activities including land management practices, recreational development and primary roads (Mattson et al. 1987), restricted roads and motorized trails (Mace et al. 1996), human use (Knight et al. 1988, Mattson 1989, McLellan and Shackleton 1989), oil and gas development (Schallenberger 1977, Reynolds et al. 1983, McLellan and Mace 1985), logging practices (Zager et al. 1983, Archibald et al. 1987, Bratkovich 1986, Hillis 1986, Skinner 1986), and forest fires (Zager et al. 1983, Blanchard and Knight 1990). While the Department recognizes the need to minimize negative impacts, it has no direct jurisdiction over land management activities on a majority of the land adjacent to the Primary Conservation Area. Therefore, the Department will provide technical advice and encourage land management agencies to consider the grizzly bear in their land management plans.

Because of the threat due to land use changes, the Department will coordinate with appropriate federal, state and county governments in an effort to conserve habitat in this portion of Wyoming.

Habitat fragmentation is not as problematic in Wyoming as it is in Montana and Idaho. For the most part, the Greater Yellowstone Ecosystem within Wyoming is intact. However, there are several two-lane highways that bisect portions of the ecosystem. Some of these highways have been scheduled for major improvements in the near future. The Department will work with appropriate land management agencies and the Wyoming Department of Transportation to minimize impacts to grizzly bears and other wildlife as these projects move forward.

Human presence in occupied grizzly bear habitat is linked to disturbance, human/grizzly bear conflicts and mortalities. In areas occupied, or likely to be occupied, by grizzly bears, the Department promotes the use of pepper spray and recommends that land management agencies require food/waste handling practices (i.e. food storage orders) that reduce the potential for conflicts.

Specific Habitat Recommendations

The following general management guidelines may be considered when evaluating the effects of existing and proposed human activities in important habitats for a variety of wildlife species, including grizzly bears:

➢ The Department will work with land management agencies to monitor habitat changes in a manner consistent with overall approaches for all other managed wildlife species.

➢ Identify and evaluate the cumulative effects of all activities for all proposed projects. Potential site-specific effects of the project being analyzed are a part of the cumulative effects evaluation, which will apply to all lands within an appropriate unit of land.

➢ Monitor, and if warranted, recommend changes in human activities on seasonally important wildlife habitats that may adversely impact wildlife species or reduce the long-term habitat effectiveness.

➢ Base road construction proposals on completed transportation plans which consider important wildlife habitat components and seasonal-use areas in relation to road location, construction period, road standards, seasons of heavy vehicle use, road management requirements, etc.

➢ Use minimum road and site construction specifications based on projected transportation needs. Schedule construction times to avoid seasonal-use periods for wildlife as designated in species-specific guidelines.

➢ Provide site-specific recommendations to locate roads, drill sites, landing zones, etc., to avoid adversely impacting important wildlife habitat.

➢ Roads, which are not compatible with area management objectives and are no longer needed for the purpose for which they were built, should be closed and reclaimed.

➢ Native plant species should be used whenever possible to provide proper watershed protection on disturbed areas. Wildlife forage and/or cover species should be used in rehabilitation projects where deemed appropriate.

- The Department recommends that land management agencies manage for an average of one mile of open road per square mile, which is consistent with the Department's elk management guidelines.

- The Department generally supports maintaining existing roadless areas and will work with local groups and land managers to identify areas where additional roads may be justified and where others could be reclaimed.

- When necessary for the benefit of wildlife, recommend seasonal road closures and/or vehicle restrictions during important seasonal time periods.

- Encourage the U.S. Forest Service and Bureau of Land Management to enforce regulations banning all motorized off road/trail use.

- Efforts will be directed towards improving the quality of habitat in site specific areas of habitually high human caused grizzly bear mortality. Increased sanitation measures, seasonal road closures, etc., could be applied.

One suggestion that originated from the public involvement process was to expand the current higher level of habitat restrictions and programs in place in the Primary Conservation Area, to grizzly bear occupied areas outside the Primary Conservation Area. It is the Department's judgment that this approach would not generate social acceptance for grizzly bears and their conservation. Incorporating grizzly bears as another component of the Department's ongoing programs for all wildlife is deemed to be a more productive approach.

4. NUISANCE GRIZZLY BEAR MANAGEMENT

Common definitions used in relation to grizzly bear nuisance management are presented in Appendix II.

The nuisance guidelines outlined in the final *Conservation Strategy* will be followed inside the Primary Conservation Area for the term of the *Conservation Strategy*. The *Draft Conservation Strategy* guidelines are presented in Appendix III.

Management of conflicts outside the Primary Conservation Area will be governed by the guidelines in this document. Outside the Primary Conservation Area, significant consideration will be given to humans when grizzly bears and people come into conflict. Agency management of nuisance grizzly bears will be based on risk management analysis that considers the impacts to humans, as well as impacts to the grizzly bear population. Response alternatives may include no action, aversive conditioning, deterrence, relocation or removal. All actions will be documented in an annual report.

The program to manage human-grizzly bear interactions, property and agriculture damage, and hunter-grizzly bear interactions outside the Primary Conservation Area, will focus on strategies and actions to prevent human-grizzly bear conflicts. Active management of individual nuisance grizzly bears is required as part of the management

program. Public safety concerns will remain paramount in agency management actions dealing with nuisance grizzly bears. Considering logistics and manpower, nuisance grizzly bears will be controlled in a timely and effective manner. Non-lethal control measures will be used whenever the techniques are appropriate and practical, while providing for public safety. Location, cause of incident, severity of incident, history of the offending grizzly bears, health, age, and sex of grizzly bears involved, will all be considered in any management action.   Response alternatives that will be utilized by the Department, follow.

Response Alternatives

No Action: The Department may take no action after the initial investigation, if the circumstances of the conflict do not warrant control or the opportunity for control is low.

Many conflicts between humans and grizzly bears are one-time events. The events leading to the conflict may not be repeated, making a response unnecessary.   In other situations, the location of the grizzly bear or the next conflict is unknown, making the opportunity to manage the conflict low until events become localized.

Aversive Conditioning, Deterrence, and Protection: The Department may employ various options that deter or preclude grizzly bears from depredation or human interaction activities (i.e. electrical fencing, bear proof structures or containers, scare devices, etc.).

Managing the cause of the conflict is often the most desirable action. Protection of property or attractants will often result in grizzly bears abandoning the area and discontinuing undesirable behaviors. Actively deterring, or aversive conditioning grizzly bears, will sometimes have the same effects. Public safety must be the foremost consideration prior to application of any management action.

Relocation: The Department may initiate capture and relocation operations when other options are not applicable or where human safety is a concern. Capture and relocation efforts will be initiated in a timely manner, when practicable.

When the cause of the conflict cannot be managed, moving the grizzly bear away from the site may resolve the problem. Relocating grizzly bears is often the preferred option when grizzly bears are occupying undesirable areas or when public safety is a concern. While relocation often has short-term desirable affects, the grizzly bear may return to the original area and cause additional conflicts, or continue the undesirable behaviors at a different location.

Removal: Lethal control may be employed when other options are not practical or not feasible.

Food-conditioned, human-habituated, or aggressive behaviors occasionally become ingrained in grizzly bears resulting in no practical non-lethal management alternative. Grizzly bears persistently displaying these behaviors are a public safety threat and often

are involved in continual property damage incidents. In addition, some grizzly bears may not be suitable for release because of injury, illness or physical condition. Removal from the population is a useful management option that should be followed when appropriate, with management of the cause of the conflict.

When applicable, lethal take of nuisance grizzly bears by affected property owners will be allowed through special authorization from the Department. The Department would direct the disposition of any grizzly bear taken under special authorization.

Grizzly bears occupying areas where the potential for conflicts are high (i.e. subdivisions) will be proactively managed to prevent damage and provide for human safety.

All sub-adult and adult grizzly bears captured in management actions to be relocated or released on site, will be permanently marked and may be radio-collared.

Grizzly bears relocated because of human- grizzly bear conflicts will be released in a location where the probability to cause additional problems is low. Nuisance grizzly bears will not be relocated into unoccupied habitat. Grizzly bears not suitable for relocation or release on site will be removed from the population.

Management Program

To effectively carry out the response alternatives, the following management procedures may be implemented:

> ➢ Within each appropriate Department Region, personnel will be trained and equipped to manage conflicts.

> ➢ Conflict reporting procedures will be made available to the public.

> ➢ Appropriate state and federal agency personnel will be trained, authorized, and equipped to manage conflicts in circumstances determined by the Department.

> ➢ The Department may provide property owners with deterrent or aversive conditioning supplies when deemed appropriate.

> ➢ Livestock depredation information and evaluation training will be made available to livestock producers and their employees.

> ➢ The Department will respond in a timely manner to reports of human-grizzly bear conflicts. The appropriate response will be implemented after evaluating the circumstance of the conflict.

Human-Grizzly Bear Interaction Management

Grizzly bears and humans interact in environments that they share. Most encounters have little or no negative effects on either humans or grizzly bears, but some result in a harmful outcome for one, the other, or both. The Department will work to prevent, manage and mitigate detrimental encounters between humans and grizzly bears by implementing the following actions:

> The Department or its authorized representative will evaluate and, if appropriate, investigate reported human-grizzly bear interactions in a timely manner. The Department will inform the affected parties or their representatives of the findings as soon as feasible.

> The Department will provide information and technical assistance for prevention, management, and mitigation of human-grizzly bear interactions.

> The Department may provide deterrent or aversive conditioning devices or supplies to the public for use in preventing or managing interactions.

> Grizzly bears may be proactively captured and relocated to prevent interactions with humans, if deemed appropriate.

> Grizzly bears may be captured and relocated to prevent additional conflicts with humans, if deemed appropriate.

> When relocation is not possible or practicable, grizzly bears may be removed from the population, if deemed appropriate.

> Grizzly bears displaying natural aggression may be removed from the population, if the particular circumstances warrant removal.

> Grizzly bears displaying unnatural aggression or considered a continued threat to human safety will be removed from the population.

> Grizzly bears displaying food-conditioned or habituated behaviors may be relocated, aversively conditioned, or removed, based on specific details of the incident. When requested, the Department will inform the affected people of the management decision.

Property Damage Management

Processed human food, gardens, garbage, livestock and pet feeds, livestock carcasses, improperly stored big game carcasses, and septic treatment systems are particularly attractive to grizzly bears near camps and residential areas, and are often the basis for property damage by grizzly bears.

The Department will identify potential sources of attractants and work with private property owners, outdoor users and government agencies to reduce the source of the

attractant with long-term solutions being emphasized. When the attractant cannot be eliminated, the Department will provide technical advice for the protection of property and the reduction of potential for human/grizzly bear conflicts. Techniques to prevent damage may include aversive conditioning, physical protection such as electric fencing, relocating or removing offending animals, and the use of deterrent devices. The Department will encourage the development of effective non-lethal damage management techniques and equipment. The Department may use the following actions to manage property damage caused by grizzly bears:

- The Department or its authorized representative will evaluate and, if appropriate, investigate reported property damage incidents caused by grizzly bears in a timely manner. The Department will inform the affected parties or their representatives of the findings as soon as feasible.

- The Department will provide information and technical assistance to the affected parties to assist with the mitigation of property damage caused by grizzly bears.

- The Department may provide deterrent or aversive conditioning devices or supplies to property owners for use in preventing damage, if deemed appropriate.

- Grizzly bears may be proactively captured and relocated to prevent damage, if deemed appropriate.

- Grizzly bears may be captured and relocated to prevent additional damage to personal property, if deemed appropriate.

- When relocation is not possible or practicable, or when it is likely it will not solve the problem because of food conditioning, habituation, or other behavioral traits, grizzly bears may be removed from the population.

Agriculture Damage Management

Domestic animals, livestock feeds, and apiaries often attract grizzly bears that can cause extensive damage to agricultural products when they are left unprotected or when grizzly bears are allowed to remain in the area. The Department will cooperate with livestock operators and land management agencies to promote livestock management techniques that reduce depredations. Depredation management will emphasize long-term, non-lethal solutions, however, relocating or removing offending animals will be necessary to resolve some conflicts. The Department will continue to promote the development of new techniques and devices that can be used to protect agricultural products from damage. The Department may use the following actions to manage agricultural damage caused by grizzly bears:

- The Department or its authorized representative will evaluate and, if appropriate, investigate reported damage to livestock or agricultural products caused by

grizzly bears, as soon as practical. The Department will inform the affected parties or their representatives of the findings, as soon as feasible.

➢ The Department will provide information and technical assistance to the affected parties to assist with the management and mitigation of agricultural damage caused by grizzly bears.

➢ The Department may provide protective, deterrent, or aversive conditioning devices or supplies to farmers, ranchers, or their representative for use in preventing damage or deterring grizzly bears.

➢ Grizzly bears may be proactively captured and relocated to prevent agricultural damage, if deemed appropriate.

➢ Grizzly bears may be captured and relocated to prevent additional damage to agricultural products, if deemed appropriate.

Grizzly bears that exhibit chronic livestock killing behaviors may be removed from the population.

The Department will pay for all compensable damage to agricultural products as provided by state law and regulation.

The Department will continue efforts to establish a long-term funding mechanism that includes resources to compensate property owners for livestock and apiary losses caused by grizzly bears. Materials will be developed that explain the damage claim program and describe the steps to obtain evaluation and payment for livestock killed or apiaries damaged by grizzly bears.

Hunter-Bear Conflict Management

Encounters between grizzly bears and hunters may result in dead or injured grizzly bears and/or injury to hunters. To provide for human safety and grizzly bear conservation, the Department may use the following actions to manage conflicts between hunters and grizzly bears.

➢ The Department will encourage hunters to report all instances of grizzly bear conflicts.

➢ The Department will encourage the development of products and techniques that can be used by hunters to manage interactions with grizzly bears in a non-lethal manner.

➢ The Department will utilize a multi-faceted hunter information and education program to assist in managing hunter-grizzly bear conflicts.

➢ The Department will investigate all reported hunter-grizzly bear conflicts resulting in human or grizzly bear injury or death.

Grizzly bears identified for removal may be given to public research institutions or public zoological parks for appropriate non-release educational or scientific purposes in compliance with state laws. Grizzly bears not suitable for release, research, or educational purposes will be lethally removed. The Department will direct the disposition of a grizzly bear lethally removed, other than by a licensed hunter. Grizzly bears taken under special authorizations shall be retained by the Department or donated to scientific or educational institutions.

A licensed hunter or individual authorized by the Department may be utilized to take specific nuisance grizzly bears deemed appropriate for removal.

Deviation from these nuisance procedures will be allowed when extraordinary circumstances dictate a need. The Department will include these circumstances in its annual report on nuisance grizzly bear management.

5. INFORMATION AND EDUCATION

In 1991, the Department launched an education outreach effort that emphasizes learning to co-exist with grizzly bears and reduce human-grizzly bear conflicts. Its focus was aimed at increasing the public's understanding and awareness of grizzly bears, their behavior, physical characteristics, and how to avoid conflicts with them.

Three "target audience" categories were identified and continue to be a high priority:

- Residents and non-residents hunting in occupied grizzly bear habitat.

- Schools, teachers and youth organizations with special emphasis on Grades 3-12.

- The general populace of Wyoming with emphasis on residents of, and visitors to, the Greater Yellowstone Ecosystem.

The tools used to reach the audience are varied, thereby maximizing the likelihood the information being offered will be available, with emphasis on those individuals and groups with the most need. The following is a compilation of actions the Department has used over the last ten years and will continue to use to reduce conflicts with large predators:

- Prior to the annual hunting seasons, 8,000-12,000 letters with information (i.e. brochures and pocket bear identification cards) were mailed to outfitters, non-resident elk hunters and all permit holders in elk and bighorn sheep areas of northwest Wyoming.

➢ Hunters were provided opportunities to acquire information at regional offices, hunter check stations, hunter information stations, hunter management stations, and through field personnel.

➢ Permanent bear display kiosks were erected at the Cody and Dubois hunter check stations, as well as the Dubois Forest Service office and the Department's Cody regional office. The bear displays include information on bear identification, food storage, and conflict avoidance.

➢ In late summer and fall, television and radio public service announcements were broadcast throughout Wyoming. The Center for Wildlife Information and the spokesperson for the national grizzly bear campaign, General Norman Schwartzkopf, have assisted in the filming.

➢ *Wyoming Wildlife News* and statewide print media news releases have gone out each fall immediately prior to and during hunting seasons.

➢ Project WILD workshops for teachers were offered with emphasis on bear activities for students.

➢ Bear education packets were purchased and mailed to all of the middle/junior high schools in Wyoming. The packets contained the Audubon Wildlife Adventure "Grizzly Bear" simulation program, the National Wildlife Federation's "Owner of the Earth" teaching guide, a list of wildlife personnel to serve as a resource for teachers, Grizzly Country publications video entitled "The Last Parable" by Montana Department of Fish, Wildlife and Parks and other miscellaneous publications.

➢ Bear education teaching trunks were purchased and made available to teachers, youth group leaders, and others for checkout through Department regional offices.

➢ A cost-shared, "Wildlife Stewardship" poster was developed with the Center for Wildlife Information for classrooms and youth group leaders and the Center's video "Give them Room to Live" and "Be Bear Aware" coloring book/activity guides were made available.

➢ A human-bear safety session was provided at each of the Department's Whiskey Mountain Youth and Teacher Conservation Camps, discussing bear behavior, conflict prevention, and human behavior in an encounter.

➢ Each spring television public service announcements were broadcast over Wyoming stations informing people about their responsibility in avoiding grizzly bear conflicts and where to obtain information.

➢ Exhibits on grizzly bears and the human role and responsibility in avoiding conflicts and conserving grizzly bear habitat are on display at the Information Center in Jackson, and at the Yellowstone Regional Airport in Cody.

➢ Community-based "Living in Bear and Mountain Lion Country" workshops were developed and are offered each spring around the state.

➢ A "Train the Trainer" workshop was conducted for state and federal agencies from Idaho, Wyoming, and Montana on how to provide the community-based "Living in Bear and Mountain Lion Country" workshops.

➢ Other workshops and programs were given upon request by the Department's Trophy Game Section, conflict resolution personnel, Education Branch, and Information Branch personnel.

➢ Publications were developed and made available. Titles include "Living in Bear Country", "Bear Necessities-How to Avoid Bears", "Grizzly Bear Encounters-Getting Out Safely", "The Forest Visitor-Storing your Food", "Women in Grizzly Country", "Mountain Biking in Grizzly Country", "Fishing in Grizzly Country", "Grizzly Bears and You-The Big Game Hunter", and "You the Hunter". These are used throughout the forests of the Greater Yellowstone Ecosystem. The publications and associated posters were cooperatively designed, printed, and distributed by the U. S. Forest Service and the Department.

➢ Bear safety publications were provided to the Cody Country "Welcome Wagon" and distributed to new Cody area residents.

➢ The Department provided training on "Hunting Safely in Grizzly Country" to the Wyoming Outfitters and Guides Association at their annual meeting.

➢ Department personnel worked cooperatively with the U.S. Fish and Wildlife Service and the Wyoming Outfitters and Guides Association to develop the "Grizzly Encounter Education Course".

➢ Seminars on hunting safely and recreating safely in bear and lion country were offered annually at the Casper Sports Show, Hunting and Fishing Heritage Exposition, and Central Wyoming Fair.

➢ "The Bear Trail" educational exhibit was set up annually at the Wyoming Hunting and Fishing Heritage Exposition. The interactive walking trail teaches participants proper camp placement and food storage, grizzly bear and black bear tracks, scat, physical identification, food habits, proper use of bear pepper spray, and options available in encounter situations.

➢ In the fall of 2001, the Department purchased and distributed copies of the video "Staying Safe in Bear Country" to all of the public libraries in northwest Wyoming. The video was developed by the Safety in Bear Country Society and the International Association for Bear Research and Management and is one of the most useful tools when describing human-bear interaction.

➢ "Bear Alert" postcards were used to inform residents when grizzly bears begin frequenting residential areas.

Human safety is of utmost concern when hunting in grizzly bear country. In order to teach hunters proper techniques for hunting in grizzly bear country, the Department will include bear safety education in all entry level and advanced hunter education classes. Approximately 7000 students are certified each year through the Department's hunter education program.

➢ A bear identification and safety test will be added to the Department's website in 2002. Black bear hunters will be encouraged to take the test to heighten their bear awareness.

➢ By January, 2004, the entry-level mandatory hunter education course subjects and instructor manuals will be written. The new entry-level course will include a one-hour class entitled "Preventing Conflicts and Avoiding Confrontations with Bear and Mountain Lion". By July, 2004, all volunteer hunter education instructors will receive this training.

The Department will continue to make available appropriate material on grizzly bear safety for everyone who hunts, recreates and works in occupied grizzly bear habitat. New material will be developed or obtained as constituent needs arise.

➢ The Department will expand its efforts on the value of carrying bear pepper spray as a deterrent when recreating and working in grizzly bear habitat. Recommendations on proper use will be incorporated whenever encounters are discussed.

➢ The Center for Wildlife Information's "Bear Pepper Spray" video is available for public checkout at each Department regional office.

The Department will provide a copy of "Staying Safe in Bear Country" video to each guest lodge in occupied grizzly bear habitat. A copy of this video will be provided to all schools located in areas frequented by grizzly bears and is also available for public checkout at each Department regional office.

The Department strongly encourages federal land management and wildlife agencies to continue their vital role in educating all users in grizzly bear safety. Federal land management agencies will be encouraged to assess needs and provide the appropriate number and type of bear resistant food storage containers, meat poles, and bear resistant garbage containers in occupied areas to protect grizzly bears and people while assuring wilderness values. The Department will seek modification of existing memoranda of understanding with federal land use agencies to accomplish these goals.

The Department will promote grizzly bears as a valuable state resource through public outreach, community based workshops, news releases, magazine articles, and radio and television spots.

The Department will provide personnel to assist in teaching the "Grizzly Encounter Education Course" for outfitters and guides and in the revision and reprinting of the course syllabus. Wyoming's outfitting industry voluntarily developed the course in partnership with the U. S. Fish and Wildlife Service, U. S. Forest Service, National Park Service, the Department, and the Professional Guides Institute. The Commission supports the continuation of this effort by the outfitting industry.

The Department will develop a two-hour seminar specifically designed to minimize hunter-grizzly bear conflicts. The first seminar will be offered in 2002. Development and implementation of a comprehensive information and education program designed for people that live, work, and recreate in grizzly bear habitat is essential to conflict prevention.

Information on preventative and aversive techniques will continue to be available to property owners, outfitters and land managers. The assistance will be refined as new techniques and ideas become available. This technical assistance will promote successful co-existence, human safety and grizzly bear conservation.

Over the course of the last decade, Wyoming's grizzly bear education outreach has been a cooperative program involving partnerships and additional funding. Other entities responsible for its success are the Bridger-Teton National Forest, Shoshone National Forest, Caribou-Targhee National Forest, the U. S. Forest Service's Missoula regional office, U. S. Fish and Wildlife Service, Center for Wildlife Information, Greater Yellowstone Coalition, Sierra Club, National Fish and Wildlife Foundation and the Interagency Grizzly Bear Committee.

6. COSTS AND FUNDING

In fiscal year 2000, the Department spent approximately $804,000 to manage grizzly bears. This amount includes $481,000 in direct costs. The remaining $323,000 was indirect costs assigned to the grizzly bear program through the Department's cost accounting system.

As grizzly bear numbers and distribution increase, management costs will also rise because of the need to collect data and manage conflicts. Total costs are difficult to determine at this time, especially since grizzly bear population expansion will continue in the near future. The costs associated with data collection and nuisance management will certainly exceed funds generated from this species. As a result, the grizzly bear program will not be self-sufficient. This is not unique, as the costs associated with managing most wildlife species exceed revenues generated by those species.

The grizzly bear is a species of national interest. Consequently, the Commission and Department believe that alternative funding should be made available to assist with the financial responsibility of managing grizzly bears. Accordingly, the Department is

assisting in development of a Northern Rocky Mountain Grizzly Bear and Gray Wolf National Management Trust. The Department is urging state and national legislators to pursue this national endowment. Other options include seeking additional funding from other sources including the Wildlife Legacy Trust, the Wildlife Heritage Foundation of Wyoming and, potentially, the Conservation and Reinvestment Act or similar state grant programs administered by the federal government. These potential funding sources could be used to partially pay for grizzly bear management.

— **W G F D** —

LITERATURE CITED

Archibald, W.R., R. Ellis and A. N. Hamilton. 1987. Responses of grizzly bears to logging truck traffic in the Kimsquit River Valley, British Columbia. International Conference on Bear Research and Management 7:251-257

Blanchard, B. M., and R. R. Knight. 1990. Reactions of grizzly bear, *Ursus arctos horribilis,* to wildfire in Yellowstone National Park. The Canadian Field-Naturalist 104: 592-594

Boyce, M.S., D.I. MacKenzie, B.F.J. Manly, M.A. Haroldson, and D. Moody. 2001.Negative binomial models for abundance estimation of multiple closedpopulations. Journal of Wildlife Management 65:498-509.

Bratkovich, A. A. 1986. Grizzly bear habitat components associated with past logging practices on the Libby Ranger District, Kootenai National Forest. pp 180-184 in: G. P. Contreras and K.

Cherry, S., M.A. Haroldson, J. Robison-Cox, and C.C. Schwartz. *In review*. Estimating total human-caused mortality from reported mortality using data from grizzly bears.

Craighead, D. J. 1998. An integrated satellite technique to evaluate grizzly bear habitat use. Ursus 10:187-201

Craighead, J. J., and J. A. Mitchell. 1982. Grizzly Bear. pp 515-556 in: J. A. Chapman and G. E. Feldhamer, eds. Wild Mammals of North America. The Johns Hopkins University Press Baltimore, Maryland, USA.

Harris, R. 1986. Sustainable harvest rates for grizzly bear populations. *in* Dood, A., B. Brannon, and R. Mace eds. Final programmatic EIS: the grizzly bear in northwest Montana. Montana Department of Fish, Wildlife, and Parks, Helena, Montana.287 pp.

Herrero, S. 1985. Bear Attacks, Their Causes and Avoidance. Winchester Press.

Hillis, M. 1986. Enhancing grizzly bear habitat through timber harvesting. Pp 176-179 in: G. P. Contreras and K. E. Evans, eds. Proceedings of Grizzly Bear Habitat Symposium. U. S. D. A., Forest Service. Intermountain Research Station, Ogden, Utah, U.S.A. Utah General Technical Report Int-07.

IGBC. 2000. Draft conservation strategy for the grizzly bear in the Yellowstone Area. Interagency Grizzly Bear Committee, United States Fish and Wildlife Service, University of Montana, Missoula, Montana.

Keating, K.A., C.C. Schwartz, M.A. Haroldson, and D. Moody. *In review*. Estimating the number of females with cubs-of-the-year in the Yellowstone grizzly bear population.

Knight, R.R., B.M. Blanchard, and L.L. Eberhardt. 1988. Mortality patterns and population sinks for Yellowstone grizzly bears, 1973-1985. Wildlife Society Bulletin 16:121-125.

Mace, R. D., J. S. Waller, T.L. Manley, L. J. Lyon, and H. Zuuring. 1996. Relationships among grizzly bears, roads, and habitat in the Swan Mountains, Montana. Journal of Applied Ecology 33:367-377

McLellan, B. N., and R. D. Mace. 1985. Behavior of grizzly bears in response to roads, seismic activity, and people. Preliminary Report, Canadian Border Grizzly Project. Cranbrook, British Columbia, Canada. 53pp.

McLellan, B. N., and D. M. Shackleton. 1989. Immediate reactions of grizzly bears to human activity. Wildlife Society Bulletin. 17:269-274

Mattson, D. J., R. R. Knight, and B. M. Blanchard. 1987. The effects of developments and primary roads on grizzly bear habitat use in Yellowstone National Park, Wyoming. International Conference on Bear Research and Management. 7:259-273

Mattson, D. J., 1989. Human impacts on bear habitat use. International Conference on Bear Research and Management. 8:33-56

Mattson, D. J., B. M. Blanchard, and R. R. Knight. 1991. Food habits of Yellowstone grizzly bears, 1977-1987.Canadian Journal of Zoology. 69:1619-1629.

Merrill, T. and D. Mattson. 2000. Defining habitat suitable for grizzly bears in the Greater Yellowstone Ecosystem. Draft. IBA Conference, Jackson, Wyoming.

Mowat, D.J. and C. Strobek. 2000. Estimating population size of grizzly bears using hair capture, DNA profiling, and mark-recapture analysis. Journal of Wildlife Management 64:183-193.

Reynolds, P. E., H. V. Reynolds, and E. H. Follmann. 1983. Responses of grizzly bear to seismic surveys in northern Alaska. International Conference on Bear Research and Management. 6:169-175.

Schallenberger, A. 1977. Review of oil and gas exploration impacts on grizzly bears. International Conference on Bear Research and Management. 4:271-276.

Servheen, C., R. Knight, D. Mattson, S. Mealy, D. Strickland, J. Varley, And J. Weaver. 1986. Report to the Interagency Grizzly Bear Committee on the availability of foods for grizzly bears in the Yellowstone ecosystem. Unpublished report. 21pp.

Skinner, A. 1986. Influence of forest clearcuts on grizzly bear use of *Hedysarum* spp. Undergraduate thesis, Department of Animal Science, University of British Columbia Vancouver, British Columbia, Canada.

Woods, J.G., B.N. McLellan, D. Paetkau, M. Proctor, P. Ott, and C. Strobeck. 1996. DNA fingerprinting applied to mark-recapture bear studies. International Bear News 5:9-10.

Woods, J.G., D Paetkau, D. Lewis, B.N. McLellan, M. Proctor, C. Strobeck. 1999. Genetic tagging free ranging black and brown bears. Wildlife Society Bulletin 27:616-627.

Wyoming Game and Fish Department. 2001. Special Report, Draft Grizzly Bear Management Plan. A Summary of the public involvement process, written comments and analysis, telephone survey results, costs, conclusions and recommendations.

Zager, P., C. Jonkel, and J. Habeck. 1983. Logging and wildfire influence on grizzly bear habitat in northwestern Montana. International Conference on Bear Research and Management.

APPENDIX I

WYOMING STATE STATUTES AND WYOMING GAME AND FISH COMMISSION REGULATIONS THAT ADDRESS DAMAGE CAUSED BY TROPHY GAME.

§ Wyoming Statute 23-2-101. Fees; restrictions; nonresident application fee; nonresident licenses; verification of residency required.

(e) Resident and nonresident license applicants shall pay an application fee in an amount specified by this subsection upon submission of an application for purchase of any limited quota drawing for big or trophy game license or wild bison license. The resident application fee shall be three dollars ($3.00) and the nonresident application fee shall be ten dollars ($10.00). The application fee is in addition to the fees prescribed by subsections (f) and (j) of this section and by W.S. 23-2-107 and shall be payable to the department either directly or through an authorized selling agent of the department. At the beginning of each month, the commission shall set aside all of the fees collected during calendar year 1980 and not to exceed twenty-five percent (25%) of the fess collected thereafter pursuant to this subsection to establish and maintain a working balance of five hundred thousand dollars ($500,000), to compensate owners or lessees of the property damaged by game animals and game birds.

§ Wyoming Statute 23-1-901: Damage Caused by Game Animals or Game Birds.

1.1.1   Article 9 – Damage Caused by Game Animals or Game Birds

23-1-901. Owner of damaged property to report damage; claims for damages; time for filing; determination; appeal; arbitration.

(a) Any landowner, lessee or agent whose property is being damaged by any of the big or trophy game animals or game birds of this state shall, not later than fifteen (15) days after the damage is discovered by the owner of the property or the representative of the owner, report the damage to the nearest game warden, damage control warden, supervisor or commission member.

(b) Any landowner, lessee or agent claiming damages from the state for injury or destruction of property by big or trophy game animals or game birds of this state shall present a verified claim for the damages to the Wyoming game and fish department not later than sixty (60) days after the damage or last item of damage is discovered. The claim shall specify the damage and amount claimed. As used in this subsection, "verified claim" means a claim which the claimant has signed and sworn to be accurate before a person authorized to administer oaths.

(c) The department shall consider the claims based upon a description of the livestock or bees damaged or killed by a trophy game animal, the damaged land, growing cultivated crops, stored crops including honey and hives, seed crops, improvements and extraordinary damage to grass. Claims shall be investigated by the department and rejected or allowed within ninety (90) days after submission, and paid in the amount determined to be due. In the event the department fails to act within ninety (90) days, the claim, including interest based on local bank preferred rates, shall be deemed to have been allowed. No award shall be allowed to any landowner who has not permitted hunting on his property during authorized hunting seasons. Any person failing to comply with any provision of this section is barred from making any claim against the department for damages. Any claimant aggrieved by the decision of the department may appeal to the commission within thirty (30) days after receipt of the decision of the department as provided by rules of practice and procedure promulgated by the commission. The commission shall review the department decision at its next meeting following receipt of notice of request for review. The commission shall review the investigative report of the department, and it may approve, modify or reverse the decision of the department.

(d) Within ninety (90) days after receiving notice of the decision of the commission, the claimant may in writing to the department call for arbitration. Within fifteen (15) days after the department receives the call for arbitration, the claimant and the department shall each appoint a disinterested arbitrator who is an elector residing in the county where the damage occurred and notify each other of the appointment. Within twenty (20) days after their appointment, the two (2) arbitrators shall appoint a third arbitrator possessing the same qualifications. If the third arbitrator is not appointed within the time prescribed, the judge of the district court of the county or the court commissioner in the absence of the judge shall appoint the third arbitrator upon the application of either arbitrator.

(e) At least twenty (20) days before the hearing, the board of arbitrators shall provide the claimant and department notice of the time and place in the county when and where the parties will be heard and the claim investigated and decided by the board. A written copy of the decision shall be promptly served upon each party. Within ten (10) days after receipt of the decision, either party may apply to the board for modification of the decision under W.S. 1-36-111. Either party may apply to the district court for vacation of a decision under W.S. 1-36-114(a) or correction or modification of a decision under W.S. 1-36-115 within thirty (30) days after receipt of the decision or within twenty (20) days after action by the board on an application for modification under W.S. 1-36-111.

(f) If no applications under subsection (e) of this section are made after receipt of the decision, the commission shall promptly pay the amount, if any, including interest based on local bank preferred rates, awarded by the board. Within thirty (30) days after the award is final, the Board's reasonable service and expense charges shall be paid by:

(i) The claimant if the award is no greater than the amount originally authorized by the commission;
(ii) Otherwise, the commission.

Wyoming Game and Fish Commission Chapter XXVIII Regulation governing Big and Trophy Game Animals or Game Bird Damage

Section 1. Authority. This regulation is promulgated by authority of W.S. 23-1-302.

Section 2. Regulations and Effective Date. The Wyoming Game and Fish Commission hereby adopts the following regulation governing damage claims, filed in accordance with W.S. 23-1-901.
Section 3. Definitions. For the purpose of this regulation, definitions will be as set forth in Title 23, Wyoming Statutes, and the Commission also adopts the following definitions:

(a) "Office of the Department" means Wyoming Game and Fish Department, 5400 Bishop Blvd, Cheyenne, Wyoming 82002.

(b) "Office of the Commission" means Wyoming Game and Fish Commission, 5400 Bishop Boulevard, Cheyenne, Wyoming 82002.
(c) "Damage" as used in W.S. 23-1-901 means actual damage as proved to have occurred by the claimant, to livestock, land, crops, improvements and extraordinary grass damage, and shall not include any amount for punitive damages under any circumstances.

(d) "Extraordinary Damage to Grass" as used in W.S. 23-1-901(c) means the consumption or use of non-cultivated grass plants in excess of the consumption or use which normally occurred during the two years immediately preceding the time period covered by the damage claim.

(e) "Permitted Hunting" as used in W.S. 23-1-901(c) means the claimant operated in such a manner as to allow or provide for hunting on his land and access to adjoining land to allow for a harvest sufficient to meet the objectives for the area and herd.

(f) "Disinterested Arbitrator" shall mean any person, otherwise qualified, who is capable of making a reasoned and unbiased decision on evidence presented by both parties to the Arbitration Board.

(g) "Hearing" as used in W.S. 23-1-901(e) shall mean a procedurally correct arbitration hearing which shall be conducted in such a manner as to afford both parties to present, examine and cross-examine all witnesses and other forms of evidence received by the arbitrators. The decision of the arbitrators shall become a part of the agency file and shall be considered co-evidence in the event of an appeal of the arbitrators' decision and any appeal there from to district court shall be conducted in conformity with the Wyoming Administrative Procedure Act.

(h) "Investigated by the Department" as used in W.S. 23-1-901(c) means a reasonable inspection of the damaged premises, crops or livestock as deemed adequate by the Department to evaluate and to report to the Commission the extent of damage incurred. Failure of the claimant to allow such reasonable inspection, upon request, shall constitute a bar to making claim as specified under W.S. 23-1-901(c).

(i) "Reasonable Service Charges" as used in W.S. 21-1-901(f) means fifty dollars ($50.00) per day while performing duties as an arbitrator.

(j) "Reasonable Expense Charges" as used in W.S. 23-1-901(f) means actual expenses incurred by the arbitrators for telephone calls, paper supplies, mail service, meeting rooms, plus per diem allowance and transportation expenses as allowed state employees by Wyoming Statutes.

Section 4. Verified Claim Requirements. The verified claim required by W.S. 23-1-901(b) shall be submitted on the form prescribed by the Department designated as "Damage Claim Affidavit." The claim shall set forth a legal description of damaged land, a description of the property damaged, the dates during which damage occurred, the type and number of big or trophy game animals or game birds which caused the damage, when the damage was discovered, to whom the damage was reported and the manner and date reported, whether or not the claimant permitted hunting during the most recent authorized hunting season for the species causing damages. Additional supporting information may be submitted and will be considered as part of the verified claim. Amended damage claims may be filed with the office of the Department in the even that all information is not immediately known by claimant. In any event, the entire claim must be submitted in writing to the office of the Department within 60 days of the last item of damage.

Section 5. Arbitration Notification Procedure. During the process of establishing an arbitration board to act upon a damage claim, written notification will be made from the claimant to the office of the Department and from the Department to the claimant regarding the names and mailing addresses of arbitrators selected by them. The two arbitrators selected shall notify in writing both the claimant and the office of the Department of the name and address of the third arbitrator selected.

Section 6. Savings Clause. If any provision of this rule or its application to any person or circumstance is held invalid or in conflict with any other provision of this rule, the invalidity shall not affect other provisions or application of this rule which can be given effect without the invalid provision or applications and to this end the provisions of this rule are severable.

APPENDIX II

DEFINITIONS OF TERMS USED IN NUISANCE
GRIZZLY BEAR MANAGEMENT

Aversive Conditioning: The application of techniques that are intended to change a bear's behavior.

Capture: Any action to catch a bear for management purposes.

Deterrence: The application of techniques that are designed to discourage a bear from causing further damage or inhabiting undesirable areas.

Depredation: Damage to any property including agricultural products.

Food Conditioned: A grizzly bear that has received a significant reward of non-natural foods such as garbage, camp food, pet food, or processed livestock food and persistently seeks those foods.

Habituated: When a grizzly bear does not display avoidance behavior around humans or in human use areas such as camps, residential areas, or along roads.

Natural Aggression: Defense of young or food, surprise encounter, or self-defense.

No Action: When the circumstances of the conflict do not warrant control or the opportunity for control is low resulting in no initiation of control actions.

Nuisance Grizzly Bear: A grizzly bear that depredates livestock, causes property damage, or uses unnatural food that has been reasonably secured from the grizzly bear; or, a grizzly bear that displays unnatural aggression toward humans or that constitutes a demonstrable immediate, or potential threat to human safety.

Property Damage: Damage to any property including agricultural products.

Protection: The application of any device or technique to protect property from bear damage.

Relocation: The capture and movement of a grizzly bear involved in a conflict with humans or their property by management authorities to a remote area away from the conflict site.

Removal: The capture and placement of a grizzly bear in an authorized public zoological or research facility or destruction of the grizzly bear. Removal can also involve lethal removal of a grizzly bear through active measures in the wild when it is not otherwise possible to capture the grizzly bear.

Unnatural Aggression: Grizzly bear behavior that includes approaching humans or human use areas, such as camps, in an aggressive way, predation on humans, or aggressive behavior when the grizzly bear is unprovoked by self-defense, defense of cubs, defense of foods, or in a close encounter.

Unnatural Foods: Includes, but is not limited to human, pet and livestock foods, garbage, gardens, livestock carrion, and game meat in possession of man.

APPENDIX III

NUISANCE GRIZZLY BEAR GUIDELINES FOR THE PRIMARY CONSERVATION AREA FROM THE DRAFT CONSERVATION STRATEGY

Introduction

Since the beginning of time, humans and grizzlies have occasionally come into conflict in areas were they live in close proximity to one another. As few as 10, and as many as 160 grizzly bear-human conflicts per year have been reported in the Greater Yellowstone Ecosystem during the most recent thirteen years (1986-1998).

The objective of management is to minimize human-bear conflicts. Management is essential to successful grizzly conservation, and is often necessary to prevent property damage, livestock losses, and human injury or death. Grizzly bears cannot be totally protected. They develop individual traits, like other species, and some of those traits are not acceptable. Management emphasis is to shift from protecting every individual in the population to assessing an individual's importance to the entire population prior to instituting management actions. Females are to continue to receive a higher level of protection than males. Management of nuisance bears requires rapid response by agencies to address situations of bear-human conflict. This agency response is to address the sources of the conflict through public education, removal of attractants, or preventative sanitation of human use areas. Agencies are to also capture, relocate, or destroy repeat offender grizzly bears when necessary and when other options have been exhausted.

Analysis of human-bear incidents indicate that most property damage incidents are the result of bears attempting to gain access to garbage, human foods, livestock or pet foods, or other human-related foods in areas of human presence. Livestock losses to grizzlies occur primarily on USFS allotments, summer ranges of cattle and sheep, although occasionally they will take livestock close to human dwellings. Occasionally bears will prey on domestic swine, fowl, and goats or will damage apiaries. They have rarely injured horses.

Although aggression towards people and human injury or death is rare, bears will occasionally harm people. Incidents of injury are usually a result of a surprise encounter, protection of cubs, defense of a food cache, harassment or when bears have become accustomed to obtaining food from humans.

Management of nuisance bears usually falls into one or more of the following categories:

1) Removing or securing the attractant;

2) Deterring the bear from the site through the use of aversive conditioning techniques;

3) Capturing and relocating the nuisance bear;

4) Removal of the bear from the wild.

Management Zones

Nuisance grizzly bears in the Yellowstone Ecosystem Area are to be managed according to whether they are inside or outside the Primary Conservation Area (PCA). The purpose of this system is to provide increased security for grizzly bears inside the PCA. Bears are to be given greater consideration in most bear-human conflicts inside the PCA. The PCA is comprised primarily of public lands managed as National Parks (YNP & GTNP), USFS wilderness areas and USFS multiple use public lands, which are essential for continued survival of the bear in the GYE Yellowstone Area. The PCA is the current grizzly bear recovery zone, and includes all lands currently managed as the recovery zone. Minimization of bear-human conflicts and management of individual nuisance bears is the primary direction within the PCA.

Outside the PCA more consideration is to be given to existing human uses in circumstances that result in a nuisance bear situation. Site-specific conflict areas within and outside the PCA are to routinely be documented and prioritized to focus pro-active management actions in order to minimize bear-human conflicts and address potential activities that may cause future conflicts.

Management Guidelines

The focus and intent of nuisance grizzly bear management inside and outside the PCA is to be predicated on strategies and actions to prevent bear-human conflicts. It is recognized that active management aimed at individual nuisance bears will occasionally be required in both areas. Management actions outside the PCA are to be implemented according to state management plans, such as Wyoming Game and Fish Department's "Criteria for Nuisance Grizzly Bear Determination and Control". These actions are to be compatible with the grizzly bear population management objectives for each state for the areas outside the PCA.

Within the PCA, management of nuisance bears is to be addressed according to the following definitions and criteria:

Definitions

Unnatural aggression by a grizzly bear is defined as behavior that includes active predation on humans, approaching humans in an aggressive way, or aggressive behavior when the bear is unprovoked by self-defense, defense of cubs, defense of foods, or in a surprise encounter.

Natural aggression by a grizzly bear is defined as defense of young, food, during a surprise encounter, or self-defense.

A bear is classified as "food conditioned" when it has received a significant food reward of human foods such as garbage, camp food, pet food, or processed livestock food.

A habituated bear is a bear that does not display avoidance behavior around humans or in human use areas such as camps or town sites or within 100 meters of open roads. Relocation is the capture and movement by management authorities of a bear involved in a conflict with humans or human-related foods to a remote area away from the conflict site, usually after fitting the bear with a radio-collar.

Repeat offense is the involvement of a bear that has been previously relocated or, if not relocated, continues to repeat a behavior that constitutes a bear-human conflict.

Removal is the capture and placement of a bear in an authorized public zoological or research facility or destruction of that bear. Removal can also involve killing the bear through active measures in the wild when it is not otherwise possible to capture the bear.

Management authorities are the designated representatives of the agencies in the PCA including Yellowstone National Park, Grand Teton National Park, Wyoming Game & Fish Dept., Montana Fish Wildlife & Parks, Idaho Fish & Game, Interagency Grizzly Bear Study Team, each of the National Forests - Gallatin, Custer, Shoshone, Bridger-Teton, Targhee, and Beaverhead, and the U.S. Fish and Wildlife Service Grizzly Bear Recovery Coordinator, as requested. These authorities are to make the decision to classify a bear as "nuisance" inside the PCA in compliance with the nuisance bear criteria. Subsequent management actions are to be coordinated and completed by state wildlife agencies, after discussing with the appropriate land management agency, outside YNP within the PCA. Because of existing Memorandums of Understanding between the WGFD and GTNP that will be continued under this Conservation Strategy, nuisance bear management are to be coordinated between those two agencies. When nuisance bears are in YNP, decisions are to be made by the park representatives with coordination with state and forest representatives.

Criteria for Nuisance Grizzly Bear Determination and Control Inside the PCA

Grizzly bears displaying unnatural aggression are to be removed from the population.

Bears displaying natural aggression are to not be removed, even if the aggression results in human injury or death, unless it is the judgment of management authorities that the particular circumstances require removal.

Bears displaying food conditioning and or habituation may be either relocated or removed based on specific details of the incident. This judgment is to be made by management authorities after considering the cause, location and severity of the incident.

Bears may be relocated as many times as judged prudent by management authorities. No bear may be removed for any offense, other than unnatural aggression, without at least one relocation unless the reason is documented in writing by representatives of affected agencies.

Bears preying on lawfully present livestock (cows, horses, goats, lamas, etc.) on public lands are to be managed according the following criteria:

1. No male grizzly bear involved in livestock depredations inside the PCA shall be removed unless it has been relocated at least one time and has been found to return and continue livestock depredations.

2. No females involved in livestock depredations inside the PCA shall be removed, even after relocation and subsequent continued depredation on livestock. The only exception to this could be in the case of animals considered dangerous to human safety through their behavior and use of cattle grazing areas where humans are present.

Management of all nuisance bear situations is to emphasize removal of the human cause of the conflict or management and education actions to limit such conflicts. Relocation and removal of grizzly bears may occur if the above actions are not successful.

Prior to any removal, except in cases of human safety, involved management authorities are to consult by phone or in person to judge the adequacy of the reason for removal and the current level of human-caused mortality so as to avoid exceeding mortality limits through such removals.

The basis for decisions on relocation and removal inside the PCA are to be criteria for management of nuisance bears in the Conservation Strategy and best biological judgment of authorities.

Removals inside the PCA are to be done by authorized state authorities outside of YNP. Removals within GTNP may be conducted by GTNP or WGFD. Removals inside YNP are to be done by authorized National Park Service authorities.

Authorities are to cooperate to provide adequate and available sites for relocations.

General criteria: Location, cause of incident, severity of incident, history of bear, health/age/sex of bear, and demographic characteristics of animals involved will all be considered in any relocation or removal. Removal of nuisance bears is to be conservative and consistent with mortality limits outlined for the population in the PCA in the Conservation Strategy. Recognizing that conservation of female bears is essential to maintenance of a grizzly population, removal of nuisance females is to be minimized. Management actions are to be carried out only with conservation of the grizzly bear population in mind, and consistent with state regulations, policy, and state and federal laws.

Specific criteria for removals: Captured grizzly bears identified for removal may be given to public research institutions or public zoological parks for appropriate non-release educational or scientific purposes as per regulations of states and National Parks. Grizzly bears not suitable for release, research, or educational purposes are to be removed as described in appropriate state management plans or incompliance with National Park rules and regulations.

Individual nuisance bears deemed appropriate for removal may be taken by a sport hunter outside of National Parks in compliance with rules and regulations promulgated by the appropriate state wildlife agency commission, as long as such taking is in compliance with existing state and federal laws, and as long as mortality limits in the Conservation Strategy are not exceeded.

All grizzly bear relocations and removals are to be documented and reported annually by the IGBMTIGBST. Such actions may be subject to the Management Review process if requested by a member of the Management Committee.

Management of nuisance bears outside the PCA is to be the sole responsibility of appropriate state wildlife agencies and is not to be regulated by the Conservation Strategy.

Appendix K. Yellowstone Grizzly Bear Management Plan (State of Idaho)

State of Idaho

Yellowstone Grizzly Bear Management Plan

to accompany HCR 62

Prepared by:
Idaho's Yellowstone Grizzly Bear
Delisting Advisory Team

As Modified by:
House Resource and
Conservation Committee
on March 13, 2002

March 2002

Table of Contents

ACKNOWLEDGMENTS

Idaho's Yellowstone Grizzly Bear Delisting Advisory Team is composed of individuals from Idaho, representing a wide variety of interests. Their primary goal was to develop recommendations for management of grizzly bears in Eastern Idaho that consider all the varied landscapes, people, current land uses, culture, grizzly bear ecology, and legal requirements once the population was removed from protection under the Endangered Species Act. Without dedication of the members and willingness to work together, this project would likely not have succeeded. Members of the Delisting Advisory Team (DAT) include:

Mark Orme, Team Leader, Idaho Falls
Dan Christopherson, Fort Hall
Brent Ferguson, Ririe
Marv Hoyt, Idaho Falls
Gerald Jeppesen, Rexburg
Delane Kritsky, Pocatello
Bruce Mincher, Idaho Falls
Jim Peek, Viola
Cindy Siddoway, Terreton
Jim Gerber, Alternate, St. Anthony
Kent Marlor, Alternate, Rexburg
Brent Robson, Alternate, Tetonia

The Delisting Advisory Team was provided logistical and technical support by a number of agency personnel representing the Governor's Office of Species Conservation (OSC), Idaho Dept. of Fish and Game (IDFG), and the U.S. Fish and Wildlife Service (USFWS) including:

Jim Caswell, OSC, Boise
Steve Huffaker, IDFG, Boise
Roger Fuhrman, IDFG, Boise
Bob Saban, IDFG, Idaho Falls
Brad Compton, IDFG, Idaho Falls
Lauri Hanauska-Brown, IDFG, Idaho Falls
Gregg Losinski, IDFG, Idaho Falls
Tanya Richardson, IDFG, Idaho Falls
Larry Dickerson, USFWS, Chubbuck

Facilitator Pat Entwistle, Horseshoe Bend, provided the necessary guidance and encouragement for the Delisting Advisory Team to move forward and complete its assignment in a timely fashion.

Disclaimer:

This plan was modified by the 56th Idaho Legislature, Second Regular Session. As a result of these amendments, certain members of the DAT may no longer support the management direction contained in this plan.

INTRODUCTION

The recommendations included within this document are only applicable to the grizzly bear population associated with Yellowstone National Park and surrounding areas. No recommendations are presented for the Selkirk, Cabinet-Yaak, or Selway-Bitterroot recovery areas. Furthermore, it is the policy of this management plan that no grizzly bears from the Yellowstone population be translocated to unoccupied range within Idaho.

Background

In the lower 48 states, grizzly bears were eliminated from 98% of their historic range during a 100-year period (Mattson et al. 1995). The 1920s and 1930s drove grizzlies to extinction throughout much of their range. Of 37 bear populations present in 1922, 31 were eliminated by 1975 (Servheen 1999). Currently there are five recognized grizzly bear populations in portions of Wyoming, Montana, Idaho, and Washington. Three of these populations contain fewer than 35 individuals.

The Yellowstone population, residing in portions of Idaho, Montana, and Wyoming currently contains an estimated 400-600 individuals. The grizzly bear was listed as "Threatened" under the Endangered Species Act in 1975, with primary management under the direction of the US Fish and Wildlife Service (USFWS). After delisting, the states would assume the primary management role within their respective state boundaries.

Currently, Idaho classifies grizzly bears as a Threatened species, making it illegal to take or possess grizzly bears except under certain circumstances, including scientific research, propagation, to stop damage to property and water rights and other specific circumstances outlined in 36-106(e)5 and 36-1107, Idaho Code. (Appendix I). In addition, the following Idaho State Statutes apply to management of all fish and wildlife species, including threatened species:

> 36-103 (a). Wildlife property of State – Preservation – Wildlife Policy. All wildlife, including all wild animals, wild birds, and fish, within the State of Idaho, is hereby declared to be the property of the State of Idaho. It shall be preserved, protected, perpetuated, and managed. It shall only be captured or taken at such times or places, under such condition, or by such means, or in such manner, as will preserve, protect, and perpetuate such wildlife, and provide for the citizens for the State and, as by law permitted to others, continuous supplies of such wildlife for hunting, fishing and trapping.

> (b). Commission to Administer Policy. Authority, power and duty of the Fish and Game Commission to administer and carry out the provisions of the Idaho Fish and Game Code. The commission is not authorized to change the state's wildlife policy but only to administer it.

> 36-201. Fish and Game Commission authorized to classify wildlife. With the exception of predatory animals, the Idaho Fish and Game Commission is hereby authorized to define by classification or reclassification all wildlife in the State of Idaho. Animals currently classified as 'predatory' include coyote, jackrabbit, skunk, weasel, and starling.

The Grizzly Bear Recovery Plan (USFWS 1993) identifies specific criteria that must be accomplished prior to a change in status for the grizzly bear. Along with specific population criteria that have been met; habitat based recovery criteria, only within the Primary Conservation Area (PCA), would be developed and a Conservation Strategy would be prepared. Amendments to the Recovery Plan and the Draft Conservation Strategy (USFWS 2000) were submitted to the public for review in the spring of 2000. The habitat based recovery criteria will be finalized and

appended to the Recovery Plan. The Conservation Strategy will be a cooperative management plan that describes agency interactions, regulatory mechanisms, population management, population monitoring, habitat monitoring, and habitat management that will be in effect after delisting. The Draft Conservation Strategy currently applies to the existing Recovery Zone (named the Primary Conservation Area in the Draft Conservation Strategy) and a 10-mile buffer. The final Conservation Strategy will have two primary roles. First, it will describe and summarize the coordinated efforts to manage the grizzly bear population and its habitat, and the public education/involvement efforts that will be applied to ensure continued conservation of the grizzly bear in the greater Yellowstone area. Secondly, it will document the regulatory mechanisms that exist to maintain the Yellowstone population as recovered through the legal authorities, policy, guidelines, management programs, monitoring programs, and the commitment of participating agencies. While the Conservation Strategy is in effect, there will be goals for population size and habitat status. If these goals are not met, the grizzly bear could be relisted.

Upon delisting, the Idaho Fish & Game Commission will have ultimate authority and obligation for managing grizzly bears within Idaho. Management of the population outside the PCA will be directed by state management plans, as approved by the Idaho Legislature, under the guidance of Idaho Dept. of Fish and Game, while management of the grizzly bear population within the PCA will be guided by the Conservation Strategy.

The Yellowstone Ecosystem Subcommittee (YES) of the Interagency Grizzly Bear Committee (IGBC) produced the "Draft Conservation Strategy for the Grizzly Bear in the Yellowstone Area." The governors of Idaho, Wyoming, and Montana appointed a 15-member citizen roundtable to review the strategy. This Governors' Roundtable identified and reached consensus on a number of issues and provided a series of recommendations. The Governors ultimately endorsed the following recommendations:

1. A Primary Conservation Area (PCA) should be designated and managed conservatively to protect a core of secure habitat and grizzly bear numbers. They endorsed the current size and management guidelines for the PCA.
2. Agencies should establish a joint agency-citizen education committee to promote better understanding and awareness of grizzly bear conservation needs. Key messages should include realistic information on grizzly bear management, living with grizzly bears, and hunting in grizzly bear country without encountering problems.
3. The Yellowstone Grizzly Management Committee (currently YES) should be expanded to include three (3) non-voting members from each state, appointed by the governors, to add citizen perspectives to management.
4. In the short term, states should continue funding essential grizzly bear recovery efforts. In the long term, better funding mechanisms are needed to distribute the cost equitably among interests that support grizzly bear conservation. The governors and congressional delegations from Idaho, Montana, and Wyoming should pursue additional federal funding.
5. State management plans for areas outside the PCA should be developed concurrently with the revision of the Draft Conservation Strategy and should seek to:
   a. Ensure the long-term viability of grizzly bears and preclude relisting.

b. Support expansion of grizzly bears beyond the PCA, into areas that are biologically suitable and socially acceptable.
c. Manage grizzly bears as a game animal, including allowing regulated hunting when and where appropriate.

Recommendation #5 initiated the development of a state plan. The section of Idaho Code that created the Office of Species Conservation authorizes a procedure to be followed in development of state management plans for Threatened and Endangered species (Appendix II).

Based on the procedure, Delisting Advisory Team members were selected in July 2001. Eight management planning meetings were held and attended by Delisting Advisory Team members, representatives of IDFG, U.S. Fish and Wildlife Service, Office of Species Conservation, regional experts on grizzly bear biology, and members of the public. Public comment was accepted throughout the plan's development. Public opinions and ideas were considered by the team and included in the plan where appropriate.

Plan Development & Scope

This document provides the recommended components of grizzly bear management in Eastern Idaho, as developed by the Delisting Advisory Team. Upon review by the Director of the Idaho Dept. Fish and Game, Fish and Game Commission, and the Idaho legislature, these recommendations will be approved and adopted as the management plan for grizzly bears in Eastern Idaho. The primary reason for most management efforts is to ensure long-term annual benefits from the wildlife resource to the human population. Such management efforts also benefit wildlife populations. A variety of "products" are provided by healthy wildlife populations, including tangibles such as harvest, watchable wildlife, scientific values, and recreational economic benefits, and intangibles such as social and cultural values. Wildlife is held in public trust for the people of Idaho, who ultimately decide which mix of products is most desirable.

Throughout this document the team has attempted to consider the interests of all Idahoans, as well as the needs of the grizzly bear, within biological, economic, social, and staffing constraints. If problems exist which are impossible to correct, it is important for the Department, in consultation with affected stakeholders, to re-evaluate and adjust management direction.

Upon review, final approval, and implementation of the recommendations contained within this document, it is recommended that a termination date not be established. Future management must be adaptive and responsive over time. As new data and knowledge of various biological and sociological factors are attained, management programs and frameworks will be adjusted and monitored as to their effect. An integral component to adaptive management is input and involvement by all affected stakeholders. The Department will work diligently toward informing and involving all publics interested in management of the grizzly bear.
Overall, the goal of the recommendations is to allow for the compatible co-existence of grizzly bears and humans in Eastern Idaho grizzly bear habitat. Management programs and frameworks must be adaptive and responsive in order to serve Idaho's citizens as well as grizzly bears.

Figure 1. Primary Conservation Area and Distribution of Grizzly Bear in Eastern Idaho (1965 - 2000).

Legend
- Verified Grizzly Bear Sighting
- Unverified Grizzly Bear Sighting
- Road
- Primary Conservation Area (PCA) Boundary
- State Boundary
- National Forest
- BLM
- State Land
- National Park
- Other Federal Land
- Private Land
- Water

Scale 1:1,100,693

Source:
Caribou - Targhee National Forest
Intermountain Region
USDA Forest Service

11/5/01

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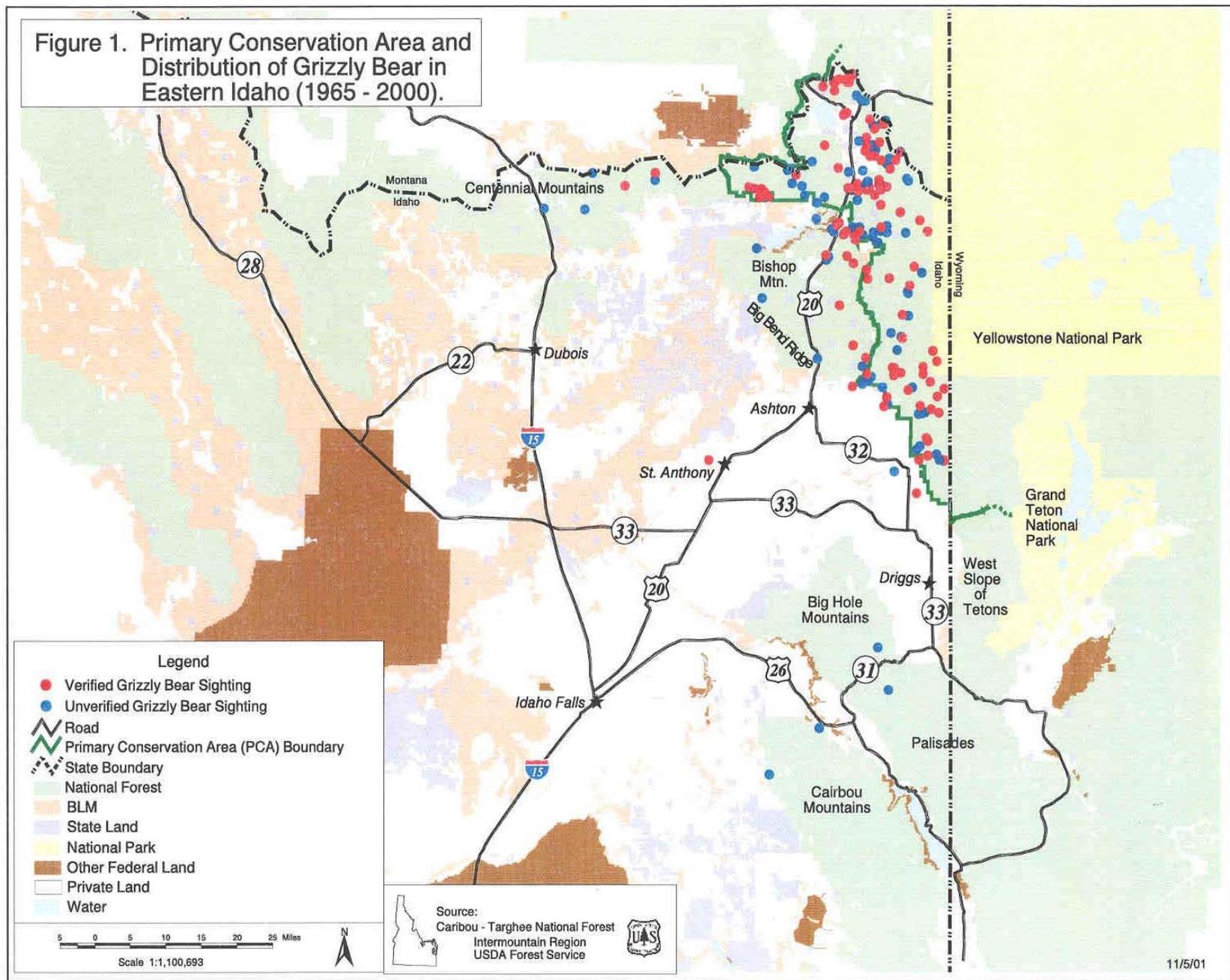
Grizzly Bear Ecology

The grizzly bear is an opportunistic omnivore that readily adapts to a wide range of habitats. Historically, suitable bear habitat existed throughout North America, but current distribution is restricted to Alaska, Canada, and four (4) western states (Miller and Schoen 1999, McLellan and Banci 1999, Servheen 1999). In Idaho, grizzly bears currently occupy the Greater Yellowstone Ecosystem (GYE, Fig. 1), Selkirk Ecosystem, and Cabinet/Yaak Ecosystem. Grizzly bears historically occupied the Bitterroot Mountains of central Idaho, but no evidence supports current occupation of the area (Melquist 1985, Groves 1987, Servheen et al. 1990, Kunkel et al. 1991). Servheen (1999) completed a review of grizzly bear distribution in the lower 48 states.

Grizzly bear home ranges within the GYE are larger than those reported for other grizzly bear populations. Larger home ranges can indicate low environmental productivity and increased foraging requirements to meet bear nutritional needs. From 1975-1987, the Interagency Grizzly Bear Study Team reported mean home range sizes of 874 km^2 for adult males and 281 km^2 for adult females in the GYE. Females with new cubs used slightly less area, and those with yearlings used more. Subadult males disperse from their natal ranges to establish new home ranges, and these spatial requirements probably limit ultimate population density.

Within the GYE, a variety of foods are available to the grizzly bear; however, seasonal variation, weather, and human disturbance can influence the bear diet. To a large degree, abundance of high-quality foods dictates body size, reproductive rates, and population density. Animal matter is arguably one of the most valuable bear foods (Welch et al. 1997, Hilderbrand et al. 1999). Bears are most successful feeding on animals that are abundant and vulnerable to their predatory skills. For some interior populations, trout may provide a high-quality seasonal food. In the GYE, it is estimated that 30-50 grizzly bears forage annually on spawning cutthroat trout (*Oncorhynchus clarki*) in tributary streams of Yellowstone Lake (Reinhard and Mattson 1990). During the spring, grizzly bear use of ungulates, both scavenged and as neonate prey, is extensive (Gunther and Renkin 1990, French and French 1990, Green 1994). The annual percentage of energy obtained from ungulate meat is considerably higher in GYE than for other interior populations (Hilderbrand et al. 1999).

Use of ungulates abates during summer as bears use habitats that supply a variety of graminoids, forbs, and root crops (Mattson et al. 1991a). Yellowstone lacks significant berry-producing habitats. Consequently, bears use high-elevation sites to feed on whitebark pine (*Pinus albicaulis*) nuts (Blanchard and Knight 1991, Mattson et al. 1991a). Pine nuts are high in fat and one of the most energy-rich foods consumed by bears. When abundant, bears use pine nuts to the exclusion of most other foods. Throughout much of its range, however, whitebark pine has been severely impacted by an exotic fungus, white pine blister rust (*Cronartium ribicola*). The rust is present and spreading in the Yellowstone area (Smith and Hoffman 1998).

Army cutworm moths (*Euxoa auxiliaris*) are also valuable seasonal foods (Klaver et al. 1986, Mattson et al. 1991b, White 1996), as they are high in lipid and calorie content (Kevan and Kendall 1997, White et al. 1999). Studies from Glacier National Park (White et al. 1999) indicate that a foraging bear can consume as many as 40,000 moths/day.

During failure of key natural food items, the search for alternative foods often results in an increase in the number of bear-human conflicts and an increase in human-caused bear mortality

(Blanchard 1990, Riley et al. 1994, Blanchard and Knight 1995). Additionally, development (e.g., summer homes, resorts, campgrounds) may result in a loss of habitat, while the attraction to these sites from poor sanitation practices may result in increased human conflict and bear mortality.

Causes of mortality in grizzly bears include natural death, illegal killing, defense of life or property killings, management actions, accidents, and unknown. Human-caused mortality is the primary cause of grizzly bear deaths (Fig. 2, Schwartz et al. in press), with the majority of deaths occurring near human facilities and access routes (Knight et al. 1988). Research has shown that grizzly bears avoid areas with high open road densities (Lloyd and Fleck 1977, Schallenberger and Jonkel 1980, Brannon 1984, Aune and Kasworm 1989). No human-caused bear mortalities have been documented in the past 17 years in Idaho. Recreational developments and various other human concentration areas can increase mortality rates of grizzly bears. Additionally, diverse attractants such as apple orchards, outfitter camps, and locations where people have persistently fed individual bears or unlawfully disposed of garbage have enticed bears into conflict situations, especially during periods of natural food shortage. The primary situations that result in human/grizzly conflict are: 1) food related – improper food storage or sanitation in either a backcountry, rural, or urban setting; 2) surprise encounters (e.g., sow defending cubs, bear defending a kill/carcass, bears surprised in close quarters and acting defensively); 3) human encroaching on a bear's space (e.g., photographer or tourist approaching a bear close enough to precipitate a defensive reaction; and 4) bears responding to a noise attractant (e.g., bear attracted to a hunter attempting to bugle or cow-call an elk, bears associating gunshots with a food source [carcass or gut pile]).

Figure 2. Causes of mortality in grizzly bears from unhunted populations in northwestern Montana and the Greater Yellowstone Ecosystem, 1975 – 1985 (Schwartz et al. in press).
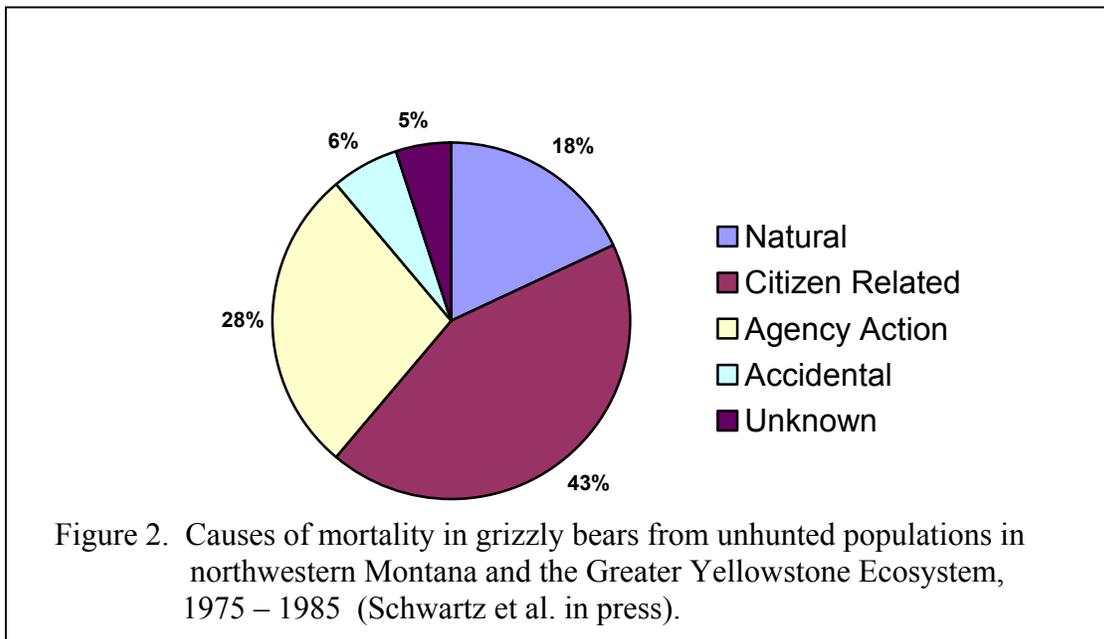
In hunted populations, harvest tends to be greater in areas with access (Miller 1990a). Hunting impacts population composition in different ways, and regulations can impact the composition of harvests (Miller 1990b, Van Daele et al. 1990). Because bears are promiscuous, regulations that direct harvests toward males and away from adult females permit higher hunter quotas (Taylor et

al. 1987). Not all bear deaths are detected and recorded. Miller (1990a) indicated that unreported sport or nuisance kills and wounding losses could represent significant sources of mortality that managers should consider.

Sustainable grizzly bear mortality levels are derived from estimates of population size and reproduction data (Miller 1990b). Because grizzly bears can sustain only very low mortality rates (a maximum of 5.7% was estimated by Miller [1990b]), most managers adopt conservative regulations to avoid overharvest.

Grizzly bears have a low reproductive rate relative to other mammals, a trait that critically impacts the species' survival in the presence of humans (Pasitschniak-Arts 1993, Craighead et al. 1995). The age of first litter production is dependent on maturation and body size (Blanchard 1987, Stringham 1990), which is positively related to diet quality (Hilderbrand et al. 1999). Mean age of first litter production from a sample of 15 females observed in Yellowstone National Park was 5.9 years (range = 5 – 9; Craighead et al. 1995). Cub litter size varies among individuals and populations but on average ranges between 1 and 3 young. Mean litter size has been correlated with adult female body mass; intake of dietary meat, primarily salmon and ungulates (Bunnell and Tait 1981, Stringham 1990, McLellan 1994, Hilderbrand et al. 1999); garbage (Stringham 1986); latitude (Bunnell and Tait 1981, Stringham 1984); climate; and a climate-carrion index (Picton 1978, Picton and Knight 1986). Litter size is also related to age, with young and old females producing fewer cubs per litter than prime-age adults (Craighead et al. 1974, 1995; Sellers and Aumiller 1994). The proportion of cubs in any population is a reflection of reproductive performance and early mortality and should be higher for more fecund populations. Although sex ratio at birth can favor males (Craighead et al. 1974; Craighead and Mitchell 1982; Knight and Eberhardt 1985, 1987), males generally have a lower rate of survival. The overall sex ratio in bear populations tends to be skewed towards females.

Agency Responsibilities

Idaho Dept. of Fish and Game (IDFG), under the direction of the Idaho Fish and Game Commission, will be the primary agency responsible for management of Yellowstone grizzly bears in Idaho. The Department, upon approval of the Idaho Legislature, will implement management actions within the financial, staffing, and legal limits that exist. Given that the grizzly bear population within the PCA includes parts of Idaho, Wyoming, Montana, Yellowstone National Park, and Grand Teton National Park jurisdictions, a highly coordinated and cooperative management effort among the management agencies will be necessary.

After delisting of the Yellowstone grizzly bear, the existing Yellowstone Ecosystem Subcommittee of the Interagency Grizzly Bear Committee will be renamed and operate as the management body responsible for coordination, implementation and evaluation of grizzly bear conservation within the Primary Conservation Area as specified in the Conservation Strategy. This group will continue as the 'Yellowstone Grizzly Bear Management Committee' and be responsible for:
1. Implementing the Conservation Strategy.
2. Ensuring that population and habitat data specified in the Conservation Strategy are collected and evaluated annually to monitor the current status of the grizzly bear population.
3. Sharing information and implementing management actions in a coordinated fashion.

4. Proposing management policy changes as necessary.
5. Establishing necessary task forces to implement management reviews and approved actions when necessary.
6. Identifying research needs and financial needs for management.
7. Implementing management and status reviews as necessary to ensure responsiveness of the agencies to changing circumstances of the grizzly or its habitat in Yellowstone.
8. Directing and coordinating information and education efforts.

The Governors of Idaho, Montana, and Wyoming have recommended that the Yellowstone Grizzly Bear Committee be expanded to include nine non-voting, governor-appointed members in order to provide local citizen perspectives to management.

The Idaho Legislature directs the Idaho Fish & Game Commission to coordinate with the IGBC and YES to incorporate citizen members with voting privileges into the Yellowstone Grizzly Bear Committee. Further, the legislature recognizes this would require an agreement by the majority of the Yellowstone Grizzly Bear Committee.

DISTRIBUTION AND OCCUPANCY

Goal: To manage a recovered grizzly bear population within suitable grizzly bear habitat in eastern Idaho and to provide for a population that is in a biologically suitable area and socially acceptable. Social acceptance of grizzly bears will depend on how management issues are approached and how much faith people have in managers.

The management direction established in the Draft Conservation Strategy is designed to maintain grizzly bear distribution and occupancy within the PCA and to keep mortalities at low levels. Management direction in the PCA has met the goals of the grizzly bear recovery plan. This management direction will allow for the grizzly bear population to occupy some limited areas outside of the PCA.

Outside of the PCA, the objective is to maintain existing resource management and recreational use and to develop a process whereby local publics can respond to demonstrated problems with appropriate management actions. By maintaining existing uses, people will feel less threatened both economically and in their lifestyles. The key to successful management of grizzly bears lies in bears utilizing lands that are not managed solely for them but in which their needs are considered along with other uses.

The majority of the biologically suitable habitat occurs on the Caribou-Targhee National Forest. A lesser amount of biologically suitable habitat occurs on public and state lands adjacent to the National Forest land. It is also anticipated that grizzly bears will occasionally occur on private lands.

During the next five to ten years, it is expected that grizzly bears will occur within the PCA and outside of the PCA in the following general areas: west through the Centennial Mountains; through the Island Park Caldera and out through the Bishop Mountain area and Big Bend Ridge areas; south along the Westslope of the Tetons and into the Palisades and Big

Hole Mountain areas (Fig. 1). Primarily roadless, these areas are the most likely to be inhabited by grizzly bears.

Grizzly bears are unique animals in their ability to exist in a wide range of habitats and habitat conditions. It would be premature to identify specific suitable habitats, given the bears flexibility in habitat use. Furthermore, it is anticipated that grizzly bears can successfully occupy a wide range of habitats in eastern Idaho and that compatible co-existence with traditional uses will be a major determining factor for their future. Grizzly bears will not be tolerated in areas with high human activity and/or development.

Bears that are trapped and relocated will only be relocated into the PCA, other grizzly bear occupied areas in Idaho, or acceptable areas outside the state. There will be no relocations into unoccupied areas in Idaho. In areas with high potential for human/grizzly bear conflicts, a variety of management options are available, including management for lower numbers of bears.

Motorized Access and Habitat Management

Inside the PCA, land management agencies will incorporate and maintain the motorized access management direction contained in the Draft Conservation Strategy. Outside of the PCA, IDFG will work with the land management agencies to achieve direction contained in approved federal land management plans, considering the needs of all wildlife species.

While IDFG recognizes the need to minimize negative impacts, it has no direct jurisdiction over land management activities on a majority of the land adjacent to the PCA. Therefore, IDFG will act in an advisory capacity with regard to potential impacts on grizzly bear habitat, and request federal land management agencies to consider the following grizzly bear issues in their land management plans for federal lands:

1. Identify and evaluate for each project proposal the cumulative effects of all activities, including past, current, and future projects.
2. Recommend management of human activities or combinations of activities on seasonally important wildlife habitats that minimize adverse impacts on the species or reduce the habitat effectiveness.
3. Continue to provide input into the planning process for all roads and new construction; recommend minimum road and site construction specifications, and construction times, based on the needs of grizzly bears and other wildlife species.
4. Recommend that roads, trails, drill sites, landing zones, etc., be located to avoid habitat components important to grizzly bears, based on site-specific evaluations.
5. Recommend that new roads that are not compatible with area management objectives and are no longer needed for the purpose for which they were built be restricted or decommissioned.
6. Recommend that native plant species be used whenever possible to provide proper watershed protection on disturbed areas. Wildlife forage and/or cover species will be used in rehabilitation projects where deemed appropriate.
7. For roads and/or trails that remain open, recommend seasonal closures and/or vehicle restrictions based on grizzly bear or other resource needs.

Livestock Conflicts

Inside the PCA, IDFG will support land management agencies in achieving the livestock management direction established in the Draft Conservation Strategy. The Targhee National Forest Land Management Plan recognizes livestock grazing as an important multiple use inside the PCA, and should be respected in the final Conservation Strategy.

On public lands outside of the PCA, while IDFG recognizes the need to coordinate wildlife and livestock management, it has no direct jurisdiction over livestock management activities. Therefore, IDFG will act in an advisory capacity with regard to impacts on grizzly bears and their habitat, encouraging land management agencies to consider the grizzly bear in their livestock management plans.

Habitat Monitoring

Inside the PCA, IDFG will adhere to the habitat monitoring requirements established in the Draft Conservation Strategy.

Outside the PCA:

1. IDFG will continue their normal monitoring programs for elk, deer, moose, kokanee, cutthroat trout, and other identified important food sources for grizzly bears.
2. On public lands, IDFG will encourage and work with land management agencies to monitor wetland and riparian habitats, whitebark pine, and important berry-producing plants.
3. On public lands, IDFG will encourage and work with land management agencies to monitor changes in motorized access. Monitoring efforts will focus on those areas that currently provide security for bears (areas that have no motorized access routes or motorized access route densities less than or equal to 1.0 mile per square mile).
4. In eastern Idaho, private lands are generally at lower elevations than most of the public lands. Undeveloped private lands may provide important spring habitat for some bears because they will provide early green-up. In addition, many of these undeveloped lower elevation lands provide important winter ranges for deer, elk, and moose, and winter-killed animals are an important food source for bears in the spring. On private lands, IDFG will work with citizens, counties, and other agencies to monitor development activities.
5. IDFG will identify important spring habitat for bears, then work with landowners to minimize impacts to bears during their period of use.

Habitat Restoration

Inside the PCA, IDFG will adhere to the habitat restoration measures as called for in the Draft Conservation Strategy.

Outside of the PCA, IDFG will encourage the public land management agencies in implementing existing management direction in land use plans. IDFG will identify site-specific changes that may be needed in existing land use plans, and will work with the public agencies through existing procedures and agreements to modify and amend land management plans. Examples of site-specific changes that may be considered include changes in motorized access, changes in livestock allotments, increasing productive whitebark pine stands, control of noxious weeds, and improvements in riparian and wetland habitats. Through this process the public will be able to have full participation in the decisions.

IDFG will assist private land owners who want to improve habitat conditions for wildlife (including the grizzly bear) on their lands by providing education materials and technical assistance.

POPULATION MONITORING

Goal: To develop and implement a science-based monitoring program that results in the data and tools necessary for IDFG to successfully manage grizzly bears.

The Draft Conservation Strategy states that human caused mortality for grizzly bears in the PCA should be limited to no more than 4% of the calculated population size (USFWS 2000). This means that mortalities in the three states and inside Yellowstone National Park must be recorded. State agencies would record all known mortalities and coordinate with the other jurisdictions to help with this assessment. Also, the Interagency Grizzly Bear Study Team will continue to monitor grizzly populations in accordance with the Draft Conservation Strategy. IDFG efforts will be coordinated with the efforts of the Interagency Grizzly Bear Study Team to ensure that the entire range of grizzly bears is monitored in Idaho and no unnecessary overlap in efforts occur. Outside the PCA, data analysis units will be established to facilitate monitoring distribution, abundance and mortality. This will be done in coordination with Wyoming and Montana.

Monitoring grizzly bears is complicated by their secretive nature and widely dispersed, low-density distribution. However, a number of techniques are available to assess population status and trend. Techniques that attempt to enumerate individuals can provide the most precise estimates of abundance. Mark-recapture estimates and DNA profiling currently provide quantitative estimates of abundance and require the greatest dedication of resources (personnel and operating dollars). These methodologies would be appropriate when finite estimates of the population are required for intensive management purposes. More qualitative assessments of populations can be accomplished by using techniques currently employed by the Interagency Grizzly Bear Study Team. Observations of females with young are documented, including results from organized aerial surveys. Distribution is further monitored by recording verified sightings of sign and/or bears. Additionally, cause-specific mortality is monitored. Although absolute estimates of abundance generally cannot be generated using observational data, relative

population status and trend can be ascertained. A monitoring program that primarily uses observational data would require fewer resources to implement than those for generating precise population estimates. Finally, a monitoring program could consist of simply documenting verified sightings to assess distribution, with population trend inferences made from changes in distribution. This framework would cost the least in resources, but the opportunities for intensive management of grizzly bears would be limited due to the lack of quantifiable information.

Preferred Monitoring Framework

Monitoring will be directed at estimating females with young, bear distribution, and mortality. Estimation of population size using observations of sows with young is used in the Yellowstone Ecosystem (Knight et al. 1995) and has been validated (Boyce et al. 2001). Since sows produce approximately two (2) cubs once every three years, a minimum estimate of the adult female breeding population can be obtained with these observations (Eberhardt and Knight 1996). The percentage of adult females in the population is 27.4% (Eberhardt and Knight 1996), so the number of unduplicated females with cubs of the year summed over a three-year period can be divided by the percentage of females in the population to obtain a minimum population estimate. This system could be extended to the known range of the population in Idaho, using the same methodologies in order to make the information-gathering process comparable with ongoing assessments.

The preferred monitoring framework is to collect data on females with young; record other bear observations, including sign, to estimate known distribution; and document cause-specific mortality. It is believed that the density of grizzly bears in Idaho during the next few years will be so low that aerial surveys would provide little if any information. Instead, IDFG shall concentrate on soliciting and recording incidental sightings. This framework is generally consistent with what is currently being collected throughout the Yellowstone Ecosystem and therefore allows for uniformity and comparability with other data collection efforts. More intensive monitoring efforts such as capture and collaring and/or DNA profiling could be used to provide more precise information as needed and when adequate funding is available. Monitoring efforts will be coordinated with the Interagency Grizzly Bear Study Team to minimize overlaps.

As with other managed wildlife species, analysis units will be established. Habitat criteria, although monitored within each analysis unit, will not be established strictly for grizzly bears.

Additional Monitoring Activities

Additional, more intensive population monitoring will depend upon need and will be coordinated with adjacent states and Yellowstone National Park, through the Interagency Grizzly Bear Study Team, since grizzly bears occupying southeastern Idaho may be expected to travel into other jurisdictions.

Trapping and radio-collaring individual bears could be conducted when needed. Radio-collared individuals allow assessment of population size, home range, habitat use, activity patterns, survival, and productivity, depending upon objectives. Census using marked bears involves extensive field effort over several years. Trapping efforts that include previously marked bears

and unmarked bears can be used to estimate population, using several mark-recapture procedures (Pollock et al. 1990).   A minimum population estimate, plus a sex/age composition of the trapped population, would then be available. This method has been successfully used on both species of bears in Yellowstone National Park (Craighead et al. 1995), southcentral Idaho (Beecham 1983), northwestern Montana (Jonkel 1971), southcentral Alaska (Miller et al. 1997), and many other areas representing a wide variety of habitat conditions and is thus applicable to southeastern Idaho.   These efforts will be incorporated into other monitoring efforts on associated species.

A bear census using hair sample collections and DNA analysis to identify individual bears is in the developmental stages (Woods et al. 1999). This technique uses a random sampling procedure stratified according to bear density across the entire occupied bear habitat at intervals throughout the period when bears are active. Strips of barbed wire to collect hair would be placed in areas frequented by bears.   Hair would first be identified by species, and if grizzly hair was collected, then a thorough analysis of the DNA would be made to identify the individual bear. Different laboratories may produce different results, so selection of a reliable analytical laboratory is important.

Bears that are captured during management activities may be sexed, aged, and marked and/or radio-collared. While these individuals will not likely provide population characteristics, changes in composition and bear distribution may imply change in population status and suggest more intensive survey effort is needed.

Hunter harvest will be intensively monitored. When hunting opportunity for grizzly bears is established, a mandatory check may be implemented for all harvested bears as is done with black bears, mountain lions, bighorn sheep, mountain goat, and moose. Locations of harvested bears may be compared with distributions obtained by other means, and may help guide hunter harvest to more effectively compensate for and reduce management actions. Reproductive tracts from females may also be collected to assess reproductive status.

PUBLIC INFORMATION AND EDUCATION

Goal: To develop, implement and disseminate a coordinated information and education program that is understandable and useful for the people who live, work, and recreate in bear habitat so as to minimize human/grizzly bear conflicts and to provide for the safety of people.

Management strategies are unlikely to succeed without useful, state-of-the-art public information and education programs. A partnership information and education approach involving IDFG, as well as other agencies, local communities, and private interests, can result in minimizing human/bear conflicts.

Information on human safety should be included in hunter education classes. Human safety is of utmost concern when hunting in grizzly bear country. Hunters and other visitors in bear country should consider carrying pepper spray or other bear-deterrent devices. Outfitters and guides will be encouraged to provide training and certification in human safety in bear country.

It is recommended that Idaho Dept. of Fish and Game:

1. Create or designate a position responsible for providing educational programs through schools, community presentations, workshops, news releases, magazine articles, videos, and radio and television announcements.
2. Continue to cooperate with federal resource management agencies in providing safety literature at trailheads and offices in bear country.
3. Sponsor a program aimed at development of "Bear Smart Communities."
4. Develop a multi-media program based on the "Living in Bear Country" program.
5. Produce and share educational materials and audio/video programs with other bear management agencies and organizations.
6. Coordinate with other agencies to develop bear education programs for specific user groups such as hunters, anglers, wood cutters, scout groups, communities, ranchers, 4-H, etc.
7. Coordinate with other entities involved in the management of Yellowstone grizzly bears to ensure that the development and use of educational materials, signs, brochures, etc., be consistent and similar throughout the tri-state area.

CONFLICT MANAGEMENT

Goal: To minimize the potential for human/grizzly conflicts while maintaining traditional residential, recreational, and commercial uses within Eastern Idaho, and to respond quickly, appropriately, and efficiently when conflict situations arise. Conflict reporting procedures will be made available to the public through personal contacts and a variety of media channels.

As previously stated in the introduction, the Governors' Roundtable recommended and the Governors endorsed that state management plans be developed for areas outside the PCA. Therefore, Idaho Code, Title 36-2404 (Appendix II) becomes applicable and requires that a state management plan provide for the management and conservation of the species once it is delisted. The plan shall contain sufficient safeguards to protect the health, private property, and economic well-being of the citizens of the State of Idaho.

Potential conflicts emerge when managing the needs of the grizzly bear while protecting human health and safety, minimizing private property damage and livestock depredation, allowing timber harvest and recreational and hunting opportunities, and providing for other wildlife species. A goal of the management plan is to provide a management framework that is quick to respond to conflicts when they arise, while providing for the welfare of the grizzly bear.

Land management agencies and local county governments are encouraged to include the grizzly bear and its interaction with other land uses in their land-use plans to avoid creating human/grizzly bear conflicts (e.g. disposal issues). Efforts are encouraged to minimize restrictions on other land uses, while providing for the needs of the grizzly bear. Expanded habitat areas for the grizzly bear are possible when the bears co-exist on land managed for other uses. This also encourages local support for increased habitat and bear populations.

Human/Grizzly Bear Conflicts

Human safety is a high priority, and the risk to human safety must be minimized. As bear numbers and distribution increase, the potential for human/grizzly conflicts will also increase. The increase in human/grizzly encounters may jeopardize the safety of humans as well as the safety of the bears. Adequate response to human safety concerns will increase local support for the grizzly bear.

There will be no prosecution of any individual who injures or kills a grizzly bear while acting in self-defense if the bear is molesting, assaulting, killing, or threatening to kill a person.

IDFG shall provide timely information to the public and land management agencies about current bear distribution, including relocations, food conditions, activity, potential and current conflicts, and behaviors. Land management agencies are encouraged to contact their permittees with information that will help them avoid conflicts.

Proper education of those who live, work, and recreate in bear-occupied areas will help to minimize human/bear conflicts. Grizzly bears are highly attracted to potential food sources. Gardens, orchards, garbage, human and pet foods, game carcasses, and septic treatment systems are attractants to bears. IDFG will work with private property owners and others to reduce the source of attractants and provide technical advice for the protection of property and the reduction of human/grizzly conflicts. Preventative measures must be given priority, as they are more effective than simply responding to problems as they occur. IDFG will encourage the development of preventative management tools and techniques as bears expand into available habitat.

Bear-resistant food storage containers, meat poles, and bear-resistant garbage containers should be provided at campsites and other bear areas. Federal and State agencies should assist in securing grant-funding for local governments to develop bear-proof garbage containers and bear-proof landfills.

The Idaho Fish and Game Commission should consider promulgating a regulation which prohibits the baiting of grizzly bears for any purpose, including hunting, photography, viewing, etc.

Livestock/Grizzly Bear Conflicts

Livestock operations that maintain large blocks of open rangeland can provide many benefits to the long-term conservation of the grizzly bear through maintenance of open space and habitats that sustain a variety of wildlife species. Livestock grazing at long time established historical levels in the PCA and surrounding areas is important to maintain, especially following delisting of the grizzly bears. Livestock operations will continue to have access to their facilities and animals regardless of the other sections of this plan. In all cases, F&G will seek permission from affected landowners and work cooperatively with them and other stakeholders.

Livestock operators can suffer significant losses from bear depredation. Upon delisting, every individual has the right to protect their person and their property, including livestock, on private,

state and federal land. If outside funding is available and the landowner is willing, efforts may include preventative programs aimed at minimizing livestock conflicts.

In cases involving livestock depredation, management actions will follow the Memorandum of Understanding (MOU) between the Idaho State Animal Damage Control Board and IDFG which states that "*The Board is responsible for prevention and control of damage caused by predatory animals and other vertebrate pests, including threatened and endangered species within the State of Idaho as described in Section 25-128, Idaho Code, and has delegated such responsibility to Wildlife Services.*" The MOU also states that "*Both parties (IDFG and WS) shall consult and cooperate in any trapping efforts. WS will be the lead agency on capture and the Department shall be responsible for immobilization, handling, and release of grizzly bears.*"

Programs will be developed to provide private landowners and livestock operators with incentives or benefits if they implement preventative measures and maintain opportunities for wildlife, including bears. Federal and State agencies should assist in securing funding sources to provide for incentives.

Upon federal delisting, the Idaho Fish and Game Commission will reclassify the grizzly bear as a game animal. The grizzly bear will be included in the big game depredation program Idaho Code, 36-1109 (Appendix III). In the future, claims for compensation shall be based on confirmed, suspected or probable losses, decrease in weaning or pregnancy rates, damage to facilities and equipment, and labor or other expenses required to resolve disruption of ranch activities.   Currently this program provides for compensation from the secondary depredation account, which does not include license/tag funds, for depredation of livestock and damage to berries and bees from black bears and mountain lions. The program will be administered by the appropriate IDFG Regional Landowner Sportsman Coordinators and Regional Supervisors.

Nuisance Grizzly Bear Management

Successful management of nuisance grizzly bears is paramount to the success of overall grizzly bear conservation. When conflicts occur they must be addressed in a timely, efficient manner. Public acceptance of grizzly bears is dependent on the prevention and alleviation of conflicts with humans, livestock, and private property. The management of nuisance bears must allow flexibility in response to a broad range of conflicts.

Inside the PCA, the nuisance guidelines presented in the Draft Conservation Strategy will be followed (Appendix III).

Outside the PCA, significant consideration will be given to humans when grizzly bears come into contact with people or private property including livestock . The focus and intent of nuisance grizzly bear management, damage management, and hunter/grizzly bear conflicts outside the PCA will be predicated on strategies and actions to prevent human/livestock/grizzly bear conflicts. It is recognized that active management aimed at individual nuisance bears will be required as part of the management program. Nuisance grizzly bears will be controlled in a timely and effective manner. Location, cause of incident, severity of incident, history of bear, and health/age/sex of bear will all be considered in any management action.

Grizzly bears occupying areas where the potential for conflicts are high (e.g., subdivisions) will be actively discouraged and/or removed to prevent damage and provide for human safety.

Criteria for Nuisance Grizzly Bear Determination and Control Outside of the PCA (see Appendix IV for definitions):

1. IDFG will investigate reported human/livestock/grizzly bear conflicts immediately. IDFG will communicate investigation findings to the affected parties or their representatives promptly.
2. Following the verification of property damage and consultation with the property owner or owner's representative and/or land management agency, IDFG will determine what management action will be initiated.
3. Grizzly bears captured during a management action that have a high probability of being chronic depredators will be removed from the population.
4. When relocation is not possible or practicable, or when it is likely it will not solve the problem, the bear will be removed from the population.
5. Grizzly bears displaying unnatural aggression or considered a threat to human safety will be removed from the population.
6. Grizzly bears displaying natural aggression will only be removed from the population when the particular circumstances warrant removal.
7. Grizzly bears displaying food conditioned or habituated behaviors, or damaging property may be relocated, aversively conditioned, or removed based on specific details of the incident. IDFG will inform the affected people and land management agencies of the management decision.
8. Grizzly bears may be preemptively moved when they are in areas where they are likely to come into conflict with humans or their property, including livestock.
9. Grizzly bears relocated because of nuisance activities will be released in a location where the probability to cause additional conflicts is low.
10. All sub-adult and adult grizzly bears that are captured in management actions and are to be relocated/released will be permanently marked and may be radio-collared.

IDFG will have the management flexibility to deviate from these nuisance protocols when extraordinary circumstances dictate a need. IDFG will prepare an annual report of these exceptions for the Commission.

Response Actions :

1. No Action: IDFG may take no action after the initial investigation if the circumstances of the conflict do not warrant immediate control or if the opportunity for control is low.

2. Averse conditioning and deterrence: IDFG may use various options to prevent grizzly bear depredation. Such options should include but are not limited to bear-proof garbage containers, scare devices, electrical fencing, etc.
3. Capture: when other options are ineffective or when human safety is a concern, IDFG will initiate capture and relocate offending animals. IDFG in consultation with appropriate entities will determine the proper relocation areas so as to minimize further conflicts.

4. Removal: lethal control of nuisance grizzly bears will be used when other options are not viable and when human safety and protection of personal property including livestock warrant such action. Kill permits will be issued under the supervision of IDFG to affected property owners or their agents.

Any bear causing a human fatality outside the PCA will be removed from the population. Appendix III outlines the actions for incidences inside the PCA.

All reported grizzly bear conflicts and subsequent IDFG corrective actions must be documented.

HARVEST MANAGEMENT

Goal: To allow for regulated harvest of grizzly bears while maintaining a viable and self-sustaining population.

Although this plan provides general guidance for the management of grizzly bear hunting opportunity, the Idaho Fish & Game Commission has ultimate authority and discretion for establishment of take seasons and methods of take for game animals.

The success of grizzly bear recovery in the Yellowstone Ecosystem justifies a management paradigm shift from one of preservation to one of conservation. The basis of conservation is sustainable use, which for wildlife resources includes regulated hunting. Recognition of the grizzly bear as a game animal will ensure that the proper resources for population and mortality monitoring will be allocated. This will benefit the long-term viability of the bear, as it has for Idaho's other hunted, large mammal species. Classification of the grizzly bear as a game animal can also be expected to improve the level of acceptance of the bear by the public living within grizzly bear range and to increase the number of stakeholders favoring grizzly bear conservation. Hunters have been long-term supporters of conservation, and the presence of legal hunters in the field may minimize the poaching of bears by those opposed to their recovery. Additionally, hunting may act as a form of reverse habituation, thus decreasing the likelihood of human/bear conflicts. The removal of individual bears will open up home ranges for subadults, also minimizing conflicts with bears that might otherwise disperse to human-use areas. Thus, hunting tends to reduce the number of management actions needed. Management actions that involve capturing bears are expensive to conduct and, to the extent that hunter harvest can substitute for this, costs will be reduced.

The hunting of grizzly bears by members of the Shoshone-Bannock Tribes is a traditional and cultural issue, which will be determined by the Governing Body of the Shoshone-Bannock Tribes after delisting of the grizzly bear is finalized. Discussions between the Shoshone-Bannock Tribal Council and the Idaho Fish & Game Commission will be held on the management of the Yellowstone grizzly bear. [1]

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[1] For purposes of future litigation, nothing herein shall be construed as recognition or endorsement of off reservation treaty rights of the Shoshone-Bannock Tribes by the State of Idaho.

It is unlikely that grizzly bear hunting seasons will be established immediately upon delisting. Establishment of grizzly bear hunting seasons will be conducted using the same process, including public meetings, as for other game species. There are three situations when hunting should be considered as a management tool for grizzly bears:

A well-conserved population is one that can sustain a harvest. As the bear population expands in accordance with the goals of this plan, a harvestable component may be produced. This situation will be identified through the monitoring protocols established elsewhere in this plan, and a hunting quota will be determined by IDFG, based on criteria outlined below.

Chronic depredation problems may indicate a bear population that is socially unacceptable for a given location. Chronic problems involve repetitive events of property damage or frequent repetitive bear use of areas of high human use, which might reasonably be expected to lead to conflict. The hunting option would be considered in conjunction with other mechanisms, such as sanitation and public education.

Individual bears may become the objects of a lethal control action per the guidelines set forth elsewhere in this plan. Such an animal, under occasional circumstances, may provide an opportunity for a hunt, at the discretion of the local IDFG office. Factors to consider when choosing to use a private hunter would be the urgency of timely action, safety, high probability of harvesting the appropriate individual, and attention to the principles of fair chase. A list of hunters desiring to participate should be maintained by IDFG, to be contacted as an opportunity occurs. It is expected that this option would be used sparingly.

All animals harvested as described above will count toward total allowable mortality quotas for the population. Harvest management will thus be considered as one component of an integrated management program for grizzly bears. It will be highly regulated, directed at individual bears as needed, and considered in annual mortality targets that will be established by IDFG in conjunction with other states and the Interagency Grizzly Bear Study Team.

Grizzly bears may be hunted in any portion of their distribution within Idaho, on any lands typically open to hunting. However, since portions of Idaho fall within the area to be managed under the Conservation Strategy, the number of grizzly bears to be removed from that area by hunting must be consistent with the established goals. That document stipulates that the sum of human-caused mortalities can not exceed 4% of the total estimated minimum population, with no more than 30% of that number being female grizzly bears. Thus, hunting mortality must be coordinated among IDFG and the other agencies that are signatory to the Conservation Strategy. A mechanism for allocation of bear quotas among the states must be negotiated among wildlife agencies of Idaho, Montana, and Wyoming. One such method may allocate tags based on the percentage of the total PCA population estimated to reside within the respective state.

Areas not covered by the Conservation Strategy may be managed less conservatively with regard to grizzly bears, in keeping with their multiple use designations. However, this plan also recognizes that the grizzly bear is a desirable component of Idaho's wildlife heritage. In general, for areas in which it is desirable to have the grizzly bear population remain stable or continue to

expand, total human-caused mortality should be maintained at no more than 5.7% (as calculated by a running 6-year average) of the total estimated minimum population, with only 30% of that number being female. Different total allowable harvest, percentage female mortality, and/or population estimate methodologies may be used in the future as new information and technology become available. A higher percentage of the male or female population may be harvested as desirable for management goals in areas where grizzly bears should be maintained at low population densities. Thus, harvest management is one of the tools used for managing the grizzly bear population.

A spring grizzly bear season is recommended to protect the female cohort. Spring bear seasons typically have a lower percentage of female harvest than do fall seasons. Population data from the previous field season may be used to establish the harvest quota. The quota will be the appropriate percentage of the population as described above, less known mortality from other sources, including accidental, natural, and control actions, as well as treaty hunting mortalities. Therefore, the size of the quota will be limited by the reliability of the population monitoring data. Uncertain data will result in conservative population estimates and harvest quotas smaller than the population might otherwise allow. Since legal harvest is one of the sources of grizzly bear mortality that can readily be managed, this plan recognizes that harvest may be suspended in years of excessive mortality from other sources.

Because grizzly bear populations are very sensitive to the level of female mortality, every effort should be made to focus the harvest on male bears in areas where it is desirable to have a stable or increasing population. Methods to ensure a predominantly male harvest may include:

1. There could be a mandatory check requirement similar to that required for mountain lions and black bears.
2. Females with young may not be harvested. Neither may cubs or young accompanying a female be harvested.
3. Early closure of hunting seasons when the allowable female quota has been harvested. The IDFG Director may enforce emergency season closures at his/her discretion.
4. A tag fee structure that would include a refund for hunters harvesting a male bear.
5. Early timing of the spring hunt. Boars typically emerge from the den earlier than sows and sows with cubs.
6. Promotion of the use of hunting methods intended to allow the hunter a better opportunity to determine sex.

The Commission could consider a once per lifetime controlled hunt limitation for grizzly bear hunts similar to the controlled hunt limitation for mountain goat, bighorn sheep, and moose hunts. The Commission could also consider mandatory training for hunters, outfitters, and guides who hunt grizzly bears. The training could include information on methods to distinguish between a grizzly bear and a black bear, clean camp rules, and safety, including the use of pepper spray.

Currently, the use of bait and hounds is not permitted for black bear hunting in Idaho 'Bear Management Units' inside the PCA. To minimize accidental grizzly bear mortality within the PCA, this practice will be continued. There will be no additional restrictions on black bear hunting methods outside of the PCA as a result of grizzly bear distribution and occupancy. It will be illegal for a hunter to take a grizzly bear using bait and/or hounds. Grizzly bear hunters may be guided or unguided.

There will be no additional restrictions on the hunting/trapping of other legally harvested animals inside or outside of the PCA as a result of grizzly bear distribution and occupancy.

Big game, including black bear, hunters desiring to hunt in known grizzly bear range will receive information on methods to distinguish between a grizzly bear and a black bear, clean camp rules, and safety, including the use of pepper spray. Any time the identification of the species of bear is in doubt, the animal should not be harvested. The rate of accidental grizzly bear kills should be monitored and additional training implemented as necessary to keep this rate acceptably low.

PROGRAM COSTS & FUNDING

Grizzly bear management is an Idaho activity that exists because grizzly bear conservation is a national priority. Idaho and a few other western states contain suitable habitat to support grizzly bears. They are managed not just for Idaho citizens, but also for the rest of the nation. It is entirely logical that all those who benefit from the presence of grizzly bears in Idaho should pay for their management. While it is beyond the scope of a state management plan to provide assurances that all agencies involved with grizzly bear management have adequate funding, it is recognized that tasks associated with assisting individuals and/or communities with preventative measures, population enumeration, depredations, and information/education could add significantly to the monetary resources needed. Monitoring population indices, habitat conditions, providing technical assistance, and interagency coordination are currently being conducted with minimal increases in funding requirements anticipated for future management.

We recommend that the Idaho legislature and Governor encourage the Congressional delegation to seek federal appropriations and funds from national business and conservation groups to fund grizzly bear management activities in Idaho. A trust or endowment concept has been developed through the Interagency Grizzly Bear Committee. This proposal is a good starting point from which to seek a stable funding mechanism for grizzly bear management.

The use of hunting license, federal aid to fish and wildlife, and nongame funds should be continued at historic levels, but additional management obligations created when the grizzly bears are returned to state management should be funded with new revenue sources. The Department will implement approved management actions within the financial, staffing, and legal limits that exist. In the event that funding is insufficient, further direction should be

provided by the legislature in order to prioritize agency efforts in the most efficient and most needed manner. Critical tasks include monitoring mortalities and response to human/livestock/grizzly bear conflicts.

Current annual expenditures for Yellowstone grizzly bear management activities in Idaho amount to approximately $21,000. Recommended management actions outlined in this document are expected to increase those costs to approximately $145,000 per year (Table 1) based on current grizzly bear population levels. With increases in both human and grizzly bear populations and inflation, future management costs will likely increase accordingly and shall be federally funded.

Table 1. Current IDFG estimated costs for management of grizzly bears in eastern Idaho and future estimates for implementation of recommendations presented within this document.

1 TASK		Personnel Costs*	Operating Costs	Capital Outlay Costs	Total Costs
Annual Aerial Observation Flights	Current Costs	1,000	3,000	0	4,000
	Future Costs	1,000	3,000	0	4,000
Monitor Key Food Sources	Current Costs	0	0	0	0
	Future Costs	1,000	250	0	1,250
Radio Telemetry & Monitoring	Current Costs	0	0	0	0
	Future Costs	500	3,500	1,500	5,500
Hair Snaring & DNA Sampling	Current Costs	0	0	0	0
	Future Costs	15,000	10,000	0	25,000
Document Distribution	Current Costs	1,000	100	0	1,100
	Future Costs	4,000	1,000	0	5,000
Monitor Mortalities	Current Costs	250	100	0	350
	Future Costs	500	200	0	700
Respond to Human/Grizzly Bear Conflicts	Current Costs	1,500	500	0	2,000
	Future Costs	3,000	1,000	0	4,000
Respond to Livestock Depredations	Current Costs	250	100	0	350
	Future Costs	500	200	0	700
Livestock Depredation Payments	Current Costs	0	0	0	0
	Future Costs	1,000	5,000	0	6,000
Trapping & Relocation	Current Costs	1,500	250	0	1,750
	Future Costs	2,500	500	1,000	4,000
Provide Materials and/or Technical Advice for Preventative Actions	Current Costs	500	0	500	1,000
	Future Costs	8,000	2,500	25,000+**	35,500+
Seek/Solicit Grants and Other External Funding Sources	Current Costs	0	0	0	0
	Future Costs	8,000	1,000	0	9,000
Provide Education Materials	Current Costs	1,000	250	0	1,250
	Future Costs	9,000	2,500	5,000	16,500
Develop and Present Education Materials	Current Costs	1,000	250	0	1,250
	Future Costs	9,000	2,500	5,000	16,500
Monitor Habitat Conditions	Current Costs	500	0	0	500
	Future Costs	500	0	0	500
Provide Technical Assistance for Habitat Restoration on Private Land	Current Costs	0	0	0	0
	Future Costs	500	100	0	600
Interagency Coordination	Current Costs	6,000	1,000	0	7,000
	Future Costs	8,000	1,500	0	9,500
TOTAL	Current Costs	14,500	5,550	500	20,550
	Future Costs	72,000	34,750	37,500+	144,250+

*   Personnel costs based on $25.00/hour including benefits.
**   Private, public, and/or corporate funding to be solicited based on future identified needs.

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REFERENCES

Aune, K., and W. Kasworm. 1989. Final report east front grizzly bear study. Montana Dept. of
       Fish, Wildlife and Parks, Helena, Montana, USA.

Beecham, J.J. 1983. Population characteristics of black bears in west central Idaho. Journal
       Wildlife Management 47:405-412.

Blanchard, B.M. 1987. Size and growth patterns of the Yellowstone grizzly bear. International
       Conference Bear Research and Management 7:99-107.

Blanchard, B.M. 1990. Relationship between whitebark pine cone production and fall
       grizzly bear movements. Pages 362-363 *in* W.C. Schmidt and K.J. McDonald,
       compilers. Proceedings – Symposium on Whitebark Pine Ecosystems: Ecology
       and Management of a High-Mountain Resource. U.S. Forest Service General
       Technical Report, INT-270.

Blanchard, B.M., and R.R. Knight. 1991. Movements of Yellowstone grizzly bears, 1975-87.
       Biological Conservation 58:41-67.

Blanchard, B.M., and R.R. Knight. 1995. Biological consequences of relocating grizzly bears in
       the Yellowstone Ecosystem. Journal Wildlife Management 59:560-565.

Boyce, M.S., D.I. MacKenzie, B.J.J. Manly, M.A. Haroldson, and D. Moody. 2001. Negative
       binomial models for abundance estimation of multiple closed populations. Journal
       Wildlife Management 65:498-509.

Brannon, R.D. 1984. Influence of roads and developments on grizzly bears in Yellowstone
       National Park. Interagency Grizzly Bear Study Team, Bozeman, Montana, USA.

Bunnell, F.L., and D.E.N. Tait. 1981. Population dynamics of bears – Implications. Pages 75-
       98 *in* C.W. Fowler and T.D. Smith, editors. Dynamics of large mammal populations.
       John Wiley and Sons, New York, New York, USA.

Craighead, J.J., and J.A. Mitchell. 1982. Grizzly Bear. Pages 515-555 *in* J.A. Chapman and
       G.A. Feldhamer, editors. Mammals of North America. Johns Hopkins University Press,
       Baltimore, Maryland, USA.

Craighead, J.J., J.S. Sumner, and J.A. Mitchell. 1995. The grizzly bears of Yellowstone: their
       ecology in the Yellowstone ecosystem, 1959-1992. Island Press, Washington, D.C.,
       USA.

Craighead, J.J., J.R. Varney, and F.C. Craighead, Jr. 1974. A population analysis of the
       Yellowstone grizzly bears. Montana Forest and Conservation Experiment Station
       Bulletin 40. University of Montana, Missoula, Montana, USA.

Eberhardt, L.L., and R.R. Knight. 1996. How many grizzlies in Yellowstone? Journal Wildlife Management 60:416-421.

French, S.P., and M.G. French. 1990. Predatory behavior of grizzly bears feeding on elk calves in Yellowstone National Park, 1986-88. International Conference Bear Research and Management 8:335-341.

Green, G. 1994. Use of spring carrion by bears in Yellowstone National Park. Thesis, University of Idaho, Moscow, Idaho, USA.

Groves, C. 1987. A compilation of grizzly bear reports from central and northern Idaho. Endangered Species Projects E-III, E-IV. Idaho Dept. of Fish and Game, Boise, Idaho, USA.

Gunther, K.A., and R.A. Renkin. 1990. Grizzly bear predation on elk calves and other fauna of Yellowstone National Park. International Conference Bear Research and Management 8:329-334.

Hilderbrand, G.V., C.C. Schwartz, C.T. Robbins, M.E. Jacoby, T.A. Hanley, S.M. Arthur, and C. Servheen. 1999. The importance of meat, particularly salmon, to body size, population productivity, and conservation of North American brown bears. Canadian Journal Zoology 77:132-138.

Jonkel, C.J., and I.M. Cowan. 1971. The black bear in the spruce-fir forest. Wildlife Monographs 27.

Kevan, P.G., and D.M. Kendall. 1997. Liquid assets for fat bankers: summer nectarivory by migratory moths in the Rocky Mountains, Colorado, U.S.A. Arctic and Alpine Research 29:478-482.

Klaver, R.W., J.J. Claar, D.B. Rockwell, H.R. Mays, and C.F. Acevedo. 1986. Grizzly bears, insects, and people: bear management in the McDonald Peak region, Montana. Pages 204-211 in Proceedings Grizzly Habitat Symposium, Missoula, Montana. U.S. Forest Service General Technical Report INT-207.

Knight, R.R., B.M. Blanchard, and L.L. Eberhardt. 1988. Mortality patterns and population sinks for Yellowstone grizzly bears, 1973-1985. Wildlife Society Bulletin 16:121-125.

Knight, R.R., B.M. Blanchard, and L.L. Eberhardt. 1995. Appraising status of the Yellowstone grizzly bear population by counting females with cubs-of-the-year. Wildlife Society Bulletin 23:245-248.

Knight, R.R., and L.L. Eberhardt. 1985. Population dynamics of Yellowstone grizzly bears. Ecology 66:323-334.

Knight, R.R., and L.L. Eberhardt. 1987. Prospects for Yellowstone grizzlies. International Conference Bear Research and Management 7:45-50.

Kunkel, K., W. Clark, and C. Servheen. 1991. A remote camera survey for grizzly bears in low human areas of the Bitterroot grizzly bear evaluation area. Idaho Dept. Fish and Game unpublished report, Boise, Idaho, USA.

Lloyd, K., and S. Fleck. 1977. Some aspects of the ecology of black and grizzly bears in southeastern British Columbia. B.C Fish and Wildlife Branch, Victoria. 55 pp.

Mattson, D.J., B.M. Blanchard, and R.R. Knight. 1991*a*. Food habits of Yellowstone grizzly bears. Journal Applied Ecology 34:926-940.

Mattson, D.J., R.G. Wright, K.C. Kendall, and C.J. Martinka. 1995. Grizzly bears. Pages 103-105 *in* E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac, editors. Our living resources: a report to the Nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. U.S. Department Interior, National Biological Service, Washington, D.C., USA.

Mattson, D.J., C.M. Gillin, S.A. Benson, and R.R. Knight. 1991*b*. Bear use of alpine insect aggregations in the Yellowstone ecosystem. Canadian Journal Zoology 69:2430-2435.

McLellan, B.N. 1994. Density-dependent population regulation of brown bears. Pages 15-24 *in* M. Taylor, editor. Density-dependent population regulation of black, brown, and polar bears. International Conference Bear Research and Management 9. Monograph Series 3.

McLellan, B.N., and V. Banci. 1999. Status and management of the brown bear in Canada. Pages 46-50 *in* C. Servheen, S. Herrero, and B. Peyton, compilers. Bears: status survey and conservation action Plan. IUCN/SSC Bear and Polar Bear Specialist Groups. IUCN, Gland, Switzerland and Cambridge, United Kingdom.

Melquist, W. 1985. A preliminary survey to determine the status of grizzly bears (*Ursus arctos horribilis*) in the Clearwater National Forest of Idaho. Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, Idaho, USA.

Miller, S.D. 1990*a*. Detection of differences in brown bear density and population composition caused by hunting. International Conference Bear Research and Management 8:393-404.

Miller, S.D. 1990*b*. Population management of bears in North America. International Conference Bear Research and Management 8:357-373.

Miller, S.D., and J. Schoen. 1999. Status and management of the brown bear in Alaska. Pages 40-46 *in* C. Servheen, S. Herrero, and B. Peyton, compilers. Bears: status survey and conservation action Plan. IUCN/SSC Bear and Polar Bear Specialist Groups. IUCN, Gland, Switzerland and Cambridge, United Kingdom.

Miller, S.D., G.C. White, R.A. Sellers, H.V. Reynolds, J.W. Schoen, K. Titus, V.G. Barnes, Jr., R.B. Smith, R.R. Nelson, W.B. Ballard, and C.C. Schwartz. 1997. Brown and black bear

density estimation in Alaska using radiotelemetry and replicated mark-resight techniques. Wildlife Monographs 133.

Pasitschniak-Arts, M. 1993. Mammalian species: *Ursus arctos*. American Society Mammalogy 439:1-10.

Picton, H.D. 1978. Climate and the reproduction of grizzly bears in Yellowstone National Park. Nature (London) 274:888-889.

Picton, H.D., and R.R. Knight. 1986. Using climate data to predict grizzly bear litter size. International Conference Bear Research and Management 6:41-44.

Pollock, K.H., J.D. Nichols, C. Brownie, and J.E. Hines. 1990. Statistical inference for capture-recapture experiments. Wildlife Monographs 107.

Reinhart, D.P., and D.J. Mattson. 1990. Bear use of cutthroat trout spawning streams in Yellowstone National Park. International Conference Bear Research and Management 8:343-350.

Riley, S.J., K. Aune, R.D. Mace, and J.J. Madel. 1994. Translocation of nuisance grizzly bears in northwestern Montana. International Conference Bear Research and Management 9:567-573.

Schallenberger, A., and C. Jonkel. 1980. Rocky Mountain east front grizzly studies, 1979. Border Grizzly Project Special Rep. No. 39. Univ. of Montana, School of Forestry, Missoula.

Schwartz, C.C., S.D. Miller, and M.A. Haroldson. *In press*. *In* Wild Mammals of North America. G. Feldhamer, B. Thompson and J. Chapman, editors. Johns Hopkins University Press.

Sellers, R.D., and L.D. Aumiller. 1994. Brown bear population characteristics at McNeil River, Alaska. International Conference Bear Research and Management 9:283-293.

Servheen, C. 1999. Status and management of the grizzly bear in the lower 48 United States. Pages 50-54 *in* C. Servheen, S. Herrero, and B. Peyton, compilers. Bears: status survey and conservation action Plan. IUCN/SSC Bear and Polar Bear Specialist Groups. IUCN, Gland, Switzerland and Cambridge, United Kingdom.

Servheen, G., A. Hamilton, R. Knight, and B. McLellan. 1990. Report of the technical review team: evaluation of the Bitterroot and North Cascades to sustain viable grizzly bear populations. Report to the Interagency Grizzly Bear Committee. U.S. Fish and Wildlife Service, Boise, Idaho, USA.

Smith, J., and J. Hoffman. 1998. Status of white pine blister rust in Intermountain Region white pines. U.S. Forest Service Intermountain Region, State and Private Forestry, Forest Health Protection Report No. R4-98-02.

Stringham, S.F. 1984. Responses by grizzly bear population dynamics to certain environmental and biosocial factors. Dissertation, University of Tennessee, Knoxville, Tennessee, USA.

Stringham, S.F. 1986. Effects of climate dump closure, and other factors on Yellowstone grizzly bear litter size. International Conference Bear Research and Management 6:33-39.

Stringham, S.F. 1990. Grizzly bear reproductive rate relative to body size. International Conference Bear Research and Management 8:433-443.

Taylor, M.K., D. DeMaster, F.L. Bunnell, and R. Schweinsburg. 1987. Modeling the sustainable harvest of female polar bears. Journal Wildlife Management 51:811-820.

U.S. Fish and Wildlife Service. 1993. Grizzly bear recovery plan. Missoula, Montana, USA.

U.S. Fish and Wildlife Service. 2000. Draft conservation strategy for the grizzly bear in the Yellowstone area. Missoula, Montana, USA.

Van Daele, L.J., V.G. Barnes, and R.B. Smith. 1990. Denning characteristics on brown bears on Kodiak Island, Alaska. International Conference Bear Research and Management 3:321-330.

Welch, C.A., J. Keay, K.C. Kendall, and C.T. Robbins. 1997. Constraints on frugivory by bears. Ecology 78:1105-1119.

White, D., Jr. 1996. Two grizzly bear studies: moth feeding ecology and male reproductive biology. Dissertation, Montana State University, Bozeman, Montana, USA.

White, D., Jr., K.C. Kendall, and H.D. Picton. 1999. Potential energentic effects of mountain climbers on foraging grizzly bears. Wildlife Society Bulletin 27:146-151.

Woods, J.G., D. Paetkau, D. Lewis, B.N. McLellan, M. Proctor, and C. Strobek. 1999. Genetic tagging free ranging black and brown bears. Wildlife Society Bulletin 27:616-627.

APPENDICES

APPENDIX I - Idaho Code

36-106(e)5.   Director of Idaho Dept. of Fish and Game

A. The director, or any person appointed by him in writing to do so, may take wildlife of any kind, dead or alive, or import the same, subject to such conditions, restrictions and regulations as he may provide for the purpose of inspection, cultivation, propagation, distribution, scientific or other purposes deemed by him to be of interest to the fish and game resource of the state.

B. The director shall have supervision overall of the matters pertaining to the inspection, cultivation, propagation and distribution of the wildlife propagated under the provision of title 36, Idaho Code. He shall have the power and authority to obtain, by purchase or otherwise, wildlife of any kind or variety which he may deem most suitable for distribution in the state and may have the same properly cared for and distributed throughout the state of Idaho as he may deem necessary.

> The director is hereby authorized to issue a license/tag/permit to a nonresident landowner who resides in a contiguous state for the purpose of taking one (1) animal during an emergency depredation hunt which includes the landowner's Idaho property subject to such conditions, restrictions or regulations as the director may provide. The fee for this license/tag/permit shall be equal to the costs of a resident hunting license, a resident tag fee and a resident depredation permit.

36-1107.   Wild animals and birds damaging property.

> Other provisions of this title notwithstanding, any person may control, trap, and/or remove any wild animals or birds or may destroy the houses, dams, or other structures of furbearing animals for the purpose of protecting property from the depredations thereof as hereinafter provided.

> The director may delegate any of the authority conferred by this section to any other employee of the Department.

> (a)   Director to Authorize Removal of Wildlife Causing Damage. Except for antelope, elk, deer or moose when any other wildlife, protected by this title , is doing damage to or is destroying any property or is likely to do so, the owner or lessee thereof may make complaint and report the facts to the director or his designee who shall investigate the conditions complained of. If it appears that the complaint is well-founded and the property of such complainant is being or is likely to be damaged or destroyed by any such wildlife protected under this title, the director may:
> > 1.   Send a representative onto the premises to control, trap, and/or remove such protected wildlife as will stop the damage to said property. Any animals or birds so taken shall remain the property of the state and shall be turned over to the director.
> > 2.   Grant properly safeguarded permission to the complainant to control, trap and/or remove such protected wildlife or to

destroy any houses, dams, or other structures erected by said animals or birds. Any protected wildlife so taken shall remain the property of the state and shall be turned over to the director.

3. Whenever deemed to be in the public interest, authorize or cause the removal or destruction of any dam, house, structure or obstruction erected by any forbearing animals, provided that no liability whatever shall accrue to the Department or the director by reason of any direct or indirect damage arising from such destruction or removal.

4. Issue a permit to any bona fide owner or lessee of property which is being actually and materially damaged by furbearing animals, to trap or kill or to have trapped or killed such animals on his own or leased premises. Such permit may be issued without cost to a landholder applicant and shall designate therein the number of furbearing animals that may be trapped or killed, the name of the person who the landowner has designated to take such furbearers and the valid trapping license number of the taker. Furbearers so taken shall be the property of the taker. Beaver so taken shall be handled in the manner provided in section 36-1104, Idaho Code. The term "premises" shall be construed to include any irrigation ditch or right-of-way appurtenant to the land for which said permit is issued.

(b) Control of Depredation of Black Bear, Mountain Lion, and Predators. Black bear, mountain lion, and predators may be disposed of by livestock owners or their employees when same are molesting livestock and it shall not be necessary to obtain any permit from the Department. Mountain lion so taken shall be reported to the director. Livestock owners may take steps they deem necessary to protect their livestock.

(c) Taking of Muskrats in Irrigation Systems Authorized. Muskrats may be taken at any time in or along the banks of irrigation ditches, canals, reservoirs or dams, by the owners, their employees, or those in charge of said irrigation ditches or canals.

APPENDIX II - Idaho Code

36-2402.   Delisting Advisory Team – Duties - Membership

(1) Director of the Idaho Dept. of Fish and Game…in cooperation and consultation with the Governor's Office of Species Conservation, may establish a Delisting Advisory Team (DAT) of no more than nine members for a threatened species or endangered species, to recommend an appropriate state species management plan for a listed species in response to a notification from the Secretary of the Interior…of intent to delist the species or sooner if deemed appropriate.

(2) The delisting advisory team members shall be broadly representative of the constituencies with an interest in the species and its management and conservation and in the economic or social impacts of management or conservation including, where appropriate, depending on the specific species, representatives of tribal governments, local government, academic institutions, private individuals and organizations and commercial enterprises. The delisting advisory team members shall be selected based upon:

        a.   Their knowledge of the species;

        b.   Their knowledge and expertise in the potential conflicts between species' habitat requirements or management and human activities;

        c.   Their knowledge and expertise in the interests that may be affected by species management or conservation; or

        d.   Other factors that may provide knowledge, information, or data that will further the intent of this act.

36-2404.   State Delisting Management Plan Requirements

(2) The delisting advisory team shall develop a state management plan for a species in response to all notification of intent to delist the species by the Secretary of the Interior or sooner if deemed appropriate. The state management plan shall provide for the management and conservation of the species once it is delisted, and contain sufficient safeguards to protect the health and safety, private property, and economic well-being of the citizens of the state of Idaho.

(3) The Department…shall provide the delisting advisory teams, the informational, technical or other needs and requirements of those teams in the performance of their duties.

(4) In developing a state delisting management plan, the delisting advisory team shall consult with the appropriate state agencies, commissions and boards.

36-2405.   Recommendation of Management Plans

(1) The delisting advisory team shall submit the management plan to the director of the Department…for review and recommendation.

(2) The director shall review the management plan and make a recommendation to the fish and game commission…The director may recommend either approval of the management plan, or recommend to return the management plan to the delisting advisory team for further study or review.

(3) If the Fish and Game Commission…finds that the management plan provides for the management and conservation of the species when it is delisted…and that reasonable safeguards are included in the management plan to protect the health, safety, private property, and economic well-being of the citizens of the state of Idaho, the Fish and Game Commission…shall approve the management plan.

(4) If the Fish and Game Commission…makes the finding required in subsection (3) of this section, the Fish and Game Commission shall forward the state management plan to the governor's Office of Species Conservation and the legislature. The management plan is subject to legislative approval.

(5) The governor's Office of Species Conservation may petition the responsible public agencies to initiate rule making to facilitate the implementation of the approved management plan.

(6) Each management plan developed pursuant to this chapter shall include a public education component that shall be developed and implemented in cooperation with other appropriate bureaus of the Department of Fish and Game…

(7) Nothing in this act shall be interpreted as granting the Department of Fish and Game…with new or additional authority.

APPENDIX III - Idaho Code

36-1109.   Control of Damage by Black Bears or Mountain Lions – Compensation for Damage.

(a)   Prevention of depredation shall be a priority management objective of the Department, and it is the obligation of landowners to take all reasonable steps to prevent property loss from black bears or mountain lions or to mitigate damage by such. The director, or his representative, will consult with appropriate land management agencies and land users before transplanting or relocating any black bear or mountain lion.

(b)   When any black bear or mountain lion has done damage to or is destroying livestock on public, state, or private land, whether owned or leased, or when any black bear has done damage to or is destroying berries or honey on private land, the owner or his representative of such livestock shall, for the purposes of filing a claim, report such loss to a representative of the U.S. Department of Agriculture animal plant and health inspection services/animal damage control (APHIS/ADC) who shall, within seventy-two (72) hours, investigate the conditions complained of. For purposes of this section, livestock shall be defined as domestic cattle and sheep. If it appears that the complaint is well founded and livestock, berries or honey of the complainant has been damaged or destroyed by such black bear or mountain lion, APHIS/ADC shall so inform the director or the Department's regional office of the extent of physical damage or destruction in question. The physical damages, without establishing a monetary value thereon, as determined by the APHIS/ADC representative shall be final, and shall be binding upon the owner or his representative and on the Department.

(c)   Any claim for damages must be in written form, shall be in the form of a claim for damages substantially the same as required in section 6-907, Idaho Code, shall be attested to by the claimant under oath, and the claim shall be for an amount of at least one thousand dollars ($1,000) in damages per occurrence. The Department shall prepare and make available suitable forms for claims for damages. Claims may be submitted only for the fiscal year (July 1 through June 30) in which they occurred. Any person submitting a fraudulent claim shall be prosecuted for a felony as provided in section 18-2706, Idaho Code.

1.   Upon receipt by the Department, the Department shall review the claim, and if approved, pay it as provided in section 36-115, Idaho Code. Failure on the part of the owner or representative to allow on-site access shall negate the claim for damages.

2.   If the Department accepts the claim for damages as submitted by the owner or his representative, the Department may approve the claim for payment, or may make a counter offer. If the owner or his representative rejects the Department's counter offer, this rejection or refusal must be in writing and submitted within five (5) working days. The value of the damage or destruction will then be determined by arbitration as set forth in section 36-1108, Idaho Code. Any claim received by the Department under the provisions of this section must be finally decided within sixty (60) calendar days of receipt by the Department. If the claim is approved

for payment, the claim must be immediately forwarded to the Department of administration for payment.

APPENDIX III – Nuisance Bear Guidelines from the Draft Conservation Strategy for the Grizzly Bear in the PCA (see Appendix IV for definitions)

The focus and intent of nuisance grizzly bear management inside and outside the PCA will be predicated on strategies and actions to prevent human/bear conflicts. It is recognized that active management aimed at individual nuisance bears will occasionally be required in both areas. Management actions outside the PCA will be implemented according to State management plans. These actions will be compatible with grizzly bear population management objectives for each State for the areas outside the PCA.

Within the PCA, management of nuisance bears will be addressed according to the following criteria.

Criteria for Nuisance Grizzly Bear Determination and Control Inside the PCA

Bears displaying unnatural aggression will be removed from the population.

Bears displaying natural aggression are not to be removed, even if the aggression results in human injury or death, unless it is the judgment of management authorities that the particular circumstances warrant removal.

Bears displaying food conditioning and or habituation may be either relocated or removed based on specific details of the incident. This judgment will be made by management authorities after considering the cause, location and severity of the incident or incidents.

Bears may be preemptively moved when they are in areas where they are likely to come into conflicts with site-specific human activities, but only as a last resort. Such preemptive moves will not count against the bear as nuisance moves.

Bears may be relocated as many times as judged prudent by management authorities. No bear may be removed for any offense, other than unnatural aggression, without at least one relocation unless the reason is documented in writing by representatives of affected agencies.

Bears preying on lawfully present livestock (cows, domestic sheep, horses, goats, llamas, etc.) on public lands will be managed according the following criteria:

> 1.   No male grizzly bear involved in livestock depredations inside the PCA shall be removed unless it has been relocated at least one time and has been found to return and continue livestock depredations.
> 2.   No females involved in livestock depredations inside the PCA shall be removed, even after relocation and subsequent continued depredation on livestock. The only exception to this could be in the case of animals considered dangerous to human safety through their behavior and use of livestock grazing areas where humans are present.

Management of all nuisance bear situations will emphasize removal of the human cause of the conflict, when possible, or management and education actions to limit such

conflicts. Relocation and removal of grizzly bears may occur if the above actions are not successful.

Prior to any removal, except in cases of human safety, involved management authorities will consult by phone or in person to judge the adequacy of the reason for removal and the current level of human-caused mortality to avoid exceeding mortality limits through such removals.

The basis for decisions on relocation and removal inside the PCA will be criteria for management of nuisance bears in the Conservation Strategy and best biological judgment of authorities.

Authorized State authorities outside of YNP and GTNP will do removals inside the PCA. Authorized National Park Service authorities will do removals within YNP and GTNP.

Authorities will cooperate to provide adequate and available sites for relocations.

General criteria: Location, cause of incident, severity of incident, history of bear, health/age/sex of bear, and demographic characteristics of animals involved will all be considered in any relocation or removal. Removal of nuisance bears will be conservative and consistent with mortality limits outlined for the population in the PCA in the Draft Conservation Strategy.

Recognizing that conservation of female bears is essential to maintenance of a grizzly population, removal of nuisance females will be minimized. Management actions inside the PCA will be carried out only with conservation of the grizzly bear population in mind, and consistent with State regulations, policy, and State and Federal laws.

Specific criteria for removals: Captured grizzly bears identified for removal may be given to public research institutions or public zoological parks for appropriate non-release educational or scientific purposes as per regulations of States and National Parks. Grizzly bears not suitable for release, research, or educational purposes will be removed as described in appropriate State management plans or in compliance with National Park rules and regulations.

Individual nuisance bears deemed appropriate for removal may be taken by a sport hunter outside of National Parks in compliance with rules and regulations promulgated by the appropriate State wildlife agency commission, as long as such taking is in compliance with existing State and Federal laws, and as long as mortality limits specified for the PCA and within ten (10) miles outside the PCA boundary as described in this Draft Conservation Strategy are not exceeded.

All grizzly bear relocations and removals will be documented and reported annually in the IGBST annual report. Such actions may be subject to the Management Review process if requested by a member of the Yellowstone Grizzly Management Committee. Management of nuisance bears outside the PCA will be the sole responsibility of appropriate State wildlife management agencies and is not regulated by the Draft Conservation Strategy.

APPENDIX IV – Definitions used for Nuisance Bear Guidelines.

Aversive conditioning: the application of techniques that are intended to change a bear's behavior.

Capture: any action to catch a bear for management purposes.

Depredation: damage to any property, including agricultural products.

Deterrence: the application of techniques that are designed to discourage a bear from causing further damage or inhabiting undesirable areas.

Food conditioned bear: a bear that has received a significant food reward of non-natural foods such as garbage, camp food, pet food, or processed livestock food and persistently seeks these foods.

Habituated bear: a bear that does not display avoidance behavior around humans or in human-use areas such as camps or town sites or within 100 meters of open roads.

Human/grizzly bear conflict: a confrontation between a human and/or his property and bear(s) in which the safety of the human and/or bear(s) is jeopardized and/or property loss occurs.

Management authorities: are the designated representatives of the agencies in the PCA including Yellowstone National Park (YNP), Grand Teton National Park (GTNP), Wyoming Game and Fish Department, Montana Fish Wildlife and Parks, IDFG, Interagency Grizzly Bear Study Team, each of the National Forests – Gallatin, Custer, Shoshone, Bridger-Teton, Targhee, and Beaverhead, and the U.S. Fish and Wildlife Service Grizzly Bear Recover Coordinator, as requested. These authorities will make the decision to classify a bear as "nuisance" inside the PCA in compliance with the nuisance bear criteria. Outside YNP and GTNP within the PCA, subsequent management actions will be coordinated and completed by State wildlife agencies, after discussing with the appropriate management authorities. When nuisance bears are in YNP or GTNP, decisions will be made by park representatives, and coordinated with State and Forest Service representatives when necessary (e.g. for bear relocations).

Natural aggression: grizzly bear behavior resulting from defense of young or food, during a surprise encounter, or self-defense.

Non-natural foods: includes, but is not limited to garbage, gardens, livestock carrion, game meat in possession of humans, and human, pet, and livestock foods.

Nuisance grizzly bear: a grizzly bear that depredates livestock, causes property damage, or uses unnatural food that has been reasonably secured from the grizzly bear; or, a grizzly bear that displays unnatural aggression toward humans that constitutes a demonstrable immediate or potential threat to human safety and/or a human injury.

Property damage: damage to any property including agricultural products.

Protection: the application of any device or techniques to protect humans and property from bear damage.

Relocation: the capture and movement of a grizzly bear involved in a conflict with humans or their property by management authorities to a remote area away from the conflict site.

Removal: the capture and placement of a bear in an authorized public zoological or research facility or destruction of that bear. Removal can also involve killing the bear through active measures in the wild when it is not otherwise possible to capture the bear.

Repeat offense: the involvement of a bear that has been previously relocated in a nuisance situation or, if not relocated, continues to repeat a behavior that constitutes a human/bear conflict.

Unnatural aggression: grizzly bear behavior that includes active predation on humans, approaching humans or human use areas, such as camps, in an aggressive way, or aggressive behavior when the bear is unprovoked by self-defense, defense of cubs, defense of foods, or in a surprise encounter.

APPENDIX V – Grizzly Bear Delisting Advisory Team Response to Public Commission Concerns (January 22, 2002)

The Grizzly Bear Delisting Advisory Team (DAT) met on January 10, 2002, to address the concerns and recommendations received from the Idaho Fish and Game Commission, as outlined in their letter to Rod Sando, dated November 30, 2001. The following summarizes the changes that have been incorporated into the "Recommendations for Grizzly Bear Management in Eastern Idaho" (hereafter referred to as the Draft Plan).

1. Commission Concern: "The possibility of immediate hunting by Native American tribal members within treaty areas needs elaboration and appropriate action, such as a Department/Tribal M.O.U., prior to delisting."

>   Response: Dan Christopherson, a member of the DAT, is a biologist working for the Shoshone-Bannock Tribes. Dan met with tribal leaders to discuss the Commission's concerns. At the Jan. 10 meeting, Dan said the tribal leaders did not want any changes in the wording that currently exists in the Draft Plan. We had considerable discussion at the meeting, and finally agreed to add this to the Draft Plan: "While IDFG does not have authority to regulate tribal harvest, discussions between the Shoshone-Bannock Tribal Council and the Idaho Fish & Game Commission will be held on the management of the Yellowstone grizzly bear."

2. Commission Concern: "The relationship and effect of the Draft Conservation Strategy to the Delisting Plan needs greater explanation and definition, in particular as it affects or defines Department of Fish and Game management authority and obligations."

>   Response: We added the following to the Introduction Section of the Draft Plan to help clarify the relationship and effect of the Conservation Strategy: "The final Conservation Strategy will have two primary roles. First, it will describe and summarize the coordinated efforts to manage the grizzly bear population and its habitat, and the public education/involvement efforts that will be applied to ensure continued conservation of the grizzly bear in the greater Yellowstone area. Secondly, it will document the regulatory mechanisms that exist to maintain the Yellowstone population as recovered through the legal authorities, policy, guidelines, management programs, monitoring programs, and the commitment of participating agencies."

3. Commission Concern: "The Idaho Fish and Game would be placed in the position of bearing major increased costs for monitoring, handling problem bears, evaluating habitat, performing cumulative effects analysis on a multiplicity of federal and other projects, and so on. We feel that the specific costs and proportionate share to be borne by the Federal government, Idaho Fish and Game, and others must be clearly indicated, with the prerequisite that adequate assurance of funding from all sources and parties must be in place prior to delisting."

Response: The DAT recognizes the concerns of the Commission regarding funding grizzly bear management. We had much discussion about what to say in the Draft Plan about funding. We added wording and reworked several paragraphs in the Program Costs and Funding Section of the Draft Plan to read as follows: "While it is beyond the scope of a state management plan to provide assurances that all agencies involved with grizzly bear management have adequate

funding, it is recognized that tasks associated with assisting individuals and/or communities with preventative measures, population enumeration, depredations, and information/education could add significantly to the monetary resources needed. Monitoring population indices, habitat conditions, providing technical assistance, and interagency coordination are currently being conducted with minimal increases in funding requirements anticipated for future management.

"We recommend that the Idaho legislature and Governor encourage the Congressional delegation to seek federal appropriations and funds from national business and conservation groups to fund the majority of grizzly bear management activities in Idaho. A trust or endowment concept has been developed through the Interagency Grizzly Bear Committee. This proposal is a good starting point from which to seek a stable funding mechanism for grizzly bear management.

"It is also logical that the legislature appropriate state revenues from general sources to fund some portions of grizzly bear management. It would be preferable to use state funds rather than federal funds to investigate, confirm, and pay depredation losses and damage claims to private property. State funds are not subject to National Environmental Protection Act and other federal oversight requirements. The use of hunting license, federal aid to fish and wildlife, and nongame funds should be continued at historic levels, but additional management obligations created when the bears are returned to state management should be funded with new revenue sources."

We addressed the concern about cumulative effects analysis. We deleted the paragraph that caused confusion about who was responsible for cumulative effects analysis. The Draft Plan now reads as follows: "While IDFG recognizes the need to minimize negative impacts, it has no direct jurisdiction over land management activities on a majority of the land adjacent to the PCA. Therefore, IDFG will act in an advisory capacity with regard to potential impacts on grizzly bear habitat, encouraging land management agencies to consider the following grizzly bear issues in their land management plans:..."

4. Commission Concern: "The authority of the Idaho Fish and Game Commission and Department to actually mange the grizzly population within the state is difficult to discern. We recognize it would be exercised in cooperation and coordination with the affected adjacent states and national park. (Note: Yellowstone National park exclusive jurisdiction is understood) but the role and authority of the continuing federal structure seems undiminished and dominant even after delisting. This complex relationship needs full and detailed explanation.

> Response: The DAT reviewed the Agency Responsibilities section of the Draft Plan. We modified the first sentence of that section to read as follows: "Idaho Dept. of Fish and Game (IDFG), under the direction of the Idaho Fish and Game Commission, will be the primary agency responsible for management of Yellowstone grizzly bears in Idaho." The Agency Responsibilities section also contains additional discussion about the Yellowstone Grizzly Bear Management Committee of which IDFG is a member.

5. Commission Concern: "Perhaps the central concern of the Commission is the fact that very significant obligations and costs would be placed on the Department, with relatively little latitude of management. Department costs, of course, would have to be borne by the State's license and tag revenues from species other than grizzly. While other potential sources of revenue are

suggested, they do not actually exist and may or may not ultimately come to pass. A strategy to limit Department obligation and costs in the absence of other funding sources is essential. The role of Wildlife Services in the handling of problem bears should be considered and discussed."

> Response: In the Agency Responsibilities section, the following statement is made: "The Department will implement approved management actions within the financial, staffing, and legal limits that exist." Also see item number 3 above.

With regard to the role of Wildlife Services, the following was added to the Draft Plan: "IDFG working with Wildlife Services (WS) will be the responsible agency dealing with livestock depredation in the same manner as other livestock depredation policies."…"In cases involving livestock depredation, management actions will follow the Memorandum of Understanding (MOU) between the Idaho State Animal Damage Control Board and IDFG which states that "The Board is responsible for prevention and control of damage caused by predatory animals and other vertebrate pests, including threatened and endangered species within the State of Idaho as described in Section 25-128, Idaho Code, and has delegated such responsibility to Wildlife Services." The MOU also states that "Both parties (IDFG and WS) shall consult and cooperate in any trapping efforts. WS will be the lead agency on capture and the Department shall be responsible for immobilization, handling, and release of grizzly bears."

6. Commission Concern: "The plan should provide for the option of hunting as a management tool at the discretion of the Idaho Fish and Game Commission whenever the population is above a specific well defined threshold, and other biological circumstances and criteria do not preclude the action. The bear population needs to be managed in the same manner as other state species by using hunting as an active tool. This is a very critical consideration and bears directly on the question involving costs to the Department."

> Response: The DAT reviewed the Harvest Management section in the Draft Plan. We believe this section clearly provides for the option of hunting as a management tool. When we reviewed this section, we realized that we used verbs such as "will" and "shall," which may have taken away necessary flexibility in providing for hunting opportunity. The DAT replaced some of those verbs with "could" and "may." The following wording was also added to this section: "Although this plan provides general guidance for the management of grizzly bear hunting opportunity, the Idaho Fish & Game Commission has ultimate authority and discretion for establishment of take seasons and methods of take for game animals."

7. Commission Concern: "The issue of geographic expansion of the population needs refinement. The specific localities should be defined, with rational stated, rather than using "conflict" as the determining factor."

> Response: The DAT reviewed the Distribution and Occupancy section of the Draft Plan. The Draft Plan provides the following with regard to geographic expansion of the population: "The majority of the biologically suitable habitat occurs on the Caribou-Targhee National Forest. A lesser amount of biologically suitable habitat occurs on public and state lands adjacent to the National Forest land. It is also anticipated that grizzly bears will occasionally occur on private lands."

"During the next five to ten years, it is expected that grizzly bears will occur within the primary PCA and will continue to expand outside of the PCA to the following general areas: west through the Centennial Mountains; through the Island Park Caldera and out through the Bishop Mountain area and Big Bend Ridge areas; south along the Westslope of the Tetons and into the Palisades and Big Hole Mountain areas (Fig. 1)."

The DAT added the following statement to the Draft Plan in the Distribution and Occupancy section: "Grizzly bears are unique animals in their ability to exist in a wide range of habitats and habitat conditions. It would be premature to identify specific suitable habitats given their flexibility in habitat use. Furthermore, it is anticipated that grizzly bears can successfully occupy a wide range of habitats in eastern Idaho and that compatible co-existence with traditional uses will be a major determining factor for their future distribution. Grizzly bears will not be tolerated in areas with high human activity and/or development.

8. Commission Concern: "The "10-mile buffer" need and rationale needs full discussion. Why does the PCA not in itself accomplish the purpose?"

> Response: The DAT reviewed the 10-mile buffer concept in detail. At the present time, the Draft Conservation Strategy for the Grizzly Bear in the Yellowstone Area requires population and mortality monitoring in the 10-mile buffer and to be included in the population monitoring and mortality within the PCA. The rationale for this is that some grizzly bears inside the PCA will have home ranges that extend into the 10-mile buffer, and therefore population and mortality monitoring should extend into the 10-mile buffer. The DAT notes that the Governor's Roundtable and currently the states of Montana and Wyoming are recommending elimination of the 10-mile buffer. However, doing away with it depends on the development of the Final Conservation Strategy for the Grizzly Bear in the Yellowstone Area (i.e., a decision on whether production and mortality will be counted within a 10mile buffer awaits completion of the Final Conservation Strategy.) We have removed all references to the 10-mile buffer in the Draft Plan except where specifically referred to in the Draft Conservation Strategy for the Grizzly Bear in the Yellowstone Area.

9. Commission Concern: "The full authority and discretion of the Commission to regulate and define hunting methods for all game species within the state (excluding YNP) should be clearly stated. Reference to specific practices should be deleted."

   Response: See item number 6 above.

APPENDIX VI – Grizzly Bear Delisting Advisory Team Response to Public Comments Summary (January 22, 2002)

Idaho Wildlife Federation
1. Motorized Access and Habitat Management. No change was made in the Draft Plan. The DAT believed the wording in the Draft Plan was OK regarding motorized access and habitat management inside the PCA versus outside the PCA.
2. Livestock/Grizzly Bear Conflicts. The DAT added wording to clarify that compensation for depredation would come from the secondary depredation account.
3. Needing a definition for the word 'promptly' in investigating human/grizzly bear conflicts. The DAT changed the word 'promptly' to 'immediately,' but declined to specify or define an exact number of minutes or hours. Each situation is going to be different depending on many site-specific variables.
4. Harvest Management. The DAT did not believe the Draft Plan should be held up while the States of Montana, Wyoming and Idaho develop a mechanism for allocating harvest of grizzly bears. The Draft Plan recognizes the need to do this and directs the State to do it.
5. Harvest Management - Fee Structure. The DAT deleted the paragraph that recommended a high fee structure.
6. Program Costs and Funding. The DAT changed this section to respond to Commission concerns, and these changes address Idaho Wildlife Federation comments.
7. Program Costs and Funding, as they relate to depredation claims. Wording for item number 2 above responds to this concern.

Michael Adams
1. Trapping and Relocating Bears. The DAT clarified the wording on trapping and relocating bears in response to his comments and other comments received from the public.
2. Confusion over removing bears causing a human fatality. The DAT made no changes in the Draft Plan. Careful reading shows that wording on page 17 is for outside the PCA, and wording on page 35 is for inside the PCA.

Idaho Farm Bureau Federation (IFBF)
1. IFBF opposes the 10-mile buffer. This was also a concern expressed by the Commission. See the DAT response to Commission concerns about the 10-mile buffer and how the DAT has responded to it.
2. IFBF recommends that the term 'publics' be expanded to include 'citizens of Eastern Idaho.' No change was made, as the DAT believes the term 'publics' includes citizens of Eastern Idaho.
3. IFBF recommends rewriting the section on motorized access and habitat management so it is more user friendly. The DAT made no changes in the Draft Plan, as the existing wording was worked out with a variety of interests who were represented on the Team.
4. IFBF objects to the statement 'IDFG will encourage land management agencies to consider the grizzly bear in their livestock management plans.' The DAT made no changes in the Draft Plan, as the existing wording was worked out with a variety of interests who were represented on the Team.

5. IFBF objects to IDFG monitoring private land development activities. The DAT made no changes in the Draft Plan, as the existing wording was worked out with a variety of interests who were represented on the Team.
6. IFBF does not support IDFG funding an I&E position for grizzly bears (they will withdraw their objection if the USFWS or Congress appropriate money). This appears to be a funding issue. The DAT made some changes in the Cost and Funding section of the Draft Plan in response to Commission concerns (see the DAT response to Commission concerns).
7. IFBF does not support license fund expenditures for creating 'Bear Smart Communities.' This appears to be a funding issue. The DAT made some changes in the Cost and Funding section of the Draft Plan in response to Commission concerns (see the DAT response to Commission concerns).
8. IFBF is concerned how IDFG will help resolve conflicts between bears and those who live, work, or recreate in bear occupied areas. No changes were made to the Draft Plan, as the DAT believes the Public Information and Education section and the Conflict Management section of the Draft Plan give direction on resolving conflicts.
9. IFBF prefers that USFWS bear the costs of securing grant funding and/or expenditures for implementing bear proof garbage containers & landfills. This appears to be a funding issue. The DAT made some changes in the Cost and Funding section of the Draft Plan in response to Commission concerns (see the DAT response to Commission concerns).
10. IFBF is concerned that aversive conditioning will not work. Aversive conditioning is still being tried and studied. The DAT did not make any changes in the Draft Plan based on this comment, and believes that aversive conditioning should be an optional management tool.
11. IFBF suggests that the statement 'Grizzly bears occupying areas where the potential for conflicts are high (i.e. subdivisions) will be proactively managed to prevent damage and provide for human safety' be clarified to mean that the bears will be 'removed quickly and permanently.' While the DAT did not use the suggested terminology, the wording in the conflict section was re-worked to clarify the DAT's intent.
12. IFBF would prefer clarification between the terms 'unnatural aggression' and 'natural aggression.' Those definitions are already in the Draft Plan in Appendix IV.
13. IFBF objects to the Shoshone-Bannock tribe exercising their treaty hunting rights off of the reservation. The DAT made no changes in the Draft Plan, as Native American treaty rights are beyond the scope of the plan.
14. IFBF opposes the use of state general funds for grizzly bear management. This appears to be a funding issue. The DAT made some changes in the Cost and Funding section of the Draft Plan in response to Commission concerns (see the DAT response to Commission concerns).

Brian Rogers
1. Harvest Management. The DAT believes the section on Harvest Management in the Draft Plan adequately addresses all of the concerns raised by Brian Rogers.
2. Maintaining Roadless Habitat on the Caribou-Targhee National Forest. The DAT believes the section on Distribution and Occupancy addresses the proper relationship between a State Management Plan and Federal land management agencies.

Predator Conservation Alliance
1. Motorized Access and Habitat Management – Protection of Roadless Areas – Habitat Restoration – Developments on Private Lands. No changes were made in the Draft Plan, as the DAT believes the section on Distribution and Occupancy addresses the proper relationship between a State Management Plan, Federal land management agencies, and private landowners.
2. Population Monitoring – should not be confined to just the 10-mile buffer. No changes were made in the Draft Plan as the population monitoring section does not confine monitoring to just the 10-mile buffer.
3. Public Information and Education. The DAT made some wording changes in the Public Information and Education section to strengthen the management direction in this section.
4. Nuisance Grizzly Bear Management – what does 'proactively managed' mean? The DAT reworded this to clarify what was meant.
5. Nuisance Grizzly Bear Management – too much emphasis on moving and killing bears. The DAT made no changes in the Draft Plan, as the existing wording was worked out with a community of interests who were represented on the Team.
6. Harvest Management. Several opinions were expressed by Predator Conservation Alliance. The DAT reviewed the Harvest Management section, and no changes were made.
7. Harvest Management – we do not understand the final line of this section about the cost of hunting fees. The DAT deleted the entire paragraph discussing the cost of hunting fees.

The Fund for Animals
1. The Fund for Animals basically said the Plan must focus first and foremost on the bears' interests, not on human interests. They wanted more direction in the Plan to restrict human activities to accommodate the grizzly bear. They stated, 'As distasteful as it may be to some, the interests of the public's wildlife should always take precedence over the interests of private domestic livestock or other commercial interests on public lands.' The DAT reviewed all of the recommendations and opinions stated in their letter, and decided that no changes were needed in the Draft Plan for the following reasons: The Draft Plan was developed with a community of interests who were represented on the Team. The DAT believes the section on Distribution and Occupancy addresses the proper relationship between a State Management Plan, Federal land management agencies, and private landowners. The DAT believes that by maintaining existing uses, people will feel less threatened both economically and in their lifestyles, thus building support and increasing tolerance for a greater expansion of the bear population. The key to a greater expansion of the grizzly bear population lies in bears utilizing lands that are not managed solely for them but in which their needs are adequately considered along with other uses.

National Wildlife Federation
1. Establishment of some kind of numerical or occupancy objectives for the species. The DAT believes the 'Grizzly Bear Recovery Plan' and the 'Draft Conservation Strategy' establish numerical and occupancy objectives for the purposes of recovering and delisting the bear from the Endangered Species Act. The Draft Plan allows for the expansion of the grizzly bear population into biological suitable and socially acceptable areas, and it establishes population and habitat monitoring criteria. The DAT does not believe it is possible to develop numerical or occupancy objectives at this time for areas outside of the PCA. It will take time to see and document how grizzly bears continue to expand and where conflicts occur before meaningful numerical or occupancy objectives can be established.
2. Translocating bears into unoccupied habitat. The DAT believes the Draft Plan is a bold plan in that it allows for the natural expansion of grizzly bears into areas that are biologically suitable and socially acceptable. No changes were made in the Draft Plan to allow for the translocating of bears into unoccupied habitat in the state of Idaho, however, the plan was altered to allow for relocation of bears to 'acceptable areas outside the state'.
3. Management on Federal Lands. No changes were made in the Draft Plan, as the DAT believes the section on Distribution and Occupancy addresses the proper relationship between a State Management Plan and Federal land management agencies.
4. Livestock grazing on public lands. No changes were made in the Draft Plan, as the DAT believes the section on Distribution and Occupancy addresses the proper relationship between a State Management Plan and Federal land management agencies.
5. Establishing habitat criteria for grizzly bears. The DAT believes that by maintaining existing uses, people will feel less threatened both economically and in their lifestyles, thus building support and increasing tolerance for a greater expansion of the bear population. The key to a greater expansion of the grizzly bear population lies in bears utilizing lands that are not managed solely for them but in which their needs are adequately considered along with other uses. No changes were made in the Draft Plan.
6. Thank you for acknowledging that the public information and education program is well designed.
7. Suggested modification to the statement that there will be no prosecution of any individual who injures or kills a grizzly bear while acting in self-defense. No changes were made in the Draft Plan, as the DAT believes the existing statement helps build public support for expansion of the grizzly bear. The Federation acknowledges that the public information and education program is well designed, and the DAT believes this will reduce human/grizzly bear conflicts.
8. Recommendation to change the statement about no additional restrictions on the hunting/trapping of other legally harvested animals inside or outside the PCA as a result of grizzly bear distribution and occupancy. The Federation would like a statement saying that some restrictions may be necessary to avoid creating problems. No changes were made in the Draft plan.

Defenders of Wildlife
1. Defenders of Wildlife basically said the Plan must focus first and foremost on the bears' interests, not on human interests. They wanted more direction in the Plan to restrict human activities to accommodate the grizzly bear. They wanted the Draft Plan to give more direction to the management of State Lands, increased population monitoring emphasis, incorporation of 'Living with Carnivores Program,' concerns about harvest

management, a section added on enforcement, and establishment of linkage zones. The DAT reviewed all of the recommendations and opinions stated in their letter, and decided that no changes were needed in the Draft Plan for the following reasons: The Draft Plan was developed with a community of interests who were represented on the Team. The DAT believes the section on Distribution and Occupancy addresses the proper relationship between a State Management Plan, Federal land management agencies, and private landowners. The DAT believes that by maintaining existing uses, people will feel less threatened both economically and in their lifestyles, thus building support and increasing tolerance for a greater expansion of the bear population. The key to a greater expansion of the grizzly bear population lies in bears utilizing lands that are not managed solely for them but in which their needs are adequately considered along with other uses. The Commission declined to participate in the 'Living with Carnivores Program.' State lands are managed as set forth by the State Constitution, and they are only a very small part of the area bears are expected to occupy. Enforcement concerns will be taken care of when the grizzly bear becomes a big game animal. Also, the State legislature sets fines, and it is not the place to do that in this Draft Plan.

Idaho Cattle Association
1. General Thoughts – recommendation that the DAT include representation from stakeholders especially livestock operators and county officials. The DAT did include a member representing livestock operators and two former county commissioners. Upon delisting, grizzly bears will not be managed by the DAT. Management of the population, including responsible parties, is discussed in the Draft Plan.
2. Size and Scope of Habitat and Distribution and Occupancy – focus only on the existing Recovery Zone or PCA. The DAT believes the grizzly bear can expand into areas that are biologically suitable and socially acceptable. The Draft Plan provides direction for maintaining existing uses, with site-specific evaluations where necessary to deal with conflicts. The DAT believes that by maintaining existing uses, people will feel less threatened both economically and in their lifestyles, thus building support and increasing tolerance for a greater expansion of the bear population. The key to a greater expansion of the grizzly bear population lies in bears utilizing lands that are not managed solely for them but in which their needs are adequately considered along with other uses.
3. The ICA had several concerns related to habitat management, native plant species, livestock conflicts, habitat monitoring, habitat restoration, and population monitoring. The DAT reviewed all of these concerns, and decided that no change was needed in the Draft Plan. The Draft Plan was developed with a community of interests who were represented on the Team.
4. Public Information and Education – need to add ranchers and/or livestock operators. The DAT did add ranchers to the list of groups in this section.
5. Conflict Management – include Wildlife Services and additional detail to allow livestock owners or their agents to remove a bear that is in the presence of their livestock. The DAT added additional wording referencing the MOU between IDFG and Wildlife Services. The DAT did not add additional detail to allow livestock owners or their agents to remove a bear that is in the presence of their livestock. Those details can be worked out between the IDFG and livestock owners as State grizzly bear management is implemented.

6. Nuisance Grizzly Bear Management – preemptive removal when necessary. The DAT added additional wording in this section of the plan to better explain when preemptive removal could be used.
7. Program Cost and Funding. The DAT added and changed wording in this section to address concerns that were raised by the Commission and others about cost and funding.

USDA – APHIS – Wildlife Services
1. Nuisance Grizzly Bear Management – clearly indicate which agencies will respond to nuisance grizzly bear problems. The DAT changed wording in the document to clearly indicate that IDFG would be the lead agency responding to problems.
2. Existing MOU between the Idaho State Animal Damage Control Board and the IDFG. The DAT added a paragraph describing the MOU and clarifying responsibilities between Wildlife Services and IDFG.

Alliance for the Wild Rockies
1. Alliance for the Wild Rockies wanted more direction in the Plan to restrict human activities to accommodate the grizzly bear. They said: "We feel that the current proposal fails to use the best available science to protect the bear and maintain long-term viability. "In general, we feel the plan relies far to heavily on managing the bears as opposed to managing the people." "We strongly request that IDFG seek expansion of food storage orders statewide." Regarding motorized access and habitat management, they said, "This statement is so weak as to be meaningless." Regarding livestock conflicts, they wanted a MOU to be developed between IDFG and land management agencies. They said, "It is critical for the long-term viability of the population that habitat protections be applied to all areas that could be reoccupied within the GYE" They recommended keeping all roadless areas roadless for the future of the grizzly bear. They wanted to see more creative ideas in addressing livestock conflicts. For nuisance grizzly bear management, they said "We are concerned that too much latitude is afforded in situation where non-habituated bears could be moved." They said: "The plan does not adequately address future uncertainties. Grizzly bear require large blocks of unfragmented undeveloped wilderness and roadless areas in order to survive. They require entire ecosystems to meet their habitat needs for sustaining their life cycles. Clear cutting, road building, oil and gas development, mining and real estate development continue to degrade important grizzly bear habitat, reducing their ability to forage and increasing their changes of conflict with humans." The DAT reviewed all of the recommendations and opinions stated in their letter, and decided that no changes were needed in the Draft Plan for the following reasons: The Draft Plan was developed with a community of interests who were represented on the Team. Many of their opinions and recommendations pertained to responsibilities of Federal land management agencies, and not the state or IDFG. The DAT believes the section on Distribution and Occupancy addresses the proper relationship between a State Management Plan, Federal land management agencies, and private landowners. The DAT believes that by maintaining existing uses, people will feel less threatened both economically and in their lifestyles, thus building support and increasing tolerance for a greater expansion of the bear population. The key to a greater expansion of the grizzly bear population lies in bears utilizing lands that are not managed solely for them but in which their needs are adequately considered along with other uses.

Caribou-Targhee National Forest

1. Provide more clarification on the relationship between the Recovery Plan, Conservation Strategy, Recovery Zone or PCA. The DAT added a paragraph in the Introduction to help clarify this relationship.
2. Clarify the membership and relationship of the various management committees. The DAT did not believe this was needed in the Draft Plan.
3. Clarify the purpose of the 10-mile buffer. The DAT reviewed the 10-mile buffer concept in detail. At the present time, the Draft Conservation Strategy for the Grizzly Bear in the Yellowstone Area requires population monitoring and mortality to occur in the 10-mile buffer and to be included in the population monitoring and mortality within the PCA. The rationale for this is that some grizzly bears inside the PCA will have home ranges that extend into the 10-mile buffer, and therefore population and mortality monitoring should extend into the 10-mile buffer. The DAT notes that the Governor's Roundtable and currently the states of Montana and Wyoming are recommending elimination of the 10-mile buffer. However, doing away with it depends on the development of the Final Conservation Strategy for the Grizzly Bear in the Yellowstone Area. We have removed all references to the 10-mile buffer in the Draft Plan except where specifically referring to the Draft Conservation Strategy for the Grizzly Bear in the Yellowstone Area.
4. "Given that the bear had a large historical range of habitats that it occupied, it seems that social acceptance, not biological suitability is the limiting factor to the bear's recovery." The DAT believes that this statement is correct, but no additional wording or changes were made in the Draft Plan.
5. "Why is livestock management singled out for coordination outside the PCA? The DAT believes there is a long history with scientific documentation that grizzly bears like livestock. Given the distribution of livestock grazing in areas that are likely to see grizzly bear expansion, we anticipate increased management and coordination.
6. Habitat Monitoring – add the following: "IDFG will identify important spring habitat for bears, the work with landowners to minimize impacts to bears during their period of use." The DAT added this wording to the Draft Plan.
7. Habitat Restoration – add "…introducing prescribed fire to achieve more diverse landscapes and early seral vegetation…" The DAT did not add this to the Draft Plan, as we thought it was a 'method' and we did not list all methods that could be used to do habitat restoration.
8. Population Monitoring – clarify all the various teams and committees working on this. The DAT did not believe this was needed in the Draft Plan.
9. Harvest Management – define 'surplus animals.' The DAT changed the wording in the Draft Plan, as the term 'surplus animals' was confusing to many publics who reviewed the Plan.

Idaho Conservation League
1. Relocation of grizzly bears. The DAT did change the wording in the Draft Plan about relocating grizzly bears to clarify where it applied.
2. Public Information and Education – list of 7 items. The DAT changed the wording as recommended by ICL.
3. Conflict Management – add the word 'quickly.' The DAT changed the wording as recommended by ICL.
4. Sanitation – the Draft Plan does not address it adequately. The DAT reviewed this concern and decided that the Draft Plan addresses it adequately.

5. Restrict kinds of baits used for management and research activities by IDFG. The DAT did not change the Draft Plan. It is important that IDFG be able to respond quickly to management needs and to be able to use the most effective baits to resolve a conflict situation.
6. Shoshone-Bannock Tribes. The DAT did not change the Draft Plan as recommended by ICL.
7. Hunting methods. The DAT did not add this to the Draft Plan, as we thought it was a 'method' and we did not list all methods that could be used.
8. Add human/grizzly bear conflicts to the definitions. The DAT agreed, and this was added to the Draft Plan.

Appendix L. Reassessing Methods to Estimate Population Size and Sustainable Mortality Limits for the Yellowstone Grizzly Bear

Reassessing Methods to Estimate Population Size and Sustainable Mortality Limits for the Yellowstone Grizzly Bear[1]

Report detailing discussion of issues covered during workshops at Fort Collins, Colorado, 1–4 February, and Bozeman, Montana, 23–25 March and 11 May 2005

photo by Dan Stahler, YNP

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CONTENTS

SUMMARY AND MANAGEMENT RECOMMENDATIONS

Workshop Objectives: Our objectives were to (1) evaluate current information to establish methods to estimate total population size and sustainable mortality, and (2) address issues of unknown and unreported mortality for the grizzly bear population in the Greater Yellowstone Ecosystem.

Results of this workshop will be used to revaluate the basis and application rules for sustainable mortality limits. Our goal is to ensure that mortality management of the Greater Yellowstone Ecosystem grizzly bear population is based on the best available science and will maintain long-term population viability. This effort was undertaken as per the commitment of all management agencies to employ adaptive management using the best available science to manage the Greater Yellowstone Ecosystem grizzly bear population.

The Yellowstone Grizzly Bear Demographics Team in cooperation with the Interagency Grizzly Bear Study Team (IGBST) will use the following procedures to establish and track sustainable mortality for grizzly bears (*Ursus arctos*) in the Greater Yellowstone Ecosystem (GYE) and recommends the following specific demographic targets for management.

Independent Females
Population estimate.—We will estimate the number of independent (age ≥2 years) female grizzly bears in the population for the GYE using methods outlined in this document. Counts of unduplicated females with cubs-of-the-year (FCOY) and sighting frequencies will follow methods outlined by Knight et al. (1995). The total number of FCOY will be estimated using the $Chao_2$ estimator (Keating et al. 2002) with observed count frequencies. Estimates of FCOY represent a segment of the female population ≥4 years of age. Total females ≥4 years of age (with and without cubs-of-the-year) will be estimated by dividing the $Chao_2$ estimator by 0.289, the estimated proportion of females ≥4 years of age in the population with cubs-of-the-year based upon transition probabilities calculated from the telemetry sample (Appendix C). The resulting estimate represents, on average, the total number of females ≥4 years of age in the GYE population. This value will be divided by 0.773, the estimated proportion of female bears ≥4 years of age in the population of females ≥2 years of age. The resulting value represents the best estimate of total independent female bears (age ≥2 years old) in the GYE.

For example, using 2004 data, we estimate 57.5 total FCOY using the $Chao_2$ estimator (Table 1) based on the observed count of 48 unique females with cubs. This results in an estimate of 199 (57.5/0.289 = 199) females ≥4 year old and 257 (199/0.773 = 257) females in the female population ≥2 year old.

Table 1. Example of empirical data and calculated estimates of total independent (age ≥2 years old) female grizzly bears in the Greater Yellowstone Ecosystem, 1999–2004.

Year	Observed count	Chao$_2$	Females ≥4 years old	Females ≥2 years old
1999	30	36.0	125	161
2000	34	51.0	176	228
2001	39	48.2	167	216
2002	49	58.1	201	260
2003	35	46.4	161	208
2004	48	57.5	199	257

Sustainable mortality limit.—The mortality limit for independent female bears will be set at 9% (equivalent to a survival rate of 91% for these age classes) of the population estimate for females ≥2 years old based on Harris et al. (2005). All mortalities will be counted including: (1) known and probable human-caused deaths, (2) reported deaths due to natural and undetermined causes, and (3) estimated unknown and unreported losses. The 9% mortality threshold was chosen because simulations suggest that with survival ≥0.91, the annual growth rate (λ) of the population is ≥1.0 with a 95% level of certainty (Harris et al. 2005, Schwartz et al. 2005*c*).

Unknown and unreported mortality.—Unknown and unreported mortality will be estimated based on the method of Cherry et al. (2002). This method assumes that all deaths associated with management removals (sanctioned agency euthanasia or removal to zoos) and deaths of radiomarked bears are known. It calculates the number of reported and unreported mortalities based on counts of reported deaths from all other causes. To demonstrate this method, using 2004 data of 5 reported deaths, we estimated that 13 actually died (reported plus unknown and unreported; Table 2). We add to this estimate bears that died as a result of agency removal (4) and deaths of radiomarked bears that were not sanctioned removals (0), to estimate total mortality from all causes = 17 (4 + 0 + 13 = 17). Details of the method and application can be found in Cherry et al. (2002). The number of publicly reported deaths of uncollared bears, together with the beta distribution estimated from the observed reporting rate (0.37 reported:0.63 unreported), are used to estimate a posterior distribution for total annual reported and unreported mortality (Appendices B and D).

Table 2. Example of empirical data and calculated estimates of unreported mortality for female grizzly bears ≥2 years old in the Greater Yellowstone Ecosystem, 1999–2004.

Year	Agency removal	Telemetry	Reported	Reported and unreported	Estimated total mortality
1999	0	0	1	2	2
2000	1	1	3	7	9
2001	5	3	1	2	10
2002	2	2	4	10	14
2003	1	0	5	13	14
2004	4	0	5	13	17

Allowable mortality limits.—To dampen variability and provide managers with inter-annual stability in the threshold, allowable mortality limits will be based on a 3-year running average of the 9% annual limit. For example, the female population estimate in 2004 was 257 female bears

≥2 years old (Table 3). The 9% annual mortality limit based on this estimate = 23 female bears (257 x 0.09). The 3-year average of allowable female mortality = 22 ([23 + 19 + 23]/3). Estimated total mortality for 2004 = 17. Therefore the estimated female mortality for 2004 was 5 bears below the allowable mortality limit of 22.

Table 3. Independent female population size, annual mortality limit based on 9% mortality, allowable female mortality limit based on the 3-year running average, and estimated total female mortality for the Greater Yellowstone Ecosystem, 1999–2004.

Year	Estimated population of females ≥2 years old	9% annual mortality limit	Allowable mortality (3-year average)	Estimated total mortality
1999	161	14		2
2000	228	21		9
2001	216	19	18	10
2002	260	23	21	14
2003	208	19	20	14
2004	257	23	22	17

Independent Males

Population estimate.—An estimate of independent males (age ≥2 year old) will be based on the estimate of independent females and the modeled sex ratio of the population (Harris et al. 2005). Based on current estimates of reproduction and survival, the modeled sex ratio is 0.377:0.623 M:F. Therefore the male segment represents 60.5% (0.377/0.623 = 0.605) of the female population (there are 0.605 male bears for every female bear).

Sustainable mortality limit.—The mortality limit for independent male bears will be set at 15% of the population estimate for males ≥2 years old based on Harris et al. (2005). All mortalities will be counted including: (1) known and probable human-caused deaths, (2) reported deaths due to natural and undetermined causes, plus (3) calculated unknown and unreported losses. The 15% mortality threshold was chosen because it approximates what occurred in the GYE from 1983–2001 (Haroldson et al. 2005), a period when population was estimated to have increased around 4–7% per year (Harris et al. 2005).

Unknown and unreported mortality.—Estimates of unknown and unreported mortality for independent males will be based on the method of Cherry et al. (2002).

Allowable mortality limits.—To dampen variability and provide managers with inter-annual stability in the mortality threshold, allowable mortality limits will be based on a 3-year running average of the 15% annual limit (Table 4). For example, the female population estimate in 2004 = 257 female bears ≥2 years old. The number of independent males (age ≥2 years) is estimated at 156 (257 x 0.605 = 156). The 15% limit based on this estimate = 23 (156 x 0.15 = 23) male bears. The 3-year average = 22 ([24 + 19 + 23]/3) and the estimated total mortality for 2004 = 23. Therefore, estimated mortality in 2004 was 1 bear above the allowable mortality limit (23 - 22 = 1).

Table 4. Independent female and male population size, annual 15% mortality limit for independent males, allowable male mortality limit based on the 3-year running average, and estimated total male mortality for the Greater Yellowstone Ecosystem, 1999–2004.

Year	Estimated population of females ≥2 years old	Estimated population of males ≥2 years old	Estimated 15% annual mortality limit	Allowable mortality (3-year average)	Estimated total mortality
1999	161	97	15		11
2000	228	138	21		35
2001	216	131	20	18	11
2002	260	157	24	21	12
2003	208	126	19	21	12
2004	257	156	23	22	23

Dependent Young

Population estimate.—The number of cubs in the annual population estimate will be calculated directly from estimates of FCOY as determined by the $Chao_2$ estimator. We assume average litter size of 2 cubs (Schwartz et al. 2005*a* estimated mean litter size = 2.04), and a 50:50 sex ratio. The number of yearlings in the population will be estimated from the number of cubs the previous year that survived. We assume cub survival = 0.638 (Schwartz et al. 2005*b*). We estimate the number of yearlings in the population in a given year by taking the estimated number of cubs the previous year times 0.638. For example, we estimate dependent young in 2004 to be 115 cubs-of-the-year (57.5 x 2 = 115) and 59 yearlings (93 cubs in 2003 x 0.638 = 59) and 115 + 59 = 174 (Table 5).

Table 5. Annual estimated number of females with cubs-of-the-year ($Chao_2$), cubs, yearlings, and dependent young in the Greater Yellowstone Ecosystem, 1999–2004.

Year	$Chao_2$	Number cubs	Number yearlings	Number dependent young
1999	36.0	72	47	119
2000	51.0	102	46	148
2001	48.2	96	65	162
2002	58.1	116	62	178
2003	46.4	93	74	167
2004	57.5	115	59	174

Sustainable mortality limit.—The mortality limit for dependent bears of both sexes will be set at no more than 9% of the total estimate in the population (4.5% for each sex assuming 50:50 sex ratio). Only reported known and probable human-caused deaths will be tallied against the threshold. Most recorded mortality of dependent young is from natural causes (Schwartz et al. 2005*b*) and is accommodated for in this limit. The 9% threshold (4.5% for each sex) approximates what was observed historically. From 1983–2001, survival to age 2 years was

estimated to be 0.52 (0.638 x 0.817). Human-caused mortality was estimated at 14.4% (approximately 30% of the 48%) for each sex (Schwartz et al. 2005*a*).

Unknown and unreported mortality.—We lack empirical data to estimate unknown and unreported mortality for dependent young. To be conservative, we assumed it was similar to that for independent bears (empirical data 0.37 reported:0.63 unreported, we simplified that to approximate 1 reported:2 unreported). Allowing for 4.5% recorded mortality for each sex and assuming an additional 9% unreported (4.5% reported: 2 x 4.5% unreported = 9%), resulted in 13.5% (4.5 + 9.0 = 13.5%) total human caused mortality for each sex. This is less than the 14.4% human-caused documented mortality for each sex from 1983–2001 as discussed above.

Allowable mortality limit.—To dampen variability and provide managers with inter-annual stability in the threshold, allowable mortality limits will be based on a 3-year running average of the 9% annual limit (Table 6).

Table 6. Annual estimated number of dependent young, estimated 9% mortality limit, allowable mortality limit based on a 3-year running average, and reported human-caused mortality from 1999–2004.

Year	Number of dependent young	Estimated 9% annual mortality limit	Allowable mortality (3-year average)	Reported human-caused losses
1999	119	11		2
2000	148	13		7
2001	162	15	13	6
2002	178	16	15	5
2003	167	15	15	3
2004	174	16	16	11

Total Population Size
Total population size will be estimated annually from the sum of independent female, independent male, and dependent bears (Table 7).

Table 7. Annual estimates of independent female, independent male, dependent young, and total population size for the grizzly bear population in the Greater Yellowstone Ecosystem, 1999–2004.

Year	Estimated population of females ≥2 years old	Estimated population of males ≥2 years old	Number of dependent young	Total population size[a]
1999	161	97	119	378
2000	228	138	148	514
2001	216	131	162	508
2002	260	157	178	595
2003	208	126	167	500
2004	257	156	174	588

[a] Slight differences in total due to rounding.

Demographic Objectives

Under the Conservation Strategy, the IGBST is responsible for carrying out a biology and monitoring review. Such reviews are triggered by negative deviations from the desired conditions established in the Conservation Strategy for population, mortality reduction, and habitat parameters. The Conservation Strategy (USFWS [U.S. Fish and Wildlife Service] 2003:6) states that "it is the goal of the agencies implementing this Conservation Strategy to manage the Yellowstone grizzly population in the entire GYA [Greater Yellowstone Area] at or above 500 grizzly bears." Because of the increased level of uncertainty in estimating total population size using the methods we propose here, and because long-term survival of the GYA grizzly bear is most closely linked to survival of adult females (Eberhardt 1977, 1990, 2002; Knight and Eberhardt 1987; Harris et al. 2005), we recommend a demographic target ≥48 adult females (age ≥4 years) be maintained annually. This target of 48 females, when extrapolated, is equivalent to a population of approximately 500 individuals.

This target of 48 will be derived from the point estimate of the $Chao_2$ estimator using frequency counts of unduplicated females with cubs. We recommend the point estimate because: (1) the $Chao_2$ estimator is either accurate relative to actual bear numbers or biased low, and (2) statistically, the point estimate is the best unbiased estimate of the mean. Because we observe normal variation about counts of females related to reproductive performance and foods (Schwartz et al. 2005*b*), we anticipate some natural variation to occur. Short-term fluctuation in counts is therefore expected. We are most concerned with long-term chronic declines in counts which might reflect a declining population. We recommend a biology and monitoring review should the estimate decline below this threshold of 48 for any 2 consecutive years. We make no effort to define all possible management scenarios that might need review. We likewise make no effort to outline in detail recommendations that might come from a biology and monitoring review because each would have its own unique combination of circumstances and data that must be evaluated in light of other information.

Management agencies lack complete control over female mortality. Hence, if the lower one-tailed 80% bound of the $Chao_2$ estimate is <48 in any given year, agencies should attempt to limit female mortality the following year as a proactive measure to help minimize exceeding the

point estimate recommendation above. To illustrate these recommendations, we provide data from 1999–2004 (Table 8).

Although male mortality has no impact on population trajectory over the long run (Harris et al. 2005), we feel that some limits are necessary. We therefore recommend that managers try not to exceed established mortality limits for males as set forth in this document. We recommend that a management review be considered should male limits be exceeded in any 3 consecutive years.

Table 8. Estimated number of females with cubs based on the $Chao_2$ estimator applied to frequency counts of females with cubs-of-the-year in the Greater Yellowstone Ecosystem, 1999–2004.

Year	$Chao_2$ estimated population of females ≥4 years old with cubs-of-the-year	Lower 80% confidence interval of the $Chao_2$ estimate	Biology and monitoring review required	Management threshold exceeded
1999	36	33	–	–
2000	51	44	no	yes
2001	48	44	no	yes
2002	58	54	no	no
2003	46	41	no	yes
2004	58	53	no	no

BACKGROUND

This project began in 2000, following a review of the current methods used to estimate sustainable mortality and issues facing management of the GYE grizzly bear. The IGBST, in cooperation with the U.S. Fish and Wildlife Service, prepared a series of proposals soliciting funding to address the following objectives: (1) evaluate the unduplicated female rule set established by Knight et al. (1995), (2) explore and evaluate techniques to generate an annual estimate of adult females (>3 years of age) incorporating uncertainty, (3) explore and evaluate techniques to generate an annual estimate of total population size incorporating uncertainty, and (4) establish a sustainable mortality quota based on recent demographic information from the GYE. Funding was obtained in FY2001. We established a demographics working group and began to address these issues. Much of the demographics work identified was completed in 2003 and 2004 and submitted for publication. This document summarizes the final phase of this research, namely establishing and recommending sustainable mortality limits for the GYE grizzly bear.

We focus on 3 components: (1) developing methods to estimate total population size, (2) establishing limits on mortality, and (3) addressing unknown and unreported mortality.

Considerable time and effort have been invested in each of these 3 components. We previously explored the application of capture–mark–recapture (CMR) techniques used to estimate bear population size. As described by White (1996), more technologically advanced approaches to CMR estimation have incorporated animals marked with radiotransmitters. The initial sample of animals is captured and marked with radios, but recaptures of these animals are obtained by observing them, not actually recapturing them. The limitation of this procedure is that unmarked animals are not marked on subsequent occasions. The advantage of this procedure is that resighting occasions are cheaper to acquire than physical captures of animals. The CMR procedure has been tested with both black (*Ursus americanus*) and grizzly bears (Schwartz and Franzmann 1991, Miller et al. 1997). We tested the applicability and accuracy of a CMR technique developed for bears in Alaska (Miller et al. 1997) to the GYE in 1998 and 1999 (Schwartz 1999, 2000). We concluded that our recapture rate was too small to return a population estimate with a reasonable confidence interval.

We also explored the application of DNA hair snaring techniques to estimate population size in the GYE. In the past 20 years, there have been significant advancements in the extraction, amplification, and analysis of DNA from hair and scats from various carnivore species (Waits 2004, Waits and Paetkau 2005). Coupled with these advances has been the application of CMR hair snaring techniques to bears (Woods et al. 1999; Mowat and Strobeck 2000; Boulanger et al. 2002, 2004). Issues with these methods include changes in behavioral responses of individuals and the effect on capture probability (Boulanger et al. 2002), genotyping and associated errors (Woods et al. 1999; Mills et al. 2000; Paetkau 2003, 2004; McKelvey and Schwartz 2004), detection rates and grid sizes (Boulanger et al. 2002), and costs (K. Kendall, U.S. Geological Survey, personal communication). We estimated that to accurately sample the GYE with population size at ±20% level of certainty would cost $3.5–5.0 million (based on 2002 data from

K. Kendall, U.S. Geological Survey, Northern Rocky Mountain Sciences Center, Glacier National Park). We ruled out subsampling a representative area due to issues of randomness and violations of statistical sampling theory. At the December 2001 meeting of the Yellowstone Ecosystem Subcommittee in Jackson Hole, Wyoming, the opportunity to pursue funding to partially cover such a population estimate was presented to the group. After considerable discussion centering on costs and potential benefits, the committee recommended the IGBST not pursue funding nor conduct DNA hair snaring in the GYE. The group unanimously felt funds could be better spent addressing management issues including bear-proof dumpsters, sanitation, and other on-the-ground activities that improved survival of bears. As a result of discussions at this meeting, we did not consider DNA CMR further.

CURRENT METHOD

For grizzly bears in the GYE, the 1982 Recovery Plan recommended the development of population monitoring methods and the establishment of mortality thresholds (USFWS 1982); these were developed and reported in the 1993 plan (USFWS 1993) and are summarized below:
- A minimum of 15 FCOY over a running 6-year average both inside the Recovery Zone and within a 10-mile area immediately surrounding the Recovery Zone.
- 16 of 18 Bear Management Units (BMUs) occupied by females with young (cubs, yearlings, or 2-year-olds) for a running 6-year sum of observations, with no 2 adjacent BMUs unoccupied.
- Known human-caused mortality not to exceed 4% of the minimum population estimate based on the most recent 3-year sum of unduplicated FCOY.
   - This rule was amended in 2000 to include probable human-caused mortalities, and cubs accompanying known and probable human-caused female deaths.
- No more than 30% of the 4% mortality shall be females.
- These mortality limits cannot be exceeded during any 2 consecutive years for recovery to be achieved. The threshold is based on a 6-year running average of mortality contrasted with the annual limit established from the 3-year sum of FCOY.

Minimum population size and allowable numbers of human-caused mortalities are calculated as a function of the number of unique FCOY. Identification and separation of FCOY follow methods reported by Knight et al. (1995).

Knight et al. (1995) developed the rule set used to distinguish sightings of unique females from repeated observations of the same female. Females were judged to be different based on 3 criteria: (1) distance between sightings, (2) family group descriptions, and (3) dates of sightings.

Minimum distance for 2 groups to be considered distinct was based on annual ranges, travel barriers, and typical movement patterns. A movement index was calculated using standard diameter of annual ranges (Harrison 1958) of all radiomarked FCOY monitored from 1 May–31 August (Blanchard and Knight 1991). The mean standard diameter for all annual ranges of FCOY was 15 km (SD = 6.7 km). They estimated the average maximum travel distance as twice

the standard diameter, or 30 km, and used this distance to distinguish sightings of unique FCOY from repeat sightings of the same female.

Family groups within 30 km of each other were distinguished by other factors. The Grand Canyon of the Yellowstone, from the lower falls to the confluence of Deep Creek, was considered a natural barrier. Females on either side of this canyon were considered unique. Knight et al. (1995) also discussed paved highways as impediments to travel and cite data presented by Mattson et al. (1987) which showed that grizzlies tended to stay >500 m from roads during spring and >2 km during summer. They provided one example where 2 families considered unique were separated by 2 major highways and were 30 km apart (see Knight et al. 1995:Table 1). Family groups were also distinguished by size and number of cubs in the litter. Once a female with a specific number of cubs was sighted in an area, no other female with the same number of cubs in that same area was regarded as distinct unless (1) the 2 family groups were seen by the same observer on the same day, (2) the 2 family groups were seen by 2 observers at different locations but similar times on the same day, or (3) 1 or both of the females were radiomarked. Because of the possibility of cub mortality, no female with fewer cubs was considered distinct in an area unless (1) she was seen on the same day as the first female, (2) both were radiomarked, or (3) a subsequent observation of a female with a larger litter was made. Knight et al. (1995) assumed that all cubs in a litter were observed and correctly counted. This assumption was strengthened by only considering observations from qualified agency personnel. Observations from the air were only included if bears were in the open and easily observed. Ground observers watched family groups long enough to insure all cubs were seen; observers reported any doubt. Finally, Knight et al. (1995) reference a time–distance criteria but did not provide specific rules for its application. The only example they provided was the separation of 2 sightings of 2 family groups observed 1 day apart and 25 km apart.

Calculations to determine the minimum population size sum the number of FCOY seen during a 3-year period minus the number of recorded adult female mortalities during that period. This value is divided by the estimated proportion of adult females in the population to extrapolate to a population estimate. Because the 3-year sum of FCOY is based on an observed number of unduplicated individuals, it provides a minimum estimate of population size (actually seen), rather than a total estimate. As such, it potentially underestimates both total population size and sustainable mortality limits. As currently used, it does not permit calculation of valid confidence bounds. Estimates of minimum population size in year t ($\hat{N}_{\min, t}$) are calculated as:

$$\hat{N}_{\min, t} = \sum_{i=t-2}^{t} \frac{\hat{N}_{obs, i} - d_i}{0.274} \tag{1}$$

where $\hat{N}_{obs, i}$ (following notation of Keating et al. 2002) is the number of unique FCOY observed in year i (as per Knight et al. 1995), and d_i is the number of known and probable human-caused mortalities of adult females (age >4) in year i.

Mortality limits are set at 4% of $\hat{N}_{\min, t}$ with no more than 30% of this 4% (1.2% of the population) being females. The 1993 recovery plan provides the following example: counts of unduplicated females from 1990–92 were 24, 24, and 23, respectively. Four adult female mortalities were recorded during this period. Following notation in Equation 1, 24 + 24 + 23 - 4 = 67. The original proportion of adult females with cubs was listed as 0.284 in the 1993 plan. That value was updated and changed to 0.274 by Eberhardt et al. (1994:Table 2:362). Using 0.274, we get a population estimate of 67/0.274 = 244, and total and female mortality limits of 9.8 and 2.9 individuals, respectively.

The current method has benefits and limitations. These include:

Benefits
- The method is conservative because limits of mortality are based only on observed females and the minimum population rather than the total population.
- The method has been used since 1993, and during that period the population is estimated to have increased between 4% and 7% per year (Harris et al. 2005:Table 18). Also, during this same period, grizzly bear distribution expanded (Schwartz et al. 2002), lending support to a growing population.

Limitations
- The constant 0.274 (Eberhardt and Knight 1996:417) represents the proportion of adult females in the population, defined as bears ≥5 years of age (USFWS 1993:Appendix C:156; Eberhardt et al. 1994:Table 2:362). Because some 4-year-old females produce cubs (Eberhardt and Knight 1996, Schwartz et al. 2005*a*), their inclusion into the above equation could result in an overestimation of total population size because the constant 0.274 represents only females ≥5 years of age. Additionally, not all females of age class 5 produce first litters, as some delay until ages 6–8 (Eberhardt and Knight 1996: Table 1:361, Schwartz et al. 2005*a*). Consequently, the proportion used to extrapolate FCOY to total population size contains an unknown amount of error.
- It is assumed that on average, adult female grizzly bears produce a litter once every 3 years. Deviations from this assumption can overestimate (interval <3 years) or underestimate (interval >3 years) population size. The estimated proportion of FCOY in any given year based upon a sample of radiocollared bears (age >3) ranges from 0.05 to 0.60 (Fig. 1). The reciprocal of this value is the years between litters for this age group (i.e., 1/0.333 = 3). During this period (1983–2003), we monitored 352 females and documented 110 cub litters. This equates to 0.315 litters/female/year or 3.2 years between litters (1/0.315), suggesting that summing over 3 years creates a small underestimation of minimum population size.
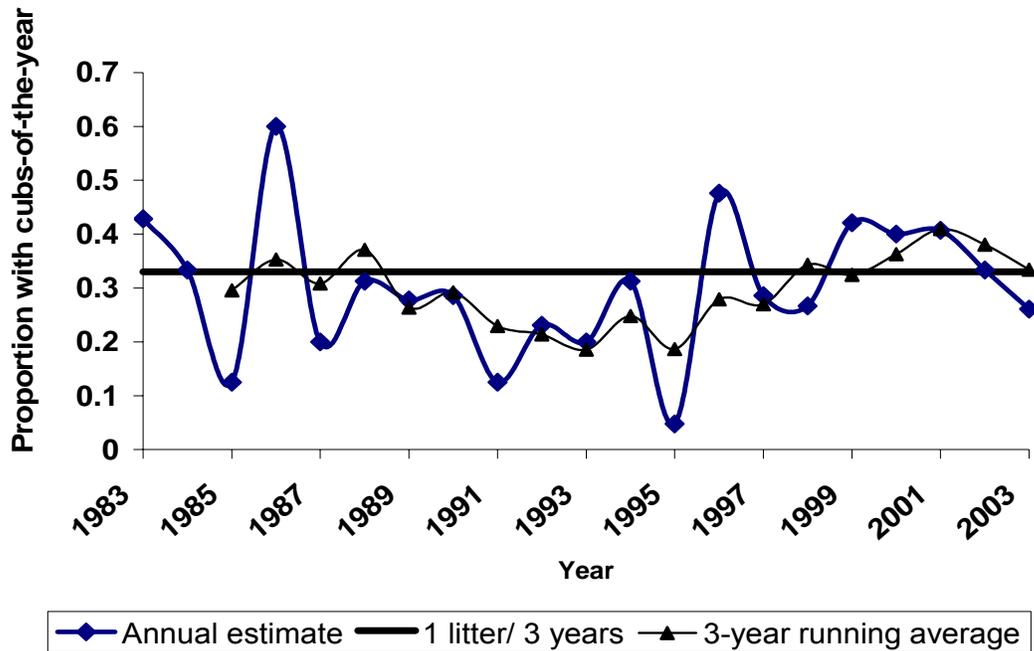
Figure 1. Proportion of radiomarked female bears >3 years old with cubs-of-the-year in the Greater Yellowstone Ecosystem, 1983–2003. The bold horizontal line represents the mean proportion if females produced exactly 1 litter every 3 years. The 3-year running average represents deviations from the assumption that females produce a litter exactly once every 3 years. Deviations above the line result in an overestimation of population size because some females produce cubs more often than once every 3 years and are therefore counted twice in the sum of 3 years. Deviations below the line result in an underestimation when summing over 3 years because some females with longer intervals (>3 years) may not be counted.

- Subtracting all known human-caused mortalities of adult females adds additional bias in the estimate of population size. Mortality limits should be calculated using the number of bears alive at the start of the season (den emergence). Therefore, any female bear killed in the year of calculations (year = t) should not be subtracted. Additionally, because the population estimate is calculated based on the sum of females with cubs, any lone female killed in year t - 2 or t - 1 should not be subtracted. A lone female killed in year t - 2 is no longer available and cannot be seen or counted in year t - 1 or year t with cubs because she is gone from the population. Therefore she cannot enter into the calculations and there is no need to subtract her. Doing so underestimates adult females in year t. The only dead females that should be subtracted are FCOY in year t - 2 and FCOY and females with yearlings in year t - 1. These females theoretically could have been part of the count of FCOY but are no longer alive in year t when the number of females in year t is estimated. This does not account for unreported loss of FCOY in t - 2 and t - 1 or for FCOY in t - 2 or t - 1 that might have lost her cubs and then died the next year when alone. There is no way of telling the reproductive

history of a lone bear killed in year *t*. Consequently no matter how we attempt to "adjust" the 3-year sum to account for dead females no longer alive in year *t*, there is potential for error. Additionally, because the counts of FCOY only represent "observed" bears, subtracting a dead female likely reduces the sum of FCOY by removing females never observed and not part of the minimum count.

- Mortality limits were based on original work by Harris (1984) which was developed using input from a generic grizzly bear population for the continental U.S. These values may not remain valid for the GYE population, and more recent data are now available.
- Harris (1984) estimated maximum human-caused mortality limits of 6%. This level was reduced to 4% in the Recovery Plan to account for unknown unreported mortality. This was based on the assumption that for every 2 reported mortalities there was 1 additional unreported death. This ratio of 2:1 was an approximation that may no longer be appropriate for the GYE population today.

Group Discussion

The group unanimously agreed that we have new peer reviewed scientific information (Cherry et al. 2002; Keating et al. 2002; Haroldson et al. 2005; Harris et al. 2005; Schwartz et al. 2005*a, b, c*) that can be used to improve existing methods, develop new methods for these management approaches, or both. The group agreed that we follow Dr. Gary White's recommendation whenever feasible to "stay as close to the data as possible." Because survival of independent females (age ≥2 years) was identified as the most important determinant of lambda (λ) with elasticity equal to 73% (Harris et al. 2005), we considered methods that allowed us to estimate independent female bears directly from the FCOY data.

WORKSHOP OBJECTIVES

Once we decided to focus our efforts on developing a new method to set sustainable mortality limits for the GYE grizzly bear, we identified a number of components that needed to be considered in this process. Our objectives were to develop scientifically defensible methods to:

1. Refine methods to estimate total population size, adult female population size, and/or total female population size and address uncertainty.

2. Establish a biologically sustainable limit on total and female mortality. The group felt it necessary to explicitly define "biologically sustainable" so it was clear how we defined, established, and evaluated this important term.

3. Account for unknown and unreported mortality and if necessary, modify the 2:1 reported:unreported ratio based on empirical data.

4. Prepare a document that details this process and present our findings and recommendations to the Yellowstone Ecosystem Subcommittee for acceptance and approval.

ALTERNATIVE POPULATION ESTIMATION METHODS

Method 1.

Replace the number of unique females observed ($\hat{N}_{obs, i}$) in Equation 1 above (see also Table 9) with one of the nonparametric estimators discussed by Keating et al. (2002). This is the method proposed in the Conservation Strategy (USFWS 2003) and should return an estimate of total population size given by the following equation:

$$\hat{N}_t = \sum_{i=t-2}^{t} \frac{\hat{N}_{keating} - d_i}{0.274} \tag{2}$$

where $\hat{N}_t$ is an estimate of total population size, and $\hat{N}_{keating}$ is one of the nonparametric estimators discussed by Keating et al. (2002).

Benefits
- Provides an unbiased estimate of total FCOY, not just those observed.
- Provides an annual estimate of uncertainty about FCOY.
- Is unbiased by changes in observer effort.
- Is a non-parametric estimator and thus avoids assumptions about form and constancy of distribution of individual sighting probabilities.
- $\hat{N}_t$ approximates the total population rather than the minimum population size. Consequently, mortality limits are a function of the total bear population.

Limitations
- Application of $\hat{N}_{keating}$ to estimate FCOY assumes Knight et al. (1995) correctly identifies individuals.
- Application of $\hat{N}_{keating}$ to estimate FCOY assumes clustering of sightings to be correct.
- Variation among individual sighting probabilities (CV) affects performance of $\hat{N}_{keating}$. It requires $n/N \geq 2$, where n is the total number of sightings and N is the population size.
- Replacing $\hat{N}_{keating}$ in the numerator of Equation (1) does not eliminate the other problems associated with it (i.e., assume 3-year breeding cycle, subtraction of all dead adult females, and the proportion of females in the population).

Discussion
Although the group felt that Equation 2 was an improvement over Equation 1 because of the value of the $\hat{N}_{keating}$ estimators, we concluded that we could develop alternative methods that would not only address switching from a minimum count to a total population estimate, but would also deal with other limitations of Equation 1. At this point our discussion shifted and we focused on $\hat{N}_{keating}$ estimators, their limitations, and recommendations for improvement.

Discussion of the Keating Estimator

The group had considerable discussion about the application of the nonparametric estimators proposed by Keating et al. (2002). The bullets below capture that discussion.

- In Keating et al. (2002), the modeled simulations only investigated CVs ≤ 1. The estimate made from the empirical data collected in 2004 had an estimated CV = 1.1. Further, the estimator of CV used is known to be biased low. This exceeded the limits of the simulations, and the group recommended that Dr. Keating run additional simulations to investigate models with CV ≥ 1.0 and possibly up to 1.5.

- Also, in 2004, the population was estimated as $\hat{N}_{SC2}$ = 72.6 (CV = 1.1) based on 202 sightings of 49 unique bears, where $\hat{N}_{SC2}$ is the population estimate using the second-order sample coverage estimator. Contained in these sightings were observations from 7 individuals inside Yellowstone National Park where the sighting frequency was ≥10 sightings/individual. Chao et al. (1993, 2000) proposed an alternate method when some sighting frequencies were very common (suggesting that these individuals would be "known" to the population). We reapplied the estimator excluding these 101 sightings from these 7 unique bears. The estimate resulted in 51.9 unique bears, from 101 sightings; with these 7 females added back into the estimate as known individuals, the population estimate is 59 bears with estimated CV = 0.45.

- To illustrate how we might use information from the modeling, Dr. Keating used Figure 5b from Keating et al. (2002) (which shows the bias in CV) and extrapolated an estimated CV based on true CV = 1.1 and $n/\hat{N}$ = 2.8. He plugged that value into Figure 1 from Keating et al. (2002) considering *n/N* and estimated the original bias for the estimate of 72.6 to be about 20% too large. With this bias correction, the new estimate was $\hat{N}_{SC2}$ = 58.

- After our discussions, it was decided that Dr. Keating would investigate the following:
  - the Chao estimators relative to the possible removal of sighting of FCOY with sighting frequencies *n* ≥ 10, or some other number
  - bias in estimates with CVs > 1.0
  - a bias correction factor
  - using a model weighted approach or alternative methods under certain circumstances (of those discussed by Keating et al. [2002])
  - Use the initial Keating estimate of $\hat{N}_{SC2}$ ($\hat{N}_{SC2}$ or a model weighted approach) to refine the total females with cubs in the population. Attempt to minimize the root mean square error. Explore using $\hat{N}_{SC2}$ estimator, which requires an initial estimate of population size, run the model, then take the resulting population estimate and put it back into the model and run it again until convergence.
  - Report results to the group at our second meeting.

- At our second workshop, Dr. Keating presented his results. During those discussions, we discovered that there was additional parameter space (distribution of sighting

probabilities) that had not been explored in the original Keating et al. (2002) simulations. Further investigation suggested that $\hat{N}_{SC2}$ could be either positively or negatively biased depending on the probability distribution modeled. This prompted a reevaluation of the $\hat{N}_{SC2}$ estimator. Further simulations confirmed the problem. Additional work based on simulation of sighting probabilities using a beta distribution with equal beta parameters and selecting from the extremes of the parameter space confirmed that $\hat{N}_{SC2}$ can take either a positive or negative bias, and in some cases quite a large positive bias. On the other hand, it was also confirmed that the Chao$_2$ estimator preformed well over the range of simulated population sizes and CVs ($\hat{N}$ = 20–80, CV = 0.0–1.75) and consistently returned estimates that were correct or biased low. Chao$_2$ did a reasonable job when sighting probabilities were high, but returned low estimates when probability sightings were quite small, likely because bears with extremely low sighting probabilities were not part of the "effective population size" from which the sample of sightings was actually drawn.

Method 2.

Use $\hat{N}_{keating}$ as the best approximation of total FCOY in the population in any given year. Estimate the annual proportion of FCOY ($\hat{P}_{FCOY}$) in the adult female population from the telemetry sample (Table 9). The number of adult females in the population ($\geq$4 years old) would be estimated as:

$$\hat{N}_{females} = \frac{\hat{N}_{keating}}{\hat{P}_{FCOY}} \tag{3}$$

We looked at data from 1986 to 2002 and estimated $\hat{N}_{females}$. A graph of these values (Fig. 2) indicates large variation among annual estimates. Some of this noise is probably associated with poor estimates of the proportion of females with cubs from the telemetry sample due to small sample size and sampling bias (Table 9). But some noise may also be associated with the $\hat{N}_{keating}$ estimator (i.e., 1995) when $n/N < 1$. All these issues affect the usefulness of this method.
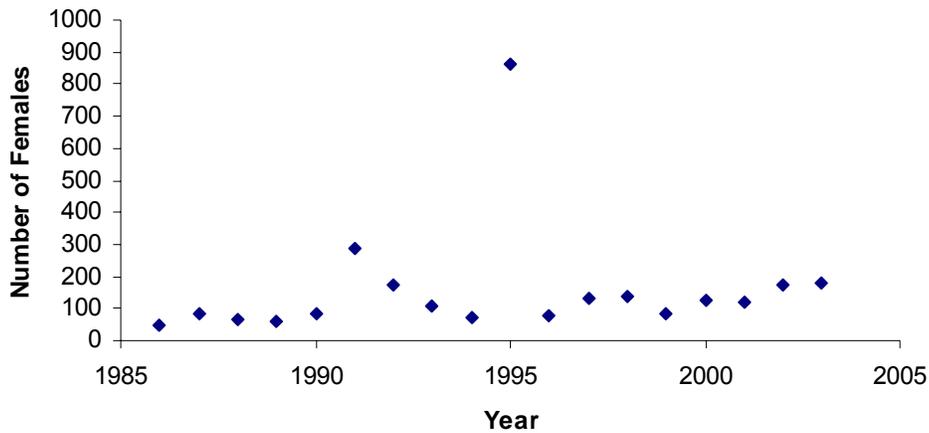
Figure 2. Estimated annual number of adult females in the Greater Yellowstone Ecosystem population based on the annual proportion of collared females ≥4 years old that produced cubs-of-the-year ($\hat{P}_{FCOY}$) divided into the annual Chao$_2$ estimator.

Benefits

- Avoids the assumption that females produce cubs exactly once every 3 years.
- Stays close to the real data. This method estimates females from empirical data.
- Avoids the need to know the sex ratio of the population.
- Avoids the need to subtract dead females.
- Estimates the "total" number of females ≥4 years old.
- The method could also be used to estimate number of independent females by calculating the proportion of "independent females" (≥2 years old) in the telemetry sample, but estimates become more extreme in 1991 (345) and 1995 (1,427).

Limitations

- $\hat{P}_{FCOY}$ depends on the telemetry sample, which in most years is small with a resulting high variance component.
- Assumes the distribution of females in the telemetry sample is the same as the distribution in the population (i.e., we have the same proportion of 4-year-olds in the sample as in the population). This assumption may not be correct. To investigate this, we plotted the proportion of collared females by age in the telemetry sample against the modeled distribution (Harris et al. 2005) of females by age class using our best estimates of reproduction (Schwartz et al. 2005a) and survival (Haroldson et al. 2005, Schwartz et al. 2005b) (Figs. 3 and 4). Results suggest the age structure based on our best estimates of survival and reproduction differ from the age-structure of our captured sample. The proportion of females ages 2 and 3 are underrepresented, whereas females ages 6–8 appear overrepresented in the telemetry sample. The proportion of females in the telemetry sample with cubs-of-the-year was 0.267 and 0.311 for females ≥4 years old and ≥2 years old, respectively.

Table 9. Number of observed unique unduplicated females (N_{obs}) with cubs-of-the-year (FCOY) based on the rule set of Knight et al. (1995), the estimated total number of unique FCOY ($\hat{N}_{Chao2}$) based on the Chao$_2$ estimator of Keating et al. (2002), the number of radiocollared females (age ≥4 years), and the proportion ($\hat{P}_{FCOY}$) and standard error (SE) of FCOY, estimated number of female bears age ≥4 or ≥2 year old, dependent young, and independent males.

							Population index				
						Female age					
						≥4	≥2				
			Annual telemetry sample			$\hat{N}_{Chao2}$	$\hat{N}_{Chao2}/$	($\hat{N}_{Chao2}/$	Dependent young		
Year	N_{obs}	$\hat{N}_{Chao2}$	(n)	($\hat{P}_{FCOY}$ [a])	(SE[b])	$/\hat{P}_{FCOY}$	0.248	0.289)/ 0.7734	$[\hat{N}_{females\,2+}(0.415)]2$	$\{\hat{N}_{Chao2,t}+[(\hat{N}_{Chao2,t-1})(0.636)]\}2$	Males age ≥2
1983			7	0.43	0.19						
1984			6	0.33	0.19						
1985			8	0.13	0.12						
1986	25	27.5	15	0.60	0.13	46	111	123	102		74
1987	13	17.3	15	0.20	0.10	86	70	77	64	70	47
1988	19	21.2	16	0.31	0.12	68	85	95	79	64	57
1989	16	17.5	18	0.28	0.11	63	71	78	65	62	47
1990	25	25.0	14	0.29	0.12	86	101	112	93	72	68
1991	24	37.8	8	0.13	0.12	290	152	169	140	107	102
1992	25	40.5	13	0.23	0.12	176	163	181	150	129	110
1993	20	21.1	15	0.20	0.10	106	85	94	78	94	57
1994	20	22.5	16	0.31	0.12	73	91	101	84	72	61
1995	17	43.0	21	0.05	0.05	860	173	192	160	115	116
1996	33	37.5	21	0.48	0.11	78	151	168	139	130	102
1997	31	38.8	21	0.29	0.10	134	156	173	144	125	105
1998	35	36.9	15	0.27	0.11	137	149	165	137	123	100
1999	33	36.0	19	0.42	0.11	86	145	161	134	119	97
2000	37	51.0	30	0.40	0.09	128	206	228	189	148	138
2001	42	48.2	27	0.41	0.09	118	194	216	179	162	131
2002	52	58.1	24	0.33	0.10	176	234	260	216	178	157
2003	38	46.4	23	0.26	0.09	178	187	208	172	167	126
2004	49	57.5					232	257	214	174	156

[a] Calculated as the sum of telemetered bears observed over 3 years with cubs/total telemetered bears observed in the same 3-year period.

[b] Calculated as $\sqrt{\dfrac{P(1-P)}{n}}$.

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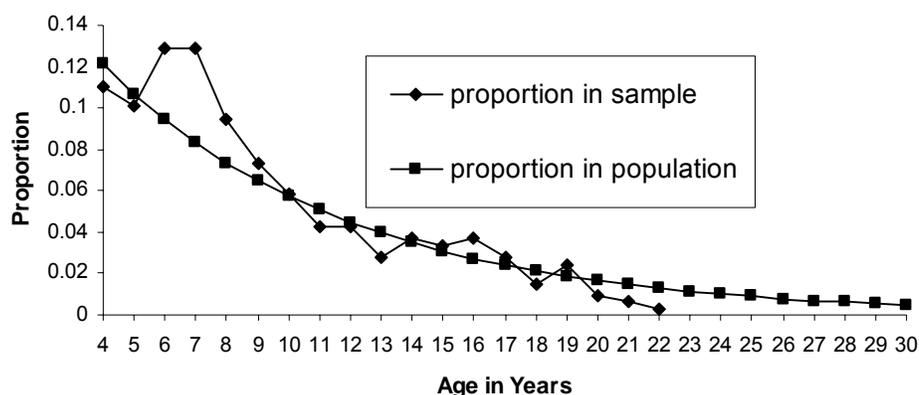
Figure 3. The proportion of female bears ≥4 years old in the telemetry sample (1983–2001) in the Greater Yellowstone Ecosystem and the proportion of these age classes in the population based on simulation modeling using empirical data on reproduction and survival (Appendix A).
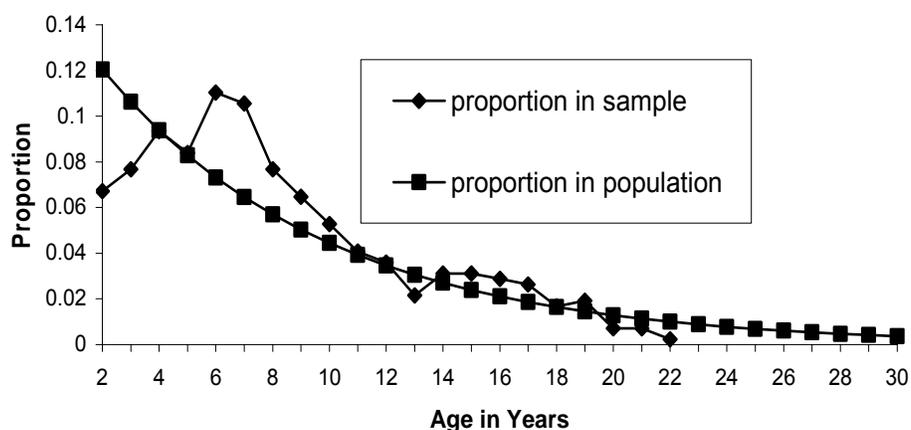
Figure 4. The proportion of female bears ≥2 years old in the telemetry sample (1983–2001) in the Greater Yellowstone Ecosystem and the proportion of these age classes in the population based on simulation modeling using empirical data on reproduction and survival (Appendix A).

Discussion

Dr. White presented information on transition rates among various states for female bears ≥4 year old (Appendix C). These transitions are unbiased relative to sampling and would help resolve the telemetry sample bias problem discussed above. His results suggest that we tend to capture more bears in the "N" state (no offspring) than those in the "C", "Y", or "T" states (with cubs, yearlings, or 2-year-olds). Consequently, the proportion of females with cubs in the telemetry sample appears biased low. Based on these discussions, we concluded we should not recommend using the telemetry sample to estimate the proportion of FCOY in any given year as the denominator of Equation 3.

We also looked at the SEs of the proportion of females with cubs in the telemetry sample (Table 9) and concluded that nearly all annual estimates were not statistically different, suggesting we could use a constant in the denominator.

Method 3.

Use the logic described in Method 2 above, but base estimates on a 3-year (or even a 6-year) running average of $\hat{N}_{keating}$ and $\hat{P}_{FCOY}$ (Table 9).

Benefits
- Running average dampens the noise in the estimate.
- Running average increases sample size.

Limitations
- Still assumes the distribution of females in the telemetry sample is the same as the distribution in the population.
- Running average is influenced by the number of years in the average. If we use a 6-year average, the variance is dampened even more than with a 3-year average. However, for a declining population, the average estimate will be greater than the true population (i.e., the previous 5 years elevate the mean). This works in reverse for a growing population and becomes equivocal for a flat trajectory. Hence the running average is conservative for a growing population but may result in over-harvest for a declining population. Alternatively, we could consider a 6-year average for a growing population but recommend it be shortened to a 3-year average should trends suggest the population is declining.

Discussion
We rejected this approach for reasons discussed under Method 2. We also had a long discussion on assumptions and issues associated with using a "running average" to smooth data. The group felt uncomfortable with such an approach because of possible unknown statistical biases.

Method 4.

Use an estimate of the proportion of females with cubs (age ≥4 years or ≥2 years) relative to an estimate of total "adult" or "independent" females in the GYE population. For example, Harris (Appendix A) estimated the proportion of females ≥2 years old accompanied by cubs based upon stochastic simulation modeling was 0.248 of all females ≥2 years of age in the GYE population. Using this value, we estimate total independent females in the GYE population with the following equation:

$$\hat{N}_{females} = \frac{\hat{N}_{keating}}{0.248} \tag{4}$$

where ($\hat{N}_{keating}$) is the number of FCOY based on one of the estimators reviewed by Keating et al. (2002), and $\hat{N}_{females}$ is an estimate of females age ≥2 years old in the population. Harris (Appendix A) estimated that on average over a 10-year simulation,

FCOY in the population constitute 0.247 (CV = 0.110) and 0.248 (CV = 0.105) of the female population ≥2 years of age when adult female survival is set at 0.949 or 0.922, respectively. He also calculated the number of females in the population age ≥4 years old as 0.314 and 0.315 (adult female survival = 0.922 or 0.948).

Benefits
- Simple to calculate.
- Avoids bias associated with the sample of collared females.
- Based on empirical data.

Limitations
- Constant in the denominator does not allow for temporal changes in reproductive rates.
- Constant in the denominator requires periodic updates.

Discussion
The group felt this was the best method. We had considerable discussion on what value to use for the denominator. Dr. White offered an alternative for estimating total number of females ≥4 years of age in the population. He used the telemetry dataset and determined the proportion of females (age ≥4) in the population with cubs-of-the-year in this sample using a multi-state model (results are in Appendix C). His estimate (0.289) was quite similar to the Harris estimate of 0.314 (Appendix A) based on modeling. Because Dr. White's estimate was based on empirical data, we chose to use it.

We discussed the value of developing an index of the female population ≥4 years of age using the constant 0.289 directly. Because analyses by Haroldson et al. (2005) found no statistical or biological difference in survival for independent subadult (ages 2–4 years) and adult (ages ≥5 years) bears, we concluded that it would be simpler to derive a single population estimate of independent females. Using data from Harris et al. (2005), we estimated the proportion of females ≥4 years and older in the population of females ≥2 years old (Tables 10 and 11). Because Harris et al. (2005) estimated the stable age distribution using both high and low survival estimates for independent females (0.92 and 0.95) which considered both high and low process variance, we evaluated both and the magnitude of difference between the 2 estimates. Results (Tables 10 and 11) indicated that there was virtually no difference in the proportional estimates when using the low or high survival rate for independent females (0.773421 vs. 0.773392). Consequently, we used 0.7734 as the proportion of females ≥4 years old in the population of independent females ≥2 years old. We used this to convert our estimate with the following equation:

$$\hat{N}_{females\ 2+} = \frac{\hat{N}_{Chao2}}{(0.289 * 0.7734)} \qquad (5)$$

where ($\hat{N}_{Chao2}$) is the number of FCOY based upon the Chao2 estimator, and 0.289 is the proportion of females ≥4 years of age accompanied by cubs-of-the-

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year (Appendix C) in the telemetry sample, and 0.7734 is the proportion of female bears ≥4 years of age in the standing population of females ≥2 years of age.

Table 10. Deterministic projections of stable age structure of the Greater Yellowstone Ecosystem grizzly bear population. Data from Harris et al. (2005:Table 18) and lx = survivorship schedule.

Age years	Adult female survival = 0.92			Adult male survival = 0.823		
	lx	Stable age distribution	Proportion by years 0–30	lx	Stable age distribution	Proportion by years 0–30
0	1.000	1.000	0.1831	1.000	1.000	0.2624
1	0.630	0.605	0.1107	0.630	0.605	0.1587
2	0.504	0.464	0.0850	0.504	0.464	0.1218
3	0.464	0.410	0.0750	0.415	0.367	0.0962
4	0.427	0.362	0.0662	0.341	0.290	0.0760
5	0.392	0.319	0.0585	0.281	0.229	0.0600
6	0.361	0.282	0.0516	0.231	0.181	0.0474
7	0.332	0.249	0.0456	0.190	0.143	0.0374
8	0.306	0.220	0.0403	0.157	0.113	0.0296
9	0.281	0.194	0.0355	0.129	0.089	0.0234
10	0.259	0.171	0.0314	0.106	0.070	0.0184
11	0.238	0.151	0.0277	0.087	0.056	0.0146
12	0.219	0.134	0.0245	0.072	0.044	0.0115
13	0.201	0.118	0.0216	0.059	0.035	0.0091
14	0.185	0.104	0.0191	0.049	0.027	0.0072
15	0.170	0.092	0.0168	0.040	0.022	0.0057
16	0.157	0.081	0.0149	0.033	0.017	0.0045
17	0.144	0.072	0.0131	0.027	0.013	0.0035
18	0.133	0.063	0.0116	0.022	0.011	0.0028
19	0.122	0.056	0.0102	0.018	0.008	0.0022
20	0.112	0.049	0.0090	0.015	0.007	0.0017
21	0.103	0.044	0.0080	0.012	0.005	0.0014
22	0.095	0.038	0.0070	0.010	0.004	0.0011
23	0.087	0.034	0.0062	0.008	0.003	0.0009
24	0.080	0.030	0.0055	0.007	0.003	0.0007
25	0.074	0.026	0.0048	0.006	0.002	0.0005
26	0.068	0.023	0.0043	0.005	0.002	0.0004
27	0.063	0.021	0.0038	0.004	0.001	0.0003
28	0.058	0.018	0.0033	0.003	0.001	0.0003
29	0.053	0.016	0.0029	0.003	0.001	0.0002
30	0.049	0.014	0.0026	0.002	0.001	0.0002

Proportion of the population ≥4 years of age	0.5462
Proportion of the population ≥2 years of age	0.7062
Proportion of females ≥4 years of age of females ≥2 years of age	0.773421
Proportion of the population ≤1 years of age	0.294
Proportion of females ≤1 years of age of females ≥2 years of age	0.416
Male:female ratio (age≥2)	0.3638:0.6362

Table 11. Deterministic projections of stable age structure of the Greater Yellowstone Ecosystem grizzly bear population. Data from Harris et al. (2005:Table 18) and lx = survivorship schedule.

	Adult female survival = 0.95			Adult male survival = 0.874		
Age years	lx	Stable age distribution	Proportion by years 0–30	lx	Stable age distribution	Proportion by years 0–30
0	1.000	1.000	0.1826	1.000	1.000	0.2451
1	0.650	0.604	0.1103	0.650	0.604	0.1481
2	0.540	0.466	0.0851	0.540	0.466	0.1142
3	0.513	0.411	0.0751	0.472	0.379	0.0928
4	0.487	0.363	0.0663	0.412	0.307	0.0753
5	0.463	0.321	0.0586	0.360	0.250	0.0612
6	0.439	0.283	0.0517	0.315	0.203	0.0497
7	0.417	0.250	0.0457	0.275	0.165	0.0404
8	0.397	0.221	0.0403	0.240	0.134	0.0328
9	0.377	0.195	0.0356	0.210	0.109	0.0266
10	0.358	0.172	0.0314	0.184	0.088	0.0216
11	0.340	0.152	0.0277	0.161	0.072	0.0176
12	0.323	0.134	0.0245	0.140	0.058	0.0143
13	0.307	0.118	0.0216	0.123	0.047	0.0116
14	0.292	0.105	0.0191	0.107	0.038	0.0094
15	0.277	0.092	0.0169	0.094	0.031	0.0077
16	0.263	0.081	0.0149	0.082	0.025	0.0062
17	0.250	0.072	0.0131	0.072	0.021	0.0050
18	0.237	0.064	0.0116	0.063	0.017	0.0041
19	0.226	0.056	0.0102	0.055	0.014	0.0033
20	0.214	0.050	0.0090	0.048	0.011	0.0027
21	0.204	0.044	0.0080	0.042	0.009	0.0022
22	0.193	0.039	0.0070	0.036	0.007	0.0018
23	0.184	0.034	0.0062	0.032	0.006	0.0014
24	0.175	0.030	0.0055	0.028	0.005	0.0012
25	0.166	0.027	0.0049	0.024	0.004	0.0010
26	0.158	0.023	0.0043	0.021	0.003	0.0008
27	0.150	0.021	0.0038	0.019	0.003	0.0006
28	0.142	0.018	0.0033	0.016	0.002	0.0005
29	0.135	0.016	0.0029	0.014	0.002	0.0004
30	0.128	0.014	0.0026	0.012	0.001	0.0003

Proportion of the population ≥4 years of age	0.547
Proportion of the population ≥2 years of age	0.707
Proportion of females ≥4 years of age of females ≥2 years of age	0.773392
Proportion of the population ≤1 years of age	0.293
Proportion of females ≤1 years of age of females ≥2 years of age	0.414
Male:female ratio (age ≥2)	0.3901:0.6099

Our annual index of population size for females ≥2 years of age is then $= \hat{N}_{females\ 2+}$. The denominator of 0.224 is not statistically different from the estimate of Harris (Appendix A) of 0.248.

We also discussed the variation in our annual estimates and how we might dampen this variation to reduce the wide swings in allowable mortality limits based on this population index. We considered using a 3-year running average of $\hat{N}_{females\ 2+}$ to dampen variation, but the group felt there were potential statistical problems with any such calculations. Consequently, we elected to generate an annual population size of independent females ≥2 years of age and use that estimate to establish an annual mortality quota.

Finally, we discussed the stable age structure and the appropriate number of age classes to consider. In their modeling, Harris et al. (2005) used 31 age classes. We evaluated this number relative to known longevity of bears and concluded it was probably quite close to the maximum life expectancy of bears in the GYE. We came to this conclusion based on the following:

Justification for using 31 Age Classes (Ages 0–30)
The IGBST documented 19 individual grizzly bears living ≥20 years in the GYE during 1975–2004. Twelve of these were known to have died, while the fates of an additional 7 were unknown (Table 12).

Table 12. Fate of radiocollared grizzly bears in the Greater Yellowstone Ecosystem, ≥20 years of age, 1975–2004.

Age	Last known fate		Total
	Alive	Dead	
20	2	3	5
21	1	3	4
22	2	3	5
24	1	1	2
25	1	1	2
28	0	1	1
Total	7	12	19

The oldest bears documented in the GYE were 25 and 28 for females and males, respectively (Table 13). The oldest female known to have produced cubs was 25. We currently (2005) have a 25-year-old female radiomarked.

Table 13. Age and sex of oldest known grizzly bears in the Greater Yellowstone Ecosystem, 1975–2004.

Age	Sex		Total
	Female	Male	
20	3	2	5
21	2	2	4
22	2	3	5
24	1	1	2

25	1	1	2
28	0	1	1
Total	9	10	19

Estimating Numbers of Cubs, Yearlings, and Independent Males:
Because our index of abundance only addressed independent females, we explored additional ways to estimate abundance of cubs, yearlings, and male bears. We elected to treat cubs and yearlings as a group because dependent young are exposed to different mortality causes, and if there is ever a hunting season, cubs and yearlings would be protected. Keeping them separate from any quota of independent female and male bears facilitates managing a hunt. We explored 2 alternative methods to estimate the cubs and yearlings in the population:

1. The first was based on the stable age distribution (Tables 10 and 11). We determined that for every female ≥2 years of age, there were 0.414 or 0.416 dependent females (cubs and yearlings), using low and high survival rates of adult females. We used the mean value (0.415) to estimate numbers of dependent females in the population by multiplying our estimate of $\hat{N}_{females\ 2+}$ from Equation 5 by 0.415

$$\hat{N}_{dependent\ young} = [\hat{N}_{females\ 2+}(0.415)]2 \qquad (6)$$

Finally, we chose to consider both sexes of cubs and yearlings together so we multiplied our estimate of dependent female bears by 2 to estimate the total number of dependent offspring in the population ($\hat{N}_{dependent\ young}$).

2. We assumed average litter size was 2 cubs (Schwartz et al. 2005*a* estimated mean litter size = 2.04), with a 50:50 sex ratio. We also assumed cub survival = 0.638 (Schwartz et al. 2005*b*). We calculated the number of cubs and yearlings in the population using the following equation:

$$\hat{N}_{dependent\ young} = \{\hat{N}_{Chao2,\ t} + [(\hat{N}_{Chao2,\ t-1})(0.638)]\}2 \qquad (7)$$

where $\hat{N}_{dependent\ young}$ is an annual estimate of dependent offspring, $\hat{N}_{Chao2,\ t}$ number of FCOY in year *t*, and $\hat{N}_{Chao2,\ t-1}$ is the number of females with cubs in year *t* - 1.

Results using this method yield fewer cubs and yearlings on average than Method 1. We used this method because the number of dependent young is calculated directly from field data.

3. We estimated the number of males directly from our estimate of independent females. Based on simulation modeling, Harris et al. (2005) estimated that the ratio of male:female bears ≥2 years old in the GYE population was

0.377:0.623. This effectively means that for each female in the population, there are 0.605 males (0.377/0.623 = 0.605). We calculated the number of independent males using the following equation (Table 9):

$$\hat{N}_{males\ 2+} = \hat{N}_{females\,2+}(0.605) \qquad (8)$$

Area of inference
During our second workshop we discussed the area of inference and application of our estimators to segments of the GYE population. The population estimators reviewed by Keating et al. (2002) are for closed populations. We concluded that our estimates are appropriate at the GYE population level. As a consequence, our estimates of sustainable mortality are also appropriate at the population level.

SUSTAINABLE MORTALITY LIMITS

To address objective 2 we considered the current method and evaluated and discussed other options.

Current Method
To facilitate recovery and to account for unknown, unreported, human-caused mortality, known human-caused mortality was set by the USFWS Grizzly Bear Recovery Plan at 4% of the minimum population estimate (USFWS 1993). Female mortality was set at 30% of this 4% limit. Limits of acceptable mortality were derived from Harris (1986) using a model of a generic bear population in the Rocky Mountains. Harris (1986) suggested that grizzly bear populations could sustain approximately 6% human-caused mortality without population decline. The difference between the 4% in the Recovery Plan and 6% of Harris (1986) allowed for an unreported loss of 2% from human causes.

Benefits
- Under the current mortality limits, the GYE population has increased at an average rate of between 4–7% per year. It appears conservative (at least when coupled with the minimum population estimate).
- It can be applied to any of the proposed population methods discussed above.

Limitations
- Estimates are based on generic grizzly bear population, not specific to the GYE.
- More updated and detailed information is available to model the population.
- Method assumed an unstated reporting rate of 2:1 (reported:unreported), which is inconsistent with current estimates for GYE grizzly bears.

Discussion
We discussed several issues. The current method only considers known and probable human-caused mortality. The 6% limit does not consider undetermined or natural mortality. This is an issue when cause of death is reported as "undetermined" because these deaths are not counted against the threshold.

However, it is likely that many of these mortalities were in fact human-caused deaths.

The 6% limit was reduced to 4% to account for an unknown and unreported mortality of 2%. This can be interpreted as 1 unreported loss for every 2 known losses. However, Knight and Eberhardt (1985:330) stated that actual mortality in the GYE "appears to be approximately double that recorded." This result is consistent with current estimates of reporting rate (Appendix B).

The recent analysis by Harris et al. (2005) suggests that the 6% sustainable mortality limit is very conservative and can be increased.

The group decided to explore alternate methods of establishing mortality limits using all of the most recent information published by Cherry et al. (2002), Harris et al. (2005), Haroldson et al. (2005), and Schwartz et al. (2005*a, b*).

ALTERNATIVE MORTALITY THRESHOLDS

Independent Females ≥2 Years Old

Adjust sustainable mortality limits to match what is required to maintain $\lambda \geq 1$ based on more recent simulation models by Harris et al. (2005). The GYE grizzly bear population is likely to maintain a positive trajectory as long as survival of independent females (aged ≥2 years) remains above approximately 0.91 (i.e., 9% annual mortality from all causes).

Benefits
- This would bring the limits in line with empirical data from the GYE as discussed by Schwartz et al. (2005*c*). Additionally, Harris et al. (2005) indicated regarding this 9% mortality that: It would seem, at first blush, to suggest a radical departure from current guidelines. For example, Harris (1986:273) recommended that 'the proportion of the female segment of the population that can be removed annually…without causing chronic decline should not exceed 3% of the female segment.' More recently, McLoughlin (2002:33) suggested that 'most grizzly bear populations in North America can tolerate approximately 3% total annual kill before declines…accelerate to unsatisfactory levels.' Careful reading, however, reveals that, beyond some minor differences in assumptions and procedures, the apparent increase in tolerable mortality we report here arises not from real discrepancies in models or parameter values but rather from different ways of expressing a similar underlying dynamic.

  Comparing our results with those of Harris (1986) is important because current management guidelines in the Yellowstone Grizzly Bear Recovery Zone (USFWS 1993, 2003) adopt an annual mortality limit derived largely from that work. First, our approach here differed fundamentally in that the earlier work attempted to estimate the mortality level associated with sustainability indefinitely. That is, Harris (1986) used a model of grizzly bear population dynamics that was self-regulating. Thus, bear populations in

Harris (1986) equilibrated (rather than growing exponentially) in the absence of killing by humans. Adding human-caused deaths to this model engaged compensatory responses that were assumed to characterize grizzly bear populations (although parameters used to build the responses were not based directly on data, but rather were interpolated from general principles). Here, our aims were more modest: to project short-term growth rates applied under a range of plausible survival rates, making no assumptions about density-dependent (or other possible) regulating mechanisms that would, no doubt, intercede to change those trajectories. Second, Harris (1986) assumed that natural mortalities, although decreasing as hunting increased, would never be entirely substituted by human-caused mortality. That is, even at the population level producing the highest sustainable yield indefinitely, background levels of natural mortality would continue. Harris' (1986) objective was to estimate the maximum human-caused mortality rate that, when embedded into the assumed compensatory structure, equilibrated the population with its carrying capacity. Here, we declined to suppose any particular relationship between human- and nonhuman-caused mortalities (to say nothing of carrying capacity). Indeed, we had no data to do otherwise, given that not a single independent female mortality in GYE attributable to non-human causes was documented during 1983–2001 (Haroldson et al. 2005). Dependent young experienced natural mortality, but because cubs and yearlings were not collared, cause of death was undetermined in many cases (Schwartz et al. 2005*b*).

Thus, contrasting our results directly with the 3% sustainable mortality rate of females estimated by Harris (1986) is inappropriate. Harris (1986) also assigned survival rates to 3 subadult female classes (ages 2, 3, and 4 years) in addition to 3 adult age classes, complicating any attempt to compare the total mortality rate sustained by adult females in his model populations with those we report here. Fortunately, we were able to rehabilitate the Harris (1986) model for application here and develop a common currency for comparison with results reported here. We discovered that maximum hunting rates he found consistent with sustainability (i.e., 6.85 female kills/year from a population of 193.5 females, or 3.54% of the female component killed annually; Harris 1986:276) corresponded to an annual survival rate of all females (cubs through the oldest class) of 0.851 (SD = 0.035, $n = 3,000$). For comparison, our survival rates of all females (irrespective of age) consistent with low probability of decline were 0.847 (SD = 0.022, $n = 3,000$) when independent female survival was 0.91 (under low process variation) and 0.852 (SD = 0.077, $n = 6,000$) when independent female survival was 0.92 (under high process variation). Thus, although the approaches and presentation of results were quite divergent, overall female survival rates consistent with nondeclining populations in both Harris (1986) and our present effort were almost identical.

McLoughlin (2002) reported that a simulated population modeled approximately on GYE grizzly bear data through 1995 displayed a breakpoint (at which persistence probability declined rapidly with additional kills) at a mortality rate of about 2.8%. However, human-caused mortalities in his model were assumed additive to natural mortality, which was set at 4.9% for females aged ≥6 years and 11.4% for females aged 2–5 years (McLoughlin 2002:Table 2.1). With approximately 30% of the female population in ages 2–5 years and 46% ≥6 years old (approximately the case if the population had achieved its stable age distribution prior to additional harvest), the mean natural mortality rate for females ≥2 years would thus be approximately 6.4%. This, added to the 2.8% annual kill, yields 9.2% total mortality of females age ≥2 years (i.e., annual survival of 0.908), which is again similar to our conclusion that λ will be ≥1 with high probability when annual female (age ≥2 years) survival rates were approximately 0.90–0.91.

Eberhardt (1990) also provided a simple deterministic model relating grizzly bear life history rates to stable trajectories. Application of the mean survival rates from our simulations to (Eberhardt 1990:587) produced $r = 0$ (i.e., λ = 1.0) with independent female (≥2 years old) survival of 0.898 and age of first reproduction set to 5 years, as well with as with independent female survival of 0.906 and age of first reproduction set to 6 years (GYE mean during 1983–2002 was 5.81 years, but Eberhardt's [1990] equation did not allow for fractional ages). Although abstract, his model further confirmed our estimates of female survival rates consistent with nondeclining trajectories.

The current approach to grizzly bear management in GYE is for management agencies to consider all forms of mortality, but to establish an annual mortality limit only for human-caused mortality. We propose that rather than counting human-caused mortalities, management agencies should focus on female survival rates irrespective of the cause of death. By counting all deaths, it becomes unnecessary to determine exactly how a bear died (which often requires subjective judgments). It also minimizes the importance of knowing the proportion of human-caused deaths not documented (e.g., Cherry et al. 2002). As long as an active monitoring program is in place (including radiotelemetry of a random sample of bears to update life-history rates as conditions change), demographic analyses can augment counts of reproductively-active females (Knight et al. 1995, Mattson 1997, Keating et al. 2002) as an indicator of overall population health.

- This limit is based on survival estimates for females ≥2 years of age. It will allow us to set limits for independent females using methods discussed above to estimate independent females in the population.
- Allows for separate limits for male bears.

Limitations
- This is a total mortality limit for independent female bears. It includes both natural and human-caused deaths. We were unable to estimate the rate of

"natural mortality" for independent female bears because we did not document any natural mortality in the telemetry sample of females from 1983–2002. This must be considered when using this method.
- The limit only addressed independent females and requires we consider dependent young separately.
- Requires we establish limits for males separately or establish a geographically-based limit system.

Discussion

The group felt it was essential to distinguish between a mortality limit that is not to be exceeded and a mortality target that is a management objective. Consequently, we defined a sustainable mortality limit for female grizzly bears (≥ 2 years of age) in the GYE as the maximum allowable mortality that the female population can sustain over time and maintain population stability (stability is defined as $\lambda = 1.0$) with a 95% level of confidence. Based on Harris et al. (2005), if we set independent female survival = 0.89, the point estimate of $\lambda = 1.005$ with a 95% confidence interval 0.97–1.04. Because this estimate overlaps 1.0, and there is a chance that when survival = 0.89, $\lambda < 1$, we recommended the following:

i. Use a survival rate of 0.91 ($\lambda = 1.03$, CI 1.0–1.05), which allows for increased confidence that $\lambda \geq 1.0$. We did this because the estimate accounts for process variation inherent in annual female survival in the GYE.

ii. The States of Wyoming, Montana, and Idaho set the near-term objective for the GYE bear population to continue expanding into suitable habitat. To assure population health with an acceptable level of risk, we chose a point estimate of survival for females that has the lower 95% CI of $\lambda = 1.0$.

We also discussed mortalities to include for tabulation of total independent female mortality. The group recommended we consider all forms of mortality, including human-caused, natural, and undetermined, against the quota. This eliminated the need to determine cause of death, eliminated the possibility of misclassification, and stays closer to our estimate of 9% total mortality from all causes. Natural mortality appears quite low for independent females in the GYE. Results presented by Haroldson et al. (2005) indicated no recorded natural deaths for independent female bears based on telemetry from 1983–2001 from a sample of 3,420 radio-months (285 bear-years). We determined the binomial confidence bounds for these data with $x = 0$, $n = 285$, where $p = x/n$ using the formula: $0 \leq p \leq 1 - \alpha^{1/n}$ (van Belle 2002). At $\alpha = 0.05$ and $n = 285$, the upper bound of the confidence interval = 0.0105. This suggests that although we did not document natural mortalities over the 19-year-period with a sample of 285 bear-years, there was a small chance we missed one. Regardless, the data suggest that natural mortalities are rare and would not contribute much to the total mortality limit whether included or excluded in the tally. Consequently, we elected to count all forms of mortality for independent female bears.

Results of these calculation and thresholds are shown in Table 14.

Dependent Offspring (Cubs And Yearlings)

We discussed the establishment of a limit on mortality for cubs and yearlings.

1. Because we often lack information on the sex of dead cubs and yearlings, we elected to establish a limit for both sexes. Although survival estimates for cubs-of-the-year (0.638) and yearlings (0.817) were lower than survival of independent bears, we elected to set the mortality limit the same for the following reasons:
    *   Only human-caused mortalities would be counted. We decided this because numbers of recorded cub and yearling mortalities are linked to the number of adult female bears collared. Most of the documented deaths of offspring of collared bears are of undetermined cause. Data presented by Schwartz et al. (2005*b*) suggests these are likely natural deaths. We cannot limit natural deaths but need to consider human-caused mortality and ensure it does not exceed sustainability. From the sample of dependent young, 10 of 32 cubs, and 1 of 5 yearlings died from human related causes. This equated to 11 of 37 (0.297) mortalities recorded as human-caused, or about 30% of recorded mortality was human-caused.

        The method of Cherry et al. (2002) to estimate unknown and unreported mortalities is based on reporting rate from a sample of telemetry bears. Dependent young were not radiomarked. We therefore elected to count only known and probable human-caused deaths for dependent young and set the limit at 9% for both sexes. We will assume reporting rates for dependent young are similar to reporting rates of independent bears (which is likely because most dependent young, especially cubs, die if their mother dies). Reporting rates for independent bears are roughly 1 reported for 2 unreported. The 9% reported limit is then roughly equivalent to a 27% total mortality rate (9% reported:18% unreported). Total mortality from birth to recruitment as a 2-year-old is 0.48 (1 - [0.638 x 0.817]). Assuming human-caused mortality remains about the same, one would expect about 14.3% of this recorded mortality to be human caused (0.48 x 0.297 = 0.143). Accounting for both sexes, this equates to about 28.6% mortality (0.143 x 2 = 0.286), which approximates the proportion of recorded human-caused mortality rates from 1983–2001 (0.297).
    *   We also discussed the implications of error in our estimates. A 9% limit is conservative for dependent young. Secondly, survival of dependent young only contributed 17.8% to the elasticity of lambda calculations (Harris et al. 2005)

Alternatively, we estimated from transition probabilities (Appendix C) that approximately 0.529 females ≥4 years of age were accompanied by either cubs or yearlings in any given year. A simpler approach would set a limit that no more than half of all females ≥4 years old tallied in the mortality quota could be accompanied by cubs or yearlings. We did not choose this alternative because it does not allow for consideration of dependent young that die independently of their mothers.

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Table 14. Estimated number of females with cubs-of-the-year ($\hat{N}_{Chao2}$) and independent females aged ≥2 years old in the Greater Yellowstone Ecosystem, 1986–2004. Mortalities were listed by cause (management removal [MGMT], known because of telemetry [TELE], reported by the public [PUBL], estimates of known, unknown, and unreported [KNO:UNR), and total. The annual mortality limit from all causes was set at 9% of the annual female estimate. The 3-year running average of mortality smoothed the limit and was used as a threshold. Status indicates if threshold was exceeded and the probability of exceeding the threshold based on the credible interval used to calculate unknown and unreported mortality.

| Year | $\hat{N}_{Chao2}$ | Females ≥2 years | Female mortality | | | | | 9% mortality limit | 3-year running average limit | Status | $\hat{P}$ of exceeding[b] |
			MGMT	TELE	PUBL	KNO:U NR[a]	Total				
1986	27.5	123	1	3	1	2	6	11			
1987	17.3	77	1	0	1	2	3	7			
1988	21.2	95	0	1	0	1	2	9	9	OK	0.003
1989	17.5	78	0	0	0	1	1	7	8	OK	0.003
1990	25.0	112	1	2	3	7	10	10	9	exceeded	0.484
1991	37.8	169	0	0	0	1	1	15	11	OK	0.000
1992	40.5	181	0	1	0	1	2	16	14	OK	0.000
1993	21.1	94	0	1	2	5	6	9	13	OK	0.031
1994	22.5	101	0	2	1	2	4	9	11	OK	0.014
1995	43.0	192	3	0	3	7	10	17	12	OK	0.235
1996	37.5	168	1	3	2	5	9	15	14	OK	0.059
1997	38.8	173	0	0	3	7	7	16	16	OK	0.036
1998	36.9	165	0	0	1	2	2	15	15	OK	0.002
1999	36.0	161	0	0	1	2	2	14	15	OK	0.002
2000	51.0	228	1	1	3	7	9	21	17	OK	0.047
2001	48.2	216	5	3	1	2	10	19	18	OK	0.010
2002	58.1	260	2	2	4	10	14	23	21	OK	0.079
2003	46.4	208	1	0	5	13	14	19	20	OK	0.115
2004	57.5	257	4	0	5	13	17	23	22	OK	0.142

[a]Data in this column are estimates of unknown and unreported mortality plus mortalities reported by the public. The method of Cherry et al. (2002) estimates the number of times an event occurred given an observed outcome and the probability of that outcome. For example, the method would estimate the number of times a coin was flipped given that 3 heads were observed and the probability of a heads was 0.5. In our case here, it estimates the number of dead bears (both reported and unreported) given the number reported by the public. So in 2004,

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given that 5 bears were reported dead, the method estimated that 13 actually died

[b]The probability of exceeding was based on the method of Cherry et al. (2002). The probability values represent the likelihood of exceeding the 3-year running limit minus the known deaths (MGMT and TELE), given a public reporting (PUBL) rate for that year. For example in 2004, the 3-year limit was 22. The probability is therefore the likelihood of exceeding 19 deaths (22 – 4 - 0 +1 = 19) given that 5 were reported.

Independent Males ≥2 Years Old
We used empirical data to establish a male mortality limit based on estimates from 1983–2001 (Haroldson et al. 2005). Estimated survival of independent male bears in the GYE equaled either 0.874 or 0.823 for the censored and assumed dead data sets. We split the difference and established the limit of mortality equal to 0.15. Results of calculations and thresholds are reported in Table 15. Male limits are based on the status quo and the past 20 years, when the GYE grizzly bear population increased in size and expanded in range.

UNKNOWN AND UNREPORTED MORTALITY

To address objective 3, we considered the current method and evaluated and discussed other options.

Current Method
- Harris (1986) suggested that grizzly bear populations could sustain approximately 6% human-caused mortality without population decline. To facilitate recovery and to account for unknown, unreported, human-caused mortality, known human-caused mortality was set by the USFWS Grizzly Bear Recovery Plan at 4% of the minimum population estimate (USFWS 1993). The reduction from 6% to 4% was justified because an assumption was made that for 2 reported mortalities, an additional one was unreported.

However, Knight and Eberhardt (1985:330) stated that actual mortality in the GYE "appears to be approximately double that recorded."

Benefits
- Simple.
- Can be applied to any of the proposed population methods above.
- Has worked in the past.

Limitations
- Does not include estimates of uncertainty.
- This ratio may have changed.

Discussion
We all agreed that there was better information and that we should explore new methods to account for unknown and unreported mortality.

Table 15. Estimated number of females with cubs-of-the-year ($\hat{N}_{Chao2}$) and independent males (≥2 years old) in the Greater Yellowstone Ecosystem, 1986–2004. Mortalities were listed by cause (management removal [MGMT], known because of telemetry [TELE], reported by the public [PUBL], estimates of known, unknown, and unreported [KNO:UNR], and total. The annual mortality limit from all causes for males ≥2 years old was set at 15% of the male population estimate. The 3-year running average of mortality smoothed the limit and was used as a threshold. Status indicates if threshold was exceeded, and the probability of exceeding it was provided based on the credible interval used to calculate unknown and unreported mortality.

| Year | $\hat{N}_{Chao2}$ | Males ≥2 years | Male mortality | | | | | 15% mortality limit | 3-year running average limit | Status | $\hat{P}$ of exceeding |
			MGMT	TELE	PUBL	UNK:UNR	Total				
1986	27.5	74	1	1	0	1	3	11			
1987	17.3	47	2	1	0	1	4	7			
1988	21.2	57	1	1	1	2	4	9	9	OK	0.031
1989	17.5	47	1	1	1	2	4	7	8	OK	0.046
1990	25.0	68	1	1	2	5	7	10	9	OK	0.154
1991	37.8	102	0	0	0	1	1	15	11	OK	0.000
1992	40.5	110	2	5	1	2	9	16	14	OK	0.031
1993	21.1	57	0	2	0	1	3	9	13	OK	0.000
1994	22.5	61	0	1	1	2	3	9	11	OK	0.010
1995	43.0	116	2	4	4	10	16	17	12	exceeded	0.750
1996	37.5	102	2	2	3	7	11	15	14	OK	0.182
1997	38.8	105	1	1	2	5	7	16	16	OK	0.016
1998	36.9	100	2	2	0	1	5	15	15	OK	0.000
1999	36.0	97	2	2	3	7	11	15	15	OK	0.140
2000	51.0	138	2	4	11	29	35	21	17	exceeded	1.000
2001	48.2	131	7	2	1	2	11	20	18	OK	0.014
2002	58.1	157	4	1	3	7	12	24	21	OK	0.036
2003	46.4	126	2	3	3	7	12	19	21	OK	0.036
2004	57.5	156	3	2	7	18	23	23	22	exceeded	0.476

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Alternative Method

Cherry et al. (2002) provided an alternative method that used a hierarchical Bayesian model, with an assumed noninformative prior distribution for the number of deaths. Information from reporting rates of deaths in radiocollared bears was used to develop a beta prior distribution on the probability that a death would be reported by the public. Data were reassessed and those results are provided in Appendix B.

Benefits
- Based on empirical data.
- Deals with uncertainty.
- Can be updated with new information.

Limitations
- The method assumes that deaths occur independently of one another.
- Deaths of instrumented and noninstrumented bears have the same probability of being reported.
- The probability of a death being reported is independent of the cause of death.
- The probability a death is reported is constant over the period on which the prior distribution is based.
- In general the estimate is sensitive to the prior distribution.
- Bayesian credible intervals are wide.
- Estimate sensitive to prior.

Discussion

We all agreed that this approach was superior to the original method. Recent information (Appendix C) suggested the at ratio of known:unknown deaths was closer to 1:2 as opposed to the 2:1 ratio used in the original method. Items that we felt needed additional investigation and tasks we assigned to Dr. Cherry included:
- Is the median the best statistic to establish the prior?
- Cherry et al. (2002) used a 3-year running average of mortalities to illustrate how to calculate the credible interval. Can we use an annual estimate?

It was recommended we use the median because it is a reasonable summary measure that works well for all posterior distributions we have seen in our data (Appendix D).

It was also recommended that the credible interval be based on the annual estimate to avoid issues with running averages.

POPULATION MONITORING

Our objectives in this report addressed establishing methods to index bear numbers, establishing of mortality thresholds for independent females, independent males, and dependent young, and accounting for unknown and unreported mortality in tallies of dead bears. The group felt that to successfully monitor the GYE bear population and ensure that mortality thresholds are in line with demographics, additional monitoring was

important. We therefore endorsed recommendations made by Schwartz et al. (2005*c*). Those recommendations are repeated here.

Simulations conducted by Harris et al. (2005) quantified and confirmed conventional wisdom that changes in λ are largely influenced by changes in survival of independent females (73% elasticity), which is principally driven by human-caused mortality. Managing human-caused female mortality was a major goal established by Interagency Grizzly Bear Committee (IGBC) in 1983, and results of our spatial analysis suggest success in this management effort.

We recommend the following to improve our abilities to understand the GYE population:
1. Identify additional areas outside the Recovery Zone (RZ) that will be designated as biologically suitable and socially acceptable habitats for grizzly bears in the GYE. The states of Idaho, Montana, and Wyoming have agreed to this in their management plans. These lands should be managed as biologically secure habitat. Biologically secure habitat in aggregate would be defined as lands where on average reproduction and survival rates result in λ = 1.
2. Maintain a representative sample of radiomarked individuals residing in biologically secure habitat for monitoring purposes. As indicated by Harris et al. (2005) results should be robust to geographic heterogeneity as long as survival rates of dependent and independent females are unbiased estimates of the entire GYE grizzly population.
3. Estimate trajectory for biologically secure habitat in aggregate at approximately 10-year intervals. Harris et al. (2005:Tables 20–22) showed that when survival of independent female bears was ≥0.91 with $m_x = 0.318$, then λ ≥ 1 about 95% of the time. Assuming that survival of independent females remains at or near our current estimate of ≥0.92, survival can be estimated with SE ≤ 0.02 from a telemetry sample ≥185 bear-years. Assuming we continue to meet the IGBC mandate of maintaining a sample of at least 25 adult females/year, we can estimate a population trajectory in biologically secure habitat approximately every 8 years.
4. Continue counts of unduplicated females with cubs in all occupied habitats.
5. Conduct a demographic review to consider alternate mortality limits based on findings in Schwartz et al. (2005*d*) and those of Cherry et al. (2002). This review must recognize that habitat carrying capacity may change, and may ultimately be reached; if this occurs, an annual management goal of λ ≥ 1 is unrealistic. We recommend exploring alternative mortality limits that consider counting all forms of mortality — not just human-caused — in any revised demographic management system, setting different mortality limits for independent females and males, and exploring mechanisms for more liberal mortality limits outside areas designated as biologically secure habitat.
6. Develop more sophisticated models of the current source–sink dynamic using covariates that might explain observed differences in mortality rates among the 3 politically defined residency zones (see Schwartz et al. 2005*e*). We recognize that our 3 zones are a rather simplistic approach to any spatial analysis.
7. Explore habitat use and home-range sizes of historically collared bears to better understand potential edge effects (White et al. 1982) associated with home range size and the geographic extent of the existing RZ.

8. Explore dispersal rates and distances within GYE to better understand where bears killed in insecure habitats originate.

9. Explore the influence of type of conflict on subsequent survival of individuals. Our a posteriori models demonstrated that survival of individuals improved with years post conflict. We suspect that conflict type (i.e., livestock, human dwellings, etc.) also could influence the rate of survival.

DEMOGRAPHIC OBJECTIVES

Under the Conservation Strategy, the IGBST is responsible for carrying out a biology and monitoring review. Such reviews are triggered by negative deviations from the desired conditions established in the Conservation Strategy for population, mortality reduction, and habitat parameters. The Conservation Strategy (USFWS 2003:6) states that "it is the goal of the agencies implementing this Conservation Strategy to manage the Yellowstone grizzly population in the entire GYA at or above 500 grizzly bears." Because of the increased level of uncertainty in estimating total population size using the methods we propose here, and because long-term survival of the GYA grizzly bear is most closely linked to survival of adult females (Eberhardt 1977, 1990, 2002; Knight and Eberhardt 1987; Harris et al. 2005), we recommend a demographic target ≥48 adult females (age ≥4 years) be maintained annually. This target of 48 females, when extrapolated, is equivalent to a population of approximately 500 individuals. We derived this figure by starting with a population of 500 bears. On average, the number of dependent young in the population based on our methods of calculation (Table 7) is approximately 31% (range 29–33 for years 1999–2004). Consequently, 69% of the population of bears is ≥2 years old which equates to 500 x 0.69 = 345 adult bears. Assuming a sex ratio of 62 females:38 males, this equates to a population of ≥2-year-old females of 215 (345 x 0.62). Females ≥4 years old constitute approximately 0.773 of the ≥2-year-old females or 215 x 0.773 = 166. Our transition probabilities suggest that approximately 28.9% of females ≥4 years old have cubs in any given year, which equates to 48 females (166 x 0.289 = 48). Using the old method (Equation 1), we would sum 3 years of counts and divide by 0.274. This equates to a population estimate of ([48 + 48 + 48]/0.274 = 526. If we replace the value 0.274 with the updated estimate from Harris (Appendix A, Table 1 of this report) of 0.289, 48 females returns a population of 498 bears. These different methods yield approximately the same number of bears.

This target of 48 will be derived from the point estimate of the $Chao_2$ estimator using frequency counts of unduplicated females with cubs. We recommend the point estimate because: (1) the $Chao_2$ estimator is either accurate relative to actual bear numbers or biased low, and (2) statistically, the point estimate is the best unbiased estimate of the mean. Because we observe normal variation about counts of females related to reproductive performance and foods (Schwartz et al. 2005*b*), we anticipate some natural variation to occur. Short-term fluctuation in counts is therefore expected. We are most concerned with long-term chronic declines in counts which might reflect a declining population. We recommend a biology and monitoring review should the estimate decline below this threshold of 48 for any 2 consecutive years. We make no effort to define all possible management scenarios that might need review. We likewise make no effort to outline in detail recommendations that might come from a biology and monitoring review

because each would have its own unique combination of circumstances and data that must be evaluated in light of other information.

Management agencies lack complete control over female mortality. Hence, if the lower one-tailed 80% bound of the $Chao_2$ estimate is <48 in any given year, agencies should attempt to limit female mortality the following year as a proactive measure to help minimize exceeding the point estimate recommendation above.

Although male mortality has no impact on population trajectory over the long run (Harris et al. 2005), we feel that some limits are necessary. We therefore recommend that managers try not to exceed established mortality limits for males as set forth in this document. We recommend that a management review be considered should male limits be exceeded in any 3 consecutive years. We further recommend that mortality limits of dependent young not be exceeded in any 3 consecutive years.

ADAPTIVE MANAGEMENT

Dale Strickland provides a brief summary of adaptive management (West, Inc. 2005), which he gleaned from Holling (1978), McLain and Lee (1996), Walters (1997), and Holling and Allen (2002). Adaptive management (AM) is characterized as a 6-step feedback loop:

1. Assessment — the point where current understanding of the system leads to development of strategies to meet management goals, prediction of outcomes of management, and the identification of key questions in the form of testable hypothesis.
2. Design — management actions and associated monitoring and research evaluate how well management meets specific management targets and address the hypothesis being tested.
3. Implementation — management is implemented according to the design.
4. Monitor — completed according to the design with data collected on specific performance measures.
5. Evaluation — outcome is evaluated against predictions about effects of management; progress toward goals is assessed.
6. Adjust — management adjusted based on evaluation of initial management actions. This adjustment can range from slight modification of the management action to a complete change in management direction, and possibly a change in the overall focus of the management program.

An AM plan includes 3 critical elements:

1. Conceptual and quantitative models that make explicit the current understanding of the system, the underlying hypotheses driving management, and key uncertainties;
2. Rigorous monitoring plans focused on reducing the most critical uncertainties and clearly evaluating progress toward management goals; and
3. A scientifically defensible plan for monitoring and research and rapid feedback from management outcomes to revised management decisions.

AM usually sets limits on goals, objectives, and management flexibility. These limits are usually based on logistical and technological feasibility, costs, and laws and regulations.

A major implication of adaptive management is that acquisition of useful data is one of the more important goals of management; therefore, the need for useful data should be considered when making management decisions. Monitoring and research should consider sources of uncertainty and attempt to reduce or eliminate them. However, the expected likelihood and costs of reducing uncertainty and the expected benefit in terms of improved management decisions will be primary considerations when prioritizing monitoring and research projects. This requires that setting of monitoring and research priorities is directly tied to the management framework.

The Conservation Strategy (USFWS 2003) recommends using AM when possible. Our approach here follows those recommendations. Much of the original demographics work (Eberhardt et al. 1994, Eberhardt 1995, Boyce et al. 2001, Haroldson et al. 2005, Harris et al. 2005, Schwartz et al. 2005*a, b, c*) has been completed and meets the assessment set of the 6-step process. Development of strategies to meet management goals (in this case a sustainable population) is the objective of this document. We have formally developed testable hypotheses. Based upon recommendations here, our scientific hypothesis would be that recommended mortality limits based on methods to estimate population size and unknown and unreported mortality will result in a stable or slightly increasing population of grizzly bears in the GYE.

Design elements for monitoring and continued research are contained within this document, as management recommendations to the demographics monograph (Schwartz et al. 2005*c*, and as part of the population monitoring recommendations of the Conservation Strategy (USFWS 2003). Annual reviews of results from all monitoring are recommended as per the Conservation Strategy.

The implementation phase is recommended to begin in 2005. Monitoring is ongoing and will continue. Counts of females with cubs and mortality documentation will be assessed annually for changes. Formal evaluation is recommended approximately every 8–10 years. Evaluation research will focus on updating demographic parameters used to estimate reproduction and survival, λ, and to reassess the stable age distribution, and transition probabilities used to estimate the number of females with cubs in any year. Should age structure, survival, or reproduction change due to density dependent relationships previously identified (Boyce et al. 2001, Schwartz et al. 2005*a, b*), or due to changes in food abundance or other natural processes adjustments to parameters used to estimate bear numbers, sustainable mortality, or unknown and unreported mortality will occur. Adjustments to this recommended protocol can occur after annual evaluations or following the more rigorous one that occurs every 8–10 years.

REPORT PREPARATION

We prepared this report to detail what we reviewed and our recommendations. We further recommend that results contained here be presented to state and federal managers for discussion, modification, and acceptance. Once this task is complete, we also recommend that these methods be presented to the Yellowstone Ecosystem Subcommittee for endorsement and application.

LITERATURE CITED

BLANCHARD, B. M., AND R. R. KNIGHT. 1991. Movements of Yellowstone grizzly bears, 1975–87. Biological Conservation 58:41–67.

BOYCE, M., B. M. BLANCHARD, R. R. KNIGHT, AND C. SERVHEEN. 2001. Population viability for grizzly bears: a critical review. International Association of Bear Research and Management Monograph Series Number 4.

BOULANGER, J., B. N. MCLELLAN, J. G. WOODS, M. E. PROCTOR, AND C. STROBECK. 2004. Sampling design and bias in DNA-based capture–mark–recapture population and density estimates of grizzly bears. Journal of Wildlife Management 68:457–46.

———, G. C. WHITE, B. N. MCLELLAN, J. WOODS, M. PROCTOR, AND S. HIMMER. 2002. A meta analysis of grizzly bear DNA mark–recapture projects in British Columbia. Ursus 13:137–152.

CHAO, A., W.-H. HWANG, Y.-C. CHEN, AND C.-Y. KUO. 2000. Establishing the number of shared species in two communities. Statistica Sinica 10:227–246.

———, M.-C. MA, AND M. C. K. YANG. 1993. Stopping rules and estimation for recapture debugging with unequal failure rates. Biometrika 80:193–201.

CHERRY, S., M. A. HAROLDSON, J. ROBISON-COX, AND C. C. SCHWARTZ. 2002. Estimating total human-caused mortality from reported mortality using data from radio-instrumented grizzly bears. Ursus 13:175–184.

EBERHARDT, L. L. 1977. Optimal policies for conservation of large mammals, with special reference to marine ecosystems. Environmental Conservation 4:205–212.

———. 1990. Survival rates required to sustain bear populations. Journal of Wildlife Management 54:587–590.

———. 1995. Population trend estimates from reproductive and survival data. Pages 13–19 in R. R. Knight and B. M. Blanchard, editors. Yellowstone grizzly bear investigations: annual report of the Interagency Study Team, 1994. National Biological Service, Bozeman, Montana, USA.

———. 2002. A paradigm for population analysis of long-lived vertebrates. Ecology 83:2841–2854.

———, B. M. BLANCHARD, AND R. R. KNIGHT. 1994. Population trend of the Yellowstone grizzly bear as estimated from reproductive and survival rates. Canadian Journal of Zoology 72:360–363.

———, AND R. R. KNIGHT. 1996. How many grizzlies in Yellowstone? Journal of Wildlife Management 60:416–421.

HAROLDSON, M. A., C. C. SCHWARTZ, AND G. C. WHITE. 2005. Survival of independent grizzly bear in the Greater Yellowstone Ecosystem, 1983–2001. *In* C. C. Schwartz, M. A. Haroldson, G. C. White, R. B. Harris, S. Cherry, K. A. Keating, D. Moody, and C. Servheen, authors. Temporal, spatial, and environmental influences on the demographics of grizzly bears in the Greater Yellowstone Ecosystem. Wildlife Monographs 161.

HARRIS, R. B. 1984. Harvest age structure as an indicator of grizzly bear population status. Thesis, University of Montana, Missoula, Montana, USA.

———. 1986. Modeling sustainable harvest rates for grizzly bears. Appendix K *in* A. Dood, R. Brannon, and R. Mace, editors. The grizzly bear in northwestern Montana. Final programmatic environmental impact statement. Montana Department of Fish, Wildlife and Parks, Helena, Montana, USA. Unit Publication, Missoula, Montana, USA.

———, C. C. SCHWARTZ, M. A. HAROLDSON, AND G. C. WHITE. 2005. Trajectory of the Yellowstone grizzly bear population under alternative survival rates. *In* C. C. Schwartz, M. A. Haroldson, G. C. White, R. B. Harris, S. Cherry, K. A. Keating, D. Moody, and C. Servheen, authors. Temporal, spatial, and environmental influences on the demographics of grizzly bears in the Greater Yellowstone Ecosystem. Wildlife Monographs 161.

HARRISON, J. L. 1958. Range of movement of some Malayan rats. Journal of Mammalogy 38:190–206.

HOLLING, C. S. 1978. Adaptive environmental assessment and management. John Wiley and Sons, New York, New York, USA.

———, AND C. R. ALLEN. 2002. Adaptive inference for distinguishing credible from incredible patterns in nature. Ecosystems 5:319–328.

KEATING, K. A., C. C. SCHWARTZ, M. A. HAROLDSON, AND D. MOODY. 2002. Estimating numbers of females with cubs-of-the-year in the Yellowstone grizzly bear population. Ursus 13:161–174.

KNIGHT, R. R., B. M. BLANCHARD, AND L. L. EBERHARDT. 1995. Appraising status of the Yellowstone grizzly bear population by counting females with cubs-of-the-year. Wildlife Society Bulletin 23:245–248.

———, AND L. L. EBERHARDT. 1985. Population dynamics of Yellowstone grizzly bears. Ecology 66:323–334.

———, AND ———. 1987. Prospects for Yellowstone grizzly bears. International Conference on Bear Research and Management 7:45–50.

MATTSON, D. M. 1997. Sustainable grizzly bear mortality calculations from counts of females with cubs-of-the-year: an evaluation. Biological Conservation 81:103–111.

———, R. R. KNIGHT, AND B. M. BLANCHARD. 1987. The effects of developments and primary roads on grizzly bear habitat use in Yellowstone National Park, Wyoming. International Conference on Bear Research and Management 7:259–273.

MCKELVEY, K. S., AND M. K. SCHWARTZ. 2004. Genetic errors associated with population estimation using non-invasive molecular tagging: problems and new solutions. Journal of Wildlife Management 68:439–448.

MCLAIN, R. J. AND R. G. LEE. 1996. Adaptive management: promises and pitfalls. Environmental Management 20:437–448.

MCLOUGHLIN, P. D. 2002. Managing risks of decline for hunted populations of grizzly bears given uncertainty in population parameters. Final Report. British Columbia Independent Scientific Panel on Grizzly Bears. Report to the British Columbia Independent Research Panel on Grizzly Bears, Victoria, British Columbia, Canada.

MILLER, S. D., G. C. WHITE, R. A. SELLERS, H. V. REYNOLDS, J. W. SCHOEN, K. TITUS, V. BARNES, JR., R. B. SMITH, R. R. NELSON, W. B. BALLARD, AND C. C. SCHWARTZ. 1997. Brown and black bear density estimation in Alaska using radiotelemetry and replicated mark–resighting techniques. Wildlife Monographs 133.

MILLS, L. S., J. J. CITTA, K. P. LAIR, M. K. SCHWARTZ, AND D. A. TALLMON. 2000. Estimating animal abundance using non-invasive DNA sampling: promise and pitfalls. Ecological Applications 10:283–294.

MOWAT, G., AND C. STROBECK. 2000. Estimating population size of grizzly bears using hair capture, DNA profiling, and mark–recapture analysis. Journal of Wildlife Management 64:183–193.

PAETKAU, D. 2003. An empirical exploration of data quality in DNA-based population inventories. Molecular Ecology 12:1375–1387.

———. 2004. The optimal number of makers in genetic capture–mark–recapture studies. Journal of Wildlife Management 68:449–452.

SCHWARTZ, C. C. 1999. Evaluation of a capture–mark–recapture estimator to determine grizzly bear numbers and density in the Greater Yellowstone Area. Pages 13–20 *in* C. C. Schwartz and M. A. Haroldson, editors. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 1998. U.S. Geological Survey, Bozeman, Montana, USA.

———. 2000. Evaluation of a capture–mark–recapture estimator to determine grizzly bear numbers and density in the Greater Yellowstone Area. Pages 15–18 *in* C. C. Schwartz and M. A. Haroldson, editors. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 1999. U.S. Geological Survey, Bozeman, Montana, USA.

———, AND A. W. FRANZMANN. 1991. Interrelationship of black bears to moose and forest succession in the northern coniferous forest. Wildlife Monographs 113.

———, M. A. HAROLDSON, AND S. CHERRY. 2005*a*. Reproductive performance for grizzly bears in the Greater Yellowstone Ecosystem, 1983–2002. *In* C. C. Schwartz, M. A. Haroldson, G. C. White, R. B. Harris, S. Cherry, K. A. Keating, D. Moody, and C. Servheen, authors. Temporal, spatial, and environmental influences on the demographics of grizzly bears in the Greater Yellowstone Ecosystem. Wildlife Monographs 161.

———, ———, K. A. GUNTHER, AND D. MOODY. 2002. Distribution of grizzly bears in the Greater Yellowstone Ecosystem, 1990–2000. Ursus 13:203–212.

———, ———, AND G. C. WHITE. 2005*e*. Study area and methods for collecting and analyzing demographic data on grizzly bears in the Greater Yellowstone Ecosystem. *In* C. C. Schwartz, M. A. Haroldson, G. C. White, R. B. Harris, S. Cherry, K. A. Keating, D. Moody, and C. Servheen, authors. Temporal, spatial, and environmental influences on the demographics of grizzly bears in the Greater Yellowstone Ecosystem. Wildlife Monographs 161.

———, ———, AND ———. 2005*b*. Survival of cub and yearling grizzly bears in the Greater Yellowstone Ecosystem, 1983–2001. *In* C. C. Schwartz, M. A. Haroldson, G. C. White, R. B. Harris, S. Cherry, K. A. Keating, D. Moody, and C. Servheen, authors. Temporal, spatial, and environmental influences on the demographics of grizzly bears in the Greater Yellowstone Ecosystem. Wildlife Monographs 161.

———, ———, ———, R. B. HARRIS, S. CHERRY, K. A. KEATING, D. MOODY, AND C. SERVHEEN. 2005*d*. Temporal, spatial, and environmental influences on the demographics of grizzly bears in the Greater Yellowstone Ecosystem. *In* C. C. Schwartz, M. A. Haroldson, G. C. White, R. B. Harris, S. Cherry, K. A. Keating, D. Moody, and C. Servheen, authors. Wildlife Monographs 161.

———, R. B. HARRIS, AND M. A. HAROLDSON. 2005*c*. Impacts of spatial and environmental heterogeneity on grizzly bear demographics in the Greater Yellowstone Ecosystem: a source–sink dynamic with management consequences. *In* C. C. Schwartz, M. A. Haroldson, G. C. White, R. B. Harris, S. Cherry, K. A. Keating, D. Moody, and C. Servheen, authors. Temporal, spatial, and environmental influences on the demographics of grizzly bears in the Greater Yellowstone Ecosystem. Wildlife Monographs 161.

U.S. Fɪsʜ ᴀɴᴅ WɪʟᴅʟɪFᴇ Sᴇʀᴠɪᴄᴇ. 1982. Grizzly bear recovery plan. U.S. Fish and Wildlife Service, Denver, Colorado, USA.

———. 1993. Grizzly bear recovery plan. U.S. Fish and Wildlife Service, Missoula, Montana, USA.

———. 2003. Final conservation strategy for the grizzly bear in the Greater Yellowstone Ecosystem. U.S. Fish and Wildlife Service, Missoula, Montana, USA.

ᴠᴀɴ Bᴇʟʟᴇ, G. 2002. Statistical rules of thumb. John Wiley and Sons, New York, New York, USA.

Wᴀɪᴛs, L. P. 2004. Using non-invasive genetic sampling to detect and estimate abundance of rare wildlife species. Pages 211–228 *in* W. L. Thompson, editor. Sampling rare or elusive species. Island Press, Washington, D.C., USA.

———, ᴀɴᴅ D. Pᴀᴇᴛᴋᴀᴜ. 2005. Non-invasive genetic sampling tools for wildlife biologists: a review of applications and recommendations for accurate data collection. Wildlife Society Bulletin 33:in press.

Wᴀʟᴛᴇʀs, C. 1997. Challenges in adaptive management of riparian and coastal ecosystems. Conservation Ecology 1(2):1. http://www.consecol.org/vol1/iss2/art1

Wᴇsᴛ, Iɴᴄ. 2005. Avian collision and electrocution risk reduction adaptive management plan for the Altamont Pass Wind Resource Area. Technical Report. West Incorporated, Laramie, Wyoming, USA.

Wʜɪᴛᴇ, G. C. 1996. NOREMARK: population estimation from mark–resighting surveys. Wildlife Society Bulletin 24:50–52.

———, D. R. Aɴᴅᴇʀsᴏɴ, K. P. Bᴜʀɴʜᴀᴍ, ᴀɴᴅ D. L. Oᴛɪs. 1982. Capture–recapture and removal methods for sampling closed populations. Los Alamos National Laboratory report LA-8787-NEPA. Los Alamos National Laboratory, Los Alamos, New Mexico, USA.

Wᴏᴏᴅs, J. G., D. Pᴀᴇᴛᴋᴀᴜ, D. Lᴇᴡɪs, B. N. McLᴇʟʟᴀɴ, M. Pʀᴏᴄᴛᴏʀ, ᴀɴᴅ C. Sᴛʀᴏʙᴇᴄᴋ. 1999. Genetic tagging of free-ranging black and brown bears. Wildlife Society Bulletin 27:616–627.

Appendix A

Age-structures of modeled Greater Yellowstone Ecosystem grizzly bear populations

**Appendix to
Final Report**

16 April 2003

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The bulk of work completing this contract is contained in the report "Trajectory of the Yellowstone grizzly bear population under alternative survival rates," which is also being submitted for publication. This Appendix deals, separately, with the work pursuant to the last named deliverable: "Estimates and confidence limits around the proportion of the Greater Yellowstone Ecosystem (GYE) grizzly bear population consisting of adult females will also be produced as part of this work. Such estimates and confidence limits are a necessary component of estimates of total grizzly bear population size."

Objective
Size of the GYE grizzly bear population is currently estimated by dividing the estimate of "adult females" by the constant 0.284 (USFWS 1993:42). It is desirable to evaluate whether this constant is appropriate, and whether it should be updated. As well, use of a constant ignores the fact that this proportion may vary among years, and thus total population size should be estimated with appropriate error terms.

Here, I employed simulation techniques used in Harris et al. (2005) to update estimates that may be useful should managers desire to estimate total population size from some index of females with cubs or females of a minimum age.

Methods
Analyses of population parameters and development of a simulation model are both described in Harris et al. (2005), Schwartz et al. (2005*a, b*), and Haroldson et al. (2005). To generate statistics for this report, I used 2 parameterizations of the full simulation: (1) mean adult female (age >2) survival at 0.949, adult male (age >2) survival at 0.874, and

yearly process variation of survival rates approximating the shrunk estimates of process variation for the data set in which bears with unresolved fates were censored at last contact (Haroldson et al. 2005:Table 13); and (2) mean adult female (age >2) survival at 0.922, adult male (age >2) survival at 0.823, and yearly process variation of survival rates approximating the shrunk estimates of process variation from the data set in which animals with unresolved fates were assumed to have died (Haroldson et al. 2005). For each parameter set, I used a model run of 10 years (paralleling the larger analysis) and performed 3,000 iterations. The resulting proportions come from a sample of 30,000 years (there is some dependence of proportions within each 10-year series). Results are summarized via 5 statistics, determined yearly: (1) proportion of females in the population with cubs-of-the-year (cubs, hereafter); (2) proportion of all females aged >2 with cubs; (3) proportion of females aged >4 with cubs; (4) proportion of females aged >5 with cubs; and (5) proportion of the total population consisting of females aged >5.

Results

Proportions of females with cubs in any given year, and by females in the presumptive "adult" ages of 5 and older are shown in Tables 1 and 2 for the 2 alternative parameter sets. Values were very similar for both simulations. The mean proportion of the total population consisting of adult females varied from 0.29 to 0.30, which are both similar to the earlier assumed value of 0.284. Without simulations, values of the proportion of the female segment made up by females with cubs in any year were not previously available.

Table 1. Proportions generated from age-structures of simulated populations with high survival and low process variance.

	Mean	CV[a]	Lower 95% CL	Upper 95% CL
Proportion of all females that are with cubs	0.176	0.097	0.145	0.212
Proportion of female 2+ that are with cubs	0.247	0.110	0.199	0.307
Proportion of female 4+ that are with cubs	0.315	0.096	0.259	0.378
Proportion of female 5+ that are with cubs	0.356	0.090	0.294	0.421
Proportion of total population that are females age ≥5	0.289	0.047	0.266	0.319

[a] Standard deviation/mean.

Table 2. Proportions generated from age-structures of simulated populations with low survival and high process variance.

	Mean	CV[a]	Lower 95% CL	Upper 95% CL
Proportion of all females that are with cubs	0.176	0.094	0.143	0.209
Proportion of female 2+ that are with cubs	0.248	0.105	0.197	0.300
Proportion of female 4+ that are with cubs	0.314	0.103	0.251	0.378
Proportion of female 5+ that are with cubs	0.353	0.101	0.284	0.424
Proportion of total population that are females age ≥5	0.299	0.036	0.278	0.320

[a] Standard deviation/mean.

Discussion

Variability of the figures provided in Tables 1 and 2 may be slightly lower than reality, because cub production varied independently each year, and variance was modeled as coming from a single distribution that was normal on the logit scale. In reality, we suspect that some very poor food years are characterized by near complete failure to breed of all available females (i.e., those of sufficient maturity who do not have cubs or yearlings from previous years at their sides). The year following such a failure, there is probably a bumper crop of cubs, because those females failing to breed during the poor year are added to those who would have been available in any case. Thus, there is probably more variability in the true ratio of females with cubs to all females than represented in these simulations.

Even were that variation to be included, coefficients of variation and confidence limits (Table 1, 2) depict variation of the entire population (i.e., reflect process variation). They do not reflect the variability that will characterize samples of the population, the magnitude of which will depend on sample size.

It would seem more straight forward to estimate the number of females from females with cubs, than the current alternative (estimating total population size from adult females). This is because the yearly estimates of the number of females with cubs do not correspond exactly to females of any particular age. Age at first reproduction is not a step function, but rather a gradually increasing function (Schwartz et al. 2005*a*). As well, breeding interval, although close to 3 years, is itself variable. Thus, additional assumptions and approximation are necessary to convert females with cubs into "adult" females. In contrast, the ratio of females with cubs:all females does not require additional assumptions or approximations (beyond those included in the simulation model). In addition, estimating the size and trend of the female segment of the population is probably more informative for conservation and management purposes than is estimating total population size.

Acknowledgments

Thanks to C. Schwartz, M. Haroldson, G. White, S. Cherry, and K. Keating for helpful discussion.

Literature Cited

HAROLDSON, M. A., C. C. SCHWARTZ, AND G. C. WHITE. 2005. Survival of independent grizzly bear in the Greater Yellowstone Ecosystem, 1983–2001. *In* C. C. Schwartz, M. A. Haroldson, G. C. White, R. B. Harris, S. Cherry, K. A. Keating, D. Moody, and C. Serveen, authors. Temporal, spatial, and environmental influences on the demographics of grizzly bears in the Greater Yellowstone Ecosystem. Wildlife Monographs 161.

HARRIS, R. B., C. C. SCHWARTZ, M. A. HAROLDSON, AND G. C. WHITE. 2005. Trajectory of the Yellowstone grizzly bear population under alternative survival rates. *In* C. C. Schwartz, M. A. Haroldson, G. C. White, R. B. Harris, S. Cherry, K. A. Keating, D. Moody, and C. Serveen, authors. Temporal, spatial, and

environmental influences on the demographics of grizzly bears in the Greater Yellowstone Ecosystem. Wildlife Monographs 161.

SCHWARTZ, C. C., M. A. HAROLDSON, AND S. CHERRY. 2005*a*. Reproductive performance for grizzly bears in the Greater Yellowstone Ecosystem, 1983–2002. *In* C. C. Schwartz, M. A. Haroldson, G. C. White, R. B. Harris, S. Cherry, K. A. Keating, D. Moody, and C. Servheen, authors. Temporal, spatial, and environmental influences on the demographics of grizzly bears in the Greater Yellowstone Ecosystem. Wildlife Monographs 161.

———, ———, AND G. C. WHITE. 2005*b*. Survival of cub and yearling grizzly bears in the Greater Yellowstone Ecosystem, 1983–2001. *In* C. C. Schwartz, M. A. Haroldson, G. C. White, R. B. Harris, S. Cherry, K. A. Keating, D. Moody, and C. Servheen, authors. Temporal, spatial, and environmental influences on the demographics of grizzly bears in the Greater Yellowstone Ecosystem. Wildlife Monographs 161.

U.S. FISH AND WILDLIFE SERVICE. 1993. Grizzly bear recovery plan. Missoula, Montana, USA.

Appendix B

Counts and estimates of mortality for independent-aged grizzly bears in the Greater Yellowstone Ecosystem

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Grizzly bears (*Ursus arctos horribilis*) in the Greater Yellowstone Ecosystem (GYE) are currently listed as threatened under the Endangered Species Act. Tracking mortality in the population is an essential component of the recovery process. Grizzly bear deaths caused by agency removals or those of instrumented bears are known or can be inferred. Additionally, the public reports an unknown portion of mortalities of uncollared bears. Cherry et al. (2002) described methodology to estimate the number of nonagency human-caused deaths of uncollared bears using a hierarchical Bayesian model with a noninformative prior distribution for the number of deaths. Critical assumptions relative to the method were identified in Cherry et al. (2002).

We applied methodology developed in Cherry et al. (2002) to estimate annual unreported mortality, from all causes, for independent aged female and male bears. We excluded possible mortalities (Craighead et al. 1988) from consideration because by definition the chance is small that these instances resulted in dead bears. Also, since we estimated for all mortalities regardless of cause, known deaths from undetermined causes are included.

Cherry et al. (2002) alternately included or excluded unexplained and unresolved losses of radiomarked bears to estimate reporting rates. We used a Delphi procedure to identify which unexplained and unresolved losses were likely mortalities. Nine experts who manage or research grizzly bears in the GYE ranked each unexplained and unresolved loss as whether it was, in their opinion, a human-caused mortality. Results of this Delphi procedure suggested that 41% (9/22) of these unexplained and unresolved losses were likely human-caused mortalities and are included as such in subsequent analyses.

We combined sexes to estimate reporting rate because there was no evidence that rates were different between sexes (Table 1). We used estimates of reporting rates developed from deaths of radiomarked bears from 1983–2004 to develop prior probability distributions that the public reported bear mortalities regardless of cause.

Table 1. Method of discovery for deaths of independent (ages ≥2 years) radiomarked grizzly bears during 1983-2004, regardless of cause. Estimated reporting rate is 37%, conversely 63% of mortalities of radiomarked bears go unreported.

Method of discovery	Frequency	%
Unreported (discovery due to telemetry)	36	63.2
Reported (discovery not due to telemetry)	21	36.8
Total	57	100

The number of publicly reported deaths of uncollared bears, together with the beta distribution estimated from the observed reporting rate, are used to estimate a posterior distribution for total annual reported and unreported mortality (Cherry et al. 2002). We used the median of the posterior distribution (Appendix D) as our best estimate of unreported mortality (Table 2, 3). Number of management removals and losses of radiomarked bears documented annually are added to the median estimate of reported and unreported mortality to estimate total annual mortality from all causes.

Table 2. Mortality counts and estimates for independent female deaths, 1986–2004.

Year	Sanctioned[a] removals	Radiomarked[b] loss	Reported[c] loss	Reported and[d] unreported loss (median)	Total[e] mortality
1986	1	3	1	2	6
1987	1	0	1	2	3
1988	0	1	0	1	2
1989	0	0	0	1	1
1990	1	2	3	7	10
1991	0	0	0	1	1
1992	0	1	0	1	2
1993	0	1	2	5	6
1994	0	2	1	2	4
1995	3	0	3	7	10
1996	1	3	2	5	9
1997	0	0	3	7	7
1998	0	0	1	2	2
1999	0	0	1	2	2
2000	1	1	3	7	9
2001	5	3	1	2	10
2002	2	2	4	10	14
2003	1	0	5	13	14
2004	4	0	5	13	17

[a] Includes removals of radiomarked bears.

[b] Losses of radiomarked bears from all causes except sanctioned management removals.

[c] Reported losses from all causes excluding sanctioned management removals and radiomarked bears.

[d] Median of creditable interval for reported and unreported loss estimates using methodology described in Cherry et al. (2002).

[e] Total mortality is the sum of sanctioned removal plus radiomarked loss plus the median for reported and unreported loss.

Table 3. Mortality counts and estimates for independent male deaths, 1986–2004.

Year	Sanctioned[a] removals	Radiomarked[b] loss	Reported[c] loss	Reported and[d] unreported loss (median)	Total[e] mortality
1986	1	1	0	1	3
1987	2	1	0	1	4
1988	1	1	1	2	4
1989	1	1	1	2	4
1990	1	1	2	5	7
1991	0	0	0	1	1
1992	2	5	1	2	9
1993	0	2	0	1	3
1994	0	1	1	2	3
1995	2	4	4	10	16
1996	2	2	3	7	11
1997	1	1	2	5	7
1998	2	2	0	1	5
1999	2	2	3	7	11
2000	2	4	11	29	35
2001	7	2	1	2	11
2002	4	1	3	7	12
2003	2	3	3	7	12
2004	3	2	7	18	23

[a] Includes removals of radiomarked bears.
[b] Losses of radiomarked bears from all causes except sanctioned management removals.
[c] Reported losses from all causes excluding sanctioned management removals and radiomarked bears.
[d] Median of creditable interval for reported and unreported loss estimates using methodology described in Cherry et al. (2002).
[e] Total mortality is the sum of sanctioned removal plus radiomarked loss plus the median for reported and unreported loss.

Literature Cited

CHERRY, S., M. A. HAROLDSON, J. ROBISON-COX, AND C. C. SCHWARTZ. 2002. Estimating total human-caused mortality from reported mortality using data from radio-instrumented grizzly bears. Ursus 13:175–184.

CRAIGHEAD, J. J., K. R. GREER, R. R. KNIGHT, AND H. I. PAC. 1988. Grizzly bear mortalities in the Yellowstone Ecosystem, 1959–1987. Montana Department of Fish, Wildlife and Parks, Helena, Montana, USA, Craighead Wildlife Institute, Missoula, Montana, USA, Interagency Grizzly Bear Study Team, Bozeman, Montana, USA, and National Fish and Wildlife Foundation, Washington, D. C., USA.

Appendix C

Estimation of Proportion of FCOY

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The purpose of this analysis was to estimate the proportion of females ≥3 years old that had cubs-of-the-year (FCOY).

Data
Data were from the reproductive database from 1983 through 2003. This database was filtered for bears ≥3 years old and research trapped, and had a good count of litter size. Not all individuals are in a continuous time series. In some cases their time series was interrupted and started again >1 year later because the individual lost its collar (or the collar went dead) and the individual was recaptured and recollared. Only 2 consecutive years of observations could be used to estimate transition rates. A total of 204 transitions were available for analysis: 54 from females with COY, 26 from females with yearling offspring, 13 with 2-year old offspring, and 111 with no offspring.

Methods
A multi-state model (Brownie et al. 1993) was used to estimate transition rates. Four states were assumed (Table 1), generating 16 possible transition probabilities (Table 2). However, 6 of these transitions are not biologically possible and are thus assumed to be zero: N to Y, N to T, C to T, Y to Y, T to Y, and T to T. Further, the sum of transitions for each state must equal 1, so only 6 transitions were estimated, with the remaining 4 obtained by subtraction. The estimated transition probabilities were N to C, C to C, C to Y, Y to C, Y to T, and T to C. All transitions to N were obtained by subtraction: N to N, C to N, Y to N, and T to N.

Table 1. The 4 states used with a multi-state model to estimate transition probabilities.

State	Code
No offspring present	N
Cubs-of-the-year present	C
Yearlings present	Y
Two-year olds present	T

Table 2. Transition probabilities estimated with the multi-state model.

Current State	Transfer to state			
	N	C	Y	T
N	Subtraction	Estimated	Zero	Zero
C	Subtraction	Estimated	Estimated	Zero
Y	Subtraction	Estimated	Zero	Estimated
T	Subtraction	Estimated	Zero	Zero

Estimation was performed with Program MARK (White and Burnham 1999) using the Brownie et al. (1993) multi-state model with maximum likelihood estimation and information-theoretic procedures for model selection (Burnham and Anderson 2002). Because only consecutive observations were analyzed, survival and capture probability parameters in the model were set to 1 and not estimated. Animals were removed from analysis after their last observation. A time-varying covariate of age of the female was included in 2 multi-state models to evaluate the effect of age on transition probabilities using a logit link. A model with each transition modeled with its own intercept and linear age effect on a logit scale was considered, followed by a model with each transition modeled with its own intercept, age and age-squared effects on a logit scale. Based on results from these models, additional post hoc, reduced models were considered where the results from the age and age-squared models suggested terms to remove that did not contribute to the fit of the model to the data. Time-specific models of the transition probabilities were not considered because of limited data available across the 21 years of observations. For the model with transition probabilities constant across time and no age covariate, the transition probabilities can be estimated directly from multinomial distributions, with this approach used to verify the estimates from Program MARK.

To estimate the proportion of the population in each state if the transition probabilities are assumed to be constant across time, the matrix of transition probabilities was raised to the 50th power and multiplied by the vector [1, 0, 0, 0]. The variance–covariance of the resulting vector was obtained numerically with the delta method.

Results

The models estimated and the model selection results (Table 3) suggest that age was an important predictor of transition probabilities. Estimates of the 6 transition probabilities for the intercept only model (no age effects) are provided in Table 4.

Table 3. Results of model selection conducted in Program MARK for the 3 models considered a priori (bottom 3 models) and the 3 additional models (top 3 models) considered post priori to estimate 6 transition probabilities.

Model	AICc	Delta AICc	AICc weights	Model likelihood	Num. par	Deviance
{psi(Age(Y to C, Y to T) *Transition*Age^2(N to C))}	303.384	0	0.63188	1	10	282.341
{psi(Age*Transition*Age^2 for N to C, Y to C, and Y to T)}	305.605	2.2207	0.20817	0.3294	12	280.112
{psi(Age*Transition +N to C Age^2)}	306.213	2.8293	0.15355	0.243	13	278.463
{psi(Age*Transition*Age^2)}	314.222	10.8376	0.0028	0.0044	18	274.852
{psi(Constant)}	314.487	11.1034	0.00245	0.0039	6	302.097
{psi(Age*Transition)}	315.998	12.6137	0.00115	0.0018	12	290.505

Table 4. Estimates of the 6 transition probabilities from the likelihood analysis of the constant model in Table 3.

Transition probability	Estimate	SE	LCI	UCI
N to C	0.475	0.045586	0.387371	0.564196
C to C	0.033898	0.02356	0.008493	0.125662
C to Y	0.79661	0.052404	0.675093	0.88071
Y to C	0.103448	0.056552	0.033745	0.276003
Y to T	0.689655	0.085909	0.502948	0.829943
T to C	0.642857	0.12806	0.376261	0.84304

The matrix of transition probabilities, including estimates obtained by subtraction, are shown in Table 5. In Table 6 are the estimates of the proportion of the population that would exist in each state assuming that transition probabilities are constant across time and age.

Table 5. Matrix of transition probability estimates.

Current state	Transfer to state			
	N	C	Y	T
N	0.525	0.475	0	0
C	0.169492	0.033898	0.79661	
Y	0.206897	0.103448	0	0.689655
T	0.357143	0.642857	0	0

Table 6. Asymptotic proportion of females in each state, with associated SE and 95% confidence intervals.

State	Estimate	SE	LCI	UCI
N	0.322529	0.056233	0.212313	0.432745
C	0.288777	0.022984	0.243728	0.333827
Y	0.230043	0.02362	0.183748	0.276338
T	0.158650	0.025705	0.108269	0.209032

Discussion

From Table 6, I conclude that 28.9% of the female population ≥4 years of age (recall I measured transitions, so bears starting at age 3 transitioned to age 4) will have cubs-of-the-year. This estimate is not affected by bias in the initial captures of the radiomarked sample. Suppose that the state of newly radiocollared animals is not in proportion to what exists in the population because some states are more likely to be trapped than others. For example, suppose that females in the N state are most likely to be collared, whereas females with offspring present are less likely. The sample used in the analysis will be weighted heavily toward the trappable state. However, estimates of the transitions are conditional on the current state. So although sample sizes will not be proportional to the actual frequencies of the states in the population, the estimates are not biased by this discrepancy in the frequency of states in the sample compared to the population. The precision of the estimates in Table 4 reflects the sample sizes available to estimate each transition.

If the frequency of the class transitioned from in the 204 transitions used in the analysis had been used to estimate the proportion of the population in each state, the estimates would have been N 0.544, C 0.265, Y 0.128, and T 0.064. These estimates differ substantially from the values in Table 6, and bias in capture frequencies. For the 74 captures of females where a radiocollar was attached, the proportions were N 0.663, C 0.229, Y 0.084, and T 0.024. These estimates of the proportion of each class captured to be radiocollared suggest that the most likely state to be captured in the sample is N, where the female is not encumbered by offspring.

However, a potential source of bias exists if radiocollared animals slip or otherwise lose their collars (possibly from death) at different rates. In particular, if females about to make a particular transition, say Y to T, are more likely to lose their radiocollars than females in other states, biased estimates of the transition probabilities will result because of this disproportional censoring, and hence biased estimates of the proportion of females in each state will result. Of the 80 losses (i.e., loss of collar or death of the female), 0.263 occurred for N, 0.400 for C, 0.250 for Y, and 0.088 for T. These values are intermediate between the estimated asymptotic distribution (Table 6) and the frequency of females collared (Fig. 1). The proportion of collars lost seems to be the highest for females with offspring, particularly cubs-of-the-year. Possibly the loss of collars for FCOY is higher because of weight loss from the energetic costs of suckling cubs.
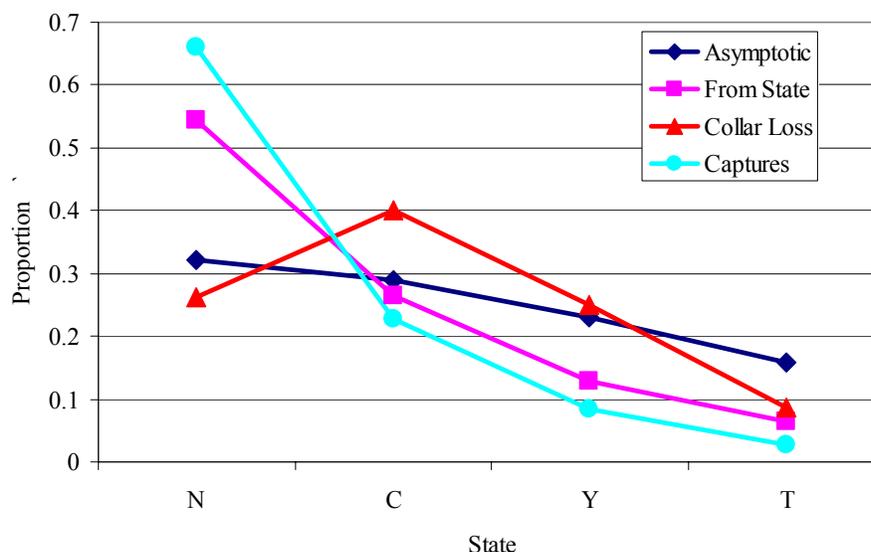
Figure 1. Proportion of females in each state for 4 estimates: "asymptotic values" are proportion of females estimated from the multi-state analysis, "from state" is the proportion of the 4 states from which the transitions were estimated, "collar loss" is the proporiton of each state losing collars, and "captures" is the proportion of each state in the sample when the animals were captured and radiocollared.

Age was important in model selection results (Table 3), particularly for the N to C transition when modeled as a quadratic. Graphs of the transition functions (Fig. 2) suggest evidence that older animals became better mothers, more capable of raising cubs to independent offspring. The transition rates of both C to Y and Y to T are increasing

early with age, and then declining at older ages. If older, more mature females become better mothers, I expect that both these transitions should increase with experience. Both C to C and Y to C transitions decrease with age, which is expected under the hypothesis of older females being better mothers. The graph for N to C (Fig. 2) also suggests that the most fertile females are of medium age, as suggested by the C to Y and Y to T curves.

{psi Age*Transition*Age^2}
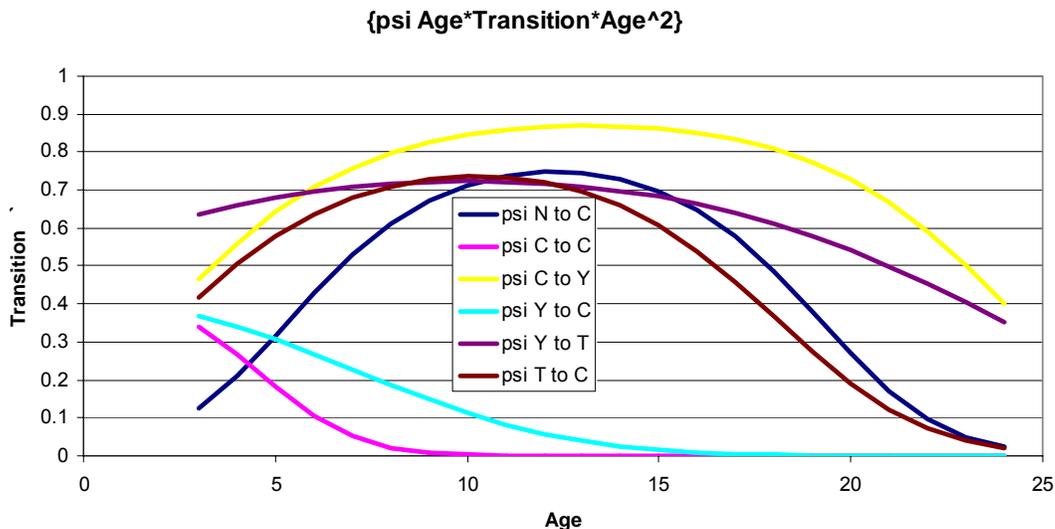
Figure 2. Age-specific transition probabilities from the quadratic model {psi(Age*Transition*Age^2)}.

Because the {psi(age x transition x age^2)} model has 18 parameters, a more parsimonious model was sought to use in modeling age effects in a population model. The top AICc model obtained post posteriori was {psi(age(Y to C, Y to T) x transition x age^2(N to C))}, where the Y to C and Y to T transitions were modeled as a linear function of age, N to C was a quadratic function of age, and the remaining transition probabilities were assumed constant (Fig. 3). This is the model that will be used to develop an age-structured model for evaluating the consistency of various estimates of survival, population size, and recruitment.

{psi(Age(Y to C, Y to T)*Transition*Age^2(N to C))}
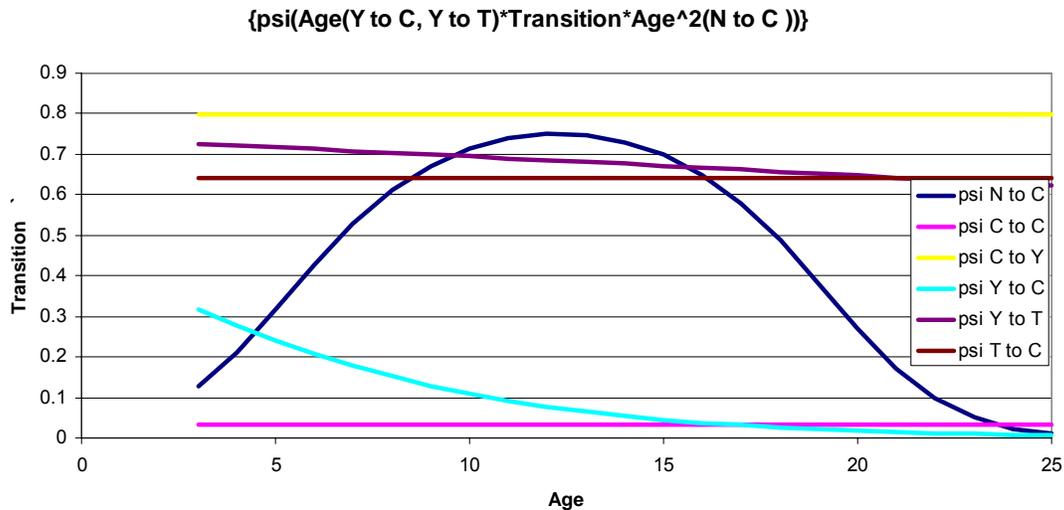
Figure 3. Transition probabilities as a function of age from the model {psi(age(Y to C, Y to T) x transition x age^2(N to C))}.

Literature Cited

BROWNIE, C., J. E. HINES, J. D. NICHOLS, K. H. POLLOCK, AND J. B. HESTBECK. 1993. Capture–recapture studies for multiple strata including non-Markovian transitions. Biometrics 49:1173–1187.

BURNHAM, K. P., AND D. R. ANDERSON. 2002. Model selection and multimodel inference: a practical information-theoretic approach. Springer-Verlag, New York, New York, USA.

WHITE, G. C., AND K. P. BURNHAM. 1999. Program MARK: survival estimation from populations of marked animals. Bird Study 46 Supplement:120–138.

Appendix D
Point Estimation using the Total Mortality Estimator

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The proposed method of estimating total mortality given a number of known and probable reported mortalities leads to a posterior distribution of total mortality. There are a number of ways of summarizing the information in this distribution to arrive at a point estimate of total mortality. Three common summaries are the mean, median, and mode of the distribution. These estimators are derived assuming different costs of being wrong. The cost of being wrong is quantified in a loss function, and an estimator is derived for each loss function by finding the one which minimizes average loss. Each estimator is briefly discussed below.

Mean

The loss function is referred to as squared error loss and the goal is to find an estimator $\hat{N}$ which minimizes $E(N - \hat{N})^2$ where the E refers to a probabilistic averaging operation. The best estimator is the mean of the posterior distribution,

$$\hat{N} = \sum_{n=0}^{\infty} nP(N = n).$$

Median

The loss function is referred to as absolute error loss and the goal is to find an estimator $\hat{N}$ which minimizes $E|N - \hat{N}|$. The best estimator is the median of the posterior distribution. We actually chose $\hat{N}$ to be the value of the posterior distribution that is smallest value of n such that $P(N \le n) \ge 0.5$.

Mode

The loss function (L) is a 0/1 loss function, where $L = 1$ if $N = \hat{N}$ and $L = 0$ if $N \ne \hat{N}$. The mean of this loss function is the mode of the posterior distribution. The mode is the value of N that has the highest probability associated with it.

There are other possible loss functions, but these 3 are the most commonly used. If the number of reported losses is small, the posterior is skewed to the right and the median is a better summary measure of center than the mean. As the number of reported losses increases, the posterior distribution becomes more symmetric and the median and mean give essentially the same result. Using the mode is analogous to finding a maximum

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likelihood estimator of *N*; however, the posterior distribution for many of the examples we have looked at is very flat. Thus, one value of *N* may be the mode but neighboring values are not very different. Further, there is little difference in the estimates generated by these 3 estimators. Therefore, we chose to use the median because it is a reasonable summary measure that works well for all posterior distributions we have seen in our data.

Appendix M. Supplement to Reassessing Methods to Estimate Population Size and Sustainable Mortality Limits for the Yellowstone Grizzly Bear

Reassessing methods to estimate population size
and sustainable mortality limits for the
Yellowstone Grizzly Bear
Workshop Document Supplement[1]
19–21 June 2006

This supplement is the result of a Workshop held at the AMK Ranch in Grand Teton National Park, 19–21 June 2006. The purpose of this workshop was to establish the scientific rationale and conduct additional analyses needed to adequately address concerns and issues raised by professional peer reviews and by the general public during the public comment period of the original document *Reassessing Methods to Estimate Population Size and Sustainable Mortality Limits for the Yellowstone Grizzly Bear* (Interagency Grizzly Bear Study Team [IGBST] 2005). We do not address all comments expressed during the public review period explicitly in this document because those have been addressed in a separate document titled *Responses to Public Comments on the Reassessing Methods Document* and are available online at http://mountain-prairie.fws.gov/species/mammals/grizzly/yellowstone.htm.

Items addressed here focus on 2 issues: (1) the wide variation about the original method proposed to index population size using annual estimates of females with cubs of the year as derived from the Chao2 estimator ($FCOY_{Chao2}$), and (2) the uncertainty about the estimate of independent females, independent males, and dependent young in the population.

Professional peer reviewers expressed concern about the wide swings in the index of population size using annual counts derived from estimates of FCOY and the use of a constant in the denominator when extrapolating $FCOY_{Chao2}$ to an index of independent females, independent males, and dependent young. In the original *Reassessing Methods* document, the group rejected using a running average over multiple years to address the variability about the annual population indices because of "possible unknown statistical biases" (IGBST 2005:25). Instead, we chose to smooth the mortality limit provided to managers "to dampen variability and provide managers with inter-annual stability in the threshold." Consequently, we recommended that allowable mortality limits be based on a 3-year running average derived from the annual index of population size (IGBST 2005:7–8).

We anticipated that the normal process (biological) variation associated with grizzly bear reproduction in the Greater Yellowstone Ecosystem (GYE) would result in wide swings in counts of FCOY and the resultant $FCOY_{Chao2}$ estimate (see Schwartz et al. 2006*a*:20, Figure 6). Female bears tend to produce litters in the year following an autumn with highly abundant naturally occurring autumn foods. Hence, using a constant

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[1] This document is the product of team work. Participants from the original workshops contributed to its production. Please cite as follows: Interagency Grizzly Bear Study Team. 2006. Reassessing methods to estimate population size and sustainable mortality limits for the Yellowstone grizzly bear: workshop document supplement. U.S. Geological Survey, Northern Rocky Mountain Science Center, Montana State University, Bozeman, Montana, USA.

in the denominator to extrapolate $FCOY_{Chao2}$ to index independent females, independent males, and dependent young failed to remove this process variation.

After considerable discussion, the group concluded that it was more appropriate to use $FCOY_{Chao2}$ as an initial estimate of FCOY. This was used along with all the data and information-theoretic model selection methods (Burnham and Anderson 2002) to select the best model for estimation of FCOY. We considered both linear and quadratic models and model averaging of the $FCOY_{Chao2}$. Model averaging has the effect of putting the numerator (model averaged estimates of number of FCOY) on the same temporal scale as the denominator (mean transition probability derived from 1983–2003) based on previous work (IGBST 2005:60–65) and thus addresses concerns about process variation causing wide swings in population estimates. The model averaging method and its application are presented in the following sections.

Estimation of number and trend for females with cubs of the year

The Chao2 estimator (Chao 1989, Keating et al. 2002, Cherry et al. 2007) is used annually to estimate the number of females with cubs of the year ($FCOY_{Chao2}$) for year i. For convenience, we will change notation and define $\hat{N}_i$ to be the value of $FCOY_{Chao2}$ in year i. The trend in this segment of the population and its rate of change (λ) can also be estimated from these annual estimates. Although the Chao2 estimator accounts for sampling heterogeneity, annual estimates of FCOY can vary because of sampling error (sampling variance) associated with the annual estimates, and because of pulsed or synchronized reproductive output by a segment of the female population (process variance). Consequently, using each annual estimate independently each year can result in wide swings in the estimate of total population size, producing results that may be inconsistent with expected changes in true population size, which complicates management. This annual variability was criticized during professional peer review. Therefore, we investigated methods to smooth these potential swings.

Methods

Monitoring numbers and λ using females with cubs. We fit the natural logarithm of the number of females with cubs $[\log(\hat{N}_i)]$ with a linear model of year (y_i):

$$\log(\hat{N}_i) = \beta_0 + \beta_1 y_i + \varepsilon_i$$

so that the population size at time zero is estimated as $\hat{N}_0 = \exp(\hat{\beta}_0)$. An additional benefit of this model is that it allows (under reasonable assumptions) estimation of the rate of population change (λ) as $\hat{\lambda} = \exp(\hat{\beta}_1)$, giving $\hat{N}_i = \hat{N}_0 \hat{\lambda}^{y_i}$. Confidence intervals on λ can be estimated as the exponential of the confidence bounds on β_1, providing an asymmetric confidence bound. Standard errors and confidence intervals for $\log(N_i)$ can be computed with the usual linear model methods, and confidence intervals for N_i can be estimated as the exponential of the confidence bounds on $\log(N_i)$.

Changes in the numbers of FCOY are representative of the rate of change of the entire population, but with additional process variation coming from the proportion of the female population that has cubs of the year (COY). Thus, random noise of $\hat{N}_i$ is coming

from both sampling variation from the Chao2 estimator and the proportion of the population with COY. When we assume a reasonably stable age and sex structure for the total population, the model provides an estimate of λ, which represents the rate of change of the entire population and a modeled estimate of FCOY for the current year. Fitting a linear relationship makes the standard assumptions of least squares regression.

Quadratic regression can be used to detect a change in $\hat{\lambda}$ (i.e., the slope of the log-linear model) through time. We fit the model

$$\log(\hat{N}_i) = \beta_0 + \beta_1 y_i + \beta_2 y_i^2 + \varepsilon_i,$$

and the estimate of β_2 provides a metric for assessing whether λ has changed through time. We expect that the estimate of β_2 will become negative as the population reaches carrying capacity and λ approaches 1. Information-theoretic model selection methods (Burnham and Anderson 2002) can be used to select between the linear and quadratic models, and hence to detect changes in $\hat{\lambda}$ and $\hat{N}_i$ as additional data are collected. We used model averaging with the linear and quadratic models of the predicted population sizes of females with cubs to estimate population sizes through time (i.e., $\hat{N}_i$), and thus smooth the variation of the Chao2 estimates. We used Akaike's information criterion weights corrected for small sample size (AIC$_c$; Burnham and Anderson 2002) to weight the estimates from the linear and quadratic models to produce our best estimate of the current number of females with cubs and λ.

Power analysis of using $\hat{N}$ to estimate λ. To assess the behavior of our proposed model selection procedure, we (i) added 2 hypothetical years of data for 2006 and 2007, assuming $\lambda = 0.9$ for both additional years, and (ii) added 4 hypothetical years of data, assuming $\lambda = 1.0$ for all additional years. In other words, we assumed that λ was equal to 0.9 for 2006 and 2007, or λ was 1.0 for 4 consecutive years.

Simply adding hypothetical years with altered λ, as above, would not constitute a power analysis of the proposed trend monitoring method, because future years' data will also contain process and sampling variation. To estimate the power of these data to detect a true reduction in λ (i.e., correctly choose the quadratic model), we estimated variance components of the Chao2 estimates from 1983–2005 and applied these in Monte Carlo projections for 10 additional years under assumed values of λ.

To separate sampling variance associated with each population estimate, ($\text{var}(\hat{N}_i)$) from process variance, we fit the linear model (above), assuming that the error term ε_i was the sum of the sampling variance and process variances (earlier analyses provided no evidence for significant serial correlation; unpublished data). For the Chao2 estimator, $\text{var}(\hat{N}_i)$ was estimated with bootstrap resampling of the data, and the variance of the resampling distribution was the estimate of $\text{var}(\hat{N}_i)$. Note that the variance of $\log(\hat{N}_i)$ is estimated, using the delta method, as $\text{var}\left(\log(\hat{N}_i)\right) = \text{var}(\hat{N}_i) / \hat{N}_i^2$.

To estimate the process standard deviation from the 1983–2006 Chao2 estimates, we used PROC NLMIXED in SAS. This procedure maximizes the likelihood of $\log(\hat{N}_i)$ for β_0, β_1, and the process SD, with the likelihood specified as a normal distribution with mean predicted by $\log(\hat{N}_i) = \beta_0 + \beta_1 y_i$ and variance

$\text{var}\big(\log(\hat{N}_i)\big) + (\text{Process SD})^2$. This model thus explicitly includes the sampling variance of $\log(\hat{N}_i)$ plus the process variance that is estimated by the procedure. Process SD was estimated to be 0.176 with SE 0.0461 and 95% confidence interval 0.0808–0.271

To estimate the expected sampling variance of future Chao2 estimates (which assumes that future sampling effort will remain approximately the same as used to collect the 1983–2006 data), the mean of the sampling variances of the log population estimates for the 1983–2006 data was computed. The sampling variance of future Chao2 estimates was sampled from a normally distributed population with mean zero and standard deviation equal to the square root of mean sampling variance. From this procedure, the estimated sampling standard deviation was 0.34.

To evaluate sensitivity of the linear and quadratic models to changes in $\hat{N}$ over 1 to 10-year intervals, we projected forward the 2006 population estimate of $N_{2006} = 52.356$ (obtained by model averaging the linear and quadratic model estimates from the 1983–2006 data), assuming alternative λ values of 0.95, 0.975, 1, 1.025, and 1.05, and using our estimates of process and sampling variation (above). Population size for each succeeding year was generated with the recursive relation
$\log(N_{i+1}) = \log(N_i) + \log(\lambda) + \delta_i$, where the process variation was added as δ_i, a normally distributed random variable with mean zero and standard deviation of 0.176. The estimated population size (corresponding to the Chao2 estimates) was taken as
$\log(N_{i+1}) + \varepsilon_{i+1}$, where the sampling variation ε_{i+1} was added as a normally distributed random variable with mean zero and standard deviation of 0.34. Each replicate was simulated independently (i.e., new data were added to the 1983–2006 data for each simulation).

One thousand replicates of each of the 50 scenarios (5 alternative λ x 10 alternative time-frames) were generated, from which we estimated the mean AIC$_c$ weight of the quadratic model, the proportion of iterations in which the quadratic term was selected (weight > 0.5), and the power of the *t*-test to reject the null hypothesis that the quadratic term was equal to zero. This realistically simulated the data and analyses managers would have available to them to make decisions about whether the true population had changed its trajectory.

Results

Monitoring numbers and λ using females with cubs. Data for 1983–2005 (Table 1) were used to estimate the rate of population change (Figure 1). The parameter estimates and AIC$_c$ weights for the linear and quadratic models (Table 2) suggest that only the linear model was needed to model changes in the FCOY$_{Chao2}$ population during this period. The estimate of λ using the linear model was 1.0479 with 95% confidence interval of 1.031 to 1.065 and was quite close to the independent estimates of Harris et al. (2006:48) using data from radiocollared bears (mean estimates of 1.04 or 1.07 under slightly different assumptions). The estimated quadratic effect (–0.00071104, SE = 0.00133) was not significant ($P = 0.6$), with 79% of the AIC$_c$ weight associated with the linear model. Thus, the linear model was the best approximating model for 1983–2005, but we also provide the model averaged estimates (Figure 1).

Table 1. Observations of females with cubs of the year (FCOY) in the Greater Yellowstone Ecosystem, 1983–2005, where m is the number of unique individuals observed after n samples and f_j is the number of individuals observed 1 or 2 times. The annual and modeled estimates (1983–2005) of $FCOY_{Chao2}$ are also provided.

			Sighting frequency		Chao2 estimate	
Year	n^a	m^a	f_1	f_2	Annual	Modeled
1983	12	10	8	2	19.33	18.46238
1984	40	17	7	3	22.25	19.40793
1985	17	8	5	0	18.00	20.39578
1986	82	24	7	5	27.50	21.42746
1987	20	12	7	3	17.25	22.50457
1988	36	17	7	4	21.20	23.62873
1989	28	14	7	5	17.50	24.80158
1990	49	22	7	6	25.00	26.02483
1991	62	24	11	3	37.75	27.30021
1992	37	23	15	5	40.50	28.62948
1993	30	18	8	8	21.11	30.01446
1994	29	18	9	7	22.50	31.45699
1995	25	17	13	2	43.00	32.95893
1996	45	28	15	10	37.55	34.52222
1997	65	29	13	7	38.75	36.14879
1998	75	33	11	13	36.93	37.84063
1999	96	30	9	5	36.00	39.59974
2000	76	34	18	8	51.00	41.42819
2001	84	39	16	12	48.23	43.32803
2002	145	49	17	14	58.07	45.30139
2003	54	35	19	14	46.40	47.35039
2004	202	48	15	10	57.55	49.47720
2005	86	29	6	8	30.67	51.68401

[a]Values differ from Keating et al. (2002) because we included females throughout the Greater Yellowstone Ecosystem. Only observations made without the benefit of radiotelemetry are included.
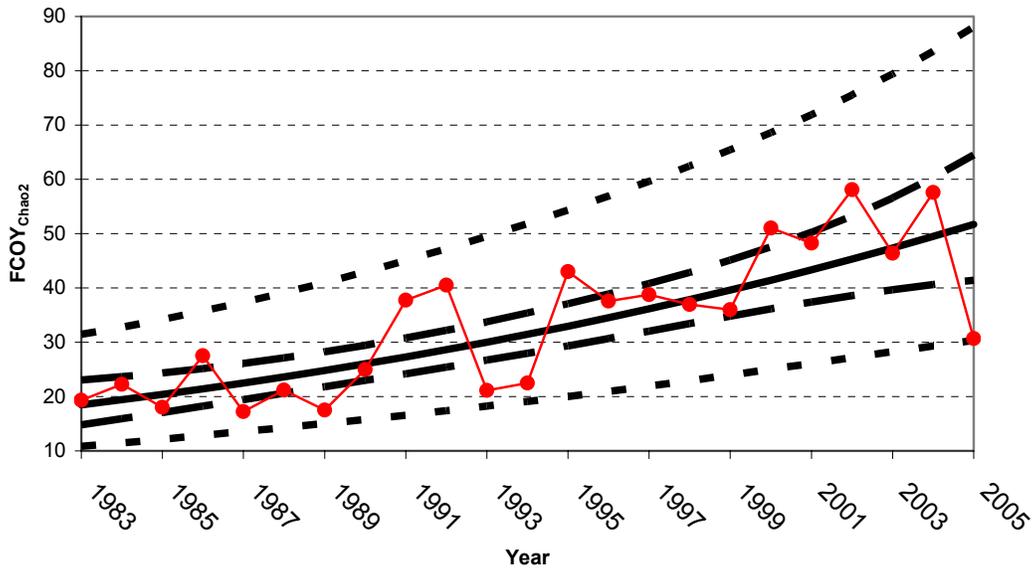
Figure 1. Model-averaged estimates of $FCOY_{Chao2}$ for 1983–2005, where the linear and quadratic models of $\log(FCOY_{Chao2})$ were fitted. The inner dashed lines represent a 95% confidence interval on the predicted population size, whereas the outer dashed lines represent a 95% confidence interval for individual population estimates. The red dotted line represents number of unique FCOY observed.

Table 2. Estimates and model selection results from fitting the $FCOY_{Chao2}$ population estimates from the Chao2 model, 1983–2005.

Model	Parameter	Estimate	Standard error	t	Pr(>t)
Linear					
	β_0	2.88051	0.10628	27.10	<0.0001
	β_1	0.04679	0.00775	6.04	<0.0001
	SSE[a]	1.27685			
	AIC$_c$	-59.2320			
	AIC$_c$ weight	0.78870			
Quadratic					
	β_0	2.80941	0.17165	16.37	<0.0001
	β_1	0.06386	0.03295	1.94	0.0669
	β_2	-0.00071104	0.00133	-0.53	0.5997
	SSE	1.25895			
	AIC$_c$	-56.5978			
	AIC$_c$ weight	0.21130			

[a]Sum of squared errors.

Power analysis of using $\hat{N}$ ***to estimate*** λ***.*** When 2 years with $\lambda = 0.9$ were added to these data, the resulting quadratic model had an AIC_c weight of 0.67847 and an estimated quadratic effect of -0.0028 (SE = 0.0012) that differed from zero ($P = 0.03$). Thus, had the Chao2 counts declined by 10% each year, our model selection would have detected this fundamental change within 2 years. Two years would not have been sufficient to detect a change to stationary Chao2 counts (Table 3), but by the third year, model weights would have shifted to favor the quadratic model, suggesting that population growth had stopped.

Table 3. Behavior of linear and quadratic models of population growth assuming identical Chao2 estimates following 2005, showing AIC_c weights (w_i) for the linear and quadratic models and P values for the quadratic term in the quadratic model.

Years of Chao2 estimates identical to 2005 values	Linear model w_i	Quadratic model w_i	Quadratic term P
2	0.73241	0.26759	0.1902
3	0.46623	0.53377	0.0561
4	0.20702	0.79298	0.0168
5	0.07439	0.92561	0.0053

When our best estimates of process and sampling variation were added to hypothetical years 1 through 10, approximately 5 years were required of the population decreasing 5% yearly (i.e., $\lambda = 0.95$) before the preponderance of evidence (AIC_c weight > 0.5) favored the quadratic model (i.e., fundamental change in state from linear increase, Figure 2). Under the scenario in which population size stabilized after year 2006 (i.e., $\lambda = 1.0$), 7 or 8 years were required for the preponderance of evidence to favor the quadratic model (depending on the criterion used, Figure 3). Power to detect a yearly decline of 2.5% was intermediate between these 2 examples. Power was lower to detect changes in λ to 1.025 or 1.05 (unpublished data), but this was neither unexpected nor worrisome under the baseline linear estimate of λ of 1.0479.
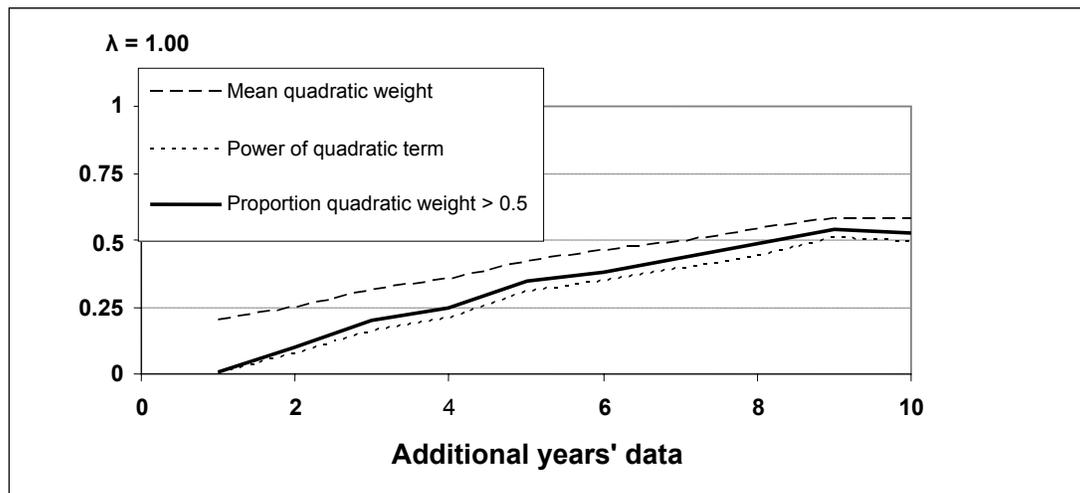
Figure 3. Mean AIC$_c$ weight of the (negative) quadratic term, proportion of simulations in which the quadratic model had greater AIC$_c$ weight than the linear model, and power of the quadratic term (i.e., probability of rejecting the linear model) when expected λ changed to 1.0 following the 1983–2006 series of estimates of females with cubs, for additional years 1 to 10 and using estimates of process and sampling variation from the data.

Discussion

FCOY are the critical segment of the population driving reproduction. Thus, we appropriately use all the data to estimate the number of FCOY each year and the rate of change of this segment as a measure of the rate of change of the entire population. Both reproductive effort and mortality of the entire population are driven by the performance of the FCOY segment.

According to the 1993 Recovery Plan (U.S. Fish and Wildlife Service 1993:20) "[a]ny attempt to use this parameter [FCOY] to indicate trends or precise population size would be an invalid use of these data." However, subsequent to the drafting of the 1993 Recovery Plan, several researchers developed methods to address varying effort and heterogeneity in sightings of females with cubs of the year, the underpinnings for the above quote. When Knight et al. (1995) published the methods used to distinguish unique females from replicate sighting of the same female and presented a method to estimate trend, there were no methods available to correct for problems of observer effort and sighting heterogeneity. Subsequent to that publication, a number of researchers provided improved methods that address varying effort and heterogeneity of sighting probabilities and use the FCOY index to estimate trend (Eberhardt et al. 1999, Boyce et al. 2001, Keating et al. 2002). The method we recommended is an extension of that research.

Summary of workshop recommendations for grizzly bear monitoring

We propose using the linear and quadratic models as described above to estimate changes in λ over time and the predicted numbers of FCOY as the best estimate of the number of FCOY annually. The results will then be used to estimate the number of

independent females, independent males, and dependent young following procedures outlined in the original *Reassessing Methods Document* (Interagency Grizzly Bear Study Team 2005). We recommend this new weighted model method replace the older method proposed in the *Reassessing Methods Document* that used the annual estimate FCOY$_{Chao2.}$

The new method addresses normal process variation and associated swings in annual counts of FCOY and dampens fluctuations arising from sampling variation because it uses the entire string of data. Details on how the methods will be applied to calculate the index of independent females, independent males, and dependent young are below.

The estimated λ and associated confidence interval demonstrate an increase in the FCOY numbers, and hence the total population. The proposed set of models will also allow managers to detect a decline in λ, and thus recognize when the population is approaching carrying capacity or decreasing. We recommend this method of estimating λ be used as an independent measure of population trajectory that can be compared to estimates derived from data using radiocollared bears as recommended in the *Reassessing Methods Document* (IGBST 2005:42–44).

For future monitoring, we recommend continued monitoring of females with cubs, fitting both linear and quadratic models to the data set, and using AIC$_c$ to evaluate the strength of these competing models. Weight favoring the quadratic term is evidence that population growth has slowed or reversed, but lack of such evidence is not necessarily proof that change has not occurred. Under the best of circumstances, this monitoring protocol leaves uncertainty about the system state during the most recent years. Gradually increasing evidence for the quadratic model over a few years (assuming a negative quadratic slope) should keep biologists and managers alert to a possible change in system state. We recommend continued monitoring of demographic rates from a sample of radiomarked females and their offspring. Although also characterized by variability and time-lags, such monitoring provides an independent measure of population vigor and is likely to be helpful in explaining hypothesized changes in numbers of females with cubs. We recommend that if the AIC$_c$ weight favors the quadratic term (i.e., >0.5) in modeling the rate of change of females with cubs in any year, a full review of the population's demographics be undertaken to better understand its status.

Because we are refitting the model with new data each year, estimates from previous years will change slightly after each iteration. We recognize that this will occur, but do not recommend retrospectively adjusting previous population estimates and accompanying mortality limits. The purpose of the model is to get the best possible estimate of the current number of females with cubs of the year borrowing information from past estimates, recognizing that with each iteration some change is expected.

Occasionally, a dead bear is reported in a year(s) subsequent to the actual year of mortality. We recommend that the IGBST, to the best of their ability, attempt to estimate actual year of death and sex and age of the individual. These mortalities would then be added into the mortality tally for year of death, and mortality totals recomputed (including estimates of unknown and unreported deaths). If adding extra bear(s) retrospectively results in exceeding the threshold in that year, the excess (tallied mortality minus threshold) would be deducted from the current years threshold (i.e., the threshold would be reduced by the difference). For example if a dead bear reported in 2006 died in 2005, that bear (and the estimated unknown and unreported mortality) would be counted

in 2005 and the updated mortality total compared to the 2005 threshold. If the 2005 threshold is exceeded, the difference would be deducted from the current years' threshold.

Establishing confidence intervals around estimates of independent females, independent males, and dependent young

The second issue raised during public and professional peer review of the *Reassessing Methods Document* (Interagency Grizzly Bear Study Team 2005) was the need to display uncertainty around the estimates of independent females, independent males, dependent young, and total population size. Here we detail methods used and present confidence intervals around those estimates.

Methods

We estimated the uncertainty associated with an estimate $\hat{\theta}$ of a parameter θ using a formula derived from the delta method (Seber 1982:7). For estimates of the form

$$\hat{\theta} = \frac{\hat{\beta}_1 \hat{\beta}_2 ... \hat{\beta}_k}{\hat{\beta}_{k+1} \hat{\beta}_{k+2} ... \hat{\beta}_n}$$

the variance of $\hat{\theta}$ was approximated by

$$\hat{var}(\hat{\theta}) = \hat{\theta}^2 \sum_{i=1}^{n} CV(\hat{\beta}_i)^2$$

where $\hat{var}(\hat{\theta})$ is the estimated variance of the index $\hat{\theta}$ (independent females, independent males, cubs, or yearlings). For estimates of the form

$$\hat{\theta} = \hat{\beta}_1 + \hat{\beta}_2 ... + \hat{\beta}_k$$

the variance of $\hat{\theta}$ was approximated by

$$\hat{var}(\hat{\theta}) = \sum_{i=1}^{n} var(\hat{\beta}_i)$$

where $\hat{var}(\hat{\theta})$ is the estimated variance of the index $\hat{\theta}$ (dependent young or population size). For both methods used to estimate variance, we assumed that covariances (correlations) of the various inputs were zero because we lacked the ability to determine their structure.

The coefficient of variation for the ratio of females 4 years and older in the population of females 2 years and older (4+ females:2+ females), and the ratio of males 2 years and older in the population of females 2 years and older (2+ males:2+ females) were derived using back-transformed logit normal distributions to model the survival parameters: cub survival, yearling survival, and adult (age 2+) survival. The variable m_x was modeled with a beta distribution so as to reproduce, as nearly as possible, the mean and 95% confidence limits about the mean, as reported in the monograph (Schwartz et al. 2006*c*). We used the PopTools extension on Excel to run Monte Carlo iterations from all distributions simultaneously, each time. We ran 10,000 iterations for each of the 2 possible mean independent female survival rates (0.922 and 0.950) and 2 possible mean

independent male survival rates (0.874 and 0.823) to generate the expected relationship between the number of 4+ and 2+ females (4+ females:2+ females) and 2+ males and 2+ females (2+ males:2+ females) when stable age distribution was achieved. We used PopTools to convert the life-table formats in the Leslie matrix formats and took age ratios from the eigenvector (i.e., stable age distribution) associated with each iteration. Variation about the ratio of adult females (age 4+) to independent females (age 2+) was derived from these simulations (Table 4). Variation about the ratio of independent males (age 2+) to independent females (age 2+) was derived from a second series of simulations (Table 5). These estimates did not include temporal variation in rates.

For estimating the number of 2+ females based on the estimated ratio of 4+ females:2+ females, and for the estimate of the proportion of 2+ males based on the ratio of 2+ males:2+ females, we used the mean and variance from the assumed dead (AD) estimate rather than the censored (C) estimate because the former included more uncertainty about estimates. Because of the random simulation process, values presented in Tables 4 and 5 differ slightly from the *Reassessing Methods Document* (0.773, 4+ females:2+ females, and 0.605, 2+ males:2+ females). We recommend using the new estimates.

Table 4. Mean, variance, and upper and lower 95% confidence limits around the ratio (4+ females:2+ females) when mean vital rates during 1983–2002 varied randomly. Line AD was when adult survival was estimated assuming all females with unresolved fates died at last contact, line C was when adult survival was estimated censoring unresolved females (as in Haroldson et al. 2006). This ratio provides a way to estimate the number of females older than yearling based on an estimate of the number of females ≥4 years old.

	Mean	Variance	Lower CL	Upper CL
AD	0.77699	0.00081	0.72459	0.83546
C	0.78446	0.00075	0.73504	0.84156

Table 5. Mean, variance, and upper and lower 95% confidence limits around the ratio (2+ males:2+ females) when mean vital rates during 1983–2002 varied randomly. Line AD was when adult survival was estimated assuming all adults with unresolved fates died at last contact, whereas line C was when adult survival was estimated censoring unresolved losses (as in Haroldson et al. 2006). This ratio provides a way to estimate the number of independent males older than yearling based on an estimate of the number of females ≥2 years old.

	Mean	Variance	Lower CL	Upper CL
AD	0.63513	0.002457	0.528489	0.720547
C	0.61093	0.001992	0.515741	0.691977

Estimates of variation for transition probabilities were presented in the *Reassessing Methods Document* (Interagency Grizzly Bear Study Team 2005:Appendix C, page 62, Table 6). Estimates of variation for litter size and cub survival can be found in Schwartz et al. (2006*a*:19) and Schwartz et al. (2006*b*:27), respectively.

Results

We used estimates of FCOY derived from model averaged estimates (Table 1). Data from counts of FCOY used to generate the annual Chao2 estimate are provided in Table 1.

   Using this formula, we generated 95% confidence intervals around the estimate of independent females (Table 6), independent males (Table 7), dependent young (Table 8), and total population size (Table 9).

Table 6. Model average estimate of FCOY$_{Chao2}$, the derived estimate of independent females (age ≥2 year old), the estimated variance, and the 95% confidence interval about the estimate. Data are based on observations of females with cubs of the year in the Greater Yellowstone Ecosystem, 1983–2005.

Year	Model averaged	$\hat{N}_i$ **2+** females	Estimated variance	95% confidence interval Lower	Upper
1983	18.46	82	52.23	68	96
1984	19.41	86	57.63	72	101
1985	20.40	91	63.59	75	106
1986	21.43	95	70.14	79	112
1987	22.50	100	77.33	83	117
1988	23.63	105	85.23	87	123
1989	24.80	110	93.88	91	129
1990	26.02	116	103.35	96	136
1991	27.30	122	113.72	101	142
1992	28.63	127	125.05	106	149
1993	30.01	134	137.43	111	157
1994	31.46	140	150.95	116	164
1995	32.96	147	165.70	122	172
1996	34.52	154	181.79	127	180
1997	36.15	161	199.32	133	189
1998	37.84	169	218.41	140	197
1999	39.60	176	239.19	146	207
2000	41.43	184	261.79	153	216
2001	43.33	193	286.36	160	226
2002	45.30	202	313.05	167	236
2003	47.35	211	342.02	175	247
2004	49.48	220	373.46	182	258
2005	51.68	230	407.55	191	270

Table 7. Derived estimate of independent males (age ≥2 year old), the estimated variance, and the 95% confidence interval about the estimate. Data are based on observations of females with cubs of the year in the Greater Yellowstone Ecosystem, 1983–2005.

Year	$\hat{N}_i$ **2+** males	Estimated variance	95% confidence interval Lower	Upper
1983	52	37.70	40	64
1984	55	41.57	42	68
1985	58	45.88	44	71
1986	61	50.62	47	75
1987	64	55.82	49	78
1988	67	61.53	51	82

Year				
1989	70	67.78	54	86
1990	74	74.63	57	91
1991	77	82.12	59	95
1992	81	90.30	62	100
1993	85	99.25	65	104
1994	89	109.01	69	109
1995	93	119.67	72	115
1996	98	131.29	75	120
1997	102	143.95	79	126
1998	107	157.74	82	132
1999	112	172.74	86	138
2000	117	189.07	90	144
2001	123	206.81	94	151
2002	128	226.08	99	158
2003	134	247.00	103	165
2004	140	269.69	108	172
2005	146	294.30	113	180

Table 8. Derived estimate of dependent young (cubs and yearlings), the estimated variance, and the 95% confidence interval about the estimate. Data are based on observations of females with cubs of the year in the Greater Yellowstone Ecosystem, 1983–2005.

$\hat{N}_i$

Year	dependent young	Estimated variance	95% confidence interval Lower	Upper
1983[a]				
1984	64	12.59	57	71
1985	67	13.90	60	74
1986	70	15.33	63	78
1987	74	16.91	66	82
1988	78	18.64	69	86
1989	81	20.54	73	90
1990	85	22.63	76	95
1991	90	24.91	80	99
1992	94	27.40	84	104
1993	99	30.13	88	109
1994	103	33.12	92	115
1995	108	36.37	96	120
1996	113	39.92	101	126
1997	119	43.80	106	132
1998	124	48.02	111	138
1999	130	52.61	116	144
2000	136	57.61	121	151
2001	142	63.05	127	158
2002	149	68.97	133	165
2003	156	75.39	139	173
2004	163	82.37	145	181
2005	170	89.94	151	189

[a]Number of yearlings estimated from the previous years estimate of cubs. Data not available.

Table 9. Derived estimate of total population size, the estimated variance, and the 95% confidence interval about the estimate. Data are based on observations of females with cubs of the year in the Greater Yellowstone Ecosystem, 1983–2005.

	$\hat{N}_i$	**Estimated**	**95% confidence interval**	
Year	**All bears**	**variance**	**Lower**	**Upper**
1983				
1984	205	111.79	184	226
1984	215	123.37	194	237
1986	226	136.09	204	249
1987	238	150.07	214	262
1988	250	165.40	224	275
1989	262	182.20	236	289
1990	275	200.60	247	303
1991	288	220.74	259	318
1992	303	242.76	272	333
1993	317	266.81	285	349
1994	332	293.08	299	366
1995	348	321.74	313	383
1996	365	353.00	328	402
1997	382	387.06	343	421
1998	400	424.16	360	440
1999	419	464.54	376	461
2000	438	508.47	394	482
2001	458	556.22	412	504
2002	479	608.09	431	527
2003	501	664.41	450	551
2004	523	725.52	470	576
2005	546	791.79	491	602

Discussion

The confidence intervals we provide were derived with a Taylor series expansion (delta method) and may be only rough approximations. Because we lacked the ability to estimate the underlying covariance structure, intervals may be too narrow (or too broad). Uncertainty is a fact that we must deal with regarding data collected on the Yellowstone grizzly bear. However, as stated by Beissinger and Westphal (1998:836) "[u]ncertainty is inherent in decision-making but is not an excuse for not making decisions." We agree. In the *Reassessing Methods Document*, we elected not to generate confidence intervals around our estimates of independent females, independent males, dependent young, and population size because we lacked valid statistical methods to do so. Here we provide approximate estimates of uncertainty because many commenters requested them. It is important to recognize that in the *Reassessing Methods Document* and this supplement, we recommend methods to estimate bear numbers and sustainable mortality limits. However, we also recommended using the point estimate and not intervals of uncertainty. We focused on point estimates because statistically they represent the best approximation of reality. Some will argue that not knowing the uncertainty about our estimates could mislead us when making recommendations or when managers are forced to make decisions. This is a valid point in general; however, we feel that the monitoring protocols established for the Yellowstone grizzly bear are multifaceted and when considered as a whole, provide us with a reasonable understanding of the current health and status of the population. Further, when faced with making decisions, the group made

recommendations that if wrong, err on the conservative side. In other words, if uncertainty leads us astray, we are more likely to underestimate bear numbers and sustainable mortality limits as opposed to overestimating them. We have made every attempt to build in conservative recommendations to cushion against uncertainty but in the real world, managers still must make decisions.

Summary of proposed methods

We recognize that the methods we originally proposed (IGBST 2005) and the newer methods proposed here might be difficult to assimilate. The Interagency Grizzly Bear Study Team will use the following procedures to establish and track sustainable mortality for grizzly bears in the Greater Yellowstone Ecosystem:

1. Raw observations of sightings of females with cubs of the year will be separated into observations of unique females and repeat observations of the same female using the methods of Knight et al. (1995).
2. The Chao2 estimator will be applied to sighting frequencies of unique females to estimate the number of females with cubs of the year in the population.
3. The number of unique females obtained from the Chao2 estimator each year will be added to the dataset and the model averaging process described above repeated.
4. The predicted number of females with cubs obtained from the model fit will be used as the best estimate of the total number of independent females in the population accompanied by cubs of the year for that year.
5. The purpose of the model is to get the best estimate of the current number of females with cubs of the year borrowing information from past estimates, recognizing that with each iteration some change is expected. We do not recommend retrospectively adjusting estimates from previous years.
6. The predicted number of females with cubs will be divided by the proportion of females ≥4 years old estimated to be accompanied by cubs of the year (transition probability = 0.289). The resulting value represents the best estimate of the total number of females in the population ≥4 years old.
7. The number of females ≥4 years old will be divided by the estimated proportion of females ≥4 years old in the population of females ≥2 years old (0.77699). The resulting value is the best estimate of the number of independent females (≥2 years old) in the population that year.
8. The sustainable mortality limit for independent females will be set at 9% of the population estimate of independent females.
9. Unknown and unreported mortality will be estimated based on the methods of Cherry et al. (2002) as described in the *Reassessing Methods Document*.
10. The number of independent males in the population will be based on the estimated ratio of independent males:independent females (0.63513) derived via stochastic modeling described above. The number of independent females in the population will be multiplied by 0.63513 and the resulting value represents the best estimate of the number of independent males that year.

11. The sustainable mortality limit for independent males will be set at 15% of the population estimate of independent males.

12. The number of cubs in the annual population estimate will be calculated directly from the model-predicted estimate of females with cubs of the year. The number of cubs will be estimated by multiplying the modeled estimate by the mean litter size (2.04) observed from 1983–2002.

13. The number of yearlings will be estimated by multiplying the estimated number of cubs from the previous year by the mean survival rate for cubs (0.638) observed from 1983–2001.

14. The sustainable mortality limit for dependent young (cubs and yearlings) will be set at 9% of the annual estimate of dependent young. Only human-caused deaths (reported known and probable) will be tallied against the threshold.

15. Unknown and unreported mortality will not be estimated for dependent young.

16. Allowable mortality limits will be established annually following methods detailed here. Because we are using modeled predictions, annual variability among years has been addressed. Consequently, we do not recommend basing annual limits on a 3-year running average as proposed in the *Reassessing Methods Document*. Rather, we recommend annual mortality limits based on the current year.

17. Estimates of uncertainty about the number of independent females, independent males, dependent young, and total population size will be derived following methods detailed in this report.

18. We recommend the demographic objective originally proposed in the *Reassessing Methods Document* (Interagency Grizzly Bear Study Team 2005:44–45) of 48 $FCOY_{Chao2}$ remains the same; however, we recommend using the predicted number based on model averaging.

19. We recommend a biology and monitoring review should this predicted estimate decline below 48 for any 2 consecutive years.

20. We also recommend the management agencies attempt to limit female mortality if the model predicted estimate of Chao2 drops below 48 in any given year.

21. We recommend a biology and monitoring review if independent female mortality exceeds the 9% limit in any 2 consecutive years.

22. We recommend a biology and monitoring review if independent male mortality exceeds the 15% limit in any 3 consecutive years.

23. We recommend a biology and monitoring review if dependent young mortality exceeds the 9% limit in any 3 consecutive years.

24. We recommend that if the AIC_c weight favors the quadratic term (i.e., >0.5) in modeling the rate of change of females with cubs, a full review of the population's demographics be undertaken to better understand its status.

25. We recommend that dead bears reported in years subsequent to actual year of mortality be tallied against year of death and mortality total be recalculated. If mortality exceeds the threshold for that year, the difference (total mortality minus threshold) should be counted against the current years' threshold. If sex cannot be

determined, sex will be assigned randomly using ratio of 59:41 male:female as recommended in Appendix A (Schwartz and Haroldson 2001:120).

Supplemental data

Nearly all the information used in the *Reassessing Methods Document* (Interagency Grizzly Bear Study Team 2005) is in the public domain. Mortality information, including date of death, sex, age, certainty of death, if the bear was marked, and approximate location are published in the study team annual reports. The status of marked bears is also published in the annual reports. This information can be used to assess reporting rates. This information can be freely accessed via the internet [http://nrmsc.usgs.gov/research/igbst-home.htm]. Data to calculate population size using methods described in the workshop are available in the tables in Keating et al. (2002), and we have updated and included them here (Table 1). Estimates of sustainable mortality and limits recommended in the *Reassessing Methods Document* are in the Wildlife Monographs (Schwartz et al. 2006*c*). The data used to generate those estimates are in the monograph. All results of Harris et al. (2006), where estimates of population growth were derived, can be duplicated from data in the other chapters of the Monograph. Raw data to calculate the transition probabilities are in Table 10.

Table 10. Data used to calculate transition probabilities (Appendix C of the original Workshop Document). Data are presented as an inp file format compatible with Program MARK.

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Literature cited

Beissinger, S. R., and M. I. Westphal. 1998. On the use of demographic models of population viability in endangered species management. Journal of Wildlife Management 62:821–841.

Boyce, M., B. M. Blanchard, R. R. Knight, and C. Servheen. 2001. Population viability for grizzly bears: a critical review. International Association of Bear Research and Management Monograph Series Number 4.

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference: A practical information-theoretic approach. Second edition. Springer-Verlag, New York, New York, USA.

Chao, A. 1989. Estimating population size for sparse data in capture–recapture experiments. Biometrics 45:427–438.

Cherry, S., M. A. Haroldson, J. Robinson-Cox, and C. C. Schwartz. 2002. Estimating total human-caused mortality from reported mortality using data from radio-instrumented grizzly bears. Ursus 13:175–184.

Cherry, S., G. C. White, K. A. Keating, M. A. Haroldson, and C. C. Schwartz. 2007. Evaluating estimators of the numbers of females with cubs-of-the-year in the Yellowstone grizzly bear population. Journal of Agricultural, Biological, and Environmental Statistics. Accepted.

Eberhardt, L. L., R. A. Garrott, and B. L. Becker. 1999. Using trend indices for endangered species. Marine Mammal Science 15:766–785.

Haroldson, M. A., C. C. Schwartz, and G. C. White. 2006. Survival of independent grizzly bear in the Greater Yellowstone Ecosystem, 1983–2001. Pages 33–42 *in* C. C. Schwartz, M. A. Haroldson, G. C. White, R. B. Harris, S. Cherry, K. A. Keating, D. Moody, and C. Servheen, authors. Temporal, spatial, and environmental influences on the demographics of grizzly bears in the Greater Yellowstone Ecosystem. Wildlife Monographs 161.

Harris, R. B., C. C. Schwartz, M. A. Haroldson, and G. C. White. 2006. Trajectory of the Yellowstone grizzly bear population under alternative survival rates. Pages 44–56 *in* C. C. Schwartz, M. A. Haroldson, G. C. White, R. B. Harris, S. Cherry, K. A. Keating, D. Moody, and C. Servheen, authors. Temporal, spatial, and environmental influences on the demographics of grizzly bears in the Greater Yellowstone Ecosystem. Wildlife Monographs 161.

Interagency Grizzly Bear Study Team. 2005. Reassessing methods to estimate population size and sustainable mortality limits for the Yellowstone grizzly bear. Interagency Grizzly Bear Study Team, U.S. Geological Survey, Northern Rocky Mountain Science Center, Montana State University, Bozeman, Montana, USA.

Keating, K. A., C. S. Schwartz, M. A. Haroldson, and D. Moody. 2002. Estimating numbers of females with cubs-of-the-year in the Yellowstone grizzly bear population. Ursus 13:161–174.

Knight, R. R., B. M. Blanchard, and L. L. Eberhardt. 1995. Appraising status of the Yellowstone grizzly bear population by counting females with cubs-of-the-year. Wildlife Society Bulletin 23:245–248.

Schwartz C. C., and M. A. Haroldson. 2001. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 2000. U.S. Geological Survey, Bozeman, MT.

———, ———, and S. Cherry. 2006*a*. Reproductive performance of grizzly bears in the Greater Yellowstone Ecosystem, 1983–2001. Pages 18–24 *in* C. C. Schwartz, M. A. Haroldson, G. C. White, R. B. Harris, S. Cherry, K. A. Keating, D. Moody, and C. Servheen. Temporal, spatial and environmental influences on the demographics of grizzly bears in the Greater Yellowstone Ecosystem. Wildlife Monographs 161.

———, ———, and G. C. White. 2006*b*. Survival of cub and yearling grizzly bears in the Greater Yellowstone Ecosystem, 1983–2001. Pages 25–31 *in* C. C. Schwartz, M. A. Haroldson, G. C. White, R. B. Harris, S. Cherry, K. A. Keating, D. Moody, and C. Servheen. Temporal, spatial and environmental influences on the demographics of grizzly bears in the Greater Yellowstone Ecosystem. Wildlife Monographs 161.

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Seber, G. A. F. 1982. The estimation of animal abundance and related parameters. Macmillian Publishing Company, Incorporated, New York, New York, USA.

U.S. Fish and Wildlife Service. 1993. Grizzly bear recovery plan. U.S. Fish and Wildlife Service, Missoula, Montana, USA.

Appendix N. Updating and Evaluating Approaches to Estimate Population Size and Sustainable Mortality Limits for Grizzly Bears in the Greater Yellowstone Ecosystem

Updating and Evaluating Approaches to Estimate Population Size and Sustainable Mortality Limits for Grizzly Bears in the Greater Yellowstone Ecosystem

Photo courtesy of John Way

10 September 2012

Interagency Grizzly Bear Study Team (IGBST)

Updating and Evaluating Approaches to Estimate Population Size and Sustainable Mortality Limits for Grizzly Bears in the Greater Yellowstone Ecosystem

10 September 2012

Report summarizing discussion of issues and analyses during workshops at Bozeman, Montana, February 3–4, 2011; July 11–12, 2011; and February 1–2, 2012

**Report prepared by
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Cover photo: Female grizzly bear with cub-of-the-year near the Madison River, Montana, May 2012. Photo by John Way.

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Executive Summary and Management Recommendations

1. Workshop objectives: Our objectives were to 1) revise current protocols for estimating population size of the Greater Yellowstone Ecosystem (GYE) grizzly bear population, 2) reevaluate current mortality limits as necessary based on this revised estimate of population size and updated demographic analyses, and 3) discuss possibility of zoning the ecosystem for mortality limits given the expanding population.

2. Background: To aid the reader in understanding the context of this workshop and the differences between management recommendations contained herein and those arising from previous workshops (see Interagency Grizzly Bear Study Team 2005, 2006), a summary of analyses and protocols underlying previous population estimates and management recommendations is provided. We include schematic diagrams of the processes involved in population estimation and derivation of mortality limits, and graphs indicating how uncertainty is accounted for.

3. Improving estimation of population abundance: Following up on the results of Schwartz et al. (2008), which demonstrated biases inherent in the existing method of indexing population size using unduplicated counts of females with cubs-of-the-year (F_{COY}) and the associated rule set of Knight et al. (1995), the group made efforts to consider alternative approaches. We considered, but ultimately abandoned, a clustering algorithm combined with Bayesian methods and ancillary data resampling to estimate the number of true F_{COY} using existing data on bear movements. We found that, although the method had considerable promise, it was quite complex, and depended on assumptions of the true spatial juxtaposition of female bears on the landscape, for which information is currently lacking. Instead, the group recommends transitioning from the current protocol for indexing abundance to a mark-resight estimator using systematic flight observation data collection since 1997. The mark-resight estimator yields an estimate of the number of F_{COY} present based on 1) the presence of a radio-marked sample, and 2) two systematic observation flights/year, during which all F_{COY} observed are recorded and, following observation, checked for marks (i.e., radio collar). This mark-resight estimator solves many of the problems inherent in the Knight et al. (1995) approach, but suffers from 1) low precision, because of small numbers of F_{COY} marked and observed, and 2) biases from geographic heterogeneity in the availability and detection probabilities of marked bears relative to unmarked bears. Ways to substantially reduce bias associated with the second disadvantage is the subject of ongoing research and analysis.

4. Preliminary analyses to update our understanding of grizzly bear vital rates from telemetry data: Mortality limits currently in place are based on demographic analyses using data from 1983 through 2001. Monitoring results from 2011 triggered a demographic review under existing protocols. Therefore, the team re-evaluated survival and fecundity of GYE grizzly bears for the time period 2002–2011, independent of previous analyses (but using consistent analytical approaches). These analyses are currently being refined, finalized, and prepared for a peer-reviewed

publication. Preliminary data suggest, however, that the rate of growth seen during the 1983–2001 period has slowed. The proximate cause of this slower growth was lower survival rates among the yearling, and possibly, cub age-classes. Survival of adult females did not change between the two time-periods. Data indicate survival of adult males increased from the earlier to the later time period. Fecundity (female cubs produced/adult female/year) declined slightly. Based on these vital rates, asymptotic population growth of the GYE grizzly bear population during 2002–2011 ranged from 0% (using a conservative assumption that unresolved fates of independent females represented mortality) to 2.2% (based on censoring data of independent females with unresolved fates). Similar to the 1983–2001 period, population growth based on grizzly bear vital rates suggested greatest vigor within the Recovery Zone but outside of Yellowstone National Park, followed by the area encompassed by Yellowstone National Park. Although population growth rates remained lowest in the area outside the Recovery Zone, this rate increased compared with the 1983–2001 period. Consequently, population growth rates are now more similar across these 3 zones of the ecosystem.

5. Preliminary analyses of intrinsic and extrinsic factors associated with grizzly bear vital rates: Preliminary analyses using Program MARK (White and Burnham 1999) and an information-theoretic framework indicated 1) density dependence and 2) resource effect hypotheses (i.e., losses of whitebark pine, WBP) are both supported by the data. WBP indices were prominent in top models estimating the transition probabilities for the proportion of females with cubs. However, indices of population density effects were better supported in models estimating juvenile survival. Thus, our conclusions regarding the primary drivers for the change in population trajectory were mixed, in part because the effects of density dependence on grizzly bear vital rates may be similar to those resulting from a reduction in food supply and may be temporally confounded as well. Analyses are ongoing and will be submitted to a peer-review journal for publication.

6. Recommended revisions to sustainable mortality limits: Based on the updated demographic rates and a deterministic analysis of population growth yielding stability, the team recommends that managers adopt a new threshold of 7.6% mortality (from all causes) for independent (2 years or older) female grizzly bears. This differs from the previously recommended threshold of 9% because 1) juvenile survival rates (and fecundity) seem to be lower during 2002–2011 than the 1983–2001 period, and 2) the team feels comfortable in recommending a strategy focused on a goal of stability rather than growth. Similar to existing protocols, the team recommends the mortality threshold of 7.6% also be adopted for dependent offspring, counting human causes only. We note that despite a reduction of the mortality threshold for independent females and dependent offspring to 7.6%, the corresponding mortality limit may represent a greater number of bears compared with previous years because of greater size of the GYE grizzly bear population and because new techniques, such as the mark-resight estimator, may reduce the low bias of current population estimates based on the Knight et al. (1995) rule set. The team recommends the existing mortality threshold for independent males (15% from all causes) be retained.

The team also recommends that a revision of the existing boundary defining Suitable Habitat be adopted as the area within which grizzly bear mortalities counting against the mortality threshold be tallied. Under this change, some grizzly bear mortalities in areas where long-term occupancy or expansion is likely unsustainable would not be counted against the mortality threshold. This change would also correct a currently existing inconsistency, under which bear mortalities are counted over a much larger area than where systematic data collection efforts occur.

1. Workshop Objectives

When initially organized in late 2010, this workshop had 3 major objectives:
1. Review and revise the rule set of Knight et al. (1995) used to determine the unique number of females with cubs-of-the-year, which has been the foundation for determining population size, with the goal of reducing bias in the estimate.
2. Evaluate current mortality limits as necessary based on an updated population estimate.
3. Discuss the possibility of zoning the ecosystem for mortality limits given the expanding population.

Subsequent to the first workshop in February 2011, population monitoring results collected during 2011 (Haroldson 2012) triggered a demographic review under existing protocols (U.S. Fish and Wildlife Service 2007*a*). This necessitated two additional tasks:

4. Evaluate current mortality limits as necessary in light of newly updated estimates of demographic (vital) rates for the GYE grizzly bear population for 2002–2011 (i.e., results of the demographic review). This time period was selected because it 1) represented an independent data set from the previous analyses based on data from 1983–2001 and 2) reflected the time period when whitebark pine began noticeably declining.

5. Produce an initial investigation of intrinsic and extrinsic factors potentially associated with changes in grizzly bear vital rates.

Results of this workshop will be used to re-evaluate the basis for, and application of, rules for sustainable mortality limits. As per the commitment of all involved management agencies, our goal is to ensure that mortality management of the Greater Yellowstone Ecosystem grizzly bear population is based on the best available science to maintain long-term population viability. We expect a number of peer-reviewed publications to result from investigations conducted as part of these workshops, and when published, they should supplant this document as an authoritative source. This report is provided now so that stakeholders can be informed of our deliberations and necessary decisions and actions can be taken using the best available science.

2. Background

The GYE grizzly bear population was listed as threatened under the Endangered Species Act in 1975. A concerted and coordinated effort by federal, state, tribal, and private land managers led to the development and implementation of conservation measures with the primary purpose to reduce grizzly bear mortality and manage for suitable and secure habitat. During the decades of the 1980s and 1990s, the Interagency Grizzly Bear Study Team documented an increase of the GYE grizzly bear population, growing from approximately 200–350 bears in the mid-1980s (Eberhardt and Knight 1996) to at least 600 in 2012.

The U.S. Fish and Wildlife Service submitted a final rule to delist the GYE grizzly bear population in March 2007. This delisting rule was challenged in court and the Federal District Court in Missoula, Montana ordered to reverse the delisting in September 2009; protections under the Endangered Species Act were reinstated in March 2010. The District Court decision was appealed on two primary issues: 1) adequacy of regulatory mechanisms after delisting (i.e., the Conservation Strategy) and 2) potential threat of whitebark pine decline on the GYE grizzly bear population. The 9th Circuit Court of Appeals rendered a decision in November 2011 and reversed the District Court decision regarding the adequacy of protections provided under the Conservation Strategy but upheld the District Court decision that the U.S. Fish and Wildlife Service had not sufficiently articulated that whitebark pine decline was not a threat to the GYE grizzly bear population.

We provide here a capsule summary of protocols in use from adoption of the 1993 Grizzly Bear Recovery Plan until 2007, when the Revised Demographic Recovery Criteria for the Yellowstone Ecosystem were implemented (U.S. Fish and Wildlife Service 2007*a*), and from 2007 through the present time. This background (Section 2) can be skipped, but may be useful for reference in understanding options for improving the protocols presented in this document. Readers wishing to examine only the considerations and results of the current (year 2011–2012) workshop should go to Section 3.

2.1. Protocol in place prior to 2007

Management guidelines were set to assure that:

- A minimum of 15 females accompanied by cubs-of-the-year (F_{COY}, hereafter) were documented over a running 6-year average, inside the Recovery Zone plus a 10-mile perimeter immediately surrounding the Recovery Zone.
- 16 of 18 Bear Management Units (BMUs) were to be occupied by females with young (cubs, yearlings, or 2-year-olds) for a running 6-year sum of observations, with no 2 adjacent BMUs unoccupied.
- Known human-caused mortality was not to exceed 4% of the conservative, minimum population size index based on the most recent 3-year sum of unduplicated F_{COY}.

      o   This rule was amended in 2000 to include probable human-caused mortalities, and cubs accompanying known and probable human-caused female deaths.

- No more than 30% of the 4% mortality were to be females (i.e., 1.2% of the minimum population size index).
- These mortality limits were not to be exceeded during any 2 consecutive years for recovery to be achieved. The threshold was based on a 6-year running average of mortality contrasted with the annual limit established from the 3-year sum of F_{COY}.

The population size and allowable numbers of human-caused mortalities were calculated as a function of the number of unique F_{COY} observed. Identification and separation of F_{COY} followed methods reported by Knight et al. (1995; these protocols came to be known colloquially as the "Knight rule set"). We summarize the protocols suggested by Knight et al. (1995) to distinguish unique individual F_{COY} seen in any given year from duplicate observations of the same F_{COY} in Appendix A.

Following determination of the number of F_{COY} observed in any year, the next step was to produce a conservative index of the number of adult females present. This was achieved by summing the number of F_{COY} seen during a 3-year period and subtracting the number of adult female mortalities recorded during this time period (Equation 1):

$$\hat{N}_{\min,t} = \sum_{i=t-2}^{t} \frac{\hat{N}_{obs,i} - d_i}{0.274},$$ (1)

where

$\hat{N}_{\min,t}$ = a conservative index of total population size in year (i-2)

$\hat{N}_{obs,i}$ (following notation of Keating et al. 2002) = number of unique F_{COY} observed in year i (as per Knight et al. [1995]), and

d_i is the number of known and probable human-caused mortalities of adult females (age >4) in year i.

To extrapolate to the number of all bears present, this value was divided by the estimated proportion of adult females in the population (0.274), assuming a stable age distribution.

This extrapolation made no claims to being an unbiased estimate of actual population size. Because the 3-year sum of F_{COY} was based on an observed number of unduplicated individuals (as described by Knight et al. [1995]), it provided a very conservative index of population size (i.e., an extrapolation from bears actually seen), rather than a true estimate of population size. As such, it undoubtedly underestimated both total population size and sustainable mortality limits. Nor did it permit calculation of valid confidence bounds.

Mortality limits were set at 4% of $\hat{N}_{\min,t}$ with no more than 30% of this 4% (1.2% of the population) to be females. The 4% total mortality and 30% female values came from

simulation work conducted by Harris (1986), suggesting that a population of grizzly bears similar to those in the U.S. Northern Rockies sustaining approximately 6% added human-caused mortality (to an assumed background level of natural mortality) would have a very low probability of decline (on average, 70% of simulated mortalities were of males). Further, to account for the likelihood that not all dead bears would be known and thus enter the calculations, it was assumed that 1 additional bear died for each 2 that were documented. This was accomplished by further reducing the mortality limit from 6% to 4% annually. These steps are summarized in Figure 1.1.
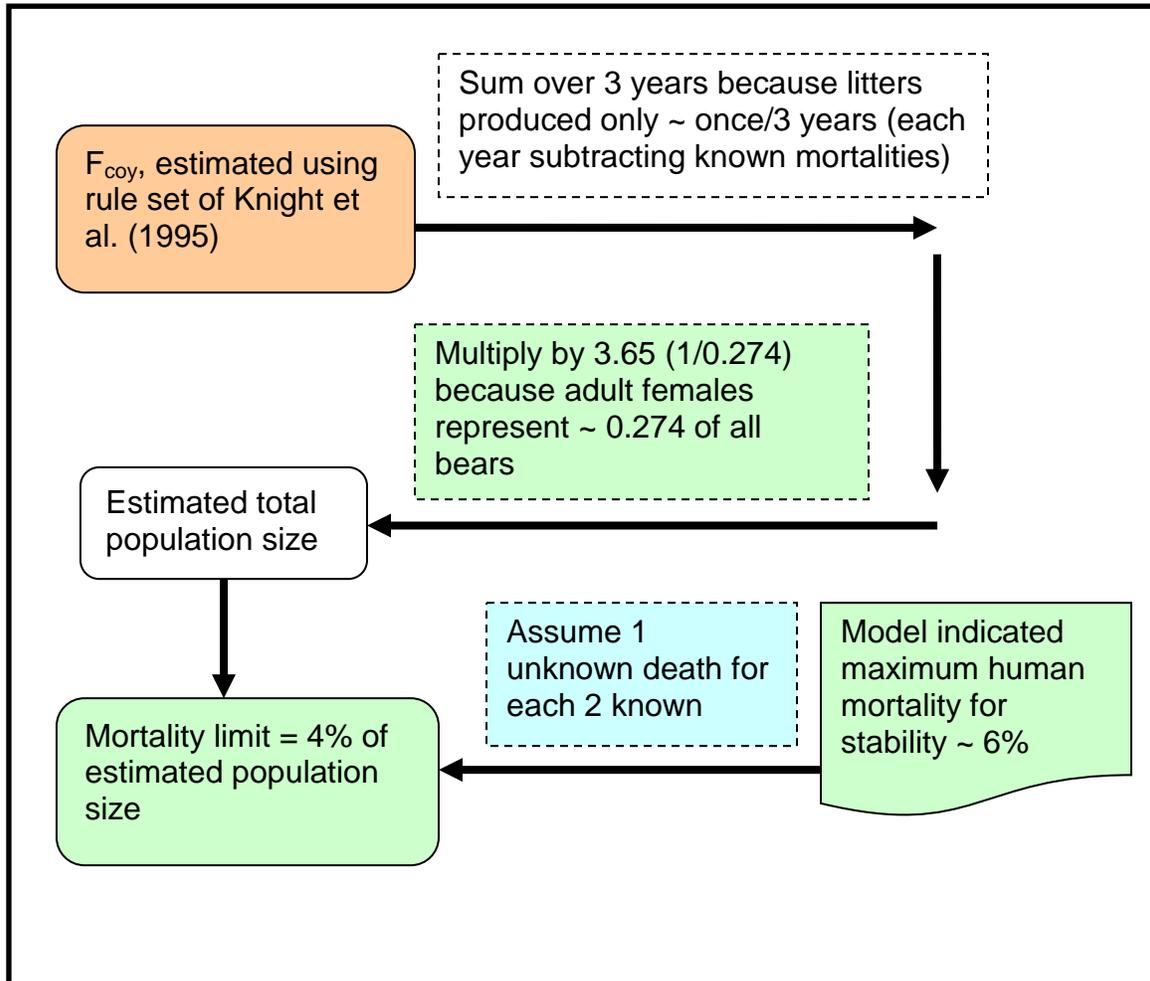

Figure 1.1. Flow chart of the protocol in place during 1993–2007 for estimating the number of grizzly bears in the Greater Yellowstone Ecosystem and limits to mortality.

This protocol had a number of characteristics, some of which could be seen as deficiencies, others as benefits:

- The 30-km rule set developed by Knight et al. (1995) to distinguish unique F_{COY} was designed to minimize Type I errors (i.e., reduce probability of mistakenly identifying sightings of the same F_{COY} as a different F_{COY}) and thus was designed to be conservative (i.e., some F_{COY} will not be identified as unique because they are too close to other F_{COY}).
- The protocol was conservative in that mortality limits were based on a conservative index of population size.
- The protocol was in place until 2007. During the 1983–2001 period, point estimates of the rate of increase of the GYE grizzly bear population ranged between 4% and 7% per year (4% if survival of independent females was calculated based on the assumption that unresolved fates represented mortalities and 7% if records of independent females with unresolved fates were censored; Harris et al. 2006: Table 18; Harris et al 2007:172). During this same period, grizzly bear distribution expanded (Schwartz et al. 2002, 2006*c*, lending additional support to a growing population.
- The constant 0.274 (Eberhardt and Knight 1996:417) represented the proportion of adult females in the population, defined as bears ≥ 5 years of age (U.S. Fish and Wildlife Service 1993: Appendix C:156; Eberhardt et al. 1994: Table 2:362). Because some 4-year-old females produce cubs (Eberhardt and Knight 1996, Schwartz et al. 2006*b*), their inclusion into the above equation could result in an overestimation of total population size because the constant 0.274 represents only females ≥ 5 years of age. Additionally, not all females of age class 5 produce first litters, as some delay reproduction until ages 6–8 (Eberhardt and Knight 1996: Table 1:361; Schwartz et al. 2006*b*). Consequently, the proportion used to extrapolate F_{COY} to total population size contained an unknown amount of error. Also, this proportion was based on the assumption of a stable age distribution, which may not be the case.
- The protocol assumed that on average, adult female grizzly bears produced a litter once every 3 years. Deviations from this assumption could overestimate (interval <3 years) or underestimate (interval >3 years) population size. The estimated proportion of F_{COY} in any given year based on a sample of radio-collared bears (age >3) ranges from 0.05 to 0.60. During this period (1983–2001), the Study Team monitored 352 females and documented 110 cub litters. This equated to 0.315 litters/female/year or 3.2 years between litters (1/0.315), suggesting that summing over 3 years generates a downward bias in estimating population size.
- Mortality limits were based on original work by Harris (1984), which was developed using input from a generic grizzly bear population for the continental U.S. These values were not specific to the GYE population. More recent ecosystem-specific data are now available.

During 2004–2006, scientists and managers involved with the GYE grizzly bear population had arrived at a consensus that newer, peer-reviewed scientific information (Cherry et al. 2002; Keating et al. 2002; Haroldson et al. 2006; Harris et al. 2006; Schwartz et al. 2006*a*, *b*, *d*) existed that should be used to improve these methods, develop new methods for these management approaches, or both.

2.2 Protocol adopted in 2007 and currently in place ("Knight-Chao2" protocol)

Following considerable analyses during the years 2000–2005, consideration of options, and input and review from both scientists and general public, a new protocol for estimating population size and mortality limits was proposed in 2005 (see Interagency Grizzly Bear Study Team 2005, 2006), and incorporated into the final Conservation Strategy for Grizzly Bears in the Greater Yellowstone Ecosystem published in 2007 (Interagency Conservation Strategy Team 2007) and the Revised Demographic Recovery Criteria for the Yellowstone Ecosystem (U.S. Fish and Wildlife Service 2007*a*). This remains the protocol in use as of the writing of this document.

2.2.1. Independent females
2.2.1.1. Estimating population size of females.—The earlier conservative index of population size has been replaced by a population estimate, albeit one that still has its roots in the method of delineating unique F_{COY} using the Knight et al. (1995) rule set. Counts of unduplicated F_{COY} and sighting frequencies continue to follow methods outlined by Knight et al. (1995). However, unlike prior to 2007, an attempt is made to estimate the total number of F_{COY} present from the distribution of the frequencies of sighting of individual F_{COY}. As implemented by Cherry et al. (2007), observed count frequencies are used to estimate a preliminary, year-specific total number of F_{COY} using the Chao2 estimator (Chao 1989) (hereafter $\hat{N}_{FCOY\text{-}Chao2}$).

F_{COY} are assumed to be ≥4 years of age because female grizzly bears in the GYE almost never produce cubs prior to this age. The total number of females ≥4 years of age in the entire population (i.e., with and without cubs-of-the-year) is estimated by dividing $\hat{N}_{FCOY\text{-}Chao2}$ by 0.289; this number is the estimated proportion of F_{COY} in the entire population of females ≥4 years of age and is based on transition probabilities calculated from the telemetry sample (see Appendix C of Interagency Grizzly Bear Study Team [2005] and for details see Schwartz and White [2008]). Thus, the resulting estimate represents, on average, the total number of females ≥4 years of age in the GYE population.

In turn, this number is divided by 0.77699, the estimated proportion of female bears ≥4 years of age in the population of females that are ≥2 years of age. The resulting value represents an estimate of total independent female bears (age ≥2 years) in the GYE. It is this, the number of females aged 2 and above that serves as the reference for mortality limits, as estimated by Harris et al. (2006).

2.2.1.2. Derivation of sustainable mortality limit.—The mortality limit for independent female bears is set at 9% of the population estimate for females ≥2 years old based on Harris et al. (2006; equivalent to a survival rate of 91% for these age classes). All mortalities are counted including: (1) agency-sanctioned management removals, (2) loss of radio-marked bears, (3) reported deaths from all causes (i.e., human, natural, and undetermined causes), and (4) an estimate of unknown and unreported losses. The 9% mortality threshold was chosen because

simulations suggested that given fecundity and survivorship for dependent offspring estimated for 1983–2001, when survival of independent-aged females was ≥0.91, the annual growth rate (λ) of the population would be ≥1.0 in 95% of simulations (Harris et al. 2006, Schwartz et al. 2006*a*).

     2.2.1.3. Application of allowable mortality limits.—To dampen variability and provide managers with inter-annual stability in the threshold, allowable mortality limits are based on a smoothed estimate of the number of F_{COY} present in the population in each year, using past years' data and estimates. Linear and quadratic regression models of the natural log of $\hat{N}_{FCOY-Chao2}$ with year are fitted as an initial estimate of trend for $\hat{N}_{FCOY-Chao2}$. Support for linear versus quadratic models is assessed using an information-theoretic analysis approach based on Akaike's Information Criterion (AIC_c; Burnham and Anderson 2002). Respective AIC_c weights of the linear and quadratic models are then used to obtain model-averaged estimates of $\hat{N}_{FCOY-Chao2}$. The model-averaged endpoint in the time series is used as the most appropriated estimate for number of F_{COY} in the population. The method described in 2.2.1.1 is applied to the model-averaged estimate of F_{COY}, and it is this estimate from which sustainability of annual mortality is assessed.

     2.2.1.4. Unknown and unreported mortality.—Unknown and unreported mortality are estimated based on the method of Cherry et al. (2002). This method assumes that all deaths associated with management removals (sanctioned agency euthanasia or removal to zoos) and deaths of radio-marked bears are known. It estimates the number of reported and unreported mortalities based on counts of reported deaths from all other causes.

2.2.2. Dependent offspring

     2.2.2.1. Estimating the number of dependent offspring.—The number of cubs in the annual population estimate is based on estimates of the model-averaged number of F_{COY} ($\hat{N}_{FCOY-Chao2}$, see section 2.2.1.1.). We use an average litter size of 2.04 cubs (Schwartz et al. 2006*b*). The number of yearlings in the population is estimated from the number of cubs the previous year that survived. We assume cub survival to be 0.638 (Schwartz et al. 2006*d*). Thus, we estimate the number of yearlings in the population in any given year by multiplying the estimated number of cubs the previous year by 0.638.

     2.2.2.2. Sustainable mortality limit of dependent offspring.—Just as for independent females, the mortality limit for dependent bears of both sexes be set at no more than 9% of the total estimate of dependent offspring in the population. The rationale for using the same mortality limit as for independent females is explained in IGBST (2005:36). However, unlike for independent females, only human-caused deaths (both reported known and probable) are tallied against the threshold (Interagency Grizzly Bear Study Team 2006).

2.2.2.3. Application of allowable mortality limit.—To dampen variability and provide managers with inter-annual stability, estimates for numbers of dependent offspring are derived from the model-averaged estimate of F_{COY} based on Chao2 and allowable mortality limits are a 9% annual limit from human causes only.

2.2.2.4. Unknown and unreported mortality.—We lack empirical data to estimate unknown and unreported mortality for dependent offspring (Interagency Grizzly Bear Study Team 2006).

2.2.3. Independent males

2.2.3.1. Population estimate for males.—An estimate of independent males (age ≥2 years old) depends on the estimate of independent females and modeled sex ratio of the population (Harris et al. 2006, Interagency Grizzly Bear Study Team 2006). Based on estimates of reproduction and survival, the sex ratio based on projections from the stable age distribution is 0.388:0.611 M:F. Therefore the male segment represents 63.5% (0.388/0.611 = 0.635) of the female population (i.e., there are 0.635 male bears for every female bear).

2.2.3.2. Sustainable mortality limit.—Based on Harris et al. (2006), the mortality limit for independent male bears is set at 15% of the population estimate for males ≥2 years old. Similar to mortality limits for independent female bears, all mortalities are counted, including: (1) agency-sanctioned management removals; (2) loss of radio-marked bears; (3) reported deaths from all causes (i.e., human, natural, and undetermined causes); and (4) an estimate of unknown and unreported losses. The 15% mortality threshold was chosen because it approximates what occurred in the GYE from 1983–2001 (Haroldson et al. 2006), a period when population was estimated to have increased around 4–7% per year (Harris et al. 2006).

2.2.3.3. Application of allowable mortality limits.—To dampen variability and provide managers with inter-annual stability in the mortality threshold, the allowable annual mortality limit is 15% of the estimate of males ≥2 years old as derived from the estimate of females ≥2 years old (see section 2.2.1.1.). For example, the 2004 estimate of females ≥2 years old was 214 bears. The number of independent males (age ≥2 years) is estimated at 136 (214 x 0.635 = 136). The 15% limit based on this estimate = 20 (136 x 0.15 = 20) male bears. Therefore, estimated total mortality for independent-aged males in 2004 (23 mortalities; Cherry et al. 2002) was 3 bears above the allowable mortality limit of 20.

2.2.3.4. Unknown and unreported mortality.—Estimates of unknown and unreported mortality for independent males are based on the method of Cherry et al. (2002), as for females.

All steps are summarized in Fig. 2.1.

2.2.4. Total population size

Total population size is estimated annually based on the sum of estimates for independent female, independent male, and dependent bears.

2.2.5. Uncertainty

Unlike the protocol in place prior to 2007, most (but not all) steps involved in this protocol contain statistically valid measures of sampling error, and thus confidence limits can be calculated for individual steps. At the least, these provide information on how certain we are of any given step along the way. In some cases, they provide explicit bases for calibrating risk, by allowing for more or less conservative management guidelines based on a range of plausible outcomes rather than a single point estimate. However, uncertainty in each step is not incorporated into subsequent steps, making it difficult to understand the degree of certainty in final estimates.

Table 2.1 summarizes the steps illustrated in Fig. 2 that begin with counting the number of F_{COY} seen yearly to estimates of mortality limits, indicating the function of each, whether the expectation of the calculation is unbiased or not, whether uncertainty of the estimator is explicitly estimated, and, if so, whether it is carried through to the next step in the process and in what way. Most steps leading up to this estimate of population size are biased towards underestimating the population. Accordingly, use of these population estimates to obtain sustainable mortality rates likely result in conservative mortality thresholds.
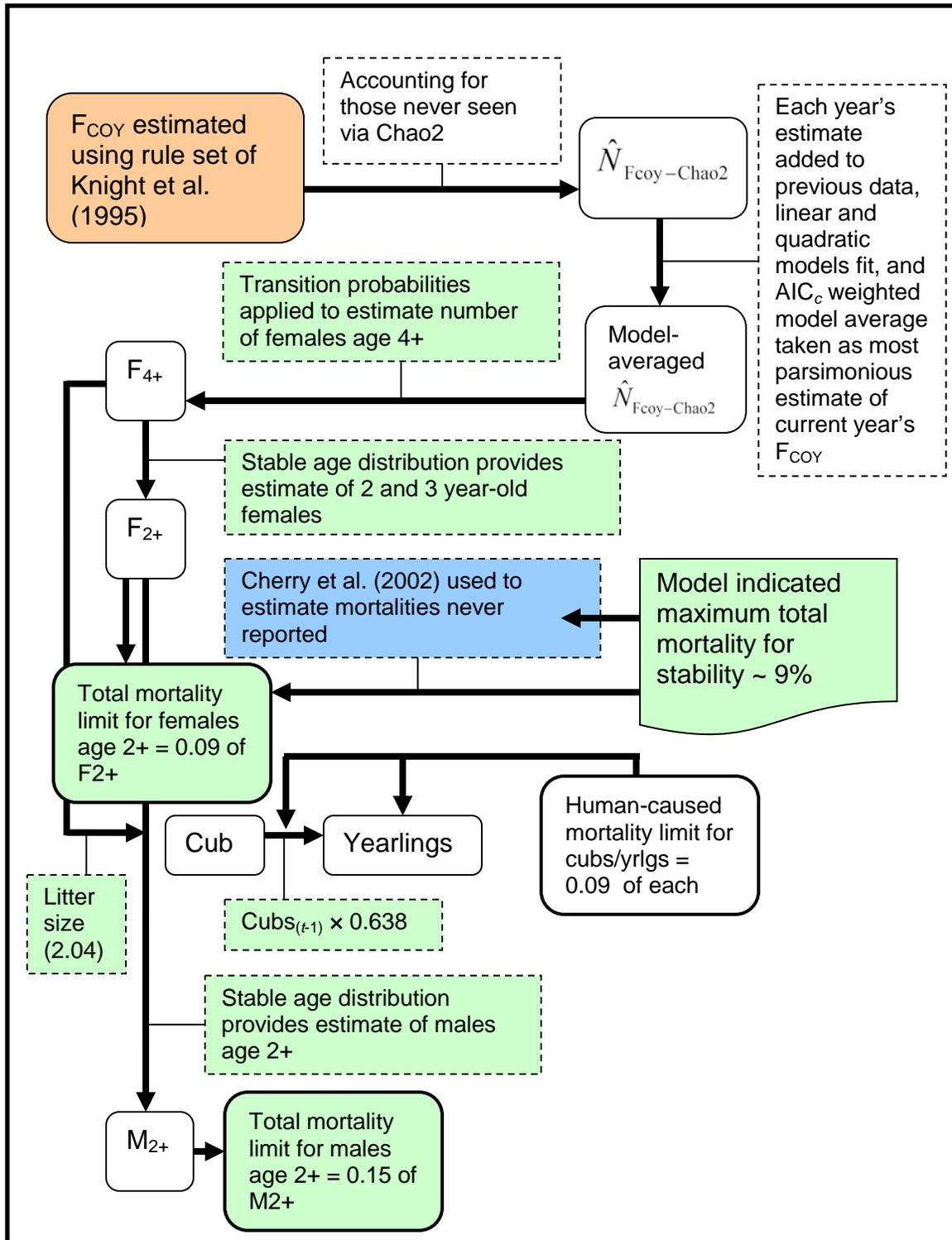
Figure 2.1. Flow chart of the protocols in place since 2007 for estimating the number of grizzly bears in the Greater Yellowstone Ecosystem and assessing sustainable mortality limits.

Table 2.1. *Current protocol (in place since 2007), showing expected biases at each step, whether or not uncertainty (from sampling error) can be estimated, and whether (or how) this uncertainty is carried through to final estimates of population size and sustainable mortality of grizzly bears in the Greater Yellowstone Ecosystem.*

Step in process	Function	Is expectation of result unbiased (U), biased low (L), or biased high (H) and implications of this	Is uncertainty available from estimation procedure? (Y or N)	Is uncertainty carried through to the final management indicator? (Y or N)
1. Knight et al. rule set	Provide an index of the number of unique F_{COY} seen from observations	L (increasing negative bias with increasing population size)	N	N
2. Chao2	Estimate number of F_{COY} ($\hat{N}_{F_{COY}-Chao2}$ $F_{COY-Chao2}$) in the GYE from observed number	L (slight negative bias depending on assumptions and sampling frequency, bias decreases as effort increases)	Y	N
3. Estimate taken from model-averaged regression (linear and quadratic)	Smoothen annual fluctuations in estimates of total number of F_{COY}	Expectation is U, but in any given year could be L or H; consequence of smoothing is delay in response to true process change	Y	N
4. Transition probability calculation	Estimate number of females 4+ from estimate of total number of F_{COY}	U	Y	N
5. Stable age distribution	Estimate number of females 2+ from estimate of females 4+	U	Y	N
6. Model sustainable mortality rate for females 2+ using stochastic simulation	Use 'assumed dead' survival rates	Slightly L (sustainable rates conservative)	Y	Y[a] (use survival rate associated with 5% probability of 10-yr decline)
	m_x unadjusted for den emergence time	Slightly L (more cubs probably produced than suggested by this approach)		
	All unaccompanied yearlings assumed dead	Slightly L (more yearlings may have survived than estimated)		
	Use mean λ over 10-yr interval	Slightly L (declines more likely in 10 years than during shorter time span)		
7. Use Cherry et al. (2002)	Estimate total number of deaths from documented deaths	Slightly L (slightly more deaths may have occurred than estimated because heterogeneity in data greater than accounted for in estimator; effect would lead to underestimating total mortality)	Y	N

[a] Uncertainty because of deviation from stable age distribution is not accounted for.

3. Improving the current approach to population estimation

The group spent considerable time discussing two alternatives to estimate size and trend of the GYE grizzly bear population. The first alternative estimates the number of F_{COY} from unduplicated sightings in the ecosystem yearly (i.e., the same raw data set currently used in the Knight et al. [1995] approach) using a sequential clustering algorithm and simultaneously estimates the F_{COY} population size using an approach called ancillary data resampling (ADR). The simultaneous estimation of the minimum number of F_{COY} sighted and population size carries uncertainty in assigning unduplicated sightings through to the population estimate. The second alternative uses more traditional mark-resight methods to estimate population size of F_{COY}, bypassing the estimate of the number sighted each year used in all previous methods. The mark-resight approach uses only data from systematic aerial surveys conducted twice yearly and radio-marked animals known to be alive and in the population, as opposed to all sightings of F_{COY} used in previous methods. The consensus of the group is that the second of these two alternatives is preferred, for reasons explained below. Methods for both alternatives are described in this section, following a review of why current methods based on the Knight et al. (1995) rule set are problematic and a better approach is desirable.

3.1. Assessing the Knight et al. (1995) rule set

It has long been recognized that the rule set established by Knight et al. (1995) to distinguish unique F_{COY} from a set of yearly observations of unmarked F_{COY}, while useful for the purposes it had initially been designed for, suffers from two flaws that permeated the entire protocol: 1) there is no way to quantify uncertainty, and 2) it is known to produce population estimates that are biased low and the magnitude of this bias increases with true population size. Thus, if measuring an increasing population, it would underestimate the rate of increase. Similarly, it would also underestimate the magnitude of the reduction in a population that was truly declining.

Schwartz et al. (2008) wrote a computer program to automate application of the Knight et al. (1995) rule set by developing algorithms that accurately replicated manual application of the rule set. They then used data from radio-marked F_{COY} to simulate performance of the rule set under various hypothetical but realistic levels of known population abundance. To accomplish the latter, radio-locations of bears from multiple years were overlaid on a map of the ecosystem as if they had all been produced in a single year, and bears were then randomly sampled from this "superpopulation" of observable bears. Sets of known (radio-marked) F_{COY} locations were placed on the map in ways that would populate areas in which few, if any, radio-marked females had been located (livetrapping bears is difficult in some geographic regions) but were known to be occupied by adult female bears. The result was a rather uniform distribution of bear locations for the simulations to evaluate the Knight et al (1995) rule set, with the goal of producing realistic inter-sighting distances and times, which are crucial components of the rule set. Repeated samples ($n = 500$ simulations) of 10, 20, 40, 80, and 100 true F_{COY} were taken from this superpopulation to represent variability in samples obtained by chance through the sampling protocol.

The result of most relevance from Schwartz et al. (2008) was that the rule set returned increasingly negatively biased results as simulated number of unique F_{COY} (and thus density) increased. With 10 true F_{COY}, the rule set was negatively biased by 12%; this bias increased to 48% for a true population of 100 F_{COY} (Fig. 3.1). Stochastic simulations of any populations with true F_{COY} of 20 or greater failed to produce a single estimate that exceeded the hypothesized population size.
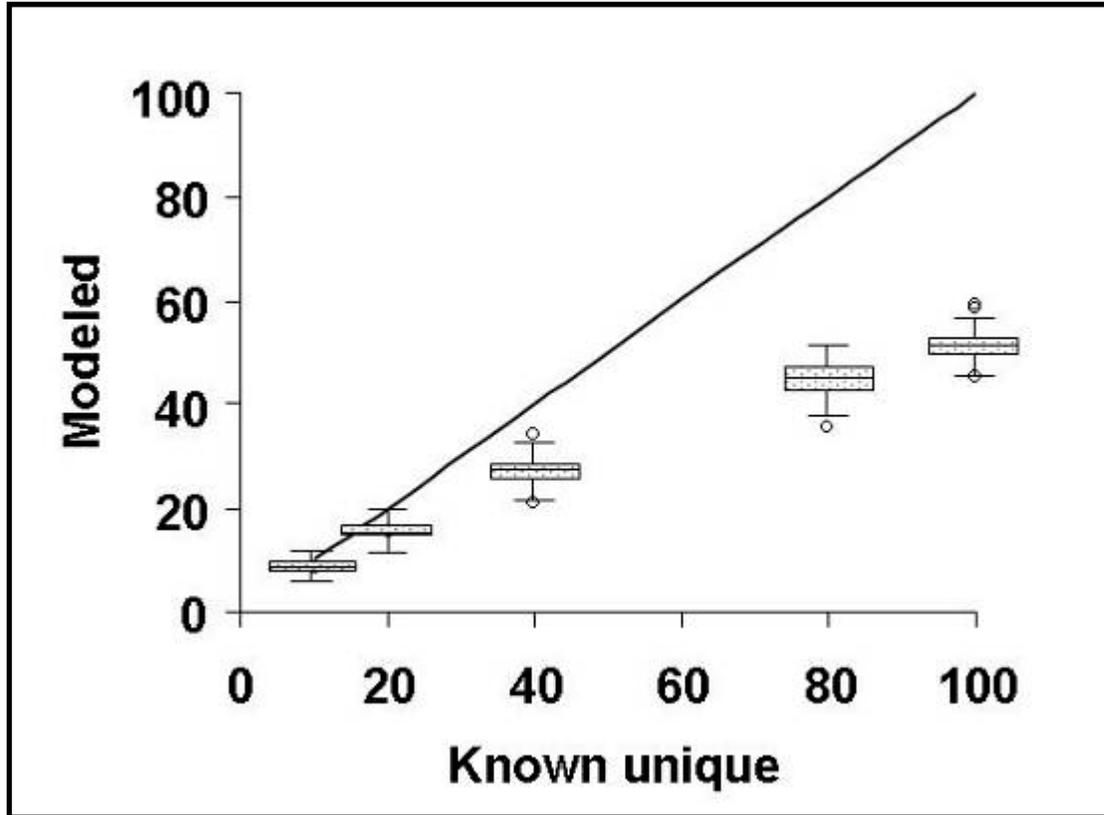
Figure 3.1. Side-by-side box plots of the simulated number of unique female grizzly bears with cubs-of-the-year (F_{COY}) in the Greater Yellowstone Ecosystem using the Knight et al. (1995) rule set to distinguish among telemetry locations for radio-collared F_{COY} sampled over a superpopulation of 10 to 100 unique sighted. In each case, n = 500 simulations. Adapted from Schwartz et al. (2008), except that reference F_{COY} line (solid line) has been corrected from that published in their paper.

One might ask if these biases resulted from errors in the way the Knight et al. (1995) rule set was conceived or executed, or alternatively, whether they are inherent in any similar attempt to distinguish unique animals from a set of unknown animals. We believe that obtaining an unbiased estimate of the true number of animals from unduplicated counts is difficult because it becomes increasingly challenging to distinguish unique animals from duplicates as density increases. Under the current methods for obtaining sightings of F_{COY}, there are few ways in which 2 sightings can be judged as representing distinct individuals, and they generally depend on such factors as number of cubs (1, 2, or 3) and the interaction of distance and time interval between sightings (summarized in Appendix A). The rule set was designed to reduce the probability of erroneously categorizing 2

sightings of a single animal as being from multiple animals but Schwartz et al. (2008) clearly showed there is a trade-off as population density increases (Fig. 3.1).

In light of these known biases, a group met in October 2007 to devise a research direction with the goal of producing a method to address these problems (Interagency Grizzly Bear Study Team 2008) and that would explicitly account for the uncertainty in estimating the number of unique F_{COY} sighted. The proposed strategy at the time was to develop a probabilistic model using a hierarchical Bayesian framework that would distinguish unique F_{COY} based on data from known (i.e., radio-marked) animals, while simultaneously estimating F_{COY} population size using methods similar to those in Wright et al. (2009). It was recognized at the outset that developing a model of true F_{COY} spatial distribution in the GYE would be required, and that this represented a substantial challenge.

3.2. Alternative #1: Sequential clustering algorithm combined with ancillary data resampling (ADR) to simultaneously estimate number sighted and F_{COY} population size

Dr. Megan Higgs, Department of Mathematical Sciences at Montana State University in Bozeman was contracted to pursue this modeling effort. She presented her preliminary results to the group on February 2 and 3, 2011, and further simulation results on July 11 and 12, 2011. Although the group ultimately concluded that they would not recommend using this approach as part of a revised management protocol, considerable time and effort was spent examining and assessing it. The following section provides a brief overview of the method Dr. Higgs developed and presented. A more detailed description is provided in Appendix B. Dr. Higgs plans to submit this work for publication in peer-reviewed literature at a later date.

The method has several steps and relies heavily on historic radio-telemetry and GPS data of F_{COY} in the study area. The method simultaneously estimates the minimum number of F_{COY} sighted (in place of the Knight et al. [1995] rule set) and the F_{COY} population size (in place of the Chao2 method) using a Bayesian model.

Stage 1: Estimate the minimum number of F_{COY} sighted (n) from all sightings within a year
      Part 1: A logistic regression model fit to historic data is used to predict the probability that two sightings are from the same bear and this is used as the basis for a sequential clustering algorithm resulting in an estimated number of unique F_{COY} sighted.
      Part 2: A cut-off value is obtained through an iterative process to remove most of the bias displayed in Fig. 3.1. Uncertainty in the estimate is quantified by repeatedly applying a sequential clustering algorithm to simulated data obtained by re-sampling from a superpopulation created from historic radio-telemetry and GPS data, similar to the strategy Schwartz et al. (2008) used to quantify uncertainty in the rule set

Stage 2: Estimate the number of F_{COY} in the population given the results from Stage 1

Part 1: This again relies on resampling from a superpopulation created from historic radio-telemetry and GPS data. Repeated sampling from the superpopulation consistent with the actual sampling protocol provides the method by which uncertainty is quantified.

Part 2: The superpopulation can be created based on combining historic data with hypotheses about the spatial distribution of F_{COY} on the landscape. We created three such superpopulations representing different assumptions about the distribution of F_{COY} within the GYE.

Part 3: Repeated sampling from each superpopulation scenario (i.e., ancillary data re-sampling) using the steps described in Appendix B resulted in quantification of the relative likelihood of different values of population size given the total number of observed sightings and the results for the minimum number of F_{COY} sighted obtained in Stage 1.

Model assessment: A simulation study was conducted to assess the performance of the models under violations of the spatial distribution assumptions. This allowed quantification of the magnitude of possible mistakes that could be made if we, for example, assume F_{COY} are preferentially distributed in high sightability areas when really they are distributed more uniformly across the region.

3.2.1 Benefits
1. The method uses all data (ground and flight data).
2. The method provides an estimate of the number of unique F_{COY} sighted.
3. Assumptions regarding the spatial distribution are based on real data from the study area and are readily visualized through plots of the superpopulations.

3.2.2. Limitations
1. The method is computationally intensive
2. The method involves many steps, which make it difficult to explain and understand.
3. The study team deemed the choice of a particular superpopulation to represent the spatial distribution assumption to be subjective.

3.2.3. Discussion
Because of the level of complexity involved in the entire method and computational time, the group decided against using this method. Also, lack of knowledge about the spatial distribution of F_{COY} across the region caused concerns regarding the choice of a particular superpopulation.

3.3. Alternative #2: Mark-resight to estimate number of F_{COY} from standardized aerial surveys

This approach takes advantage of the fact that, beginning in 1997, standardized aerial surveys have been flown twice per summer by experienced pilots and observers, whose

tasks have been to 1) count all bears observed without the aid of telemetry, taking special care to ensure the presence of cubs-of-the-year and number of cubs-of-the-year were correctly documented, and 2) when a F_{COY} is observed, use telemetry receivers to determine whether or not that particular female is wearing a radio collar. These data naturally form the basis for mark-resight estimation of population size, pioneered by Rice and Harder (1977; see White 1996), and subsequently elaborated and extended by other investigators (Miller et al. 1997). In short, the total number of animals of interest (population size) is estimated by considering their detection probability. In this case detection probability is estimated by the distribution of number of re-sightings of the marked (radio-collared) F_{COY} (whose number is known exactly). The maximum number of re-sightings per year in this case is two (i.e., one during each set of observation flights).

Normally, an estimate would be produced for each sampling period (for large mammals, sampling typically occurs once per year) during which the number of marks is known and a set number of resighting surveys occurs. However, in the case of GYE grizzly bears, both the number of marked F_{COY} and the number subsequently observed during the observation flights are smaller than needed for standard yearly application of mark-resight methods (in 6 of the 15 years, no marked F_{COY} were re-sighted, which would make estimates in those years impossible; Table 3.1). Indeed, the Interagency Grizzly Bear Study Team previously studied the feasibility of this technique using all radio-marked bears with 1998–1999 data and concluded that resighting probabilities were too low, and uncertainty of population estimates too great, to apply the technique (Schwartz 1998, 1999).

However, if the assumption can be made that the probability a marked F_{COY} will be seen 0, 1, or 2 times during the 2 observation flights is generally similar from year to year (i.e., the yearly frequencies are manifestations of a single, underlying multinomial distribution), then the entire 15-year data set can be used to generate the probability of detection. Under this assumption, the number of marked F_{COY} in the population and the number of unmarked F_{COY} seen during observation flights varies yearly, but rather than using that individual year's distribution to model resighting probability, the overall resighting probability based on the 15-year aggregated sightings of F_{COY} is applied to each individual year.

Any approach using these data also assumes that the population of F_{COY} is closed within each sampling period (i.e., no deaths of F_{COY} between the first and second flights). Given the high survival rate of adult females (see later sections), this assumption seems biologically acceptable.

One additional assumption underlying use of this method is that the probability of observing a radio-marked F_{COY}, without using telemetry, does not differ from the probability of observing an unmarked F_{COY}. This assumption could be violated if marked F_{COY} differ from unmarked F_{COY} in behavior, habitat preference, pilot knowledge of their whereabouts, or geographic distribution. Study team members were unable to imagine any reasonable situation that would lead to either behavioral or habitat differences

between collared and uncollared F_{COY}. Bears are not collared from aircraft, and thus recently collared bears are unlikely to react to them differently than uncollared bears. Further, F_{COY} are rarely captured and radio-marked in the year they have cubs; most collared F_{COY} wear collars that were attached in earlier years. The study team also indicated it is very unlikely that pilots and observers more readily find marked (radio-collared) F_{COY} than unmarked F_{COY} because they so rarely observed them visually (~10% of the time), even during telemetry flights. Pilots are under strict protocol not to locate F_{COY} using telemetry during observation flights.

With the exception of one characteristic of the data, study team scientists felt that the geographic distribution of collared female bears is generally representative of the geographic distribution and relative density of female bears in the population. The exception was that uncollared F_{COY} are more likely to use army cutworm moth sites for feeding in late summer than collared F_{COY}. Previous work has shown that a subset of bears in the GYE population typically spends 6 to 10 weeks in late summer (mid-July to late September) of most years feeding in alpine scree slopes on these moths (Mattson et al. 1991, Bjornlie and Haroldson 2011). These bears are thus highly visible and have constituted a substantial proportion of bears seen during observation flights. However, capturing and marking bears has been particularly difficult in these portions of the GYE. Early in the season, these remote and high-elevation areas are typically snow-covered, access is difficult, and ground-trapping has rarely occurred. Later in the season, when access improves, most of the bears that would be the subject of capture efforts have already begun feeding on army cutworm moths and are difficult to attract to capture sites. Thus, the proportion of radio-marked F_{COY} among those feeding on these high-visibility sites is lower than in the remainder of the ecosystem because of sampling limitations.

Table 3.1. Number of marked female grizzly bears with cubs-of-the-year (F_{COY}) known to be in the Greater Yellowstone Ecosystem population, number observed once or twice during twice-yearly observation flights, and total number of unmarked F_{COY} (i.e., not wearing operating radio collars) observed each year, 1997–2011.

Year	Marked F_{COY} available	Marked F_{COY} observed once	Marked F_{COY} observed twice	Unmarked F_{COY} observed
1997	6	2	0	16
1998	4	2	0	26
1999	6	1	0	7
2000	7	0	0	16
2001	9	5	0	32
2002	5	0	0	65
2003	4	1	0	25
2004	4	2	0	35
2005	3	0	0	22
2006	8	0	1	43
2007	6	3	0	45
2008	5	1	1	42
2009	6	0	0	28
2010	3	0	0	38
2011	3	1	0	28

Were mark-resight estimates to be applied ecosystem-wide without considering moth sites, the results would be positively biased (the probability of observing uncollared bears in this area is actually much greater than suggested by the proportion of marked bears that are re-sighted). However, the study team was able to identify moth sites and animals observed on them during each year. Thus, the study team proceeded with a preliminary mark-resight estimator that omitted any bears (marked or unmarked) observed at moth sites. In the remainder of the ecosystem, the assumptions of equal observability among marked and unmarked bears seems reasonable, thus the group viewed this approach as providing an unbiased estimator of the yearly number of F_{COY} within the GYE, excluding areas where bears feed on moths.

There are several alternative estimators for use with mark-resight data that differ in their generality (e.g., how well they handle heterogeneity of individual resighting probabilities) and assumptions. Megan Higgs and Gary White presented the group with the results of 3 different estimators:

      1) a Bayesian approach, in which uncertainty in the probabilities of re-sightings obtained from data on marked animals is incorporated to obtain the posterior distribution for F_{COY} population size for areas of the GYE covered by observation flights, excluding the moth sites. Higgs et al. (in review) present several methods, exact and approximate, to obtain the appropriate posterior distribution for this problem.

      2) the Poisson-log normal approach of McClintock et al. (2009), which has recently been incorporated into Program MARK, provides similar results to those obtained by Higgs et al. (in review); and

      3) the generalized binomial model of Bowden and Kufeld (1995), which is available in Program NOREMARK.

Although the latter two are considered approximations, it is noteworthy that both accommodate heterogeneity in resighting probabilities (although the Bowden estimator is designed for situations in which resighting is without replacement within each occasion).

All estimators returned point estimates and confidence (or credible) intervals that did not differ practically, reducing the team's concern regarding the choice of modeling approach.

Preliminary estimates of the number of F_{COY} based on this method suggest they will generally be greater than the numbers returned by the "Knight-Chao2" approach. Because of small sample sizes, confidence intervals surrounding each point estimate are wide. A formal manuscript was submitted in March 2012 to a peer-reviewed journal by Megan Higgs, Gary White, Mark Haroldson, and Dan Bjornlie, which is currently in review.

3.3.1. Benefits
If an unbiased correction factor can be developed for the problem of observations at moth sites, this approach can provide an unbiased estimate of the number of F_{COY} within the GYE, from which population estimates can be projected based on proportions of animals in each age-class (as in the current protocol). Unlike the current procedure, trends reflected in this estimate should reflect true trends,

because there is no known density-associated bias. As currently implemented, it requires no additional research effort, because it uses animals that would be captured and collared in any case (for marked animals) and observation flights that have been consistently conducted since 1997 (for resightings).

3.3.2. Limitations

As currently implemented, the approach yields imprecise estimates (i.e., confidence intervals are large). In particular, the estimator produced with currently available data is somewhat sensitive to the small number of marked F_{COY} observed during both flights (most marked F_{COY} were never observed during flights, Table 3.1.). It also produces annual estimates of F_{COY} that vary considerably. Thus, a smoothing technique, such as regression on time, would be useful to better discern trends, rather than management responding to annual variation of estimates. To be used indefinitely in the future, a well-distributed sample of adult females must be radio-marked and, importantly, the larger this sample is, the more precise the estimator will be. Annual observation flights, similar to those conducted beginning in 1997, must be continued.

3.3.3 Work still to be done

3.3.3.1. Refine and update the geographic area to be excluded because of moth sites.—During the workshop, study team members provided an initial analysis that excluded marked F_{COY} resightings and sightings of unmarked F_{COY} within areas designated as moth feeding sites. A formal and objective procedure for defining areas inhabited by bears that use the moth sites during the period of observation flights is being developed. The downward bias resulting from excluding the moth sites entirely may be alleviated should it be possible to devise an additional estimate for moth sites only. To accomplish this, counts of F_{COY} during observation flights of confirmed moth sites will be conducted and evaluated for an annual moth-only addition to the mark-resight estimate. The accuracy of aerial observations of F_{COY} at moth sites will be evaluated based on simultaneous aerial and ground observations.

3.3.3.2. Work on an appropriate smoothing function.—The current protocol calls for fitting both linear and quadratic terms to series of F_{COY} estimates returned by the "Knight-Chao2" approach, with the single-best estimate in each year taken as the model-averaged mean using AIC_c weights. A similar approach could be applied to the series of estimates from the mark-resight approach. However, this approach may yet be improved by considering additional plausible models beyond the linear and quadratic. The quadratic model imposes a declining trend during later years of a series, thus not allowing for the possibility of population size becoming stable. Functions that include an asymptote would impose stability, thus not allowing for the possibility of a true decline. Because an a priori way to select among these possibilities does not exist, a larger array of candidate models of trend on time, weighted using AIC_c or similar information-theoretic methods, would offer the most objective assessment of recent population trends. We note that fitting smoothing functions will require several years as

counts of F_{COY} based on moth-only observation flights could not be backcast but will only accumulate with additional years of data.

3.3.3.3. Power analysis.—Power analysis would estimate the ability of this monitoring protocol to correctly detect a specified change in state (e.g., increase to decline), given existing estimates of process and sampling variation and specified time frames. A similar analysis was already published for the "Knight-Chao2" approach (Harris et al 2007:174). The anticipated time frame to complete these power analyses is the end of 2012.

3.3.3.4. Improve the precision of mark-resight estimates by expanding it to all females with dependent offspring.—Protocols for aerial observation flights require pilots, upon finding a $F_{COY,}$ to determine whether bears are radio-marked. However, unlike in the "Knight-Chao2" protocol, which depends on the unique nature of F_{COY} to discriminate one individual from another, it may be possible to expand the subset of the population estimated beyond F_{COY}. For the GYE, sample size of marked and unmarked animals would approximately double (assuming a roughly 3-year reproductive cycle) if all observations of adult females with any offspring were considered. This would require little or no additional investment of time on the part of pilots and observers, or reconsideration of the areas to exclude from moth sites (see 3.3.3.1, above). In extrapolating to the total number of females (and from there, to total population size), transition probabilities would still be used, but the ratio to use would be all females except those in the "no offspring" state. However, this approach could fail if the detection probability of females with yearlings or 2-year-olds differs from that of females with cubs-of-the-year. Additionally, aerial observations of females with unrelated, young males could potentially be misclassified as females with offspring or vice versa. Because of these 2 limitations, the study team will first conduct analyses to examine the feasibility of improving precision based on increasing the sample size of marked females. Completion of these analyses is anticipated by the end of 2012.

3.4. Other alternative approaches to population estimation

Both the core study team members and larger group represented at the workshops were mindful of alternative approaches that exist to estimate the population size and trend of bears. Retrospective analyses using statistical population reconstruction (e.g., Gove et al. 2002) may be a potential avenue worth exploring and some simpler population reconstructions have already been completed. These would primarily be useful in either supporting or casting doubt on estimates obtained yearly because inference would lag behind management needs by a few years.

The group was also aware of, and had direct research experience, with mark-recapture estimators using either ingested marks (e.g., tetracycline, Garshelis and Visser 1997, Garshelis and Noyce 2006) or DNA from hairs (Woods et al. 1999, Kendall et al. 2009, Clark et al. 2010). These approaches had previously been considered by GYE managers and deemed currently impractical for budgetary reasons.

3.5. Discussion

The primary motivation for exploring alternative estimation techniques was the desire to obtain unbiased estimates of population size. The group clearly sees the mark-resight approach as the single best available alternative from which to estimate the number of adult females in the GYE (and thus total population size). As preliminary results have shown (Higgs et al., in review), there is an expectation that this technique will produce population estimates that are ≥ than those produced by the Knight-Chao2 approach. The mark-resight technique, unlike the Knight-Chao2 approach, is not increasingly biased low as population size increases (Higgs et al., in review). Although evaluations sofar indicate precision of the mark-resight estimator is low, we note that uncertainty associated with the Knight-Chao2 estimates likely is understated (Higgs et al., in review). We take the view of Paulik (1963) and other population biologists that an approximately unbiased estimate with low precision is always better than a highly precise but biased estimate. We thus conclude the mark-resight technique meets the first workshop objective (see Section 1). However, the group also discussed that 3 issues be further evaluated: (1) low precision, (2) correction factor for F_{COY} observed at moth sites, and (3) trend estimation.

3.5.1 Low precision
Precision of mark-resight estimates of F_{COY} would increase if additional females could be radiomarked. Field sampling constraints limit opportunities to increase sample size of marked females so it is important to determine trade-offs between sample size and precision. Analyses will be conducted to examine the effect of increased sample size on precision, with final evaluations expected by the end of 2012

3.5.2 Correction for F_{COY} observed at moth sites
The current estimate of the zone of influence around army cutworm moth sites for F_{COY} (5,000 m from moth site boundary, based on telemetry data of independent females that used moth sites) is being evaluated by the study team. Evaluation of the effectiveness of this correction is based on comparison of F_{COY} from simultaneous ground and aerial observations (8 flights at 5 different sites) during 2012. Congruence of >95% between ground and aerial estimates would indicate a separate census of F_{COY} at moth sites is feasible, and would serve to adjust the mark-resight estimate. This issue should be addressed by the end of 2012.

3.5.3 Trend estimation
Power analyses are planned to determine the effectiveness to track changes in population trends under different scenarios of population size and change. Final evaluations are expected by the end of 2012. Application of this technique to develop and evaluate trend data, however, will take several years; whereas mark-resight estimates excluding moth feeding sites will be backcast to 1997, estimates that are corrected for F_{COY} using moth sites started in 2012. Therefore, trend data of F_{COY} estimates including moth sites require accumulation of additional years of data.

Because final evaluation of the mark-resight estimator is pending, there was consensus that data required for the "Knight-Chao2" estimator continue to be collected, and these estimates be updated and reported annually.

4. Preliminary analyses to update our understanding of grizzly bear vital rates from telemetry data

The study team has completed preliminary demographic analyses of the GYE grizzly bear population that update those published by Schwartz et al. (2006*e*). That publication examined the population during the years 1983–2001 (with an additional year for reproduction only). New analyses covered the period 2002–2011. Most of these new analyses use Program MARK to estimate rates of survival (cubs, yearlings, subadults, adult females, and adult males) and transition rates among reproductive classes of females (which, in combination with litter sizes, yield fecundity).

With two exceptions, analytical approaches and assumptions followed closely those of Schwartz et al. (2006*e*). The two exceptions were:

      1) Whereas the data set of 1983–2001 provided no basis for recognizing a distinct category of subadult females (aged 2–4) whose survival differed from adult females (aged ≥5 years), model selection procedures applied to the 2002–2011 data in which animals with unresolved fates were assumed to have died supported such a classification (although model selection for 2002–2011 data in which animals with unresolved fates were censored at last contact did not). Thus, subsequent models under the former assumption incorporated 4 age-classes for females: cubs, yearlings, 2–4 years-olds (subadults), and 5+ years old (adults).

      2) Schwartz et al (2006*b*) made no adjustment for the raw reproductive rate (m_x) estimated from multiplying litter size by probability of an adult female being in the "with cubs" state. The updated analyses for 2002–2011 adjusted m_x to account for the discrepancy between the dates on which litter sizes were first documented and the date on which cub survival was modeled as beginning. Schwartz et al. (2006*b*:20) pointed out that the reproductive rate (at cub emergence) later used in population projections (m_x = 0.318) was likely biased low by approximately 13% because the mean date of first litter size documentation was 65 days later than the date on which cub survival was estimated. The study team's new analysis adopted the alternative procedure of Mace et al. (2012:122), which is more appropriate when combining m_x with cub survival rates as part of a life-table or matrix-based estimation of a rate of increase.

Results of these preliminary analyses are summarized in Table 4.1., which are provided here as a work in progress. Readers are cautioned that these analyses are ongoing, have not yet been thoroughly vetted or peer-reviewed, and that further work could result in revisions. Nonetheless, the broad outlines of changes in the demographic characteristics of the GYE grizzly bear population during the 2 periods (1983–2001 vs. 2002–2011; see Fig. 4.2) appear robust and are of sufficient importance to management that we believe these tentative results should be shared and considered at this time.

Table 4.1. Demographic rates of the Greater Yellowstone Ecosystem grizzly bear population, 2002–2011, as estimated from preliminary (as yet unpublished) analyses, compared with analogous results from 1983–2001 (Schwartz et al. 2006e). For each vital rate, the point estimate is provided above, and 95% confidence limits are provided below.

Vital rate	2002–2011		1983–2001[a]	
	Point Estimate	95% CI	Point Estimate	95% CI
Cub survival	0.553	0.421-0.667	0.640	0.443-0.783
Yearling survival	0.539	0.346-0.698	0.817	0.489-0.944
Subadult (age 2-4) survival[b]	0.948	0.917-0.968	0.950	0.926-0.965
Subadult (age 2-4) survival[c]	0.887	0.803-0.937	0.922	0.857-0.959
Adult (5+) female survival[b]	0.948	0.917-0.968	0.950	0.926-0.965
Adult (5+) female survival[c]	0.943	0.910-0.964	0.922	0.857-0.959
Adult (5+) male survival[b]	0.948	0.917-0.968	0.874	0.810-0.920
Adult (5+) male survival[c]	0.943	0.910-0.964	0.881	-
Fecundity (adjusted)	0.336	0.264-0.409	0.362	-
Fecundity (unadjusted)[d]	0.286	0.227-0.345	0.318	0.277-0.359

[a] Rates were estimated using a combined subadult and adult age class.

[b] Animals with unresolved fates were censored at last contact; no sex or age-class effect was observed.

[c] Animals with unresolved fates were assumed dead for this analysis; an age-class effect was observed.

[d] These reproductive rates are considered to be biased low for the 1983–2001 period (thus biasing λ low); adjusted fecundity was used in analogous estimations done by the study team for the 2002–2011 period (Table 4.2.)

Table 4.2. Point estimates (and, where calculated, 95% confidence intervals) of the rate of growth of the Greater Yellowstone Ecosystem grizzly bear population, λ (and bears within spatial subsets of it, weighted by the proportion of time spent in each), during the current period of analysis (2002–2011) and the previous period of analysis (1983–2001). A. Survival rates of independent females estimated with unresolved fate animals censored at last contact. B. Survival rates of independent females estimated with unresolved fate animals assumed dead (entire GYE only).

Geographic area	2002–2011	95% CI	1983–2001	95% CI
A.				
Entire GYE	1.022	0.966–1.060[a]	1.076	1.008–1.115[b]
YNP [c]	1.022	-	1.054	-
Beyond YNP but within recovery zone [c]	1.041	-	1.121	-
Beyond recovery zone [c]	0.965	-	0.887	-
B.				
Entire GYE	1.003	- [d]	1.041	0.972–1.096[b]

[a] Confidence interval based on techniques presented in Harris et al. (2007).

[b] Harris et al. (2007:172).

[c] We provide these separate λ estimates for each zone because of their management implications, but note that evidence for differences among zones was weak: confidence intervals for the untransformed covariate "zones" overlapped zero.

[d] We did not calculate confidence interval for this scenario; based on scenario A., the 95% confidence interval would likely be similar in width and bound 1.0.

Final analyses have yet to be completed but a few notable points were stressed by the study team and are relevant to the group's deliberations regarding revision of mortality limits:

1) Although confidence intervals for the two time periods overlapped (thus a formal statistical test may fail to show strong evidence of difference), the consensus among the scientific group was that evident declines in cub and yearling survival rates were real.

2) Subadult survival also seems to have declined (although again, a rigorous statistical test might not support this) because AIC_c supported a model for the 2002–2011 data in which age class was included as a covariate, which was not the case for the 1983–2001 period. However, this was only evident when independent survival was based on the scenario in which bears with unresolved fates were assumed dead; no difference was detected for survival of subadult and adult bears when bear with unresolved fates were censored.

3) The point estimate for fecundity was only slightly lower for the later period compared with the earlier period. Mean observed litter size during 2002–2011 was 2.12 cubs, similar to the mean observed during 1983–2002 of 2.04 cubs. Therefore, The

asymptotic proportion of a 4+ female having cubs-of-the-year was 0.269 during the latter period, compared with 0.289 during the earlier period.

4) Survival of adult males appeared to have increased between the 2 time periods.

5) Taken together, these vital rates yielded an estimated asymptotic λ very close to 1.0 during the 2002–2011 period (treating bears with unresolved fates as having died at last contact, estimated λ was 1.003; treating bears with unresolved fates as censored at last contact, estimated λ was 1.022; Table 4.2). Thus, the population increase that occurred during 1983–2002 had evidently slowed or stopped during 2002–2011. Because true vital rates during the 10-year period 2002–2011 may have changed, we cannot pinpoint when the change in trend occurred, or whether the population trajectory in future years will change from that estimated during this time period.

6) As during the earlier period, population growth rates during 2002–2011 were highest when modeled for the population living within the Recovery Zone but beyond the boundary of Yellowstone National Park, lowest beyond the Recovery Zone boundaries, and intermediate within Yellowstone National Park. However, divergence in these trends appeared to narrow during the latter period because there was little support for models with a zone covariate. The growth rate of bears as modeled within the Recovery Zone but outside of Yellowstone National Park declined markedly from the earlier to the later period; the growth rate within Yellowstone National Park declined slightly, and the (negative) rate of growth for bears outside the Recovery Zone actually increased from the earlier to the later period (Table 4.2).

5. Preliminary analyses of intrinsic and extrinsic factors associated with grizzly bear vital rates

The study team completed a number of preliminary analyses with the objective of improving our understanding of the reasons population growth has slowed in recent years. In particular, the team has employed linear models, both in Program MARK and other statistical software, to examine the strength of evidence for various hypotheses relating indices of population density and measure of whitebark pine abundance to vital rates in recent years. In recognition of the fact that vital rates (as well as measured physiological parameters) are likely also functions of sex, age, and other plausible environmental factors (e.g., proportion of time spent within the Recovery Zone boundary), these were also considered in models.

These analyses are currently being refined and re-checked; specific analyses are not yet available for publication in this report. However, the consensus among the assembled group, upon considering the preliminary analyses conducted thus far, is that these data are consistent with both the hypothesis of density-dependence (i.e., the population has grown with respect to a relatively stable carrying capacity, i.e., $N/K \approx 1$) and the hypothesis of adverse effects associated with resource changes, such as whitebark pine decline (i.e., K has declined). These two potential mechanisms are confounded to a large extent. The grizzly bear population has grown by 4% to 7% during the 1980s and 1990s up until ~2002, after which density-dependent effects would be expected to manifest themselves. However, the lower population growth of 0% to 2% during 2002–2011 also coincides with the period in which availability of whitebark pine seeds and other food resources (e.g., cutthroat trout in tributary streams of Yellowstone Lake) declined. Obtaining a better understanding if, and how, these two processes (density dependence and changing food resources) may have contributed to changes in population growth, and their relative contribution, is challenging and is currently the primary research focus for the Interagency Grizzly Bear Study Team. A synthesis report regarding whitebark pine decline, density dependence, and ecological plasticity of grizzly bears in the GYE will be finalized by October 2013. The consensus among the group is the GYE bear population remains healthy and stable at this time and there are no indications the grizzly bear population has entered a prolonged declining trend.

6. Recommended revisions to sustainable mortality limits

The existing protocol uses the results of modeling conducted by Harris et al. (2006) to estimate that, with the GYE exhibiting vital rates similar to those documented during 1983–2001, total mortality of adult females at 9% or below would have a very low probability of inducing a population decline. With the updated analysis of GYE grizzly bear vital rates during 2002–2011 (particularly those indicating possible reductions in cub and yearling survival in recent years), these limits require re-examination.

6.1. Revised limits

6.1.1. Independent females

As an initial approximation, we recommend that mortality limits applicable to independent females be 7.6% of the annual population estimate for independent-aged females. This is a revision of the currently-used 9% (Section 2.2.1.2.), and is based on 1) the revised estimates of vital rates for female grizzly bears during 2002–2011, and 2) a deterministic life-history projection that produces $\lambda \approx 1.0$ with these updated fecundity and survival rates for dependent offspring, and an independent female survival of 0.924. Thus, if survival rates for dependent offspring and fecundity remain similar to those estimated during 2002–2011, mortality (regardless of source) leading to annual survival of independent-aged females of ≥ 0.924 (i.e., annual mortality rate of 0.076 or 7.6%) would, on average, not produce a declining trend. We note that in addition to this mortality limit being based on updated vital rates from 2002–2011, it differs conceptually from the previously adopted one of 9% in being based on a deterministic model, rather than on the independent female survival rate yielding annual population growth rate of $\lambda \geq 1.0$ in 95% of simulations (Harris et al. 2006). The workshop attendees agreed that this conceptual shift was appropriate because wildlife populations in general, and grizzly bears in particular, cannot be managed for growth in perpetuity, especially when the boundary of suitable habitat is generally well defined because of limits on available habitat and incompatibility with human activities beyond this boundary (see Section 6.2). Thus, a change in management objective from one of population growth for recovery to maintenance of a stable grizzly bear population (i.e., $\lambda \approx 1.0$) is biologically logical and desirable, and compatible with management objectives of state and federal agencies charged with managing grizzly bears in the GYE. Secondly, we note that despite the lower mortality threshold of 7.6%, the number of female bears representing that mortality limit may be greater than previous years because population size has increased and because new techniques, such as the mark-resight estimator, may reduce the low bias of current population estimates based on the Knight et al. (1995) rule set.

As in the current protocol (Section 2.2.1.4.), as part of estimating the number of unmarked bears dying, we recommend that unknown and unreported mortality be estimated based on the method of Cherry et al. (2002). This method assumes that all deaths associated with management removals (sanctioned agency euthanasia or

removal to zoos) and deaths of radio-marked bears are known. It estimates the number of unreported mortalities based on counts of reported deaths from all other causes.

6.1.2. Dependent offspring
Just as for independent females, we recommend the mortality limit for dependent bears be set at no more than 7.6% of the total estimate of dependent offspring in the population. The rationale here is similar to Section 2.2.2.2. (i.e., based on IGBST 2005:36), albeit using this revised number. As currently, and unlike for independent females, only human-caused deaths (both reported known and probable) would be tallied against the threshold.

6.1.3. Independent males
As in the previous protocol (Section 2.2.3.2.), no data exist that could be used to inform a sustainable mortality limit for males, because population trajectory is generally independent of male survival rates. Our recommendation therefore is that the current mortality limit of 15% of the annual population estimate of independent males be retained, which is a conservative criterion.

As in the current protocol (Section 2.2.3.4.), we recommend that estimates of unknown and unreported mortality for independent males be based on the method of Cherry et al. (2002).

The suggested protocol is illustrated in Fig 6.1., whereas Table 6.1. illustrates these steps with additional information on uncertainty and bias.
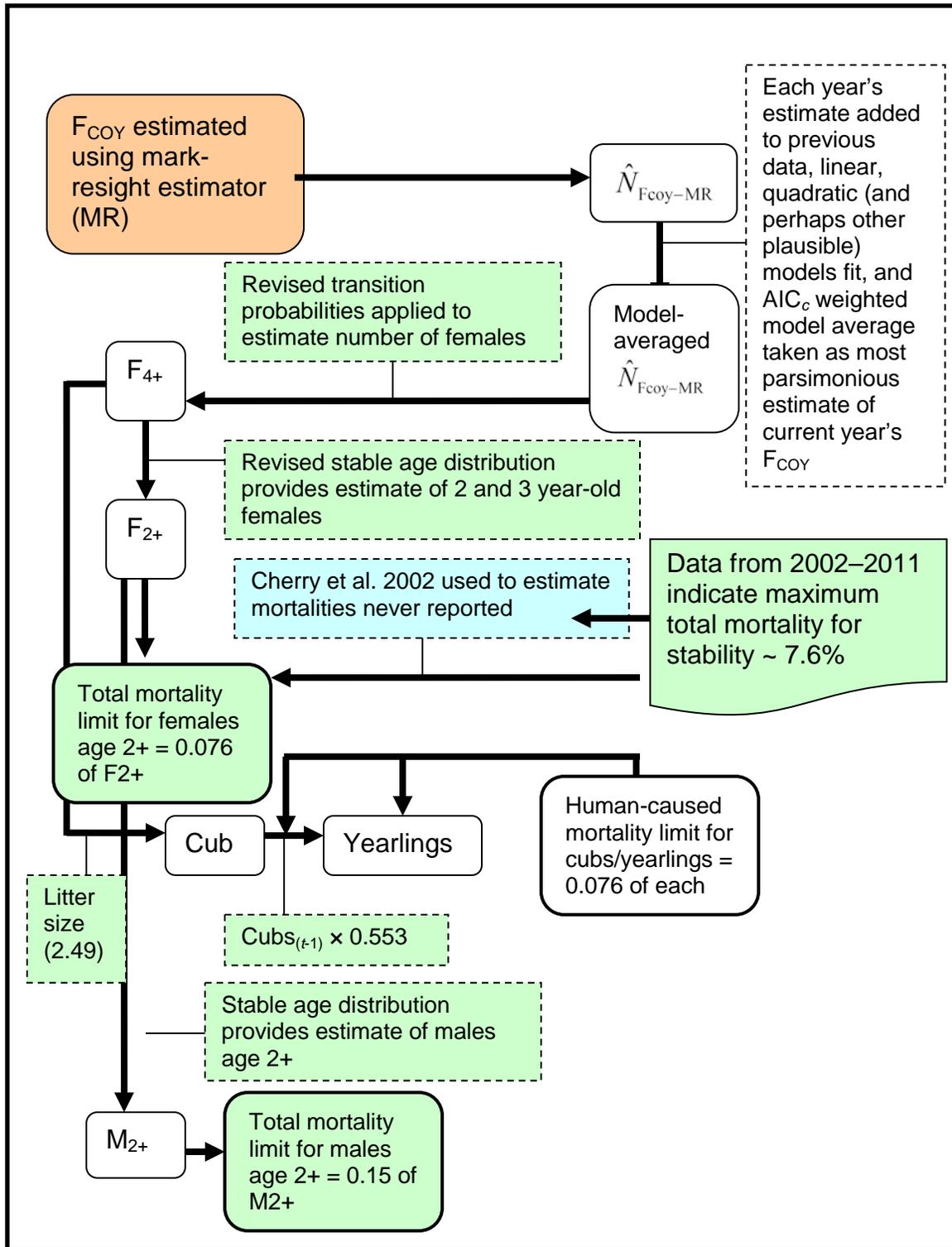
Figure 6.1. Recommended revised flow chart of protocols for estimating the number of grizzly bears in the Greater Yellowstone Ecosystem and limits to mortality.

Table 6.1. Recommended protocol (2012), showing expected biases at each step, whether or not uncertainty (from sampling error) can be estimated, and whether (or how) this uncertainty is carried through to final estimates of grizzly bear population size and sustainable mortality in the Greater Yellowstone Ecosystem.

Step in process	Function	Is expectation of result unbiased (U), biased low (L), or biased high (H) and implications of this	Is uncertainty available from estimation procedure? Y or N)	Is uncertainty carried through to the final management indicator? (Y or N)
1. Mark-resight	Estimate total number of F_{COY} in the GYE from observation flights and marked F_{COY}	U (if satisfactory correction factor for moth site issue can be developed)	Y	N
2. Estimate taken from model-averaged regression (linear, quadratic, other plausible models)	Smoothen annual fluctuations in estimates of total number of F_{COY}	Expectation is U, but in any given year could be L or H; consequence of smoothing is delay in response to true process change	Y	N
3. Transition probability calculation	Estimate number of females 4+ from estimate of total number of F_{COY}	U	Y	N
4. Stable age distribution	Estimate number of females 2+ from estimate of females 4+	U	Y	N
5. Estimate sustainable mortality rate for females 2+ from new demographic analyses	Use survival rates where animals with unresolved fates are censored at last contact	U	Y	N (this differs from 2007 protocol, in which mortality limit had built-in conservative feature because was based on a model suggesting <10% probability of decline; under proposed rate, expected probability of decline = 50%)
	All unaccompanied yearlings assumed dead	Slightly L (slightly conservative because more yearlings may have survived than estimated)	N	
	Use fecundity (m_x) adjusted for date of emergence	U (Note change from previous protocol where this was labeled 'L', i.e., conservative)	Y	
6. Use Cherry et al. (2002)	Estimate true number of deaths from documented deaths	Slightly L (slightly more deaths may have occurred than estimated because heterogeneity in data greater than accounted for in estimator; effect would lead to underestimating total mortality)	Y	N

6.2. Revision of area within which mortality limits apply

Under the existing protocol, grizzly bear mortality limits apply to the entire Conservation Strategy Management Area (U.S. Fish and Wildlife Service 2007*a*). All mortalities occurring within this area are counted and total mortality is estimated (Cherry et al. 2002) to assess whether mortality limits have been exceeded or if a Biology and Monitoring Review is necessary under the Conservation Strategy implementation protocol. As the bear population in the GYE has increased in size and geographic extent, an increasing proportion of these mortalities have occurred outside the Recovery Zone boundary (Fig. 6.2); many of these have occurred in areas of private land ownership where the team consensus is that permanent occupation by grizzly bears is biologically and socially inappropriate or unlikely. Many mortalities are occurring in peripheral areas where the potential to support future maintenance or growth of the GYE grizzly bear population is limited.
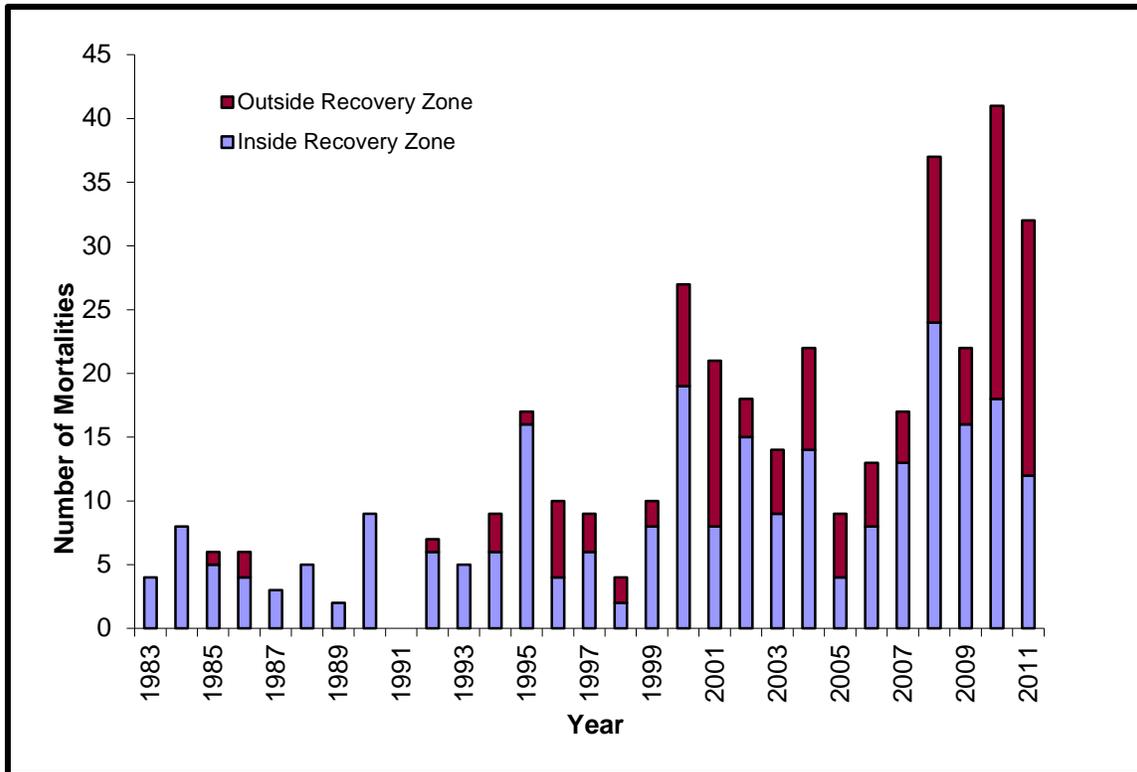
Figure 6.2. Number of mortalities of independent-aged grizzly bears inside and outside the Recovery Zone, Greater Yellowstone Ecosystem, 1983–2011.

In the grizzly bear recovery plan, the Recovery Zone (Fig. 6.3) is defined as the area "within which the population and habitat criteria for achievement of recovery will be measured" (U.S. Fish and Wildlife Service 1993:17). Whereas this may be true, maintenance of an increased bear population in numbers and distribution outside the Recovery Zone helps ensure long-term viability of this population. There is valuable habitat outside the Recovery Zone on public land, grizzly bears currently occur in many of these areas, and grizzly bears have a management future in these areas. Therefore, the

group agreed that mortalities occurring beyond the Recovery Zone boundary on these public lands should be subject to mortality management.

Figure 6.3. Greater Yellowstone Ecosystem, showing proposed boundary beyond which grizzly bear mortalities would not be counted against formalized mortality limits. This boundary is based on U.S. Fish and Wildlife Service Suitable Habitat designation (derived from ecoregions; U.S. Fish and Wildlife Service 2007b) and inclusion of narrow areas along valleys bounded mostly by suitable habitat that could act as potential mortality sinks (see text) for a total area of 49,928 km^2 . The purple line delimits the existing Recovery Zone (23,828 km^2) (termed the "Primary Conservation Area" in the conservation strategy), within which recovery criteria are required. Yellowstone National Park Boundary shown for reference only.
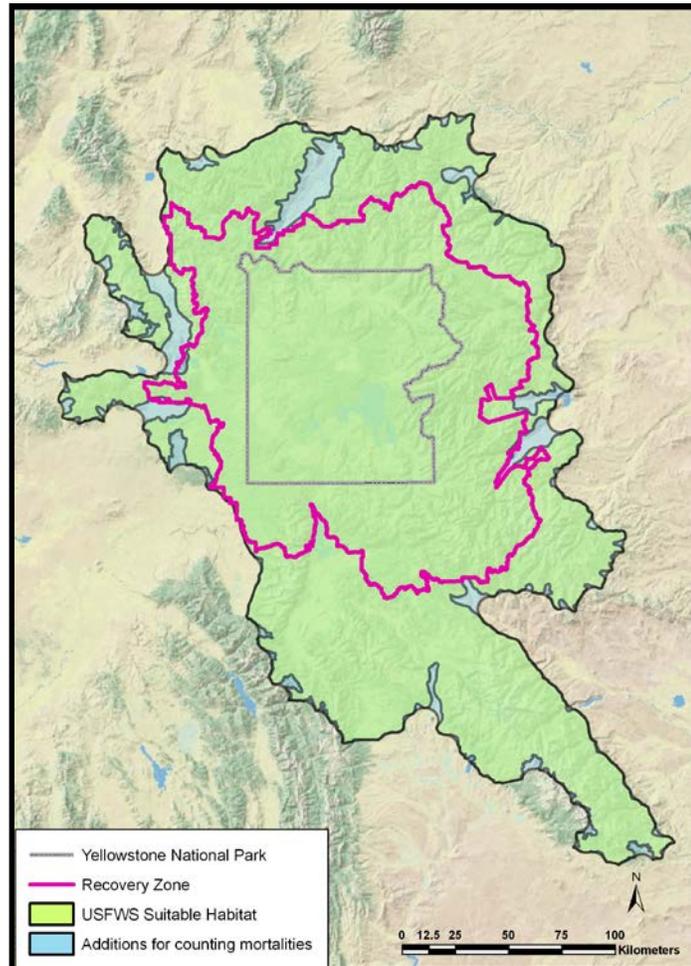
To achieve mortality management in the area appropriate to the long-term conservation of the Yellowstone population and to assure that the area of mortality management was the same as the area where the population estimates are made, the group considered using the boundary developed in 2007 by the U.S. Fish and Wildlife Service (U.S. Fish and Wildlife Service 2007*b*) for what was termed "suitable habitat" as a reasonable way to define areas where mortality are managed (Fig. 6.3). There was general agreement that this suitable habitat boundary (enclosing a total area of 46,035 km^2) is sufficiently large to support a viable population in the long term, such that mortalities beyond it could be excluded from consideration. Importantly, this area closely resembles the area in which unique F_{COY} are surveyed and for which population size is estimated. This area is thus most appropriate for applying mortality limits. The study team noted, however, that because the suitable habitat boundary was drawn using mountainous ecoregions, there were narrow, linear areas along valley floors that did not meet the definition of suitable habitat and where population sinks may be created. This phenomenon, in which the quantity and quality of suitable habitat is diminished because of interactions with surrounding, less suitable habitat, is known as an "edge effect" (Lande 1988, Yahner

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1988, Mills 1995). Edge effects are exacerbated in small habitat patches with high perimeter-to-area ratios (i.e., those that are long and narrow) and in wide-ranging species such as grizzly bears because they are more likely to encounter surrounding, unsuitable habitat (Woodroffe and Ginsberg 1998:2126). Mortalities in these areas would be outside suitable habitat but could have disproportionate effects on the population generally contained within the suitable habitat zone, potentially acting as mortality sinks. The study team recommends considering an alternative boundary that includes these narrow areas outside suitable habitat, but largely bounded by it (Fig. 6.3). During 2002–2011, 25 of 225 mortalities (11%) of independent-aged bears occurred outside the boundary of this composite area (Fig. 6.4). An additional issue with the U.S. Fish and Wildlife Service suitable habitat line was that the Recovery Zone occurs outside it in several small areas. This issue can be resolved by using suitable habitat plus the potential sink areas for a boundary that has the greater extent The so altered suitable habitat boundary plus potential sink areas would contain approximately 49,928 km^2 (see Fig. 6.4)

Figure 6.4. Known and probable mortalities of independent grizzly bears (2 years or older) during 2002–2011 (n = 225) and their occurrence relative to the U.S. Fish and Wildlife Service Suitable Habitat designation (U.S. Fish and Wildlife Service 2007b), Greater Yellowstone Ecosystem. Recommended alternative boundary includes narrow areas bordered mostly by suitable habitat that can potentially function as mortality sinks (blue polygons). Of 225 mortalities of independent-aged bears during this period, 25 occurred outside the modified suitable habitat line (9 females, 16 males). The Recovery Zone (termed the "Primary Conservation Area" in the conservation strategy) represents the area within which recovery criteria are required. Yellowstone National Park Boundary shown for reference only.

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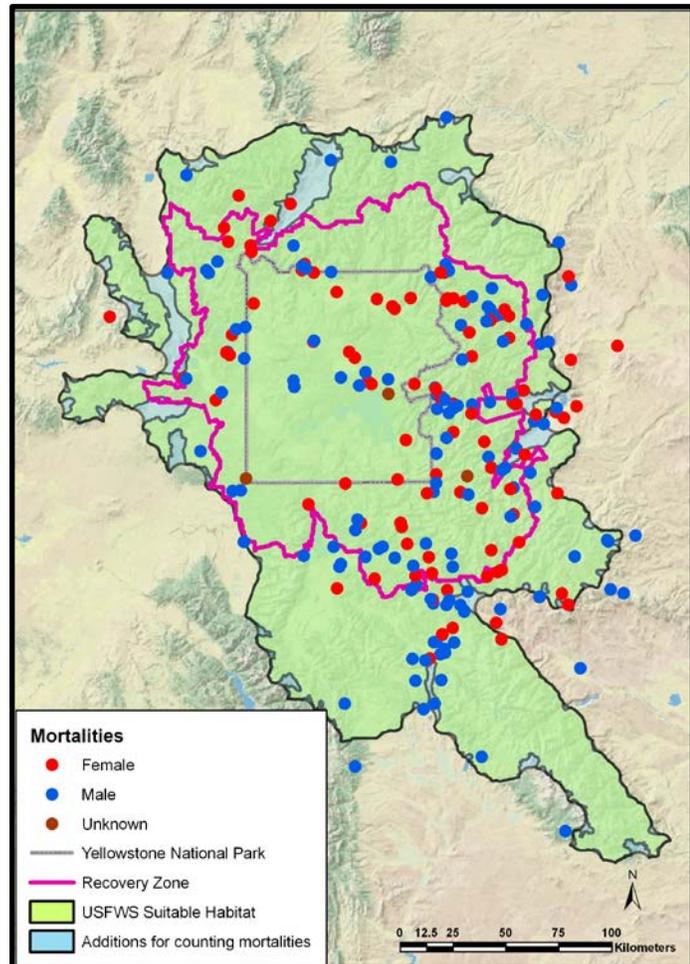
6.3. Alternatives considered but not recommended

6.3.1. Use rates leading to sustainability other than those suggested from demographic analyses

In response to several managers who expressed a desire for more flexibility in handling conflict bears, the group considered whether higher mortality limits (e.g., >9% for independent females) could be justified. Several members noted that, despite occasionally exceeding the mortality limits, the GYE population steadily increased from 1983 until the recent (2002–2011) stagnation of population growth. They also noted the 9% mortality limit incorporates a number of conservative decision points within the protocol (Table 1.1), and that even under the current situation of lower population growth, adult female survival remains high. Following presentation of the provisional demographic analyses from 2002–2011 (summarized in Section 4), this alternative was not pursued further.

6.3.2. Discount mortalities for individuals in some way that reflects their value to future population growth

Similarly (see section 6.3.1.), the group initially considered the suggestion that, because some sex-age classes of grizzly bears are known to exert much less influence on population trajectory than others, mortality quotas might reasonably be varied to reflect these. Analyses could potentially be pursued using either elasticities (from Leslie matrices) or reproductive values (from life-table analyses). The group elected not to pursue this possibility because of the complexity of implementing variable mortality limits based on age and sex.

Report Preparation

We prepared this report to document our review, discussions, and recommendations. We further recommend that results contained here be presented to state and federal managers for discussion, modification, and acceptance and to the general public for comment. Once this task is complete, we also recommend that these methods be presented to the Yellowstone Ecosystem Subcommittee of the Interagency Grizzly Bear Committee for endorsement.

Literature Cited

BJORNLIE, D., and M. A. HAROLDSON. 2011. Grizzly bear use of insect aggregation sites documented from aerial telemetry and observation. Pages 33–35 *in* C. C. Schwartz, M. A. Haroldson, and K. West, editors. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 2010. U.S. Geological Survey, Bozeman, Montana, USA.

BOWDEN, D. C., AND R. C. KUFELD. 1995. Generalized mark-sight population-size estimation applied to Colorado moose. Journal of Wildlife Management 59:840–851.

BURNHAM, K. P., AND D. R. ANDERSON. 2002. Model selection and multimodal inference: a practical information-theoretic approach. Second edition. Springer-Verlag, New York, New York, USA.

CHAO, A. 1989. Estimating population size for sparse data in capture–recapture experiments. Biometrics 45:427–438.

CHERRY, S., M. A. HAROLDSON, J. ROBISON-COX, AND C. C. SCHWARTZ. 2002. Estimating total human-caused mortality from reported mortality using data from radio-instrumented grizzly bears. Ursus 13:175–184.

CHERRY, S., G. C. WHITE, K. A. KEATING, M. A. HAROLDSON, AND C. C. SCHWARTZ. 2007. Evaluating estimators of the number of females with cubs-of-the-year in the Yellowstone grizzly bear population. Journal of Agricultural, Biological, and Environmental Statistics 12:195–215.

CLARK, J. D., R. EASTRIDGE, AND M. J. HOOKER. 2010. Effects exploitation on black bear populations at White River National Wildlife Refuge. Journal of Wildlife Management 74:1448–1456.

EBERHARDT, L.L., B. M. BLANCHARD, AND R. R. KNIGHT. 1994. Population trend of the Yellowstone grizzly bear as estimated from reproductive and survival rates. Canadian Journal of Zoology 72:360–363.

EBERHARDT, L.L., AND R. R. KNIGHT. 1996. How many grizzlies in Yellowstone? Journal of Wildlife Management 60:416–421.

GARSHELIS, D. L., and K. V. NOYCE. 2006. Discerning biases in a large scale mark-recapture population estimate for black bears. Journal of Wildlife Management 70(6):1634–1643.

GARSHELIS, D. L., and L. G. VISSER. 1997. Enumerating megapopulations of wild bears with an ingested biomarker. Journal of Wildlife Management 61(2):466–480.

GOVE, N. E., J. R. SKALSKI, P. ZAGER, AND R. L. TOWNSEND. 2002. Statistical models for population reconstruction using age-at-harvest data. Journal of Wildlife Management 66:310–320.

HAROLDSON, M. A. 2012. Assessing trend and estimating population size from counts of unduplicated females. Pages 10–15 *in* C. C. Schwartz, M. A. Haroldson, and K. West, editors. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team 2011. U.S. Geological Survey, Bozeman, Montana, USA.

HAROLDSON, M. A., C. C. SCHWARTZ, AND G. C. WHITE. 2006. Survival of independent grizzly bear in the Greater Yellowstone Ecosystem, 1983–2001. *In* C. C. Schwartz, M. A. Haroldson, G. C. White, R. B. Harris, S. Cherry, K. A. Keating, D. Moody, and C. Servheen, authors. Temporal, spatial, and environmental influences on the demographics of grizzly bears in the Greater Yellowstone Ecosystem. Wildlife Monographs 161.

HARRIS, R. B. 1984. Harvest age structure as an indicator of grizzly bear population status. Thesis, University of Montana, Missoula, Montana, USA.

HARRIS, R. B. 1986. Modeling sustainable harvest rates for grizzly bears. Appendix K *in* A. Dood, R. Brannon, and R. Mace, editors. The grizzly bear in northwestern Montana. Final programmatic environmental impact statement. Montana Department of Fish, Wildlife and Parks, Helena, Montana, USA. Unit Publication, Missoula, Montana, USA.

HARRIS, R. B., C. C. SCHWARTZ, M. A. HAROLDSON, AND G. C. WHITE. 2006. Trajectory of the Yellowstone grizzly bear population under alternative survival rates. *In* C. C. Schwartz, M. A. Haroldson, G. C. White, R. B. Harris, S. Cherry, K. A. Keating, D. Moody, and C. Servheen, authors. Temporal, spatial, and environmental influences on the demographics of grizzly bears in the Greater Yellowstone Ecosystem. Wildlife Monographs 161.

HARRIS, R. B., G. C. WHITE, C. C. SCHWARTZ, AND M. A. HAROLDSON. 2007. Population growth of Yellowstone grizzly bears: uncertainty and future monitoring. *Ursus* 18: 167–177.

HIGGS, M. G. C. WHITE, M. A. HAROLDSON, AND D. J. BJORNLIE. Mark-resight analysis for female grizzly bears with cubs-of-the-year: sparse data and a latent multinomial model. Journal of Agricultural and Biological Statistics (in review).

INTERAGENCY CONSERVATION STRATEGY TEAM. 2007. Conservation Strategy for Grizzly Bears in the Greater Yellowstone. Working document, downloaded from http://www.fws.gov/mountain-prairie/species/mammals/grizzly/yellowstone.htm

INTERAGENCY GRIZZLY BEAR STUDY TEAM. 2005. Reassessing methods to estimate population size and sustainable mortality limits for the Yellowstone grizzly bear. Interagency Grizzly Bear Study Team, U.S. Geological Survey, Northern Rocky Mountain Science Center, Montana State University, Bozeman, Montana, USA. Downloaded from http://www.fws.gov/mountain-prairie/species/mammals/grizzly/yellowstone.htm

INTERAGENCY GRIZZLY BEAR STUDY TEAM. 2006. Reassessing methods to estimate population size and sustainable mortality limits for the Yellowstone grizzly bear: workshop document supplement. U.S. Geological Survey, Northern Rocky Mountain Science Center, Montana State University. Downloaded from http://www.fws.gov/mountain-prairie/species/mammals/grizzly/yellowstone.htm

INTERAGENCY GRIZZLY BEAR STUDY TEAM. 2008. Reassessing methods to distinguish unique females with cubs-of-the-year in the Greater Yellowstone Ecosystem. Interagency Grizzly Bear Study Team, U.S. Geological Survey, Northern Rocky Mountain Science Center, Montana State University, Bozeman, Montana, USA.

KEATING, K. A., C. C. SCHWARTZ, M. A. HAROLDSON, AND D. MOODY. 2002. Estimating numbers of females with cubs-of-the-year in the Yellowstone grizzly bear population. Ursus 13:161–174.

KENDALL, K. C., J. B. STETZ, J. BOULANGER, A. C. MACLEOD, D. PAETKAU, AND GARY C. WHITE. 2009. Demography and genetic structure of a recovering grizzly bear population. Journal of Wildlife Management 73:3–17.

KNIGHT, R. R., B. M. BLANCHARD, AND L. L. EBERHARDT. 1995. Appraising status of the Yellowstone grizzly bear population by counting females with cubs-of-the-year. Wildlife Society Bulletin 23:245–248.

LANDE, R. 1988. Genetics and demography in biological conservation. Science 241:1455–1460.

MACE, R. D., D. W, CARNEY, T. CHILTON-RADANDT, S. A. COURVILLE, M. A. HAROLDSON, R. B. HARRIS, J. JONKEL, M. MADEL, T. L MANLEY, C. C. SCHWARTZ, C. SERVHEEN, J. S. WALLER, AND E. WENUM. 2012. Grizzly bear population vital rates and trend in the Northern Continental Divide Ecosystem, Montana. Journal of Wildlife Management 76:119–128.

MATTSON, D. M., C.M. GILLIN, S.A. BENSON, AND R.R. KNIGHT. 1991. Bear use of alpine insect aggregations in the Yellowstone ecosystem. Canadian Journal of Zoology 69:2430–2435.

MCCLINTOCK, B. T., WHITE, G. C., ANTOLIN, M. F., AND D. W. TRIPP. 2009. Estimating abundance using mark-resight when sampling is with replacement or the number of marked individuals is unknown. Biometrics 65:237–246.

MILLER, S. D., G. C. WHITE, R. A. SELLERS, H. V. REYNOLDS, J. W. SCHOEN, K.TITUS,V. G. BARNES, R. B. SMITH, R. R. NELSON, W. B. BALLARD, AND C. C. SCHWARTZ. 1997. Brown and black bear density estimation in Alaska using radiotelemetry and replicate mark-resight techniques. Wildlife Monograph 133.

MILLS, L. S. 1995. Edge effects and isolation: red-backed voles on forest remnants. Conservation Biology 9:395–403.

PAULIK, G. J. 1963. Estimates of mortality rates from tag recoveries. Biometries 19:28–57.

RICE, W. R., AND J. D. HARDER. 1977. Application of multiple aerial sampling to a mark-recapture census of white-tailed deer. Journal of Wildlife Management 41:197–206.

SCHWARTZ, C. C. 1998. Evaluation of a capture-mark-recapture estimator to determine grizzly bear numbers and density in the Greater Yellowstone Area. Pages 13–20 *in* C. C. Schwartz, and M. A. Haroldson, editors. Yellowstone Grizzly Bear Investigations: annual report of the Interagency Grizzly Bear Study Team, 1998. U.S. Geological Survey, Bozeman, Montana, USA.

SCHWARTZ, C. C. 1999. Evaluation of a capture-mark-recapture estimator to determine grizzly bear numbers and density in the Greater Yellowstone Area. Pages 15–18 *in* C. C. Schwartz, and M. A. Haroldson, editors. Yellowstone Grizzly Bear Investigations: annual report of the Interagency Grizzly Bear Study Team, 1999. U.S. Geological Survey, Bozeman, Montana, USA.

SCHWARTZ, C. C., R. B. HARRIS, AND M. A. HAROLDSON. 2006*a*. Impacts of spatial and environmental heterogeneity on grizzly bear demographics in the Greater Yellowstone Ecosystem: a source–sink dynamic with management consequences. *In* C. C. Schwartz, M. A. Haroldson, G. C. White, R. B. Harris, S. Cherry, K. A. Keating, D. Moody, and C. Servheen, authors. Temporal, spatial, and environmental influences on the demographics of grizzly bears in the Greater Yellowstone Ecosystem. Wildlife Monographs 161.

SCHWARTZ, C. C., M. A. HAROLDSON, AND S. CHERRY. 2006*b*. Reproductive performance for grizzly bears in the Greater Yellowstone Ecosystem, 1983–2002. *In* C. C. Schwartz, M. A. Haroldson, G. C. White, R. B. Harris, S. Cherry, K. A. Keating, D. Moody, and C. Servheen, authors. Temporal, spatial, and environmental influences on the demographics of grizzly bears in the Greater Yellowstone Ecosystem. Wildlife Monographs 161.

SCHWARTZ, C. C., M. A. HAROLDSON, M. A., CHERRY, S., AND KEATING, K. A. 2008. Evaluation of rules to distinguish unique female grizzly bears with cubs in Yellowstone. Journal of Wildlife Management, 72:543–554.

SCHWARTZ, C. C., M. A. HAROLDSON, K. A. GUNTHER, AND D. MOODY. 2002. Distribution of grizzly bears in the Greater Yellowstone Ecosystem, 1990–2000. Ursus 13:203–212.

SCHWARTZ, C. C., M. A. HAROLDSON, K. A. GUNTHER, AND D. MOODY. 2006*c*. Distribution of grizzly bears in the Greater Yellowstone Ecosystem, 1990–2004. Ursus 17:63–66.

SCHWARTZ, C. C., M. A. HAROLDSON, AND G. C. WHITE. 2006*d*. Survival of cub and yearling grizzly bears in the Greater Yellowstone Ecosystem, 1983–2001. *In* C. C. Schwartz, M. A. Haroldson, G. C. White, R. B. Harris, S. Cherry, K. A. Keating, D. Moody, and C. Servheen, authors. Temporal, spatial, and environmental influences on the demographics of grizzly bears in the Greater Yellowstone Ecosystem. Wildlife Monographs 161.

SCHWARTZ, C. C., M. A. HAROLDSON, G. C. WHITE, R. B. HARRIS, S. CHERRY, K. A. KEATING, D. MOODY, AND C. SERVHEEN. 2006*e*. Temporal, spatial, and environmental influences on the demographics of grizzly bears in the Greater Yellowstone Ecosystem. Wildlife Monographs 161.

SCHWARTZ, C. C., AND G. C. WHITE. 2008. Estimating reproductive rates for female bears: proportions versus transition probabilities. Ursus 19:1–12.

U.S. FISH AND WILDLIFE SERVICE. 1993. Grizzly bear recovery plan. U.S. Fish and Wildlife Service, Missoula, Montana, USA. Available from: http://www.fws.gov/mountain-prairie/species/mammals/grizzly/Grizzly_bear_recovery_plan.pdf

U.S. FISH AND WILDLIFE SERVICE. 2007*a*. Grizzly Bear Recovery Plan supplement: revised demographic criteria for the Yellowstone Ecosystem. Federal Register 72:11377. Available from: http://www.fws.gov/mountain-prairie/species/mammals/grizzly/Grizzly_Bear_Recovery_Plan_Supplement_Demographic.pdf

U.S. FISH AND WILDLIFE SERVICE. 2007*b*. Grizzly bears; Yellowstone distinct population; Notice of petition finding; Final rule. Federal Register 72:14865. Available from: http://www.fws.gov/mountain-prairie/species/mammals/grizzly/FR_Final_YGB_rule_03292007.pdf

WHITE, G. C. 1996. NOREMARK: population estimation from mark–resighting surveys. Wildlife Society Bulletin 24:50–52.

WHITE, G. C., AND K. P. BURNHAM. 1999. Program MARK: survival estimation from populations of marked animals. Bird Study 46:120–139.

WOODROFFE, R., AND J. R. GINSBERG. 1998. Edge effects and the extinction of populations inside protected areas. Science 280:2126–2128.

WOODS, J. G., D. PAETKAU, D. LEWIS, B. L. MCLELLAN, M. PROCTOR, AND C. STROBECK. 1999. Genetic tagging free-ranging black and brown bears. Wildlife Society Bulletin 27:616–627.

WRIGHT, J. A., R. J. BARKER, M. R. SCHOFIELD, A. C. FRANTZ, A. E. BYROM, and D. M. GLEESON. 2009. Incorporating genotype uncertainty into mark-recapture-type models for estimating abundance using DNA samples. Biometrics 65:833–840.

YAHNER, R. H. 1988. Changes in wildlife communities near edges. Conservation Biology 2: 333–339.

Appendix A

Summary of 'rule set' for identifying unique individual females with cubs-of-the-year (Knight et al. 1995)

Knight et al. (1995) developed a rule set used to distinguish sightings of unique females from repeated observations of the same female. Females were judged to be unique based on 3 criteria: (1) distance between sightings, (2) family group descriptions, and (3) dates of sightings. Minimum distance for 2 groups to be considered distinct was based on annual ranges, travel barriers, and typical movement patterns. A movement index was calculated using standard diameter of annual ranges (Harrison 1958) of all radiomarked F_{COY} were monitored 1 May–31 August (Blanchard and Knight 1991). The mean standard diameter for all annual ranges of F_{COY} was 15 km (SD = 6.7 km). They estimated the average maximum travel distance as twice the standard diameter, or 30 km, and used this distance to distinguish sightings of unique F_{COY} from repeat sightings of the same female.

Family groups within 30 km of each other were distinguished by other factors. The Grand Canyon of the Yellowstone, from the lower falls to the confluence of Deep Creek, was considered a natural barrier. Females on either side of this canyon were considered unique. Knight et al. (1995) also discussed paved highways as impediments to travel and cite data presented by Mattson et al. (1987), which showed that grizzlies tended to stay >500 m from roads during spring and >2 km during summer. They provided one example where 2 families considered unique were separated by 2 major highways and were <30 km apart (see Knight et al. 1995:Table 1). Family groups were also distinguished by size and number of cubs in the litter. Once a female with a specific number of cubs was sighted in an area, no other female with the same number of cubs in that same area was regarded as distinct unless (1) the 2 family groups were seen by the same observer on the same day, (2) the 2 family groups were seen by 2 observers at different locations but similar times on the same day, or (3) 1 or both of the females were radiomarked. Because of the possibility of cub mortality, no female with fewer cubs was considered distinct in an area unless (1) she was seen on the same day as the first female, (2) both were radiomarked, or (3) a subsequent observation of a female with a larger litter was made. Knight et al. (1995) assumed that all cubs in a litter were observed and correctly counted. This assumption was strengthened by only considering observations from qualified agency personnel. Observations from the air were only included if bears were in the open and easily observed. Ground observers watched family groups long enough to insure all cubs were seen; observers reported any doubt. Finally, Knight et al. (1995) reference a time-distance criteria but did not provide specific rules for its application. The only example they provided was the separation of 2 sightings of 2 family groups observed 1 day apart and 25 km apart.

This protocol was later criticized by Craighead et al. (1995) as unproven, and later by Mattson (1997), who pointed out ways in which the number of F_{COY} might be influenced by search effort or other annual factors unrelated to true abundance. Methods to identify

unique F_{COY} that are similar in spirit to Knight et al. (1995), if necessarily slightly different in the particular rule set, have also been applied in the Banff ecosystem of Alberta, Canada (Brodie and Gibeau 2007), and the Cantabrian Mountains of Spain (Palomero et al. 1997). Brodie and Gibeau (2007) pointed out, however, that estimates of population trend based on this approach were quite imprecise. The application of the approach to the Cantabrian Mountain grizzly bear population in Spain was also criticized for reasons similar to those articulated by Mattson (1997) by Fernández-Gil et al (2010; see also Palomero et al. 2010; Ordiz et al. 2007).

Schwartz et al. (2008) provided a detailed analysis of the behavior of the Knight et al. (1995) rule set in the Greater Yellowstone Ecosystem. These findings are discussed in the main body of this report.

Literature Cited (Appendix A)

BLANCHARD, B., AND R. KNIGHT. 1991. Movements of Yellowstone grizzly bears. Biological Conservation 58:41–67.

BRODIE, J. F., AND M. L. GIBEAU. 2007. Brown bear population trends from demographic and monitoring-based estimators. Ursus 18:137–144.

CRAIGHEAD, J. J., J. S. SUMNER, AND J. A. MITCHELL. 1995. The grizzly bears of Yellowstone: their ecology in the Yellowstone ecosystem, 1959–1992. Island Press, Washington, D.C., USA.

FERNÁNDEZ-GIL, A., A. ORDIZ, AND J. NAVES. 2010. Are Cantabrian brown bears recovering? Ursus 21:121–124

HARRISON, J. L. 1958. Range of movement of some Malayan rats. Journal of Mammalogy 38:190–206.

KNIGHT, R. R., B. M. BLANCHARD, AND L. L. EBERHARDT. 1995. Appraising status of the Yellowstone grizzly bear population by counting females with cubs-of-the-year. Wildlife Society Bulletin 23:245–248.

MATTSON, D. M. 1997. Sustainable grizzly bear mortality calculations from counts of females with cubs-of-the-year: an evaluation. Biological Conservation 81:103–111.

MATTSON, D. M., R. R. KNIGHT, AND B. M. BLANCHARD. 1987. The effects of developments and primary roads on grizzly bear habitat use in Yellowstone National Park, Wyoming. International Conference on Bear Research and Management 7:259–273.

ORDIZ, A., J. NAVES, A. FERNANDEZ, D. HUBER, P. KACZENSKY, Y. MERTZANIS, A. MUSTONI, S. PALAZON, P. QUENETTE, G. RAUER, AND C. RODRIGUEZ. 2007. Distance-based criteria to identify minimum number of brown bear females with cubs in Europe. Ursus 18:157–166.

PALOMERO, G., F. BALLESTEROS, C. NORES, J. C. BLANCO, J. HERRERO, AND A. GARCÍA-SERRANO. 2007. Trends in number and distribution of brown bear females with cubs-of-the-year in the Cantabrian Mountains, Spain. Ursus 18:145–157.

PALOMERO, G., F. BALLESTEROS, C. NORES, J. C. BLANCO, J. HERRERO, AND A. GARCÍA-SERRANO. 2010. Are brown bears recovering in the Cantabrian Mountains? Reply to Fernández-Gil et al. Ursus 21:125–127

SCHWARTZ, C. C., HAROLDSON, M. A., CHERRY, S., AND KEATING, K. A. 2008. Evaluation of rules to distinguish unique female grizzly bears with cubs in Yellowstone. Journal of Wildlife Management, 72:543–554.

Appendix B

The ADR approach presented by Dr. Megan Higgs, Montana State University[a]

1. Logistic regression for classification of sightings of individual bears to identify correlates of multiple sightings being of a single individual.

Ancillary data resampling (ADR) approaches the problem of distinguishing unique F_{COY} by relying strictly on empirical data from GYE grizzly bears (in contrast to Knight et al. 1995 which used rules of thumb coarsely derived from those data). Similarly to Schwartz et al. (2008), the ADR approach uses radio-telemetry data from previously marked F_{COY} (both conventional VHF radio-collars and GPS collars) as the basis for all inference. A map of the GYE is "populated" with a "superpopulation" of bear locations. Each location is from a real bear and retains its spatial and temporal orientation with regard to other locations from the same bear, as well as information on litter size. Simulations then proceed from randomly selecting from the desired number of bears from this superpopulation.

The first stage of the ADR approach begins by using logistic regression to quantify the probability that any given two observations of unknown F_{COY} were of the same bear. Logistic regression is a well-known statistical approach to using a series of explanatory variables to describe or predict a phenomenon that exists on a binary scale. In this case, the phenomenon of interest is whether two sightings of F_{COY} are of the same animal or not. Working with Interagency Grizzly Bear Study Team biologists, Dr. Higgs identified the following variables as useful in predicting the probability of two sighting being of the same bear:
    1) distance between locations,
    2) whether the number of cubs was the same,
    3) if different, whether number of cubs and increased or decreased,
    4) whether both observations occurred during March–April,
    5) whether both observations occurred during May,
    4) whether both observations occurred during June,
    5) whether both observations occurred during July,
    6) whether both observations occurred during August,
    7) an interaction term between distance (variable 'a') and whether both observations were made during March–April (variable 'd'),
    8) a similar interaction term between variable 'a' and variable 'e',
    9) a similar interaction term between variable 'a' and variable 'f',
    10) interaction between 'a' and 'g',
    11) interaction between 'a' and 'h',
    12) an interaction term involving the distance between locations ('a') and whether the time interval between the 2 observations was <3 days;

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13) an interaction term involving whether the number of cubs seen was the same ('b'), and whether the time interval between the 2 observations was < 3 days.

These predictor variables were all selected based on a prior knowledge of the data set consisting of many years of F_{COY} observations; all make intuitive sense and are similar conceptually to the variables used in the Knight et al. (1995) rule set. For example, it should be obvious that two observations from very distant locations are less likely to be of the same F_{COY} than of two different F_{COY}. Similarly, observations of F_{COY} with same number of cubs are more likely to be of a single bear than observations in which number of cubs differed (note, however, that cubs sometimes die, so an observation of a F_{COY} with *n* cubs could represent the same animal as a subsequent observation of a F_{COY} with *n*-1 or even *n*-2 cubs). Because F_{COY} move at different rates as the non-denning season progresses, the timing (i.e., month) of observations was also found to be a useful predictor. Exploratory data analyses also revealed that, whereas the time interval between observations was important, an important distinction could be made based on whether the intervals between observations was <3 days.

Various logistic regression models were developed based on a data set consisting of all pairwise comparisons of observations of known (e.g., radiomarked) F_{COY} during 1976–2003. The final model was that which minimized AIC. Coefficients for this predictive model are presented in Table 2. For example, the negative sign for distance (variable 'a') indicates that as distance between observation increased, probability of the F_{COY} being the same animal decreased; the positive sign for litter size being the same indicates that, when true, it was more likely that the observations were of a single animal than when false. The strongly negative coefficient for litter size increasing with time reflects the implausibility of litter size increasing with time. Some coefficients have signs (positive vs. negative) that are counter-intuitive because of the interactive effect of all when combined together (i.e., signs predicting the probability that 2 observations were of a single F_{COY} might have differed had they been entered into a single-variable model).

Using a logistic regression model to predict the probability that any 2 observations of unknown F_{COY} has the beneficial property of having been developed by objective, statistical methods, and being based on a large sample of known bears. It is useful in clarifying and quantifying relationships suspected to exist between correlates of observations and truth.

Table 2. Selected (best-fitting) logistic regression model of the probability that any 2 grizzly bear observations were from a single female with cubs-of-the-year (F_{COY}), based on radio-marked F_{COY} monitored in the Greater Yellowstone Ecosystem, 1976–2003. Standard errors of slopes are not shown because they were developed from non-independent data, and because they were not used in the resulting clustering algorithm.

Variable label and description	Parameter estimate
a Distance between locations	−0.143
b Whether number of cubs same	3.356
c Whether number of cubs and increased	−4.514
d Whether both observations occurred during March–April	0.744
e Whether both observations occurred during May	0.921
f Whether both observations occurred during June	0.786
g Whether both observations occurred during July	0.001
h Whether both observations occurred during August	−0.196
i Interaction: a X d	−0.191
j Interaction: a X e	−0.147
k Interaction: a X f	−0.080
l Interaction: a X g	−0.032
m Interaction: a X h	−0.009
n Interaction: a X time interval between observations <3 days	−0.163
o Interaction: b X time interval between observations <3 days	2.218

2. Choosing optimal cut-off values for the probability of being same bear for that number of observations

Unfortunately, even the best-fitting logistic regression model only gets us part-way to the desired end-point. This is because it provides only a *probability* of two observations being of the same individual F_{COY}, whereas what we require is a *classification* algorithm; i.e., one that "decides", for each observation of a F_{COY}, whether it should be considered to represent a unique individual or not.

Thus, the next step in the ADR procedure is an algorithm that aggregates observations of F_{COY} into clusters representing sightings of the same animal, using the predicted probabilities generated from the logistic regression model (each pair of observations of F_{COY} is associated with the series of variables required by the logistic regression model and summarized in Table 2). The clustering itself is briefly described in the next section, and depends on selection of a cut-off value along the probability scale (0,1) to move from quantifying to categorizing. To retain constant bias (or lack thereof) across the range of number of Fcoy sighted, the cut-off value must change as the number of unique animals sighted changes. For example, the figure similar to Fig. 3.1 would require a different cut-off value for each value on the x-axis. Thus, through the cut-off specification determined through simulation, the method attempts to solve the bias problem of the rule set shown in Fig. 3.1.

The algorithm calls for finding cut-off values to minimize bias in identifying unique F_{COY} over the range of plausible values of the number of F_{COY} observations each year

(which will be known) and the true number of F_{COY} present (which will be unknown). That is, cut-off values are selected so that the median of the distribution of the number of unique F_{COY} observed based on the sequential clustering algorithm is equal to the number known (from the telemetry data) to have been observed.

3. Clustering algorithm

Dr. Higgs concluded that a sequential clustering algorithm was both the simpler computationally and closer to the way data are actually accumulated than algorithms that attempt to find the most likely clusters from all possible groupings of that year's F_{COY} observations. Thus, the algorithm begins with the first observation of F_{COY} in that year, and considers this known. The 2nd observation is taken in chronological order, the coefficients from Table 2 applied to the pair of observations to calculate a probability of the 2nd observation being the same F_{COY} as the 1st observation; it is classified as either the same or a unique F_{COY}, based on a comparison of the cut-off value with this probability. This process continues chronologically, observation by observation. Where a cluster of >1 observations has been identified by the algorithm, probabilities of the new observation are calculated for each observation within the cluster, and the mean of those probabilities is taken as the value for that cluster. The cut-off value is then used to classify the new observation as either a unique bear, or, if not unique, as belonging to the cluster with the highest probability.

4. Quantifying uncertainty in the estimate of minimum number sighted using re-sampling from historic data.

To quantify uncertainty in the estimate (obtain a posterior distribution) of the minimum number sighted, Dr. Higgs used a Monte Carlo re-sampling approach modeled after the work in Schwartz et al. (2008) that initially demonstrated and quantified the low bias in the previously used methods. For many re-samples under a known true number of sighted animals, the sequential clustering algorithm is applied to obtain a distribution of estimates that can then be compared with the true value. Dr. Higgs presented the group with evidence that, based on simulations analogous to those conducted in Schwartz et al. (2008) showing the low bias of the previous method, this procedure is capable of predicting an unbiased distribution of F_{COY} present from sets of unidentified F_{COY} observations, over the true range of F_{COY} 10 to 100. Using the superpopulation of bears previously developed by Schwartz et al. (2008) from radio-marked bears as a reasonable approximation to the GYE situation and cut-off values optimized to reduce bias, the ADR procedure produced clusters that, on balance, replicated the number of F_{COY} known to be present.

5. Repeat for different maps (because true density or distribution are not known)

Had this had been all that was required, the group consensus might well have been that this approach provided a convincing and defendable alternative to estimating minimum number of F_{COY} sighted in a year as an alternative to the Knight et al. (1995) rule set. Unfortunately, all inference (i.e., moving from unknown F_{COY} observations to unbiased

number of F_{COY} clusters representing the number of unique F_{COY} observed) depended on the particular "superpopulation" of bears that served as the basis for simulations. Although bear locations came from real bears and each retained known spatial and temporal associations with other locations from the same real bear, the group identified additional areas in which a single, GYE superpopulation, such as used by Schwartz et al. (2008) might fail to reflect reality:

1) F_{COY} captured and marked for radiotracking (or GPS tracking) likely did not reflect an unbiased geographic distribution of all F_{COY} available for observation. This was relevant because the spatial orientation of observations is a critical part of the clustering procedure;

2) The process of relocating a bear using radio-telemetry or GPS collars (i.e., data underlying the likelihood function used in the clustering) may not accurately reflect the process of observing a bear visually. Visibility varies within the GYE, as functions both of vegetation and access to human eyes (relatively few telemetry relocations were associated with a visual observation of the F_{COY}). Even if only the subset of radio-locations were used on which a visual observation was made, this process may also differ from how observations unaided by telemetry are made.

Without knowing the true distribution of F_{COY} in the ecosystem, or how visible any might be given where it lived, the decision was made to develop 3 alternative models of distribution. Each would form the basis for alternative "superpopulations" of bears, which, in turn, would be the basis for the re-sampling that provided the foundation for quantifying uncertainty (obtaining posterior distributions) for minimum number of individuals sighted *and* Fcoy population size using the ADR method (discussed in Section 5):

1) *Uniform scenario.*—A rather uniform spatial distribution scenario, in which the GYE was populated by F_{COY} locations without regard to geography or to the spatial juxtaposition of observations made during 1997–2010 (this latter was developed by Mark Haroldson by applying fixed kernel density methods to non-telemetry observations of F_{COY} from both ground and aerial observers; this was initially labeled "medium" during the workshop). The implicit assumption here was that F_{COY} are distributed and can be observed relatively uniformly within the GYE, and that the irregularities in spatial configuration seen among radio-marked bears resulted from inability to capture bears equally throughout the system, or to monitor them once marked;

2) *Proportional sighting scenario.*—A rather peaked spatial distribution scenario, in which the GYE was populated by F_{COY} locations in a way that followed the spatial distribution suggested by historic sightings of Fcoy without the aid of telemetry (this was initially labeled "high" during the workshop). In other words, this represents the situation where Fcoy have greater density in areas where they are most often sighted. This is thought to be plausible because of associations between habitat type and sightability;

3) *Inverse sighting scenario.*—An inversely concentrated spatial distribution scenario, in which F_{COY} locations were deliberately concentrated in areas where relatively few had actually been observed (this was initially labeled "low" during the workshop).

Note that each scenario was built relative to a spatial distribution of historic F_{COY} observations, but this distribution was itself an unknown mixture of true F_{COY} distribution and detection probability given true presence (which itself was likely a function of vegetation cover and human density in the area).

6. Estimate the number of F_{COY} actually present from those estimated to have been observed using ancillary data resampling (ADR).

As described in the section on the Knight et al. (1995) rule set, we need to be able to estimate the Fcoy population size in any year, not merely the number seen (to avoid yearly heterogeneity caused by variable sighting effort and conditions, i.e., Mattson 1997, others). The current algorithm does this by way of a frequency-of-capture approach (Chao2; see Keating et al. 2002, Cherry et al. 2007). The ADR approach avoids the 2-step nature of this process by directly estimating the number of F_{COY} actually present (i.e., accounting for those never seen in any given year) in a hierarchical Bayesian framework that simultaneously assesses the posterior distribution of F_{COY} observed and those truly present. In any case, these relationships will depend on the assumed spatial juxtaposition of F_{COY}, and thus will vary depending on which of the underlying scenarios is used to develop it. Because 3 different scenarios (i.e., superpopulations) were developed, 3 slightly different versions of the model are considered.

7. Preliminary tests of the ADR approach

It was deemed appropriate to test how the method would perform using data generated under a model different from the one being fit (i.e. supposing the assumed superpopulation describing the spatial distribution is incorrect). During the July 2011 meetings, Dr. Higgs presented the preliminary results of the method when applied to the 3 alternative "superpopulations" of bears from which samples were taken. Each superpopulation reflected an alternative hypothesis about the true spatial distribution of F_{COY} (not just those observed) within the GYE relative to distribution evident from only radio-marked bears.[a] Simulation provides an easy and intuitive way to evaluate the performance of the models under known data-generating models. With 3 models specifying the possible relationships among the known and unknown factors, and 3 sampling scenarios, we had 9 sets of simulation results to examine for any given postulated true number of F_{COY} in the population.

Results of these simulations yielded the following conclusions:

      1) Bias in the predicted number of F_{COY} observed was negligible when sampling from the same scenario as the model used to develop it, except when the distribution was based on the high scenario, in which case it was always biased low, by about 8–10%.

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[a] In all 3 scenarios, locations of F_{COY} marked using conventional VHF telemetry collars were retained in their original spatial positions. Because F_{COY} marked using GPS collars had many more locations from which to sample, these locations were the ones that were used to "fill-out" the superpopulations, and were placed on the landscape according to an algorithm that objectively reflected the assumptions of each scenario.

2) Widths of approximate 95% credibility intervals of the means of posterior distributions of observed F_{COY} were 11 to 13% of the mean when population size was small, and 7 to 11% of the mean when population size was large;

3) Bias in the predicted number of F_{COY} actually present was rather large and depended greatly on the data underlying the model generation and the scenario used for data sampling under the ADR. For example, when applying a model developed under the proportional sighting scenario to data sampled using the inverse sighting scenario (Table 6, first line), bias was about -23%; when applying a model developed under the inverse sighting scenario to data sampled using the uniform scenario, bias was +31%. We note that the inverse sighting scenario was chosen to assess the influence of an extreme superpopulation. Therefore, these estimates of bias are likely exaggerated.

4) Widths of approximate 95% credibility intervals of the means of posterior distributions of estimated F_{COY} actually present were large, often exceeding 100% of the true number. For example, when the true number of F_{COY} was 55, and the model using the uniform scenario was applied to samples selected from the inverse sighting scenario, the 95% credibility interval of the number of F_{COY} predicted, although almost unbiased, ranged from 38 to almost 78.

We have no way of knowing which of the scenarios used to develop the superpopulations was close to the true superpopulation and, in fact, do not know if a different scenario altogether may be more representative of the true superpopulation. Therefore, we have no way of choosing among the models or superpopulations for resampling. Although the method was shown to be potentially unbiased and to track population trends reliably when applied to a single hypothetical map (e.g., that produced by Schwartz et al. 2008), it was not consistently unbiased nor precise when applied to an array of data that represented hypotheses we felt must be considered given our uncertainty about the true spatial distribution of F_{COY} on the GYE landscape.

Literature Cited (Appendix B)

CHERRY, S., G. C. WHITE, K. A. KEATING, M. A. HAROLDSON, AND C. C. SCHWARTZ. 2007. Evaluating estimators of the number of females with cubs-of-the-year in the Yellowstone grizzly bear population. Journal of Agricultural, Biological, and Environmental Statistics 12:195–215.

KEATING, K. A., C. C. SCHWARTZ, M. A. HAROLDSON, AND D. MOODY. 2002. Estimating numbers of females with cubs-of-the-year in the Yellowstone grizzly bear population. Ursus 13:161–174.

KNIGHT, R. R., B. M. BLANCHARD, AND L. L. EBERHARDT. 1995. Appraising status of the Yellowstone grizzly bear population by counting females with cubs-of-the-year. Wildlife Society Bulletin 23:245–248.

MATTSON, D. M. 1997. Sustainable grizzly bear mortality calculations from counts of females with cubs-of-the-year: an evaluation. Biological Conservation 81:103–111.

SCHWARTZ, C. C., HAROLDSON, M. A., CHERRY, S., AND KEATING, K. A. 2008. Evaluation of rules to distinguish unique female grizzly bears with cubs in Yellowstone. Journal of Wildlife Management, 72:543–554.

Appendix C

	Inside USFWS suitable habitat (proposed)				Inside USFWS conservation management area (current)				Difference (proposed - current)
Year	Sanctioned removal	Radioed	Reported	Total	Sanctioned removal	Radioed	Reported	Total	
1986	1	2	1	4	1	2	1	4	0
1987	1	0	1	2	1	0	1	2	0
1988	0	1	0	1	0	1	0	1	0
1989	0	0	0	0	0	0	0	0	0
1990	1	2	3	6	1	2	3	6	0
1991	0	0	0	0	0	0	0	0	0
1992	0	1	0	1	0	1	0	1	0
1993	0	1	2	3	0	1	2	3	0
1994	0	2	1	3	0	2	1	3	0
1995	3	0	5	8	3	0	5	8	0
1996	1	1	2	4	1	1	2	4	0
1997	0	0	3	3	0	0	3	3	0
1998	0	0	1	1	0	0	1	1	0
1999	0	0	1	1	0	0	1	1	0
2000	0	1	6	7	1	1	6	8	-1
2001	2	3	1	6	5	3	1	9	-3
2002	2	2	4	8	2	2	4	8	0
2003	0	0	5	5	0	0	5	5	0
2004	3	1	5	9	4	1	5	10	-1
2005	0	0	2	2	0	0	2	2	0
2006	0	1	1	2	1	1	1	3	-1
2007	3	2	6	11	3	2	6	11	0
2008	3	1	10	14	3	1	10	14	0
2009	0	3	6	9	0	2	7	9	0
2010	3	2	5	10	6	2	5	13	-3
Total	23	26	71	120	32	25	72	129	-9

Counts of known and probable mortalities by categories for independent aged female grizzly bears under alternative count lines, Greater Yellowstone Ecosystem, 1986–2010. Sustainability is set at 9% of the estimated population size for independent-aged females.

Appendix D

Counts of known and probable mortalities by categories for independent aged male grizzly bears under alternative count lines, Greater Yellowstone Ecosystem, 1986–2010. Sustainability is set at 15% of the estimated population size for independent-aged males.

Year	Inside USFWS suitable habitat (proposed)				Inside USFWS conservation management area (current)				Difference (proposed - current)
	Sanctioned removal	Radioed	Reported	Total	Sanctioned removal	Radioed	Reported	Total	
1986	0	0	1	1	1	0	1	2	-1
1987	1	0	0	1	1	0	0	1	0
1988	2	1	1	4	2	1	1	4	0
1989	0	1	1	2	0	1	1	2	0
1990	0	1	2	3	0	1	2	3	0
1991	0	0	0	0	0	0	0	0	0
1992	0	5	1	6	0	5	1	6	0
1993	0	2	0	2	0	2	0	2	0
1994	4	1	1	6	4	1	1	6	0
1995	2	3	4	9	2	3	4	9	0
1996	2	0	2	4	2	1	3	6	-2
1997	1	1	3	5	1	1	4	6	-1
1998	0	1	0	1	2	1	0	3	-2
1999	2	2	5	9	2	2	5	9	0
2000	1	2	14	17	2	3	14	19	-2
2001	4	2	3	9	7	2	3	12	-3
2002	3	1	5	9	4	1	5	10	-1
2003	1	3	3	7	2	3	4	9	-2
2004	2	2	5	9	3	2	7	12	-3
2005	1	1	2	4	4	1	2	7	-3
2006	1	3	3	7	1	3	3	7	0
2007	1	1	4	6	2	1	4	7	-1
2008	6	5	11	22	7	5	11	23	-1
2009	2	3	5	10	3	2	6	11	-1
2010	8	1	11	20	11	2	13	26	-6
Total	44	42	87	173	63	44	95	202	-29

Appendix E

Yearly results for sustainability of independent females under the current 9% mortality limit (red horizontal line), Greater Yellowstone Ecosystem, 1986–2010. Independent female mortalities were exceeded in 3 years under current methods.
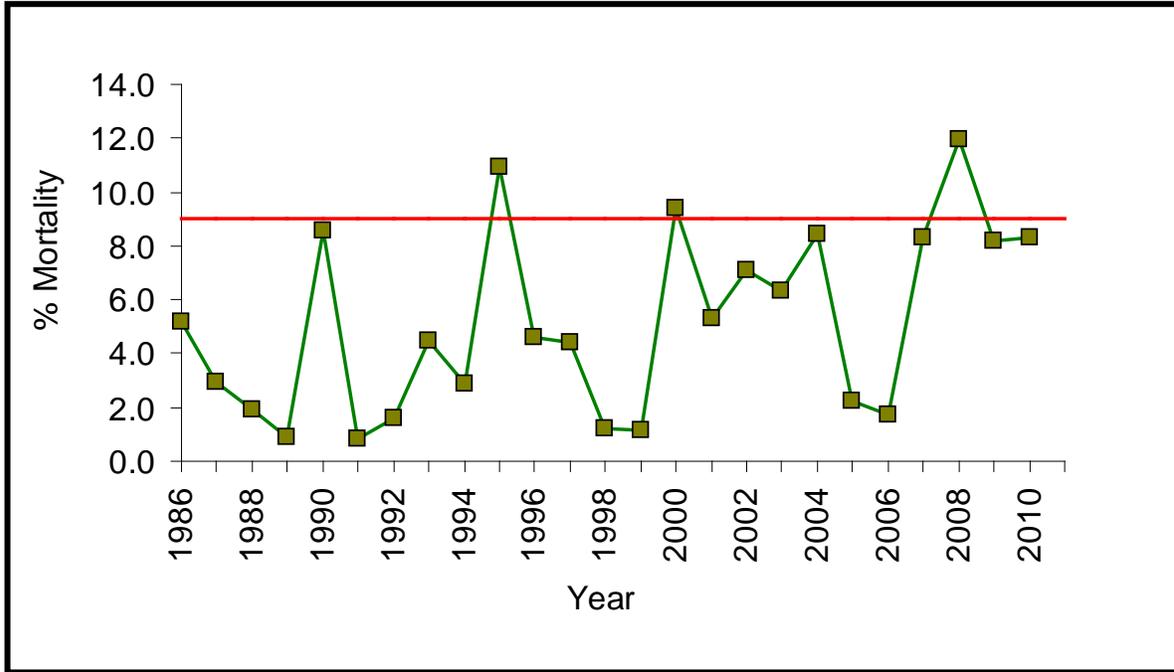
Appendix F

Yearly results for sustainability of independent males under the current 15% mortality limit (red horizontal line), Greater Yellowstone Ecosystem, 1986–2010. Independent male mortalities were exceeded in 6 years under current methods.

Appendix O. Grizzly Bear Management Plan for the Wind River Reservation

Grizzly Bear Management Plan for the Wind River Reservation

**Eastern Shoshone and Northern Arapaho Tribes
Ft. Washakie and Ethete, WY
&
Shoshone and Arapaho Tribal Fish
and Game Department
Ethete, WY**

**Assisted by the U.S. Fish and Wildlife Service
Fish and Wildlife Conservation Office
Lander, WY**

March 3, 2009

_____   3/3/09
Ivan Posey, Chairman Eastern Shoshone Tribe   Date

_____   3/3/09
Harvey Spoonhunter, Chairman Northern Arapaho Tribe   Date

Summary

➢ The intent of this plan is to support the co-existence of grizzly bears and people. It looks neutrally upon grizzly bears and considers them as a wildlife species for which management is essential due to tensions that will arise between the needs of grizzly bears and the needs of people. Traditional views of the Eastern Shoshone and Northern Arapaho Tribes (Tribes) recognize grizzly bears as an elder relative, as strong, as great and as deserving of respect and placed here by the Creator for a purpose.

➢ Tribes have sole authority for managing grizzly bears within the Wind River Reservation (Wind River) boundaries, and will seek assistance from and cooperation with the Yellowstone Grizzly Bear Coordinating Committee (YGBCC, a subcommittee of the Interagency Grizzly Bear Committee), the Interagency Grizzly Bear Study Team (IGBST) and the Wyoming Game and Fish Department (WGFD). Since the Yellowstone Ecosystem grizzly population crosses jurisdictional boundaries, cooperative efforts are necessary.

➢ Monitoring of the grizzly bear population within Wind River's boundaries will be done by the Tribes working in cooperation with the IGBST. Monitoring protocols and annual reports of monitoring efforts on Wind River will be part of the IGBST's annual reports.

➢ At this time, the Tribes do not designate a specific number of individual grizzly bears for which it will manage.

➢ Grizzly bears will likely confine themselves to remote areas in the Owl Creeks and Wind River mountains; however, they may occasionally wander near developed areas.

➢ Grizzly bears will be managed as a trophy game animal for which a hunting tag is required. Harvest may occur at the discretion of the Tribes' Joint Business Council (JBC) once the grizzly bear population reaches a sustainable size and will manage within the mortality limits as set forth by the Final Conservation Strategy (Conservation Strategy) for the Grizzly Bear in the Greater Yellowstone Area (GYA) 2007.

➢ Efforts to manage grizzly bears include trapping and radio-collaring, surveying by plane and remote cameras, conducting surveys for cone production on whitebark pine trees, expanding availability of food storage poles and metal containers at trailheads and campsites in the Owl Creek and Wind River mountains, and providing information to the public. Options to handle depredating grizzly bears will be evaluated on a case-by-case basis, and will include but are not limited to: no action, using non-lethal methods, radio-collaring and releasing on-site, relocating or immediate removal by lethal means. Tribes will not reimburse for grizzly bear depredations of livestock.

➢ This plan applies to all lands within the 1868 exterior boundary of Wind River, as modified by the Lander Agreement of 1872 and Thermopolis Agreement of 1896.

Acknowledgements

We gratefully appreciate those that helped create this plan and provided information: the JBC, Bob St. Clair, Ben Warren, Rawlin Friday, Burton Hutchinson, Merle Haas, Ardeline Spotted Elk, Abraham Spotted Elk, Nancy Dice, Leonard Amos, Leonard Moss, Manfred Guina, Reba Teran, George Leonard, Richard Baldes, Richard Thunder, Chris Servheen and Jarvis Gust. We also gratefully appreciate the cooperation and assistance from WGFD employees that trained Tribal Fish and Game (TFG) wardens in trapping and handling grizzly bears, were the lead in conducting the remote camera study, and provided insight into developing this plan: Dave Moody, Dan Bjornlie, Sam Lockwood, Lee Knox, Dan Thompson, Justin Clapp, and Brian DeBolt.

Introduction

The grizzly bear (*Ursus arctos*) conjures images of power, respect, fear, solitude, and wilderness. Traditional tribal views often hold the grizzly bear in esteem while some contemporary views see them as a serious threat to human safety, competitors, livestock killers and in other negative ways. The intent of this plan is to support the co-existence of grizzly bears and people. Management is essential due to tensions that will arise between the needs of grizzly bears and the needs of people. Grizzlies have the potential to affect resources important to Tribal people such as outdoor recreation, big game populations and livestock. People have the potential to affect grizzly bears by changing habitat and food resources through development, climate change and harvesting of big game. This plan will guide the Tribes in conserving and sustainably managing grizzly bears for this and future generations on all lands within the 1868 exterior boundary of Wind River, as modified by the Lander Agreement of 1872 and Thermopolis Agreement of 1896 (the Lander Agreement removed the South Pass portion of Wind River and the Thermopolis Agreement removed the northeast corner of Wind River in the Thermopolis area).

In 1975, the grizzly bear was designated as threatened under the Endangered Species Act in the lower 48 states. Since then, its population grew and expanded throughout the GYA, including Wind River (Schwartz *et al.* 2006). In 2007, the grizzly bear was delisted and primary management was turned over from the federal government to the states and tribes. The Conservation Strategy requires a minimum of 500 grizzly bears be maintained in the GYA. As of 2007, there was an estimated 571 grizzly bears in the GYA (Schwartz *et al.* 2008).

Coordination between parties involved in grizzly bear conservation is important, especially since bears routinely cross jurisdictional boundaries. With coordination, mutual benefits occur between parties that ultimately lead toward better conservation and management of grizzly bears. The Tribes are members of the YGBCC, which is the local sub-committee of the IGBC that is responsible for overseeing conservation of grizzly bears in the GYA. Tribes are also in the process of establishing a cooperative Memorandum of Understanding with the IGBST. The IGBST is an interdisciplinary group of scientists and biologists responsible for long-term monitoring and research efforts on grizzly bears in the GYA, and works closely with the IGBC. The Memorandum of Understanding will allow assistance and data-sharing to occur.

The Lander Fish and Wildlife Conservation Office (LFWCO) of the FWS has had a long and productive relationship assisting the Tribes in managing their fish and wildlife resources on Wind River since 1941. The JBC and TFG were assisted by the LFWCO in developing this plan.

Tribal Elder Views

Interviews of Shoshone and Arapaho Elders were conducted from August 2005 to February 2007. Visits were made to the Ft. Washakie, Ethete and Arapaho senior centers, Rocky Hall, individuals' homes, the Tribal College, and the Shoshone Cultural Center. During these interviews traditional history, stories, meanings, and memories along with current opinions were obtained and collated into the following:

Traditional views recognize grizzly bears as an elder relative, as strong, as great, as master of the forest and as deserving of respect and placed here by the Creator for a purpose. The Shoshone word for grizzly bear, "Bee-yah-ah-gwy" means "big bear." Grizzlies were like a wise uncle that knew best. When appearing in a vision, one was to follow what the grizzly bear showed you. Both Shoshones and Arapahos have a traditional Pow Wow dance honoring the grizzly bear.

Grizzlies were to be left alone and people were supposed to be careful around them. Bears generally wouldn't bother you; however, sometimes people had to kill them. If they were killed, then all parts were to be used. Bear oil was used to treat arthritis, rugs were used to stay warm and of course the meat was eaten. Claws were used in decorative dress and were worn by men because it was impressive and showed high status. A segment of the Arapahos' are members of a bear clan and see the grizzly bear as sacred. Members of the clan are not supposed to harm the bear.

Grizzlies modeled virtuous things to people such as strength, independence and care for family. One traditional story told of a bear family that stayed in a cave, caring for their young. The bear talked to an old man and told him that they were very much alike - that it had a family just like the man and was trying to care for them and to exist just the same. The grizzly bear, along with other animals, used to talk with people through telepathy.

As for current opinions, some Elders said that grizzly bears should be protected. Some said grizzly bears were dangerous and to stay away from them. Another mentioned that as long as grizzly bears stayed away from her house, she was OK with them. One man wanted the Business Councils to talk with the elders directly and ask the elders themselves for their input.

Biology and Current Status

Biology: Grizzly bears are large omnivores averaging 425 pounds for males and 295 pounds for females in northwest Wyoming (Schwartz *et al.* 2006). However, weight varies greatly during the year due to a bulk-up in fall that sustains them during winter hibernation. Females generally have a litter size of 2, breed every 3 years and have their first litter at age 4 to 6. Females peak reproductively at about 9 years and can produce cubs until 25 years of age. Breeding occurs between mid-May and mid-July. Typical annual survival rates are 0.77 for adult males, 0.94 for adult females, 0.80 for subadult females, and 0.84 for cubs. Home range size for females and males in northwest Wyoming averaged 105 mi^2 and 325 mi^2, respectively (Schwartz *et al.* 2006).

Feeding Habits: Grizzly bears consume a wide variety of vegetation, insects and mammals (Schwartz *et al.* 2003). Foods of major importance include whitebark pine cones (*Pinus albicaulis*), army-cutworm moths (*Euxoa auxiliaries*), elk calves (*Cervus canadensis*) and ungulate carcasses. Whitebark pine cones are an important high-quality food source for grizzly bears, particularly during the late summer and fall (Mattson and Reinhart 1994). Substantial whitebark pine stands occur in both the Owl Creek and Wind River mountains (Figures 1 & 2). Bear-human conflicts are often reduced during years in which cone production is high because bears remain in high elevation areas where whitebark occurs and are thus distant from human developments (Mattson and Reinhart 1994).

Grizzly bears' reproductive success increases during years of abundant cone production (Mattson and Jonkel 1990). Blister rust and pine beetle infestations throughout the west are causing major declines in whitebark (Keane and Arno 1993). This too is apparent on Wind River as large stands of whitebark are succumbing to pine beetle as evidenced by the red-topped trees in Figure 3. Tree mortality appears to be more prominent in the Owl Creek Mountains; however, stands in the Wind River Mountains are showing effects as well.

Army-cutworm moths aggregate in large masses under high alpine talus slopes throughout the Absaroka and Wind River Mountains. These moth aggregation sites are an important high-quality food source for grizzly bears (Mattson *et al.* 1991) and can comprise nearly ½ of their annual caloric intake (White 1996). There are 2 known army-cutworm moth sites in the Absaroka Mountains that have been visited by grizzly bears that were radio-collared on Wind River in 2006. Additional moth sites do occur in the Wind River Mountains, but at this time grizzly bears have not been observed using them (Dave Moody, personal communication 2007).

Elk calves, winter-killed ungulate carcasses and gut piles from harvested big game provide a major source of protein-rich food for grizzly bears. In a 3-year study in Yellowstone National Park, black and grizzly bears accounted for 55 to 60% of mortalities of elk calves that were less than 30 days old (Barber *et al.* 2005). Estimates of wintering ungulates on Wind River are: 6500 to 7500 antelope, 3200 to 4800 deer, 7000 to 9000 elk, 100 to 200 moose, and 350 to 450 bighorn sheep. In 2007, approximately 1,130 Tribal hunters harvested 96 pronghorn antelope, 495

Stands of whitebark pine in the Owl Creek Mountains
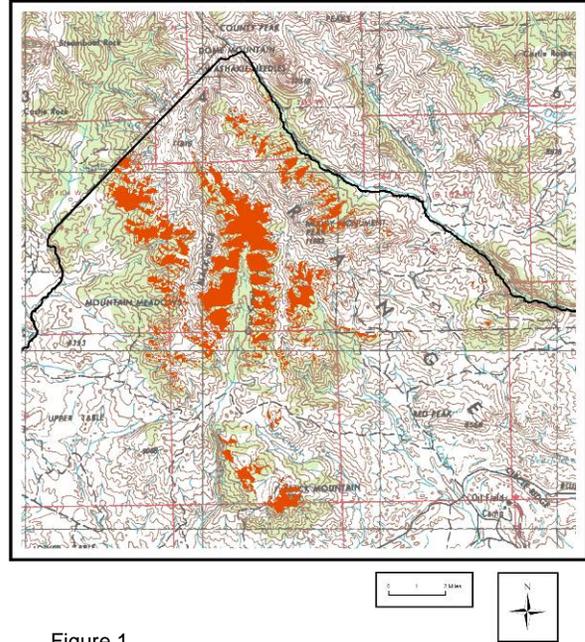
Figure 1.

Stands of whitebark pine in the Wind River Mountains
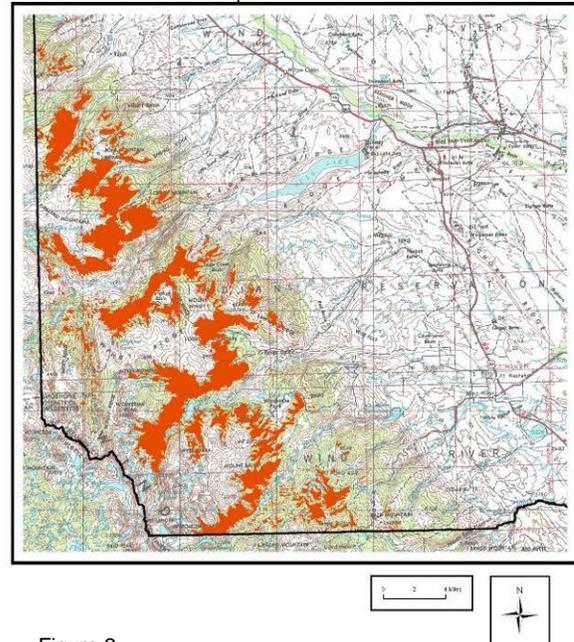
Figure 2.

deer, 527 elk, 3 moose, and 16 bighorn sheep. Gut piles from harvested big game provide an important food source for grizzly bears prior to entering the den (Dave Moody, personal communication 2008).

Available Habitat: The vast majority of Wind River's 2,260,000 acres is remote and sparsely populated. Elevations range from 4,500 to 12,250 feet. Habitat types

Figure 3. Dying and dead whitebark pine due to pine beetle infestation, Trail Ridge, Owl Creek, 2007.

include desert, grassland, shrubland, agriculture, montane, and alpine. Specifically, 458,000 acres are forests, 1,290,000 acres are shrubland, and 183,000 acres are grassland and alpine meadow. There are at least 734,000 acres of potential grizzly bear habitat with 161,000 acres and 100,000 acres currently occupied by grizzly bears in the Owl Creek and Wind River mountains, respectively (Figure 4).

Current Population Status: As of September 2008, there were 3 grizzly bears with active radio-collars in the Owl Creek Mountains. These included #531 (a 10 to 12 yr-old female), #532 (a 5 to 6 yr-old male) and #537 (a 5 to 6 yr-old female) (Figure 4). Bear #459 (an 11 yr-old male) recently dropped its collar in May 2008 and likely still occurs on Wind River. All of these bears were captured and radio-collared in the Crow Creek Basin and East Fork areas during a joint trapping effort between the TFG, WGFD and LFWCO lasting 2 ½ weeks in July and August 2006 (Figure 5). Two additional grizzly bears were radio-collared, however one died in August 2006 and the other dropped its GPS collar in May 2007 (Figure 6). The number of bears trapped during this short period greatly exceeded all expectations.

During July and August 2008, a remote camera study was conducted in the Wind River Mountains between Bob Creek and Bull Lake Creek to document presence and distribution of grizzlies (Lockwood *et al.* 2008). During the 49-day study, there were 8 detections of grizzly bears as follows: an adult female with 2 yearling cubs on 6 occasions in the Kirkland Park area, an adult male on 1 occasion in the Bold Mountain area, and three 2-year-olds in the Bob Creek drainage (Figure 4). Based on the aforementioned data, Wind River has a moderate and expanding population of grizzly bears. Supporting evidence for this observation is that the population in the Greater Yellowstone Ecosystem grew at a 4 to 7 % annual rate between 1983 and 2001 (Conservation Strategy 2007) and has continued to grow since.

Potential grizzly bear habitat on Wind River and locations of 3 male and 3 female radio-collared bears in the Owl Creek Mtns, July 2006 to Sept 2008, and 1 male, 3 2-yr-olds, and 1 female with 2 yearlings captured on remote camera in the Wind River Mtns, July 2008.

WRIR Grizzly Locations July 2006 to Sept 2008
SEX
▲ Unkown
● Female
■ Male
//// Potential Grizzly Bear Habitat on Wind River
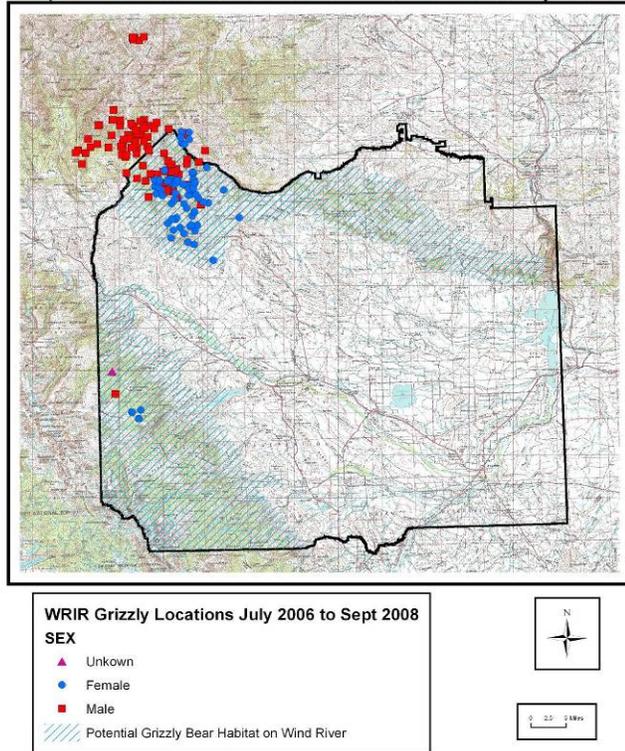
Figure 4.

Figure 5. TFG wardens Western Thayer, Ben Warren and Herman St. Clair with sedated grizzly bear, Crow Creek, 2006.

Livestock: Though generally not a food source, cattle, primarily calves, can be depredated upon by grizzly bears. In 2 cattle allotments near Blackrock just west of Togwotee Pass, Wyoming, grizzly bears were responsible for 78 of 182 calves that were lost (43%) between 1994 and 1996 (Anderson *et al.* 2002). However, this loss represented only 1 to 2% of the 6,000 calves that ranged on the allotments during that time period. Grizzly bear density was high as there were at least 10 bears on the allotments. Three grizzlies were responsible for 90% of the losses and once removed by management action, calf depredations were reduced dramatically. During this time period fewer than 9 adult cows were depredated by grizzly bears. Cattle are the primary livestock utilizing range on Wind River. There are approximately 135 permittees that ran 23,100 cow/calf pairs utilizing 163,400 Animal Unit Months on Tribal lands in 2001 (Bureau of Indian Affairs 2002). Approximately 140 horses also ranged on these lands. There are no free-ranging domestic sheep or other livestock utilizing Wind River.

Figure 6.

Management

As mentioned previously, this plan attempts to balance the needs of grizzly bears and the needs of people. In order to do this, adequate knowledge of the distribution and population size of grizzlies is essential. With this knowledge, appropriate management decisions can be made that will ensure Wind River's grizzly bear population will be sustained in perpetuity for the benefit of the bear and the benefit of current and future tribal members, while allowing removal of bears as needed for the protection of human safety and personal property.

Population Monitoring: Methods for monitoring include radio-collaring, remote camera surveys, aerial surveys, and public reports. Trapping and radio-collaring efforts will adhere to approved practices so that grizzly bears are handled humanely and efficiently. Currently, the TFG has one bear trap that was constructed by a TFG warden. A second is planned for construction (Figure 7).

As mentioned in the Biology and Current Status section, a cooperative remote camera study was done in the
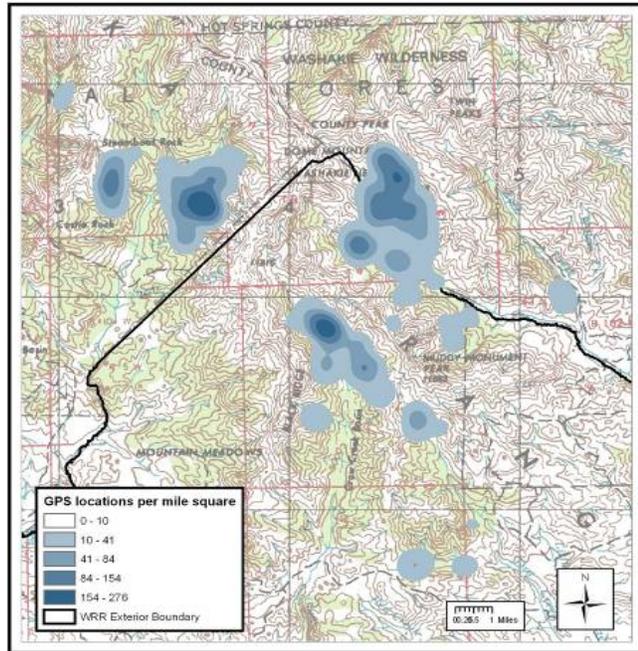
Figure 7. Western Thayer investigating TFG bear trap in Crow Creek Basin, 2006.

Wind River Mountains in 2008 (Figure 8). Excellent data were obtained on the distribution of grizzly bears in the northern third of the Wind River Mountains, from Bob Creek to Bull Lake Creek. A similar study will be conducted on the southern two-thirds of the Wind River Mountains between Bull Lake Creek and Trout Creek within the next 2 years. This will further our knowledge of distribution throughout the remaining portion of the Wind River Mountains located on Wind River.

Telemetry flights are an important monitoring tool. Flights for the 3 radio-collared grizzly bears in the Owl Creek Mountains will continue to be contracted by the WGFD. Flights typically occur every 10 days beginning in April and continuing until it's documented that a bear has denned, usually in November or December. Monitoring radio-collared bears provides important information related to distribution, seasonal habitat utilization, dates of denning, den site selection, cause of death, and survival rates by age and sex class.

Figure 8. Grizzly female with yearling cubs captured by digital image during remote camera survey, 2008.

Another important monitoring method are summer observation flights. Members of the IGBST conduct annual survey flights throughout the GYA. In 2007, 74 flights were conducted, each lasting approximately 2.5 hours (IGBST 2007). Aerial monitoring will involve conducting 2 summer surveys of 2 to 2.5 hours in length in each of 3 observation units: West Owl Creek (#46), North Wind River (#48) and South Wind River (#49) (Figure 9). All grizzly bears observed will be plotted with GPS and recorded to age and number in group. Females with cubs-of-the-year (COY) are especially important to document. The number of females with COY are used to estimate population size and the allowable mortality thresholds for the entire ecosystem. Typically, a pilot and one observer conduct the survey. Currently, there is a shortage of flight services that can conduct these surveys. Sky Aviation, the company that performs these flights in this part of Wyoming, may have difficulty conducting addtional flights on Wind River due to limited staff and equipment (Dave Stinson, personal communication 2008). Another flight service may be available in 2009. All data from flights will be provided to the WGFD and the IGBST for inclusion in the Yellowstone ecosystem database maintained by the IGBST.

Population Management: Tribes have the sole responsibility for managing grizzly bears on Wind River, but will seek assistance from and cooperation with the


Figure 9.

8

IGBST and WGFD. At this time, the Tribes do not designate a specific number of grizzly bears for which it will manage, and future strategy will depend on the number of grizzly bears present on Wind River and the direction the Tribes wish to take.

Occasionally, grizzly bears may conflict with people. For example, a hungry bear becomes habituated and spends an inordinate amount of time around human developments, threatening human safety. Or, a grizzly bear becomes a habitual livestock depredator. These are termed "Grizzly Bears of Concern" and will require management action (see Table 1 below for further discussion). Removal of grizzly bears by management action takes precedence over hunter harvest.

Relocating Grizzly Bears of Concern to areas outside Wind River is an option. Prior to relocating, TFG personnel will contact the WGFD to coordinate an appropriate release area and to ensure that bears are radio-collared with the appropriate frequency. Once a grizzly bear is moved off Wind River, it becomes the jurisdiction of the WGFD. Personnel from the Bridger-Teton National Forest (BTNF) and Shoshone National Forest (SNF) indicated that they are willing to accept livestock depredating bears. When relocating is desired, the TFG will contact the North Zone Wildlife Biologist for the BTNF in Jackson or the Wildlife Biologist for the SNF in Cody who will then contact their respective Forest Supervisor for approval. Personnel with Yellowstone National Park stated that it's highly unlikely that they will accept grizzly bears from Wind River since they do not accept bears from anywhere outside the park.

Once the grizzly bear population is of a sustainable size, the Tribes may allow hunter harvest if so desired. Currently, the grizzly bear is designated as a trophy game animal for which the season is closed. Given the limited number of grizzly bears on Wind River and within the GYA, the season may remain closed for a period of time. Because individual grizzly bears each require vast areas of secure habitat and because this habitat is relatively limited on Wind River, the population will remain small. Consequently, when hunter harvest is allowed, take will be very limited to help ensure future sustainability of the population.

Once hunter harvest is allowed, the season timing and length, harvest quota and other specifics will be proposed annually by the TFG and LFWCO for approval by the JBC in accordance with the following requirements:

> ➢ The Tribes will attempt to follow mortality limits as laid out in the Conservation Strategy. Mortality from all causes should not exceed 15% for males $\geq$2 yrs-old and 9% for females $\geq$2 yrs-old in order to sustain grizzly populations. Types of mortalities include known natural-caused and all human-caused such as human-related accidents, management action, and hunter harvest.
> ➢ Tribal hunters must posses a grizzly bear tag issued by TFG.
> ➢ Selection of hunters will be by random drawing.
> ➢ Young or females with young may not be harvested.
> ➢ Hunters will be required to report harvest to the TFG and the LFWCO within 72 hours. The LFWCO will record all known removal (harvest, management action, illegal, accidents and any other removal) and provide this information to the TFG and IGBST. All mortality information will be provided to the IGBST as soon as possible by phone, preferably within 24 hours of the mortality. This rapid reporting will allow the IGBST to keep track of the annual mortality levels throughout the ecosystem to help assure the mortality limits are not exceeded.

Table 1. Summary of take. Take means removal of a grizzly bear by placing in captivity, relocating to another location, or killing and may occur in the following instances:

Provision	Allowance
Take in self defense.	Any person may take a grizzly bear in self defense or the defense of others.
Protection of human life and safety.	The Tribes may promptly remove any grizzly bear determined by the Tribes to be a threat to human life or safety.
Tribal government take of Grizzly Bear of Concern.	''Grizzly Bear of Concern'' is defined as a grizzly bear that attacks humans or any domestic animal including livestock, dogs (excludes hounds that are in pursuit of a bear), and livestock herding and guarding animals, damages personal property, or becomes habituated to human food and/or people and spends an inordinate amount of time around human developments, threatening human safety. Management removal by TFG or other authorized personnel will occur on a case-by-case basis and will consider history of offending bear's behavior, threat to human safety, evidence of the attack, potential for future conflicts, degree of damage, presence of unusual grizzly bear attractants, any previously specified animal husbandry practices that have been implemented, effectiveness of other methods, etc. Non-lethal methods (relocating, hazing, rubber bullets, electric fencing, etc.) will be considered on a case-by-case basis when depredation has occurred. Lethal removal will be used if non-lethal methods are impractical and ineffective.
Additional take provisions for Tribal government employees.	Authorized tribal agents (i.e., employees of the TFG authorized by the JBC to manage grizzly bears), acting in the course of official duties, may take a grizzly bear from the wild, if such action is for: (1) scientific purposes; (2) to avoid conflict with human activities; (3) to relocate a grizzly bear to improve its survival and recovery prospects; (4) to aid or euthanize sick, injured, or orphaned grizzly bears; (5) to salvage a dead specimen which may be used for scientific study; and (6) to aid in law enforcement investigations involving grizzly bears.
Hunter Harvest by enrolled member.	Under authorization of the JBC, the TFG may issue tag(s) that allow for the harvest of grizzly bear(s) by licensed hunters during approved seasons. Hunters must apply for a tag and be entered into a random drawing. At the writing of this plan, the grizzly bear season is closed.

Bear Depredations: Grizzly bears will likely spend the bulk of time in remote areas of the Owl Creeks and Wind River mountains where the majority of suitable habitat resides. Cattle are also present in these areas during the late spring, summer and fall and may be subject to grizzly bear depredation. Grizzly bears may also occasionally occur in lower elevation sagebrush uplands and near agricultural lands. Cattle are present in these areas during winter months and calving season. Consequently, grizzly bears may kill livestock and may need to be relocated or lethally removed. This will be assessed on a case-by-case basis as mentioned above. Compensation for livestock losses will not be provided by the Tribes. The Tribes will cooperate with and utilize assistance offered by the LFWCO, Animal and Plant Health Inspection Service (APHIS) - Wildlife Services and WGFD when capturing or lethally removing grizzly bears. All mortality due to removal of depredating bears will be provided to the IGBST as soon as possible by phone, preferably within 24 hours of the mortality. TFG personnel have received and will continue to receive training in determining grizzly bear kills of livestock, capturing techniques, and appropriate care and handling. Any illegal take will be investigated by the TFG in cooperation with the local Special Agent of the FWS if desired.

A typical depredation scenario is as follows:
- ➢ A livestock owner finds a dead calf in his pasture. He covers the carcass with a tarp to protect the scene. He notifies the TFG.
- ➢ TFG contacts the local APHIS Wildlife Services personnel and/or the LFWCO for assistance if needed. TFG visits scene and determines whether calf was killed by a grizzly bear.
- ➢ TFG will discuss options with owner to determine course of action. Actions could include: no action to see if depredation continues; attempt to trap and radio-collar grizzly bear to assess presence near livestock and identification of grizzly bear if depredation

continues; relocate grizzly bear; remove livestock carcasses or other items that may be acting as an attractant; suggest confining or moving livestock if feasible to deter future depredation; consider using non-lethal methods such as rubber bullets and the like; or lethally remove grizzly bear by shooting or trapping and euthanizing humanely.

Habitat Management: New human developments (wind turbines, oil and gas wells, homesites, and the like) should be avoided or minimized within occupied grizzly habitat. The density of roads, the vehicular use of those roads, and human developments have a major impact on how suitable an area is for grizzly bears (Conservation Strategy 2007). The BIA's Wind River Reservation Forest Management Plan (2004) recognizes the importance of grizzly bears and their habitat by the following guidelines. The plan has a no net increase in roads in the Wind River Roadless Area and in the Monument Peak area of the Owl Creek Mountains. In addition, throughout the remaining portion of grizzly habitat a road density of 1 mile of open road per mile^2 or less will be maintained in order to sustain the integrity and security of grizzly bear habitat.

In order to assess the level of cone production for whitebark pine, transects will be established and surveys conducted each year. A transect was established on Bold Mountain in August 2008. Additional sites will likely be established in Washakie Park and on Trail Ridge. On each transect, 10 trees are marked permanently and all cones attached to the tree from that year are counted. These are recorded and sent to the IGBST annually.

Food Storage: Minimizing contact of bears with non-natural foods is an effective method of reducing bear habituation to people. Habituation can result in a bear becoming a threat to human safety and personal property (IGBST 2008). The TFG has erected food poles at campsites in Crow Creek Basin and will be installing metal storage containers as well. Efforts will be expanded to include the Wind River Mountains. In bear habitat, homeowners will be encouraged to store garbage, grain, etc. in bear-proof buildings or containers. For those with beehives, use of electric fencing will be encouraged. To further minimize human/bear conflicts, the prohibition of baiting bears will continue.

Public Outreach: The TFG and LFWCO will be jointly responsible for the creation and distribution of outreach materials. Pamphlets will be developed for handout to tribal hunters and other interested individuals and will provide information on grizzly bears biology, tribal management, depredation protocols, etc. This will also be incorporated into existing outreach programs (for example, hunter safety). Signage will be installed and maintained in bear habitat and backcountry users will be encouraged to carry pepper spray. Sample signs that encourage good food storage in bear habitat and that help differentiate black bears from grizzly bears are attached in Appendix A.

Disposition of Grizzly Bear Parts: Grizzly bear parts resulting from confiscation of illegal harvest or from management removal will be housed by TFG and disseminated at the discretion of the JBC for religious, cultural, traditional and/or educational purposes. Sale of parts disseminated by the JBC is not permitted. To obtain a grizzly bear part, a tribal member must submit a letter of request to the TFG stating the intended use and purpose. Once received, a minimal delay may occur in order to confirm the legitimacy of the request with the JBC. Surplus parts may be donated for educational purposes to schools on Wind River.

Definitions

APHIS: Animal and Plant Health Inspection Service.

BTNF: Bridger-Teton National Forest.

COY: cubs-of–the-year. These are cubs that are < 1 year old.

Depredation: a grizzly bear attack that resulted in the immediate or recent (< 1 week) death of a domestic animal.

Domestic animal: animals that have been selectively bred over many generations to enhance specific traits for their use by humans, including use as pets. This includes livestock and dogs (excludes hounds that are in pursuit of a bear).

Enrolled Member: a person officially recognized by the Eastern Shoshone or Northern Arapaho as a member of their tribe.

FWS: US Fish and Wildlife Service.

GYA: Great Yellowstone Area – portions of Wyoming, Montana, and Idaho near Yellowstone National Park, including Wind River.

Grizzly Bear of Concern: a grizzly bear that attacks humans or any domestic animal including livestock, dogs (excludes hounds that are in pursuit of a bear), and livestock herding and guarding animals, damages personal property, or becomes habituated to human food and/or people and spends an inordinate amount of time around human developments, threatening human safety.

IGBC: Interagency Grizzly Bear Committee – a multi-agency group created in 1983 to lead the effort to recover the grizzly bear in the lower 48 states.

IGBST: Interagency Grizzly Bear Study Team - an interdisciplinary group of scientists and biologists responsible for long-term monitoring and research efforts on grizzly bears in the Greater Yellowstone Area. Representatives are from the U.S. Geological Survey, National Park Service, U.S. Fish and Wildlife Service, U.S. Forest Service, Montana State University, and the states of Idaho, Montana, and Wyoming. The Tribes are currently working on a cooperative MOU with the IGBST.

JBC: Joint Business Council of the Eastern Shoshone and Northern Arapaho Tribes.

Livestock: cattle, sheep, horses, mules, domestic bison, and herding and guarding animals (llamas, donkeys, and certain breeds of dogs commonly used for herding and guarding livestock).

LFWCO: FWS Lander Fish and Wildlife Conservation Office.

Private land: all land that is not under Federal Government ownership and administration. Tribal land is considered private land.

Remove: place in captivity, relocate to another location, or kill.

SNF: Shoshone National Forest

Take: to remove.

TFG: Shoshone and Arapaho Tribal Fish and Game Department.

Tribal land: Tribal trust, allotted, and fee-title Indian-owned land within the exterior boundaries of Wind River.

Tribes: the Eastern Shoshone and Northern Arapaho Tribes of the Wind River Reservation.

Ungulate: hoofed animal.

WGFD: Wyoming Game and Fish Department

YGBCC: Yellowstone Grizzly Bear Coordinating Committee – the local sub-committee of the IGBC responsible for the Greater Yellowstone Area. Tribes are members.

Literature Cited

Anderson, C.R., M.A. Ternent, and D.S. Moody. 2002. Grizzly bear-cattle interactions on two grazing allotments in northwest Wyoming. Ursus 13:247-256.

Barber, S.M., L.D. Mech, and P.J. White. 2005. Yellowstone elk calf mortality following wolf restoration: bears remain top summer predators. Yellowstone Science 13(3)37-44.

Bureau of Indian Affairs. 2002. Range Unit Information for 2001. 55pp.

Bureau of Indian Affairs. 2004. Wind River Reservation Forest Management Plan.

Interagency Conservation Strategy Team. 2007. Final conservation strategy for the grizzly bear in the Greater Yellowstone Area. 160 pp.

Interagency Grizzly Bear Study Team. 2005. Reassessing methods to estimate population size and sustainable mortality limits for the Yellowstone grizzly bear. 67 pp.

Keane, R.E. and S.F. Arno. 1993. Rapid decline of whitebark pine in western Montana: evidence from 20-year remeasurements. Western Journal of Applied Forestry 8(2):44-47.

Landenburger, L., R.L. Lawrence, S. Podruzny, and C. Schwartz. 2006. Mapping whitebark pine distribution throughout the Greater Yellowstone Ecosystem. ASPRS Conference. 11 pp.

Lockwood, S.T., L. I. Knox, D.D. Bjornlie, and D.J. Thompson. 2008 Wind River Indian Reservation grizzly bear camera study. Wyoming Game and Fish Department. 8 pp.

Mattson, D.J. and D.P. Reinhart. 1994. Bear use of whitebark pine seeds in North America. Pages 212-220 *in* W.C. Schmidt and F.-K. Holtmeier (eds). Proceedings -- International Workshop on Subalpine Stone Pines and their Environment: the Status of Our Knowledge. General Technical Report INT-GTR-309. Ogden, Utah: U.S. Forest Service Intermountain Research Station. Found on website http://www.conifers.org/pi/pin/albicaulis.htm.

Mattson, D.J., B.M. Blanchard, and R.R. Knight. 1991. Food habits of Yellowstone grizzly bears, 1977-87. Canadian Journal of Zoology 69:1619-1629.

Mattson, D.J. and C. Jonkel. 1990. Stone pines and bears. Pages 223-236 *in* W.C. Schmidt and K.J. McDonald, compilers. Proceedings-symposium on whitebark pine ecosystems: ecology and management of high-mountain resource. U.S. Forest Service. General Technical Report INT-270.

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 Monograph 161.

Schwartz, C.C., S.D. Miller, and M.A. Haroldson. 2003. Grizzly bear. Pages 556-586 *in* G.A. Feldhamer, B.C. Thompson and J.A. Chapman, editors. Wild mammals of North America: biology, management, and conservation. Second edition. The Johns Hopkins University Press, Baltimore, Maryland.

Schwartz, C.C., M.A. Haroldson and K. West. 2008. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team. 125 pp.

White, G.C. 1996. Two grizzly bear studies: moth feeding ecology and male reproductive biology. Ph.D. Thesis, Montana State University, Bozeman. 79 pp.

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Appendix A.

FOOD STORAGE

Protect your family and wildlife. Store all foods and attractants properly. Make them unavailable to wildlife at night and when unattended during the day.

ATTRACTANTS ARE:

Food, beverages, toiletries, game meat, carcass parts, processed livestock food, pet food and garbage.

UNAVAILABLE MEANS:

Hung at least 10 feet high and 4 feet from any vertical support.

Stored inside a bear-resistant container or hard sided vehicle.

Game meat, if properly stored, at least 100 yards from sleeping area, recreation site, or Forest Service Trail System.

Game meat, if left on the ground, at least one-half mile from any sleeping area or recreation site, and 200 yards from a Forest Service System Trail.

Coolers ARE NOT Bear-Resistant!

BEAR SAFETY FOOD STORAGE PRECAUTIONS STRONGLY RECOMMENDED BETWEEN MARCH 1 AND DECEMBER 1.

PLEASE KEEP A CLEAN CAMP!

www.IGBConline.org

Center For Wildlife Information
www.BeBearAware.org
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Appendix P. Memorandum of Agreement between the States of Idaho, Montana, Idaho, and Wyoming Regarding the Management and Allocation of Discretionary Mortality of Grizzly Bears in the Greater Yellowstone Ecosystem

To Be Added Upon Finalization