Species Status Assessment for the Grizzly Bear (*Ursus arctos horribilis*) in the Lower-48 States: A Biological Report

Photo Credit: Frank van Manen / USGS

Prepared by the U.S. Fish and Wildlife Service
Grizzly Bear Recovery Office, Missoula, Montana

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Writers and Contributors:

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Executive Summary

This species status assessment (SSA) documents the results of our comprehensive review of the life history, ecology, threats, and viability for the grizzly bear (*Ursus arctos horribilis*) in the conterminous (lower-48) United States (hereafter, grizzly bear). The grizzly bear is listed as threatened under the Endangered Species Act (Act) in the lower-48 States (40 FR 31734; July 28, 1975), and this listed entity is the subject of this SSA report. As such, unless specified otherwise, we use the term “species” to refer to the listed entity and the term “ecosystem” to refer to the populations of this listed entity. This SSA report is intended to provide the best available biological information to inform the U.S. Fish and Wildlife Service’s (Service’s) decisions for the grizzly bear under the Act, including a 5-year status review and any additional actions, as needed.

We used the three-part SSA framework (Service 2016, entire; Smith *et al.* 2018, entire) to guide our biological risk assessment for the grizzly bear in the lower-48 States. An SSA begins with a compilation of the best available biological information on the species, including its taxonomy, life history, and habitat, and its ecological needs at the individual, population, and species levels, based on how environmental factors are understood to act on the species and its habitat (Service 2016, p. 6). Next, an SSA describes the current condition of the species’ habitat and demographics, and the probable explanations for past and ongoing changes in abundance and distribution within the species’ ecological settings, such as areas representative of the geographic, genetic, or life history variation across the species’ range (Service 2016, p. 6). Lastly, an SSA forecasts the species’ response to probable future scenarios of environmental conditions and conservation efforts (Service 2016, p. 6). As a result, the SSA characterizes the species’ viability, or its ability to sustain populations in the wild over time based on the best scientific understanding of current and future abundance and distribution within the species’ ecological settings.

Throughout the assessment, the SSA uses the conservation biology principles of resiliency, redundancy, and representation, collectively known as the “3Rs,” as a lens to evaluate the current and future condition of the species (Service 2016, p. 6). Resiliency is the ability for populations to sustain in the face of environmental and demographic stochastic events, or for populations to recover from years with low reproduction or reduced survival, and is associated with population size, growth rate, connectivity, and the quality and quantity of habitats. Redundancy is the ability for a species to withstand catastrophic events, for which adaptation is unlikely, and is associated with the number and distribution of populations. Representation is the ability of a species to adapt to changes in the environment and is associated with its diversity, whether ecological, genetic, behavioral, or morphological.

In the first phase of our SSA analysis, we identified what the grizzly bear in the lower-48 State’s needs, first in terms of the habitat factors needed by individuals to breed (including all stages of reproduction), feed, shelter, and disperse, then in terms of the demographic factors that populations need to be resilient, and finally, what the grizzly bear in the lower-48 States needs for redundancy and representation (Chapter 4). In the second phase of our analysis, we evaluated the stressors and conservation efforts that influence the needs (Chapter 5), and then we evaluated the current condition of those needs in terms of the 3Rs (Chapter 6). In the third and final phase of our analysis, we projected the future condition of the needs, again in terms of the 3Rs, using future scenarios to capture uncertainty associated with the future to year 2050 to 2065 (Chapter 7). For the purpose of this assessment, we define viability as the ability of the grizzly bear to sustain populations in natural ecosystems over a biologically meaningful timeframe, in this case, by approximately the middle of the 21st century (2050 to 2065). The 2050 to 2065 timeframe for this assessment is a period that allows us to reasonably project the duration of conservation efforts due to the typical duration of forest plans, potential effects of various stressors, and accounts for approximately two to three generation intervals of grizzly bear. This timeframe is consistent with the time scale for which we have data available for the grizzly bear and for which we can project conservation actions.

Summary of Life History, Taxonomy, Ecology, and Distribution

The grizzly bear is a large, long-lived mammal that occurs in a variety of habitat types in portions of Idaho, Montana, Washington, and Wyoming in the lower-48 States. Grizzly bears hibernate in the winter, typically in dens, feed on a wide variety of foods, weigh up to 363 kilograms (800 pounds), and live more than 25 years in the wild. Grizzly bears are light brown to nearly black and are so named for their “grizzled” coats with silver or golden tips. Grizzly bears (*Ursus arctos horribilis*) are a member of the brown bear species (*U. arctos*) that occurs in North America, Europe, and Asia. The subspecies *U. a. horribilis* is limited to North America (Rausch 1963, p. 43; Servheen 1999, pp. 50–53). Grizzly bears have three life stages: dependent young, subadults, and adults.

Historically, the grizzly bear occurred throughout much of the western half of the contiguous United States, central Mexico, western Canada, and most of Alaska. An estimated 50,000 to 100,000 grizzly bears were distributed in one large contiguous area throughout all or portions of 18 western States (i.e., Washington, Oregon, California, Idaho, Montana, Wyoming, Nevada, Colorado, Utah, New Mexico, Arizona, North Dakota, South Dakota, Minnesota, Nebraska, Kansas, Oklahoma, and Texas). Populations declined in the late 1800s with the arrival of European settlers, government-funded bounty programs, and the conversion of habitats to agricultural uses. Grizzly bears were reduced to less than 2 percent of their former range in the lower-48 States by the time grizzly bear was listed as threatened under the Act in 1975, and the estimated population in the lower-48 States was 700 to 800 individuals. Only five areas in mountainous regions, national parks, and wilderness areas contained populations, including the Northern Continental Divide in northwest Montana; the Greater Yellowstone area in northwest Wyoming, eastern Idaho, and southwest Montana; the Cabinet-Yaak Mountains in northeast Idaho and northwest Montana; the Selkirk Mountains in northwest Idaho and northeast Washington; and the North Cascades range in northcentral Washington. The Northern Continental Divide, Selkirk, and Cabinet-Yaak populations extend into Canada to varying degrees. Although there is currently no known population in the North Cascades, it constitutes a large block of contiguous habitat that spans the international border. Grizzly bears were also known to have existed in the recent past in two additional areas, the Bitterroot Mountains in central Idaho and western Montana, and the San Juan Mountains in Colorado. The Grizzly Bear Recovery Plan refers to these areas as grizzly bear ecosystems (Service 1993, p. 10). In 1993, the Service designated six of these areas as recovery areas, and recommended further evaluation of the seventh, the San Juan Mountains, to determine recovery potential (Service 1993, p. 121).

Grizzly bear populations in the lower-48 States have significantly expanded since the time of listing in 1975 and now occupy approximately 6 percent of their historical range in the lower-48 States (Haroldson *et al.* 2020a, *in press*). Currently, grizzly bears primarily exist in four ecosystems: the Northern Continental Divide (NCDE), Greater Yellowstone (GYE), Cabinet-Yaak (CYE), and Selkirk (SE) ecosystems. There are no known populations in the North Cascades and Bitterroot (BE) ecosystems and no known populations outside these defined ecosystems, although we have documented bears, primarily solitary, outside these ecosystems (Figure 1). Outside the lower-48 States, approximately 55,000 grizzly bears exist in the largely unsettled areas of Alaska and western Canada (Alaska Department of Fish and Game 2020, entire; COSEWIC 2012, p. vi). In North America, grizzly bears occupy approximately 60 percent of their historical range (Haroldson *et al.* 2020a, *in press*).

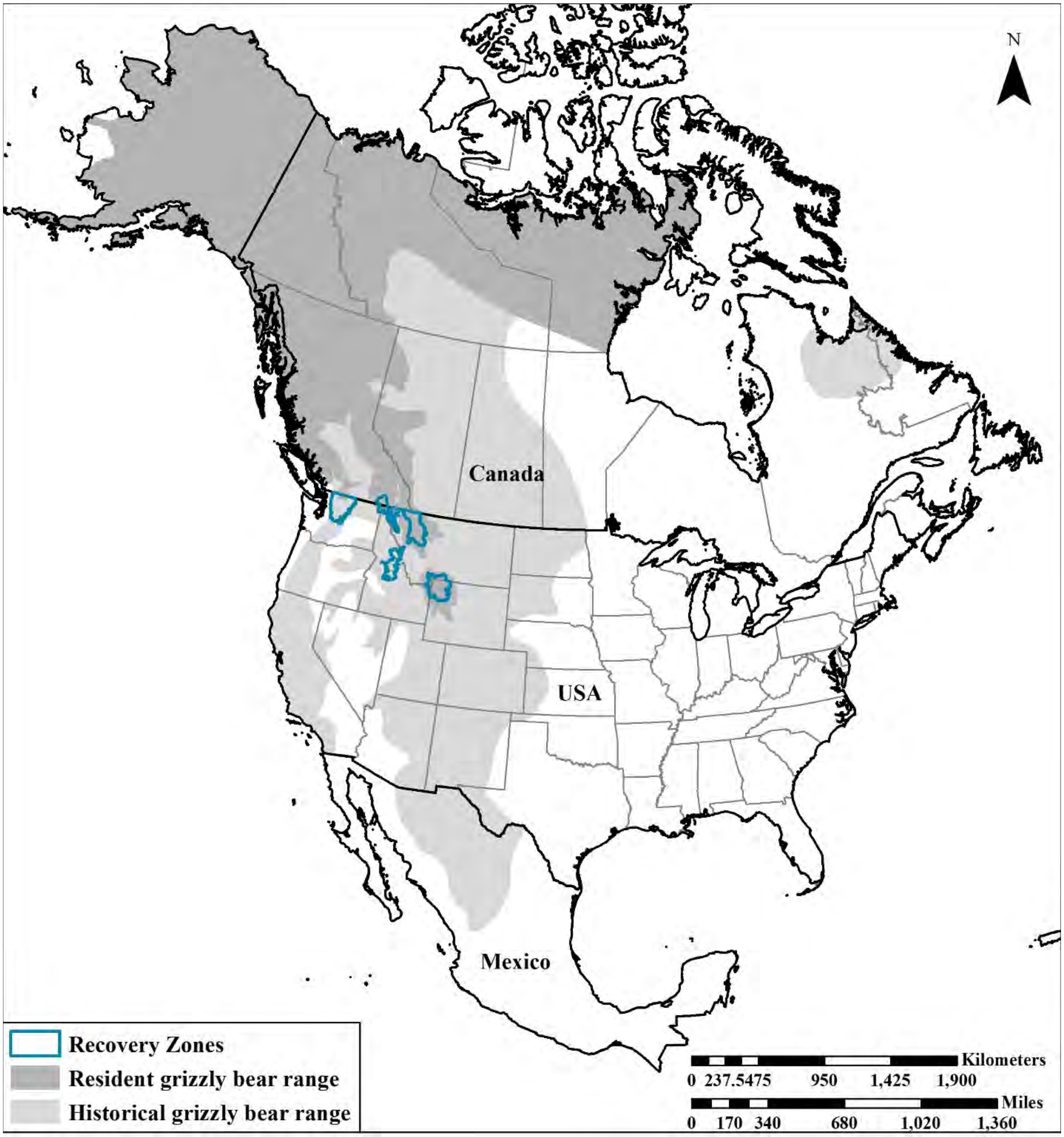

Figure 1. Map of historical and current grizzly bear range in North America and the six recovery zones for grizzly bear in the lower-48 States. Currently, grizzly bears primarily exist in four ecosystems: the Northern Continental Divide (NCDE), Greater Yellowstone (GYE), Cabinet-Yaak (CYE), and Selkirk (SE) ecosystems. There are currently no known populations in the North Cascades and Bitterroot (BE) ecosystems and no known populations outside these defined ecosystems, although we have documented bears, primarily solitary, outside these ecosystems. Ecosystems are generally considered to be the larger area surrounding the recovery zones in which grizzly bears may be anticipated to occur as part of the same population.

Summary of Needs

In general, a grizzly bear's individual habitat needs and daily movements are driven by the search for food, mates, cover, security, or den sites. All life stages need large intact blocks of land to breed, feed, shelter and disperse; cover to shelter; high-caloric foods to feed and breed;

and dens as winter shelter. For the purposes of this model, breeding includes all stages of reproduction. In order to be resilient, grizzly bear populations need sufficient abundance for genetic and demographic health, stable to positive population trends, high adult female survival, adequate survival of all other life stages, fecundity and recruitment that is at least equal to mortality that translates into stable to increasing population trends, and genetic diversity. Grizzly bears in the lower-48 States need multiple, resilient ecosystems distributed across a broad geographic range in order to be redundant and withstand catastrophic events. Additionally, grizzly bears in the lower-48 States need genetic and ecological diversity in order to preserve variation and the ability to adapt to changing conditions (Figure 2).

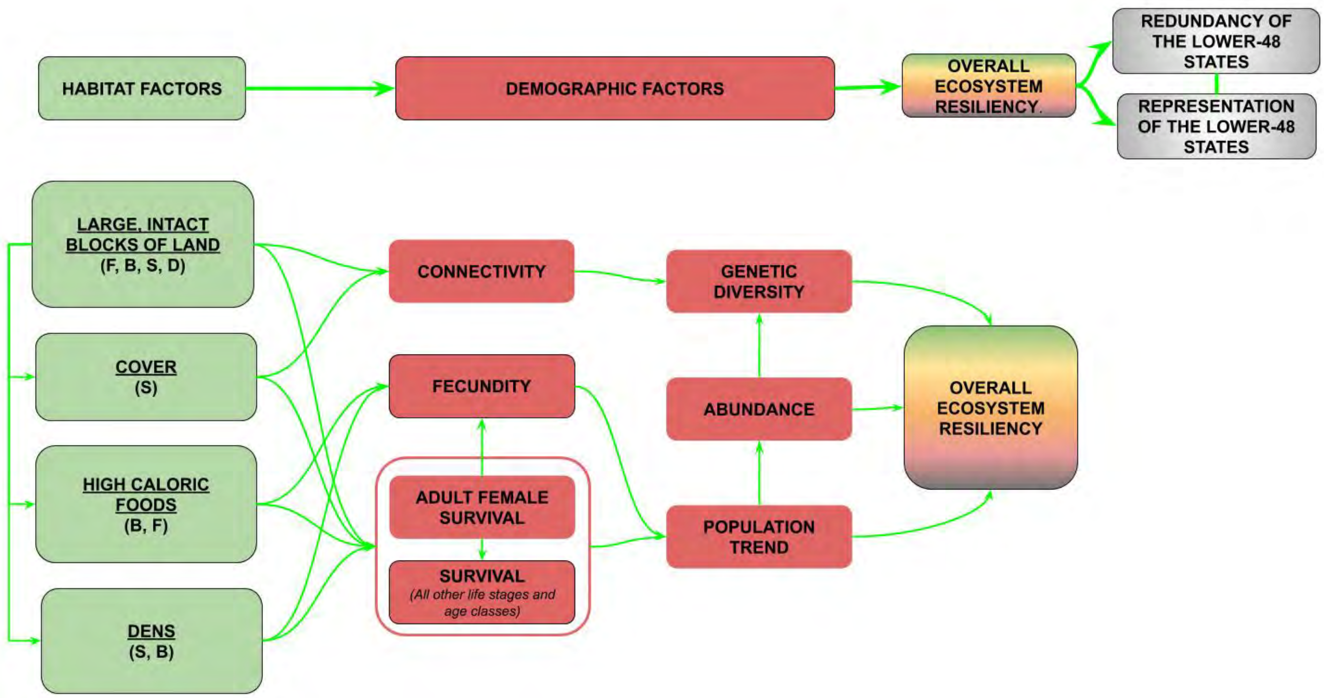

Figure 2. Conceptual model of needs for grizzly bear ecosystem resiliency, in terms of habitat factors (green boxes) needed by individuals to breed (B; includes all stages of reproduction), feed (F), shelter (S), and disperse (D), and demographic factors (red boxes) that ecosystems need to be resilient. Green arrows represent positive relationships between nodes. The core conceptual model for resiliency is provided at the top of the figure for reference.

Summary of Cause-and-Effects

We evaluated sources, stressors, and other activities that can positively (conservation actions) or negatively (stressors) affect grizzly bears at the individual, ecosystem, or lower-48 States levels, either currently or into the future (Chapter 5). We also evaluated the potential cumulative effects of stressors that may act together in concert to influence ecosystem resiliency. A stressor is defined as the potential change in demographics, such as an increase in human-caused mortality, or the habitat resources needed by the species, such as a decrease in high-caloric foods that causes a demographic response such as a decrease in abundance. We evaluated the potential effects of three categories of stressors on the grizzly bear: those with habitat-related effects; sources of human-caused mortality; and other stressors. These stressors are interrelated to varying degrees (e.g., habitat stressors around motorized access are related to both habitat and human-caused mortality). Stressors with potential habitat-related effects include: motorized access and its management; developed sites; livestock allotments; mineral and energy development; recreation; vegetation management; habitat fragmentation; development on private lands; and activities that may disturb dens. Sources of human-caused mortality that we evaluated include: management removals; accidental killings (e.g., train and vehicular strikes); mistaken identity kills; illegal killings; and defense of life kills. We also evaluated other stressors including: disease; natural predation and mortality; lack of connectivity and low genetic health; changes in food resources; effects of climate change; and catastrophic events, such as earthquakes and volcanic eruptions. There are a variety of conservation efforts and mechanisms across the six ecosystems that either reduce or ameliorate stressors, or improve the condition of habitats or demographics, such that the stressor does not individually or cumulatively effect the resiliency of an ecosystem. These conservation efforts or mechanisms include: Federal land protections, such as the Wilderness Act and Inventoried Roadless Areas (IRAs); State and private forestlands with motorized restrictions; habitat improvements/vegetation management; attractant removal and community sanitation measures, such as food storage orders; conservation easements; information and education (I&E) programs; effective law enforcement; and augmentation or translocation programs.

We developed a conceptual model to illustrate the relationships between the stressors, conservation effects, and their potential influence on ecosystem resiliency (Figure 3). Then, we evaluated the potential effects of the stressors on ecosystem resiliency, considering current and future conservation efforts.

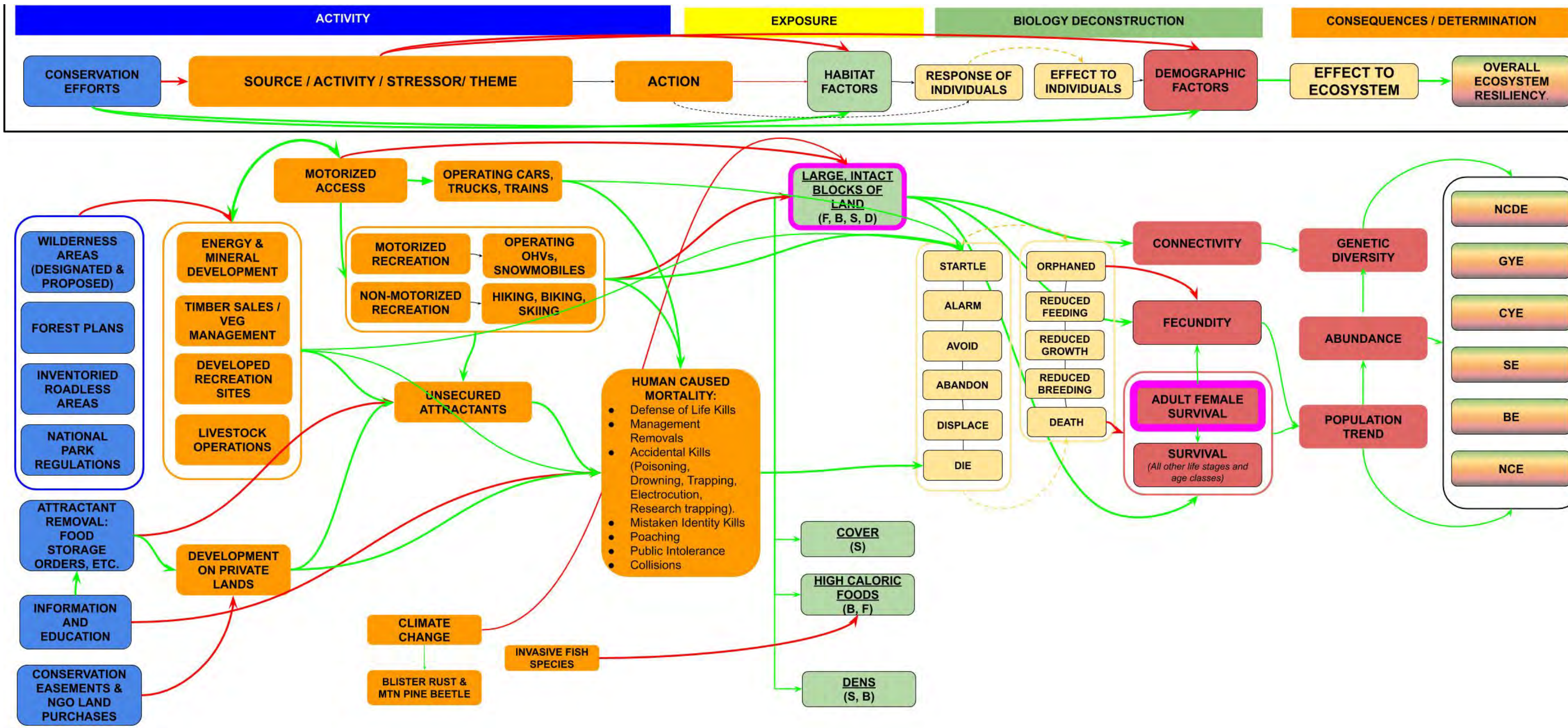

Figure 3. A conceptual model for the primary causes-and-effects (stressors and conservation efforts) that may the resiliency of grizzly bear ecosystems in the lower-48 States. The core conceptual model for resiliency at the top of the figure has been expanded to include activity and exposure pathways and is included for reference. We also evaluated potential effects of natural predation and mortality, connectivity and genetic health, catastrophic events such as earthquakes and volcanic eruptions, potential future effects associated with legal hunting, which are not displayed in this conceptual model. Green arrows represent positive relationships between nodes and red arrows represent negative relationships between nodes. B = breeding (includes all stages of reproduction); F = feeding; S = sheltering; D = dispersal.

Summary of Current Condition

To evaluate resiliency for each ecosystem, we developed a categorical model, called a condition category table, to calibrate resiliency based on a range of conditions for two habitat factors (natural, high-caloric foods and large intact blocks of land) and six demographic factors (adult female survival, abundance as measured by population targets and number of bears, population trend, fecundity, inter-ecosystem connectivity, and genetic diversity). We selected these habitat and demographic factors based on their importance to resiliency and because we had information to evaluate them relatively consistently across all six ecosystems. We then used the condition category table like a key to evaluate resiliency for each ecosystem by systematically evaluating the condition for each habitat and demographic factor. To calculate an overall score for resiliency, we assigned weighted values to the resiliency categories and then calculated a weighted average of the habitat and demographic factor ranking. We weighted the demographic factor for abundance as measured by the estimated number of bears, three times, due to its relative importance to the resiliency of each ecosystem and to balance its weight proportionally to four other demographic factors (Figure 4).

$$\begin{aligned}\boldsymbol{Overall\ Resiliency}\\ = (&\boldsymbol{High\ Caloric\ Foods}\\ &+ \boldsymbol{Large\ Intact\ Blocks\ of\ Land}\\ &+ \boldsymbol{Adult\ Female\ Survival}\\ &+ \boldsymbol{Population\ Target}\ + \mathbf{3}\\ &* (\boldsymbol{Number\ of\ Bears})\\ &+ \boldsymbol{Population\ Trend}\\ &+ \boldsymbol{Fecundity}\\ &+ \boldsymbol{InterEcosystem\ Connectivity}\\ &+ \boldsymbol{Genetic\ Diversity})/\mathbf{11}\end{aligned}$$

<u>Calculation of Thresholds for Overall Resiliency Condition</u>

Max Score	4	
Intervals	0.8	
	Min	**Max**
High (4)	3.2	4
Moderate (3)	2.4	3.2
Low (2)	1.6	2.4
Very Low (1)	0.8	1.6
Extirpated – X (0)	0.0	0.8

Figure 4. Formula and thresholds used to calculate an overall score for resiliency for each ecosystem based on our evaluation of condition for the two habitat factors and six demographic factors.

Table 1. Condition category table (categorical model) used to evaluate resiliency for the six ecosystems of grizzly bear in the lower-48 States, based on the condition of two habitat factors and six demographic factors.

<table>
<tr><th rowspan="3">Resiliency Categories</th><th colspan="2">Habitat Factors</th><th colspan="7">Demographic Factors</th></tr>
<tr><th rowspan="2">Natural, High-Caloric Foods</th><th rowspan="2">Large, intact blocks of land</th><th rowspan="2">Adult Female Survival</th><th colspan="2">Abundance</th><th rowspan="2">Population Trend</th><th rowspan="2">Fecundity</th><th rowspan="2">Inter-Ecosystem Connectivity</th><th rowspan="2">Genetic Diversity</th></tr>
<tr><th>Population Target</th><th>Number of Bears (3x)</th></tr>
<tr><td>Evaluation Metrics</td><td>Body fat data, stable isotope analysis, and/or direct monitoring of food sources</td><td>Status of meeting various habitat standards; existence of other protections that ensure habitat security</td><td>Estimate survival rates using using peer reviewed methodology[1]</td><td>Recovery criteria and/or Conservation Strategies indicate population target; the methods we use to estimate the number of bears depends on the ecosystem</td><td>The methods we use to estimate the number of bears varies by ecosystem</td><td>The method we use to estimate population trend varies by ecosystem and reflects long-term trend.</td><td>A BMU is occupied by a reproductive female at least once in a 6-year window</td><td>Monitor immigration into ecosystems during the most recent generational interval (10 to 15 years) (through radio-collared bears, DNA sampling, marked individuals)</td><td>Effective population size, heterozygosity, allelic richness, inbreeding rates</td></tr>
<tr><td>High (4)</td><td>Diverse, high-caloric, natural foods are not limiting</td><td>Availability of secure habitat is sufficient to meet individual needs</td><td>Survival rate is above 0.93</td><td>At or above target</td><td>More than 800 bears</td><td>Lambda greater than 1</td><td>All BMUs within the recovery zone are occupied</td><td>Females have immigrated and bred (demonstrating demographic connectivity)</td><td>Sufficient for long-term fitness</td></tr>
<tr><td>Moderate (3)</td><td>Diverse, high-caloric, natural foods are somewhat limiting</td><td>Availability of secure habitat to meet individual needs is somewhat limiting</td><td>Survival rate is between 0.90–0.93</td><td>80–99 percent of target</td><td>400–799 bears</td><td>Lambda is stable or slightly declining (between 0.98 and 1)</td><td>70–99% of the BMUs within the recovery zone are occupied</td><td>Males have immigrated and bred (demonstrating genetic connectivity)</td><td>Sufficient for short-term fitness</td></tr>
<tr><td>Low (2)</td><td rowspan="2">Diverse, high-caloric, natural foods are limiting</td><td rowspan="2">Availability of secure habitat to meet individual needs is limiting</td><td rowspan="2">Survival rate is below 0.90</td><td>50–79 percent of target</td><td>91–399 bears</td><td rowspan="2">Lambda is below 0.98</td><td>50–69% of the BMUs within the recovery zone are occupied</td><td>Evidence of an immigrant that has established a home range within the ecosystem but no documented breeding</td><td>Sufficient for short-term fitness, but with high levels of inbreeding</td></tr>
<tr><td>Very Low (1)</td><td>Less than 50 percent of the target and has evidence of reproduction.</td><td>Fewer than 90 bears and a known population</td><td>Less than 50% of the BMUs are occupied</td><td>Immigrant is documented within the ecosystem but no evidence of home range establishment or breeding</td><td>Insufficient for short-term or long-term fitness</td></tr>
<tr><td>Extirpated (0)</td><td>Diverse, high-caloric, natural foods are absent</td><td>There is no secure habitat</td><td>No known population</td><td>No known population</td><td>No known population</td><td>No known population</td><td>No BMUs occupied</td><td>No connectivity</td><td>No known population</td></tr>
</table>

[1] Data from radio-collared individuals is currently used to estimate survival rates.

Table 2 summarizes our evaluation of current resiliency for each ecosystem. Currently, the NCDE and GYE have high resiliency due to the generally high and moderate conditions for habitat and demographic factors. The SE has moderate resiliency and the CYE has low resiliency primarily due to very low numbers of bears, although this factor could improve as bears reproduce and expand in the future (Table 2). Despite the moderate condition of habitats, without known populations, the BE and North Cascades are currently functionally extirpated, and therefore have no resiliency (Table 2). As a result, these two ecosystems also do not currently contribute to redundancy and representation.

Table 2. Current condition for six ecosystems for grizzly bear in the lower-48 States, evaluated used the condition category table for resiliency. We calculated an overall score for resiliency as the weighted average of all factors, with "number of bears" weighted three times due to its importance to resiliency. High=4, Moderate = 3, Low=2, Very Low=1, and Functionally Extirpated (X) = 0, with score thresholds as Moderate= 2.4–3.19, Low= 1.6–2.39, Very Low=0.8–1.59= Very Low Condition; and less than 0.79 = Functionally Extirpated (X) Condition. An X in number of bears results in an overall condition of X, regardless of the other factors. In general, ecosystems with higher resiliency have a greater probability of persistence over the next 30 to 45 years, based on their ability to withstand stochastic events, than ecosystems with lower resiliency.

CURRENT CONDITION										
	Habitat Factors		Demographic Factors							
Ecosystem	Natural, High-Caloric Foods	Large, intact blocks of land	Adult Female Survival	Abundance		Population Trend	Fecundity	Inter-Ecosystem Connectivity	Genetic Diversity	RESILIENCY
				Population Target	Number of Bears (3x)					
NCDE	High	High	High	High	High	High	Moderate	High	High	**High**
GYE	High	High	High	High	Moderate	High	High	X	Moderate	**High**
CYE	Moderate	Moderate	High	Low	Very Low	High	Low	Moderate	Low	**Low**
SE	Moderate	Moderate	Moderate	Moderate	Very Low	High	Moderate	Moderate	Moderate	**Moderate**
BE	Moderate	Moderate	X	X	X	X	X	Very Low	X	**X**
North Casca-des	Moderate	Moderate	X	X	X	X	X	X	X	**X**

Redundancy describes the number and distribution of ecosystems, such that the greater the number and the wider the distribution of the ecosystems, the better grizzly bears in the lower-48 States can withstand catastrophic events. Grizzly bears in the lower-48 States currently occupy four ecosystems, two with high resiliency, one ecosystem with moderate resiliency, and one ecosystem with low resiliency. Two ecosystems are currently functionally extirpated, with no resiliency, so do not contribute to redundancy. The four ecosystems are currently distributed from north to south and east to west as illustrated in Figure 5. Representation is currently captured by ecological diversity inherent within the four resilient ecosystems (Figure 5). For example, the GYE, contained in the Middle Rockies ecoregion, is dominated by forested, mountainous habitat, and dry sagebrush to the east and south, and includes hydrothermal features and other unique geologic features. The NCDE includes parts of the Great Plains, Middle Rockies, and Northern Rockies ecoregions, and habitat varies from wet forested lands west of Glacier Park to much drier habitat to the east, including prairie grasslands. The CYE and SE are both contained within the Rocky Mountains, and are characterized by wet, forested mountains. The BE is primarily contained in the Idaho Batholith ecoregion, and contains mountainous regions, canyons, dry, partly wooded mountains, grasslands, high glacial valleys, and hot dry canyons. The North Cascades is composed of high, rugged mountains, and has a high concentration of active glaciers.

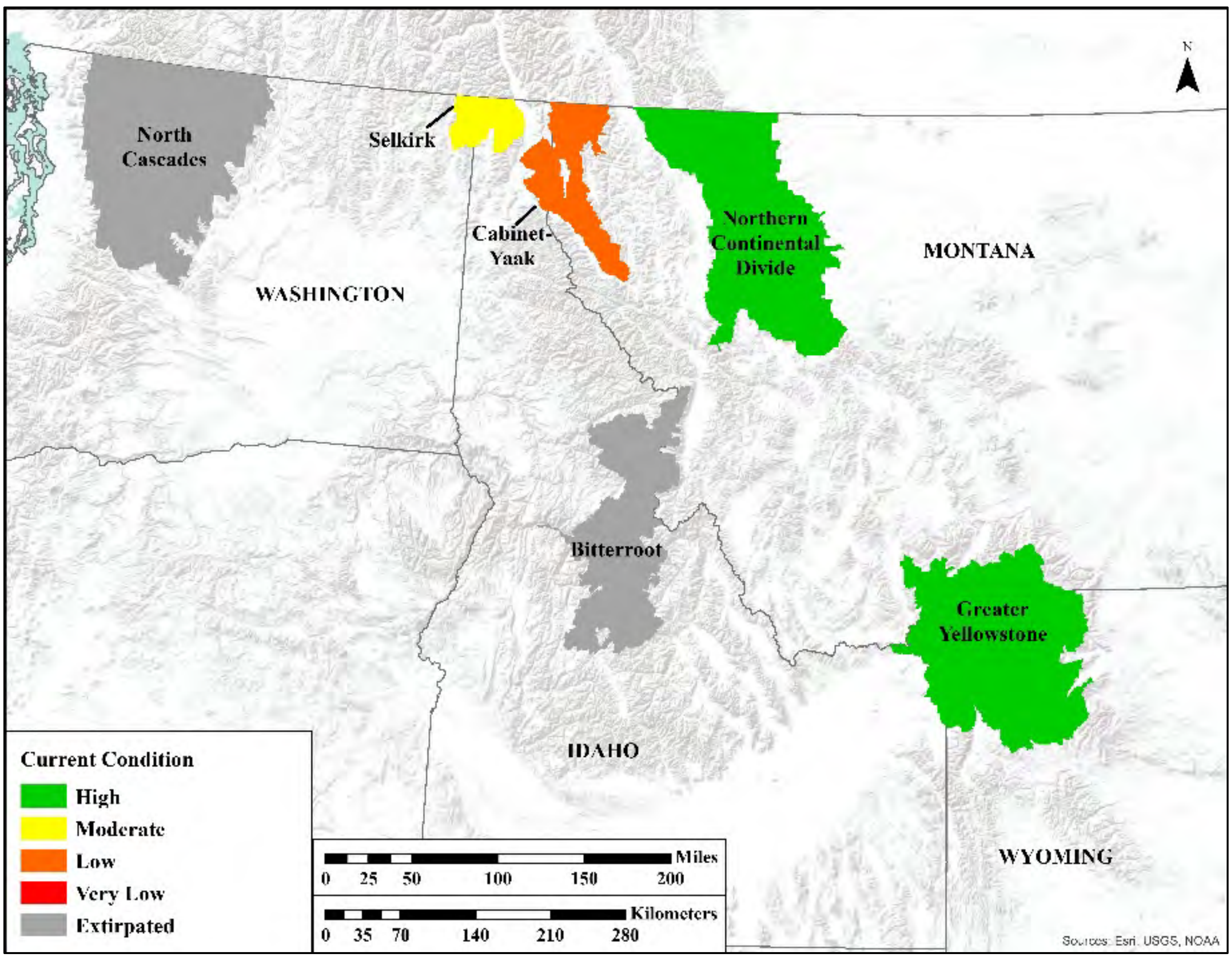

Figure 5. Map of the overall current condition for the six grizzly bear ecosystems in the lower-48 States, in terms of resiliency, redundancy, and representation. Colors represent the current resiliency for each ecosystem, based on the current condition of two habitat factors and six demographic factors for each ecosystem. Ecosystems with higher levels of resiliency are at less risk from environmental and demographic stochasticity. Currently, the Greater Yellowstone (GYE) and Northern Continental Divide (NCDE) ecosystems have high resiliency, the Selkirk ecosystem (SE) has moderate resiliency, and the Cabinet-Yaak ecosystem (CYE) has low resiliency. The North Cascades and Bitterroot (BE) ecosystems are in an extirpated condition currently, so have no resiliency. Four ecosystems (GYE, NCDE, SE, and CYE) distributed as illustrated on the map contribute to redundancy and these ecosystems feature a diversity of ecological types used by the grizzly bear for representation.

Summary of Future Conditions

We projected a range of plausible future conditions for the grizzly bear in the lower-48 States, 30 to 45 years into the future, a biologically meaningful timeframe that captures approximately two to three generation intervals for grizzly bear. A generation interval is defined for grizzly bears as the approximate time that it takes a female to replace herself in the population. For female grizzly bears, average generation intervals range from 10 to 15 years. Given the longevity of grizzly bears, up to 30 years in the wild, 2 to 3 generation intervals represent a time period during which a complete turnover of the population would have occurred and any positive or adverse changes in the demographics of the population would be detectable. This timeframe also considers the possibility that conservation measures that reduce and regulate potential stressors, such as land management plans, could be revised by applicable land management agencies at least once.

We used future scenario planning to describe plausible futures for the grizzly bear and to capture uncertainty associated with the future. We developed two pessimistic future scenarios, two optimistic future scenarios, and one continuation future scenario. These future scenarios that we used to project the condition for the grizzly bear in the lower-48 States are:

- **Future Scenario 1 – Significantly Decreased Conservation**: Under this scenario, conservation actions decrease significantly, largely through the termination or non-renewal of plans or regulations, and rate of private land development increases dramatically;
- **Future Scenario 2 – Decreased Conservation**: Under this scenario, conservation actions decrease, but not as significantly as Scenario 1, due to decreased effectiveness and implementation of conservation actions and mechanisms, and rate of private land development increases;
- **Future Scenario 3 – Continuation of Conservation:** Under this scenario, conservation actions continue at their same rate, magnitude, and effectiveness as current condition, and rate of private land development remains the same;
- **Future Scenario 4 – Increased Conservation:** Under this scenario, conservation actions increase or improve, and rate of private land development decreases, and rate of private land development decreases;
- **Future Scenario 5 – Significantly Increased Conservation:** Under this scenario, conservation actions increase significantly, and rate of private land development decreases dramatically.

Although there may be different probabilities associated with our future scenarios, all five of our scenarios are equally plausible for the purposes of our SSA analysis. Table 17 summarizes each of the future scenarios in more detail. We then used the same methodology that we used to evaluate current condition to project the resiliency for the six ecosystems 30 to 45 years into the future. We projected the future condition for the two habitat factors and six demographic factors for each of the five future scenarios and then calculated an overall resiliency score for each ecosystem under each scenario using the same weighted average. After evaluating resiliency, we then evaluated redundancy and representation for each future scenario.

With a significant decrease in conservation under Scenario 1, there are subsequent decreases in resiliency across the habitat and demographic factors over the next 30 to 45 years (Table 3). Both the NCDE and GYE decrease in overall resiliency from high to moderate, the SE declines from moderate to very low, and the CYE declines from low to very low. Although resiliency decreases, redundancy and representation remain the same under Scenario 1, with four ecosystems distributed similarly to current condition within their ecological types (Figure 6).

With a decrease in conservation efforts under Scenario 2, potential decreases in overall resiliency are less severe than under Scenario 1. Under Scenario 2, both the NCDE and GYE remain in high overall resiliency, the CYE remains in low resiliency, but the SE drops from moderate to low overall resiliency (Table 3). Although resiliency decreases, redundancy and representation remain the same under Scenario 2, with four ecosystems distributed similarly to current condition within their ecological types (Figure 6).

Under Scenario 3, the continuation scenario, all stressors and conservation efforts continue at their same rate and magnitude 30 to 45 years into the future. The current levels of funding and effectiveness and implementation of conservation actions and mechanisms stay the same under this scenario. As a result, the NCDE and GYE remain in high resiliency, the SE stays moderate resiliency, but the CYE improves in overall resiliency from low to moderate (Table 3). The BE and North Cascades ecosystems remain in a functionally extirpated condition, with no resiliency under the continuation scenario (Table 3). Redundancy and representation stay the same as current conditions under this scenario (Figure 6).

With an increase in conservation under Scenario 4, redundancy and representation improve, as both the BE and North Cascades shift from functionally extirpated condition with no resiliency to low resiliency. The NCDE and GYE remain in high resiliency, the SE remains moderate, and the CYE improves from low to moderate resiliency (Table 3). Risk from potential catastrophic events is now spread across six instead of four ecosystems (redundancy) with additional ecological diversity gained at the northwestern and central extents of the overall range (representation) (Figure 6).

Future Scenario 5 is an optimistic scenario under which conservation increases significantly. As a result, resiliency, redundancy, and representation for the grizzly bear improve. Under this scenario, the NCDE and GYE stay in high resiliency, but the CYE and SE improve to high resiliency. The BE and North Cascades shift from functionally extirpated condition with no resiliency to low resiliency under this scenario (Table 3). Four ecosystems have high resiliency under this scenario, and catastrophic risk is spread across six ecosystems (redundancy) with additional ecological diversity gained at the northwestern and central extents of the overall range (representation) (Figure 6).

Table 3. Current and future conditions in terms of overall resiliency for six ecosystems for the grizzly bear in the lower-48 States. NCDE= Northern Continental Divide Ecosystem, GYE= Greater Yellowstone Ecosystem, CYE= Cabinet-Yaak Ecosystem, SE= Selkirk Ecosystem, BE=Bitterroot Ecosystem. Future projections are 30 to 45 years into the future under five plausible future scenarios: Scenario 1= conservation decreases significantly, Scenario 2=conservation decreases, Scenario 3 = conservation stays the same, Scenario 4 = conservation increases, and Scenario 5 =conservation increases significantly.

CURRENT AND FUTURE RESILIENCY						
	Current Condition	Future Scenario 1 ↓↓ Conservation	Future Scenario 2 ↓ Conservation	Future Scenario 3 Continuation Conservation	Future Scenario 4 ↑ Conservation	Future Scenario 5 ↑↑ Conservation
NCDE	High	Moderate	High	High	High	High
GYE	High	Moderate	High	High	High	High
CYE	Low	V Low	Low	Moderate	Moderate	High
SE	Moderate	V Low	Low	Moderate	Moderate	High
BE	X	X	X	X	Low	Low
North Cascades	X	X	X	X	Low	Low

Currently, redundancy for the grizzly bear is described as four ecosystems, the NCDE, GYE, CYE, and SE, as they are distributed from north to south and east to west across the lower-48 States. Catastrophic risk is spread across these four ecosystems and their ecological diversity contributes to representation. Two ecosystems, the BE and North Cascades have no populations, are not resilient, so do not currently contribute to redundancy or representation. In 30 to 45 years, redundancy is maintained across the future scenarios and never falls below the four, currently resilient ecosystems as they are distributed. Although redundancy stays the same from now to the future, if conservation efforts decrease, as under Scenarios 1 and 2, resiliency decreases, and the four ecosystems are at greater risk to stochastic events. But if conservation efforts increase, as under Scenarios 4 and 5, resiliency in the BE and North Cascades improves, as does redundancy, as the number and distribution of ecosystems increases from four to six ecosystems. This improvement in redundancy reduces risk to the grizzly bear from catastrophic events (Table 4). To summarize redundancy across the future scenarios, catastrophic risk to the grizzly bear stays the same if conservation efforts continue at their current rate and effectiveness, catastrophic risk decreases with increased conservation as the BE and North Cascades have low resiliency, and catastrophic risk increases if conservation efforts are reduced. Representation declines with decreases in conservation efforts, stays the same with a continuation of conservation efforts, but ecological diversity increases if conservation efforts increase primarily through improving resiliency of the BE and North Cascades ecosystems.

Our SSA characterizes the viability for the grizzly bear in the lower-48 States, or its ability to sustain populations in the wild over time, based on expert judgement and the best scientific understanding of its current and future abundance, distribution, and diversity. Based on our assessment of the 3Rs, currently and 30 to 45 years into the future, viability for the grizzly bear in the lower-48 States improves slightly if conservation efforts continue at their current rate and levels of effectiveness. If conservation efforts declines, viability also decreases. If conservation efforts increase, viability improves.

Table 4. Summary of current and future (30 to 45 years) viability, in terms of resiliency, redundancy, and representation, for the grizzly bear in the lower-48 States.

VIABILITY: CURRENT AND FUTURE 3Rs						
	Current Condition	***Future Scenario 1*** ↓↓ ***Conservation***	***Future Scenario 2*** ↓ ***Conservation***	***Future Scenario 3*** ***Continuation Conservation***	***Future Scenario 4*** ↑ ***Conservation***	***Future Scenario 5*** ↑↑ ***Conservation***
Resiliency	2 High 1 Moderate 1 Low 2 Extirpated	2 Moderate 2 Very Low 2 Extirpated	2 High 2 Low 2 Extirpated	2 High 2 Moderate 2 Extirpated	2 High 2 Moderate 2 Low	4 High 2 Low
Redundancy	4 ecosystems, as distributed	4 ecosystems, as distributed	4 ecosystems, as distributed	4 ecosystems, as distributed	6 ecosystems, as distributed	6 ecosystems, as distributed
Representation	Ecological diversity across 4 ecosystems	Ecological diversity across 4 ecosystems	Ecological diversity across 4 ecosystems	Ecological diversity across 4 ecosystems	Ecological diversity across 6 ecosystems	Ecological diversity across 6 ecosystems

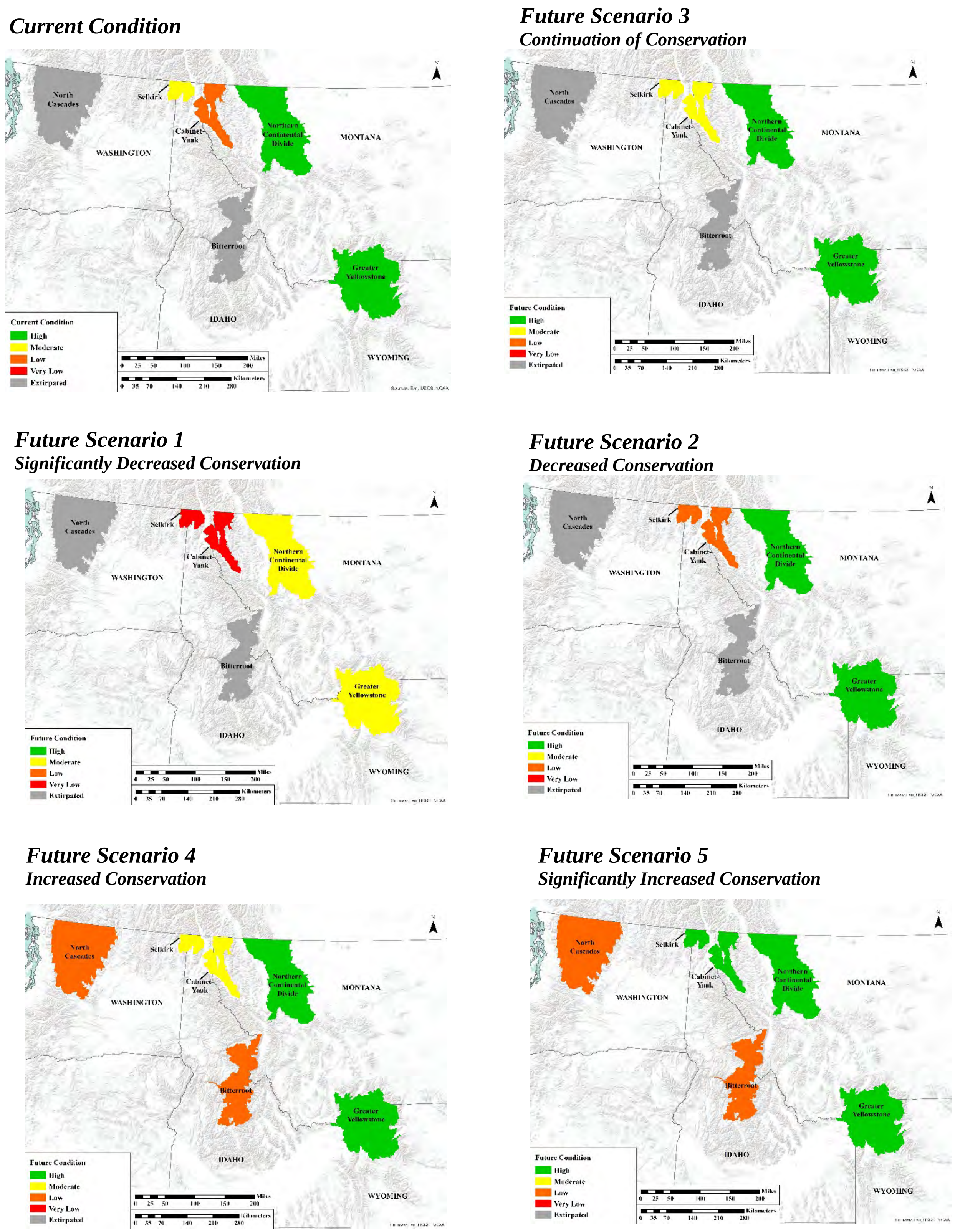

Figure 6. Current and future (30 to 45 years) conditions for resiliency, redundancy, and representation for grizzly bear in the lower-48 States.

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List of Acronyms

ARM	Administrative Rule of Montana
B.C.	British Columbia
BE	Bitterroot Ecosystem
BIR	Blackfeet Indian Reservation
BLM	Bureau of Land Management
BMU	Bear Management Unit
BORZ	Bears Outside Recovery Zone
CS&KT	Confederated Salish and Kootenai Tribes
CYE	Cabinet-Yaak Ecosystem
DCA	Demographic Connectivity Area
DMA	Demographic Monitoring Area
DNRC	Montana Division of Natural Resources Conservation
DPS	Distinct Population Segment
EIS	Environmental Impact Statement
FIR	Flathead Indian Reservation
GNP	Glacier National Park
GTNP	Grand Teton National Park
GYE	Greater Yellowstone Ecosystem
HCP	Habitat Conservation Plan
I&E	Information and Education
IDFG	Idaho Department of Fish and Game
IGBC	Interagency Grizzly Bear Committee
IGBST	Interagency Grizzly Bear Study Team
IPCC	Intergovernmental Panel on Climate Change
IRA	Inventoried Roadless Area
JDR	John D. Rockefeller Memorial Parkway
MFWP	Montana Fish, Wildlife, and Parks
NCDE	Northern Continental Divide Ecosystem
NF	National Forest
NGO	Nongovernmental organizations
NPS	National Park Service
NRA	National Recreation Area
OMRD	Open Motorized Route Density
ROD	Record of Decision
SE	Selkirk Ecosystem
Service	U.S. Fish and Wildlife Service
SSA	Species Status Assessment
TMRD	Total Motorized Route Density
TRU	Total reported and unreported
USDA FS	U.S. Department of Agriculture Forest Service
USDOI	U.S. Department of the Interior

USFS	U.S. Forest Service
USGS	U.S. Geological Survey
WDFW	Washington Department of Fish & Wildlife
WGFD	Wyoming Game and Fish Department
WRR	Wind River Reservation
WSA	Wilderness Study Area
YES,	Yellowstone Ecosystem Subcommittee
YNP	Yellowstone National Park

Chapter 1: Introduction and Analytical Framework

This species status assessment (SSA) report summarizes the biology, life history, ecology, and stressors (threats) for the grizzly bear (*Ursus arctos horribilis*) in the conterminous (lower-48) United States (hereafter, grizzly bear). This report also summarizes the results of a biological risk assessment for the grizzly bear, using the SSA framework (Service 2016, entire; Smith *el al*. 2018, entire). The SSA framework is an analytical approach to deliver foundational science to help inform the Service's decisions under the Act (Service 2016, p. 4). This SSA report is intended to provide a clear, in-depth characterization of the species' biology and ecology; the influence of environmental stressors and conservation management actions on the species' viability; its current biological status, also called its "current condition;" and its projected, plausible future biological status, also called its "future condition," under a range of future scenarios. Viability describes the ability of a species to sustain populations in the wild over time (Service 2016, p. 9). This SSA report for the grizzly bear provides foundational scientific information to help inform recovery planning and the U.S. Fish and Wildlife Service's (Service's) responsibilities under the Act, including a 5-year status review and other actions, as needed. This SSA report is a living document and can be easily updated as new scientific information becomes available in order to best support all functions of our Endangered Species program.

Figure 7. The SSA framework's three basic stages (Service 2016, p. 6).

Importantly, this SSA report does not make any decisions by the Service, such as whether a species' status under the Act should be changed. It is not a decision document constituting a final agency action. Instead, this SSA report provides a review of the best available scientific and commercial information regarding the biological status, or condition, of the grizzly bear. Thus, this SSA report is a stand-alone, science-based document produced independently from the Service's application of policy or regulation, and it provides a review of the available information strictly related to the life-history, ecology, stressors, and current and future viability of the grizzly bear. Any decisions under the Act, such as a 5-year status review recommendation, will be made by the Service after reviewing this document and all relevant laws, regulations, and policies, and the results of any decisions to change status will be announced in the *Federal Register*, with opportunities for public input, if appropriate.

The SSA framework has three, iterative assessment phases, as summarized below and illustrated above in Figure 7.

- Phase I: Species' Needs – An SSA begins by describing the ecological needs of the species at the individual, population, and species levels based on how environmental factors act on the species and its habitat.

- Phase II: Current Species' Condition – Next, an SSA describes the current condition of the species' habitat and demographic needs, and the probable explanations for past and ongoing changes in the abundance of populations the distribution and diversity of the species.
- Phase III: Future Species' Condition – Lastly, as SSA projects the species' response to probable future scenarios of environmental conditions and conservation efforts.

As a result, the SSA characterizes the species' viability, or its ability to sustain populations in the wild over time, based on the best scientific understanding of its current and future abundance, distribution, and diversity (Service 2016, p. 6).

Throughout this report, we describe the needs and viability of the grizzly bear in terms of the conservation biology principles of resiliency, redundancy, and representation, collectively known as the 3Rs (Shaffer and Stein 2000, pp. 307–310; Wolf *et al.* 2015, entire; Service 2016, pp. 12–13, 21; Smith *et al.* 2018, entire). The 3Rs are defined as follows:

- **Resiliency** is the ability for populations to persist in the face of stochastic events, or for populations to recover from years with low reproduction or reduced survival, and is associated with population size, growth rate, and the quality and quantity of habitats. Resiliency is positively related to abundance (population size) and growth rate and may be influenced by connectivity between populations. Populations need an abundance of individuals within habitat patches of adequate quantity and quality to survive and reproduce despite disturbance (Service 2016, p. 12).

- **Redundancy** is the ability for the species to withstand catastrophic events, such as a rare destructive natural event or episode involving many populations for which adaptation is unlikely and is associated with the number and distribution of populations. Redundancy is about spreading risk among multiple populations to minimize potential loss of the species from catastrophic events and is characterized by having multiple, resilient populations distributed within the species' ecological settings and across the species' range. Redundancy can be measured by the number of populations, their spatial extent, and degree of connectivity.

- **Representation** is the ability of a species to adapt to changes in the environment over time and is associated with its diversity, whether ecological, genetic, behavioral, or morphological. It is characterized by the breadth of genetic and environmental diversity within and among populations and measures of representation may include the number of varied occupied niches, genetic diversity, heterozygosity, alleles per locus, or other geographic, genetic, or life history variation of the species.

In general, species risk will decrease, or at least does not increase, with increases in representation, resiliency, and redundancy. In other words, the more redundant and representative the species is, and the more resilient its populations, the more likely the species is to sustain populations over time, even under changing environmental conditions. We use the 3Rs together to characterize the current and projected future viability for the grizzly bear. For the purpose of this assessment, we define viability as the ability of the grizzly bear to sustain populations in natural ecosystems over a biologically meaningful timeframe, in this case, by approximately the middle of the 21st century (2050 to 2065). Viability is not a specific state, but rather a continuous measure of the likelihood that the species will sustain populations over time (Service 2016, p. 9). Therefore, exploring and describing the relationships of what influences the 3Rs given the species' unique life history does not result in a conclusion on whether the species is viable, but instead sets out foundational relationships used to explore potential changes from the species' current condition to its projected future conditions (Service 2016, p. 13). In addition, the term viability denotes a trajectory opposite to extinction and a focus on species conservation (Service 2016, p. 9). The 2050 to 2065 timeframe for this assessment is a period that allows us to reasonably project the duration of conservation efforts due to the typical duration of forest plans, potential effects of various stressors, and accounts for approximately two to three generation intervals of grizzly bear. This timeframe is consistent with the time scale for which we have data available for the grizzly bear and for which we can project conservation actions.

In this SSA report, we:

- First summarize grizzly bear biology, including its taxonomy, historical and current distribution, its habitat, life history, and life cycle (Chapter 2);
- Then summarize our regulatory history with grizzly bears and ongoing recovery efforts and conservation partnerships (Chapter 3);
- Then describe the ecological needs at the individual, population, and species (lower-48 States) levels in terms of resiliency, redundancy, and representation (Chapter 4);
- Identify known stressors (threats) that negatively influence viability and the conservation actions that positively influence viability (Chapter 5);
- Then describe the current condition, also in terms of the resiliency of ecosystems, and the redundancy and representation for the grizzly bear (Chapter 6); and
- Finally, we project the response of the grizzly bear to probable future scenarios of environmental conditions and conservation efforts (Chapter 7) and summarize a comparison of projected future conditions with current condition (Chapter 8).

The Service's decisions under the Act are based on an assessment of a species' risk of extinction. This SSA report is intended to inform an assessment of extinction risk by describing the grizzly bear's current biological status (Chapter 6) and assessing how this status may change in the future under a range of plausible future scenarios (Chapter 7). We evaluate the current biological status of the grizzly bear by assessing the factors that positively and negatively affect the grizzly bear (Chapter 5) and describe the current condition of the species in terms of the 3Rs (Chapter 6). We then evaluate the future biological status by describing a range of plausible future scenarios representing a range of conditions for the primary factors affecting the species and forecasting the future condition for each scenario in terms of the 3Rs (Chapter 7).

Core Conceptual Model for Viability used for the SSA

For our assessment of viability, we relied on the SSA framework's core conceptual model for resiliency to describe the current and future viability of grizzly bears in the lower-48 States, in terms of the 3Rs (Service 2016, p. 10; Smith *et al.* 2018, entire) (Figure 8). This conceptual model illustrates the relationship between habitat factors that are important to individuals, demographic factors that are important to populations, the resiliency of these populations, and the redundancy and representation at the species-level. As described in more detail below, for this SSA, we refer to populations of grizzly bear in the lower-48 States as ecosystems. Habitat factors are those resources needed by individual grizzly bears to breed (including all stages of reproduction), feed, shelter, and survive from one stage in its life cycle to the next and allow successful dispersal of some individuals. Demographic factors include abundance and trends that ecosystems need to be resilient to stochastic events. In general, a species needs a certain number and distribution of resilient populations in order to withstand catastrophes (redundancy) and diversity to adapt to novel, environmental change (representation).

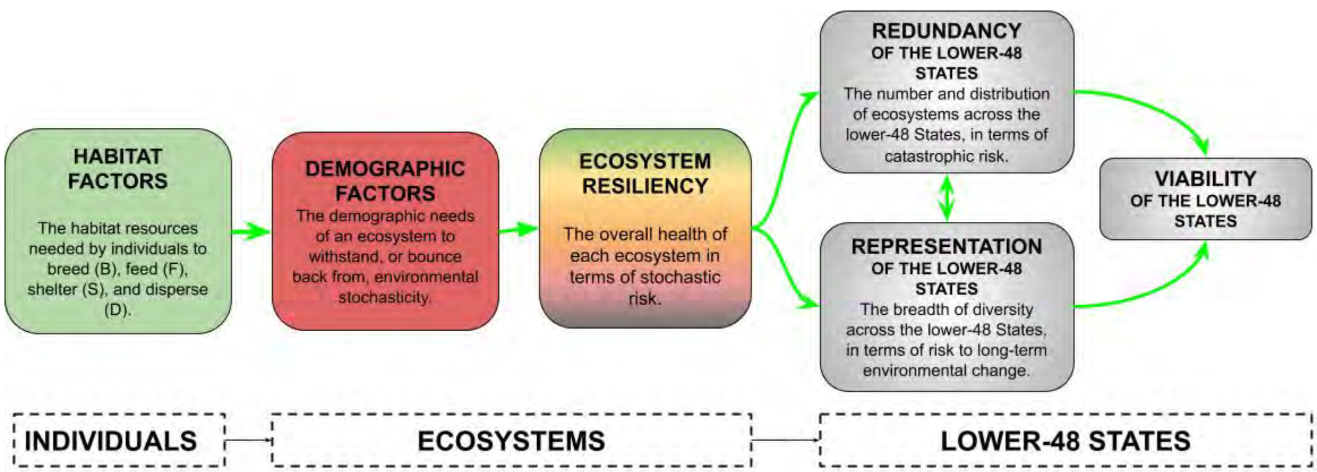

Figure 8. Simple core conceptual model used for our analysis of viability for grizzly bear in the lower-48 States, in terms of the 3Rs of conservation biology: resiliency, redundancy, and representation. Throughout this report, habitat factors are illustrated in green and demographic factors in red. Model based on the core conceptual model for the species status assessment (SSA) framework (Service 2016, p. 10). Throughout our assessment, ecosystems are synonymous with populations and are the scale at whch we evaluated the 3Rs.

Ecosystems to Evaluate the 3Rs

According to the SSA framework, at the population level we describe the resources, circumstances, and demographics that most influence the resiliency of a population. These may vary if populations are distributed across different ecological settings. Species viability corresponds to the resiliency of its populations, and therefore, it is necessary to understand and determine for the analysis how populations should be defined for the subject entity of the SSA analysis. For some species, identifying population structures or other delineations, may be helpful and necessary in order to evaluate resiliency (Service 2016, p. 12).

As described below in Chapter 3 under *Geographic Boundaries for Recovery Planning*, Federal, State, and Tribal partners have delineated a variety of geographic boundaries on maps, such as recovery zones, to illustrate areas important to grizzly bear recovery planning, and where grizzly bear populations occur. For the purposes of our SSA, we refer to populations of the grizzly bear in the lower-48 States as ecosystems. Therefore, we evaluated resiliency, redundancy, and representation at the scale of these ecosystems. As described in our recovery planning documents, ecosystems are areas that have the potential to provide adequate space and habitat to maintain the grizzly bear as a viable and self-sustaining species (Service 1993, p. 33). The plan acknowledged that linkage would be necessary for isolated populations to increase and sustain themselves at recovery levels (Service 1993, pp. 23, 24). Ecosystems are generally considered to be the larger area surrounding the recovery zones in which grizzly bears may be anticipated to occur as part of the same population. For this assessment, we evaluated the 3Rs at the scale of the six ecosystems identified in the 1993 Recovery Plan (Service 1993), as described below (Figure 9):

1. The **Greater Yellowstone Ecosystem (GYE)** is located in northwest Wyoming, eastern Idaho, and southwestern Montana and refers to the larger ecological system containing and surrounding Yellowstone National Park (YNP). The GYE includes portions of five National Forests (NFs); YNP, Grand Teton National Park (GTNP), and the John D. Rockefeller Memorial Parkway (JDR; administered by GTNP); and State, Tribal, and private lands. The GYE is generally defined as those lands surrounding YNP with elevations greater than 1,500 meters (m) (4,900 feet (ft)) (see U.S. Department of Agriculture Forest Service (USDA FS) 2004, p. 46; Schwartz *et al.* 2006b, p. 9). While we consider the terms “Greater Yellowstone Area” and “Greater Yellowstone Ecosystem” to be interchangeable, we use GYE. In the GYE, plant communities vary from grasslands at lower elevations (less than 1,900 m (6,230 ft)) to conifer forests at mid-elevations and subalpine and alpine meadows at higher elevations (greater than 2,400 m (7,870 ft));

2. The **Northern Continental Divide Ecosystem (NCDE)** is located in northwest Montana and refers to the larger ecological system containing and surrounding Glacier National Park (GNP) and is the southern portion of a larger Rocky Mountain divide population that spans the U.S.-Canada border. The NCDE also includes portions of four NFs (the Flathead, Helena-Lewis and Clark, Kootenai, and Lolo), State, Bureau of Land Management (BLM), Tribal, and private lands. The NCDE is part of the Canadian Rockies, Middle Rockies, Northern Rockies, Northwestern Glaciated Plains, and Northwestern Great Plains ecoregions (Woods *et al.* 1999, entire). Plant communities vary from short grass prairie and wheat fields at lower elevations (less than 1,900 m (6,230 ft)) on the eastern foothills to extensive conifer forests at mid-elevation and subalpine and alpine meadows at higher elevations (greater than 2,400 m (7,870 ft)) in the mountainous core;

3. The **North Cascades Ecosystem (North Cascades)** constitutes a large block of contiguous habitat that spans the international border but is isolated from grizzly bear populations in other parts of the U.S. and Canada. The U.S. portion of the ecosystem is bounded roughly by the Okanogan Highlands and Columbia Plateau on the east, Snoqualmie Pass to the south, the Puget lowlands to the west, and the Canadian border to the north. The recovery zone encompasses all of North Cascades National Park Complex (North Cascades National Park, Ross Lake National Recreation Area (NRA), and Lake Chelan NRA), portions of two NFs (the Mount Baker-Snoqualmie, and Okanogan-Wenatchee), State, Tribal, and private lands. The ecosystem spans the crest of the Cascade Range from the temperate rainforests of the west side to the dry ponderosa pine forests and sage-steppe on the east side, and comprises one of the most intact wildlands in the contiguous United States;

4. The **Selkirk Ecosystem (SE)** refers to the larger ecological system surrounding the recovery zone in northwest Idaho, northeast Washington, and southeast British Columbia (B.C.). SE includes portions of two NFs (the Idaho Panhandle and Colville), State, Tribal, and private lands. The SE recovery zone includes part of Canada because the habitat in the U.S. portion was thought to not be of sufficient size to support a minimum population (Service 1993, p. 12) and the biological population (comprised of contiguous occupied habitat) extends into Canada up to B.C. Highways (Hwys.) 3 and 3A (Proctor *et al* 2005, p. 2410; Proctor *et al.* 2012, p. 14). However, because the grizzly bear in the lower-48 States is the listed entity and the subject of this biological report, we did not consider grizzly bears in Canada as part of our analysis except when the best available data for the relevant demographic factors, such as population trend and abundance, include the Canadian portion of this ecosystem in their estimation. We acknowledge this assumption in our evaluation of current and future condition. The SE ranges in elevation from 540 m (1,772 ft) to 2,375 m (7,792 ft), and includes vegetation dominated by various forested types;

5. The **Cabinet-Yaak Ecosystem (CYE)** refers to the larger ecosystem surrounding the recovery zone in northwest Montana and northeast Idaho. It includes portions of three NFs (the Kootenai, Idaho Panhandle, and Lolo), State, and private lands. The Kootenai River bisects the CYE, with grizzly bear habitat within the Cabinet Mountains to the south and the Yaak River drainage to the north, which has partially isolated the Cabinet portion of this ecosystem from a bear movement and breeding perspective (Proctor *et al.* 2012, p. 14; Kasworm *et al.* 2020, p. 32). The Yaak portion of this ecosystem extends into Canada to B.C. Hwy. 3 in what is contiguous occupied habitat (Proctor *et al.* 2005, p. 2410; Proctor *et al.* 2012, p. 14; Kasworm *et al.* 2020, p. 32). Elevations range from 610 m (2,001) to 2,664 m (8740 ft), and vegetation is diverse with climax forest species, open huckleberry shrub fields, and lush riparian meadows throughout the area;

6. The **Bitterroot Ecosystem (BE)** refers to the larger ecological system surrounding the recovery zone in central Idaho and western Montana, and includes portions of four NFs (the Nez Perce-Clearwater, Bitterroot, Lolo, and Salmon-Challis), State, and private lands (Service 1996, p. 1; 65 FR 69624, November 17, 2000; Service 2000, pp. 1–3). The recovery zone encompasses two large wilderness areas and is one of the largest

contiguous blocks of public land remaining in the lower-48 States. Elevations range from 457 m (1,500 ft) along the Clearwater River to 3,859 m (12,662 ft) on Borah Peak. Vegetation communities range from dry pine forests in the south to wetter cedar-hemlock forests primarily in the north.

Because the currently listed entity for grizzly bear is the entire lower-48 United States (40 FR 31734, July 28, 1975; 50 CFR 17.11), we discuss historical range in the lower-48 States in addition to these six ecosystems in *Historical Range and Distribution*, below (Figure 14). Records show that grizzly bears historically existed throughout all or portions of only 18 western States (i.e., Washington, Oregon, California, Idaho, Montana, Wyoming, Nevada, Colorado, Utah, New Mexico, Arizona, North Dakota, South Dakota, Minnesota, Nebraska, Kansas, Oklahoma, and Texas) (Servheen 1989, pp. 1–2; Service, p. 9; Servheen 1999, pp. 50–51). The original 1975 listing erroneously includes areas outside this historical range; therefore, we exclude these erroneously included areas from our analysis.

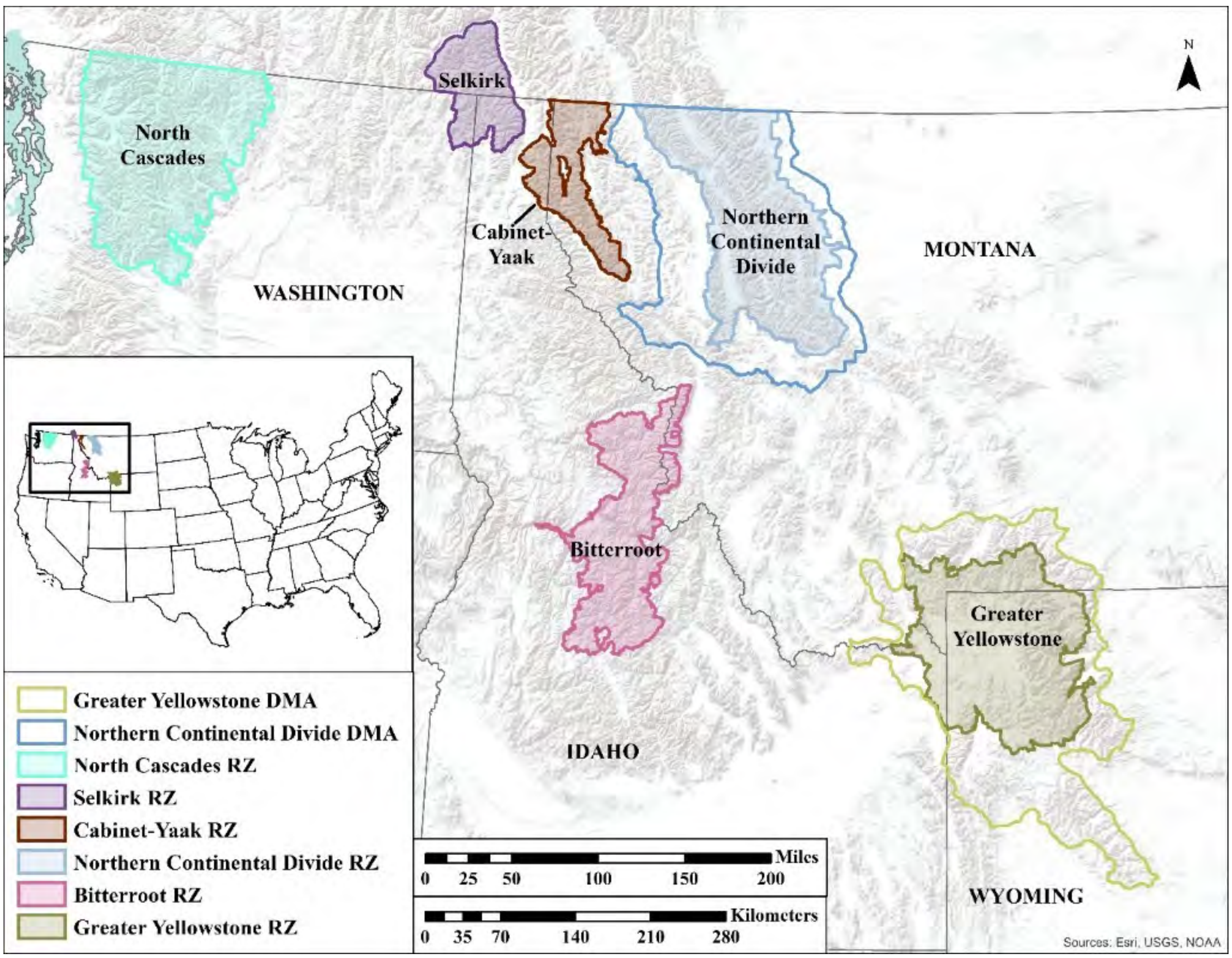

Figure 9. Recovery zones (RZ) and demographic monitoring areas (DMA), where applicable, for the six ecosystems identified in the Recovery Plan, the Northern Continental Divide (NCDE), Greater Yellowstone (GYE), Cabinet-Yaak (CYE), Selkirk (SE), Bitterroot (BE) and North Cascades ecosystems. DMAs surround and include the recovery zones in the GYE and NCDE. The Service has not defined ecosystem boundaries for any of the ecosystems across the lower-48 States, but for the purposes of our analysis, ecosystems are generally the larger area surrounding the recovery zone. For our SSA, we evaluated resiliency at the scale of these ecosystems, which are synonymous with populations for our assessment.

Analytical Framework used for the Species Status Assessment

We followed the three-phase SSA framework for our biological risk assessment of the grizzly bear in the lower-48 States. The three phases of the analysis are identifying the needs at the individual, population, and species levels, then evaluating the current condition and future condition of those needs (Service 2016, p. 6; Smith *et al.* 2018, entire). Specifically, the SSA-framework begins with an assessment of the species needs, followed by an assessment of the current condition of those needs, considering positive and negative factors that influence resiliency, and ending with an evaluation of the projected future condition of those same needs (Service 2016, p. 6). Throughout our analysis for this SSA, ecosystems are synonymous with populations.

Figure 10 is a conceptual model for our SSA for grizzly bear in the lower-48 States, based on the SSA's three-phase framework and the core conceptual model for viability in terms of the 3Rs. As summarized in this report, we first reviewed the life history, ecology, historical and current range and distribution, life stages, and life cycle for the grizzly bear (Chapter 2). We also reviewed recovery planning and other conservation efforts (Chapter 3). Next, based on our review of the life history and ecology, we identified the habitat factors needed by individuals, the demographic factors needed in the grizzly bear ecosystems, and the redundancy and representation needed by grizzly bears within the lower-48 States (Chapter 4). Then we evaluated stressors and conservation actions that affect resiliency, either positively or negatively, by directly influencing demographic factors and indirectly by influencing habitat factors (Chapter 5). We then evaluated the current condition for each of these habitat and demographic needs for each of the six ecosystems, and then summarized current condition for grizzly bear in terms of the 3Rs (Chapter 6). Finally, we developed future scenarios to capture that range of uncertainty regarding future conservation actions and repeated the evaluation of condition for all six ecosystems, under each future scenario, using the same methodology that we used to evaluate current condition (Chapter 7). We then summarized the change in conditions from current to future to summarize risk to the grizzly bear in the lower-48 States in terms of the 3Rs (Chapter 8).

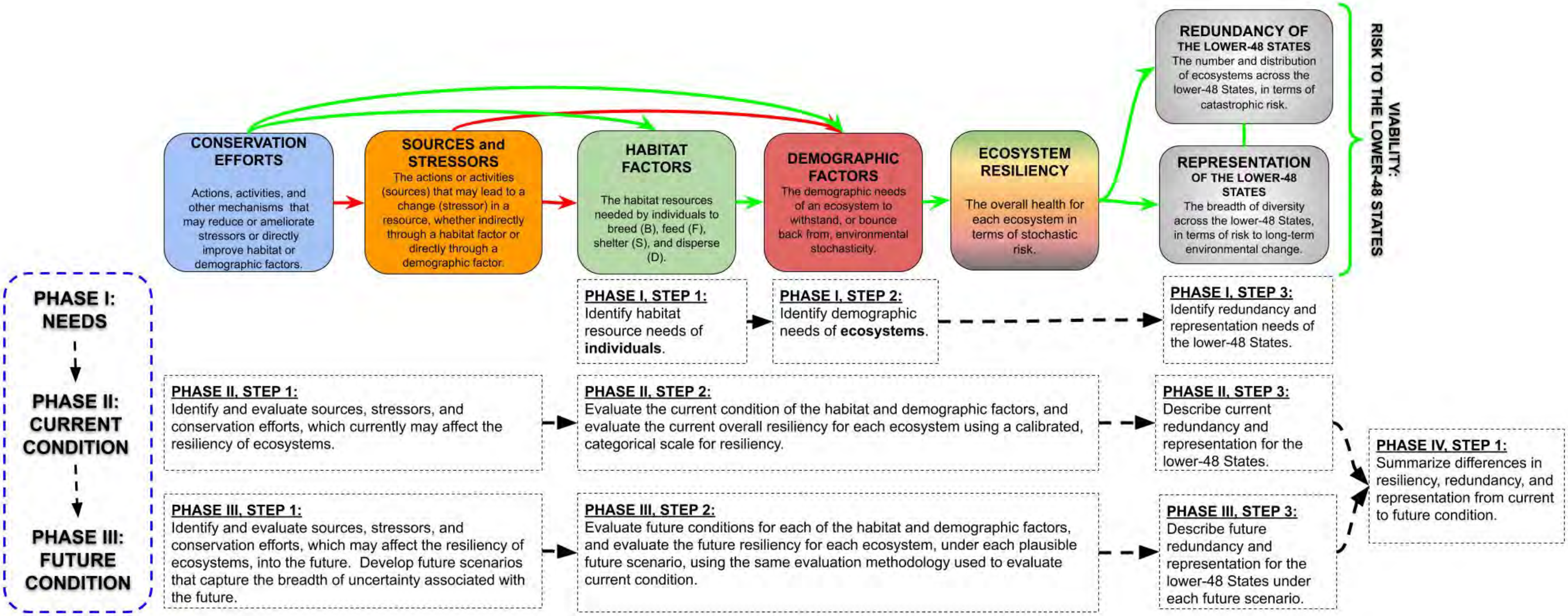

Figure 10. A conceptual model of our analytical framework for the SSA that we used to evaluate current and future condition for the grizzly bear in the lower-48 States. The three-phase SSA framework (species needs, current condition, and future condition) and the core conceptual model for viability guided our analysis (Service 2016, p. 6; Smith et al. 2018, entire). Green arrows represent positive relationships between nodes and red arrows represent negative relationships between nodes. Dashed boxes and arrows represent the steps of our analysis. Throughout our SSA, ecosystems are synonymous with populations.

Chapter 2: Description, Distribution, and Ecology of the Lower-48

In this chapter, we describe the grizzly bear in the lower-48 States, as well as its taxonomy, historical and current distribution, and life history. This review provides scientific background on grizzly bear life history and ecology in advance of our identification of ecological needs at the individual, ecosystem, and lower-48 States levels in Chapter 4.

Species Description

Grizzly bears are generally larger and heavier than other bears. Adult males average 200 to 300 kilograms (kg) (400 to 600 pounds (lb)) and adult females 110 to 160 kg (250 to 350 lb) in the lower-48 States (Craighead and Mitchell 1982, pp. 517–520; Schwartz *et al.* 2003a, p. 558). Although their coloration can vary widely from light brown to nearly black (LeFranc *et al.* 1987, pp. 17–18), they can be distinguished from black bears by longer less curved front claws, humped shoulders, and a facial profile that appears to be concave (Craighead and Mitchell 1982, p. 517). The coat features longer guard hairs over a dense underfur with tips that are usually silver or golden in color – hence the name "grizzly" (Figure 11). Grizzly bears are long-lived mammals, generally living to be around 25 years old (LeFranc *et al.* 1987, pp. 47, 51), although some wild bears have lived for over 35 years.

Figure 11. Grizzly bears in the lower-48 States are larger and heavier than other bears, with coloration that can vary widely from light brown to nearly black and long guard hairs that give a "grizzled" appearance (Photos by U.S. Fish and Wildlife Service).

Taxonomy

Grizzly bears (*Ursus arctos horribilis*) are a member of the brown bear species (*U. arctos*) that occurs in North America, Europe, and Asia. The subspecies *U. a. horribilis* is limited to North America (Rausch 1963, p. 43; Servheen 1999, pp. 50–53) and is a widely recognized subspecies of brown bear that historically existed throughout much of continental North America, including most of western North America from the Arctic Ocean to central Mexico (Hall 1984, pp. 4–9;

Trevino and Jonkel 1986, p. 12). Grizzly bears in the conterminous (lower-48) United States are listed as threatened under the Act and are the subject of this SSA report. Throughout this report we use "grizzly bear" to refer to this listed entity in the lower-48 States.

Life Stages and Life Cycle

Grizzly bears have three life stages: dependent young, subadults, and adults (Figure 12). Dependent young are usually less than two years old and depend on and are associated with their mother, relying on her for food, protection, and survival. There are two primary sub-categories of dependent young: (1) cubs-of-the-year or cubs, defined as cubs born during the most recent denning season and less than one year old; and (2) yearlings. Cubs nurse after birth in the den and after den emergence, but also increasingly eat foods with their mother once outside the den. Yearlings den with their mother but do not nurse in the den. Outside of the den, yearlings eat the same foods as their mother, but also occasionally nurse.

Shortly after den emergence, two-year-old offspring generally leave their mother to become subadults. Subadults are typically not sexually mature enough to breed; however, a small percentage of 3-year-old females do breed and produce cubs as 4-year-olds. Some subadults, generally males, may disperse away from their mother and establish their own home range (see *Behavior and Life History* below for further details).

Adult bears are more than four years old and have reached sexual maturity. Some bears may not breed until they are older than five years old, but they have the ability to reproduce once they reach the adult stage. Adults generally live into their mid to late 20s (LeFranc *et al.* 1987, pp. 47, 51; van Manen *et al.* 2014, p. 326), although some wild bears have lived for over 35 years. Female reproductive senescence starts around age 25 for those long-lived individuals (Schwartz *et al.* 2003b, p. 114).

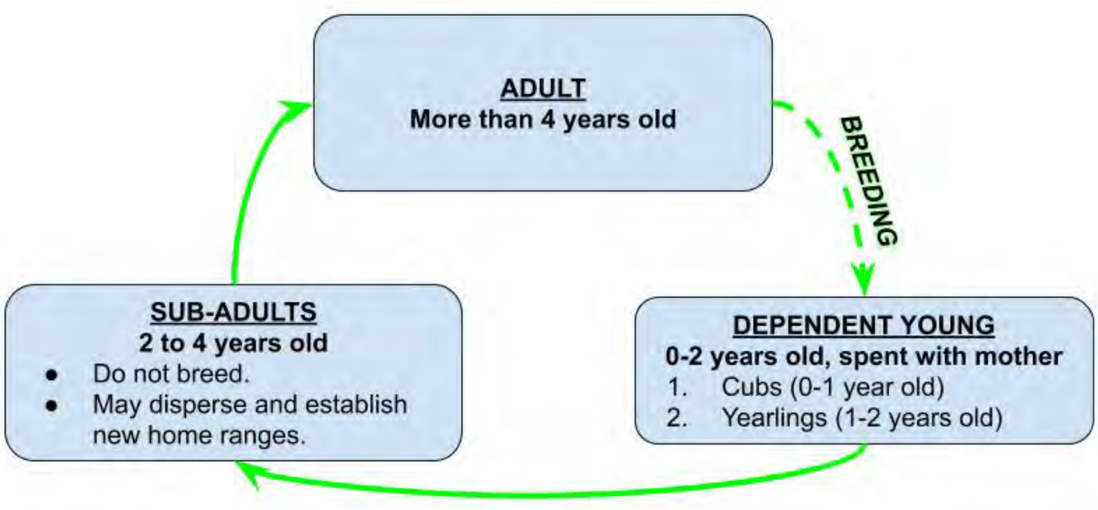

Figure 12. Life cycle diagram for the grizzly bear, with three life stages: dependent young, subadults, and adults. There are two sub-stages of dependent young: cubs and yearlings.

Habitat

Grizzly bears use a variety of habitats (LeFranc *et al.* 1987, p. 120). In general, a grizzly bear's individual habitat needs and daily movements are largely driven by the search for food, mates, cover, security, or den sites. The available habitat for bears is also influenced by people and their activities. Human activities are the primary factor impacting habitat security and the ability of bears to find and access foods, mates, cover, and den sites. Other factors influencing habitat use and function for grizzly bears include overall habitat productivity (e.g., food distribution, quality, and abundance), the availability of habitat components (e.g., denning areas, cover types), grizzly bear social dynamics, learned behavior and preferences of individual grizzly bears, grizzly bear population density, and random variation.

The six ecosystems occur in mountainous ecoregions and each provide the habitat heterogeneity necessary for adequate food, denning, and cover resources. Because there are limited opportunities to increase or control these habitat components, the objective for grizzly bear habitat management has been and continues to be to reduce or mitigate the risk of human-caused mortality and displacement. An effective habitat management tool for reducing grizzly bear mortality risk on public lands is managing motorized access to ensure bears have secure areas away from humans (Nielsen *et al.* 2006, p. 225; Schwartz *et al.* 2010, p. 661). Unmanaged motorized access: (1) increases human interaction and potential grizzly bear mortality risk; (2) increases displacement from important habitat; (3) increases habituation to humans; and (4) decreases habitat where energetic (i.e., food) requirements can be met with limited disturbance from humans (Mattson *et al.* 1987, pp. 269–271; McLellan and Shackleton 1988, pp. 458–459; McLellan 1989, pp. 1862–1864; Mace *et al.* 1996, pp. 1402–1403; Schwartz *et al.* 2010, p. 661). Managing motorized access on public lands helps ameliorate these impacts. Other habitat management tools that minimize displacement and reduce grizzly bear mortality risk include regulating livestock allotments and developed sites on public lands. Implementing food storage orders on public lands also reduces mortality risk for both humans and grizzly bears. Requiring users and recreationists in grizzly bear habitat to store their food, garbage, and other bear attractants so that they are inaccessible to bears reduces encounters and human-grizzly bear conflicts. In addition, encouraging users and recreationists to carry bear spray and know how to use it helps reduce the potential for injury to people and bears.

The primary factors affecting grizzly bears at both the individual and ecosystem levels are excessive human-caused mortality and human activity that reduces the quality and quantity of habitats, which increases the potential for human-caused mortality, both directly and indirectly. Regulating human-caused mortality through habitat management is an effective approach, as evidenced by increasing grizzly bear populations in the lower-48 States where motorized access standards exist and have been met (e.g., GYE and NCDE). This requires ongoing monitoring of the grizzly bear population to understand if it is sufficiently resilient to allow for a conservative level of human-caused mortality without causing population decline. Although motorized access standards exist in the CYE and SE that have contributed to a positive population trend, these standards have not yet been fully implemented. The BE recovery zone is 98 percent wilderness;

however, motorized access standards have not been developed for adjacent areas to the north and east, where female occupancy is necessary for natural recolonization of the BE. The North Cascades has a “no net loss” policy (USDA FS 1997, entire); however, we have not evaluated whether this 1997 “no net loss” approach provides an adequate amount of secure habitat for a healthy grizzly bear population.

Behavior and Life History

Adult grizzly bears are normally solitary except when breeding or when females have dependent young (Nowak and Paradiso 1983, p. 971), but they are not territorial and home ranges of adult bears frequently overlap (Schwartz *et al.* 2003a, pp. 565–566). Home range size is affected by resource availability, sex, age, and reproductive status (LeFranc *et al.* 1987, p. 31; Blanchard and Knight 1991, pp. 48–51; Mace and Waller 1997b, p. 48). Generally, females with cubs-of-the-year or yearlings have the smallest home range sizes (Aune and Kasworm 1989, p. 53; Blanchard and Knight 1991, pp. 48–49; Mace and Roberts 2011, pp. 26–28). Table 3 shows the average annual home range sizes observed in each ecosystem for adult males and females. The large home ranges of grizzly bears, particularly males, enhance maintenance of genetic diversity in the population by enabling males to mate with numerous females (Blanchard and Knight 1991, pp. 46–51; Craighead *et al.* 1998, p. 326).

Young, female grizzly bears usually establish home ranges within or overlapping their mother’s (Waser and Jones 1983, p. 361; McLellan and Hovey 2001, pp. 841, 843; Schwartz *et al.* 2003a, p. 566). This pattern of home range establishment can make dispersal of females across landscapes a slow process. Radio-telemetry and genetic data suggest females typically establish home ranges an average of 9.8 to 14.3 km (6.1 to 8.9 mi) away from the center of their mother’s home range, whereas males generally disperse farther, averaging 29.9 to 42.0 km (18.6 to 26.0 mi) away from the center of their mother’s home range (McLellan and Hovey 2001, p. 842; Proctor *et al.* 2004, p. 1108). Maximum dispersal distances of 67–176 km (42–109 mi) have been documented in the NCDE and GYE (Blanchard and Knight 1991, pp. 50, 55; McLellan and Hovey 2001, p. 841; Peck *et al.* 2017, p. 2). Studies also indicate that females can and do disperse long distances up to 80–90 km (50–56 mi), typically on the periphery of expanding populations. Although the frequency of long-distance dispersal by females is much lower than males, it can contribute to range expansion and demographic connectivity between populations (Swenson *et al*. 1998, pp. 822–824; Jerina and Adamic 2008, pp. 1495–1497).

Table 5 shows the average annual home range sizes observed in each ecosystem for adult males and females; home range sizes vary among the ecosystems because of population densities and habitat productivity (Mace and Roberts 2011, p. 28; Bjornlie *et al.* 2014b, p. 5) as well as methodology.

Table 5. Average annual home range sizes for adult male and female grizzly bear in the six ecosystems (NCDE = Northern Continental Divide Ecosystem; GYE = Greater Yellowstone Ecosystem; CYE = Cabinet-Yaak Ecosystem; SE = Selkirk Ecosystem; and BE = Bitterroot Ecosystem).

Ecosystem	Average Female Home Range Size	Average Male Home Range Size	Citation
NCDE	358 km^2 (138 mi^2)	1,364 km^2 (527 mi^2)	MFWP, unpublished data*
GYE	130 km^2 (50 mi^2)	475 km^2 (183 mi^2)	Bjornlie *et al.* 2014b, supplement 3**
CYE	329 km^2 (127 mi^2)	2,162 km^2 (835 mi^2)	Kasworm 2020, *in litt.**
SE	297 km^2 (115 mi^2)	624 km^2 (241 mi^2)	Kasworm 2020, *in litt.**
BE	NA	NA	NA
North Cascades	NA	NA	NA

* Using 100% minimum convex polygons
** Using 95% minimum convex polygons

Breeding

Grizzly bears have a promiscuous mating system (Hornocker 1962, p. 70; Craighead and Mitchell 1982, p. 522; Schwartz *et al.* 2003a, p. 563). Mating occurs from May through July with a peak in mid-June (Craighead and Mitchell 1982, p. 522; Nowak and Paradiso 1983, p. 971). Although females mate in spring and early summer, their fertilized embryos do not implant into the uterus for further development until late fall. Fat stores obtained by female grizzly bears at the end of fall are positively correlated with earlier birth dates and faster growth rates of their cubs (Robbins *et al.* 2012, p. 543). Additionally, a body fat threshold may exist below which females may not produce cubs, even when bred (Robbins *et al.* 2012, p. 543). Cubs are born in the den in late January or early February and nurse for 3 to 4 months inside the den. Offspring typically remain with the female for about 2.5 years. Age of first reproduction, litter size, and inter-birth interval (the average number of years between litters) may be related to nutritional state and/or density dependent effects (Stringham 1990, p. 433; McLellan 1994, p. 20; Hilderbrand *et al.* 1999, pp. 135–136 Schwartz *et al.* 2006b, p. 21; van Manen *et al*. 2016, pp. 307–308).

Table 6 lists the average age of first reproduction, litter size, and inter-birth interval for each ecosystem.

Table 6. Average age of first reproduction, litter size, and inter-birth interval for the six ecosystems (NCDE = Northern Continental Divide Ecosystem; GYE = Greater Yellowstone Ecosystem; CYE = Cabinet Yaak Ecosystem; SE = Selkirk Ecosystem; and BE = Bitterroot Ecosystem).

Ecosystem	Age of First Reproduction	Litter Size	Inter-birth Interval	Citation
NCDE	5.8	2.1	3	Mace and Waller 1997a, p. 108; Costello *et al.* 2016, pp. 56–57
GYE	5.8	2.12	2.78	Schwartz *et al.* 2006b, pp. 19–20; IGBST 2012, p. 34
CYE	6.3	2.19	3.0	Kasworm *et al.* 2020a, pp 37–38
SE	6.3	2.18	3.4	Kasworm *et al.* 2020b, pp. 25–26.
BE	NA	NA	NA	NA
North Cascades	NA	NA	NA	NA

Grizzly bears have one of the slowest reproductive rates among terrestrial mammals, resulting primarily from the reproductive factors described above: late age of first reproduction, small average litter size, and the long inter-birth interval (Nowak and Paradiso 1983, p. 971; Schwartz *et al.* 2003a, p. 564). Given the above factors, it may take a female grizzly bear 10 or more years to replace herself in a population (Service 1993, p. 4). The slow reproductive rate should also be understood in the context of having one of the longer life spans of terrestrial mammals (*Ursus arctos* in 90th percentile for longevity) (Healy *et al.* 2014, entire). A population is made up of numerous overlapping generations. It is possible for mothers, daughters, and granddaughters to be reproductively active at the same time. Grizzly bear females typically cease reproducing some time in their mid-to-late 20s (Schwartz *et al.* 2003b, pp. 109–110).

Hibernation and Denning

Grizzly bears hibernate in winter; hibernation is a life history strategy bears use to cope with seasons of low food abundance. In preparation for hibernation, bears increase their food intake dramatically during a process called hyperphagia (Craighead and Mitchell 1982, p. 544). Hyperphagia occurs throughout the 2 to 4 months prior to den entry (i.e., August through November). During hyperphagia, excess food is converted into fat, and grizzly bears may gain as much as 1.65 kg/day (3.64 lb/day) (Craighead and Mitchell 1982, p. 544). Grizzly bears must consume foods rich in protein and carbohydrates in order to build up fat reserves to survive denning and post-denning periods (Rode and Robbins 2000, pp. 1643–1644). Fat stores are crucial to the hibernating bear as they provide a source of energy and insulate the bear from cold temperatures, and are equally important in providing energy to the bear upon emergence from the den when food is still sparse relative to metabolic requirements (Craighead and Mitchell 1982, p. 544).

Grizzly bears in the lower-48 States hibernate in dens for four to six months each year, typically entering dens between October and December, with males entering their dens later than females (Mace and Waller 1997a, p. 39; Linnell *et al.* 2000, p. 401; Haroldson *et al.* 2002, p. 29; Kasworm *et al.* 2020a, pp. 49–52; Kasworm *et al*. 2020b, pp 32–35). Females give birth to cubs in the den in late January to early February. On average, males exit dens from early March to late April (Haroldson *et al.* 2002, p. 29; Kasworm *et al.* 2020a, pp. 49–52; Kasworm *et al*. 2020b, pp 32–35; Interagency Grizzly Bear Study Team (IGBST), unpublished data; Montana Fish, Wildlife and Parks (MFWP), unpublished data). Females typically emerge from their dens from mid-March to mid-May, with females with cubs emerging later from mid-April to late-May (Mace and Waller 1997a, p. 37; Haroldson *et al.* 2002, p. 29; Kasworm *et al.* 2020a, pp. 49–52; Kasworm *et al*. 2020b, pp 32–35; IGBST, unpublished data; MFWP, unpublished data).

Grizzly bears typically hibernate alone in dens, except for females with young and subadult siblings who occasionally hibernate together. Grizzly bears usually dig dens on steep slopes where wind and topography cause an accumulation of deep snow and where the snow is unlikely to melt during warm periods. Most dens are located at higher elevations, above 2,500 m (>8,000 ft) in the GYE and 1,942 m (6,400 ft) in the NCDE (Mace and Waller 1997a, p. 39; Haroldson *et al.* 2002, p. 33) and on slopes ranging from 30 to 60 degrees (Judd *et al.* 1986, p. 115; Mace and Waller 1997a, pp. 39–40). Approximately 66 percent (6,815 km^2 (2,631 mi^2)) of the GYE is potential denning habitat, and it is well distributed, so its availability is not considered a limiting factor for grizzly bears in the GYE (Podruzny *et al.* 2002, p. 22). In the NCDE, approximately 29 percent (6,815 km^2 (2,631 mi^2)) of the recovery zone is potential denning habitat; its availability is not considered a limiting factor for grizzly bears in the NCDE (Costello 2018, *in litt*.). In the CYE, the majority of den sites occurred above 1,600 m (5,248 ft), often on northerly and easterly aspects, though all aspects were used (Kasworm *et al.* 2020a, p. 53). In the SE, the majority of dens were located above 1,600 m (5,248 ft), often on easterly aspects, but all aspects were used (Kasworm *et al.* 2020b, p. 36). Given the variety of den site use, den availability does not appear to be a limiting factor for populations at this time in the CYE or SE. The North Cascades contains large areas at high elevations with isolated, steep, snow-packed slopes and many natural caves to serve as potential den sites. Additional areas associated with ridge systems stemming from major volcanic peaks may provide den sites at lower elevations within the North Cascades (Almack *et al.* 1993, p. 23). Davis and Butterfield (1991, p. 26) assessed the northern part of the BE recovery zone and areas to the immediate north and concluded that deep snow and mountainous terrain provides adequate denning habitat.

Denning increases survival during periods of food scarcity and inclement weather (Craighead and Craighead 1972, pp. 33–34). During this period, bears do not eat, drink, urinate, or defecate (Folk *et al.* 1974, pp. 376–377; Nelson 1980, p. 2955). Hibernating grizzly bears exhibit a marked decline in heart and respiration rate, but only a slight drop in body temperature (Nowak and Paradiso 1983, p. 971). Due to their relatively constant body temperature in the den, hibernating grizzly bears may be aroused and have been known to exit or relocate dens when disturbed by seismic or mining activity (Harding and Nagy 1980, p. 278; Reynolds *et al.* 1986, p. 174) or other human activities (Swenson *et al.* 1997, p. 37). Dens are rarely used twice by an individual, although individuals usually use the same general area from year-to-year (Servheen and Klaver 1983, p. 205; Schoen *et al.* 1987, p. 300; Miller 1990, p. 285; Linnell *et al.* 2000, p. 403). Females display stronger area fidelity than males and generally stay in their dens longer, depending on reproductive status (Judd *et al.* 1986, pp. 113–114; Schoen *et al.* 1987, p. 300; Miller 1990, p. 283; Linnell *et al.* 2000, p. 403). Females with cubs usually spend a few weeks close to their den upon emergence, unlike solitary bears.

Cover

Grizzly bears use a variety of cover types to rest and shelter. Grizzly bears often select bed sites with horizontal and vertical cover, especially at day bed sites (Ordiz *et al*. 2011, p. 63) suggesting that bed site selection is important for concealment from humans. Blanchard (1978, pp. 27–29) documented the relative importance of cover to grizzly bears in a 4-year study in the GYE. Ninety percent of 2,261 aerial radio locations of 46 instrumented grizzly bears were in forest cover too dense to observe the bear. Sahlén *et al*. (2011, p. 156) also found that brown bears in Sweden denned in denser cover when closer to villages. Blanchard (1978, p. 45) recorded the importance of an interspersion of open areas as feeding sites associated with cover: "Only 1 percent of the relocations were in dense forest more than a kilometer from an opening." This is likely because diverse habitat complexes, such as forest interspersed with moist grass-forb meadows, provide both abundant food and cover. Generally, areas with vegetative cover are important to grizzly bears for use as bedding sites (Servheen and Lee 1979, pp. 57, 60; Munro *et al*. 2006, p. 1119). Schallenberger and Jonkel (1980, p. 54) found that grizzly bears preferred forest in over 80 percent of their radio relocations. Beds underneath any type of vegetative cover (not necessarily always forest cover) provide bears shade during the hottest parts of the day and a place to sleep at night.

Nutritional Ecology (Feeding)

The lower-48 States provides highly diverse landscapes containing a wide array of habitat types and bear foods across and within the ecosystems. Plant communities vary from grasslands at lower elevations (less than 1,900 m (6,230 ft)) to shrub fields created by fires, avalanches, or timber harvest, to conifer forests at mid-elevations and subalpine and alpine meadows at higher elevations (greater than 2,400 m (7,870 ft)). Grizzly bears are opportunistic omnivorous and display great diet plasticity—even within a population (Edwards *et al.* 2011, pp. 883–886), shifting their diet according to foods that are most nutritious (i.e., high in fat, protein, and/or carbohydrates) and available (Mealey 1980, pp. 284–291; Servheen 1981, pp. 99–102; Kendall 1986, pp. 12–18; Mace and Jonkel 1986, p. 108; Martinka and Kendall 1986, pp. 21–22; LeFranc *et al.* 1987, pp. 111–114; Aune and Kasworm 1989, pp. 63–71; Kasworm and Their 1993, pp. 38–41; McLellan and Hovey 1995, pp. 706–709; Schwartz *et al.* 2003a, pp. 568–569; Van Daele *et al*. 2012, pp. 25–27; Gunther *et al.* 2014, p. 65). Gunther *et al.* (2014, p. 65) conducted an extensive literature review and documented over 260 species of foods consumed by grizzly bears in the GYE, representing 4 of the 5 kingdoms of life. The ability to use whatever food resources are available is likely one reason brown bears are the most widely distributed bear species in the world, occupying habitats from deserts to alpine mountains and everything in between. This ability to live in a variety of habitats and eat a wide array of foods makes grizzly bears a generalist species. In contrast, specialist species (e.g., mountain lions) eat only a few specific foods or live in only one or two specific habitat types (Krebs 2009, p. 100). Morphological adaptations that support a diverse diet include crushing molars and the greatest intestinal length relative to body length of any carnivore (Mealey 1975, pp.109–110, 113–114).

Grizzly bear diets are highly variable among individuals, seasons, and years, and between ecosystems (Servheen 1983, pp. 1029–1030; Mattson *et al.* 1991*a*, pp. 1625–1626; LeFranc *et al.* 1987, pp. 113–114; Felicetti *et al.* 2003, p. 767; Schwartz *et al.* 2003a, pp. 568–569; Felicetti *et al.* 2004, p. 499; Fortin *et al.* 2013, p. 278; Costello *et al.* 2014, p. 2013; Gunther *et al.* 2014, p. 65). They opportunistically seek and consume whatever plant and animal foods are available to them. Grizzly bears will consume almost any food available including living or dead mammals or fish, insects, worms, plants, human-related foods, and garbage (Knight *et al.* 1988, pp. 123–124; Mattson *et al.* 1991a, p. 1620; Mattson *et al.* 1991b, p. 2433; Schwartz *et al.* 2003a, pp. 568–569; Gunther *et al.* 2014, entire). In areas where animal matter is less available, berries, grasses, roots, bulbs, tubers, seeds, and fungi are important in meeting protein and caloric requirements (LeFranc *et al.* 1987, pp. 111–114; Schwartz *et al.* 2003a, pp. 568–569). Grizzly bears often sample new foods so that they have alternative options in years when preferred foods are scarce (Mattson *et al.* 1991a, p. 1625). In the GYE, Blanchard and Knight (1991, p. 61) noted that, “After 10 years of food habits data collection, new feeding strategies continued to appear annually in this population.”

Grizzly bears opportunistically prey on livestock, agricultural crops, and other human foods. Cattle and sheep depredation rates are generally higher where bear densities are higher and in later summer months (Wells *et al*. 2018, pp. 5–6). In the GYE and NCDE, depredation is generally higher where livestock is more abundant, such as areas with livestock allotments and privately owned ranchland. Grazing is less common in the CYE and SE, and depredation rates are correspondingly lower. Grizzly bears also opportunistically prey on small livestock, such as chickens, llamas, and goats, which primarily occur on private land.

Food resources are especially important during the period leading up to hibernation when grizzly bears must consume energetically rich foods to build up fat reserves to survive denning and post-denning periods (Rode and Robbins 2000, pp. 1643–1644). As discussed in *Hibernation and Denning* above, fat stores provide a source of energy and insulate the bear from cold temperatures during hibernation (Craighead and Mitchell 1982, p. 544). Also, fat stores obtained by female grizzly bears at the end of fall are positively correlated with earlier birth dates and quicker growth rates of their cubs (Robbins *et al.* 2012, p. 543). Additionally, a body fat threshold may exist below which females may not produce cubs, even when bred; studies have shown that females with less than 20 percent body fat are unlikely to produce cubs (Robbins *et al.* 2012, p. 543).

Historical Range and Distribution

For this biological report, we considered the historical range of grizzly bears circa 1850. We determined that this timeframe is appropriate for measuring the historical grizzly bear range because it is a period for which published faunal (animals characteristic of a region) records document grizzly bear range, bear occurrence, and local extirpation events (Mattson and Merrill

2002, p. 1125). Additionally, it precedes the major distribution changes in response to excessive human-caused mortality and habitat loss (Servheen 1999, p. 51).

Historical range of the grizzly bear began receding with the arrival of Europeans to North America, with rapid extinction of populations from most of Mexico and from the central and southwestern United States and California (Craighead and Mitchell 1982, p. 516). Prior to the arrival of Europeans, grizzly bears occurred throughout much of the western half of the contiguous United States, central Mexico, western Canada, and most of Alaska (Figure 13) (Roosevelt 1907, pp. 27–28; Wright 1909, pp. vii, 3, 185–186; Merriam 1922, p. 1; Storer and Tevis 1955, p. 18; Rausch 1963, p. 35; Herrero 1972, pp. 224–227; Schwartz *et al.* 2003a, pp. 557–558; Hall 1984, pp. 4–9; Trevino and Jonkel 1986, p. 12). Historically, an estimated 50,000–100,000 grizzly bears were distributed in one large contiguous area throughout all or portions of 18 western States (i.e., Washington, Oregon, California, Idaho, Montana, Wyoming, Nevada, Colorado, Utah, New Mexico, Arizona, North Dakota, South Dakota, Minnesota, Nebraska, Kansas, Oklahoma, and Texas) (Figure 14) (Servheen 1990, pp. 1–2; Servheen 1999, pp. 50– 51; Service 1993, p. 9). Grizzly bears were probably most common in the Rocky Mountains, along the Upper Missouri River, and in California (Storer and Tevis 1955, pp. 15–21; Schneider 1977, pp. 15, 17, 25–36; Mattson and Merrill 2002, pp. 1125, 1127–1128; Haroldson *et al.* 2020, *in press.*). Historically, grizzly bears were less common or did not occur in large expanses of the North American deserts and Great Plains ecoregions (Rollins 1935, p. 191; Wade 1947, p. 444; Mattson and Merrill 2002, p. 1128; Haroldson *et al.* 2020, *in press.*).

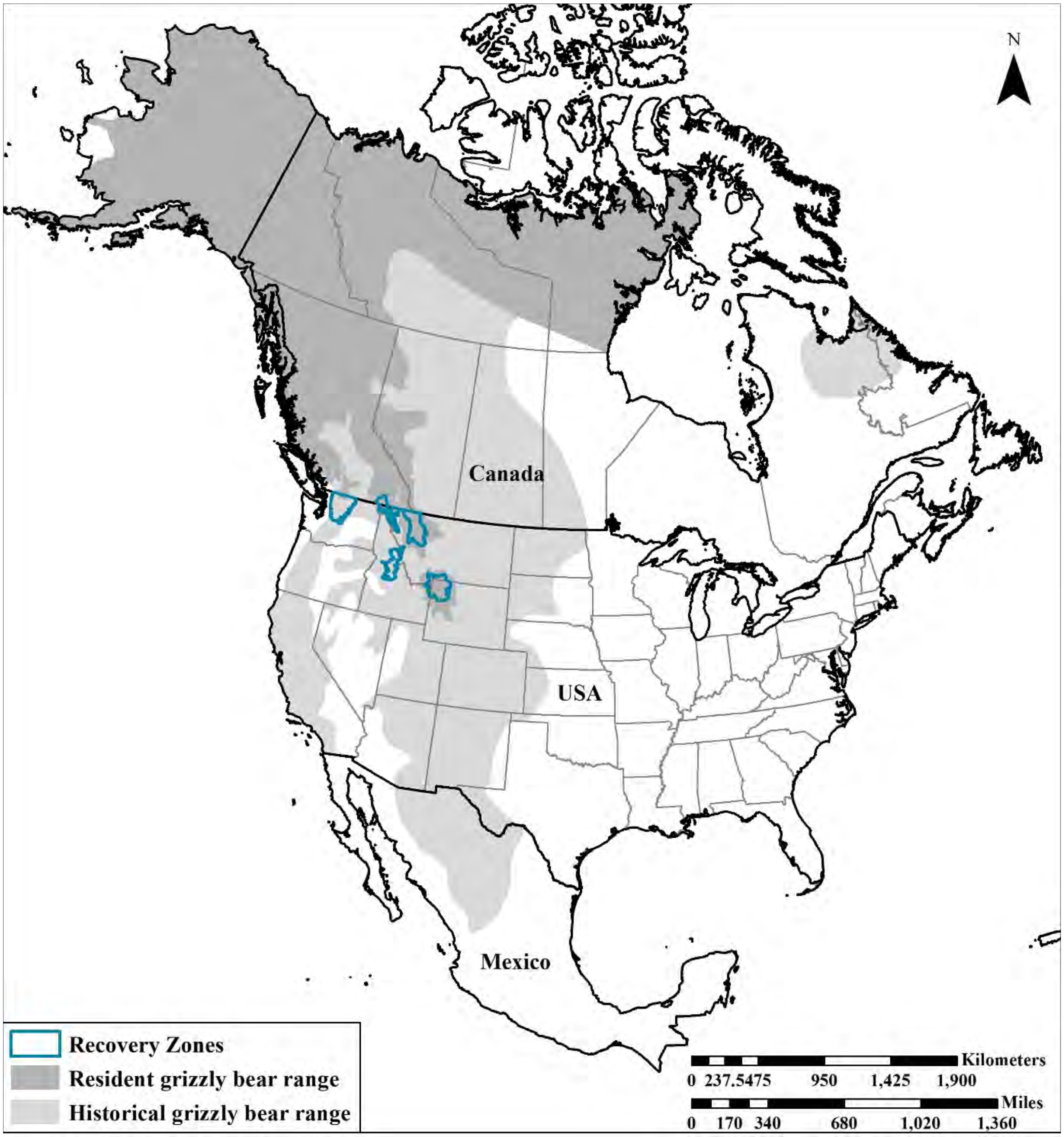

Figure 13. Historical and current grizzly bear distribution in North America circa 1850 (Haroldson et al. 2020a, in press) and recovery zones for the six ecosystems identified in the Recovery Plan, Northern Continental Divide (NCDE), Greater Yellowstone (GYE), Cabinet-Yaak (CYE), Selkirk (SE), Bitterroot (BE), and North Cascades.

With the arrival of Europeans to North America, grizzly bears were seen as a threat to livestock and human safety and, therefore, an impediment to westward expansion and settlement. In the 1800s, in concert with European settlement of the American West and government-funded bounty programs aimed at eradication, grizzly bears were shot, poisoned, and trapped wherever they were found (Roosevelt 1907, pp. 27–28; Wright 1909, p. vii; Storer and Tevis 1955, pp. 26–27; Leopold 1967, p. 30; Koford 1969, p. 95; Craighead and Mitchell 1982, p. 516; Servheen 1999, pp. 50–51). The resulting declines in range and population were dramatic. Grizzly bears were reduced to close to 2 percent of their former range in the lower-48 States by the 1930s, with a corresponding decrease in population, approximately 125 years after first contact with European settlers (Figure 14, above) (Service 1993, p. 9; Servheen 1999, p. 51). Of 37 grizzly bear populations thought to be present in 1922 within the lower-48 States, 31 were extirpated by the time of listing in 1975, and the estimated population in the lower-48 States was 700–800 animals (Figure 14) (Mattson and Merrill 2002, p. 1125).

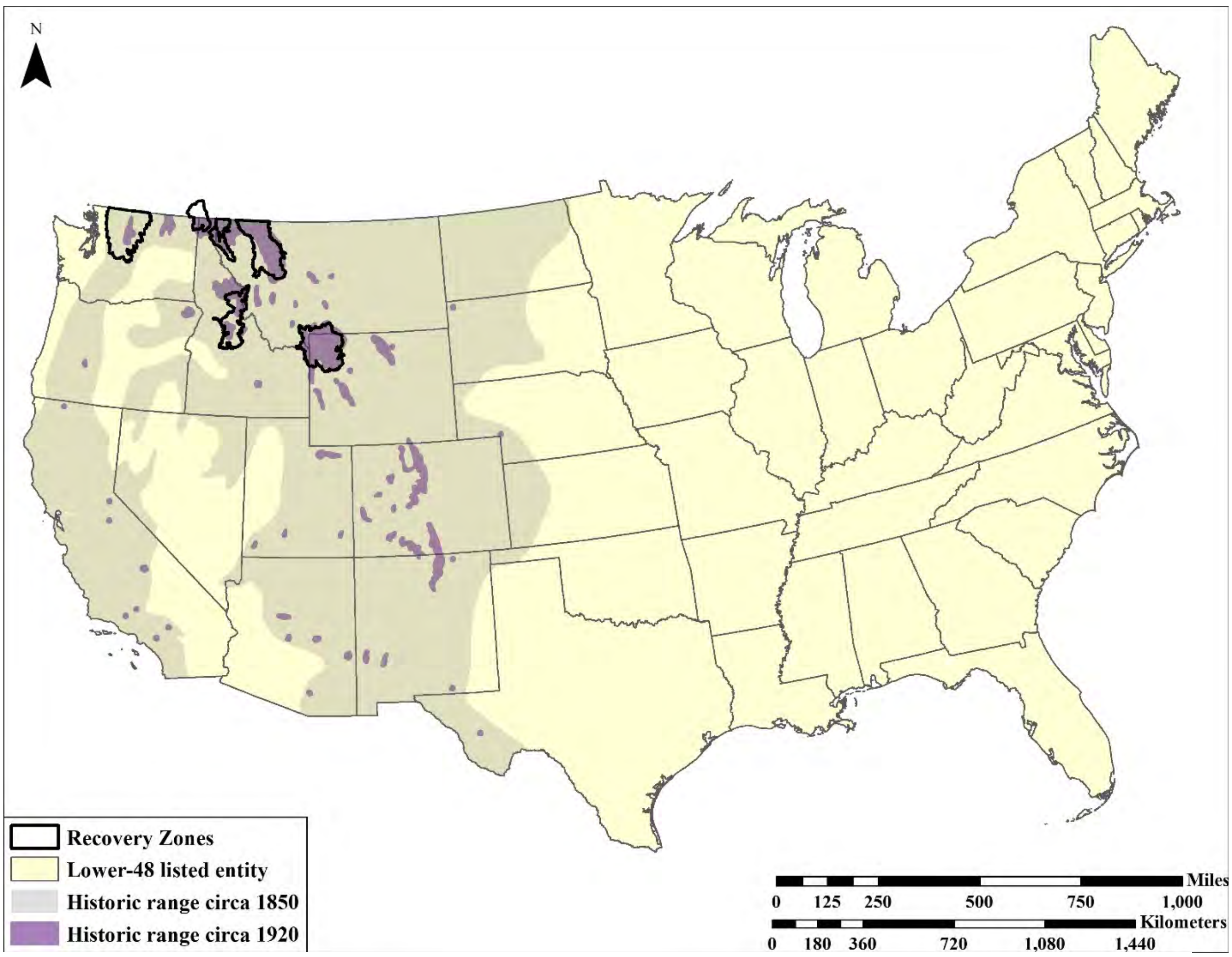

Figure 14. Historical grizzly bear distribution in the lower-48 States circa 1850 (Haroldson et al. 2020a, in press) and 1920 (Mattson and Merrill 2002, p. 1125), and recovery zones for the six ecosystems identified in the Recovery Plan, Northern Continental Divide (NCDE), Greater Yellowstone (GYE), Cabinet-Yaak (CYE), Selkirk (SE), Bitterroot (BE), and North Cascades.

Most of the shortgrass prairie on the east side of the Rocky Mountains and other areas within historical range has been converted into agricultural land (Woods *et al.* 1999, entire), and high densities of traditional food sources are no longer available due to land conversion and human occupancy of urban and rural lands. Traditional food sources such as bison and elk have been reduced and replaced with domestic livestock such as cattle, sheep, chickens, goats, pigs, beehives, and agricultural crops, which can become food sources for grizzly bears, leading to conflicts with humans. While food sources such as grasses and berries are abundant in some years in the riparian zones within which the bears travel, these are not reliable every year and can only support a small number of bears. These nutritional constraints of natural foods and the potential for associated human-bear conflicts limit the potential for a self-sustaining population of grizzly bears to develop in the prairies, although we expect some grizzly bears to live in these areas.

In the early 20th century, regulations recognizing bears (black and grizzly) as game animals, protecting females and their offspring, and setting harvest limits (either season or bag limit) were designed to stop future extirpations. In some areas, the protections came too late. By 1975, grizzly bear populations in the lower-48 States had been reduced in number and restricted largely to the confines of National Parks and Wilderness areas in Washington, Idaho, Montana, and Wyoming (40 FR 31734, July 28, 1975; Service 1982, p. 10; Dood *et al.* 1986, p. 166; Craighead *et al.* 1995, pp. 41–42; Schwartz *et al.* 2003a, pp. 575–579), although significant numbers remained in Alaska and northern Canada. Grizzly bears were relegated to these areas in the lower-48 States primarily because of limited human influences. High grizzly bear mortality in 1970 and 1971, following closure of the open-pit garbage dumps in YNP (Gunther 1994, p. 550; Craighead *et al.* 1995, pp. 34–36), and concern about grizzly bear population status throughout its remaining range, primarily due to habitat destruction and excessive human-caused mortality, prompted the 1975 listing of the grizzly bear as a threatened species in the lower-48 States under the Act (40 FR 31734, July 28, 1975). When the grizzly bear was listed in 1975, the population estimate in the GYE ranged from 136 to 312 individuals (Cowan *et al.* 1974, pp. 32, 36; Craighead *et al.* 1974, p. 16; McCullough 1981, p. 175). Around the time of listing it was estimated that the entire NCDE population had been reduced to as few as 300 bears (Dood *et al.* 1986; p. 166; Service 1993, p. 12), primarily within GNP and surrounding Wilderness areas. Little was known about populations in the CYE, SE, North Cascades, and BE at the time of listing (Service 1982, pp. 12–13).

In 1993, the Service's Recovery Plan designated six recovery areas (GYE, NCDE, CYE, SE, BE, North Cascades), and recommended further evaluation of other potential areas to determine recovery potential (Service 1993, pp. 11, 15–16, 121). The San Juan Mountains was specifically identified for further evaluation, but no confirmed sightings of grizzly bears have occurred there since a grizzly bear mortality in 1979 (Service 1993, p. 11). It recommended conducting an evaluation of these areas to focus on habitat values, size of area, human use and activities in general, relation to other areas where grizzly bears exist, and historical information (Service 1993, p. 121). The Service conducted this analysis, focusing on secure core habitat in historical range outside of the six ecosystems in 2019–2020 (see *Appendix A* for further discussion).

The most crucial element in grizzly bear recovery is habitat. Areas of suitable habitat must be of adequate size to support a population, diverse such that it provides a wide range of foods, and isolated from development and human activities, where human-bear interactions, which often result in higher bear mortalities, are minimal (Service 1993, p. 21; Craighead and Mitchell 1982, p. 530). In general, road access probably poses the most imminent threat to grizzly bear habitat, and therefore the Recovery Plan recommended that road management be given the highest priority for grizzly bear recovery (Service 1993, pp. 21–22). For this reason, both the NCDE and GYE incorporate threshold levels for motorized access and secure habitat (areas with no motorized access) into habitat-based recovery criteria (Service 2007, 2018, entire). Although we have not yet developed habitat-based recovery criteria for the remaining ecosystems, the CYE and SE have implemented motorized access standards, the BE recovery zone is 98 percent wilderness, and the North Cascades has a "no net loss" policy (USDA FS 1997, entire; USDA FS 2011a, entire). The Recovery Plan also specified that areas to be considered for grizzly bear recovery must have the potential to sustain themselves as viable grizzly bear populations, either as large populations or through linkage to other populations (Service 1982, p. 1; Service 1993, pp. 13, 15, 24, 121). Therefore, our evaluation of potentially suitable habitats considered habitat security (roads) and size, human presence (Federal, State, and Tribal land ownership), historical range, and the potential to maintain a self-sustaining population.

We analyzed habitat security (secure core and secure habitat) for Federal, State, and Tribal lands within mapped historical grizzly bear range circa 1850 (Mattson and Merrill 2002, p. 1125). We report secure core as: the percentage of Federal, State, and Tribal lands within the analysis area with no motorized routes that are more than 500 m (1,650 ft) from an open or gated motorized route and at least 2,500 acres (10.1 km^2 (3.9 mi^2)) in size. We report secure habitat as: the percentage of Federal, State, and Tribal lands within the analysis area with no motorized routes that are more than 500 m (1,650 ft) from an open or gated motorized route and at least 10 acres (0.31 km^2 (0.016 mi^2)) in size. The largest area of secure core habitat within grizzly bear historical range outside of the six ecosystems (NCDE, GYE, North Cascades, BE, SE, and CYE) is the Sierra Nevada Mountain Range in California. We further analyzed the Sierra Nevada Range to determine if the area contains enough secure core/habitat to support an isolated grizzly bear population. We also analyzed secure core/habitat in the San Juan Mountains because of the Recovery Plan recommendation to do so (Service 1993, pp. 16, 121). Finally, we considered the potential of these areas to maintain a self-sustaining population by examining potential population size and the future ability of individuals to move between ecosystems (e.g., potential for linkage), including distance from existing grizzly bear populations and potential barriers to dispersal (Service 1993, pp. 13, 24, 121). Details of this analysis can be found in Juliusson and Fortin-Noreus (2020, entire), *Appendix A* in this biological report.

Our goal was to compare the amount of secure core/habitat in the Sierra Nevada and San Juan mountains with secure core/habitat in recovery zones, therefore we calculated secure core using the definition used in the NCDE and secure habitat using the definition used in the GYE (see *Appendix B* for secure core/habitat definitions). We could not calculate core areas consistent with methodology used in the CYE, SE, and North Cascades because data for high-use trails was unavailable. The analysis area for the Sierra Nevada Mountains is 52,531 km^2 (20,282 mi^2) in size, of which 76 percent (39,872 km^2 (15,395 mi^2)) is Federal, State, and Tribal lands. Forty-three percent of Federal, State, and Tribal lands is secure core and 47 percent is secure habitat. The San Juan Mountains analysis area is 26,512 km^2 (10,236 mi^2) in size, of which 82 percent (21,636 km^2 (8,354 mi^2)) is Federal, State and Tribal lands. Fifty-two percent of Federal, State, and Tribal lands is secure core and 56 percent is secure habitat. It is important to keep in mind that the specific boundary and size of analysis areas influence the percent core and secure habitat. Our selection of these boundaries was based largely on big areas of Federal lands and political boundaries; however, analysis areas also include some chunks that are primarily private land or checkerboards of private and public land. The process we used is likely somewhat different from that used to designate the original recovery zones, and comparisons between these 2 analysis areas and recovery zones should be made with caution.

These percentages of secure core and secure habitat in the Sierra Nevada (43 and 47 percent, respectively) and San Juan Mountains (52 and 56 percent, respectively) are significantly lower than that in the NCDE and GYE recovery zones (NCDE Subcommittee 2018, Appendix 4; YES 2016b, Appendix E). Secure habitat averages 85.6 percent of the recovery zone in the GYE (YES 2016, Appendix E) and secure core averages 76.4 percent of the recovery zone in the NCDE (NCDE Subcommittee 2018, Appendix 4). In addition, research in the NCDE indicated that 68 percent secure core is the minimum threshold necessary for successfully reproducing adult female grizzly bears (Manley 1993, *in litt*.; Service 1995, p. 6). Our analysis did not calculate route density and secure core/habitat by bear management subunit as in the NCDE and GYE. Doing so would likely highlight smaller areas within the Sierra Nevada and San Juan Mountains that have higher levels of secure core and are more suitable for grizzly bears. However, the total amount of public access to Federal, State, and Tribal lands in the Sierra Nevada and San Juan Mountains is high, and we would expect resultant high human-caused mortality levels and habitat displacement (McLellan and Shackleton 1988, pp. 458–459; McLellan 1989, pp. 1862–1864; Mace et al. 1996, pp. 1402–1403; Schwartz *et al.* 2010, p. 661).

At 52,531 km^2 and 26,512 km^2 (20,282 mi^2 and 10,236 mi^2), the Sierra Nevada and San Juan Mountains, respectively, are larger in area than either the CYE or SE recovery zones, and could be large enough to support a population of grizzly bears (we define a population as two or more reproductive females or one female reproducing during two separate years (Service 2000, pp. 3-14–15)). However, natural recolonization of these areas is unlikely because of the distance from existing grizzly bear populations. The Sierra Nevada and San Juan mountain ranges are very far (greater than 880 km (550 mi) and 480 km (300 mi), respectively) from current grizzly bear populations. Maximum dispersal distances of 67–176 km (42–109 mi) for males have been documented in the NCDE and GYE (Blanchard and Knight 1991, pp. 50, 55; McLellan and Hovey 2001, p. 841; Peck *et al.* 2017, p. 2), while female grizzly bears rarely disperse long distances (Swenson *et al*. 1998, pp. 822–824; Jerina and Adamic 2008, pp. 1495–1497). Recolonization and recovery of a new area would require continuous occupation by females, and for areas at great distance from existing populations, this is not likely to occur.

Additionally, the areas between the Sierra Nevada and San Juan mountain ranges and current populations include large blocks of rangeland with open canopy coverage, agriculture and private lands, and are bisected by several major highways and interstates. Increasing human development will increase these barriers in the future. Thus, the likelihood of even one male bear successfully immigrating from existing populations to these areas is minimal, and it is even more unlikely that a population would naturally recolonize and achieve recovery.

A population could be established through reintroduction. However, neither of these areas are large enough to contain sufficient numbers of bears to maintain long-term fitness, and ongoing translocations would likely be needed to ensure long-term genetic health. A total population size of approximately 400 animals is needed for short-term fitness (Miller and Waits 2003, p. 4338) and the population would require one to two effective immigrants from one of the other established grizzly bear populations approximately every 10 years (e.g., a generation interval) to ensure genetic health over the long term (Mills and Allendorf 1996, pp. 1510, 1516; Newman and Tallmon 2001, pp. 1059–1061; Miller and Waits 2003, p. 4338). Given these factors, at this time we believe the possibility of populations naturally recolonizing these areas is almost impossible; even if a population were reintroduced, there is a very low likelihood of natural linkage to existing populations needed to maintain long-term fitness and become self-sustaining (Service 1982, p. 1; Service 1993, p. 13, 24).

Although other grizzly bear populations and unoccupied recovery zones included in the lower-48 States, such as the GYE, North Cascades, and BE, are currently isolated, they are within male dispersal distance of existing populations, and connectivity is possible. In addition, with the expanding NCDE population, the BE is expected to be within female dispersal distance in the future. For example, The GYE grizzly bear population remains isolated today, with no evidence of genetic exchange with any other population; however, the distance between current distributions of grizzly bears in the GYE and NCDE has decreased recently and distributions are now are close (75 km (47 mi)) (Bjornlie 2019, *in litt*.) with multiple verified sightings in between, and it is likely that natural connectivity will occur in the near future.

The North Cascades does not currently contain a grizzly bear population and the area remains isolated from other existing populations. Natural recolonization by females is unlikely in the near future due to the low numbers of bears in nearby populations and the highly fragmented landscape in between (NPS and Service 2017, p. 5). However, if a population is established in the North Cascades, there are other populations close enough that could provide occasional male immigrants, thereby ensuring long-term genetic fitness. There are at least three populations within long-distance dispersal range (67–176 km (42–109 mi)) (Blanchard and Knight 1991, pp. 50, 55; McLellan and Hovey 2001, p. 841; Peck *et al.* 2017, p. 2), from the North Cascades, including the Stein-Nahatlatch, Squamish-Lillooet, Garibaldi-Pitt Grizzly Bear Population Units in Canada. If restoration in the North Cascades occurs in the future, the North Cascades has the potential to become a self-sustaining population that is connected with other existing populations.

The BE is also isolated and does not currently contain a population. However, at least five grizzly bears have been confirmed in areas immediately surrounding the recovery zone over the last 15 years, including a collared bear dispersed from the CYE into the BE recovery zone in 2019. These examples indicate that connectivity is possible.

The SE and CYE are small recovery zones and do not have the potential to contain 400 bears. However, both recovery zones are contiguous with grizzly bear habitat northward into Canada, and a recovered population would be a subset of a much larger population. Bears can and do move between recovery zones and contiguous habitat to the north, thereby enabling demographic connectivity and long-term genetic fitness.

Our initial analysis indicated other areas within grizzly bear historical range that currently contain substantial secure habitat, such as the Uinta and Mogollon Mountains in the southwestern U.S. (Juliusson 2019, *in litt*.). All of these areas are smaller than the Sierra Nevada and San Juan Mountains and have the same limiting factors that more than likely prevent them from supporting a self-sustaining population, including: low amounts of secure core, extremely low potential of linkage to existing grizzly bear populations due to high human densities, transecting highways and interstates, agriculture, lack of cover, and high densities of motorized routes. Therefore, we did not conduct subsequent analyses on these other areas.

Summary of Methods used to Measure Population Trends and Annual Estimates

Wildlife managers and population ecologists monitor a number of factors to gauge the status of a population and make scientifically informed decisions. These measures include estimates of population size, population trend, density, and current range extent. While population size is a well-known and easily understood metric, it only provides information about a population at a single point in time. Wildlife managers often want to know how a population is changing over time and why. For grizzly bears in the lower-48 States, the methods used to estimate population trends and numbers vary by ecosystem due to differing level of available resources, the history of monitoring efforts and types of data collected, and the size of each ecosystem (see *Appendix C* for further details). As managers and technical experts review new techniques or approaches for potential adoption, they should consider the technique's cost, field sampling logistics, utility to managers, and the ability to investigate trends over time.

In the GYE, the IGBST uses four independent methods to estimate population trend: (1) the model-averaged Chao2 counts of females with cubs, which is also used to estimate population size (see explanation of model-averaged Chao2 in *Appendix C*); (2) a mark-resight estimator for numbers of females with cubs (i.e., capture-recapture data (IGBST annual reports[2])); (3) deterministic and stochastic population projections based on deterministic life table analysis of vital rates of radio-monitored bears (in their entirety: Schwartz *et al*. 2006b; IGBST 2012); and (4) population reconstruction (minimum number of known live bears) based on capture and mortality records (IGBST, unpublished data).

In the NCDE, the population trend is estimated using two methods: (1) a deterministic projections from vital rates; and (2) individual-based, stochastic population modeling (Costello *et al.* 2016, p. 69). The population estimate is based on a genetic capture/recapture study conducted in 2004 (Kendall *et al.* 2009, entire) and subsequent estimates of population trend (Costello *et al.* 2016, p. 16).

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[2] IGBST Annual Reports are available at: *https://www.usgs.gov/science/interagency-grizzly-bear-study-team?qt-science_center_objects=4#qt-science_center_objects*

In the CYE and SE, population growth rates are estimated using population projection of bootstrapped vital rates using program Booter 1.0 (Hovey and McLellan 1996, pp. 1411–1412; Kasworm *et al.* 2020a, pp. 10–11; Kasworm *et al*. 2020b, pp. 8–9). Minimum population sizes are estimated using two methods: (1) DNA analysis of hair from captured bears, hair corrals, and rub sites, and opportunistic efforts; and (2) calculated based on observed females with cubs as set forth in the 1993 Recovery Plan (UFWS 1993, pp. 83–84, 101–102; Kasworm *et al.* 2020a, p. 13; Kasworm *et al*. 2020b, p. 10).

There are currently no known populations within the North Cascades or BE, so population monitoring is not being conducted at this time. We define a population as two or more reproductive females or one female reproducing during two separate years (Service 2000, pp. 3-14–15). However, we document all verified sightings within or near these ecosystems.

Geographic Boundaries

We refer to several geographic boundaries relevant to the grizzly bear in this biological report: ecosystems, recovery zones, demographic monitoring areas (DMAs), demographic connectivity areas (DCAs), management zones, bear management units (BMUs), and bears outside recovery zones (BORZ). Figure 9, above, illustrates how recovery zones and DMAs relate to each other. Individual ecosystem maps are below (Figures 14–18). Various boundaries were created for management and monitoring purposes. We briefly discuss here for context but see below for full discussion of management and monitoring.

Ecosystems

The Service has not explicitly defined ecosystem boundaries on the landscape for any of the ecosystems across the lower-48 States. However, ecosystems are generally considered to be the larger area surrounding the recovery zones in which grizzly bears may be anticipated to occur as part of the same population. Throughout our assessment, ecosystems are synonymous with populations, and are the extent at which we evaluated the 3Rs.

Recovery Zones

The 1993 Recovery Plan, and subsequent supplements, identified recovery zones at the core of each of the six ecosystems to further recovery efforts (in their entirety: Service 1993, 1996, 1997, 2000) (Figure 9, above). Each recovery zone represents an area large enough and of sufficient habitat quality to support a recovered grizzly bear population (Service 1993, p. 17). The Recovery Plan recognized that grizzly bears will move and reside permanently in areas outside the recovery zones; however, only the area within the recovery zone is managed primarily for grizzly bear habitat (Service 1993, p. 18). The plan acknowledged that linkage would be necessary for isolated populations to increase and sustain themselves at recovery levels (Service 1993, pp. 23, 24). The recovery zones identified are: (1) the GYE in northwestern

Wyoming, eastern Idaho, and southwestern Montana at 23,853 km^2 (9,210 mi^2); (2) the NCDE of north-central Montana at 23,135 km^2 (8,932 mi^2); (3) the North Cascades area of north-central Washington at 25,305 km^2 (9,770 mi^2); (4) the SE area of northern Idaho, northeast Washington, and southeast B.C. at 6,575 km^2 (2,539 mi^2); (5) the CYE area of northwestern Montana and northern Idaho at 6,705 km^2 (2,589 mi^2); and (6) the BE in the Bitterroot Mountains of central Idaho and western Montana at 15,100 km^2 (5,830 mi^2).

Demographic Monitoring Areas (DMAs)

The recovery plan describes a 10-mile buffer around each recovery zones within which demographic recovery criteria are monitored. The NCDE and GYE demographic monitoring areas (DMAs) serve a similar concept, including and surrounding the recovery zone (Figure 9, above). The DMA is the area in which the population is annually surveyed for and estimated for the GYE and within which the mortality limits apply for the GYE and NCDE. For both areas, boundaries took into consideration physical and recognizable features, however several differences exist. For the GYE, the IGBST developed the DMA using suitable habitat (see *Appendix D*) as the basis and added areas that are possible mortality sinks (areas where death rates exceed birth rates). These generally represented long and narrow areas where human influence could have disproportionate effects (i.e., "edge effect") on the population generally contained within the suitable habitat zone (IGBST 2012, p. 42; Woodroffe and Ginsberg 1998, p. 2126). By including these areas, any extra mortality due to edge effects would be included in the count against the mortality threshold. The GYE DMA includes suitable habitat plus the potential sink areas for a total area of approximately 49,931 km^2 (19,278 mi^2) (Figure 9, above). The GYE DMA contains 100 percent of the recovery zone and 100 percent of suitable habitat, as shown in *Appendix D*. For the NCDE, the recovery zone and Zone 1 (see description below) comprise the DMA, which is 42,549 km^2 (16,440 mi^2). The following were considered in development of the NCDE DMA boundary: avoiding inclusion of adjacent areas that are in a different conservation status; preserving linkage opportunities to other grizzly bear populations; inclusion of contiguous or semi-contiguous large blocks of public land where population expansion and linkage habitat exists; exclusion of areas that are primarily private lands to the east; and recognizing that there is a reasonable limit to the mortality monitoring area and the dispersal capability of grizzly bears. For the other ecosystems, the mortality limits in the Recovery Plan apply within a 10-mile buffer around the recovery zone. DMAs have not been identified for other ecosystems.

Demographic Connectivity Areas (DCAs) and Zones 1, 2, and 3 for the NCDE

Zone 1 (the portion of the DMA outside the recovery zone) provides a 19,444 km^2 (7,507 mi^2) buffer around the NCDE recovery zone, where the population objective is continuous occupancy by grizzly bears and habitat protections that are compatible with a stable to increasing grizzly bear population (see Figure 17 for zone boundaries). Zone 1 contains two demographic connectivity areas (DCAs), the Ninemile DCA (2,094 km^2 (808 mi^2)) and the Salish DCA (1,902 km^2 (734 mi^2)). Within the DCAs, specific protections were identified to support female occupancy and eventual demographic connectivity (e.g., female dispersal) to the CYE and to serve as a source population for the BE. The objective of Zone 2, at 18,854 km^2 (7,280 mi^2) is to provide the opportunity for grizzly bears to move between the NCDE and adjacent ecosystems (e.g., the GYE). Other areas within the NCDE (eastern Montana) are referred to as Zone 3 (the extent of Zone 3 will be determined in future Service decisions). In contrast to Zones 1 and 2, Zone 3 does not provide habitat linkage to other grizzly bear ecosystems. The focus of management in Zone 3 is conflict prevention and a quick response to human-grizzly bear conflicts.

Bear Management Units (BMUs)

Bear management units (BMUs) and subunits are analysis areas used to track habitat security and distribution criteria for females within recovery zones (Christensen and Madel 1982, p. 6; USDA FS 1997, entire; Service 2007c, pp. 20, 41, 44–46; USDA FS 2011a, pp. 4–5, 66; NCDE Subcommittee 2018, pp. 16, 145–146; Service 2018, p. 9). BMUs approximate the lifetime size of a female's home range and were delineated using topographic and hydrologic features. In some cases, BMUs may not reflect current lifetime female home range estimates within each ecosystem because home range sizes change with population densities and in some cases, more ecosystem specific data is available now than at the time they were established. They vary in size from approximately 250 km^2 (96 mi^2) to 1,380 km^2 (532 mi^2). Subunits are analysis areas that approximate the annual home range size of adult females. Where identified, subunits provide the optimal scale for evaluation of seasonal feeding opportunities and landscape patterns of food availability for grizzly bears (Weaver *et al.* 1986, p. 236). In the GYE, 18 different BMUs were designated within the recovery zone and each BMU was further subdivided into subunits, resulting in a total of 40 subunits contained within the 18 BMUs (Figure 21, below). In the NCDE, 23 different BMUs were designated within the recovery zone and each BMU was further subdivided into subunits, resulting in a total of 126 subunits contained within the 23 BMUs (Figure 22, below). In the CYE, 22 BMUs were designated within the recovery zone (Figure 23, below); in the SE, 10 BMUs were designated within the U.S. portion of the recovery zone (Figure 23, below); and lastly in the North Cascades, 42 BMUs were designated in the recovery zone (Figure 24, below). Subunits have not been designated in these 3 ecosystems. BMUs have also been identified for two population units in B.C., with six in the South Selkirk population unit (the Canadian portion of the SE recovery zone) and six in the Yahk population unit adjacent to the CYE (MacHutchon and Proctor 2016, p. 61). In the BE, neither BMUs nor subunits have been designated yet.

Bears Outside Recovery Zones (BORZ)

The 1993 Recovery Plan recognized that grizzly bears could occur outside the recovery zone lines and that the mere presence of bears outside of the boundary was not sufficient reason to change the recovery zones (Service 1993, p. 18). While observation data are limited and these habitats have not been evaluated to determine if they are of significant biological value, on-going and future land management activities in these areas could result in adverse effects (e.g., incidental take) on grizzly bears (USDA FS 2011a, entire). These areas were called Bears Outside Recovery Zones (BORZ) for the CYE and SE. The biologists involved in the 2002–2003 BORZ analysis recognized that the mapping may need to be revisited and updated periodically. Consequently, in 2011, an interagency team of biologists revisited the BORZ for the CYE and SE to refine maps of occupied grizzly bear habitat and developed a process to consistently identify these areas based on the number and type of observations and the use of an objective mapping unit boundary to help define these areas (Allen 2011, entire). Delineation was based on three or more credible sightings within the last 16 years in individual 6th order watershed Hydrologic Unit Codes (HUCs). Sixth order HUCs were selected because of their size (typically 40–162 km^2 (15–63 mi^2)) and their common use as cumulative effects boundaries for watershed, fisheries, and wildlife analyses in environmental documents by the USFS. Adjacent HUCs with enough grizzly bear use to be considered recurring were combined to create contiguous areas of recurring use. The methodology allowed for future expansion in the overall size of the BORZ if adjacent 6th order HUCs experienced repeated visitation by bears. The size and juxtaposition of individual BORZ were not developed to imitate BMUs in the recovery zone. Tolerance of grizzly bear presence in areas of human occupation is an important consideration that may limit population expansion in the future (see *Preventative Measures to Address Public Attitudes towards Grizzly Bears and Reduce Mortality*).

Current Range, Distribution, and Trends

Outside the lower-48 States, approximately 55,000 grizzly bears currently exist in the largely unsettled areas of Alaska and western Canada (Figure 13) (Alaska Department of Fish and Game 2020, entire; COSEWIC 2012, p. vi); however, populations within the lower-48 States are much more fragmented (McLellan *et al*. 2016, pp. 2–5). While the range of bears in some ecosystems has significantly expanded since 1975, the overall range and distribution of bears in the lower-48 States remain below historical levels at approximately 6 percent of historical range (Haroldson *et al*. 2020a, *in press*).

Within the lower-48 States, grizzly bear populations currently exist primarily within and around four ecosystems (CYE, GYE, NCDE, and SE) that include portions of four States (Idaho, Montana, Washington, and Wyoming). Grizzly bear range has been expanding in these areas, and multiple grizzly bear sightings have been confirmed in potential linkage areas between the existing ecosystems and also within the BE; however, there is no known population in the BE or between ecosystems. There is also no known population in the North Cascades.

Though this SSA deals mainly with the listed entity in the lower-48 states, Canadian grizzly bear populations and habitat are contiguous with the four ecosystems along the international border (NCDE, CYE, SE, and North Cascades; Figure 15). Radio-collared individuals have demonstrated the permeability of the international border in three (NCDE, CYE, and SE) of the four ecosystems (Mace and Roberts 2011 p. 31; Kasworm *et al.* 2020a, p. 72–99; Kasworm *et al*. 2020b, p. 47–61). Although there is currently no known population in the North Cascades, it constitutes a large block of contiguous habitat that spans the international border. Canadian bear populations are critical to future management of these transboundary populations and can provide genetic and demographic connectivity (Proctor *et al*. 2012, pp. 31–34). Canadian population and management information is provided in Appendix X.

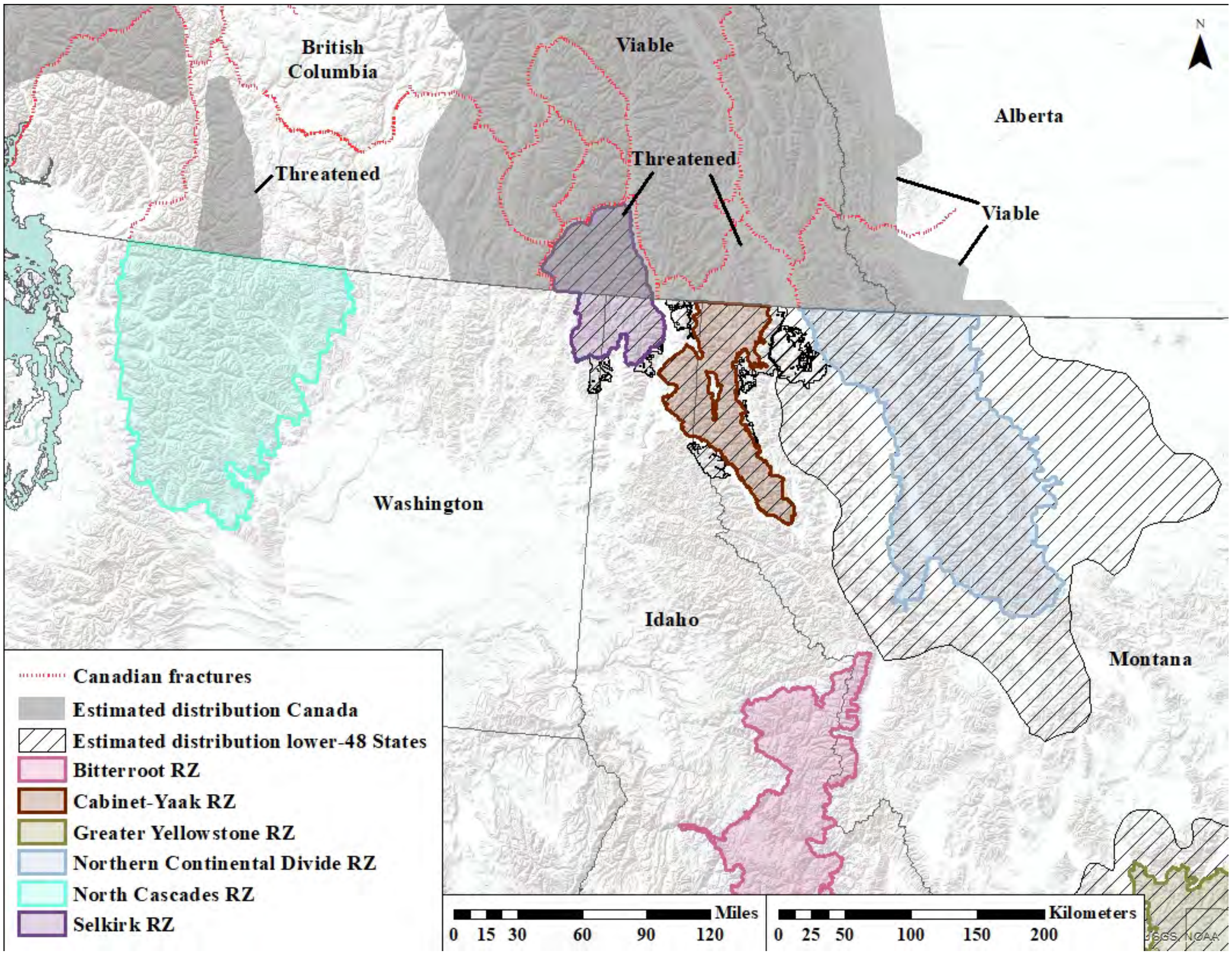

Figure 15. Map of estimated distributions in trans-boundary populations and potential fracture zones in Canada (Proctor et al. 2012, p. 14; Proctor et al. 2015, p. 2).

Total numbers in the lower-48 States are estimated at least 1,913 individuals (1,068 in the NCDE, 737 in the GYE DMA, 55–60 in the CYE, and a minimum of 53 in the U.S. portion of the SE, although some bears have home ranges that crossed the international border) (Table 7) (Costello 2020, *in litt.*; Haroldson *et al.* 2020b, p. 13; Kasworm *et al.* 2020a, p. 40; Kasworm *et al*. 2020b, p 19). In the GYE, this estimate does not capture the entire distribution of grizzly bears. As mentioned above, grizzly bears have been verified in linkage areas between ecosystems, however, there are likely few resident grizzly bears in the lower-48 States outside of these areas.

Table 7. Current population estimates of grizzly bears in the six ecosystems in the lower-48 States (NCDE = Northern Continental Divide Ecosystem; GYE = Greater Yellowstone Ecosystem; CYE = Cabinet-Yaak Ecosystem; SE = Selkirk Ecosystem; and BE = Bitterroot Ecosystem).

Ecosystem	Estimated Number of Bears	Citation
NCDE	1,068	Costello 2020, *in litt.*
GYE (as measured in the Demographic Monitoring Area)	737	Haroldson *et al.* 2020b, p. 13
CYE	55-60	Kasworm *et al.* 2020a, p.40
SE	Minimum of 53 in U.S. portion, B.C. estimate in progress	Kasworm *et al.* 2020b, p. 19
BE	No known population	
North Cascades	No known population	

Below, we summarize the current distribution and trends for each ecosystem. In Chapter 3, we summarize recovery planning efforts and progress toward recovery goals for each ecosystem. In addition to the to the six ecosystems identified in the Recovery Plan, linkage zones "between currently separated populations that provide adequate habitat for low densities of individuals to exist and move between two or more larger areas of suitable habitat" were identified as desirable (Service 1993, pp. 24–25).

The Greater Yellowstone Ecosystem (GYE)

The Greater Yellowstone Ecosystem (GYE) is located in northwest Wyoming, eastern Idaho, and southwestern Montana and refers to the larger ecological system containing and surrounding YNP (Figure 16). As of 2019, the GYE grizzly bear population was estimated to be 737 individuals inside the DMA (Haroldson *et al.* 2020b, p. 12), more than double the estimated population size of 136 to 300 at the time of listing in 1975 (Cowan et al. 1974, pp. 32, 36; Craighead et al. 1974, p. 16; McCullough 1981, p. 175). This estimate does not capture the entire distribution of bears in the GYE. As predicted by Pyare *et al*. (2004, pp. 5–6), grizzly bears have naturally recolonized many areas and currently occupy about 98 percent of suitable habitat (45,822 km^2 (17,692 mi^2)) and 98 percent of the DMA (48,695 km^2 (18,801 mi^2)), and are expanding beyond the DMA. Twenty-nine percent of the current estimated distribution occurs beyond the DMA (20,041 km^2 ((7,738 mi^2)) (Bjornlie and Haroldson 2019, p. 26; Fortin-Noreus 2019, in litt.). We do not have an estimate for the number of grizzly bears ecosystem-wide, however it is important to recognize that bears are permanently occupying areas beyond the DMA. Grizzly bears have nearly tripled the extent of their occupied range in the GYE since the early 1980s (Service 1982, p. 11; Bjornlie and Haroldson 2019, p. 26).

Together, the four methods the IGBST uses to collectively calculate population trends support the interpretation that the GYE grizzly bear population experienced robust population growth from the mid to late 1980s through the late 1990s, followed by a slowing of population growth since the early 2000s. From 1983 to 2002, the GYE experienced a 4.2 to 7.6 percent per year population growth rate (Harris *et al.* 2006, p. 48). The population trajectory that includes the most recent data is based on Chao2 estimates for females with cubs for the period 2002 to 2019, which indicates a relatively constant population size for this reproductive segment of the population within the DMA, but with some evidence in recent years of an increasing trend (Haroldson *et al.* 2020b, p. 13). As the grizzly bear population in the GYE has increased in numbers they have also expanded their range beyond the recovery zone, into other suitable habitat in the DMA and also outside the DMA.

No population can grow forever because required resources are finite. Carrying capacity is the maximum number of individuals a particular environment can support over the long term without resulting in population declines caused by resource depletion (Vandermeer and Goldberg 2003, p. 261; Krebs 2009, p. 148). Many factors affect carrying capacity of animal populations in the wild and carrying capacity itself typically varies over time. Populations usually fluctuate above and below carrying capacity, resulting in relative population stability over time (i.e., lambda value of approximately 1.0 over the long term) (Colinvaux 1986, pp. 138–139, 142; Krebs 2009, p. 148). For populations at or near carrying capacity, population size may fluctuate just above and below carrying capacity around a long-term mean, sometimes resulting in annual estimates of growth rate (lambda) showing a declining population. However, to obtain a biologically meaningful estimate of average annual population growth rate for a long-lived species like the grizzly bear that reproduces only once every 3 years and typically does not start reproducing until at least 4 years old, we must examine lambda over a longer period of time to see what the average trend is over that specified time. This is not an easy task. For grizzly bears, it takes at least 6 years of monitoring of at least 30 females with radio collars to accurately estimate average annual population growth (Harris *et al.* 2011, p. 29).

Mechanisms that regulate or control population size fall into two broad categories: density-dependent effects and density-independent effects. Generally, factors that limit population growth more strongly as population size increases are density-dependent effects, or intrinsic factors, usually expressed through individual behaviors, physiology, or genetic potential (McLellan 1994, p. 15). Extrinsic factors, such as drought or fire that kill individuals regardless of how many individuals are in a population, are considered density-independent effects (Colinvaux 1986, p. 172). These extrinsic factors may include changes in resources, predators, or human impacts and may cause carrying capacity to vary over time. Population stability (i.e., fluctuation around carrying capacity or a long-term equilibrium) is often influenced by a combination of density-dependent and density-independent effects. Among grizzly bears, manifestations of density-dependent population regulation can include: (1) decreased yearling and cub survival due to increases in intraspecific killing (i.e., bears killing other bears), (2) decreases in home range size, (3) increases in generation time, (4) increases in age of first reproduction, and (5) decreased reproduction (McLellan 1994, entire; Eberhardt 2002, pp. 2851–2852; Kamath *et al.* 2015, p. 5516; McLellan 2015, pp. 13–14; van Manen *et al*. 2016, pp. 307–308). Indicators that density-independent effects are influencing population growth can include:

(1) larger home range sizes (because bears are roaming more widely in search of foods) (McLoughlin *et al.* 2000, pp. 49–51), (2) decreased cub and yearling survival due to starvation, (3) increases in age of first reproduction due to limited food resources, and (4) decreased reproduction due to limited food resources.

Despite the challenges involved in determining whether a population is affected more strongly by density-dependent or density-independent effects, the IGBST provided evidence based on several decades of data that supports density-dependent effects were likely a factor in the recent slowing in population growth in the GYE; these findings are consistent with other research suggesting that the GYE grizzly bear population in the core area of its range is at or near carrying capacity (van Manen *et al.* 2016, entire). Schwartz *et al.* (2006b, entire) estimated survivorship of cubs-of-the-year, yearlings, and independent (2 years old or older) bears as well as reproductive performance to estimate population growth. They examined geographic patterns of population growth based on whether bears lived inside YNP, outside the Park but inside the recovery zone, or outside the recovery zone entirely. Based on decreased cub and yearling survival inside YNP compared to outside YNP, Schwartz *et al.* (2006b, p. 29) concluded that grizzly bears were approaching carrying capacity inside YNP. Consistent with findings by Schwartz *et al.* (2006b, p. 29), the IGBST (2012, p. 33) documented lower cub and yearling survival than in the previous time period. The slowing of population growth since the early 2000s was primarily a function of this lower survival of dependent young (i.e., cubs and yearlings) and moderate reproductive suppression (IGBST 2012, p. 8). Additionally, survival of cubs-of-the-year and reproduction were lower in areas with higher grizzly bear densities but showed no association with estimates of decline in whitebark pine tree cover, suggesting that density-dependent factors contributed to the change in population growth (van Manen *et al*. 2016, entire). Importantly, annual survival of independent females (the most influential age-sex cohort on population trend) remained the same while independent male survival increased (IGBST 2012, p. 33). In addition, female home range sizes have decreased in areas of greater bear densities, as would be expected if density-dependent regulation is occurring (Bjornlie *et al.* 2014b, p. 4) (see *Food Resources in the GYE*, below, for more detailed information). Collectively, these studies indicate that the growth rate of the GYE grizzly bear DMA population has slowed as bear densities have approached carrying capacity, particularly in the core area of their current range.

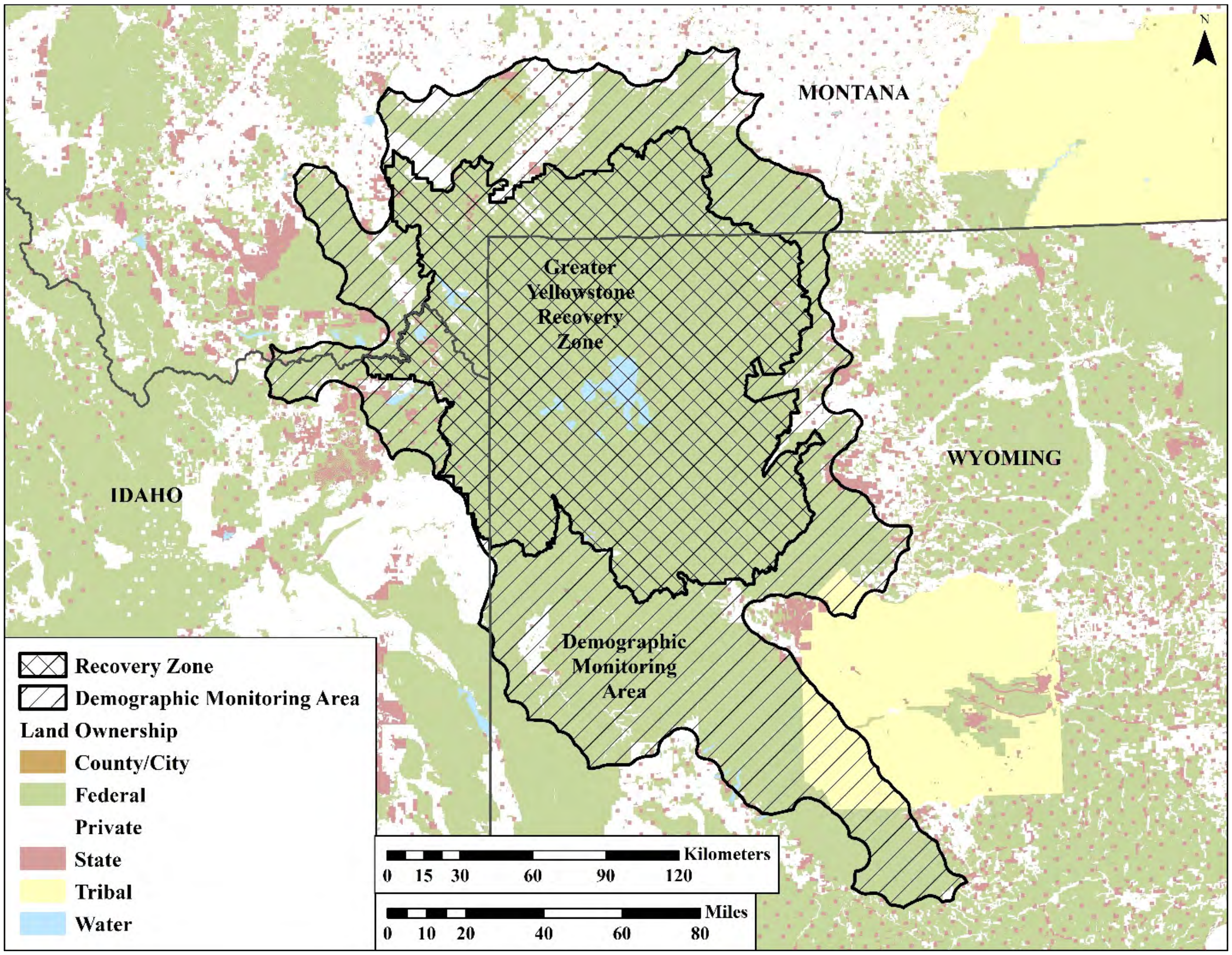

Figure 16. Map of the Greater Yellowstone Ecosystem (GYE). Land ownership and boundaries are shown for the recovery zone and the Demographic Monitoring Area (DMA). The DMA surrounds and includse the recovery zone.

Northern Continental Divide Ecosystem (NCDE)

The Northern Continental Divide Ecosystem (NCDE) is located in northwest Montana and refers to the large ecological system containing and surrounding GNP (Figure 17). Grizzly bears historically occurred throughout the area of the NCDE (Stebler 1972, pp. 297–298), but they were less common in prairie habitats (Rollins 1935, p. 191; Wade 1947, p. 444). Historical grizzly bear presence in these drier, grassland habitats was associated with rivers and streams where grizzly bears used bison carcasses as a major food source (Burroughs 1961, pp. 57–60; Herrero 1972, pp. 224–227; Stebler 1972, pp. 297–298; Mattson and Merrill 2002, pp. 1128–1129).

Since the 1975 listing of grizzly bears as threatened under the Act, the NCDE grizzly bear population has more than doubled in size and range (from 24,800 km^2 (9,600 mi^2) to 63,924 km^2 (24,681 mi^2)) (Dood *et al.* 1986, p. 166; Service 1993, pp. 11–12; Kendall *et al.* 2009, p. 3; Mace *et al.* 2012, p. 124; Costello *et al.* 2016, p. 2; Costello 2019, *in litt.*; MFWP, unpublished data). The NCDE population has increased from as few as 300 bears in 1986 to an estimated 765 bears in 2004, based on a genetic capture/recapture population estimate (Dood 1986, p. 166; Kendall *et al.* 2009, p. 9). The population is contiguous with grizzly bears in Canada (Figure 15). Applying a calculated population growth of 2.3 percent annually since 2004, the 2019 population estimate was estimated at 1,068 individuals throughout the NCDE (Costello *et al.* 2016, p. 2; Costello 2020, *in litt.*).

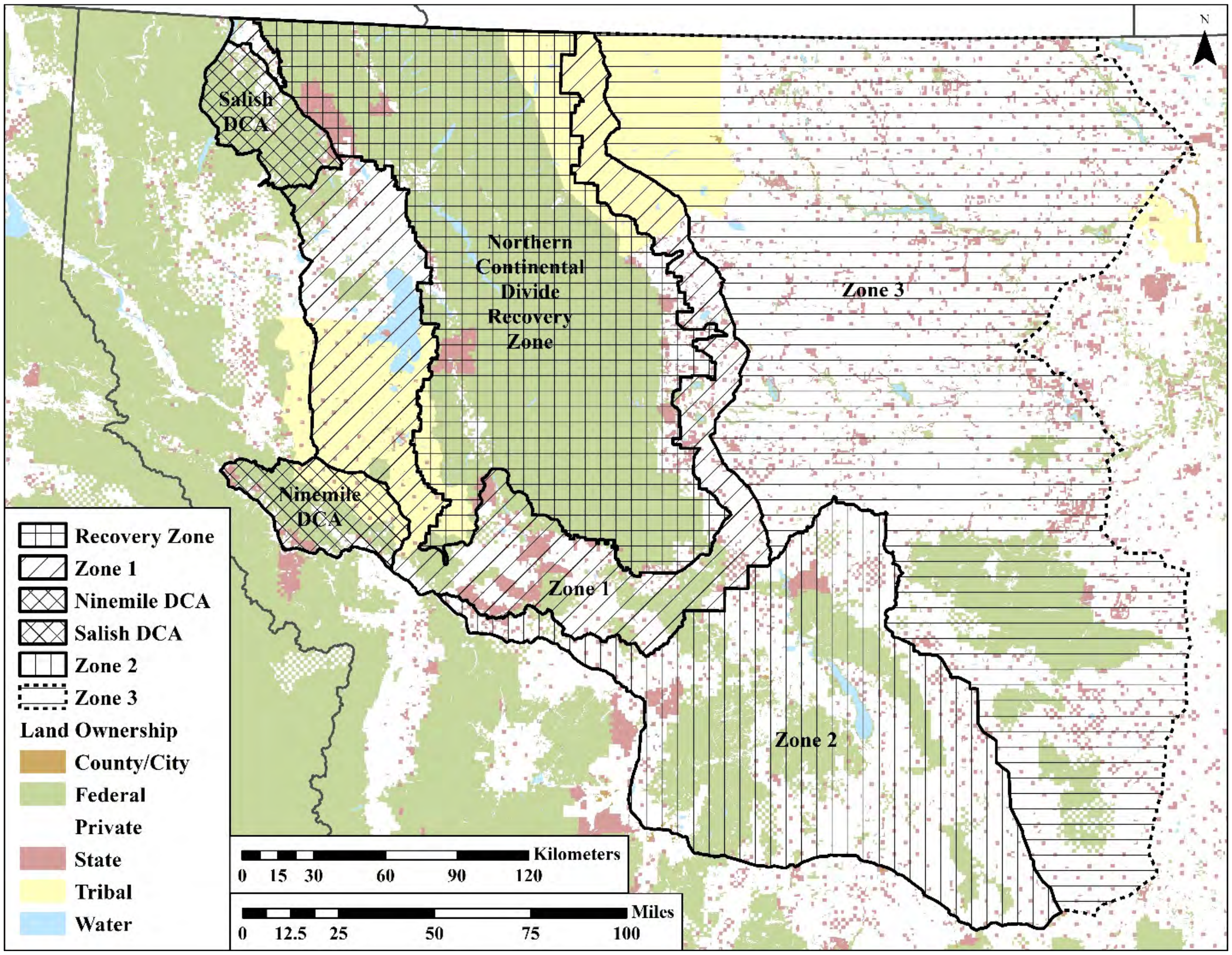

Figure 17. Map of the Northern Continental Divide Ecosystem (NCDE). Land ownership and boundaries are shown for the NCDE grizzly bear recovery zone, management Zones 1, 2, and 3, and demographic connectivity areas (DCAs). The demographic monitoring area (DMA) is comprised of the recovery zone and Zone 1. The eastern and southern extent of Zone 3 will be determined in future Service decisions.

Cabinet-Yaak Ecosystem (CYE)

The Cabinet-Yaak Ecosystem (CYE) refers to the larger ecosystem surrounding the recovery zone in northwest Montana and northeast Idaho (Figure 18). Based on known fates of radio collared individuals and reproductive outputs, it is estimated that the population of grizzly bears in the CYE is currently increasing, with an annual growth rate of 0.9 percent between 1983 and 2019 (Kasworm *et al.* 2020a, p. 39). This is a significant improvement from earlier trend calculations that indicated the population was declining, and now represents 12 years of an improving trend since 2006 (Kasworm *et al.* 2020a, p. 40;). The trend calculation utilizes all native (non-augmentation) collared bears from the U.S. and the Yahk population unit in B.C. (Kasworm *et al*. 2020a, p. 11–12). Additional information on populations and management in B.C. is provided in Appendix X. A population estimate derived from mark and recapture efforts estimated the U.S. population in 2012 at 48–50 individuals (Kendall *et al*. 2016, p. 80). Using DNA analysis of hair from captured bears, hair corrals, and rub sites, and opportunistic efforts, Kasworm *et al.* (2020a, p. 29) identified a minimum of 54 individuals in 2018. Some of these individuals likely have home ranges that overlap with Canada. The Kootenai River bisects the CYE approximately in half, with the Cabinet Mountains to the south and the Yaak River drainage to the north, and may have limited movement between the two (Kasworm *et al.* 2020a, p. 7). While no movement was detected prior to 2010, three males have been detected on both sides of the Kootenai River in the last decade (Kasworm *et al.* 2020a, p. 32). No gene flow associated with reproduction by these males has yet to be detected in the Cabinet Mountains. Due to the short distance between these two populations, full connectivity remains a management goal and evidence to date suggests progress towards that goal.

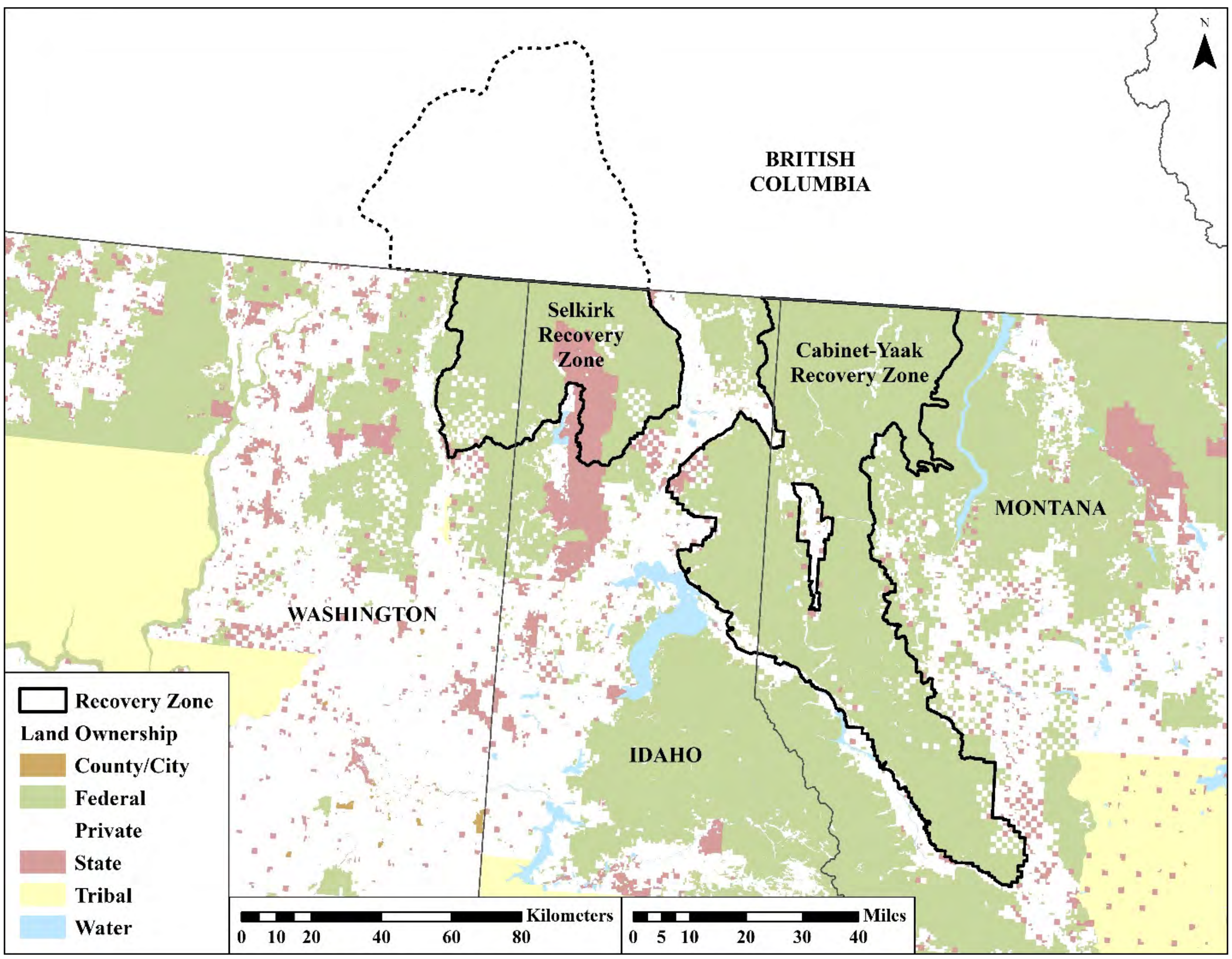

Figure 18. Map of the Cabinet-Yaak (CYE) and Selkirk (SE) Ecosystems. Land ownership and recovery zone boundaries are shown for the CYE and SE. Based on the 1993 Recovery Plan, the SE recovery zone extends into Canada, therefore, some of the demographic information (i.e., female survival and population trend) we have is based on the entire recovery zone (so includes bears in Canada).

Selkirk Ecosystem (SE)

The Selkirk Ecosystem (SE**)** refers to the larger ecological system surrounding the recovery zone in northwest Idaho, northeast Washington, and southeast B.C. (Figure 18, above). DNA analysis of hair from captured bears, corrals, rub sites, opportunistic collection efforts, and collared bears identified a minimum of 53 grizzly bears (23 male, 24 female, 6 unknown) within the U.S. portion of the SE in 2018 (Kasworm *et al*. 2020b, p. 19). Some of these individuals likely have home ranges that overlap with Canada, for which there is not an updated estimate. There were an estimated 58 bears in the Canadian portion of the population as of 2005 (Proctor *et al.* 2007, p. 19). Based on known fates of radio collared individuals and reproductive outputs, it is estimated that the population of grizzly bears in the SE, including Canada, is currently increasing, with an annual growth rate of 2.5 percent between 1983 and 2019 (Kasworm *et al.* 2020b, pp. 26–27). The trend calculation utilizes all collared bears in the U.S. and B.C. The U.S. and B.C. population estimates for the SE are not completely exclusive because numerous bears overlap in their home ranges, therefore adding estimates together would cause some double counting. An estimate of 83 bears for the international population was made in 2010 (Proctor *et al.* 2012, p. 31). A new effort to estimate the population is ongoing on the B.C. side of the SE and should be integrated with U.S. data and complete in 2022. Additional information on populations and management in B.C. is provided in Appendix X.

Bitterroot Ecosystem (BE)

The Bitterroot Ecosystem (BE) refers to the larger ecological system surrounding the recovery zone in central Idaho and western Montana (Figure 19). At the time of listing, there were no known grizzly bears in the BE. It was believed that no grizzly bears occurred in the BE until a young male grizzly bear was killed just to the north of the BE recovery zone in 2007. To assess the presence of grizzly bears in the northern Bitterroot Mountains portion of the BE in the area in which the grizzly bear was killed in 2007, a systematic survey for grizzly bears was conducted during 2008 and 2009 using DNA hair corrals and cameras (Servheen and Shoemaker 2010, entire). No photos of or hair samples from grizzly bears were obtained during this study. While we did not document any grizzly bears in the study area, because the survey covered a limited area, we could not conclude they were absent from the area at that time. There have been four confirmed individuals in the area immediately surrounding the BE recovery zone since 2007, including a collared male grizzly bear that dispersed from the CYE in 2019, a male grizzly bear that dispersed from the SE documented in 2019 and 2020, a verified sighting of unknown sex in 2019, and a male grizzly bear that dispersed from the NCDE documented in 2018 that was subsequently trapped and returned to the NCDE. However, because we have not documented a population or any female bears in the BE, we view the BE as currently unoccupied as per the definition of a population (two or more reproductive females or one female reproducing during two separate years) of grizzly bears in the Bitterroot Environmental Impact Statement (EIS) (Service 2000, pp. 3-14–15).

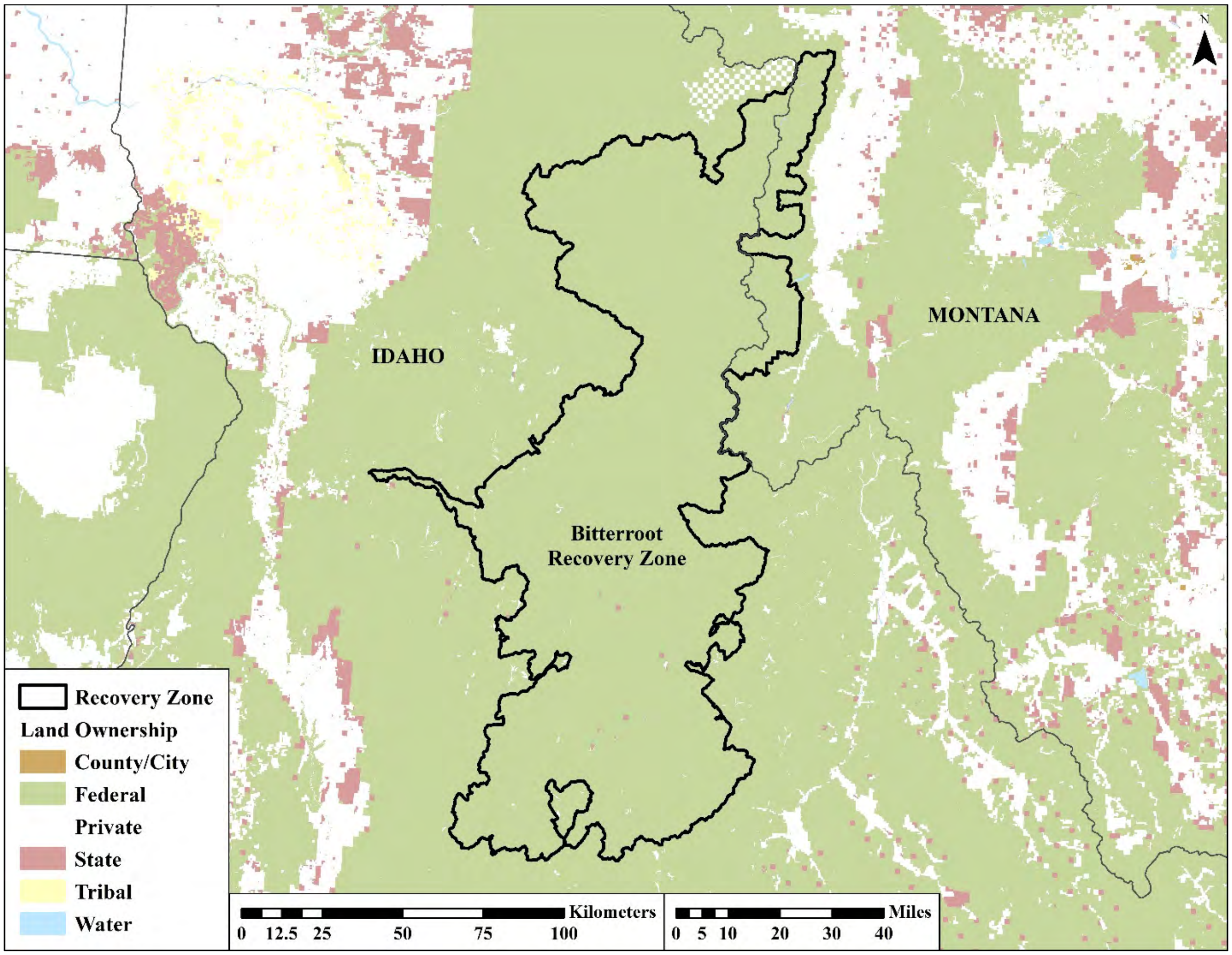

Figure 19. Map of the Bitterroot Ecosystem (BE). Land ownership and the recovery zone boundary is shown for the BE.

North Cascades Ecosystem

The North Cascades Ecosystem (North Cascades) is the larger ecological system surrounding the recovery zone in Washington, which contains the North Cascades National Park Complex (North Cascades National Park, Ross Lake National Recreation Area (NRA), and Lake Chelan NRA (Figure 20). There have been four confirmed grizzly bear sightings of two individuals within the B.C. portion of the North Cascades during the past decade (NPS and Service 2017, p. 42). In the B.C. portion of the North Cascades the population was estimated to be about 6 grizzly bears in 2012 (MFLNR 2012, p. 3). While the listed entity includes only the U.S. portion of this contiguous grizzly bear habitat, information from B.C. grizzly bears detected immediately north of the border are included as they may occasionally move into the U.S. The most recent confirmed observation within the U.S. portion of the North Cascades was in 1996, south of Glacier Peak (North Cascades Subcommittee 2016, *in litt.*, as cited in NPS and Service 2017, p. 42). The most recent direct evidence of reproduction was a confirmed observation of a female and cub on upper Lake Chelan in 1991 (Almack *et al.* 1993, p. 34). The lack of recent evidence of reproduction indicates that a grizzly bear population, as defined in the Bitterroot EIS (Service 2000, pp. 3-14–15), no longer exists within the North Cascades (NPS and Service 2017, p. 42).

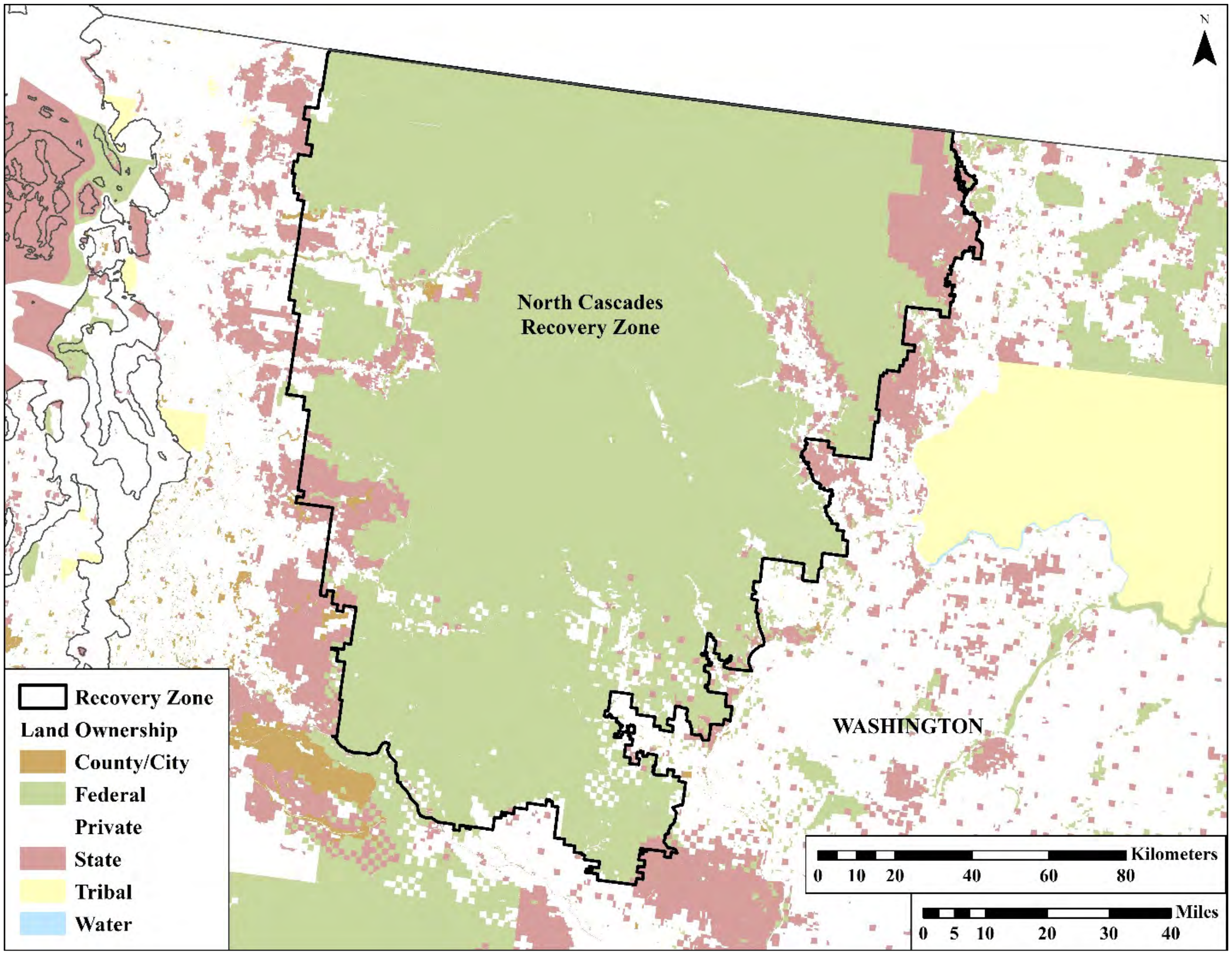

Figure 20. Map of the North Cascades Ecosystem. Land ownership and the recovery zone boundary is shown for the North Cascades.

Summary of Current Range, Distribution, and Trends

Estimated population size and distribution in both the GYE and NCDE have more than doubled since listing (Cowan *et al.* 1974, pp. 32, 36; Craighead *et al.* 1974, p. 16; McCullough 1981, p. 175; Dood *et al.* 1986, p. 166; Service 1993, pp. 11–12; Costello *et al.* 2016, p. 2; Bjornlie and Haroldson 2019, p. 26; Costello 2019, in litt.; Haroldson *et al.* 2020b, p. 13). The SE and CYE have also experienced positive population growth rates and increases in population sizes (Kasworm *et al.* 2020a, p. 39; Kasworm *et al.* 2020b, pp 26–27). Although there is still no known population within the BE, there are multiple verified sightings that have occurred in linkage zones close to the BE and the current estimated distribution for the NCDE grizzly bear population is only 7 km (4.3 mi) to the northeast of the BE recovery zone boundary. The North Cascades is currently unoccupied by a grizzly bear population.

Chapter 3: Regulatory History and Recovery Planning

In this chapter, we summarize our regulatory history for the grizzly bear. We also summarize recovery planning efforts for grizzly bears in the lower-48 States and provide summaries of recovery progress for each ecosystem. We have a 45-year history of working with a number of dedicated partners towards the recovery of grizzly bears in the lower-48 States. These efforts have led to increases in the number of and distribution of bears across Idaho, Montana, Washington, and Wyoming, and unprecedented collaboration in grizzly bear management and conservation.

Regulatory History

On July 28, 1975, we published a rule to designate the grizzly bear as threatened in the conterminous (lower-48) United States (40 FR 31734). When we listed the grizzly bear, we identified the dramatic decreases in historical range and land management practices (e.g., timber harvest and livestock grazing) in formerly secure grizzly bear habitat and excessive human-caused mortalities as the primary stressors (40 FR 31734, July 28, 1975). In the 1990s, the Service received a number of petitions to change the status of grizzly bear populations in the North Cascades, SE, and CYE. We determined that reclassifying grizzly bears in those ecosystems to endangered was warranted but precluded by higher priorities beginning in 1991 for the North Cascades (56 FR 33892, July 24, 1991), 1993 for the CYE (58 FR 8250, February 12, 1993), and 1999 for the SE (64 FR 26725, May 17, 1999). In 2014, the Service determined that the CYE and SE populations had recovered to the point that they were no longer warranted but precluded from listing as endangered (79 FR 72487, December 5, 2014). In 2017, in *Alliance for the Wild Rockies* v. *Zinke et al.*, the District Court of Montana remanded the determination that the CYE grizzly bear was not warranted but precluded for endangered status back to the Service for further consideration. Therefore, the legal status of the CYE and North Cascades populations remains warranted but precluded from uplisting to endangered. In accordance with the Act, we developed a Grizzly Bear Recovery Plan (Service 1982, entire) and have revised that plan as necessary (in their entirety: Service 1993, 1996, 1997, 2007*a*, 2007*b*, 2017, 2018).

In 2000, the Service designated the BE as a nonessential experimental population with special status under section 10(j) of the Act and published a final EIS and Record of Decision (ROD) to release an experimental population of grizzly bears in that ecosystem (65 FR 69624, November 17, 2000). In 2001, the Service published a proposed rule to remove the 10(j) regulations, but the rule was never finalized. The ROD remains in effect, but it has never been funded for implementation. The current section 10(j) rule for grizzly bears in the Bitterroot Grizzly Bear Experimental Population Area (50 CFR § 17.84(1)) does not apply to grizzly bears that have dispersed into the area on their own. The Service has not released or reintroduced any grizzly bears into the area; therefore, grizzly bears that have dispersed into the area on their own, including all recent verified sightings, are not covered by the 10(j) rule and are protected as threatened under the Act.

On November 17, 2005, we proposed to designate the GYE population of grizzly bears as a Distinct Population Segment (DPS) and to remove (delist) this DPS from the Federal List of Endangered and Threatened Wildlife (70 FR 69854). On March 29, 2007, we finalized this proposed action, designating the GYE population as a DPS and removing (delisting) grizzly bears in the GYE from the Federal List of Endangered and Threatened Wildlife (72 FR 14866). This final determination was vacated and remanded by the U.S. District Court for the District of Montana on September 21, 2009, in *Greater Yellowstone Coalition* v. *Servheen, et al.,* 672 F.Supp.2d 1105 (D. Mont. 2009). The District Court ruled against the Service on two of the four points brought against it: that the Service was arbitrary and capricious in its evaluation of whitebark pine and that the identified regulatory mechanisms were inadequate because they were not legally enforceable. In compliance with this order, the GYE grizzly bear population was once again made a threatened population under the Act (16 U.S.C. 1531 *et seq*.) (see 75 FR 14496, March 26, 2010).

The Service appealed the District Court decision and, on November 15, 2011, the Ninth Circuit Court of Appeals issued an opinion affirming in part and reversing in part the district court's decision vacating and remanding the final rule delisting grizzly bears in the GYE (*Greater Yellowstone Coalition* v. *Servheen, et al.*, 665 F.3d 1015 (9th Cir. 2011)). The Ninth Circuit held that the Service's consideration of regulatory mechanisms was permissible because the elements of the 2007 GYE Conservation Strategy were incorporated into binding regulatory documents, specifically NF Plans and National Park Service (NPS) Superintendent's Compendia. However, the Ninth Circuit found that the Service inadequately explained why the loss of whitebark pine was not a threat to the GYE grizzly bear population. In compliance with this order, the GYE population of grizzly bears remained federally listed as "threatened" under the Act, and the IGBST initiated more thorough research into the potential impact of whitebark pine decline on GYE grizzly bears.

On March 11, 2016, we proposed to designate the GYE population of grizzly bears as a DPS and to remove (delist) this DPS from the Federal List of Endangered and Threatened Wildlife (81 FR 13174). On June 30, 2017, we finalized this proposed action, designating the GYE population as a DPS and removing (delisting) grizzly bears in the GYE from the Federal List of Endangered and Threatened Wildlife (82 FR 30502). In this final rule, among the other findings, we responded to the District Court's remand and the Ninth Circuit's determination that the Service failed to support its conclusion that whitebark pine declines did not threaten GYE grizzly bears. This final determination was vacated and remanded by the U.S. District Court for the District of Montana on September 24, 2018, in *Crow Indian Tribe, et al.* v. *United States, et al.*, 343 F. Supp. 3d 999 (D. Mont. 2018). The Montana District Court cited three main issues in vacating the rule: (1) the Service did not sufficiently assess the effect of delisting the GYE population on the recovery of grizzly bears in the rest of the lower-48 States; (2) the Service and its partners did not commit to recalibration of potential new population estimators in the future to ensure the ongoing applicability of the 2016 GYE Conservation Strategy's mortality limits; and (3) the Service inadequately analyzed the genetic health of the GYE grizzly bear population. In compliance with this order, the GYE grizzly bear population was once again made a threatened population under the Act (16 U.S.C. 1531 *et seq*.) (see 84 FR 37144, July 31, 2019). The Service appealed the District Court decision and, on July 8, 2020, the Ninth Circuit Court of Appeals issued an opinion affirming the Montana District Court's decision vacating and remanding the final rule delisting grizzly bears in the GYE (*Crow Indian Tribe v. United States*, 965 F.3d 662 (9th Cir. 2020).

Partners in Grizzly Bear Recovery

Grizzly bear recovery has required, and will continue to require, cooperation among numerous state and federal government agencies, Tribes, and the public for a unified management approach. These agencies have been funding and performing actions to increase grizzly bear recovery, management, monitoring, and enforcement efforts within their jurisdictions for decades.

The interagency group guiding grizzly bear conservation efforts throughout the six ecosystems identified in the recovery plans is the IGBC. The IGBC was created in 1983 to coordinate federal and state management efforts and research actions to recover grizzly bears in the lower-48 States One of the objectives of the IGBC is to change land management practices to more effectively provide security and maintain or improve habitat conditions for the grizzly bear (USDA and US Department of Interior (USDOI) 1983, entire). The updated mission statement of the IGBC is to "to achieve recovery and delisting, and to support ongoing conservation of grizzly bear populations and their habitats after delisting in areas of the western United States through interagency coordination of policy, planning, management, research and communication."

IGBC members include upper level managers from the Service, USFS, U.S. Geological Survey (USGS), BLM, and the States of Idaho, Montana, Washington, and Wyoming (USDA and USDOI 1983, entire). The IGBST Team Leader, the USFS National Carnivore Program Leader, the Information, Education & Outreach Subcommittee Chair, and the Service Grizzly Bear Recovery Coordinator are advisors to the IGBC providing scientific information on grizzly bear populations and their habitat as well as information, education and outreach. The IGBC consists of an Executive Committee and Subcommittees for each of the ecosystems, including the Yellowstone Ecosystem Subcommittee (YES)[3], NCDE Subcommittee[4], SE and CYE

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[3] Subcommittee members include mid-level managers and representatives from the Service; the five GYE NFs (the Shoshone, Beaverhead Deerlodge, Bridger Teton, Custer Gallatin, and Caribou-Targhee); Yellowstone National Park (YNP); Grand Teton National Park (GTNP); the Wyoming Game and Fish Department (WGFD); Montana Fish, Wildlife, and Parks (MFWP); the Idaho Department of Fish and Game (IDFG); theBureau of Land Management (BLM); county representatives from each affected State; and the Shoshone Bannock, Northern Arapahoe, and Eastern Shoshone Tribes (USDA and USDOI 1983).

[4] Subcommittee members include mid-level managers and representatives from the Service; the four NCDE NFs (the Flathead, Helena-Lewis and Clark, Kootenai, and Lolo); GNP;MFWP; BLM; a county representative from the State of Montana; the Blackfeet Tribe; and the Confederated Salish and Kootenai Tribes (CS&KT) (USDA and USDOI 1983).

Subcommittee[5], North Cascades Subcommittee[6], and BE Subcommittee[7]. Members are representatives from each State, Federal, and Tribal agency with management jurisdiction for grizzly bear populations or habitat, as well as representatives from county governments. Each subcommittee has: (1) a Science/Technical Team to provide relevant information on the grizzly bear population(s) and their habitat, and (2) an Information, Education & Outreach working group. The leaders or chairs of these teams/groups advises the subcommittee on these matters.

The IGBST in the GYE is unique from other subcommittee science teams in that it was created by a formal MOU in 1973, with the USGS serving as its coordinating agency. The IGBST collects, manages, analyses, and distributes the scientific-based information regarding habitat and demographic parameters necessary to make informed management decisions about grizzly bear habitat and conservation in the GYE. Since its formation in 1973, the published work of the IGBST has made the GYE grizzly bear population one of the most studied in the world. The wealth of biological information produced by the IGBST over the years includes 30 annual reports, hundreds of articles in peer-reviewed journals, dozens of theses, and other technical reports (see: *https://www.usgs.gov/science/interagency-grizzly-bear-study-team?qt-science_center_objects=40#qt-science_center_objects*). Members of the IGBST include scientists and wildlife managers from the Service, USGS, NPS, USFS, academia, and each State wildlife agency involved in GYE grizzly bear recovery. The Science/Technical teams from the BE, NCE, SE and CYE, and NCDE also include representatives from state and federal agencies and tribes. These teams determine research needs for the respective populations, coordinate monitoring efforts, and advise the subcommittee on biological questions.

Overview of Recovery Planning

In accordance with section 4(f)(1) of the Act, the Service completed a Grizzly Bear Recovery Plan (Recovery Plan) in 1982 (Service 1982, p. ii). Recovery plans serve as road maps for species recovery—they lay out where we need to go and how to get there through specific actions. Recovery plans are not regulatory documents and are instead intended to provide guidance to the Service, States, and other partners on methods of minimizing threats to listed species and on criteria that may be used to determine when recovery is achieved. The Recovery Plan identified six recovery ecosystems, each containing a recovery zone at its core, within the conterminous United States thought to support grizzly bears (see *Geographic Boundaries for*

[5] Subcommittee members include mid-level managers and representatives from the Service; the four SE/CYE NFs (the Colville, Idaho Panhandle, Lolo, and Kootenai); MFWP; IDFG; Washington Department of Fish & Wildlife (WDFW); a county representative from each affected state; the Kootenai Tribe of Idaho; the Kalispel Tribe of Indians; and the British Columbia Ministry of Forests.
[6] Subcommittee members include mid-level managers and representatives from the Service; the two North Cascades NFs (the Okanogan-Wenatchee and Mt. Baker-Snoqualmie); North Cascades National Park; WDFW; and British Columbia Ministry of Environment.
[7] Subcommittee members include mid-level managers and representatives from the Service; the seven BE NFs (Salmon-Challis, Bitterroot, Idaho Panhandle, Lolo, Nez Perce-Clearwater, Payette, and Sawtooth); MFWP; IDFG; and a county representative from each affected State.

Recovery Planning for further details) (Service 1993, pp. 10–13, 17–18). Today, current grizzly bear distribution is primarily within and around these areas identified as recovery zones.

In 1993, the Service completed revisions to the Recovery Plan to include additional tasks and new information that increased the focus and effectiveness of recovery efforts (Service 1993, pp. 41–58). In 1996 and 1997, we released supplemental chapters to the Recovery Plan to guide recovery in the Bitterroot and North Cascades recovery zones, respectively (in their entirety: Service 1996, 1997). For the GYE, we updated the demographic recovery criteria and supplemented the Recovery Plan chapter for the GYE with habitat-based recovery criteria in 2007 (72 FR 11376, March 13, 2007; Service 2007a, 2007b). We proposed revisions to the demographic recovery criteria for the GYE in 2013, but never finalized them (78 FR 17708, March 22, 2013; Service 2013). We again proposed revisions to recovery criteria for the GYE concurrent with the proposed delisting rule in 2016 (81 FR 13174, March 11, 2016) to reflect the best available science and the final revised demographic recovery criteria were appended to the Recovery Plan in 2017 (Service 2017, entire). Although it is not necessary to update recovery plans prior to delisting, the *Recovery Plan Supplement: Revised Demographic Recovery Criteria* was updated to reflect the best available science because the 2016 GYE Conservation Strategy directly incorporates the Recovery Plan for post-delisting monitoring. In 2018, we supplemented the Recovery Plan chapter for the NCDE with habitat-based recovery criteria (Service 2018, entire). Below, we report the status of recovery criteria for all ecosystems.

Recovery Criteria

The 1993 Recovery Plan, and subsequent supplements, outlined three demographic recovery criteria for each ecosystem. For all ecosystems, the first criterion establishes a minimum population size through the monitoring of unduplicated females with cubs. The second criterion ensures reproductive females (i.e., females with young) are well distributed across the recovery zone and are not concentrated in one portion of the ecosystem. The third criterion outlines annual human-caused mortality limits that would allow the population to achieve and sustain recovery. We updated the GYE demographic recovery criteria in 2007 and again in 2017 to reflect the best available science, including expansion of mortality limits in the third criterion to include total mortality (in their entirety: Service 2007a, 2017). For more information on the methods we used to determine these criteria, refer to the 1993 Recovery Plan and subsequent supplements (in their entirety: Service 1993, 1996, 1997, 2007a, 2017).

Due to a settlement agreement in *Fund for Animals* v. *Babbitt*, 967 F.Supp. 6 (D.D.C. 1997) regarding the 1993 Recovery Plan, the Service agreed to establish habitat-based recovery criteria for each ecosystem prior to publishing any proposed rule to delist that grizzly bear population. In addition, the Service agreed to convene a workshop during the public comment period on the draft habitat-based recovery criteria. Habitat-based recovery criteria were published as supplemental chapters to the 1993 Recovery Plan for the GYE and the NCDE in 2007 and 2018, respectively (in their entirety: Service 2007b, 2018). The Service has not yet developed habitat-based recovery criteria for the remaining ecosystems.

There is no published method to deductively calculate minimum habitat values required for a healthy and recovered population. Grizzly bears are long-lived, opportunistic omnivores whose food and space requirements vary depending on a multitude of environmental and behavioral conditions and on variation in the experience and knowledge of each individual bear. Grizzly bear home ranges overlap and change seasonally, annually, and with reproductive status. While these considerations make the development of habitat criteria difficult, we established criteria by assessing the habitat features that were compatible with a stable to increasing grizzly bear population in the past, and then used these habitat conditions as threshold values that must be maintained to ensure a healthy population (i.e., a "no net loss" or baseline approach), as suggested by Nielsen *et al.* (2006, p. 227). The most crucial element in grizzly bear recovery is an adequate amount of habitat that is diverse, provides a wide range of foods, and is isolated from development and human activities, where human-bear interactions, which often result in higher bear mortalities, are minimal (Service 1993, p. 21; Craighead and Mitchell 1982, p. 530). The Service found in the 1993 Recovery Plan that motorized access posed the most imminent stressor to grizzly bear habitat and recommended that road management be given the highest priority for grizzly bear recovery (Service 1993, pp. 21–22). Motorized access management is focused on both habitat security and mortality reduction and is therefore an important management tool for grizzly bear populations. By reducing motorized route densities and thus mortality rates in grizzly bear habitat, it provides habitat security, especially for females, by allowing them to utilize their habitat for reproduction while optimizing survival by minimizing human-caused mortality. For this reason, both the NCDE and GYE habitat-based recovery criteria define threshold levels for secure core/habitat (areas with no motorized access), livestock allotments, and developed sites as their habitat-based recovery criteria (Service 2007b, pp. 2–6; Service 2018, pp. 5–8).

Recovery Progress

Below, we summarize recovery planning efforts and progress toward meeting recovery goals for each ecosystem.

Recovery Planning and Progress in the GYE

Habitat-based Recovery Criteria for the GYE

On June 17, 1997, we held a public workshop in Bozeman, Montana, to develop and refine habitat-based recovery criteria for the grizzly bear, with an emphasis on the GYE. This workshop was held as part of the settlement agreement in *Fund for Animals* v. *Babbitt*, 967 F.Supp. 6 (D.D.C. 1997). A *Federal Register* notice notified the public of this workshop and provided interested parties an opportunity to participate and submit comments (62 FR 19777, April 23, 1997). After considering 1,167 written comments, we developed biologically based habitat recovery criteria, which were appended to the 1993 Recovery Plan in 2007 (Service

2007*b*, entire), with the overall goal of maintaining or improving habitat conditions at levels that existed in 1998.

As discussed above in *Recovery Criteria*, because of the inability to calculate minimum habitat values for a recovered population, we use a "no net loss" approach by assessing what habitat factors are compatible with a stable to increasing grizzly bear population. The 1998 baseline for habitat standards was chosen because the levels of secure habitat and developed sites on public lands remained relatively constant in the 10 years preceding 1998 (USDA FS 2004, pp. 140–141), and the selection of 1998 ensured that habitat conditions existing at a time when the population was increasing at a rate of 4 to 7 percent per year (Schwartz *et al.* 2006b, p. 48) would be maintained. In addition, levels of motorized routes were decreasing during the years preceding the 1998 baseline as exhibited by an average reduction (elimination) of 59.9 km (37.2 mi) of road per year from 1986 to 2002 on NF lands within the recovery zone (USDA FS 2006a, p. 200). The 1998 baseline was determined through a GIS analysis of the amount of secure habitat, open and total motorized route densities, the number and capacity of livestock allotments, and the number and capacity of developed sites on public lands for each of the 40 bear management subunits located in the recovery zone.

For the GYE, secure habitat refers to those areas with no motorized access that are at least 10 acres (0.31 km^2 (0.016 mi^2)) in size and more than 500 m (1,650 ft) from a motorized access route (open or gated) or recurring helicopter flight line (USDA FS 2004, p. 18). Our definition of secure habitat includes areas as small as 10 acres (0.31 km^2 (0.016 mi^2)) in size because both the IGBST and YES concluded that all secure habitats are important for grizzly bears in the GYE, regardless of size, particularly in peripheral areas. Research by Schwartz *et al*. (2010, p. 661) supported this conclusion and demonstrated a direct link between this definition and grizzly bear survival in the GYE. Non-motorized trails were not excluded from secure habitat because research indicates that non-motorized trails do not significantly affect grizzly bear survival, and that survival is better explained by the absence of motorized routes (Schwartz *et al*. 2010, p. 659).

Habitat-based recovery criteria—The habitat-based recovery criteria established objective, measurable values for levels of motorized access, secure habitat, developed sites, and livestock allotments (i.e., "the 1998 baseline") for the GYE (see the 2016 GYE Conservation Strategy for 1998 baseline values) (YES 2016b, Appendix E). The 1998 baseline values will not change through time, unless the changes will benefit bears (e.g., expansion of existing administrative sites to enhance public land management if other viable alternatives are not available, modifications to dispersed or developed sites to reduce grizzly bear conflicts, such as installing bear-resistant storage structures). As each of these criteria are central to potential present or threatened destruction, modification, or curtailment of habitat or range, they are discussed in detail under Chapter 5. The Grizzly Bear Annual Habitat Monitoring Report includes changes and corrections to the 1998 baseline and is included in the IGBST Annual Reports.

Status: These habitat-based recovery criteria have been met or improved upon since their incorporation into the Recovery Plan (Service 2007*b*, entire).

Additionally, we developed several monitoring items that may help inform management decisions or explain population trends: (1) trends in the location and availability of food sources such as whitebark pine (*Pinus albicaulis*), cutthroat trout (*Oncorhynchus clarkii*), army cutworm moths (*Euxoa auxiliaris*), and ungulates (bison (*Bison bison*) and elk (*Cervus canadensis*)); and (2) grizzly bear mortality numbers, locations, and causes; human-grizzly bear conflicts; conflict bear management actions; bear-hunter conflicts; and livestock-bear conflicts (YES 2016a, pp. 33–91). Federal and State agencies monitor these items, and the IGBST produces an annual report of the results. This information is used to examine relationships between food availability, human activity, and demographic parameters of the population such as survival, population growth, or reproduction.

Demographic Recovery Criteria for the GYE

Since the 1993 Recovery Plan was released, we have evaluated and updated how we assess those recovery criteria in the GYE as newer, better science became available. These revisions include implementing new scientific methods to determine the status of the GYE grizzly bear population in the DMA, estimate population size, and determine what levels of mortality the population could withstand to maintain recovery goals (i.e., the sustainable mortality rate). The Wildlife Monograph: "Temporal, Spatial, and Environmental Influences on The Demographics of Grizzly Bears in The Greater Yellowstone Ecosystem" (Schwartz *et al.* 2006b, entire); the report: "Reassessing Methods to Estimate Population Size and Sustainable Mortality Limits for the Yellowstone Grizzly Bear" (IGBST 2005, entire); and the report: "Reassessing Methods to Estimate Population Size and Sustainable Mortality Limits for the Yellowstone Grizzly Bear Workshop Document Supplement 19–21 June, 2006" (IGBST 2006, entire) provided the scientific basis for revising the demographic recovery criteria in the GYE in 2007 (72 FR 11376, March 13, 2007; Service 2007a, entire). Similarly, we once again revised the demographic recovery criteria in the GYE in 2017 (81 FR 13174, March 11, 2016; Service 2017, entire) based on updated demographic analyses that used the same methods as previous assessments (Schwartz *et al.* 2006b, pp. 9–16) and were reported in the IGBST's 2012 report: "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 2012 IGBST Report). Based on recommendations in the 2012 IGBST report, the Service modified the area where mortality limits apply to match the area that is monitored for unique adult female grizzly bears with cubs-of-the-year and in which the population size is estimated (i.e. the DMA).

Below, we detail each of the most current demographic criteria that were appended to the 1993 Recovery Plan in 2017 (Service 2017, entire).

Demographic Recovery Criterion 1 for the GYE—Maintain a minimum population size of 500 grizzly bears and at least 48 females with cubs-of-the-year in the DMA (Figure 16, above) as indicated by methods established in published, peer-reviewed scientific literature and calculated by the IGBST using the most updated Application Protocol as posted on their website. If the estimate of total population size drops below 500 in any year or below 48 females with cubs-of-the-year in 3 consecutive years, this criterion would not be met. The 48 females with cubs-of-the-year metric is a model-averaged number of documented unique females with cubs-of-the-year.

A minimum population size of at least 500 animals within the DMA will ensure short-term genetic health (Miller and Waits 2003, p. 4338) and is not a population goal. Five hundred is a minimum population threshold and that will ensure the short-term fitness of the population is not threatened by losses in genetic diversity in such an isolated population. The goal is to maintain the population well above this threshold to ensure that genetic issues are not a detriment to the short-term genetic fitness of the GYE grizzly bear population.

Status: In 2019, based on the model-averaged Chao2 method there were 58 females with cubs within the DMA. Applying the updated vital rates, 58 females with cubs is equates to an estimated population of 737 individuals (Haroldson *et al.* 2020b, p. 13). This recovery criterion has been met since 2003.

Demographic Recovery Criterion 2 for the GYE—Sixteen of 18 BMUs within the recovery zone (Figure 21) must be occupied by females with young, with no two adjacent BMUs unoccupied, during a 6-year sum of observations. This criterion is important as it ensures that reproductive females occupy the majority of the recovery zone and are not concentrated in one portion of the ecosystem. If less than 16 of 18 BMUs are occupied by females with young for 3 successive 6-year sums of observations this criterion would not be met. See Table 8 below for most current 3 consecutive 6-year sums of observations data.

Status: This recovery criterion has been met since at least 2001.

Table 8. Demographic recovery criterion 2 is measured by the number of occupied bear management units (BMUs) for each 6-year sum of observations.

	Number of BMUs occupied by females with young by year								**Criteria met (16 of 18 occupied at least once)**
6-year period	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	
2012–2017	15	18	18	17	18	17			Yes
2013–2018		18	18	17	18	17	18		Yes
2014–2019			18	17	18	17	18	18	Yes

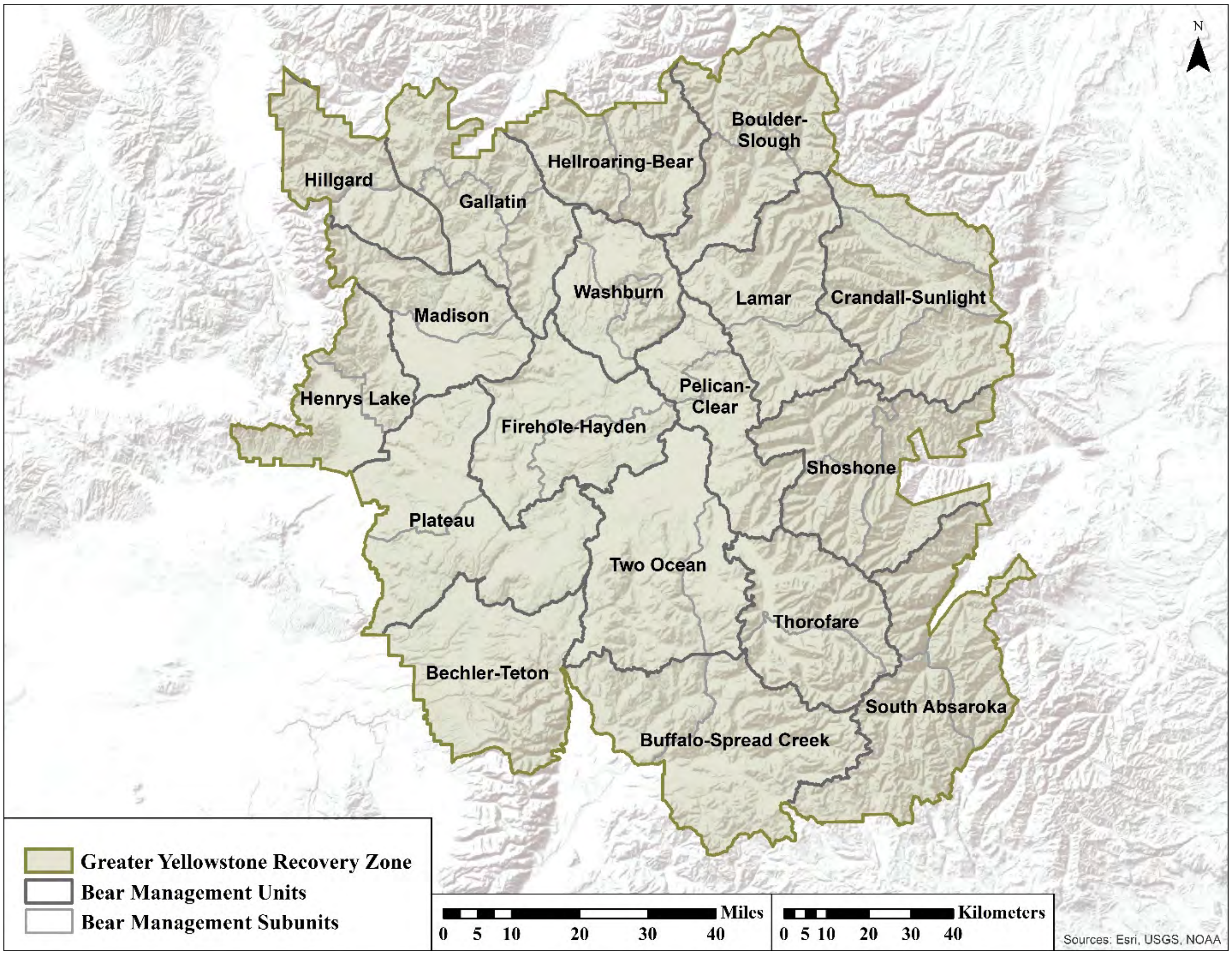

Figure 21. Bear Management Units (BMUs) and subunits for the Greater Yellowstone Ecosystem.

Demographic Recovery Criterion 3 for the GYE—Maintain the population within the DMA around the 2002–2014 model-averaged Chao2 population estimate average size (average = 674; 95% CI = 600–747; 90% CI = 612–735) by maintaining annual mortality limits for independent females (≥ 2 years old), independent males (≥ 2 years old), and dependent young as shown in Table 9. These adjustable mortality rates were calculated as those necessary to manage the population to the modeled-averaged Chao2 population estimate of 674 bears, which occurred during the time period that this population had a relatively flat population trajectory (2002–2014). If mortality limits are exceeded for any sex/age class for 3 consecutive years and any annual population estimate falls below 612 (the lower bound of the 90% confidence interval), the IGBST will produce a Biology and Monitoring Review to inform the appropriate management response. If any annual population estimate falls below 600 (the lower bound of the 95% confidence interval), this criterion would not be met and there would be no discretionary mortality (mortalities that are the result of hunting or management removals) except as necessary for human safety.

Criterion 3 counts known and probably mortalities from all causes of independent (at least 2 years old) male and female grizzly bears from all sources against annual mortality limits while counting only known and probable human-caused mortalities against annual mortality limits for dependent young (less than 2 years old). For independent females and males, counted mortalities include: (1) known and probable human-caused mortalities; (2) reported deaths due to natural and undetermined causes; and (3) a statistical estimate for unknown/unreported human-caused mortalities. The IGBST will continue to use the methods of Cherry *et al*. (2002, entire) to estimate unknown/unreported mortalities each year based on the number of known, reported human-caused deaths (Cherry *et al*. 2002, p. 179; IGBST 2005, pp. 39–41) until and unless new and improved scientifically methodology becomes available.

The population estimates derived from the model-averaged Chao2 estimates of females with cubs had stabilized during the period of 2002–2014, and the mean population estimate over that time period was 674 (95% CI = 600–747), which is not statistically different from the population size of 683 when the GYE population was considered recovered and delisted in 2007 (72 FR 14866, March 29, 2007). This recovery criterion was selected because it represents: a population level that is sufficiently robust to provide for the viability of the species, a period where the ecosystem was likely at or near long-term carrying capacity, and the conservative nature of a population estimate derived from counts of females with cubs (Schwartz *et al.* 2008, entire). The population naturally stabilized primarily because of reduced survival of dependent young and lower reproduction in areas with higher grizzly bear densities, suggesting density-dependent effects associated with the population approaching carrying capacity (van Manen *et al.* 2016, entire).

Status: In 2019 there were 26 known and probable grizzly bear mortalities within the DMA: 3 independent females, 17 independent males, 2 independent bears of unknown sex, and 5 dependent young of unknown sex (Haroldson and Frey 2020, pp. 28–29). Using randomly assigned sex for the 2 independent bears for which sex was unknown, the estimated total mortality was 3.5 percent of the estimated population of independent females and 11.7 percent of the estimated population of independent males. There were no documented human-caused mortalities for dependent young within the DMA in 2019. Documented known and probable mortality rates for all age and sex classes were below the total mortality limits in 2019. This criterion has been met for all age and sex classes since 2012. While mortality rates within the DMA have been above morality thresholds in several years, the average has remained under the threshold over the recent period of 2010 to 2019 with 7.0 percent for independent females and 12.0 percent for independent males.

Table 9. Total mortality rate used to establish annual total mortality limits for independent females, independent males, and dependent young inside the Demographic Management Area (DMA). These mortality limits are on a sliding scale to achieve the population goal inside the DMA of the model-averaged Chao2 population size of 674 between 2002–2014 (95% CI = 600–747). For populations less than 600, there will be no discretionary mortality unless necessary for human safety.

	Total Grizzly Bear Population Estimate*		
	≤674	675–747	>747
Total mortality rate for independent FEMALES	<7.6%	9%	10%
Total mortality rate for independent MALES	15%	20%	22%
Total mortality rate for dependent young	<7.6%	9%	10%
Total mortality: Documented known and probable grizzly bear mortalities from all causes including but not limited to: management removals, illegal kills, mistaken identity kills, self-defense kills, vehicle kills, natural mortalities, undetermined-cause mortalities, grizzly bear hunting, and a statistical estimate of the number of unknown/unreported mortalities.			

* using the model-averaged Chao2 estimate

Recovery Planning and Progress in the NCDE

Habitat-based Recovery Criteria for the NCDE

On July 7, 2016, and January 3, 2018, we held public workshops in Missoula, Montana, to develop and refine habitat-based recovery criteria for the grizzly bear, with an emphasis on the NCDE. *Federal Register* notices and notices in local newspapers notified the public of these workshops and provided interested parties an opportunity to participate and submit comments (81 FR 29295, May 11, 2016; 82 FR 58444, December 12, 2017). After considering 282 written and oral comments, we developed biologically based habitat-based recovery criteria with the overall goal of maintaining or improving habitat conditions at levels that existed in 2011. Habitat-based recovery criteria for the NCDE were proposed in 2017, and then finalized as a supplement to the 1993 Recovery Plan in 2018 (Service 2018, entire).

The habitat-based recovery criteria established objective, measurable values for levels of motorized access, secure core habitat, developed sites, and livestock allotments for the NCDE (see the NCDE Conservation Strategy for 2011 baseline values) (NCDE Subcommittee 2018, Appendices 4 and 5). As discussed above in *Recovery Criteria*, because of the inability to calculate minimum habitat values for a recovered population, we use a “no net loss” approach by assessing what habitat factors are compatible with a stable to increasing grizzly bear population. We selected 2011 levels (i.e., the “baseline”) as our baseline year because secure core habitat was increasing and motorized route density was decreasing between 2004 and 2011 (NCDE Subcommittee 2018, Chapter 1; Service 2018, pp. 24–25), and the NCDE grizzly bear population was increasing at a rate of 2 to 3 percent annually during this time (Mace *et al.* 2012, p. 124; Mace 2012, *in litt.*; Costello *et al.* 2016, p. 2; Service 2018, p. 3). For example, in the Flathead NF, the amount of core habitat (IGBC 1998, p. 4) increased by approximately 400 km^2 (155 mi^2) from 1995 to 2004, and by another 170 km^2 (65 mi^2) from 2004 to 2011 (Ake 2018a, *in litt.*). Habitat conditions in 2011 are believed to be representative of conditions that supported and contributed to the population growth observed from 2004 to 2011. For each of the 126 BMUs located in the recovery zone, the baseline was determined through a GIS analysis of the amount of secure core habitat, open and closed road densities, the number and capacity of livestock allotments, and the number and capacity of developed sites on public lands (NCDE Subcommittee 2018, Chapter 3, Appendices 4 and 5).

For the NCDE, we define secure core habitat as those areas on Federal lands within the analysis area more than 500 m (1,650 ft) from a motorized access route and at least 2,500 acres (10.1 km^2 (3.9 mi^2)) in size, and in place for 10 years (Service 2018, pp. 5, 12). Non-motorized trails were not excluded from secure core because research indicates that non-motorized trails do not significantly affect grizzly bear survival, and that survival was better explained by the absence of motorized routes (Schwartz *et al*. 2010, p. 659).

The habitat-based recovery criteria ensure that the baseline values will not change through time, except as allowed under the application rules, unless the changes benefit bears. As the management objectives in the habitat-based recovery criteria are central to potential present or threatened destruction, modification, or curtailment of habitat or range, each of these criteria are discussed in detail under Chapter 5. The habitat-based recovery criteria were appended to the Recovery Plan in 2018.

Status: These habitat-based recovery criteria have been met or improved upon since their incorporation in the draft NCDE Conservation Strategy in 2013 (NCDE Subcommittee 2018, Chapter 3, Appendices 4 and 5; Service 2018, entire).

Demographic Recovery Criteria for the NCDE

Demographic Recovery Criterion 1 for NCDE—Maintain ten females with cubs inside GNP and 12 females with cubs outside GNP over a running 6-year average both inside the recovery zone and within a 10-mile area immediately surrounding the recovery zone, excluding Canada. The Recovery Plan identified this criterion as a method to estimate the minimum population size for the NCDE, which equates to a minimum population size of 391 grizzly bears (Service 1993, pp. 61–62). This estimate is thought to be an underestimate of the actual number due to "the forested nature of much of the NCDE" (Service 1993, p. 62).

Status: We attempted to reconstruct the original criterion using radio-telemetry data and public sightings. High grizzly bear densities have been documented within GNP (Kendall *et al.* 2009, pp. 11–12; Costello *et al.* 2016, pp. 22–23). Since 2010, GNP has recorded yearly sightings of females with young, averaging 44 females with young annually after removing duplicates based on date, time, and descriptions. These family group sightings include females with cubs and yearlings, and so estimates are higher than for females with cubs alone; however, family group observations within GNP are 4 times higher than the original recovery criterion for observations of females with cubs. With a 3-year reproductive cycle approximately a third of the family groups would be females with cubs. Combined with the conservative nature of observation-based estimates within the NCDE, the Service believes the target of 10 females with cubs inside GNP has been met and exceeded. In addition, radio-telemetry data indicate that the target of 12 females with cubs outside GNP has been met since 2012 (Costello 2017, pp. 1–3).

In addition, Kendall *et al.* (2009, p. 9) genetically sampled the entire recovery zone and the surrounding areas thought to be occupied by bears to produce a scientifically-reliable population estimate of 765 bears (95% CI = 715–831). A similar survey has not been conducted since 2004 due to cost limitations; however, radio-telemetry (location), DNA, and mortality data are collected annually to calculate population distributions and annual growth rates for the population. Together, these data are combined in stochastic demographic models to project total population size for the NCDE, with a 2019 estimate of 1,068 bears (95% CI = 890–1,283) (Costello *et al.* 2016, pp. 69–70; Costello 2020, *in litt.*). Given that the 2019 lower 95 percent confidence interval of 890 bears is more than double the minimum population size target of the Recovery Plan (391 bears), the Service concludes that the NCDE grizzly bear population has well exceeded this demographic criterion.

Demographic Recovery Criterion 2 for the NCDE—Twenty-one of 23 BMUs within the recovery zone (Figure 22) must be occupied by females with young, with no two adjacent BMUs unoccupied, during a 6-year sum of observations. The Recovery Plan (Service 1993, p. 61) established this criterion to ensure that reproductive females occupy the majority of the recovery zone and are not concentrated in one portion of the ecosystem.

Status: This criterion has been met since 2009, with females with young occupying 22 of 23 BMUs within the NCDE during the 6-year sum of observations since from 2014–2019 (NCDE Subcommittee 2018, table 2; Costello and Roberts 2020, p. 8).

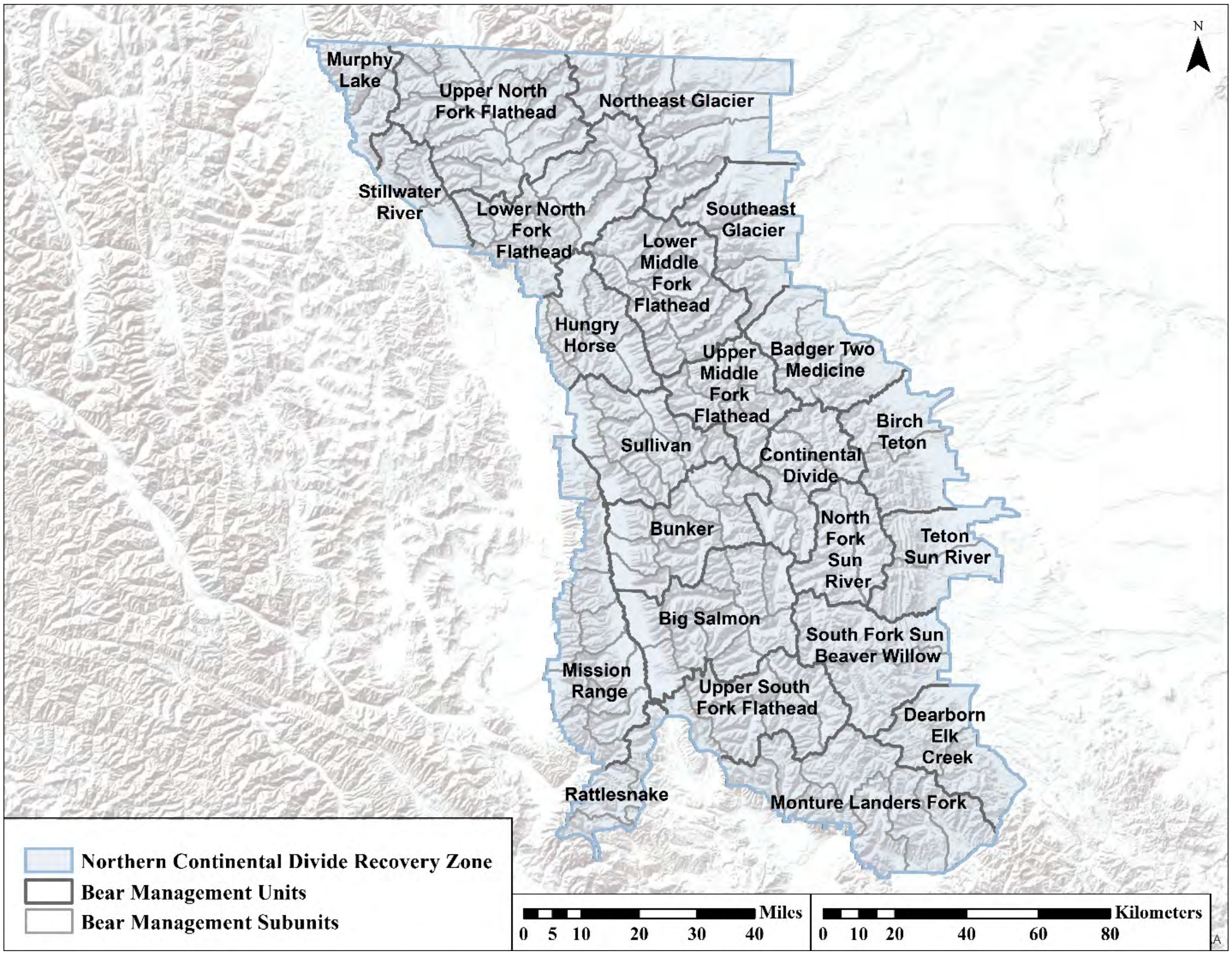

Figure 22. Bear Management Units (BMUs) and subunits for the Northern Continental Divide Ecosystem.

Demographic Recovery Criterion 3 for the NCDE—The 6-year average of known and probable human-caused mortality cannot exceed 4 percent of the minimum population estimate based on the most recent 3-year sum of unduplicated females with cubs; no more than 30 percent of this 4 percent mortality limit shall be females; and these human-caused mortality limits cannot be exceeded during any 2 consecutive years for recovery to be achieved. In other words, human-caused female mortality cannot exceed 1.2 percent of the minimum population estimate. The Recovery Plan identified this criterion as a method to limit known human-caused mortality to a level that is sustainable for a recovered NCDE grizzly bear population (Service 1993, p. 61; Servheen 2001, entire). The known and probable, human-caused mortality threshold was set at 4 percent because unknown and/or unreported human-caused mortality was known to occur but current methods to estimate these unknown/unreported mortalities were not available when the Recovery Plan was written (Service 1993, p. 62).

Status: We assessed this criterion using the same index of minimum population size described in *Demographic Recovery Criterion 1*, the lower 95th percentile of the estimated population size, for human-caused mortalities inside the DMA. Since 2009, the 6-year average for human-caused total mortality has been less than 4 percent of the minimum population size and the 6-year average for human-caused female mortality has been less than 1.2 percent of the minimum population size (Table 10) (Costello *et al.* 2016, p. 69; Costello 2017, pp. 2, 6; Costello and Roberts 2018, pp. 7–8; Costello 2020, *in litt.*; MFWP unpublished data). For the most recent 6-year average (2014–2019) of known and probable, human-caused mortality, the mortality limit was 35.7 bears/year for total mortality and 10.7 bears/year for female mortality. The documented 6-year average for this time period was 25.3 bears/year for total mortality and 10.2 bears/year for female mortality. This criterion has been met since 2009 (Costello 2017, pp. 2, 6; Costello and Roberts 2018, pp. 7–8; Costello 2020, *in litt.*; MFWP, unpublished data).

Table 10. Assessment of human-caused mortalities inside the NCDE Demographic Monitoring Area (DMA) from 2004 to 2019 for demographic recovery criterion 3. This table includes all known and probable human-caused mortalities for independent females, independent males, and dependent young.

Year	Lower 95th percentile of estimated population size	Documented annual human-caused mortality		Documented 6-year average human-caused mortality		Limit for 6-year average human-caused mortality	
		Female	Total	Female	Total	Female	Total
2004	694	14	24				
2005	703	8	18				
2006	717	3	13				
2007	732	1	22				
2008	747	7	13				
2009	765	5	14	7.3	17.3	9.2	30.6
2010	780	4	16	5.7	16.0	9.4	31.2
2011	795	13	28	6.5	17.7	9.5	31.8
2012	810	3	17	6.5	18.3	9.7	32.4
2013	823	13	28	7.5	19.3	9.9	32.9
2014	835	12	19	8.3	20.3	10.0	33.4
2015	851	8	19	8.3	21.2	10.2	34.0
2016	864	11	16	10.0	21.2	10.4	34.6
2017	876	2	20	8.2	19.8	10.5	35.0
2018	892	12	41	9.7	23.8	10.7	35.7
2019	890	16	40	10.2	25.3	10.7	35.7

At the time that these recovery criteria were developed, there was no way to estimate unknown/unreported mortalities. We can now estimate these types of mortality to more accurately ensure sustainable levels of mortality. As discussed in the NCDE Conservation Strategy (NCDE Subcommittee 2018, Chapter 2, Appendix 2) and in the *Human-Caused Mortality* section of this SSA, mortality is currently, and will continue to be, calculated for total reported and unreported mortality (TRU mortality). TRU mortality includes known and probable reported mortality from all causes (e.g., human-caused, natural, and undetermined) as well as an estimate of unknown/unreported mortality (using the methods of Cherry *et al.* 2002, entire).

Recovery Planning and Progress in the CYE

The 1993 Recovery Plan outlines three demographic recovery criteria for the CYE recovery zone:

Demographic Recovery Criterion 1 for the CYE—Maintain six females with cubs over a running 6-year average both inside the recovery zone and within a 10-mile area immediately surrounding the recovery zone, excluding Canada.

Status: Unduplicated females with cubs (excluding Canada) varied from two to five per year and averaged 3.0 per year from 2014–2019 (Kasworm *et al.* 2020a, p. 16). This recovery criterion has not been met.

Demographic Recovery Criterion 2 for the CYE—Maintain eighteen of 22 BMU's (Figure 23) occupied by females with young from a running 6-year sum of verified evidence.

Status: Twelve of 22 BMUs had sightings of females with young during 2014–2019 (Kasworm *et al.* 2020a, p. 16). Therefore, this recovery criterion has not been met.

Demographic Recovery Criterion 3 for the CYE—Known, human-caused mortality cannot exceed 4 percent of the population estimate based on the most recent 3-year sum of females with cubs. No more than 30 percent shall be females. These mortality limits cannot be exceeded during any 2 consecutive years for recovery to be achieved.

Status: The target for the minimum number of unduplicated females with cubs in the first recovery criterion equates to the recovery goal of approximately 100 grizzly bears in the CYE recovery zone (Service 1993, p. 83). The 2017–2019 sum of unduplicated females with cubs (8) equates to a minimum estimated population size of 47 individuals (Service 1993, p. 102; Kasworm *et al.* 2020a, p. 16). Utilizing the minimum estimated population size, the total mortality limit is 1.9 bears per year and the female mortality limit is 0.6 bears per year. Ten known or probable human-caused mortalities of grizzly bears have occurred in or within 10 miles of the CYE recovery zone in the U.S. during 2014–2019, including 3 females and 7 males (Kasworm *et al.* 2020a, p. 16). This means that average annual human-caused mortality for 2014–2019 was 1.5 bears per year and 0.5 females per year, which is less than the calculated mortality limits. The recovery plan established a goal of zero human-caused mortality for this recovery zone until the minimum population reached approximately 100 bears. However, it also stated "In reality, this goal may not be realized because human bear conflicts are likely to occur at some level within the ecosystem." Therefore, even if the goal of zero mortality is not met, it is important to evaluate the recovery criterion to determine if we are making progress towards recovery. During the 2014–2019 reporting period we were meeting all mortality limits and were moving closer to recovery for this criterion.

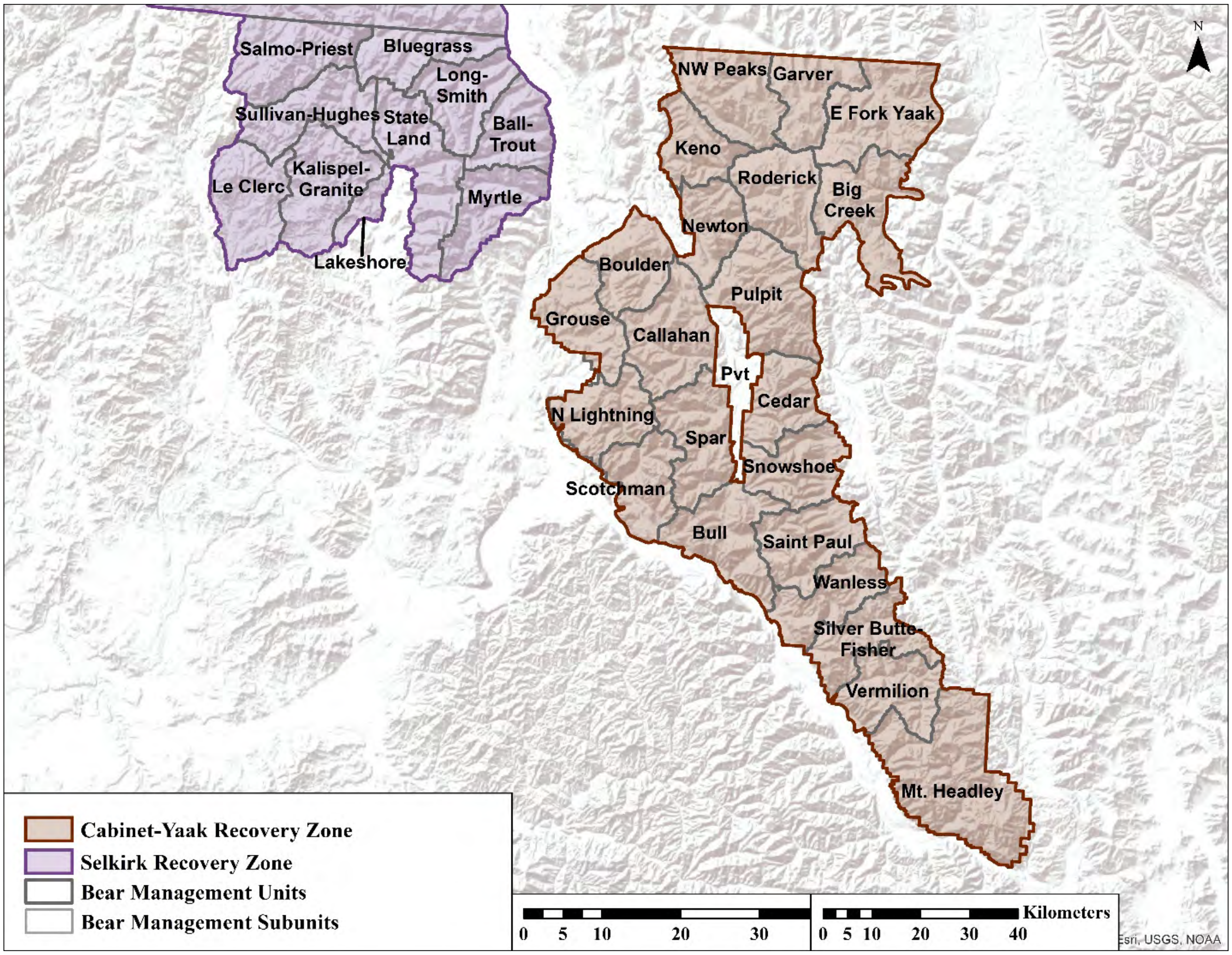

Figure 23. Bear Management Units (BMUs) for the Cabinet-Yaak and Selkirk Ecosystems.

Recovery Planning and Progress in the SE

The Selkirk area in the U.S. is the southern tip of the Selkirk Mountain Range that extends northward into B.C. The area of the U.S. portion is limited by the fact that the Selkirk range ends approximately 60 km (23 mi) south of the border. Because there is not sufficient area for a viable grizzly bear population on the U.S. side, and because the bears in the area regularly move across the border, a portion of the Selkirk Range on the B.C. side was included in the designated SE recovery zone (Service 1993, p. 101). The inclusion of this area brought the size of the SE to approximately 5,180 km^2 (2,000 mi^2), the size thought to be necessary to support a minimum population of 90 bears. It is recognized that the SE is contiguous with grizzly bear habitat northward into B.C., and that the 90 bears projected as the goal in this recovery zone are a subset of a much larger population. The population goal for the recovery zone is set to ensure sufficient bears exist throughout the area to ensure a continued population in the U.S. portion of this recovery zone.

The 1993 Recovery Plan outlines three demographic recovery criteria for the SE recovery zone:

Demographic Recovery Criterion 1 for the SE—Maintain six females with cubs over a running 6-year average both inside the recovery zone and within a 10-mile area immediately surrounding the recovery zone, including Canada.

Status: Unduplicated sightings of females with cubs (including Canada) varied from 2 to 6 per year and averaged 3.67 per year from 2014–2019 (Kasworm *et al.* 2020b, p. 12). This recovery criterion has not been met.

Demographic Recovery Criterion 2 for the SE—Maintain seven of 10 BMU's (Figure 23) occupied by females with young from a running 6-year sum of verified evidence.

Status: Eight of the 10 BMUs were occupied by females with young during 2014–2019 in the U.S. portion of the recovery zone (Kasworm *et al.* 2020b, p. 12). Therefore, this recovery criterion has been met.

Demographic Recovery Criterion 3 for the SE—Known, human-caused mortality cannot exceed 4 percent of the population estimate based on the most recent 3-year sum of females with cubs. No more than 30 percent shall be females. These mortality limits cannot be exceeded during any 2 consecutive years for recovery to be achieved.

Status: The target for the minimum number of unduplicated females with cubs in the first recovery criterion equates to the recovery goal of approximately 90 grizzly bears in the SE recovery zone (Service 1993, p. 101). The 2017–19 sum of unduplicated females with cubs (9) equates to a minimum estimated population size of 45 individuals (Service 1993, p. 102; Kasworm *et al.* 2020b, p. 12–16), the total mortality limit is 1.8 bears per year and the female mortality limit is 0.5 bears per year. Thirteen known or probable human-caused mortalities of grizzly bears occurred in or within 10 miles of the SE recovery zone in the U.S. or in the B.C. portion of the SE during 2014–2019, including 6 females (1 in the U.S. and 5 in B.C.) and 7 males (2 in the U.S. and 5 in B.C.) (Kasworm *et al.* 2020b, p. 12–13). This means that average annual human-caused mortality for 2014–2019 was 2.2 bears per year and 1.0 females per year. The mortality level for total human-caused mortality and the level of female human-caused mortality exceeded the calculated limit during 2014–2019. The Recovery Plan established a goal of zero human-caused mortality for this recovery zone until the minimum population reached approximately 90 bears. However, it also stated "In reality, this goal may not be realized because human bear conflicts are likely to occur at some level within the ecosystem." Therefore, even if the goal of zero mortality is not met, it is important to evaluate the recovery criterion to determine if we are making progress towards recovery. Thus, during the 2014–2019 reporting period we did not meet the mortality limits.

Recovery Planning and Progress in the BE

The 1996 Recovery Plan Supplement outlines three demographic recovery criteria for the BE recovery zone: (1) 14 females with cubs over a running 6-year average, subject to revision as more information becomes available; (2) delineation and occupancy of BMUs will be determined at a future date; (3) the goal for known, annual human-caused mortality remains zero until at least 90 grizzly bears are established. At that time, known, human-caused mortality is not to exceed 4 percent of the minimum estimate, with no more than 30 percent of this mortality limit shall be females (Service 1996, p. 4). The target for the minimum number of unduplicated females with cubs in the first recovery criterion equates to the recovery goal of approximately 280 grizzly bears.

Status: In the BE there is no known population and none of these demographic criteria have been met.

Recovery Planning and Progress in the North Cascades

The Recovery Plan Supplement for the North Cascades did not establish specific demographic criteria for numbers of females with young, BMUs occupied (Figure 24), or sustainable levels of human-caused mortality due to a lack of information for the ecosystem (Service 1997, p. 3). However, the Recovery Plan sets a recovery goal in the North Cascades of 200–400 grizzly bears in the U.S. portion of the ecosystem (Service 1997, p. 3). The first action set forth in the supplement is to “establish the population objective for recovery and identify the limiting factors” (Service 1997, p. 5). The supplement established a goal of zero known, human-caused mortalities (Service 1997, p. 4). There have been zero human-caused grizzly bear mortalities in the North Cascades. However, we are not meeting recovery goals in the North Cascades and we do not have a verified grizzly bear population on the U.S. side at this time. The supplement describes a recovered population as “one that: (a) has the capability to offset human-caused mortality; (b) is large enough to survive the effects of demographic and environmental stochasticity; and (c) is well distributed throughout the ecosystem (based on BMU occupancy by females with young).”

In 2017, the Service and North Cascades National Park released a range of alternatives to recover the grizzly bear population in the North Cascades. The draft EIS addressed several proposed action alternatives, all of which proposed to achieve a restoration goal of 200 grizzly bears in the North Cascades. The action alternatives differed in the rate and total number of grizzly bears released, and the timeframe for achieving the restoration goal of 200 grizzly bears. The proposed restoration proved controversial, and in response to a congressional request included in an appropriations bill, a second comment period on the draft EIS was opened in July 2019. On July 7, 2020, the Service and NPS announced their decision to discontinue the proposal to develop and implement a Grizzly Bear Restoration Plan for the North Cascades Ecosystem.

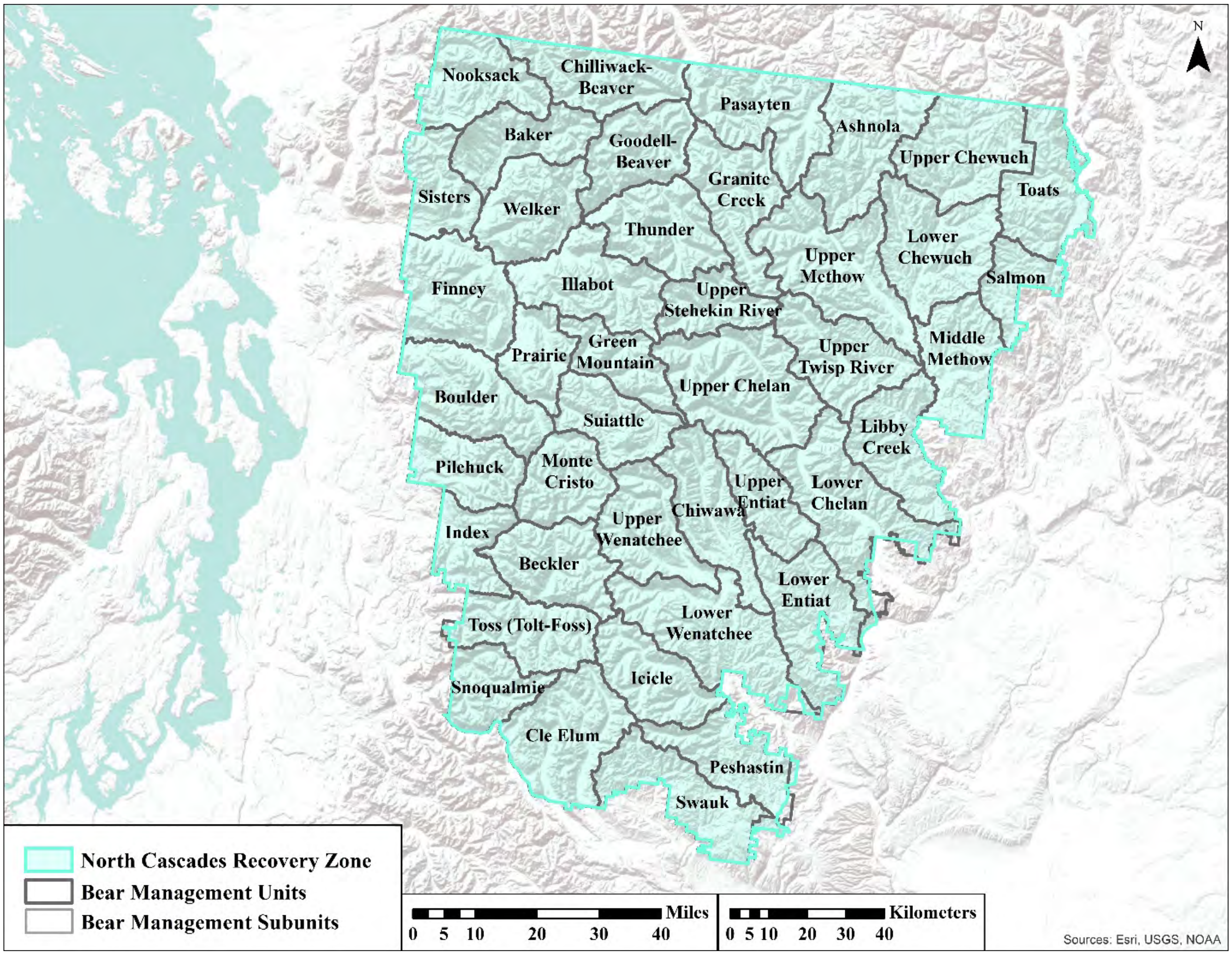

Figure 24. Bear Management Units (BMUs) for the North Cascades Ecosystem.

Conservation Strategies

A conservation strategy is one of two separate delisting requirements outlined in the Recovery Plan. The plan sets forth two criteria for delisting: that recovery criteria are met, and the development and completion of an interagency conservation strategy that will ensure that adequate regulatory mechanisms will continue to be present after delisting (Service 1993, p. 16). The strategy should list legal authorities, policy, management programs, and the continued commitment of management agencies to maintain a high standard of management after delisting of the grizzly bear population. Interagency groups have completed conservation strategies for the GYE and NCDE.

Chapter 4: Needs of the Grizzly Bear in the Lower-48 States

The needs of a species can be evaluated hierarchically, starting at the lowest level with an individual's basic resource needs for breeding (including all stages of reproduction), feeding, sheltering, and dispersal. Then, needs can be described at the population and species levels by describing resiliency needed for populations to withstand stochastic events, redundancy to withstand catastrophic events, and representation to adapt to environmental change. In this chapter, we summarize these needs for grizzly bear individuals, ecosystems, and the lower-48 States. Our understanding of individual, ecosystem, and lower-48 States needs presented were derived from our discussion of life history and ecology in Chapter 2. For the grizzly bear in the lower-48 States, habitat factors that individuals need are large intact blocks of land, cover, high-caloric foods, and dens (Figure 25). Demographic factors that ecosystems need include, fecundity, survival, genetic diversity, population trend, abundance, and connectivity, depending on the population size (Figure 25). Together, the habitat and demographic factors influence the resiliency of ecosystems. In general, the lower-48 States needs a sufficient number and distribution of ecosystems with ecological and genetic diversity across the range to withstand catastrophic events and adapt to environmental change. We discuss these needs below.

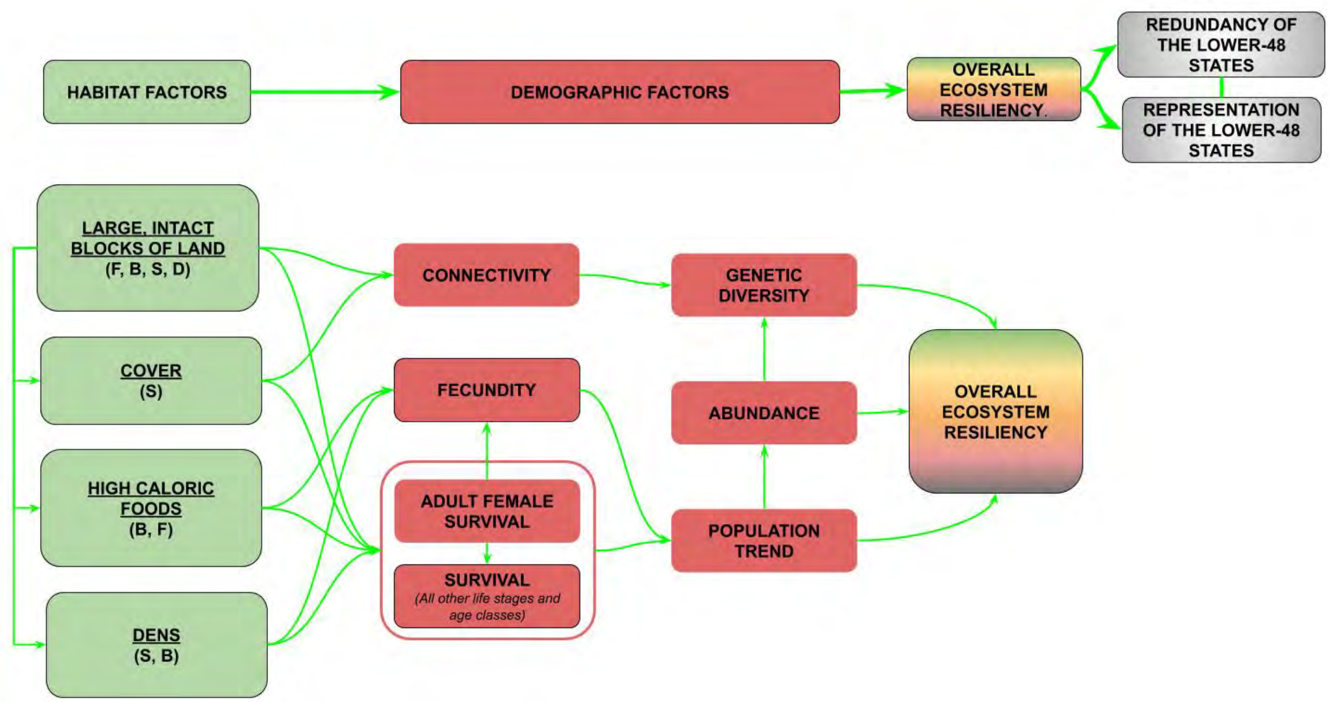

Figure 25. Conceptual model for grizzly bear ecosystem resiliency, in terms of habitat factors (green boxes) needed by individuals to breed (B; includes all stages of reproduction), feed (F), shelter (S), and disperse (D), and demographic factors (red boxes) that ecosystems need to be resilient. Green arrows represent positive relationships between nodes. The core conceptual model is provided at the top of the figure for reference.

Individual Needs

In general, a grizzly bear's individual habitat needs, and the daily movements needed to find these resources, are largely driven by the search for food, mates, cover, security, or den sites. We identified the following four habitat factors needed by individual grizzly bears to successfully move from one life stage to the next:

- Large, intact (i.e., relatively undisturbed by motorized access or other human development) blocks of land, needed by all life stages to breed, feed, shelter and disperse;
- Cover, needed by all life stages to shelter;
- High-caloric foods, needed by all life stages to feed and breed; and
- Dens as shelter for all life stages, and specifically for females that are pregnant or with offspring.

Large intact blocks of land directly influence the quality and quantity of the other three resource needs, which highlights the importance of this habitat factor to all life stages. The larger, more-intact, and diverse the block of land, it follows that high-caloric foods, dens, and cover would be more readily available to individuals. We describe each of these habitat needs in more detail below.

Large, Intact Blocks of Land

Grizzly bears need intact blocks of land of sufficient size to accommodate their large annual home range sizes (Table 5) and provide breeding range, high-caloric foods, cover for shelter, dens for hibernation, and areas for dispersal (Mace *et al.* 1996, pp. 1402–1403; Schwartz *et al.* 2010, p. 661). Grizzly bears also need large, intact blocks of land with limited human influence and thus low potential for displacement and human-bear interactions that could result in human-caused mortality or other conflicts, such as development or livestock grazing (Service 1993, p. 21; Craighead and Mitchell 1982, p. 530; Schwartz *et al.* 2010, p. 661–662). Secure large blocks of land generally have protections with limited motorized access and developed sites, and low risk of habitat loss and fragmentation.

High-Caloric Foods

As described in Chapter 2, grizzly bears need high-caloric foods throughout the non-denning period to satisfy nutritional requirements for feeding and breeding. Before winter, high-caloric foods are particularly important as bears prepare to hibernate in dens, where they will rely on fat stores to overwinter. In general, grizzly bears need a sufficient quantity and diversity of natural, high-caloric foods.

Dens (Breeding and Sheltering)

As described in Chapter 2, hibernation is a central aspect of grizzly bear life history, and all life-stages of bears need dens to hibernate. In order to successfully hibernate, grizzly bears need dens that provide sufficient protection from environmental conditions and from human disturbance.

Cover (Sheltering)

As described in more detail in Chapter 2, grizzly bears need sufficient cover to shelter from environmental or human-caused factors. Grizzly bears need cover to avoid humans and rest safely. Cover may include forests, riparian areas, or other vegetative or structural sources.

Ecosystem-Level Needs

We evaluated the ecosystem-level needs of grizzly bears in terms of the demographic factors each ecosystem needs to be resilient. We identified six primary demographic factors that are important to resiliency of an ecosystem (Figure 25, above):

- Abundance;
- Population trends;
- Adult female survival;
- Survival of all other life stages;
- Fecundity;
- Connectivity; and
- Genetic diversity.

In general, an ecosystem needs sufficient levels of each of these demographic factors in order to be resilient. The greater each demographic factor, the greater the resilience of the ecosystem. Adult female survival influences abundance and population trends more than survival rates of males or dependent young (Eberhardt 1977, p. 210; Knight and Eberhardt 1985, p. 331; Schwartz *et al.* 2006b, p. 48). For example, low adult female survival contributed to the decline in the GYE prior to the mid-1980s (Knight and Eberhardt 1985, p. 331). Female movement within and between ecosystems influences population trend (Proctor *et al.* 2012, pp. 5, 26–28) and abundance (Service 1993, pp. 27, 83, 101; Service 1997, p. 29). Connectivity also influences the genetic diversity of the ecosystem. Male and female movements within and between ecosystems can enhance genetic diversity and reduce genetic fragmentation (Miller and Waits 2003, pp. 4337–4338; Proctor *et al.* 2005, pp. 27–28; Proctor *et al*. 2018, p. 361).

Lower-48-States-Level Needs

We evaluate needs at the lower-48 States level in terms of the circumstances that support the redundancy and representation of grizzly bears in the lower-48 States.

Redundancy

Redundancy describes the ability of a species to withstand catastrophic events. Redundancy gauges the likelihood that grizzly bears in the lower-48 States can withstand or "bounce back" from catastrophic events such as rare destructive natural events or episodes involving multiple or large portions of ecosystems. In general, well-distributed species are considered more redundant than species confined to a narrower geographic distribution (Carroll *et al.* 2010, pp. 5–6; Redford *et al.* 2011; Smith *et al.* 2018, pp. 306–307). Grizzly bears in the lower-48 States need multiple resilient ecosystems distributed across a geographical area to reduce the risk of catastrophic events. A sufficiently wide distribution of multiple ecosystems ensures that all ecosystems are not exposed to the same catastrophic event at the same time, thereby reducing risk to the species.

Representation

Representation describes the ability of a species to adapt to changing environmental conditions. The breadth of genetic, ecological, behavioral, morphological, and physiological diversity within and among populations can be a measure of representation (Smith *et al.* 2018, pp. 306–307). Ultimately genetic diversity provides for morphological and behavioral plasticity that allows a species to respond to various environments (i.e., inhabit and thrive in various habitat types). Representation gauges the probability that the grizzly bear is capable of using different habitats in response to a change in its environment. The more representation or diversity a species has (genetic, morphological, and/or behavioral), the more capable it is of adapting to changes (natural or human caused) in its environment. For grizzly bears in the lower-48 States, we considered genetic and ecological diversity for representation across the six ecosystems. Grizzly bears need sufficient genetic and ecological diversity across their range in the lower-48 States to adapt to changing environmental conditions. Grizzly bears also display dietary adjustability across ecosystems and exploit a broad diversity of habitat types.

Summary of Grizzly Bear Needs in the Lower-48 States

Grizzly bears in the lower-48 States need access to large, intact blocks of land that provide cover, high-caloric foods, dens, and areas for dispersal. The specific quality and quantity of these resources influence the ability of individual grizzly bears to reproduce, grow, and survive at different life stages. These resources support resilient ecosystems, which may be characterized generally by abundance, trends, survival rates, and connectivity levels that are sufficient to withstand environmental stochasticity and support fecundity. Specific quantities or qualities needed for each of these factors may vary by ecosystem. In general, grizzly bears in the lower-48 States need multiple, resilient ecosystems distributed across a broad range in order to be redundant and withstand catastrophic events. Additionally, grizzly bears in the lower-48 States in general need genetic and ecological diversity to preserve variation and adapt to changing conditions.

Chapter 5: Cause-and-Effects – Stressors and Conservation Efforts

Before we evaluate current and future conditions, we explore the environmental changes, whether natural or anthropogenic, that may have occurred to result in the species' current condition and that may influence condition into the future (Service 2016, p. 14). In this chapter, we discuss the causes-and-effects that may influence the viability of the grizzly bear in the lower-48 States, by either directly or indirectly affecting the habitat or demographic resources that we identified as needs in Chapter 4. In order to inform our evaluations of current and future condition, we evaluated the sources, stressors, and activities that can positively (conservation actions) or negatively (stressors) affect grizzly bears at the individual, ecosystem, or lower-48 States level, either currently or into the future. By identifying the anthropogenic and natural factors that influence the habitat and demographics of the grizzly bear, we can evaluate the current and future resiliency of each ecosystem, and the cumulative effects on those ecosystems determine conditions related to redundancy and representation.

A stressor is a change in a habitat or demographic resource, such as a decrease in high-caloric foods or decrease in abundance. Some stressors may directly influence the demographics of an ecosystem through mortality of individuals resulting from actions or activities, such as vehicular strikes, while others, such as development on private lands, may affect habitat factors that may indirectly affect individuals by influencing demographic factors. Some stressors may directly affect individuals and habitat factors at the same time. The stressors that we evaluated for grizzly bear include:

- Motorized access and its management;
- Developed recreation sites;
- Livestock allotments;
- Mineral and energy development;
- Recreation;
- Vegetation management, such as prescribed burns and riparian area protections;
- Habitat fragmentation;
- Development on private lands;
- Activities that may disturb dens;
- Sources of human-caused mortality, including;
    - Management removals;
    - Accidental killings (automobile and train collisions, drowning, poisoning, capture-related);
    - Mistaken identity kills;
    - Illegal killings;
    - Defense of life kills; and
    - Undetermined human-caused;
- Disease;
- Natural predation and mortality;
- Connectivity and genetic health;
- Changes in food resources;
- Effects of climate change; and

- Catastrophic events, such as earthquakes and volcanic eruptions.

We also evaluated legal hunting as a potential future stressor.

Conservation efforts that either reduce a stressor or improve the condition of habitat or demographics include:

- Federal land protections, such as motorized restrictions, the Wilderness Act, and Inventoried Roadless Areas (IRAs);
- Attractant removal or storage, such as food storage orders and community sanitation measures;
- Conservation easements and other private land trust acquisitions;
- Information and education (I&E) programs;
- Augmentation or translocation programs;
- State and private forestlands with motorized restrictions; and
- Effective law enforcement.

Figure 26 provides a conceptual model for how stressors and conservation efforts may influence individuals and the resiliency of grizzly bear ecosystems.

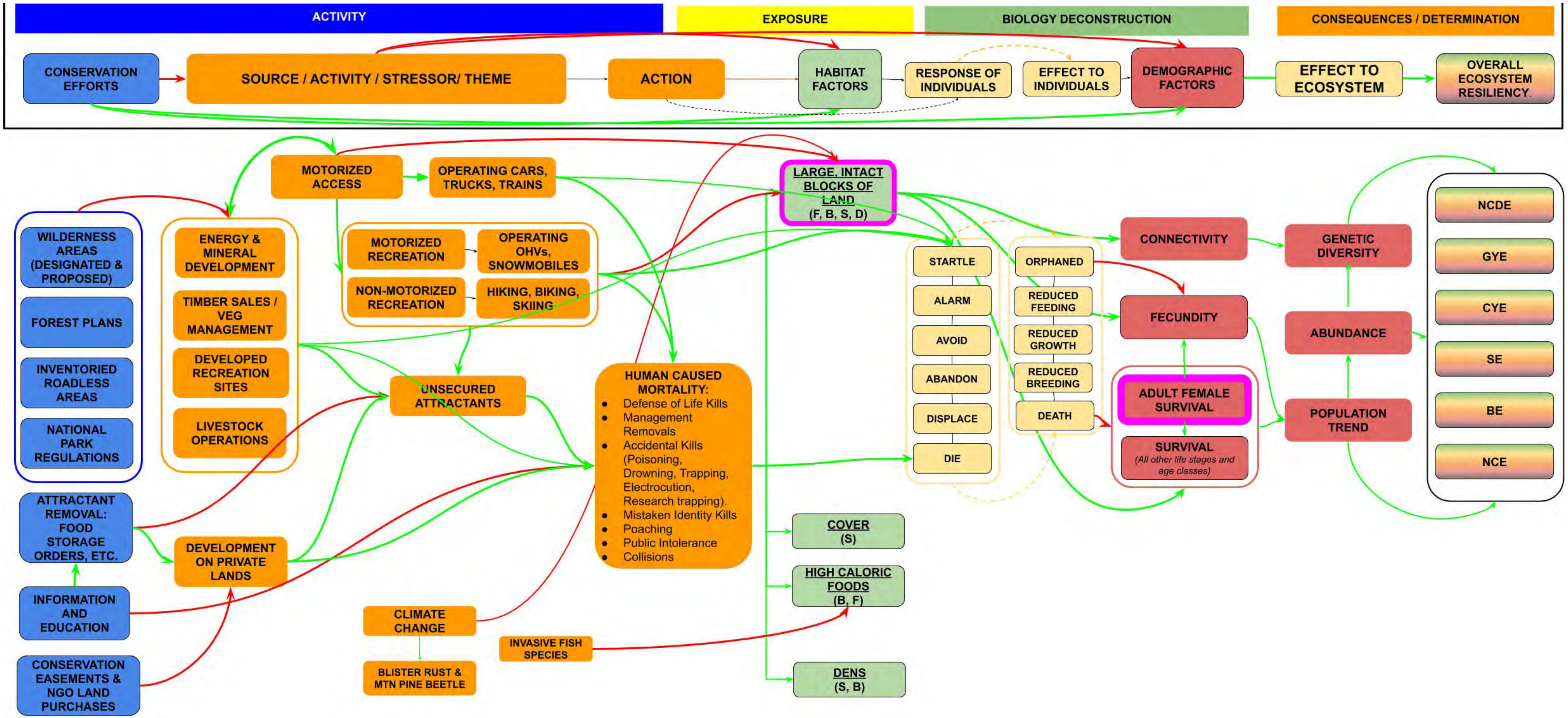

Figure 26. A conceptual model for the primary causes-and-effects (conservation efforts and stressors) that may affect individuals and cumulatively influence the resiliency of grizzly bear ecosystems in the lower-48 States. The core conceptual model for resiliency at the top of the figure has been expanded to include activity and exposure pathways and is included for reference. We also evaluated potential effects of natural predation and mortality, connectivity and genetic health, catastrophic events such as earthquakes and volcanic eruptions, potential future effects associated with legal hunting, which are not displayed in this conceptual model. B = breed (includes all stages of reproduction), F = feed, S = shelter, and D = dispersal. Green arrows represent positive relationships between nodes and red arrows represent negative relationshups between nodes.

Regulations That Influence Stressors

Protected Areas

Wilderness Areas, Proposed Wilderness, Recommended Wilderness, Wilderness Study Areas (WSAs), and IRAs can enhance the security of habitat for grizzly bears since these designations protect grizzly bear habitat from new road construction, new oil and gas development, new livestock allotments, and timber harvest (Figure 27).

The Wilderness Act of 1964 (16 U.S.C. 1131 *et seq.*) does not allow for timber harvest, new road construction, new livestock allotments, new developed sites, and new mining claims in designated Wilderness areas, with the exception of valid existing rights. If pre-existing valid mining claims are pursued, the plans of operation are subject to reasonable regulation to protect wilderness values with mitigation to offset potential impacts from development.

Recommended wilderness is managed as wilderness until Congress either formally designates the lands as wilderness or releases them to non-wilderness multiple use management (NPS 2006, pp. 79–80). These areas were recommended by the land management agency, based on a wilderness study, for consideration for designation as Wilderness. WSAs (Wilderness Study Act of 1977) have been designated by Congress as areas having wilderness characteristics and warranting further study by Federal land management agencies (e.g., USFS or BLM) and consideration by Congress as formally designated Wilderness. Individual NFs manage WSAs to maintain their wilderness characteristics, generally until Congress acts to either designate them as permanent Wilderness or releases them to multiple use management. This generally means that individual WSAs are protected from timber harvest, new road construction, new livestock allotments, and new developed sites, subject to valid existing rights. If mining claims are pursued, the plans of operation are subject to reasonable regulations to protect wilderness values with mitigation to offset potential impacts from development. Existing uses at the time of creation of the WSAs are generally allowed to continue so long as the wilderness characteristics of the area are maintained.

The 2001 Roadless Areas Conservation Rule (66 FR 3244, January 12, 2001; hereafter referred to as the “Roadless Rule”) prohibits new road construction, road re-construction, and commercial timber harvest in IRAs on Federal lands. If mining claims are pursued, the plans of operation are subject to reasonable regulations to protect roadless characteristics with mitigation to offset potential impacts from development. Motorized roads and trails may exist within IRAs subject to forest travel management plans. Potential changes in the management of these areas are not anticipated because the Roadless Rule was upheld by the Tenth Circuit Court of Appeals in 2011. (See *Wyoming* v. *USDA*, 661 F.3d 1209 (10^{th} Cir. 2011)).

These lasting land designations ensure that large proportions of recovery zones and additional areas outside the recovery zones remain secure for grizzly bears into the future without the development of new roads, extractive industries, or other human structures.

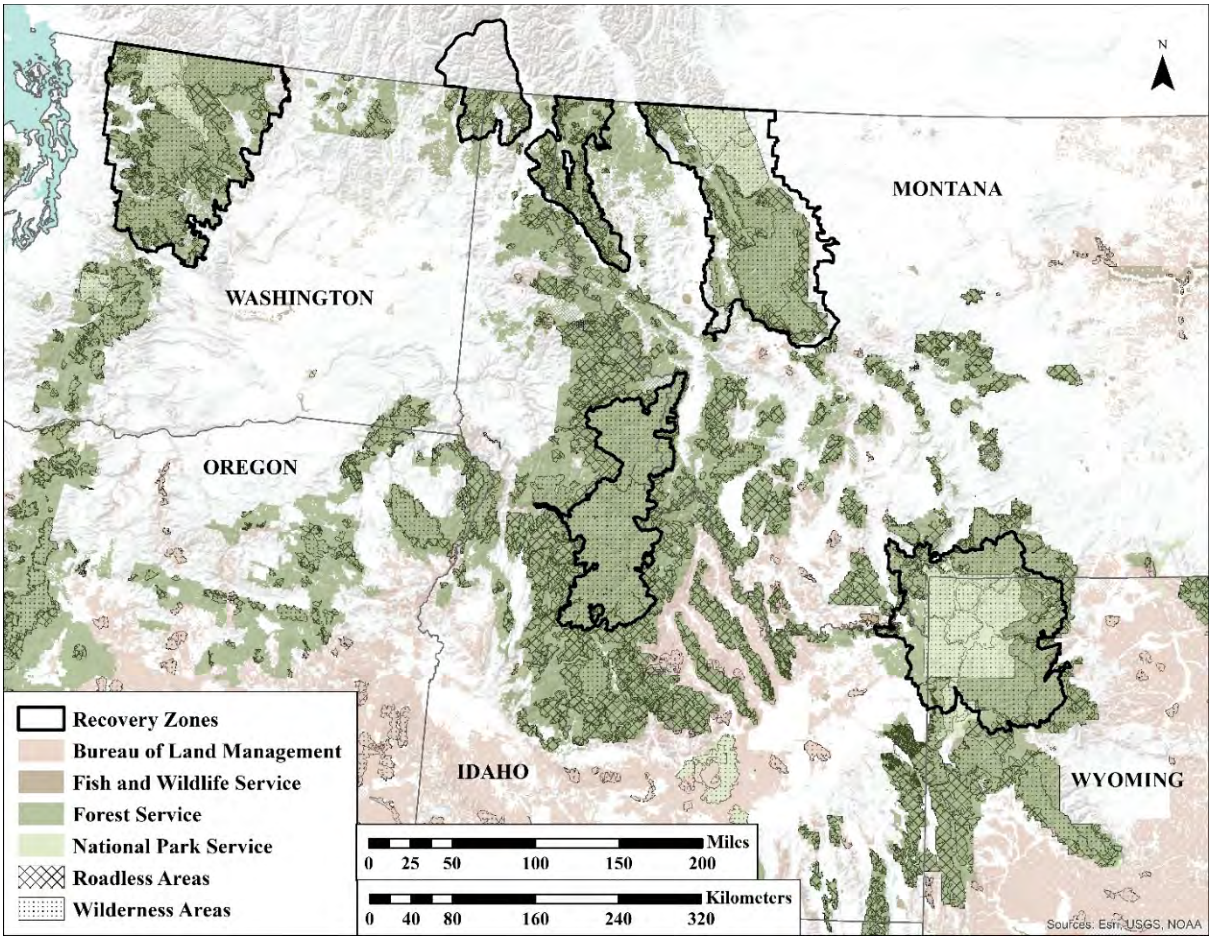

Figure 27. Federal lands, Wilderness Areas, and Inventoried Roadless Areas within and between the six grizzly bear recovery zones. Wilderness areas include congressionally designated Wilderness Areas, Wilderness Study Areas, and recommended Wilderness Areas within Glacier, Yellowstone, and Grand Teton National Parks

Protected Areas inside the GYE

The GYE recovery zone is 23,853 km^2 (9,210 mi^2) in size. Ninety-eight percent of the Recovery Zone is federally managed land, including all of YNP, as well as portions of GTNP, the Shoshone, Beaverhead-Deerlodge, Bridger-Teton, Caribou-Targhee, and Custer Gallatin NFs. Approximately 82 percent (19,642 km^2 of 23,853 km^2 (7,583 mi^2 of 9,210 mi^2)) of lands inside of the GYE recovery zone are considered "protected lands." These protected lands include Congressionally-designated Wilderness Areas (36 percent: Absaroka-Beartooth, Jedediah Smith, Lee Metcalf, North Absaroka, Teton, Washakie, and Winegar Hole Wilderness Areas), other Wilderness (35 percent; e.g., Recommended, Potential, and Eligible Wilderness in YNP, GTNP, and the John D. Rockefeller, Jr. Memorial Parkway), and IRAs (11 percent of the recovery zone).

Specifically, 16,950 km^2 (6,544 mi^2) of the recovery zone is Wilderness (8,610 km^2 (3,324 mi^2)), recommended wilderness (8,253 km^2 (3,187 mi^2)), or eligible wilderness (87 km^2 (33 mi^2)). This secure suitable habitat is biologically significant to the GYE grizzly bear population because it allows for protections against human activities inside the recovery zone, in addition to the 1998 baseline (for further details on the protections provided by the 1998 baseline, see *Motorized Access in the GYE*, *Developed Sites in the GYE,* and *Livestock Allotments in the GYE,* below). Recommended wilderness in YNP and GTNP will be managed as wilderness until Congress has either formally designated the lands as wilderness or releases them to non-wilderness multiple use management (NPS 2006, pp. 79–80).

IRAs currently provide 2,239 km^2 (864 mi^2) of secure habitat for grizzly bears inside the recovery zone. This amount of secure habitat is less than the total area contained within IRAs (2,692 km^2 (1,039 mi^2)) because some motorized use occurs due to roads that existed before the area was designated as roadless.

In addition, a large proportion of suitable habitat outside the recovery zone remains secure for grizzly bears into the future without the development of new roads, extractive industries, or other human structures because of lasting designation as Wilderness, WSAs, and IRAs. Of the 23,131 km^2 (8,931 mi^2) of suitable habitat outside of the recovery zone in the GYE, 59 percent (13,685 km^2 (5,284 mi^2)) is managed and protected by the USFS as Congressionally-designated Wilderness (6,799 km^2 (2,625 mi^2)), WSAs (708 km^2 (273 mi^2)), or IRAs (6,179 km^2 (2,386 mi^2)). This area of secure habitat is less than the total area contained within IRAs (8,871 km^2 (3,425 mi^2)) because some motorized use occurs due to roads that existed before the area was designated as roadless.

Protected Areas inside the NCDE

The NCDE recovery zone is 23,135 km^2 (8,932 mi^2) in size. Seventy-eight percent of the recovery zone is federally managed land, including all of GNP, as well as portions of the Flathead, Helena-Lewis and Clark, Kootenai, and Lolo NFs, and the Flathead (FIR) and Blackfeet Indian Reservations (BIR). Nearly 67 percent (15,653 km^2 of 23,119 km^2 (6,044 mi^2 of 8,926 mi^2)) of lands inside the recovery zone are considered "protected lands." These protected lands include Congressionally-designated Wilderness Areas (30 percent: Bob Marshall, Great Bear, Mission Mountains, Rattlesnake, and Scapegoat Wilderness Areas), other Wilderness (18 percent; e.g., WSAs, Recommended Wilderness, and Confederated Salish & Kootenai Tribes (CS&KT) Wilderness), and restricted motorized-use areas (19 percent; IRAs, Tribal roadless areas, Tribal Primitive Areas, and NRAs). This secure core habitat is biologically significant to the NCDE grizzly bear population because it allows for protections against human activities inside the recovery zone, in addition to the 2011 baseline (for further details on the protections provided by the 2011 baseline, see *Motorized Access in the NCDE*, *Developed Sites in the NCDE,* and *Livestock Allotments in the NCDE,* below).

As discussed above, the Wilderness Act of 1964 does not allow for new road construction, new developed sites, and mining claims in designated Wilderness, with the exception of valid existing rights. There are approximately 50 pre-existing mining claims located in 4 of the 23 BMUs inside the recovery zone (Ake 2018c, *in litt.*). If pre-existing valid mining claims are pursued, the plans of operation are subject to reasonable regulation to protect wilderness values with mitigation to offset potential impacts from development.

There are two Tribal wilderness areas within the recovery zone, the Mission Mountains and the Sleeping Woman (Ninemile Divide) that are designated through Tribal Ordinances (Ordinance 79A; Resolution 82-173) which prohibits the building of roads or the use of motorized equipment “except as necessary to meet the minimum requirements for administration of the Area.” In addition, Resolution 86-47 provides for a Buffer Zone around the Mission Mountain wilderness area to reduce the impacts of activities that may occur in non-wilderness areas on Tribal Wilderness. Additional protections occur on the FIR in Tribal primitive areas and Tribal roadless areas. There is one Tribal primitive area on the FIR within the recovery zone, the South Fork Jocko Primitive Area that is 181 km^2 (70 mi^2) (Tribal Resolutions 4575), on which there will be no commercial forest activities and no net increase in open roads (CS&KT 2000, p. 91). Tribal primitive areas are only open to Tribal members and their immediate non-member family members to provide for “solitude and an unconfined type of recreation.” In addition, there are several roadless areas, the Ravalli/Valley (Hewolf) Complex (32 km^2 (12 mi^2)) and Burgess (7 km^2 (3 mi^2)), that are unavailable to motorized use and logging or only allow helicopter logging (CS&KT 2000, pp. 91, 141).

Proposed and recommended wilderness on the Flathead NF, Lolo NF, and GNP will be managed as wilderness until Congress has either formally designated the lands as wilderness or releases them to non-wilderness multiple use management (USDA FS 1986a, p. III-37; GNP 1999, p. 8; NPS 2006, pp. 79–80; USDA FS 2018b, p. 318; USDA FS 2018e, pp. 89–90). Portions of the Rattlesnake NRA on the Lolo NF are recommended wilderness. The non-wilderness portion of the Rattlesnake NRA is designed to balance the needs of dispersed, non-motorized recreation and restoration (USDA FS 1986a, pp. III-144–149).

In addition, five percent (748 km^2, 289 mi^2) of Zone 1 is protected as Wilderness, WSAs, or IRAs. At 105 km^2 (40 mi^2), the Rattlesnake NRA overlaps the recovery zone but primarily occurs within Zone 1. Within the Ninemile DCA, 22 percent of the lands are managed by the Lolo NF as IRAs and 18 percent are managed by the CS&KT as wilderness and roadless areas. In Zone 2, 10 percent (1,944 km^2 (751 mi^2)) is protected as Wilderness, WSAs, or IRAs.

Protected Areas inside the CYE

The Cabinet-Yaak recovery zone is 6,705 km^2 (2,589 mi^2) in size. Nearly 98 percent of the recovery zone is federally managed land, including portions of the Kootenai, Idaho Panhandle, and Lolo NFs. Blocks of contiguous habitat extend into B.C., making this an international population. Within the CYE recovery zone, 44 percent of lands are protected as designated Wilderness (Cabinet Mountain Wilderness: 379 km^2 (146 mi^2)) or IRAs (2,568 km^2 (992 mi^2)).

Protected Areas inside the SE

The Selkirk Mountains recovery zone is 6,575 km^2 (2,539 mi^2) in size and is unique in that the recovery zone extends north into Canada, with approximately half of the recovery zone (3,020 km^2 (1,116 mi^2) occurring in the U.S. Nearly 79 percent of the recovery zone in the U.S. is federally managed land, including portions of the Idaho Panhandle and Colville NFs. Three percent (167 km^2 (65 mi^2)) is designated Wilderness (Salmo-Priest Wilderness). The Colville National Forest Plan also includes 60 km^2 (23 mi^2) of recommended wilderness within the SE recovery zone (CNFLMP 2019, p. 149). In B.C., 82 percent of the recovery zone is managed by the province.

Protected Areas inside the BE

The BE recovery zone includes about 14,984 km^2 (5,785 mi^2) of contiguous national forest lands in central Idaho and western Montana. The recovery zone focuses on wilderness, with 98 percent (14,840 km^2 (5,730 mi^2)) of the recovery zone designated Wilderness, including the Selway-Bitterroot Wilderness and the Frank Church-River of No Return Wilderness. Additional protected areas surround the recovery zone, including the Gospel Hump Wilderness Area (810 km^2 (313 mi^2)) to the west of the recovery zone and large areas to the north of the recovery zone that are protected as IRAs (18,325 km^2 (7,075 mi^2)).

Protected Areas inside the North Cascades

The North Cascades recovery zone is 24,773 km^2 (9,565 mi^2) in size, including 90 percent public lands and 10 percent private lands. The recovery zone includes all of the North Cascades National Park Complex and most of the Mount Baker-Snoqualmie, Wenatchee and Okanogan National Forests. Eleven percent (2,725 km^2 (1,052 mi^2)) of the recovery zone is protected by the National Park Service (North Cascades National Park Complex). Sixty-three percent of lands are protected as designated Wilderness (10,842 km^2 (4,186 mi^2)) or as IRAs (5,187 km^2 (2,118 mi^2)).

Motorized Access

When we listed the grizzly bear in 1975, we acknowledged that human access to formerly secure grizzly bear habitat made bears more susceptible to human-caused conflicts and increased human-caused mortality (40 FR 31734, July 28, 1975). We recognized that managing human access to grizzly bear habitat would be the key to effective habitat management by reducing human-caused mortality and increasing habitat effectiveness. An extensive body of literature supports this approach (Mattson *et al.* 1987, pp. 269–271; McLellan and Shackleton 1988, pp. 458–459; McLellan 1989, pp. 1862–1864; Mace *et al.* 1996, pp. 1402–1403; Schwartz *et al.* 2010, p. 661; Boulanger *et al.* 2013, p. 283; McLellan 2015, p. 12; Proctor *et al.* 2019, entire). Unmanaged motorized access impacts grizzly bears by:

(1) Increasing human interaction and potential grizzly bear mortality risk;
(2) Increasing displacement from important habitat;

(3) Increasing habituation to humans; and
(4) Decreasing available habitat where energetic requirements can be met with limited disturbance from humans.

The Interagency Grizzly Bear Committee Taskforce Report recognized that these impacts could be minimized through motorized access management (IGBC 1998, p. 1). The Taskforce Report recommended three parameters for a consistent approach to motorized access management between and within the grizzly bear ecosystems: (1) open motorized route density, (2) total motorized route density, and (3) core areas (IGBC 1998, p. 1). Although the Taskforce Report defined each of these parameters, it recognized that each ecosystem subcommittee would apply the recommendations based on ecosystem-specific information and recommend ecosystem specific habitat conditions that should be maintained to provide habitat security. See *Appendix B* for further details on the differences in secure core/core area/secure habitat definitions between ecosystems.

In general, motorized access brings humans into grizzly bear habitats, and increased human presence may disturb, displace, or kill grizzly bears if human-interactions trigger activities that are associated with human-caused mortality, such as defense of life kills or management removals (Figure 26, above). Motorized access includes the operation of vehicles and other equipment along roads, highways, trails, and tracks, and it facilitates motorized and non-motorized forms of recreation into grizzly bear habitats. In addition to facilitating access to recreation, energy and mineral development, vegetation management, developed sites, and livestock operations may also necessitate motorized routes and thus provide additional sources of this stressor (Figure 26, above). Motorized access may indirectly influence the resiliency of ecosystems by reducing the quality and quantity of large-intact blocks of land (Figure 26, above). It may also directly influence the resiliency of ecosystems by reducing demographic factors, such as abundance or survival, if individuals are startled, dispersed, or killed (Figure 26, above). Direct mortality from motorized access may occur following strikes or from activities associated with human-caused mortality (Figure 26, above). An effective habitat management tool for reducing grizzly bear mortality risk is managing motorized access to ensure bears have secure areas away from humans (Nielsen *et al.* 2006, p. 225; Schwartz *et al.* 2010, p. 661; Proctor *et al.* 2019, pp. 19–20). Well-managed motorized access provides large proportions of secure core habitat on federal lands that helps ameliorate the impacts of displacement and increased human-caused mortality risk in grizzly bear habitat. Motorized access that is well-managed on state, local, or private lands may also provide conservation benefit to bears.

Motorized Access in the GYE

The 1998 baseline and associated management policies help ensure adequate secure habitat and amelioration of impacts from motorized access inside the recovery zone (USDA FS 2006b, entire). In the GYE, secure habitat is defined as areas more than 500 m (1,650 ft) from a motorized access route or reoccurring helicopter flight line and greater than or equal to 10 acres (0.31 km^2 (0.016 mi^2)) in size (Service 2007b, p. 4). In the 1998 baseline, secure habitat comprised 45.4 to 100 percent of the total area within a given bear management subunit with an average of 85.6 percent throughout the entire recovery zone (YES 2016b, Appendix E). The draft habitat-based recovery criteria determined that 37 of the 40 subunits have sufficient levels of secure habitat (Service 2007b, pp. 34–35). These levels of secure habitat have been successfully maintained and we expect they will be maintained or improved upon in the future by keeping levels of open and total motorized route densities at or below baseline levels, with allowances for authorized federal projects according to the application rules (see the 2016 GYE Conservation Strategy for a detailed description of the application rules; USDA FS 2006b, entire; YES 2016a, pp. 62–64), as directed by the 2016 GYE Conservation Strategy and the MOU signed by all State and Federal partner agencies (YES 2016a, pp. 13–14). Three subunits were identified as “in need of improvement” from 1998 levels (Service 2007b, p. 4). These three subunits have shown on average a 7.5 percent increase in secure habitat and these improved levels serve as the new baseline for these three subunits with the implementation of the 2006 Gallatin National Forest Travel Management Plan (USDA FS 2006c, pp. 30, 83–84). Although there are no standards for motorized route density, monitoring protocols requires that open motorized route density (OMRD) and total motorized route density (TMRD) inside the recovery zone be annually monitored and reported against 1998 levels (YES 2016b, Appendix E).

The 2016 GYE Conservation Strategy indicates that temporary changes in secure habitat may not exceed 3 years, can affect no more than 1 percent of the largest subunit size within that BMU, may occur in only one subunit at a time, and that project roads will not be open to public use (YES 2016a, pp. 63–64). It is reasonable and biologically sound to provide management flexibility and discretion to land management agencies so they can fulfill their mandates of balancing and accommodating multiple uses (USFS) and providing for public recreation while conserving resources (NPS). These allowances for temporary changes to secure habitat were based on known levels of project activities occurring during the 1990s, a time during which the GYE grizzly bear population was known to be increasing (Harris *et al*. 2006, p. 48). There are no biological data to demonstrate that the temporary 1 percent level of secure habitat disturbance in any subunit has had any detrimental effect on the grizzly bear population. These temporal and spatial restrictions, as well as the requirement that all secure habitat be restored upon completion of a temporary project, mean there will be no permanent loss of secure habitat in any subunit. For permanent changes, replacement habitat must be in place for at least 10 years before it can be used for mitigation for future projects, including logging.

Of the 23,131 km^2 (8,931 mi^2) of suitable habitat outside of the recovery zone, all of which occurs within the DMA boundary, the USFS manages 17,581 km^2 (6,788 mi^2), or 76 percent. The area most likely to be occupied by grizzly bears outside the recovery zone in Idaho is on the Caribou-Targhee NF. The 1997 Targhee Forest Plan includes motorized access standards and management prescriptions outside the recovery zone that provide for long-term security in 59 percent of existing secure habitat in Idaho outside of the recovery zone (USDA FS 2006a, pp. 78, 109). The Eastern Shoshone and Northern Arapaho Tribes manage the 1,373 km^2 (530 mi^2) of suitable habitat within the boundaries of the Wind River Reservation (WRR), all of which is outside the recovery zone. The WRR Forest Management Plan calls for no net increase in roads in the Wind River Roadless Area and the Monument Peak area of the Owl Creek Mountains. In the remaining lands occupied by grizzly bears, open road densities of 0.6 km/km^2 (1 mi/ mi^2) or less will be maintained (Eastern Shoshone and Northern Arapaho Tribes 2009, p. 11). GTNP manages 829 km^2 (320 mi^2), or 3.5 percent, of suitable habitat outside of the recovery zone. Protections for grizzly bears throughout NPS lands include, but are not limited to, seasonal area closures and food storage orders, provided through the GTNP Superintendent's Compendium (GTNP and JDR 2019, pp. 7, 15–16, 24).

State grizzly bear management plans add another layer of habitat protection outside the recovery zone. Habitat management on Federal public lands is largely directed by Federal land management plans, not State management plans. However, the three State grizzly bear management plans recognize the importance of areas that provide security for grizzly bears in suitable habitat outside of the recovery zone on public lands. For example, the Montana and Wyoming plans recommend limiting average road densities to 0.6 km/km^2 (1 mi/mi^2) or less in these areas and will consider wildlife in any road construction or reconstruction proposals (MFWP 2013, pp. 37–39; WGFD 2016, pp. 18–20). Both States have similar standards for elk habitat on State lands and note that these levels of motorized access benefit a variety of wildlife species while maintaining reasonable public access. Similarly, the Idaho plan recognizes that management of motorized access outside the recovery zone should focus on areas that have road densities of 0.6 km/km^2 (1 mi/mi^2) or less (Idaho's Yellowstone Grizzly Bear Delisting Advisory Team 2002, p. 10).

Because of the positive effect that secure habitat has on grizzly bear survival and reproduction, one of the objectives of the habitat-based recovery criteria and the 2016 GYE Conservation Strategy is no net decrease in the 1998 baseline levels of secure habitat inside the recovery zone so that the recovery zone can continue to function as a source area for grizzly bears in the GYE. Meeting these objectives limit negative impacts of motorized access in the GYE.

Motorized Access in the NCDE

The 2011 baseline and associated management policies help ensure adequate secure habitat and amelioration of impacts from motorized access inside the recovery zone. In the NCDE, secure core habitat is defined as those areas on Federal lands more than 500 m (1,650 ft) from a motorized access route and at least 2,500 (10.1 km^2 (3.9 mi^2)) in size and in place for 10 years (Service 2018, pp. 5, 12). In the baseline, secure core habitat comprised 45.4 to 100 percent of the total area within a given BMU subunit with an average of 76.4 percent throughout the entire recovery zone (NCDE Subcommittee 2018, Appendix 4). These levels of secure core habitat have been successfully maintained and will continue to be maintained or improved on Federal lands within the recovery zone by maintaining levels of open and total motorized route densities at or below baseline levels (NCDE Subcommittee 2018, Chapter 3 and Appendix 4; USDA FS 2018c, p. 31; USDA FS 2018d, pp. 10–11). Moreover, projects on Federal lands that temporarily change the amount of secure core habitat will be subject to the motorized access objectives in the NCDE Conservation Strategy as codified in land management plans. These objectives limit temporary increases to OMRD to 5 percent, temporary increases to TMRD to 3 percent, and temporary decreases to secure core to 2 percent per bear management subunit as running averages per decade (NCDE Subcommittee 2018, Chapter 3; USDA FS 2018d, pp. 1-7, 1-19, 1-31, 1-42; USDA FS 2018e, pp. 65–66). The rationale for allowing temporary changes is that similar levels of temporary changes were evaluated and allowed on Federal lands through the Endangered Species Act section 7 consultation while the grizzly bear was listed as threatened and were associated with an increasing grizzly bear population (NCDE Subcommittee 2018, Chapter 3).

State and Tribal land management entities in the recovery zone have also agreed to manage motorized access on non-federal lands in accordance with their existing plans (in their entirety: CS&KT 2000; Blackfeet Nation 2008; DNRC 2011). Lands managed under the Montana Department of Natural Resources and Conservation (DNRC) Habitat Conservation Plan (HCP) will minimize construction of new open roads with caps on the total miles of open and restricted roads during the life of the HCP (DNRC 2011, pp. 13, 18). On other State lands, there will be no permanent net increase of open road density (Administrative Rule of Montana (ARM) 36.11.433). The Blackfeet Nation Forest Management Plan will not allow increases in open motorized route densities in any of the BMU subunits (Blackfeet Nation 2008, p. 11). Total road densities will be improved by closing non-essential roads to reduce the high road densities where they occur (Blackfeet Nation 2008, p. 32). On the FIR, in accordance with the CS&KT Forest Management Plan, no permanent increases in open or total motorized road densities and no permanent decreases in secure core habitat will be allowed in the Mission Mountain Tribal Wilderness Area and there will be no net increase in open roads in the South Fork Jocko Primitive Area (CS&KT 2000, p. 141). The remaining FIR lands will be managed such that open road densities will not exceed 2.4 km/km^2 (4 mi/mi^2) and total roads will remain at or below levels that existed in 1999 (CS&KT 2000, pp. 294–295). Total road densities will be improved by removing 15 percent of road spurs in currently roaded areas over the life of the Plan, by 2030 (CS&KT 2000, p. 295).

Additional limitations on motorized routes occur on USFS, BLM, and DNRC lands outside of the recovery zone but inside Zone 1. Outside the recovery zone, the USFS manages 4,241 km^2 (1,637 mi^2), or 22 percent, of lands in Zone 1, on which there will be no net increase in the linear miles or density of roads that are open for public motorized use during the non-denning season (USDA FS 2018d, pp. 10–11, 1-14–1-15, 1-27, 1-50; USDA FS 2018e, pp. 132–133). The BLM has 374 km^2 (144 mi^2) in Zone 1 in which there will be no net increase in the linear miles or road densities of open roads (BLM 2019a, p. 39; BLM 2019b, p. 2-20). The DNRC HCP regulates motorized access management on 586 km^2 (226 mi^2) of State land in Zone 1 to minimize construction of new open roads and prohibit commercial forest activities during the spring period in identified spring habitat (DNRC 2011, p. 11).

The two DCAs in Zone 1, the Salish and Ninemile, are intended to provide opportunities for female grizzly bears to establish home ranges and exist at low densities in areas between the NCDE and CYE and the NCDE and BE, as is consistent with female dispersal and connectivity requirements (McLellan and Hovey 2001, p. 842; Proctor *et al.* 2005, pp. 2413–2415; Proctor *et al.* 2012, p. 35; Proctor *et al.* 2015, pp. 8–12; Proctor *et al.* 2018, pp. 356–361). The USFS manages 79 percent of lands within the Salish DCA (1,505 of 1,901 km^2 (581 of 734 mi^2)). On the Kootenai NF, the Salish DCA overlaps almost entirely with the Tobacco BORZ; increases in permanent linear miles of open or total roads or motorized trails are not allowed within the Tobacco BORZ (USDA FS 2018b, p. 73; USDA FS 2018d, p. 10). On the Flathead NF portion of the Salish DCA, there will be no net increase above the baseline in linear miles of open motorized routes (USDA FS 1986b, pp. II-62–63; USDA FS 2018a, pp. 179–180). Seventy percent of lands within the Ninemile DCA are managed by the USFS and the CS&KT. On the Lolo NF, 22 percent of USFS lands are IRAs. The remainder of USFS lands in the Ninemile DCA will be managed for no net increase above the baseline density of motorized access routes during the non-denning season (USDA FS 2018d, pp. 10–11). See the NCDE Conservation Strategy for linear route densities in the DCAs (NCDE Subcommittee 2019, Appendix 6). Eighteen percent of the lands managed by the CS&KT in the Ninemile DCA are wilderness and roadless areas. Open road densities are managed remain at or below 2.4 km/km^2 (4 mi/mi^2) and total road miles are managed to remain at or below what existed in 1999 on the remaining lands managed by the CS&KT in the Ninemile DCA (CS&KT 2000, pp. 294–295).

In Zone 2, regulatory mechanisms are in place to ensure habitat management direction is compatible with providing genetic connectivity to other populations on land managed by BLM, USFS, and DNRC. BLM, USFS, and DNRC lands constitute 35 percent of Zone 2. The remainder is privately owned (62 percent) or local government, water, or other state and federal lands (3 percent). As of 2018, 23 percent of Zone 2 was occupied, however there have been multiple verified sightings in Zone 2 between the NCDE and GYE occupied areas. Other areas within the NCDE are referred to as Zone 3. In contrast to Zones 1 and 2, Zone 3 does not provide habitat linkage to other grizzly bear ecosystems. As mentioned above, Zone 3 is largely private land with agricultural land uses, making it less suitable for continual occupancy by grizzly bears. Therefore, there is no need for habitat protections specifically developed for grizzly bears on Federal, State, or Tribal lands in Zone 3 in order to support the NCDE grizzly bear population.

Because of the positive effect that secure core habitat has on grizzly bear survival and reproduction, one of the habitat-based recovery criteria objectives and NCDE Conservation Strategy is no net decrease in levels of secure core habitat inside the recovery zone so that the recovery zone can continue to function as a source area for grizzly bears in the NCDE. Meeting these objectives will limit negative impacts of motorized access in the NCDE.

Motorized Access in the CYE and SE

The majority of lands within the CYE and SE recovery zones are managed by the USFS, which has incorporated motorized route density standards into its management plans to effectively provide secure habitat (core) for grizzly bears. In the CYE recovery zone, 97 percent of land (6,530 km^2 (2,589 mi^2) of 6,705 km^2 (2,589 mi^2)) is managed by the Kootenai, Idaho Panhandle, and Lolo NFs. Forty-six percent (3,020 km^2 (1,166 mi^2) of 6,575 km^2 (2,539 mi^2)) of the SE recovery zone is in the U.S., with the remainder in B.C., Canada. In the U.S. portion of the SE recovery zone, 79 percent of land (2,376 km^2 (917 mi^2) of 3,020 km^2 (2,609 mi^2)) is managed by the Idaho Panhandle and Colville NFs. Standards for motorized access management in the CYE and SE grizzly bear recovery zones were first incorporated into forest plans for the Kootenai, Lolo, and Idaho Panhandle NFs through the "Forest Plan Amendments for Motorized Access Management within the Selkirk and Cabinet-Yaak Grizzly Bear Recovery Zones" (2011 Amendment) (USDA FS 2011a, entire). The 2011 Amendment established BMU-specific levels for motorized route densities and core areas based on the recommendations of Wakkinen and Kasworm (1997, entire), who summarized data from female grizzly bears that survived to successfully reproduce to provide recommendations for levels of motorized route densities and core areas. (USDA FS 2011a, p. 36; USDA FS 2011b, pp. 23–27). In the CYE and SE, core areas are defined as those areas greater than 500 m (1,650 ft) from any open motorized route or high-use non-motorized route. These motorized access management standards have subsequently been incorporated into the Kootenai, Idaho Panhandle, and Colville NFs Land Management Plan (USDA FS 2015a, 2015b; USDA FS 2019, pp. 60, 63–64).

The motorized access standards established in the 2011 Amendment affect 22 BMUs in the CYE recovery area (USDA FS 2011a, p. 31; USDA FS 2020a, p. 17). As of 2019, 8 BMUs within the CYE recovery zone meet the management standards under the new access management plans and 14 do not (USDA FS 2011a, p. 31; USDA FS 2020a, pp. 1–2). Of the 14 that do not yet meet standards, 5 BMUs are within 1 percent of meeting the standard for all of the criteria. The USFS is currently working on an implementation schedule for the remaining BMUs to achieve all standards.

The motorized access standards established in the 2011 Amendment affect 8 of the 10 BMUs in the U.S. portion of the Selkirk Recovery area (USDA FS 2011a, p. 31; USDA FS 2020a, p. 17). As of 2019, 2 of the 8 BMUs within the U.S. portion of the SE recovery zone did not meet its proposed access management standards under the new Access Management plans (USDA FS 2020a, p. 2). One of the BMUs that does not meet the standards is within 1 percent of meeting the standard for all criteria. The USFS is currently working on an implementation schedule for the remaining BMUs to achieve all standards.

The two BMUs unaffected by the 2011 Amendment motorized access standards are either administered by the Idaho Department of Lands (IDL; State BMU) or have a high proportion of non-federal lands (LeClerc BMU), thereby limiting the ability to implement motorized access standards. There are no road or habitat security data available for the State BMU and the above-mentioned standards do not apply to this BMU.

The checkerboard land ownership patterns in the LeClerc BMU limits any single landowner from implementing BMU-wide motorized access management, however the Colville NF manages NF lands in this BMU for no net increases in motorized access (USDA FS 2018f, pp. 63–64). Additionally, Stimson Lumber Company, the primary private landowner in the LeClerc

BMU, voluntarily manages its timber harvest activities through a Conservation Agreement with the FWS and the Colville NF (Service 2001, Appendix A). This Conservation Agreement and the FWS Biological Opinion (Service 2001, entire) commit Stimson and the Colville NF to leave hiding cover within created openings, along open roads, and within riparian habitats. Stimson also committed to log during the winter in some areas to reduce disturbance, and report logging activities and road use annually. The Conservation Agreement was upheld in a challenge brought by the Selkirk Alliance before the 9th Circuit Court of Appeals in a July 17, 2003 ruling (No. 02-35635) and has now been implemented for 14 years.

Overall, motorized route densities have been reduced and core areas have increased in the CYE and SE since the grizzly was listed (Summerfield *et al*. 2004, entire; USDA FS 2020a). For the CYE, between 2002 and 2019 there was a 33 percent reduction in total motorized routes and a 27 percent increase in core areas across the 22 BMUs (USDA FS 2011a, pp. 70–72; USDA FS 2020a, pp. 1–2). During this same time period, there was a 10 percent increase in open motorized routes (USDA FS 2011a, pp. 70–72; USDA FS 2020a, pp. 1–2). For the SE, between 2002 and 2019 there was a 10 percent reduction in total motorized routes and a 10 percent increase in core areas across the 22 BMUs (USDA FS 2011a, p. 73; USDA FS 2020a, p. 2). During this same time period, there was a 4 percent increase in open motorized routes (USDA FS 2011a, p. 73; USDA FS 2020a, p. 2). Some increases in OMRD and TMRD in individual BMUs in the CYE and SE from 2002 to 2019 were a result of corrections to the road layer, which does not reflect a change in conditions on the ground but a more accurate reflection of roads.

The portion of the SE in B.C. outside of protected areas has varying levels of open roads, however a large portion (700 km^2 (270 mi^2)) of that area lies within ownership of the Nature Conservancy of Canada that limits access to their lands (Proctor *et al* 2018, p. 358). The B.C. South Selkirk had an average open road density of 1.2 km/km^2 and 50 percent secure habitat, as defined in MacHutchon and Proctor (2016, p. vi) as further than 500 m (1,650) from an open road and greater than 10 km^2 (3.86 mi^2) in size. The B.C Yahk area north of the CYE is heavily roaded (average 1.6 km/km^2 and 24 percent secure habitat) with little access control (MacHutchon and Proctor 2016, p. 84, see Appendix X for more information on Canadian management).

In addition to the standards inside the recovery zone, BORZ were incorporated into NF Plans for the Kootenai, Idaho Panhandle, and Lolo NFs in 2004 (USDA FS 2004). The motorized access standards established in the 2011 Amendment affect 3,869 km^2 (1,494 mi^2) outside the recovery zone known to be occupied by grizzly bears (BORZ) in the CYE and 506 km^2 (195 mi^2) outside the recovery zone known to be occupied by grizzly bears (BORZ) in the SE (USDA FS 2011a, p. 31; USDA FS 2020a, p. 17). USFS plan direction does not allow increases in open or total linear miles of road above the baseline values in the 2011 Amendment in BORZ (USDA FS 2011a, p. 22; USDA FS 2015a, pp. 150–151; USDA FS 2015b, pp. 154–155). This approach is based on the premise that because the area has been determined to be occupied by bears, then management should at least maintain status quo. Also, timber harvest activities in these areas are coordinated across multiple watersheds to minimize disturbance from road use to grizzly bears (USDA FS 2011a, p. 23; USDA FS 2015a, p. 150; USDA FS 2015b, p. 155).

The USFS submits annual reports to the Service summarizing compliance with the 2011 Forest Plan Amendment that detail annual changes by BMU. The 2019 monitoring report confirmed compliance with the ROD (USDA FS 2020a, pp. 16–23). Full implementation of the motorized access standards in the Amendment, road densities, and core areas will be managed in a way that minimizes negative impacts of motorized access. Further monitoring of the populations and cause-specific mortality would help determine the success of this management strategy.

Idaho Department of Lands (IDL) manages approximately 914 km^2 (353 mi^2) within the SE and CYE, and 53 km^2 (21 mi^2) within the GYE. IDFG personnel review IDL management plans to ensure planned activities are compatible with the needs of the grizzly bear. Additionally, a MOA between IDL and IDFG for cooperative road closures in the SE and CYE to reduce human-caused grizzly bear mortality between outlines closure standards, signage, reporting standards and funding (IDL and IDFG 2012, entire). Additional measures include shorter timber sale seasons and required bear behavior training for field staff.

Motorized Access in the BE

Nearly 100 percent of land (15,086 km^2 (5,825 mi^2) of 15,100 km^2 (5,830 mi^2)) within the BE recovery zone is managed by the USFS, including the Salmon-Challis, Bitterroot, Lolo, and Nez Perce-Clearwater NFs. Although BMU boundaries and motorized access standards have not yet been determined for the BE recovery zone, the BE recovery zone is more than 98 percent Wilderness (see *Protected Areas*) and therefore, any impact of motorized access on grizzly bears in the BE recovery zone is likely very minimal. However, consideration should be given to motorized access in potential connectivity areas between other ecosystems and the BE to facilitate natural recolonization.

Motorized Access in the North Cascades

In the North Cascades recovery zone, 86 percent of land (21,770 km^2 (8,405 mi^2) of 25,305 km^2 (9,770 mi^2)) is managed by North Cascades National Park and by the Mount Baker-Snoqualmie and Wenatchee-Okanogan NFs. Core areas for the North Cascades are defined as those areas greater than 500 m (1,650 ft) from any open motorized route or high-use non-motorized route. Federal land management agencies identified an approach to protect secure habitat (core) for 42 BMUs in the recovery zone in 1997 (USDA FS 1997, entire). Motorized access standards were not set but the Federal land management agencies manage for “no net loss” of secure habitat from the 1997 baseline. The interim direction allows for one change to be made in secure habitat in each BMU without review by the North Cascades IGBC Subcommittee. The amount of secure habitat varies by BMU, ranging from 21 to 92 percent with an average of 59 percent secure habitat. This criterion for “no net loss” has been met for all BMUs with the following changes in secure habitat made since 1997: two situations in which a small reduction in secure habitat was approved in BMUs that contained more than 90 percent secure habitat; and minor reductions in secure habitat proposed due to high use trail construction in some BMUs currently exceeding 80 percent secure habitat.

Access management direction for North Cascades National Park was were published in the Ross Lake NRA General Management Plan (NPS 2012, entire). It stipulated that: (1) BMUs within the park complex would be managed for greater than 70 percent core (IGBC 1998, p. 4); (2) that NPS would consult with USFS on any proposal for a high-use trail in the park that would tip a shared BMU below 70 percent, or if the shared BMU was already below the 70 percent target; and (3) North Cascades NP would "strive to minimize, avoid or mitigate impacts on high quality spring and fall grizzly bear habitat" (NPS 2012, p. 82). One mile of road is scheduled to be removed (awaiting funding) and the new proposed trails would remove less than 1 percent core from each of the 4 BMUs in which they occur, none of which is high quality grizzly bear habitat (NPS 2012, p. 82).

The Okanogan-Wenatchee NF published a Notice of Intent in the Federal Register on June 30, 2011 to begin the process of revising their forest plan, but that action is currently on hold. In the interim, the Okanogan-Wenatchee NF continues to implement the "no net loss" policy. A Travel Analysis Report was completed in 2015 and recommended decommissioning or closing approximately 3,172 km (1,970 mi) of the 127,800 km (7,950 mi) of roads to OHV use on the Okanogan-Wenatchee NF (USDA FS 2015c). A final decision on the travel management plan for the Okanogan-Wenatchee NF has not yet been made. Any action taken in this regard will require a NEPA process. The Mount Baker Snoqualmie NF has not started a plan revision as of 2017 and continues to use the "no net loss" policy (USDA FS 1997, entire).

Current OMRD and TMRD levels are unknown on the USFS lands, though core area levels are managed under the "no net loss" policy. Partly because of the lack of data regarding OMRD or TMRD levels on USFS lands, the influence of motorized access on the resiliency of the North Cascades is unknown. Further monitoring of any potential future population and cause-specific mortality will determine the success of the current "no net loss" policy.

Summary of Motorized Access

Motorized access, which brings humans and their vehicles into grizzly bear habitats, may indirectly influence grizzly bears by reducing the availability of large, intact blocks of land or directly by disturbing, displacing, or killing individual bears through increased noise, activity, presence, vehicle strikes, or other activities associated with human-caused mortality (Figure 26, above). A variety of conservation efforts or mechanisms, such as the Wilderness Act, IRAs, and federal land management plans help reduce the potential effects of motorized access on the resiliency of ecosystems. Currently, conservation mechanisms have reduced the negative effects of motorized access in the GYE and NCDE, and these conservation mechanisms are expected to continue into the future. Although conservation mechanisms are expected to reduce potential effects of motorized access in the BE recovery zone, additional data are needed to inform potential effects of motorized access in potential connectivity areas to facilitate natural recolonization of the BE. Motorized access remains an issue for the CYE, SE, and North Cascades, where conservation mechanisms to address motorized access are not yet finalized or standards have not been met. Although progress has been made towards meeting the standards in the CYE and SE, additional improvements are needed. One challenge in the CYE and SE is that they have a much lower proportion of protected areas (i.e., federal lands that have wilderness protections) than the other ecosystems (see *Protected Areas* above for further discussion). Additional data are needed to inform the potential effect of motorized access in the North Cascades.

Developed Sites

The primary concern related to developed sites is direct mortality from human-bear conflicts, such as unsecured attractants (e.g., garbage) and resulting management removals (Harding and Nagy 1980, p. 277; McLellan and Shackleton 1988, p. 451; Mattson and Knight 1991, p. 3; Mattson *et al.* 1992, p. 432; Mace *et al.* 1996, p. 1403; McLellan *et al.* 1999, p. 918; Woodroffe 2000, entire; Johnson *et al.* 2004, pp. 974–975) (Figure 26, above). While human-grizzly bear conflicts at developed sites on public lands continue to occur, agencies have successfully worked to reduce conflicts and resulting mortalities. However, human-bear conflicts on private land have been increasing due to expanding grizzly bear distributions and are now more common than those on public lands (Cooley *et al*. 2018, entire). Secondary concerns include temporary or permanent habitat loss and displacement due to increased length of time of human use and increased human disturbance to surrounding areas (Harding and Nagy 1980, p. 277; McLellan and Shackleton 1988, p. 451; Mattson 1990, entire; White *et al.* 1999, pp. 3–5; Fortin *et al.* 2016, pp. 9–19).

“Developed sites” refer to those sites or facilities on public land with features intended to accommodate public use or recreation, such as toilets, picnic tables, and garbage containers. “Administrative sites” are those sites or facilities constructed for use primarily by government employees to facilitate the administration and management of public lands. In contrast to developed or administrative sites, “dispersed sites” are those not associated with a developed site, such as camping outside of designated campgrounds where no services are provided. These sites typically have minimal to no site modifications, have informal spacing, and possibly include primitive road access. Dispersed sites are not counted as developed sites

Developed Sites in the GYE

Examples of developed sites in the GYE include, but are not limited to, campgrounds, picnic areas, trailheads, boat launches, rental cabins, summer homes, lodges, service stations, restaurants, visitor centers, and permitted resource exploration or extraction sites such as oil and gas exploratory wells, production wells, plans of operations for mining activities, and work camps. Administrative sites are tracked as developed sites, and examples include headquarters, ranger stations, patrol cabins, park entrances, Federal employee housing, and other facilities supporting government operations.

In the GYE, the 1998 baseline and management policies limit the impact of developed sites on grizzly bears. Developed sites on public lands are currently inventoried and tracked in GIS databases. As of 1998, there were 593 developed sites on public land within the recovery zone (YES 2016b, Appendix E). As of 2017, the number of developed sites on public lands had decreased to 575 (Greater Yellowstone Area Grizzly Bear Habitat Modeling Team 2018, p. 117). Regulatory mechanisms in place ensure that the NPs and NFs within the GYE recovery zone will continue to manage developed sites at or below 1998 levels within each bear management subunit, with some exceptions for administrative and maintenance needs (USDA FS 2006b, entire; YES 2016a, pp. 54–73). Exceptions to the 1998 baseline for administrative and maintenance needs are narrow in scope and require mitigation (i.e., food storage structures) to reduce potential detrimental impacts to grizzly bears (see the 2016 GYE Conservation Strategy for a detailed description of the exception guidance, which are referred to as application rules; YES 2016a, pp. 64–66). In areas of suitable habitat inside the recovery zone, the NPS and the USFS enforce food storage rules aimed at decreasing grizzly bear access to human foods (YES 2016a, pp. 30–31, 84–85). These regulations will continue to be enforced and are in effect for nearly all currently occupied grizzly bear habitat within the GYE (YES 2016a, pp. 30–31, 84–85).

Management strategies and regulations also address developed sites outside the recovery zone in the GYE. There are over 500 developed sites on the five NFs in the areas identified as suitable habitat outside of the recovery zone and within the DMA (USDA FS 2004, p. 138). Existing USFS food storage regulations and outreach and education in these areas will continue to reduce the potential for human-grizzly bear conflicts. The number and capacity of developed sites are subject to management direction established in Forest Plans. If data indicate that management removals at developed sites on public lands are related to increased mortality above the sustainable limits discussed above, managers may choose to close specific developed sites or otherwise alter management in the area in order to maintain resiliency and maintain a population that continues to meet recovery criteria.

Developed Sites in the NCDE

In the NCDE, examples of developed recreation sites include, but are not limited to, campgrounds, picnic areas, trailheads, boat launches, rental cabins, summer homes, lodges, restaurants, and visitor centers. Examples of administrative sites in the NCDE include headquarters, ranger stations, patrol cabins, park entrances, federal employee housing, and other facilities supporting government operations. Administrative sites will be reported but are not counted as developed recreation sites.

As of 2011, there were 1,074 developed recreation sites on public land within the recovery zone (NCDE Subcommittee 2018, Appendix 5; USDA FS 2018a, p. 155; USDA FS 2018b, p. 226). Plans in place direct GNP and the NFs within the recovery zone to manage overnight developed recreation sites at 2011 levels within each bear management subunit with limited increases (NCDE Subcommittee 2018, Chapter 3; USDA FS 2018d, pp. 1-7, 1-19, 1-31, 1-42; USDA FS 2018e, p. 60; GNP 2019, p. 11). The number of or capacity of developed recreation sites managed for overnight use can increase no more than once (e.g., a net of one campground may be added or expanded) in each BMU every 10 years (NCDE Subcommittee 2018, Chapter 3; USDA FS 2018d, pp. 1-7, 1-19, 1-31, 1-42; USDA FS 2018e, p. 60). This was chosen as a threshold because similar levels of increases occurred in the period prior to 2011 during the time when the population of grizzly bears in the NCDE continued to increase (Ake 2017, entire). All increases were reviewed and approved via section 7 consultation. Such increases allowed managers to actively respond to resource damage, safety, and attractant concerns, and to respond to increasing public demand for recreation facilities. Developed recreation sites on public lands are currently inventoried and tracked in GIS databases.

The NCDE Conservation Strategy contains exceptions for administrative and maintenance needs (NCDE Subcommittee, Chapter 3). These exceptions to the baseline for administrative and maintenance needs are narrow in scope and require mitigation (i.e., food storage structures) to reduce potential detrimental impacts to grizzly bears (see the NCDE Conservation Strategy for a detailed description of the exception guidance, which are referred to as application rules; NCDE Subcommittee 2018, Chapter 3; USDA FS 2018d, pp. 1-11–1-13, 1-23–1-26, 1-35–1-38, 1-46–1-49; USDA FS 2018e, pp. 77–78).

In conclusion, the NPS and USFS within the NCDE recovery zone will continue to manage overnight developed recreation sites, with regulated increases, to 2011 levels within each bear management subunit, with some exceptions as per the application rules (NCDE Subcommittee 2018, Chapter 3; USDA FS 2018d, pp. 1-7, 1-19, 1-31, 1-42; USDA FS 2018e, p. 60). In addition, food storage regulations are in place on these public lands (see *Preventative Measures: Food Storage Orders* for further details; NPS 2010, p. 4; GNP 2019, pp. 12–18; NCDE Subcommittee 2018, Chapter 4; USDA FS 2018a, p. 182; USDA FS 2018d, pp. 9, 1-5, 1-17, 1-29, 1-40). These commitments are in place and will help to maintain resiliency of the NCDE.

Outside the recovery zone in the NCDE, there are over 150 overnight developed recreation sites on the four NFs in Zone 1 (Ake 2018b, *in litt.*). The number and capacity of overnight developed recreation sites are subject to management direction established in Forest Plans. Additionally, existing USFS food storage regulations will continue to minimize the potential for human-grizzly bear conflicts through food storage requirements, outreach, and education. Should the Monitoring Team determine developed sites on public lands in Zone 1 are related to increases in mortality beyond the sustainable limits discussed above, managers may choose to close specific developed sites or otherwise alter management in the area in order to maintain a population that continues to meet recovery criteria and population objectives in the NDCE Conservation Strategy. Commitments by the USFS, and BLM to manage lands to maintain a population that continues to meet recovery criteria (NCDE Subcommittee, Chapter 3; USDA FS 2018c, 2018d, and 2018e; BLM 2019a, p. 39; BLM 2019b, p. 2-20) will help to maintain resiliency of the NCDE.

Developed Sites in the SE, CYE, BE and North Cascades

There are currently no standards or tracking for developed sites inside the CYE, SE, BE or North Cascades. However, the BE, CYE, and North Cascades recovery zones, are characterized by large acreage of Wilderness Areas and IRAs. These designations increase the security of habitat for grizzly bears. Within the CYE recovery zone, 44 percent of lands are protected as designated Wilderness (379 km^2 (146 mi^2)) or IRAs (2,568 km^2 (992 mi^2)). The BE recovery zone is 98 percent designated Wilderness (14,840 km^2 (5,730 mi^2)). In the North Cascades, 63 percent of lands are protected as designated Wilderness (10,842 km^2 (4,186 mi^2)) or is IRAs (5,187 km^2 (2,118 mi^2)). In the U.S. portion of the SE recovery zone, some protection is provided by the 3 percent (227 km^2 (88 mi^2)) that is designated or recommended Wilderness. These designations are supported by regulatory mechanisms, as discussed above in *Protected Areas*, independent of the Act that protect grizzly bear habitat from new road construction, new oil and gas development, new livestock allotments, and timber harvest. While developed sites are not prohibited in IRAs, the lack of road construction limits development.

Summary of Developed Sites

Increasing populations in the GYE and NCDE indicate that developed sites and any associated habitat loss or displacement are not limiting grizzly bear populations. Operation and maintenance of developed sites may result in mortality of grizzly bears if interactions result in activities associated with human-caused mortality; however, conservation strategies have reduced negative effects in the GYE and NCDE, and the Wilderness Act and other regulations reduces this stressor in the North Cascades, CYE, SE, and BE. Additional data would help inform the potential effects of developed sites on grizzly bear populations in the CYE, SE, BE, and North Cascades.

Livestock Allotments on Federal Lands

When grizzly bears were listed in 1975, the Service identified "livestock use of surrounding national forests" as detrimental to grizzly bears "unless management measures favoring the species are enacted" (40 FR 31734, July 28, 1975). Impacts to grizzly bears from livestock operations potentially include:

(1) Direct mortality from control actions resulting from livestock depredation;
(2) Direct mortality due to control actions resulting from grizzly bear habituation and/or learned use of bear attractants, such as livestock carcasses and feed;
(3) Increased chances of a grizzly bear livestock conflict;
(4) Displacement due to livestock or related management activity; and
(5) Direct competition for preferred forage species.

Human-caused mortality resulting from management removals is the main impact to grizzly bears associated with livestock (for further discussion, see *Human-caused Mortality*, below). The effects of displacement and direct competition with livestock for forage are considered negligible to grizzly bear population dynamics because, even with direct grizzly bear mortality, current levels of livestock allotments have not precluded grizzly bear population growth and expansion.

Livestock Allotments in the GYE

In the GYE, the 1998 baseline and management policies limit the impact of livestock allotments on grizzly bears in the recovery zone. The Recovery Plan Supplement: Habitat-based Recovery Criteria for the Yellowstone Ecosystem (Service 2007*b*, entire) and the USFS ROD implementing their forest plan amendments (USDA FS 2006b, entire) established habitat standards regarding livestock allotments. The number of active livestock allotments, total acres affected, and permitted sheep animal months within the recovery zone will not increase above 1998 levels (USDA FS 2006b, p. 5; YES 2016a, pp. 56, 67–68). Due to the higher prevalence of grizzly bear conflicts associated with sheep grazing, existing sheep allotments will be phased out as the opportunity arises with willing permittees (USDA FS 2006b, p. 6; YES 2016a, pp. 67–68).

A total of 106 livestock allotments existed inside the recovery zone in 1998: 72 active and 13 vacant cattle allotments and 11 active and 10 vacant sheep allotments, with a total of 23,090 sheep animal months (Grizzly Bear Habitat Modeling Team 2018, p. 112). Sheep animal months are calculated by multiplying the permitted number of animals by the permitted number of months. Any use of vacant allotments will be permitted only if the number and net acreage of allotments inside the recovery zone does not increase above the 1998 baseline (YES 2016a, p. 68). Since 1998, the Caribou-Targhee NF has closed ten sheep allotments (6 active and 4 vacant) within the recovery zone, while the Shoshone NF has closed four sheep allotments (2 active and 2 vacant) and the Gallatin NF has closed six sheep allotments (2 active and 4 vacant) (Greater Yellowstone Area Grizzly Bear Habitat Modeling Team 2018, p. 112). This has resulted in a reduction of 21,120 sheep animal months, a 91 percent reduction, from the total calculated for 1998 within the recovery zone, and is a testament to the commitment that land management agencies have to the ongoing success of the grizzly bear population in the GYE. As of 2018, there is only one active sheep allotment within the recovery zone on the Caribou-Targhee NF as part of the USDA Sheep Experiment Station, but this allotment has not been issued a grazing permit since 2008. In addition, the NFs have closed 15 active and 5 vacant cattle allotments within the recovery zone since 1998 (Greater Yellowstone Area Grizzly Bear Habitat Modeling Team 2018, p. 112). GTNP currently allows cattle to graze in the park at the East Elk Ranch Pastures/Allotment, longhorns to graze in the park under a Life Lease Agreement, horses to graze, and cattle to graze in inholdings. Grizzly bear conflicts related to livestock have also been reduced in the recovery zone through requirements to securely store and/or promptly remove attractants associated with livestock operations (e.g., livestock carcasses, livestock feed, etc.).

The mandatory restriction on creating new livestock allotments and the voluntary phasing out of livestock allotments (cattle and sheep) with recurring conflicts further ensure that the recovery zone will continue to function as source habitat (USDA FS 2006b, p. 6). Although it is possible to reopen closed allotments, such an action would be subject to NEPA review and the majority of allotments would have a low probability of reopening because the rationale behind closing them is still applicable (e.g., limited forage).

In 2004, there were roughly 150 active cattle allotments and 12 active sheep allotments in suitable habitat outside the recovery zone (USDA FS 2004, p. 129). The Targhee NF closed two of these sheep allotments in 2004, the Shoshone NF closed one of these sheep allotments in 2005, and there have not been any new allotments created since then (USDA FS 2006a, p. 168; Landenburger 2014, *in litt*.; Rice 2019, *in litt.*). In areas with chronically high levels of livestock depredations, grizzly bear management removals are often higher. However, mortality limits in the revised demographic recovery criteria and 2016 GYE Conservation Strategy minimize the risk of population-level impacts. In addition, the IGBST regularly monitors and spatially maps all grizzly bear mortalities (both inside and outside the recovery zone), causes of death, and the source of the problem, and will conduct a Biology and Monitoring review if these objectives have not been achieved. These commitments and controls currently in place limit negative impacts of livestock grazing on the GYE grizzly bear population.

Livestock Allotments in the NCDE

In the NCDE, the 2011 baseline and management policies limit the impact of livestock allotments on grizzly bears in the NCDE recovery zone. The Recovery Plan Supplement: Habitat-based Recovery Criteria for the NCDE (Service 2018, entire), the Revised Forest Plan for the Flathead NF (USDA FS 2018e, p. 80), and the USFS ROD implementing their forest plan amendments for the Helena-Lewis and Clark, Kootenai, and Lolo NFs (USDA FS 2018d, p. 20) established habitat standards regarding livestock allotments. A total of 190 livestock allotments existed on Federal and State lands inside the recovery zone in the 2011 baseline. Of these allotments, there were 186 active and 4 vacant cattle allotments and 1 active and zero vacant sheep allotments, with a total of 133 sheep animal months (NCDE Subcommittee 2018, Chapter 3; USDA FS 2018a, p. 468–469; USDA FS 2018b, p. 256).

Land managers within the recovery zone have also agreed to manage livestock allotments into the future to maintain grizzly bear recovery in the NCDE. Specifically, within the recovery zone, management direction limits the number of cattle allotments on Federal or FIR lands to at or below the baseline (CS&KT 1997, p. 6, 19–20; NCDE Subcommittee, Chapter 3; USDA FS 2018a, p. 183; USDA FS 2018b, p. 15). In addition, the number of sheep allotments and permitted sheep animal months within the recovery zone will not increase above the baseline on Federal, State, and FIR lands (CS&KT 1997, p. 6, 19–20; DNRC 2010b, p. 2-18; NCDE Subcommittee 2018, Chapter 3, Appendix 10; USDA FS 2018a, p. 156; USDA FS 2018b, p. 15). All BIR lands within the recovery zone are currently allotted for livestock grazing. Due to the higher prevalence of grizzly bear conflicts associated with sheep grazing, existing sheep allotments will be phased out as the opportunity arises with willing permittees (NCDE Subcommittee 2018, Chapter 3; USDA FS 2018d, pp. 1-11, 1-23, 1-35, 1-46). Currently there are only 2 sheep allotments on USFS land within the recovery zone, both on the Helena-Lewis and Clark NF (USDA FS 2018b, p. 138). All other sheep allotments have been phased out or relocated outside of the recovery zone (USDA FS 2018b, p. 138). Any use of vacant allotments will only be permitted if the number of allotments inside the recovery zone does not increase above the baseline (NCDE Subcommittee 2018, Chapter 3; USDA FS 2018d, pp. 1-10–1-11, 1-22–1-23, 1-34–1-35, 1-45–1-46; USDA FS 2018e, pp. 80–81).

The restriction on creating new livestock allotments and the voluntary phasing out of livestock allotments with recurring conflicts further ensure that the recovery zone will continue to function as source habitat. Although it is possible to reopen closed allotments, such an action would be subject to NEPA. Moreover, the majority of allotments would have a low probability of reopening because the rationale behind closing them would still be applicable (i.e. the allotments were no longer viable grazing areas). In the future, because there will continue to be no net increase above baseline levels in cattle or sheep allotments allowed on public lands inside the recovery zone.

Outside the recovery zone, there were 31 active cattle allotments and 2 active sheep allotments in Zone 1 in 2015 (USDA FS 2018b, p. 256). On the Flathead NF alone, the number of livestock allotments in the DMA has decreased by more than 50 percent since 1986 (USDA FS 2018a, p. 468). The BLM will allow no new sheep allotments and no new livestock allotments of any kind in Zone 1 (BLM 2019a, p. 39; BLM 2019b, p. 2-20). On USFS lands, there will be no increase in the number of active sheep allotments or in the permitted animal months above the baseline. The USFS is committed to working with willing permittees to retire allotments with recurring conflicts that cannot be resolved by modifying grazing practices (NCDE Subcommittee 2018, Chapter 3; USDA FS 2018d, p. 1-11, 1-23, 1-35, 1-46). Under the DNRC HCP, small livestock allotments will be discouraged, and mitigation measures will be taken to minimize the risk of grizzly bear conflicts (DNRC 2010a, p. 4-347). These controls and commitments currently in place limit negative impacts of public land livestock allotments on the NCDE grizzly bear population.

Livestock Allotments in the CYE, SE, BE, and North Cascades

There are currently no standards for livestock allotments inside the CYE, SE, BE, and North Cascades. However, the BE, CYE, and North Cascades, recovery zones, are characterized by large acreage of Wilderness Areas and IRAs, where the lack of road construction limits access. These designations also are supported by regulatory mechanisms that protect grizzly bear habitat from new livestock allotments, among other things. There are four active allotments on the Kootenai NF within the CYE (USDA 2013a, pp. 542–543) and two active allotments on the Idaho Panhandle NF within the SE (USDA 2013b, p. 592) in those recovery zones.

Summary of Livestock Allotments

The expanding populations in the GYE and NCDE indicate that livestock allotments and associated habitat loss are not limiting grizzly bear populations. Operation and maintenance of livestock operations often results in mortality of grizzly bears through management removals of grizzly bears that repeatedly prey on livestock; however, conservation strategies have reduced negative effects of livestock allotments in the GYE and NCDE, and the Wilderness Act and other regulations reduces this stressor in the North Cascades, CYE, and BE. There are four active allotments on the Kootenai NF within the CYE (USDA 2013a, pp. 542–543) and two active allotments on the Idaho Panhandle NF within the SE (USDA 2013b, p. 592) in those recovery zones. Additional data would help inform the potential effects of livestock allotments on grizzly bear populations in the CYE, SE, BE, and North Cascades.

Energy and Mineral Development

The primary concerns related to mineral and energy development are human-caused mortalities and displacement due to habitat loss. Oil and gas development is associated with higher road densities, increased human access, and resultant human-bear encounters and human-caused grizzly bear mortalities (McLellan and Shackleton 1988, pp. 458–459; McLellan and Shackleton 1989b, pp. 377–379; Mace *et al.* 1996, pp. 1402–1403). Mineral and energy development could also cause displacement and habitat loss.

Disturbance in the den could result in increased energetic costs and possibly den abandonment, which, in theory, could ultimately lead to a decline in physical condition of the individual or even cub mortality (Swenson *et al*. 1997, p. 37; Graves and Reams 2001, p. 41). However, den disturbance or abandonment is rarely observed, and there have been no documented cases of such abandonment as the result of energy and mineral development by grizzly bears in the lower-48 States. Harding and Nagy (1980, p. 278) documented two instances of den abandonment during fossil fuel extraction operations in northern Canada. One bear abandoned its den when a seismic vehicle drove directly over the den (Harding and Nagy 1980, p. 278). The other bear abandoned its den when a gravel mining operation destroyed the den (Harding and Nagy 1980, p. 278). Reynolds *et al.* (1986, entire) also examined the effects of tracked vehicles and tractors pulling sledges. In 1978, there was a route for tractors and tracked vehicles within 100 m (328 ft) of a den inhabited by a female with three yearlings. This family group did not abandon their den at any point (Reynolds *et al.* 1986, p. 174). They describe one instance of possible den abandonment within 200 m of a seismic line; however, they also describe other cases where a supply train came within 100m of a den, with no abandonment (Reynolds *et al.* 1986, p. 174). Information on whether and how seismic exploration associated with oil and gas development or mining disturbs denning grizzly bears is lacking, bear responses are mixed, and existing information is from northern areas.

Energy and Mineral Development in the GYE

Inside the GYE recovery zone, management of oil, gas, and mining are tracked as part of the developed site standard (YES 2016a, pp. 64–67). There were no active oil and gas leases inside the recovery zone as of 1998 (USDA FS 2006a, p. 209); however, in 2019 there were two active phosphate leases partially in the recovery zone and six suspended oil and gas leases in or partially in the recovery zone (Vaculik 2019, *in litt.*). Based on Forest Plan direction, there are approximately 243 km^2 (94 mi^2) of secure habitat that could allow surface occupancy for oil and gas projects within the recovery zone (USDA FS 2006a, figures 48 and 96). This comprises less than 4 percent of all suitable habitat within the recovery zone. Additionally, 1,354 pre-existing mining claims were located in 10 of the subunits inside the recovery zone (YES 2016b, Appendix E), but only 28 of these mining claims had operating plans. These operating plans are included in the 1998 developed site baseline. While claimants under the 1872 General Mining Law have a right to explore for and develop valuable mineral deposits on their claims, the USFS develops appropriate mitigations for these claims through analysis and the NEPA process (42 U.S.C. 4321–4347.1970, as amended).

Under the conditions of the 2016 GYE Conservation Strategy regulatory mechanisms ensure that any new oil, gas, or mineral project will be approved only if it conforms to secure habitat and developed site standards (Service 2007*b*, pp. 5–6; YES 2016a, pp. 61–67). For instance, any oil, gas, or mineral project that permanently reduces the amount of secure habitat will have to provide replacement secure habitat of similar habitat quality (based on our scientific understanding of grizzly bear habitat); any change in developed sites will require mitigation equivalent to the type and extent of the impact, and such mitigation must be in place before project initiation or be provided concurrently with project development as an integral part of the project plan (YES 2016a, p. 62). Only one project that temporarily changes the amount of secure habitat is allowed in any subunit at any time (YES 2016a, p. 63). Mitigation of any project will occur within the same subunit and will be proportional to the type and extent of the project (YES 2016a, p. 62).

In suitable habitat outside the GYE recovery zone, oil and gas development presents another potential influence on the grizzly bears. According to current Forest Plan direction, less than 19 percent (3,213 km^2 (1,240 mi^2)) of suitable habitat outside the recovery zone on USFS land allows surface occupancy for oil and gas development. As of 2019, there were no active oil and gas wells in suitable habitat but there were 54 active and suspended leases in, or partially in, suitable habitat (2 are phosphate leases on the Caribou-Targhee that overlap with the recovery zone and the remaining ones are oil and gas leases) (Vaculik 2019, *in litt.*). Any proposed mineral development on Federal land would be subject to environmental review under the NEPA process, which requires Federal agencies to consider environmental effects that include, among others, impacts to wildlife, including possible mitigation measures. Additionally, only a small portion of this total land area will contain active projects at any given time, if at all. For example, as of 2019 there are approximately 5 km^2 (2 mi^2) of active oil and gas leases in suitable habitat where surface occupancy for oil and gas development may be allowed per the terms of the lease (Vaculik 2019, *in litt.*). At this time there are no leasing decisions authorizing new leases in suitable habitat in the GYE.

Because any new mineral or energy development is approved and will continue to be approved only if it conforms to the secure habitat, developed site, and motorized access standards set forth in the habitat-based recovery criteria and the GYE Conservation Strategy, negative impacts of such development on grizzly bear populations in the GYE will be limited.

Energy and Mineral Development in the NCDE

Management of oil, gas, and mining are tracked as part of the habitat standards (NCDE Subcommittee 2018, Chapter 3). Forty-seven percent of lands within the recovery zone are unavailable to oil and gas leasing and new mining claims due to their status as Congressionally designated Wilderness Areas, National Park, or other special designations (NCDE Subcommittee 2018, Chapter 3). Public Law 109-432 made additional lands outside of designated Wilderness Areas on the Rocky Mountain Ranger District of the Helena-Lewis and Clark NF, some areas of the Flathead NF, and BLM lands along the Rocky Mountain Front unavailable to future leasing, location, and entry.

As of 2012, there were 247 oil and gas leases inside the recovery zone, 94 percent of which occurred on USFS lands (NCDE Subcommittee 2018, Chapter 3). No surface occupancy[8] will be allowed for new oil and gas leases on Federal lands within the recovery zone and Zone 1 (USDA FS 2018d, pp. 1-13, 1-25, 1-37, 1-48; USDA FS 2018e, p. 78). Based on Forest Plan direction, there are approximately 8,500 km^2 (3,250 mi^2) within the recovery zone that could allow surface occupancy for oil and gas projects (Ake 2018c, *in litt.*), which comprises approximately 37 percent of the recovery zone; however, currently all oil and gas leases are suspended within the recovery zone. Additionally, there are approximately 50 pre-existing mining claims located in 4 of the 23 BMUs inside the recovery zone (Ake 2018c, *in litt.*). One mine, the Cotter Mine, is expected to be developed in the Helena NF (USDA FS 2018b, p. 50). Otherwise, there are no Plans of Operations or Notices of Intent to explore or operate any commercial mines inside the recovery zone on USFS or BLM lands (NCDE Subcommittee 2018, Chapter 3; USDA FS 2018b, p. 50). There is some copper and silver exploration occurring at this time, but all new Plans of Operation and permits for mineral activities will include measures to reasonably mitigate potential impacts to grizzly bears or their habitat (NCDE Subcommittee 2018, Chapter 3; USDA FS 2018d, pp. 1-11–1-14; USDA FS 2018e, pp. 77–79). Appropriate mitigation measures, including food/attractant storage requirements, will be included in any future Plans of Operation inside the recovery zone and Zone 1 (i.e., the DMA).

Moreover, any new projects not subject to the Mining Law of 1872 or the Federal Onshore and Gas Leasing Reform Act of 1987, including oil, gas, or mineral projects, will be approved by land management agencies only if they conform to secure core habitat and developed site standards (NCDE Subcommittee 2018, Chapter 3; USDA FS 2018d, Appendix 1; USDA FS 2018e, pp. 65–67). For instance, an oil, gas, or mineral project that reduces the amount of secure core habitat permanently will have to provide replacement secure core habitat of similar habitat quality (based on our scientific understanding of grizzly bear habitat) (NCDE Subcommittee 2018, Chapter 3; USDA FS 2018d, pp. 1-11–1-14, 1-23–1-26, 1-35–1-38, 1-46–1-49; USDA FS 2018e, pp. 78–79). Any such mitigation must be in place before project initiation or be provided concurrently with project development as an integral part of the project plan (NCDE Subcommittee, Chapter 3; USDA FS 2018d, pp. 1-9, 1-21, 1-33, 1-44; USDA FS 2018e, pp. 50, 61).

Outside the recovery zone, on lands managed by the USFS, BLM, and DNRC in Zone 1, habitat protections for mineral projects and mitigations for measures for oil and gas will be identical to those described for the recovery zone (see above). According to current Forest Plan and BLM direction, no surface occupancy is allowed for oil and gas development in Zone 1. Currently there are 140 oil and gas leases in Zone 1, 87 percent of which are on USFS lands (NCDE

[8] No surface occupancy: a fluid mineral leasing stipulation that prohibits use or occupancy of the land surface in order to protect identified resource values. Lessees may develop the oil and gas or geothermal resources under the area restricted by this stipulation through use of directional drilling from sites outside the no surface occupancy area.

Subcommittee 2018, Chapter 3). Any proposed mineral development on Federal land would be subject to environmental review under the NEPA process, which requires Federal agencies to consider environmental effects that include, among others, impacts to wildlife, including possible mitigation measures.

Because any new mineral or energy development are approved and will continue to be approved only if it conforms to the motorized access standards and food/attractant storage requirements set forth in the USFS plans and the NCDE Conservation Strategy, negative impacts of such development on grizzly bear populations in the NCDE will be limited.

Energy and Mineral Development in the CYE, SE, BE, and North Cascades

There are currently no standards or tracking for energy and mineral development inside the CYE, SE, BE or North Cascades. However, motorized access standards in the CYE and SE, the "no net loss" policy in the North Cascades, and the large wilderness areas and IRAs in the BE, CYE, and North Cascades may help address or avoid energy and mineral development effects by increasing habitat security for grizzly bears. In 2019, reauthorization of the Land and Water Conservation Fund permanently withdrew 1,376 km^2 (531 mi^2) in the Methow Headwaters in the North Cascades from new mineral exploration and mine development.

Summary of Energy and Mineral Development

Habitat loss or destruction caused by energy and mineral development are not limiting populations in the GYE and NCDE. Operation and maintenance of energy and mineral development may result in mortality of grizzly bears if interactions result in activities associated with human-caused mortality; however, conservation plans have reduced negative effects in the GYE and NCDE, and the Wilderness Act and other regulations reduces this stressor in the North Cascades, CYE, SE, and BE. Additional data would help inform the potential effect of energy and mineral development in the CYE, SE, BE, and North Cascades.

Recreation

Recreation can be divided into six basic categories based on season of use (winter or all other seasons), mode of access (motorized or non-motorized), and level of development (developed or dispersed) (USDA FS 2006a, p. 187; USDA FS 2018a, pp. 316–2018). There is a national trend of increased outdoor recreation (White *et al.* 2016, pp. 3–4, 7). The primary concern related to increased recreation is that it may increase the probability of human-grizzly bear encounters, with subsequent increases in human-caused mortality (Mattson *et al.* 1996, p. 1014). Developed sites associated with recreation can also directly limit secure grizzly bear habitat. Finally, individuals recreating in bear country could disrupt access to food resources (like army cutworm moth aggregation sites and huckleberry fields). We do not have information suggesting that current and projected levels of non-motorized recreation, including mountain biking, require limitations. Although non-motorized trails may cause displacement of grizzly bears to varying degrees, grizzly bear mortality related to non-motorized recreation is rare and population-level impacts have not been documented (Jope 1985, pp. 34–36; McLellan and Shackleton 1989a, pp. 270–274; Kasworm and Manley 1990, p. 81, 84; Mace and Waller 1996, pp. 463–465; White *et al*. 1999, p. 149).

Hunting of game (e.g., elk, black bears, upland birds) within grizzly bear habitat can also increase the chances of grizzly bear mortalities due to defense-of-life and mistaken identification killings (see *Human-caused Mortality* for further details). Hunting of grizzly bears is not currently allowed in the lower-48 States. Mistaken identification killings of grizzly bears by black bear hunters are both accidental and illegal. Mistaken identification is prosecuted as illegal take, and all such grizzly bear mortality is fully investigated to determine cause. Black bear hunting over bait is allowed in portions of Idaho and Wyoming. Black bear hunting over bait is not allowed in Montana or Washington. Hunting over bait can be a source of mortality (due to mistaken identity killings) and conflicts (due to conditioning to human foods). Under current regulations (under Section 4(d) of the Act), it is legal for private citizens to kill grizzly bears if it is in self-defense or defense of others (50 CFR § 17.40). These self-defense situations have occurred with elk hunters during surprise encounters, at hunter-killed carcasses or gut piles, or when packing out carcasses.

Snowmobiling and other winter sports (i.e., backcountry skiing) are other forms of recreation that can potentially affect grizzly bears by increasing the probability of human-grizzly encounters and potential disturbance of denning grizzly bears. Disturbance of grizzly bears in the den can result in cub abandonment or early den exit, which could kill a grizzly (if they leave before food is readily available). Although there are no data or information suggesting winter recreational use is negatively affecting grizzly bear populations in the lower-48 States, the potential for disturbance and impacts to reproductive success exists and monitoring will continue to support adaptive management decisions about winter recreation use in areas where disturbance is documented or likely to occur. Potential impacts of winter recreation are discussed in further detail in *Appendix E*.

Recreation in the GYE

At least 5 million people visit and recreate in the National Parks and NFs of the GYE annually (USDA FS 2006a, pp. 176, 184; Wilmot 2018, p. 65; Gunther 2018, p. 66). Based on past trends, visitation and recreation are expected to increase in the future. For instance, YNP has shown an approximate 19 percent increase in the number of people visiting each decade since the 1950s (Gunther 2018, p. 66); however, the number of backcountry overnight stays has remained relatively constant from the 1970s through 2010s (Gunther 2018, p. 58).

Inside the recovery zone, the vast majority of lands available for recreation are accessible through non-motorized travel only (USDA FS 2006a, p. 179). Motorized recreation during the summer, spring, and fall inside the recovery zone is limited to existing roads as per standards in the habitat-based recovery criteria and the 2016 GYE Conservation Strategy that restrict increases in roads or motorized trails. Recreation at developed sites such as lodges, downhill ski areas, and campgrounds are limited by the developed sites habitat standard described in the habitat-based recovery criteria and the 2016 GYE Conservation Strategy. Ongoing I&E efforts are an important contributing factor to successful grizzly bear conservation and will continue under the 2016 GYE Conservation Strategy (YES 2016a, pp. 92–95). The number and capacity of existing developed sites on Federal lands has not increased from the 1998 baseline and are limited as per the habitat-based recovery criteria and the 2016 GYE Conservation Strategy. For a more complete discussion of projected increases in recreation in the GYE NFs, see the Final EIS for the Forest Plan Amendment for Grizzly Bear Habitat Conservation for the GYE NFs (USDA FS 2006a, pp. 176–189).

Recreation in the NCDE

At least 3 million people visit and recreate in GNP and the NFs of the NCDE annually (NPS 2018a, entire; USDA FS 2018a, p. 322; USDA FS 2018b, p. 287). Based on past trends, visitation and recreation are expected to increase in the future. For instance, GNP has shown an approximate 8 percent increase in the number of people visiting each year since 1930 (NPS 2018a, entire); however, the number of people recreating in the backcountry has remained relatively constant from the 1970s through 2010s (NPS 2018b, entire).

Inside the recovery zone, approximately 67 percent of lands available for recreation are accessible only through non-motorized travel because of their status as protected areas (see *Protected Areas* above for further discussion; NCDE Conservation Strategy 2018, Chapter 3, figure 7). In order to reduce the risk of human-grizzly bear conflicts when constructing new trails, the USFS will employ measures such as locating trails outside of seasonally important grizzly bear habitat (i.e., riparian management zones or avalanche chutes) (USDS FS 2018a, p. 183). Motorized recreation during the summer, spring, and fall inside the recovery zone are limited to roads and trails open to such use as per the standards in the NCDE Conservation Strategy and land management plans that restrict increases in roads or motorized trails (NCDE Subcommittee 2018, Chapter 3; USDA FS 2018c, p. 31; USDA FS 2018d, pp. 9–11). Similarly, overnight recreation at developed sites such as lodges and campgrounds are limited by the developed sites habitat standard described in the NCDE Conservation Strategy and land management plans. Increases in the number and capacity of existing developed sites on public lands are limited under habitat-based recovery criteria and NCDE Conservation Strategy (NCDE Subcommittee 2018, Chapter 3; Service 2018, entire; USDA FS 2018c, p. 31; USDA FS 2018d, pp. 1-7, 1-19, 1-31, 1-42).

Recreation in the CYE and SE

Visitor use is not available specifically for the CYE and SE recovery zones. The USDA FS National Visitor Use Monitoring program provides estimates for the volume and type of recreational visitation to each NF at least once per decade. In the past decade, NFs in the CYE had over 3 million site visits and the SE had over 1 million site visits (USDA FS 2020b); however, these forests encompass an area that is much larger (approximately 4 and 2 times) than the area of the CYE and SE recovery zones, respectively. In addition, the USFS is currently evaluating the congressionally designated Pacific Northwest National Scenic Trail, which bisects both the CYE and SE. Potential impacts of the trail are unknown at this time; however, if user levels increase sufficiently it could create a decrease in core areas as defined in Forest plans (USDA FS 2011a, p. 36; USDA FS 2011b, pp. 23–27).

Recreation in the BE

Visitor use is not available specifically for the BE recovery zone. The USDA FS National Visitor Use Monitoring program provides estimates for the volume and type of recreational visitation to each NF at least once per decade. In the past decade, NFs in the BE had over 2 million site visits (USDA FS 2020b); however, these forests encompass an area that is approximately three times the area BE recovery zone. Inside the recovery zone, approximately 98 percent of lands available for recreation are accessible through non-motorized travel only because of their status as designated Wilderness (see *Protected Areas* above for further discussion). Baiting for black bear hunting is currently allowed in the BE. This may be a source of mortality (due to mistaken identity) and conflicts (due to conditioning to human foods) should grizzly bears recolonize this ecosystem. The first known grizzly bear to move into the BE was killed by a black bear hunter over bait in 2007.

Recreation in the North Cascades

The North Cascades Park Complex and surrounding forests within the North Cascades provide a diverse array of recreational opportunities, including hiking, backpacking, camping, climbing, fishing, horseback riding, bicycling, boating, winter sports, and wildlife viewing. The North Cascades Park Complex contains North Cascades National Park, Ross Lake NRA, and Lake Chelan NRA. It is estimated that recreational use of federal lands in the North Cascades is 8 million visitor days per year; however, visitor use is not equally distributed (NPS and Service 2017, p. 63). The majority of trails in the North Cascades occur in wilderness and roadless areas (NPS and Service 2017, p. 63). Based on past trends, visitation and recreation are expected to increase in the future. For instance, the North Cascades Park Complex has shown an approximate 9 percent increase in the number of people visiting each year since 1999 (NPS 2020).

Inside the recovery zone, approximately 63 percent of lands available for recreation are accessible through non-motorized travel only because of their status as protected areas (see *Protected Areas* above for further discussion). The Federal land managers agreed to manage for “no net loss” of core areas within the North Cascades recovery zone until the agreement is superseded by a forest/park plan amendment or revision (USDA FS 1997, p. 1). The 2012 Ross Lake Recreation Area General Management Plan (GMP) includes provisions that any new trails proposed within the Ross Lake GMP would constitute reductions of less than 1 percent in each of the four BMUs with an intent to retain core area levels of 70 percent or higher per BMU (NPS

2012, p. 82). In addition, any new trails will occur in areas that are not high-quality grizzly bear habitat (NPS 2012, p. 74).

Vegetation Management

Vegetation management projects typically include timber harvest, thinning, prescribed fire, and salvage of burned, diseased, or insect-infested stands. Vegetation management programs can negatively affect grizzly bears by:

(1) Temporarily removing cover;
(2) Disturbing or displacing bears from habitat during the vegetation management activity;
(3) Increasing human-grizzly bear conflicts or mortalities as a result of unsecured attractants; and
(4) Increasing mortality risk as a result of increased human-grizzly bear encounters or displacement due to new roads into previously roadless areas and/or increased vehicular use on existing restricted roads, especially if roads remain open to the public after vegetation management is complete (McLellan and Shackleton 1988, pp. 458–459; McLellan and Shackleton 1989b, pp. 377–379; Mace *et al.* 1996, pp. 1402–1403; Schwartz *et al.* 2010, p. 661; Boulanger and Stenhouse 2014, p. 15; Proctor *et al.* 2017, pp. 53–54; Lamb *et al.* 2018, pp. 1412–1415; Proctor *et al.* 2019, entire).

Vegetation management can also result in positive effects on grizzly bear habitat once the project is complete, provided key habitats such as riparian areas and food production areas are maintained or enhanced. For instance, tree removal for thinning or timber harvest and prescribed burning or weed control, can result in localized increases in bear foods through increased growth of grasses, forbs, and berry-producing shrubs (Zager *et al.* 1983, p. 124; Kerns *et al.* 2004, p. 675). Vegetation management may also benefit grizzly bear habitat by controlling undesirable invasive species and improving riparian management in important food production areas. Changes in the distribution, quantity, and quality of cover are not necessarily detrimental to grizzly bears as long if they are coordinated on a landscape scale to ensure that grizzly bear needs are addressed throughout the various projects occurring on at any given time.

Vegetation Management in the GYE

In the GYE, vegetation management occurs throughout the GYE on lands managed by the USFS and NPS. In the GYE, although there are known, usually temporary, impacts to individual bears from timber management activities, these impacts have been adequately mitigated using the Guidelines in place since 1986, and will continue to be managed at levels acceptable to the grizzly bear population under the 2016 GYE Conservation Strategy. In addition, approximately 82 percent of the recovery zone in the GYE are considered "protected lands" (see *Protected Areas* above for further details), which does not allow timber harvest. State and private forestlands with motorized restrictions add additional conservation protections.

Timber harvest can disturb, displace, or remove cover for grizzly bears. According to current Forest Plan direction, 23 percent (4,773 km^2 (1,843 mi^2)) of suitable habitat outside the recovery zone on USFS land has both suitable timber and a management prescription that allows scheduled timber harvest. Only a small portion of this total land area will contain active projects at any given time, if at all. For example, less than 2 percent (9.6 km^2 (3.7 mi^2)) of the roughly 4,773 km^2 (1,843 mi^2) identified as having both suitable timber and a management prescription that allows timber harvest, was actually logged annually from 2003 to 2018 (Jackson 2019, *in litt*.).

Vegetation Management in the NCDE

Vegetation management occurs throughout the NCDE on lands managed by the USFS, NPS, DNRC, BLM, FIR, BIR, and MFWP. Despite potential negative impacts from vegetation management, mortality risk from vegetation management activities are and will continue to be largely mitigated through motorized access standards and food storage requirements (NPS 2010, p. 4; GNP 2019, pp. 11–18; USDA FS 2018c, p. 31; USDA FS 2018d, pp. 8–11; USDA FS 2018e, pp. 42–43; NCDE Subcommittee 2018, Chapters 3 and 4), and State and private forestlands with motorized restrictions. Nearly 67 percent of the recovery zone is unavailable for general, commercial timber harvest through Federal and Tribal designations (such as Wilderness Areas, WSAs, and other protective designations; see *Protected Lands* above for further information). Although there are known, usually temporary, impacts to individual bears from timber and other vegetation management activities, these impacts have been adequately mitigated using the Guidelines in place since 1986, and will continue to be managed at levels acceptable to the grizzly bear population under the NCDE Conservation Strategy and land management plans (CS&KT 2000, p. 284; Blackfeet Nation 2008, pp. 10–12; DNRC 2010b, p. 1-26–27; NCDE Subcommittee 2018, Chapter 3; USDA FS 2018c, pp. 42–43; USDA FS 2018d, 1-9–1-10, 1-21–1-22, 1-33–1-34, 1-44–1-45).

Vegetation management projects are designed to: enhance forage production, except in areas that are frequented by people such as campgrounds; retain or develop cover adjacent to forest openings and highway crossing areas; protect important habitats such as avalanche chutes, riparian areas, and berry-producing shrubs; and minimize the impacts of motorized access (USDA FS 2018a, pp. 143, 184–185; USDA FS 2018b, p. 16). The extent of protected lands inside the recovery zone and management standards in the NCDE Conservation Strategy and land management plans regarding vegetation management, limit potential negative impacts of vegetation management to the NCDE grizzly bear population.

Outside the NCDE recovery zone, 71 percent of Zone 1 outside the DCAs, 46 percent of Zone 1 inside the DCAs, and 27 percent of Zone 2 on USFS land has both suitable timber and a management prescription that allows scheduled timber harvest according to current Forest Plan direction (Ake 2019a, *in litt*.). On USFS lands from 2004 to 2018, an average of only 3 percent of Zone 1 outside the DCAs, 4 percent of Zone 1 inside the DCAs, and 7 percent of Zone 2 was actually logged annually (Ake 2019a, *in litt.*). Additionally, only a small portion of this total land area will contain active projects at any given time, if at all.

Other Protections: Additional protections occur on Federal (BLM and USFS) and Tribal lands outside of the recovery zone but inside the DMA in Zones 1 and 2. Of the 19,460 km^2 (7,514 mi^2) in Zone 1 and the 18,854 km^2 (7,280 mi^2) in Zone 2, the USFS manages 4,351 km^2 (1,680 mi^2) of Zone 1 and 4,655 km^2 (1,797 mi^2) of Zone 2, or 22 percent and 24 percent respectively. An additional 29 and 6 percent in Zones 1 and 2, respectively, is managed by the BLM, FIR, and BIR. The Blackfeet Tribe manages the 1,605 km^2 (620 mi^2) of Zone 1 within the boundaries of the BIR. Under the Blackfeet Reservation Forest Management Plan forestry activities are not allowed during critical periods in identified denning and spring foraging habitat (Blackfeet Nation 2008, p. 12). In addition, the Blackfeet Fish and Wildlife Department implement measures to prevent human-grizzly bear conflicts, such as attractant storage (Blackfeet Tribal Business Council 2013, p. 9). The CS&KT manage the 3,559 km^2 (1,374 mi^2) of Zone 1 within the boundaries of the FIR. The FIR Forest Management Plan focuses on reducing human-bear conflicts and providing secure quality habitat for grizzly bears through forest management practices such as selective logging and prescribed fire (CS&KT 2000, p. 111).

Vegetation Management in the CYE, SE, BE, and North Cascades

Despite potential negative impacts from vegetation management, mortality risk from vegetation management activities are and will continue to be largely mitigated through motorized access standards in the CYE and SE and the “no net loss” policy in the North Cascades. Motorized access standards identify core habitat which must remain in place for 10 years at a minimum. In reality many of these core blocks remain in place for much longer than 10 years. This designation does limit some vegetation management activities that rely on motorized access, however, does not preclude prescribed burning or helicopter supported timber harvest. These activities must also go through the consultation process under Section 7 to determine their effects on listed species. In addition, the large acreage of Wilderness Areas and Inventoried Roadless areas reduce the effects of vegetation management in the CYE, BE, and North Cascades. State and private forestlands with motorized restrictions further reduce the potentially negative effects of vegetation management.

Habitat Fragmentation

Habitat fragmentation can cause loss of connectivity and indirectly increase human-caused mortalities. Habitat fragmentation may be caused by human-caused mortality and human activities, such as habitat modification, road building, and human developments and settlement. Because grizzly bears live at relatively low population densities, disperse slowly, and are vulnerable to human-caused mortality, anthropogenic habitat fragmentation may influence grizzly bear populations that occur in close proximity to human population centers and continuous linear rural development associated with highways (Forman and Alexander 1998, pp. 222–223; Proctor *et al.* 2012, pp. 23–28, 35; Lindenmayer and Fischer 2006, entire). In general, habitat fragmentation and isolation can increase vulnerability to threats, such as decreased demographic or genetic connectivity. Males and females have different susceptibility to habitat fragmentation as females are more easily fragmented than males for several reasons (Proctor *et* *al.* 2005, p. 2414; Proctor *et al.* 2012, p. 23). Female dispersal is gradual (McLellan and Hovey 2001, p. 843), usually significantly shorter than males (McLellan and Hovey 2001, p. 841; Proctor *et al.* 2004, p. 1113), and holds the potential for small population augmentation and/or demographic rescue through their ability to bear offspring post-immigration into small isolated populations. For these reasons, females tend to be the focus of demographic fragmentation/connectivity goals (Proctor *et al.* 2005, p. 2414; Proctor *et al.* 2012, pp. 26–27). In addition, dispersal patterns suggest that to enhance or re-establish female connectivity, female occupancy of linkage areas is necessary to facilitate inter-generational connectivity (McLellan and Hovey 2001, p. 843; Proctor *et al.* 2005, p. 2414; Proctor *et al.* 2015, p. 8; Proctor *et al.* 2018, pp. 363–364). Long distance dispersal distance by males enables immigrants to act as a counter to genetic fragmentation and loss of nuclear genetic diversity (e.g., GYE) (Proctor *et al.* 2012, p. 27; Peck *et al.* 2017, p. 15).

To minimize future habitat fragmentation and degradation, Federal agencies evaluate road construction projects on Federal lands throughout the GYE, NCDE, CYE, and SE for impacts to grizzly bear habitat connectivity (NCDE Subcommittee 2018, Chapter 3; USDA FS 2018c, p. 33; USDA FS 2018d, p. 2, YES 2016a, pp. 82–83, Service 2007*b*, pp. 38–41). By identifying areas used by grizzly bears, officials can mitigate potential impacts from road construction during and after a project. Federal agencies will continue to identify important crossing areas by collecting information about known bear crossings, bear sightings, ungulate road mortality data, bear home range analyses, and locations of game trails. The data will be used to reduce grizzly bear mortality due to vehicle collisions, identify bear access to seasonal habitats, to help maintain traditional dispersal routes, and to decrease the risk of fragmentation of individual home ranges. For example, work crews will place temporary work camps in areas with lower risk of displacing grizzly bears, and food and garbage will be kept in bear-resistant containers. Highway planners will incorporate warning signs and crossing structures such as culverts or underpasses into projects when possible to facilitate safe highway crossings by all wildlife.

Additionally, the conflict prevention, response, and outreach elements of conservation strategies and agency plans play an important role in preventing habitat fragmentation by keeping valleys that are mostly privately owned from becoming mortality sinks for grizzly bears attracted to human food sources (Servheen *et al*. 1981, pp. 2–3, 17–29; Dood 2006, pp. 32–38; Blackfeet Tribal Business Council 2013, pp. 6–10; NCDE Subcommittee 2018, Chapter 4). To reduce conflict, Federal, State, and Tribal management authorities remove the source of conflict (e.g., removing or securing attractants) and use non-lethal solutions (e.g., aversive conditioning) when possible. I&E efforts and community sanitation measures emphasize keeping private property (including livestock and domestic pets) bear resistant, use of electric fencing to keep bears out of attractants (e.g., orchards, chicken coops, garbage, and bee yards), and use of bear-resistant garbage containers to keep bears out of garbage.

Fragmentation in the GYE

The GYE grizzly bear population is currently a contiguous population across its range, and there are no data to indicate habitat fragmentation within this population is occurring. In other words, there is no indication that human activities are preventing grizzly bears from moving freely within the ecosystem.

Fragmentation in the NCDE

Kendall *et al.* (2009, p. 10) identified human-caused habitat fragmentation within the NCDE across the U.S. Hwy. 2 / BNSF rail line corridor. Although this corridor does not currently prevent demographic and genetic connectivity within the NCDE (Waller and Servheen 2005, pp. 996–998; Mikle *et al.* 2016b, supplementary table 3), Waller and Miller (2015, pp. 34–36) documented substantial increases in traffic volume along U.S. Hwy. 2, particularly during nighttime hours when grizzly bears are most likely to cross the highway (see *Genetic Health* for further details). Measures of genetic diversity from the NCDE are similar to those from undisturbed populations in Canada and Alaska leading to the conclusion that the NCDE population has high genetic diversity and is sufficiently connected to other populations as discussed below in *Genetic Health in the NCDE*.

Fragmentation in the CYE, SE, BE, and North Cascades

Inside the CYE, SE, BE, and North Cascades recovery zones, habitat-based recovery criteria will be developed prior to any proposed delisting that imposes thresholds that address the threat identified at the time of listing of destruction and modification of habitat. These standards will limit human-bear interactions and resultant mortality, but also will limit impacts to grizzly bear habitat connectivity. Land management practices that result in road construction and the conversion of large tracts of private land into residential subdivisions can prevent grizzly bears from moving between populations (Proctor *et al.* 2012, p. 35). There is no indication that such potential barriers exist within the SE, BE, and North Cascades recovery zones.

Fragmentation has occurred, and currently still occurs, between the Yaak and Cabinet Mountains portions of the CYE and is related to human settlement, U.S. Hwy. 2, and a busy rail line (Proctor *et al*. 2018, p. 350). Corridors have been identified (Proctor *et al*. 2015, p. 553) and management to re-establish connectivity between these two areas has included non-lethal management of appropriate conflict bears, land purchases, electric fencing programs to rescue attractants and conflicts, and more (Proctor *et al*. 2018, p. 366). There is recent evidence that some movements are starting to take place (Kasworm *et al*. 2020a, p. 32) and functional connectivity remains a management objective.

Private Land Development

Private land development may lead to habitat fragmentation (see *Habitat Fragmentation* above for further discussion). Rapidly accelerating growth of human populations in some areas outside of the recovery zones continue to define the limits of grizzly bear range, and will likely limit:

- the expansion of the grizzly bear populations onto private lands in some areas outside the recovery zones;
- connectivity between ecosystems, such as the CYE and SE; and
- natural recolonization of the BE and North Cascades.

Urban and rural sprawl (low density housing and associated businesses) has resulted in increasing numbers of human-grizzly bear conflicts with subsequent increases in grizzly bear mortality rates in more human-dominated landscapes. Private lands account for a disproportionate number of bear deaths and conflicts (Service 2007*c*, figures 15 and 16; Schwartz *et al.* 2010, p. 661; Proctor *et al.* 2012, p. 33; MFWP, unpublished data).

Conservation easements on private lands maintain open lands for wildlife use by protecting against potential future subdivision and development while maintaining traditional land uses. Public agencies (e.g., the Service) or qualified land trusts (e.g., The Nature Conservancy, The Vital Ground Foundation) place conservation easements, in cooperation with the landowner. In addition, land trusts or other private conservation organizations have purchased land for the purpose of wildlife conservation. Easements and land trusts can be especially effective at reducing habitat fragmentation and increasing connectivity of secure grizzly bear habitat. Private lands that limit road access also contribute to conservation benefits for bears.

In addition to addressing threats from private land development through conservation easement programs, Federal, State, and Tribal wildlife management agencies respond to conflicts on public and private lands. While human-grizzly conflicts at developed sites on public lands do occur, the most frequent reason for management removals are conflicts on private lands (Servheen *et al.* 2004, p. 21; MFWP, unpublished data). Depending on the situation, appropriate responses may include proactively removing or securing attractants; public outreach and education; discouraging the grizzly bear from visiting the area using non-lethal methods; capturing and relocating a grizzly bear to a new area; and/or removing the grizzly bear from the population (Servheen *et al*. 1981, pp. 2–3, 17–29; Dood 2006, pp. 32–38; Idaho's Yellowstone Grizzly Bear Delisting Advisory Team 2002, pp. 14–18; Blackfeet Tribal Business Council 2013, pp. 6–10; MFWP 2013, pp. 49–59; YES 2016a, pp. 86–90; WGFD 2016 pp. 20–22; NCDE Subcommittee 2018, Chapter 4). Proctor *et al.* (2018, entire) describe a comprehensive program to reduce human-bear conflicts on a fragmented landscape. They were able to reduce human-caused mortality and increase connectivity in and between ecosystems through land trust acquisitions and easements, attractant management, non-lethal management of appropriate conflict bears, and public outreach and education. Other methods to reduce conflicts on private land include effective enforcement of regulations and food storage regulations. The feeding of grizzly bears is prohibited on private lands in Montana (ARM 87-6-216) and in some counties and cities in Idaho and Wyoming.

Private land development in the GYE

In the GYE, one percent of the recovery zone and nearly 13 percent of the DMA outside of the recovery zone is privately owned. As private lands are developed and secure habitat on private lands declines, State and Federal agencies will work together through the Coordinating Committee to balance impacts from private land development (Idaho's Yellowstone Grizzly Bear Delisting Advisory Team 2002, p. 10; MFWP 2013, p. 37; WGFD 2016, p. 15).

Easements and the purchase of private lands by land trusts have protected 35 percent (89 of 251 km^2 (35 of 97 mi^2) of the privately owned inside the recovery zone and 34 percent (1,129 of 3,289 km^2 (436 of 1,270 mi^2) of privately owned land inside the DMA outside the recovery zone. In addition, 2,870 km^2 (1,108 mi^2) of privately owned land that is to the north and northwest of the DMA, including lands that straddle the DMA boundary, that are inside the GYE are protected by easements or owned by land trusts. These lands occur in potential connectivity areas between the GYE and both the BE and the NCDE. State and Federal agencies will continue to assist nongovernmental organizations (NGOs) and other entities to identify and prioritize potential lands suitable for permanent conservation through easements and other means as much as possible (Service 2007*c*, p. 54).

The large areas of widely distributed suitable habitat on public lands in the GYE that are protected by Federal legislation help to minimize risk posed by human population growth on private lands and ensure that the grizzly bear grizzly bear population that continues to meet recovery criteria.

Private land development in the NCDE

In the NCDE, 7 percent of habitat within the recovery zone and nearly 47 percent of habitat in Zones 1 and 2 is privately owned. As private lands are developed and as secure habitat on private lands declines, State and Federal agencies will work together through the Coordinating Committee to balance impacts on the grizzly bear population (Dood 2006, pp. 45–46; NCDE Subcommittee 2018, Chapters 1 and 3).

Public agencies (e.g., the Service) or qualified Land Trusts (e.g., The Nature Conservancy, The Vital Ground Foundation) have placed conservation easements, in cooperation with the land owner, on 39 percent (639 of 1,655 km^2 (247 of 639 mi^2)) of the privately owned land in the recovery zone, 21 percent (1,507 of 7,160 km^2 (582 of 2,764 mi^2)) of the privately owned land in Zone 1, and 10 percent (1,153 of 11,723 km^2 (445 of 4,526 mi^2)) of the privately owned land in Zone 2. In addition, Land Trusts or other private conservation organizations own 6 percent (96 km^2 (37 mi^2)) of private land in the recovery zone, 7 percent (498 km^2 (204 mi^2)) of private land in Zone 1, and 1 percent (94 km^2 (32 mi^2)) of private land in Zone 2. Zones 1 and 2 provide potential connectivity areas from the NCDE to the GYE, BE, and CYE. State and Federal agencies will continue to assist NGOs and other entities to identify and prioritize potential lands suitable for permanent conservation through easements and other means as much as possible (Servheen *et al*. 1981, pp. 34–35; Dood 2006, pp. 36, 45; NCDE Subcommittee, Chapter 3; USDA FS 2018d, p. 2; USDA FS 2018e, pp. 70, 131).

Private land development in the CYE

Agencies and non-governmental organizations are working to reduce fragmentation that has occurred due to private land development in important linkage areas (Proctor *et al*. 2015, p. 8) between the CYE and SE. Land acquisition and exchange has placed additional areas within the CYE recovery zone in the public domain, which benefits the long-term conservation of the species. There have been several major land exchanges in particular that have been beneficial to grizzly bear habitat within the CYE. In 1997 the Kootenai NF completed a land exchange in which 87 km^2 (33 mi^2) of land owned by Plum Creek Timber Company were placed in public ownership and administered by the Kootenai NF the benefit of grizzly bear and other species. Motorized access is managed under the BMU-specific standards described above. Almost all of this land was within the CYE grizzly bear recovery zone. In 2005, MFWP purchased almost 5 km^2 (2 mi^2) in the Bull River Valley between the East and West Cabinet Mountains. A conservation easement on an adjacent 2 km^2 (1 mi^2) was accepted by the State of Montana from the Avista Company. The area, now known as the Bull River Wildlife Management Area is managed by MFWP and provides linkage of public land across the river valley and will have value for a number of species including bull trout, westslope cutthroat trout, grizzly bear, lynx, and bald eagle. This acquisition and easement limit motorized access, limit future subdivision and home site development, and protect population linkage across the Bull River valley. In 2007, another adjacent 2 km^2 (1 mi^2) was added to the management area by purchase and cooperative management with Revett Minerals. In addition, in 2017 and 2018, Vital Grounds and the Yukon Conservation Initiative purchased 0.17 km^2 (0.07 mi^2) of habitat in the Hwy. 2 linkage zone near the confluence of the Yaak and Kootenai Rivers which divides the Yaak and Cabinet Mountains. Overall, these conservation efforts are important first steps to ensuring habitat fragmentation does not become a larger threat to this population of grizzly bears.

In 2013, an easement with the Stimson Lumber Company was finalized that will protect almost 110 km^2 (42 mi^2) of private timber lands near Troy, Montana. MFWP holds this easement, which will maintain working forests, conserve fish and wildlife habitat, and maintain public recreation access while avoiding sale and subdivision of these lands. This easement compliments the purchase in 2011 of 0.32 km^2 (0.12 mi^2) along the Kootenai River by Vital Ground to protect and promote habitat linkage across the Kootenai River between the Yaak River and Cabinet Mountains portions of the CYE. In 2019 an additional Stimson Lumber Company easement on 90.2 km^2 (34.8 mi^2) was completed near Libby. Easements have also been placed on 8.8 km^2 (3.5 mi^2) of additional lands either inside or on the periphery of the CYE grizzly bear recovery zone from 1995 to 2011. These easements protect grizzly bear and its habitat by limiting further subdivision and sale of these lands.

The Nature Conservancy of Canada and the Transboundary Grizzly Bear Project have protected 2.9 km^2 (1.1 mi^2) of private lands in three sites along Hwys. 3 and 3A. These acquisitions and easements occurred in linkage areas between Canadian grizzly bear populations and the CYE grizzly bear population. These acquisitions and easements will benefit the CYE by protecting important linkage habitat between the Purcell and Selkirk Mountain ranges in B.C. and immediately north of the Yaak portion of the CYE.

Private land development in the SE

As discussed in *Private Land Development in the CYE*, there is an ongoing effort to reduce fragmentation that has occurred due to private land development in important linkage areas between the CYE and SE. The Nature Conservancy of Canada purchased 550 km^2 (213 mi^2) of private land within the SE recovery zone in Canada in 2008. The location of these lands directly connects to an existing network of parks and wildlife management areas, creating a contiguous protected area of more than 1,012 km^2 (391 mi^2), enough for wide-ranging animals like mountain caribou and grizzly bears to maintain connectivity with U.S. populations of these species. There is currently a team of managers and biologists writing a management plan for the area that includes considerations for grizzly bears. This private land purchase represents a significant improvement to grizzly bear habitat in the SE recovery zone. In 2013, the Nature Conservancy of Canada and the Transboundary Grizzly Bear Project protected 1.5 km^2 (0.6 mi^2) of lands linking the Purcell and Selkirk Mountain ranges at the south end of Kootenay Lake through a combination of acquisition and conservation covenants. These lands will be managed through a plan being developed by the Nature Conservancy of Canada. Between 2001 and 2018, Vital Ground has completed five land acquisitions in Bismark Meadows protecting nearly 4 km^2 (1.5 mi^2) that provides valuable, low-lying spring habitat. Overall, these conservation efforts are important first steps to ensuring habitat fragmentation does not become a larger threat to this population of grizzly bears.

Private Land Development in the BE

In the GYE, more than 2,800 km^2 (1,080 mi^2) of privately owned land are protected by easements or owned by land trusts in potential connectivity areas between the GYE DMA and the BE. In the NCDE, more than 600 km^2 (230 mi^2) of privately owned land are protected by easements or owned by land trusts in potential connectivity areas in Zone 1, leading to the BE from the north. In addition, more than 700 km^2 (270 mi^2) of privately owned land are protected by easements or owned by land trusts potential connectivity areas from the GYE and NCDE leading to the BE. To facilitate natural recolonization of the BE, strategies to minimize human-caused mortality will need to be applied in the intervening linkage areas and may include access management.

Private Land Development in the North Cascades

Approximately 10 percent (2,500 km^2 (965 mi^2)) of the North Cascades recovery zone are private lands and more than 320 km^2 (123 mi^2) of these privately owned lands are protected by easements. In addition, more than 66 km^2 (25 mi^2) of privately owned land are protected by easements in potential connectivity areas between the North Cascades and the SE recovery zone. To facilitate natural recolonization of the North Cascades, strategies to minimize human-caused mortality will need to be applied in the intervening linkage areas, and may include access management

Summary of Habitat-Related Effects

As summarized above, the following stressors could reduce or fragment grizzly bear habitats:

(1) Motorized access management,
(2) Developed sites,
(3) Livestock allotments,
(4) Mineral and energy development,
(5) Recreation, and
(6) Vegetation management.

We also discussed potential stressors of disturbance at den sites, habitat fragmentation, and land development, as they pertain to successful grizzly bear recovery and management.

Within the GYE and NCDE recovery zones, the Service developed objective and measurable habitat-based recovery criteria to limit habitat degradation and human-caused mortality risk related to motorized access, developed sites, and livestock allotments (i.e., the 1998 and 2011 baselines, respectively). Habitat-based recovery criteria will be developed for each of the remaining ecosystems in the future. In the meantime, motorized access standards are in place for Federally managed lands within the CYE and SE, Federal lands within the North Cascades are managing for a "no net loss" policy, and the BE is 98 percent wilderness.

Recreation in all of the ecosystems is limited through existing road and developed site standards. Additionally, I&E campaigns educate visitors about how to recreate safely in bear country and avoid human-bear conflicts. There are no data available on the impacts of snowmobiling or other winter recreation on grizzly bears to suggest an effect on grizzly bear survival or recovery of the population. Although vegetation management may temporarily impact individual grizzly bears, these activities are coordinated on a BMU or subunit scale according to the Guidelines to mitigate for any potentially negative effect. As a result of vegetation management, there may also be positive effects on grizzly bears where key habitats are maintained or enhanced. Finally, there are no data to indicate that habitat fragmentation is occurring within any of the ecosystems, with the exception of U.S. Hwy. 2 in the CYE.

In addition to the protections discussed by individual land management plans discussed above, Federal agencies evaluate proposed road construction, developed site, livestock allotment, vegetation, and mineral and energy development projects on Federal lands throughout areas where bears may occur through Section 7 consultation.

Summary of Habitat-Related Effects within the GYE

Within suitable habitat, different levels of management and protection are applied to areas based on importance to the population. Restrictions on motorized access, developed sites, and livestock allotments ensure that they will be maintained within the recovery zone at or below 1998 levels, a time when the population was increasing at a rate of 4 to 7 percent per year (Schwartz *et al*. 2006b, p. 48). Additionally, secure habitat will be maintained at or above 1998 levels within the recovery zone. The GYE NFs and NPs will continue their 15-year history of implementation through the legal implementation of the appropriate planning documents that incorporate the 1998 baseline values as habitat standards (USDA FS 2006b, p. 26). Together, these two Federal agencies manage 98 percent of lands within the recovery zone. The primary factors related to past habitat destruction and modification have been reduced through changes in management practices that have already been formally incorporated into regulatory documents. As it has done for the last decade, the IGBST will continue to monitor compliance with the 1998 baseline values and will also continue to monitor grizzly bear body condition, fat levels, and diet composition. Accordingly, the recovery zone, which comprises 51 percent of the suitable habitat within the DMA boundaries and contains 80 percent of all females with cubs-of-the-year for all or part of the year (Haroldson 2019a, *in litt*.), will remain a highly secure area for grizzly bears, with habitat conditions maintained at or above levels documented in 1998. Maintenance of the 1998 baseline values inside the recovery zone will continue to adequately ameliorate negative impacts on grizzly bear habitat.

Suitable habitat outside the recovery zone provides additional ecological resiliency and habitat redundancy to allow the population to respond to environmental changes. Together, the USFS and NPS manage nearly 80 percent of suitable habitat within the DMA outside of the recovery zone. Habitat protections specifically for grizzly bear conservation are not necessary here because other binding regulatory mechanisms are in place for 59 percent of suitable habitat outside the recovery zone. Specifically, in these areas, the Wilderness Act, the Roadless Areas Conservation Rule, and NF Land Management Plans limit development and motorized use. Management of individual projects on public land outside the recovery zone will continue to consider and minimize impacts on grizzly bear habitat. Continued efforts by NGOs and Tribal, State, and county agencies will reduce human-bear conflicts on private lands (YES 2016a, pp. 86–91).

Other management practices on Federal lands have been changed to provide security and to maintain or improve habitat conditions for grizzly bears. All operating plans for oil and gas leases must conform to secure habitat and developed site standards, which require mitigation for any change in secure habitat.

In summary, the stressors discussed under *Habitat-Related Effects* continue to occur across the current range of the GYE but have been mitigated such that they likely impact only a small proportion of the population. Additionally, although population growth has slowed in the DMA, expansion of occupied range outside the DMA continues and habitat protections are in place to reduce the effects of this stressor and maintain resiliency of the GYE currently and into the future.

Summary of Habitat-Related Effects within the NCDE

Within the NCDE recovery zone, which includes the range with the highest density of females with cubs (Costello *et al.* 2016, p. 22), habitat protections are in place specifically for grizzly bear conservation. Inside the recovery zone, restrictions on motorized access, developed sites, and livestock allotments ensure that they will be maintained at or improved upon baseline levels, with limited allowances for increases in developed recreation sites. Additionally, secure core habitat will be maintained at or above baseline levels. The primary factors related to past habitat destruction and modification have been reduced through changes in management practices that have already been incorporated into regulatory documents (in their entirety: CS&KT 2000; Dood 2006; Blackfeet Nation 2008; DNRC 2010a, 2010b; USDA FS 2018c, 2018d, 2018e; BLM 2019b). The NCDE NFs and GNP will continue their history of implementing the appropriate planning documents that incorporate the baseline values as habitat standards (NCDE Subcommittee 2018, Chapter 3, Appendices 4 and 5; in their entirety: USDA FS 2018c, 2018d, and 2018e). Together, these two Federal agencies manage 78 percent of lands within the recovery zone.

Regulations have been put into place by the BLM, BIR, FIR, and DNRC to implement habitat protections on an additional 13 percent of lands in the recovery zone (in their entirety: BLM 1986; CS&KT 2000; Blackfeet Nation 2008; DNRC 2010a, 2010b; BLM 2019b). Accordingly, the recovery zone, which comprises 54 percent of the DMA, will remain a highly secure area for grizzly bears, with habitat conditions maintained at or improved upon the baseline. Maintenance of the baseline values inside the recovery zone by Federal land management agencies (i.e., USFS, NPS, and BLM) and habitat protections on State and Tribal lands will continue to adequately ameliorate the multitude of stressors on grizzly bear habitat. As it has done for the last decade, the Monitoring Team will continue to monitor compliance with the baseline values and will also continue to monitor grizzly bear body condition, fat levels, and diet composition.

Habitat in Zone 1 outside the recovery zone provides additional ecological resiliency and redundancy to allow the population to respond to environmental changes. Regulations have been put into place by the USFS, BLM, BIR, FIR, and DNRC to implement habitat protections on 47 percent of lands (or 100 percent of non-private lands) in Zone 1 (in their entirety: BLM 1986; CS&KT 2000; Blackfeet Nation 2008; DNRC 2010a, 2010b; NCDE Subcommittee 2018, Chapter 3; USDA FS 2018c, 2018d, and 2018e; BLM 2019a, 2019b). Management of individual projects on public land in Zone 1 will continue to consider and minimize impacts on grizzly bear habitat. NGOs and State and county agencies will seek to minimize human-bear conflicts on private lands (Servheen *et al*. 1981, pp. 2–3, 17–29; Dood 2006, pp. 32–38; Blackfeet Tribal Business Council 2013, pp. 6–10; NCDE Subcommittee 2018, Chapter 4). These and other conservation measures ensure that changes to habitat outside the recovery zone in Zone 1 will continue to be protected.

Other management practices on Federal lands have been changed to provide security and to maintain or improve habitat conditions for grizzly bears. All operating plans for oil and gas leases within the recovery zone and Zone 1 must conform to secure core habitat and developed site standards, which require mitigation for any change in secure core habitat (USDA FS 2018d, pp. 1-11–1-14, 1-23–1-26, 1-35–1-38, 1-46–1-49; USDA FS 2018e, pp. 77–79).

In summary, the stressors discussed under *Habitat-Related Effects* occur across the current range of the NCDE but have been mitigated such that they only affect a small proportion of the population. Additionally, the population has increased and stabilized while its current range has expanded. The habitat protections that are in place are sufficient to maintain resiliency of the NCDE currently and into the future.

Summary of habitat-related effects in the CYE, SE, BE, and North Cascades

Numerous improvements in habitat security for grizzly bears, such as motorized access standards, land acquisitions, and conservation easements in the CYE and SE have occurred since 2011, and will remain in place. However, most BMUs in the CYE are not currently in compliance with the Forest Plan standards. Most BMUs on Federal lands in the SE are meeting their access management standards and a conservation agreement is in place in the LeClerc BMU, for which motorized access standards do not apply because of the high level of non-Federal lands. However, it would be desirable to have more information and management certainty about motorized access management in the State BMU and in the Canadian portion of the SE recovery zone. Additional improvements to habitat security are described in the USFS's 2011 ROD and the USFS is currently working on an implementation schedule for the remaining BMUs to achieve all standards. In the North Cascades, 64 percent of the recovery zone is protected from motorized routes due to designation as Wilderness or IRA. However, access management standards have not been developed or implemented for BMUs in the recovery zone and without an inventory of OMRD and TMRD we are unable to assess the severity of these impacts. In the BE, 98 percent of the recovery zone is protected from motorized routes due to designation as Wilderness. Standards are needed to maintain resiliency of the CYE, SE, BE and North Cascades grizzly bear populations.

Mortality-Related Effects

The stressors and conservation actions we describe below can also increase or decrease direct mortality of grizzly bears. In our monitoring and reporting, we categorize grizzly bear mortalities into three categories: natural mortalities, mortalities with undetermined cause, and human-caused mortalities.

Human-Caused Mortality

Excessive human-caused mortality, including "indiscriminate illegal killing" and management removals, was the primary factor contributing to grizzly bear decline during the 19th and 20th centuries (Leopold 1967, p. 30; Koford 1969, p. 95; Servheen 1990, p. 1; Servheen 1999, pp. 50–52; Mattson and Merrill 2002, pp. 1129, 1132; Schwartz *et al.* 2003a, p. 571), eventually leading to their listing as a threatened species in 1975 (40 FR 31734, July 28, 1975). Grizzly bears were seen as a threat to livestock and human safety and, therefore, an impediment to westward expansion. Both the Federal Government and most early settlers were dedicated to eradicating large predators. Grizzly bears were shot, poisoned, trapped, and killed wherever humans encountered them (Servheen 1999, p. 50). In the early 20th century, regulations recognizing bears (black and grizzly) as game animals, protecting females and their offspring, and setting harvest limits (either season or bag limit) were designed to stop future extirpations. In some areas, the protections came too late. By the time grizzly bears were listed under the Act in 1975, there were only a few hundred remaining in the lower-48 States in less than 2 percent of their former range (Service 1993, pp. 8–10).

Negative human attitudes towards grizzly bears fueled historical grizzly bear declines (see *Historical Range and Distribution* above for further discussion) and continues to be an important factor in grizzly bear conservation and management. While there has been a positive shift in public perceptions and attitudes towards grizzly bears in the last several decades, human-caused mortalities continue to be the leading cause of grizzly bear mortalities range wide.

We differentiate types of human-caused mortalities into: (1) accidental killings; (2) management removals; (3) mistaken identity killing; (4) defense of life kills; and (5) illegal killings, or poaching (Figure 26, above). In addition, methods by Cherry *et al.* (2002, entire) are used to calculate a statistical estimate of the number of unknown/unreported human-caused mortalities (see *Mortality Limits* for further details). This section discusses current sources and impacts of human-caused mortalities on the grizzly bear populations; summarizes current and future preventative measures being taken to proactively reduce human-caused grizzly bear mortalities and improve public attitudes towards grizzly bears; and discusses how mortality thresholds prevent future detrimental effects of human-caused mortalities on grizzly bear populations.

Accidental killings encompass a broad range of mortality sources such as deaths from vehicle collisions, train strikes, unintentional poisoning, electrocution, drowning, and research trapping.

Management removals are allowed under the Act through a section 4(d) rule (50 CFR 17.40(b)). These types of removals encompass grizzly bear mortalities resulting from conflicts at developed sites (e.g., bears attracted to anthropogenic food sources), livestock depredation, and other situations where human life or property is considered threatened by bear presence. While lethal to the individual grizzly bears involved, management removals can promote conservation grizzly bears by reducing illegal killing of bears, providing an opportunity to educate the public about avoiding conflicts, and promoting tolerance of grizzly bears by responding promptly and effectively when bears pose a threat to public safety or repeatedly depredate livestock. Without the support of the people that live, work, and recreate in grizzly bear country, grizzly bear conservation will not be successful.

Mistaken identity killings are killings of grizzly bears by black bear hunters; although unintentional they are considered a form of illegal take. Black bear hunting over bait is allowed in portions of grizzly bear range outside of the YE, CYE, and SE in Idaho and Wyoming and has resulted in some mistaken identity mortality. Black bear hunting over bait is not allowed in Montana or Washington. Conversely, under current regulations, it is legal to kill grizzly bears if it is in self-defense or defense of others (50 CFR § 17.40); we call deaths from this source "defense of life kills."

We define poaching as intentional, illegal killing of grizzly bears. People may kill grizzly bears for several reasons, including a general perception that grizzly bears in the area may be dangerous, frustration over livestock depredations, or to protest land-use and road-use restrictions associated with grizzly bear habitat management (Servheen *et al.* 2004, p. 21).

Human-Caused Mortality in the GYE

From 1980 to 2002, 66 percent (191) of the 290 known grizzly bear mortalities were human-caused (Servheen *et al.* 2004, p. 21). The main types of human-caused mortality were human site conflicts, self-defense, and illegal kills, all of which can be partially mitigated for through management actions (Servheen *et al.* 2004, p. 21). Despite these mortalities, this period corresponds to one during which the GYE grizzly bear population experienced population growth and range expansion (see our March 29, 2007 final rule (72 FR 14866) for further discussion). Since then, the IGBST has updated these demographic vital rates using data from 2002–2011 (IGBST 2012, entire). Below, we evaluate human-caused mortality for 2002–2019, as it represents the most recent and best available information on the subject.

From 2002 to 2019, 83 percent (340) of the 412 known and probable grizzly bear mortalities for independent aged bears within the GYE DMA were human-caused (Table 11) (van Manen 2020, *in litt.*). Although the number of human-caused mortalities of independent female and male grizzly bears have increased gradually over this time period, human-caused mortality as a proportion of estimated population size (i.e., the rate of mortality) has remained relatively constant (Haroldson 2019d, *in litt.*). Overall, human-caused mortality rates have been low enough to allow the GYE grizzly bear population to increase in number and range (Schwartz *et al.* 2006a, pp. 64–66; Schwartz *et al.* 2006b, p. 48; Bjornlie *et al.* 2014a, p. 184).

Table 11. Causes of grizzly bear mortalities in the GYE, 2002–2019. This table includes all known and probable mortalities for independent females and males, inside and outside the demographic monitoring area (DMA).

	Inside DMA			Outside DMA		
Cause of mortalities (all sources)	**Number of mortalities**	**Avg./ year**	**Percent total**	**Number of mortalities**	**Avg./ year**	**Percent total**
Natural	34	1.9	8	1	0.1	1
Undetermined	38	2.1	9	2	0.1	2
Human-caused	340	18.9	83	101	5.6	97
Total mortalities	**412**	**22.9**	**100**	**104**	**5.8**	**100**
Human-caused mortalities	**Number of mortalities**	**Avg./ year**	**Percent of human-caused**	**Number of mortalities**	**Avg./ year**	**Percent of human-caused**

Accidental						
Automobile collision	32	1.8	9	2	0.1	2
Capture related	8	0.4	2	0	0.0	0
Drowning	0	0.0	0	4	0.2	4
Poisoning	1	0.1	<1	0	0.0	0
Defense of life	109	6.1	32	11	0.6	11
Illegal *	22	1.2	6	2	0.1	2
Management removal						
Site conflicts/Human safety**	71	3.9	21	39	2.2	39
Injured or diseased bear	2	0.1	1	0	0.0	0
Livestock depredation	71	3.9	21	37	2.1	37
Mistaken identification***	24	1.3	7	6	0.3	6

* Illegal includes poaching, malicious, and defense of property kills.
** Site conflicts/human safety include anthropogenic food and property damage related management removals in the front- and backcountry.
***Mistaken identification includes grizzly bear kills over bait. Four instances of bears killed over bait are included.

Human-Caused Mortality in the NCDE

From 1975 to 2019, 91 percent (613) of the 670 known and probable grizzly bear mortalities for independent aged bears within the NCDE DMA were human-caused (Table 12) (MFWP, unpublished data). In addition to the categories of human-caused mortalities discussed above, legal hunting of grizzly bears (i.e., recreational purposes) was allowed in the NCDE from 1975 until 1991, under a special rule authorizing take in the 1975 listing (40 FR 331734, July 28, 1975). However, while human-caused mortalities of grizzly bears have increased gradually each year, the level of these mortalities as a proportion of the estimated population size (i.e., mortality rate) has remained relatively constant (MFWP, unpublished data). Overall, human-caused mortality rates have been low enough to allow the NCDE population to increase in number and range (Costello 2019, *in litt.*; MFWP, unpublished data).

Table 12. Causes of grizzly bear mortalities in the NCDE, 1975–2019. This table includes all known and probable mortalities for independent females and males, inside and outside the demographic monitoring area (DMA).

	Inside DMA			Outside DMA		
Cause of mortalities (all sources)	**Number of mortalities**	**Avg./ year**	**Percent total**	**Number of mortalities**	**Avg./ year**	**Percent total**
Natural	21	0.4	3	0	0.0	0
Undetermined	36	0.8	5	1	<0.1	2
Human-caused	613	13.6	91	45	1.0	98
Total mortalities	**670**	**14.9**	**100**	**46**	**1.0**	**100**
Human-caused mortalities	**Number of mortalities**	**Avg./ year**	**Percent of human-caused**	**Number of mortalities**	**Avg./ year**	**Percent of human-caused**
Accidental						
Automobile collision	33	1.9	5	2	<0.1	4
Capture related	18	0.7	3	1	<0.1	2

Drowning	0	0.0	0	1	<0.1	2
Poisoning	2	<0.1	<1	1	<0.1	2
Train collision	33	0.7	5	3	0.1	7
Defense of life	61	1.4	10	5	0.1	11
Illegal *	128	2.8	21	15	0.3	33
Legal hunting	124	2.8	20	0	0.0	0
Management removal						
Augmentation**	15	0.3	2	0	0.0	0
Site conflicts/Human safety***	91	2.0	15	1	<0.1	2
Injured or diseased bear	6	0.1	1	1	<0.1	2
Livestock depredation	56	1.2	9	11	0.2	24
Unknown	3	<0.1	<1	1	<0.1	2
Mistaken identification	39	0.9	6	1	<0.1	2
Unknown	1	<0.1	<1	2	<0.1	4

* Illegal includes poaching, malicious, and defense of property kills.
** When bears are relocated from the NCDE to augment the CYE population, they are counted as mortalities in the NCDE.
*** Site conflicts include both anthropogenic food and property damage related management removals. Human safety includes incidents in both the front and backcountry.

Human-Caused Mortality in the CYE, SE, BE, and North Cascades

From 1982 to 2019, 73 percent (47) of the 64 known and probable grizzly bear mortalities in the CYE were human-caused (Table 13) (Kasworm *et al.* 2020a, pp. 33). We recognize that some grizzly bears in the CYE and SE have home ranges overlap the international border; however, it is most appropriate to discuss human-caused mortality for the U.S. portion of the SE because that is the area encompassed by the listed entity, the lower-48 States. From 1982 to 2019, 77 percent (27) of the 35 known and probable grizzly bear mortalities in the U.S. portion of the SE recovery zone were human-caused (Table 2) (Kasworm *et al.* 2020b, p. 23). There have been no known, human-caused mortalities in the North Cascades since 1967, however the last verified sighting in the North Cascades occurred in 1996. In the BE recovery zone, the last known, human-caused mortality occurred in 1932 and there has only been one verified sighting in the recovery zone since the 1940s, a collared bear from the CYE that spent several weeks in the northern part of the recovery zone in 2019. There have been 2 known human-caused mortalities inside the lower-48 States outside of these areas.

Table 13. Causes of known and probable grizzly bear mortalities from 1982 to 2019 in the CYE and the U.S. portion of the SE.

	CYE			SE		
Cause of mortalities (all sources)	**Number of mortalities**	**Avg./ year**	**Percent total**	**Number of mortalities**	**Avg./ year**	**Percent total**
Natural	15	0.39	23	7	0.18	20
Unknown/undetermined	2	0.05	3	1	0.03	3
Human-caused	47	1.24	73	27	0.71	77
Total mortalities	**64**	**1.68**	**100**	**35**	**0.92**	**100**
Human-caused mortalities*	**Number of mortalities**	**Avg./ year**	**Percent of human-caused**	**Number of mortalities**	**Avg./ year**	**Percent of human-caused**
Accidental	4	0.11	9	1	0.03	4

Defense of life	8	0.21	17	0	0	0
Illegal poaching	8	0.21	17	5	0.13	18
Management removal	2	0.05	4	3	0.08	11
Mistaken identification	8	0.21	17	7	0.18	26
Unknown**	17	0.45	36	11	0.29	41

* Orphaned dependent offspring were classified according to cause of death of their mother.
** Includes mortalities that are under investigation.

Sources and Impacts of Human-Caused Mortality

No grizzly bears have been removed from the lower-48 States since 1975 for commercial, scientific, or educational purposes. Outside of the limited time period in which hunting was allowed in the NCDE, no grizzly bears have been removed from the rest of the lower-48 States since 1975 for recreational purposes. Hunting of grizzly bears in the lower-48 States is not currently allowed. The remaining sources of human-caused mortalities can be broken down into five main categories:

(1) Management removals,
(2) Accidental killings,
(3) Mistaken identity killings,
(4) Illegal killings, and
(5) Defense of life killings.

We summarize each of these below.

Management Removals:

Management removals encompass grizzly bear mortalities resulting from conflicts at developed sites (e.g. bears attracted to anthropogenic food sources), livestock depredation, and other situations where human life or property is considered threatened by bear presence. The majority of management removals result from attractant-related conflicts at sites associated with frequent or permanent human presence (i.e., developed sites) and livestock depredations. Management removals are allowed under the Act through a section 4(d) rule (50 CFR 17.40(b)). Management removals are conducted by trained Federal, State, and Tribal bear managers. Current regulations allow management removals of bears constituting a demonstrable but non-immediate threat to human safety, bears constituting an immediate threat to human safety, or bears committing significant depredations to lawfully present livestock, crops, or beehives under certain circumstances (50 CFR 17.40(b) (1) (i) (C)). These types of removals encompass grizzly bear mortalities resulting from conflicts at developed sites (e.g., bears attracted to anthropogenic food sources), livestock depredation, and other situations where human life or property is considered threatened by bear presence.

In the GYE, between 2002 and 2019, management removals resulted in 144 mortalities, accounting for 42 percent of human-caused mortalities within the DMA. In the NCDE, between 1975 and 2019, management removals resulted in 171 mortalities within the DMA, accounting for 28 percent of all human-caused mortalities. From 1982 to 2019, management removals resulted in 2 mortalities in the CYE and in 3 mortalities in the SE, accounting for 4 percent and

11 percent, respectively, of all human-caused mortalities (Kasworm *et al.* 2020a, p. 33; Kasworm *et al.* 2020b, p. 23). Below we discuss two types of management removals in further detail, site conflicts and livestock depredation.

Site Conflicts

Management removals at site conflicts usually involve unsecured attractants, including garbage, human foods, chickens, pet/livestock foods, bird food, livestock carcasses, wildlife carcasses, barbeque grills, compost piles, orchard fruits, or vegetable gardens. These conflicts often involve food-conditioned bears actively seeking out unsecured attractants or bears that were habituated to human presence seeking natural sources of food in areas near human structures or roads. While these mortalities are clearly related to unsecured, human-attractants, they are also related to human attitudes, knowledge, and tolerance toward grizzly bears. Many of these mortalities can be prevented through changes in human perceptions and actions including limiting bear access to human-related food sources, and increased human-understanding and tolerance towards grizzly bears (see *Preventative Measures* below for further discussion). These factors are common targets of the 2016 GYE Conservation Strategy and Federal, State, and Tribal I&E Programs (discussed in detail below in *I&E Programs*). In the GYE, conflicts at front- or back-country sites (on either public or private lands) were responsible for 49 percent (71 of 144) of management removals and 21 percent (71 of 340) of all human-caused mortality within the DMA between 2002 and 2019 (van Manen 2020, *in litt.*).

In the NCDE, the majority of management removals result from attractant-related conflicts at sites associated with frequent or permanent human presence, either in the front- or back-country. Conflicts at developed sites (on both public and private lands) were responsible for 53 percent (91 of 171) of management removals and 15 percent (91 of 613) of all human-caused mortalities within the DMA conducted between 1975 and 2019 (MFWP, unpublished data).

In the CYE site conflicts accounted for both of the management removals. In the SE, site conflicts accounted 2 of 3 of management removals

Livestock Depredation

In the GYE, management removals due to grizzly bear conflicts with livestock accounted for 49 percent (71 of 144) of management removals and 21 percent (71 of 340) of all human-caused mortalities in the DMA between 2002 and 2019 (van Manen 2020, *in litt.*). Only 2 of these 71 mortalities occurred inside the recovery zone where multiple measures to reduce livestock conflicts are in place (van Manen 2020, *in litt.*). The USFS phases out sheep allotments within the DMA as opportunities arise to resolve conflicts (see discussion in *Livestock Allotments* in *Habitat Destruction and Modification*, above). Additionally, the alternative chosen by the USFS during its NEPA process to amend the five NF plans for grizzly bear habitat conservation inside the recovery zone includes direction to resolve recurring conflicts on livestock allotments through retirement of those allotments with willing permittees (USDA FS 2006b, pp. 16–17; YES 2016a, pp. 67–68). Livestock grazing permits throughout occupied grizzly bear habitat inside the GYE include special provisions regarding reporting of conflicts, proper food and attractant storage procedures, and carcass removal to reduce the potential for depredations. The

USFS monitors compliance with these special provisions associated with livestock allotments annually (Servheen *et al.* 2004, p. 28). Moreover, all three State management plans contain direction on reducing grizzly bear-livestock conflicts and cooperating with private landowners to reach this goal (Idaho's Yellowstone Grizzly Bear Delisting Advisory Team 2002, pp. 15–16; MFWP 2013, pp. 51–53; WGFD 2016, pp. 22–23). The 2016 GYE Conservation Strategy also recognizes that removal of individual conflict bears is sometimes required, as a few individual bears often are responsible for multiple livestock depredations (Jonkel 1980, p. 12; Knight and Judd 1983, p. 188; Anderson *et al.* 2002, pp. 252–253).

In the NCDE, management removals due to grizzly bear conflicts with livestock (on both public and private land) accounted for nearly 33 percent (56 of 171) of all bear management removals and 9 percent (56 of 613) of all known and probably mortalities within the DMA between 1975 and 2019 (MFWP, unpublished data). Only 1 of these 60 mortalities occurred inside the recovery zone within NF lands where several measures to reduce livestock conflicts are in place. The USFS phases out sheep allotments within the recovery zone as opportunities arise and only one active sheep allotment remains inside the recovery zone (USDA FS 2018b, p. 64). The USFS also has closed sheep allotments outside the recovery zone and there are only two active sheep allotments in Zone 1 (USDA FS 2018b, p. 64). Livestock grazing permits on Federal lands include special provisions regarding reporting of conflicts, proper food storage and attractant storage procedures, and carcass removal to reduce the potential for depredation (USDA FS 2018d, pp. 1-10, 1-22, 1-34, 1-45; USDA FS 2018e, pp. 80–81;). We expect the USFS will continue to implement these measures that reduce grizzly bear conflicts with livestock and limit allotments to baseline levels (see *Habitat Destruction and Modification* for further discussion; USDA FS 2018d, pp. 1-10, 1-22, 1-34, 1-45; USDA FS 2018e, pp. 80–81). The NCDE Conservation Strategy also recognizes that removal of individual conflict bears is sometimes required, as many livestock depredations involve a few individual bears (Jonkel 1980, p. 12; Knight and Judd 1983, p. 188; Anderson *et al.* 2002, pp. 252–253; NCDE Subcommittee 2018, Chapter 4).

In the SE, management removals due to grizzly bear conflicts with livestock accounted for 33 percent (1 of 3) of all management removals. In the CYE, livestock depredation was a co-factor in one of the removals due to site conflicts included above.

Strategy for Management Removals

The Interagency Grizzly Bear Guidelines (Guidelines) plans guide decisions about management removals of conflict bears and keep this source of human-caused mortality within the mortality limits (USDA FS 1986c, pp. 53–54), emphasizing the individual's importance to the entire population. Females will continue to receive a higher level of protection than males. Location, cause of incident, severity of incident, history of the bear, health, age, and sex of the bear, and demographic characteristics are all considered in any relocation or removal action. State, Tribal, and NPS bear managers coordinate and consult with each other and relevant Federal agencies (i.e., Service, USFS, BLM) about conflict bear relocation and removal decisions (50 CFR 17.40). The Guidelines, the 2016 GYE Conservation Strategy, and the NCDE Conservation Strategy emphasize removal of the cause of the conflict when possible, or management and education action to limit such conflicts. In addition, the I&E team coordinates the development, implementation, and dissemination of programs and materials to aid in preventative management of human-bear conflicts. Federal, State, and Tribal partners recognize that successful management of human-grizzly bear conflicts requires an integrated, multi-agency approach to continue to keep human-caused grizzly bear mortality within sustainable levels.

Overall, we consider agency management removals a necessary component of grizzly bear conservation. Conflict bears can become a threat to human safety and erode public support if they are not addressed. However, we recognize the importance of managing these sanctioned removals within sustainable levels, and Federal, Tribal, and State management agencies are committed to working with citizens, landowners, and visitors to address unsecured attractants to reduce the need for grizzly bear removals. Mortality limits (see discussion on *Mortality Limits* below) currently in place ensure that overall mortality, including management removals, remains within sustainable limits.

Accidental Killings

Humans kill grizzly bears unintentionally in a number of ways, including vehicle collisions, train collisions, unintentional poisoning, drowning, electrocution, and mortalities associated with research trapping. Accidental killings as a result of unintentional poisoning, electrocution, and drowning in irrigation canals are extremely low, as evidenced in the discussion below.

Accidental Killings in the GYE

From 2002 to 2019, there were 41 reported accidental mortalities inside the DMA (totaling 12 percent of human-caused mortality for this time period) (van Manen 2020, *in litt.*).

Automobile collisions accounted for 9 percent (32 of 340) of human-caused mortality from 2002 to 2019 (van Manen 2020, *in litt.*). Measures to reduce vehicle collisions with grizzly bears include removing roadkill carcasses from the road so that grizzly bears are not attracted to the roadside (Servheen *et al.* 2004, p. 28). Cost-effective mitigation efforts to facilitate safe crossings by wildlife will be voluntarily incorporated in highway construction or reconstruction projects on Federal lands within suitable grizzly bear habitat (YES 2016a, pp. 82–83).

For the first time since 1982, there were grizzly bear mortalities possibly associated with scientific research capture and handling in 2006. That year, four different bears died within 4 days of being captured, most likely from clostridium infections, but the degraded nature of the carcasses made the exact cause of death impossible to determine. In 2008, two more grizzly bear mortalities suspected of being related to research capture and handling occurred. A necropsy confirmed the cause of death for one of these bears as a clostridium infection at the anesthesia injection site. Once the cause of death was confirmed, the IGBST changed its handling protocol to include antibiotics for each capture (Haroldson and Frey 2009, p. 21). There has not been a research-related capture mortality from clostridium infection since. In 2013, a snared subadult female grizzly bear killed by a large, probably male bear (Haroldson and Frey 2013, p. 27). In 2019, a subadult male that died from exertional myopathy in a culvert trap before it was drugged (Haroldson 2020, *in litt.*). IGBST's rigorous protocols and adaptive approach dictating proper bear capture, handling, and drugging techniques have effectively reduced the risk of mortality due to captures.

Accidental poisonings accounted for less than 1 percent (1 of 340) of human-caused mortality from 2002 to 2019 (van Manen 2020, *in litt.*). This accidental poisoning was the unintended result of a grizzly bear consuming rat poison and Coleman fuel when it raided a backcountry camp (Haroldson 2019c, *in litt.*).

Accidental killings of grizzly bears in the GYE comprise a small portion of total mortalities and are factored into total mortality limits (described in detail in *Mortality Limits* below) which limit their impact on population resiliency.

Accidental Killings in the NCDE

From 1975 to 2019, 86 reported accidental mortalities accounted for 14 percent of all recorded human-caused mortalities in the DMA (MFWP, unpublished data). Since 1975, there have been 18 capture related mortalities (totaling 3 percent of human-caused mortality) (MFWP, unpublished data). However, from 2004 to 2019, only around 1 percent of captures resulted in mortality; more than half of these mortalities occurred in situations where bear managers were responding to conflict situations, when and where conditions for capture are sometimes problematic (MFWP, unpublished data). For example, when trapping at a livestock carcass for a livestock killing bear, multiple bears, including family groups, are frequently attracted to the trap site and this may increase chances of intraspecific mortality. This type of accidental mortality is rare because of the rigorous protocols and adaptive approach dictating proper bear capture, handling, and drugging techniques.

Automobile and train collisions accounted for 11 percent (66 of 613) of human-caused mortality from 1975 to 2019 (MFWP, unpublished data). These mortality sources have increased significantly since 2000, likely due to the growth and expansion of grizzly bear populations and increasing vehicle traffic. Measures to reduce vehicle and train collisions with grizzly bears include removing roadkill carcasses from the road and spilled grain and carcasses from railways so that grizzly bears are not attracted to the roadside/railway (Servheen *et al.* 2004, p. 28; Service 2004, entire). Wildlife crossing structures, with guide fencing, can also be very effective at reducing highway collisions; however, they require significant resources and long-term planning. All of these measures are being implemented to varying degrees in different parts of the NCDE (NCDE Subcommittee 2018) and have been successful in reduced the potential for mortalities caused by train collisions. In addition, the signatories to the NCDE Conservation Strategy have been cooperating for many years to improve protections for wildlife traversing highways and this is expected to continue (Dood 2006, p. 43; NCDE Subcommittee 2018, Chapter 3; USDA FS 2018c, p. 33; USDA FS 2018d, p. 2). Montana Department of Transportation and MFWP recently signed a MOA to institutionalize cooperation and collaboration of wildlife and transportation issues (MT Department of Transportation and MFWP 2020). Also, the two agencies co-convened the Montana Wildlife and Transportation Summit to strengthen working relationships between stakeholders, share information, and develop strategies to plan and implement wildlife accommodations; reduce animal-vehicle collisions; and protect wildlife and their movement across state highways.

Accidental poisonings accounted for less than 1 percent (2 of 613) of human-caused mortality from 1975 to 2019 (MFWP, unpublished data). Both of the accidental poisonings were the unintended result of grizzly bears consuming poison that was targeting rodents.

Accidental killings of grizzly bears in the NCDE comprise a small portion of total mortalities and are factored into total mortality limits (described in detail in *Mortality Limits* below), which limit their impact on population resiliency.

Accidental Killings in the CYE and SE

From 1982 to 2019, 9 percent (4 of 47) of all human-caused mortalities in the CYE and 4 percent (1 of 27) of all human-caused grizzly bear mortalities in the SE were accidental (Kasworm *et al.* 2020a, p. 33; Kasworm *et al.* 2020b, p. 23). In the CYE, three of these accidental mortalities, all females, were the result of collisions with trains. The fourth accidental mortality in the CYE was capture-related mortality and was the result of another grizzly bear killing a smaller grizzly bear trapped in a foot snare for research purposes. This type of accidental mortality is rare because of the rigorous protocols and adaptive approach dictating proper bear capture, handling, and drugging techniques. In the SE, the single accidental mortality was due to a train collision.

Measures to reduce vehicle and train collisions with grizzly bears include removing roadkill carcasses from the road and spilled grain and carcasses from railways so that grizzly bears are not attracted to the roadside/railway (Servheen *et al.* 2004, p. 28; Service 2004, p. entire). Although these measures can be successful in reducing the percentage of human-caused mortalities caused by train collisions there are currently no HCPs in the CYE or SE mandating adoption of such measures. There are three rail lines that pass through or alongside the CYE and SE operated by BNSF, Montana Rail Link, and Union Pacific Railroad. Without mitigation plans in place, there is potential for the frequency of vehicle and train collisions to increase as the population recovers, such that train mortalities to influence the resiliency of the CYE and SE.

Mistaken Identity Killings:

Mistaken identity killings are both accidental and illegal. Mistaken identification is prosecuted as illegal take, with any grizzly bear mortality fully investigated to determine cause. This will likely always be a source of mortality due to the similarity of appearance between black bears and grizzly bears. However, preventative actions, such as I&E programs targeted at hunters to emphasize patience, awareness, and correct identification of targets can reduce this type of mortality. Black bear hunting over bait is allowed in portions of Idaho and Wyoming outside of occupied grizzly bear range in the GYE, CYE, and SE and has resulted in some mistaken identity mortality. Black bear hunting over bait is not allowed in Montana or Washington.

Mistaken Identity Killings in the GYE

Twenty-four mortalities (7 percent of human-caused mortality) were associated with mistaken identification of grizzly bears by black bear hunters within the DMA from 2002–2019 (van Manen 2020, *in litt.*). Four of these mistaken identity mortalities occurred over bait in

Wyoming. The 2016 GYE Conservation Strategy identifies I&E programs targeted at hunters that emphasize patience, awareness, and correct identification of targets to help reduce grizzly bear mortalities by inexperienced black bear and ungulate hunters (YES 2016a, pp. 92–95). Beginning in license year 2002, the State of Montana required that all black bear hunters pass a Bear Identification Test before receiving a black bear license (see *http://fwp.mt.gov/education/hunter/bearID/* for more information and details). Idaho and Wyoming provide a voluntary bear identification test online (IDFG 2011; WGFD 2016, p. 16). In addition, all three States include grizzly bear encounter management as a core subject in basic hunter education courses. Although we have no information on the effectiveness of these programs, we assume they have some positive impact on reducing the threat of mortality due to mistaken identification. Mistaken identity killings are factored into total mortality limits (described in detail in *Mortality Limits* below), and I&E programs aimed at preventing mistaken identification killings limit potential risks to the GYE grizzly bear population from this stressor.

Mistaken Identity Killings in the NCDE

Mistaken identification of grizzly bears by black bear hunters accounted for 6 percent (39 of 613) of human-caused grizzly bear mortalities in the DMA from 1975 to 2019. Beginning in license year 2002, the State of Montana required that all black bear hunters pass a Bear Identification Test before receiving a black bear license (see *http://fwp.mt.gov/education/hunter/bearID/*). In addition, the NCDE Conservation Strategy identifies I&E programs targeted at hunters that emphasize patience, awareness, and correct identification of targets to help reduce grizzly bear mortalities from inexperienced black bear and ungulate hunters (Dood *et al.* 2006, p. 54; NCDE Subcommittee 2018, Chapters 1 and 4). As in the GYE, mistaken identity killings are factored into total mortality limits (described in detail in *Mortality Limits* below), and I&E programs aimed at preventing mistaken identification killings limit potential risks to the population.

Mistaken Identity Killings in the CYE, SE, BE, and North Cascades

From 1982 to 2019, mistaken identification of grizzly bears by black bear hunters accounted for 17 percent (8 of 47) of human-caused mortalities in the CYE and 26 percent (7 of 27) of human-caused grizzly bear mortalities in the SE (Kasworm *et al.* 2020a, p. 33; Kasworm *et al.* 2020b, p. 23). In addition, there was one mistaken identification killing of a grizzly bear over bait inside the BE, which originated from the SE and occurred outside but in close proximity to the recovery zone. One other instance of mistaken identity killing of a grizzly bear over bait occurred in the area between the CYE and BE. Both Idaho and Washington launched educational campaigns in 2011 to reduce mistaken identity by black bear hunters by teaching them how to correctly identify the two bear species. Idaho also offers a voluntary online bear identification test (https://idfg.idaho.gov/hunt/bear-info/overview). Beginning in 2019, Washington State required black bear hunters hunting in grizzly bear recovery areas to take the bear identification test on the WDFW website or an equivalent test from another state (WDFW 2019, p. 70). Reducing this source of human-caused mortality is especially desirable in the CYE and SE due to the small population size, in the BE and North Cascades where there are currently no known populations, and in potential connectivity areas between the ecosystems.

Illegal Killings

We define poaching as intentional, illegal killing of grizzly bears. People may kill grizzly bears for several reasons, including a general perception that grizzly bears in the area may be dangerous, frustration over livestock depredations, or to protest land-use and road-use restrictions associated with grizzly bear habitat management (Servheen *et al.* 2004, p. 21). Regardless of the reason, poaching continues to occur.

State and Federal law enforcement agents have cooperated to ensure consistent enforcement of laws protecting grizzly bears. Currently, State and Federal prosecutors and enforcement personnel from each State and Federal jurisdiction work together to make recommendations to all jurisdictions, counties, and States on uniform enforcement, prosecution, and sentencing relating to illegal grizzly bear kills. This cooperation means illegal grizzly bear mortalities are often prosecuted under State statutes instead of the Act. The U.S. Department of Justice's "McKittrick Policy" requires proof of intent, that the individual knowingly killed a listed species under the Act, for Federal prosecution. However, intent is not necessary for prosecution under State law. During an investigation, the investigative officers usually meet with both local and Federal attorneys to decide if prosecution will be more successful under State or Federal jurisdiction. In most instances where the U.S. Attorney has declined prosecution conflicts, the States have taken over those prosecutions through State courts. There have been successful prosecutions under both Federal and State laws. There is a long record of this enforcement approach being effective, and no reason to doubt its effectiveness.

Illegal killings are factored into mortality limits for each ecosystem, and I&E campaigns (described in detail in *Preventative Measures*) are used to reduce the potential threat of poaching. These programs address illegal killing by working to change human perceptions and beliefs about grizzly bears, and lack of tolerance to some restrictions on use of Federal lands designed for grizzly bear protection (Servheen *et al.* 2004, p. 27).

Illegal killings in the GYE

We are aware of at least 22 illegal killings in the GYE DMA between 2002 and 2019 (van Manen 2020, *in litt.*). This constituted 6 percent of known grizzly bear mortalities from 2002 to 2019. These illegal killings occurred during a period when poaching was subject to Federal prosecution. Independent of the Act, all three affected States and the Eastern Shoshone and Northern Arapaho Tribes of the WRR have enacted regulatory mechanisms that require State or Tribal authorization for grizzly bear take, with illegal poaching remaining prosecutable under State and Tribal laws because grizzly bears are designated as a game animal (W.S. 23-1-101(a)(xii)(A); W.S. 23-3-102(a); MCA 87-2-101(4); MCA 87-1-301; MCA 87-1-304; MCA 87-5-302; IC 36-2-1; IDAPA 13.01.06.100.01(e); IC 36-1101(a); Idaho's Yellowstone Grizzly Bear Delisting Advisory Team 2002, pp. 18–21; MFWP 2013, p. 6; Eastern Shoshone and Northern Arapahoe Tribes 2009, p. 9; WGFD 2016, p. 9; YES 2016a, pp. 104–116). Although it is widely recognized that poaching still occurs, illegal killings of grizzly bears in the GYE comprise a small portion of total mortalities and are factored into total mortality limits (described in detail in *Mortality Limits* below), which limit their impact on population resiliency.

Illegal killings in the NCDE

From 1975–2019, at least 128 illegal killings occurred within the NCDE DMA, constituting 21 percent of known grizzly bear mortalities (MFWP, unpublished data). Independent of the Act, the State of Montana and the Tribes have enacted regulatory mechanisms that require State or Tribal authorization for grizzly bear take, with illegal poaching remaining prosecutable under State and Tribal laws, since grizzly bears are designated as a game animal (MCA § 87-2-101(4); MCA 87-1-301; MCA 87-1-304; MCA 87-5-302; FIR Tribal Ordinance 44D; Blackfeet Business Council 2018, p. 29; NCDE Subcommittee 2018, Chapter 6). Illegal killings continue to occur but are not a level significant to hinder population stability or range expansion.

Illegal killings in the CYE, SE, BE, and North Cascades

From 1982 to 2019, at least 8 illegal killings occurred in the CYE and at least 5 illegal killings occurred in the SE, constituting 17 and 18 percent of known human-caused grizzly bear mortalities, respectively (Kasworm *et al.* 2020a, p. 33; Kasworm *et al.* 2020b, p. 23). In addition, there was one illegal killing in the connectivity areas between the CYE and BE of a bear that originated from the NCDE as part of the augmentation program. Independent of the Act, the States of Idaho, Montana, and Washington have regulations that make it illegal to kill a grizzly bear other than in defense of life (ARM 14.9.1403; IDAPA 13.01.06.100.01(e); Washington Administrative Code 220-610-010). While we recognize that illegal killings will never be eliminated entirely, reducing this source of human-caused mortality is desirable in the CYE and SE due to the small population sizes.

Defense of Life Killings

Grizzly bears may be legally taken in self-defense or in defense of others (50 CFR 17.40(b)). In the GYE DMA, from 2002 to 2019, 32 percent (109 of 340) of human-caused grizzly bear mortalities were self-defense or defense of other person kills (van Manen 2020, *in litt.*). In the NCDE DMA, from 1975 to 2019, 10 percent (61 of 613) of human-caused grizzly bear mortalities were self-defense or defense of other person kills (MFWP, unpublished data). In the CYE, from 1982 to 2019, 17 percent (8 of 47) of human-caused mortalities were from self-defense or defense of other person kills (Kasworm *et al.* 2020a, p. 33). These grizzly bear mortalities occurred primarily with elk hunters on public lands during the fall, but also at other times and locations (IGBST 2009, p. 18; Haroldson 2019b, *in litt.*; MFWP, unpublished data). Self-defense situations often occur during surprise encounters, at hunter-killed carcasses or gut piles, or when packing out carcasses. Federal and State agencies have many options to potentially reduce conflicts with hunters (IGBST 2009, pp. 21–31), but self-defense mortalities will always be a reality when conserving a species that is capable of killing humans. By promoting the use of bear spray and continuing I&E programs pertaining to food and carcass storage and retrieval, risk to hunters can be substantially reduced and many of these grizzly bear deaths can be avoided. Only one defense of life kill has occurred in the U.S. portion of the SE from 1982–2019 (Kasworm *et al.* 2020b, p. 23). Defense of life mortalities will always occur with a species that can pose a threat to humans; however, they are factored into mortality limits (see discussion on *Mortality Limits* below), and this source of mortalities is not a limiting factor to the resiliency of grizzly bear populations in the lower-48 States.

Preventative Measures to Address Public Attitudes towards Grizzly Bears and Reduce Mortality

This section discusses preventative measures used to affect human attitudes toward grizzly bears, thereby reducing future human-caused mortality. Public support is paramount to any successful large carnivore conservation program (Servheen 1998, p. 67). Historically, human attitudes played a primary role in grizzly bear population declines by promoting a culture and government framework that encouraged excessive, unregulated, human-caused mortality. Through government-endorsed eradication programs and perceived threats to human life and economic livelihood, Europeans settling the Western United States were able to effectively eliminate most known grizzly bear populations after less than 100 years of westward expansion. Attitudes about grizzly bears vary geographically and demographically; however, positive attitudes toward the grizzly bear and its conservation are more prevalent now than in previous decades (Kellert *et al.* 1996, pp. 983–986). We discuss three strategies that proactively prevent grizzly bear mortality: (1) I&E programs; (2) food storage orders; (3) and hazing guidelines.

I&E Programs

Although some human-caused grizzly bear mortalities are accidental (e.g., vehicle collisions), management removals in response to human-grizzly bear conflicts, defense of life kills, mistaken identity killings, and illegal killings are responsible for the majority of known and probable human-caused mortalities. These sources of mortality can be reduced if adequate I&E are provided to people who live, work, and recreate in occupied grizzly bear habitat and if proper management infrastructure is in place (Linnell *et al.* 2001, p. 345). Public outreach presents an opportunity to effectively integrate human and ecological concerns into comprehensive programs that can modify societal beliefs about, perceptions of, and behaviors toward grizzly bears.

The objective of I&E is to proactively address human-grizzly bear conflicts by informing the public about the root causes of these conflicts and providing suggestions on how to prevent them (YES 2016a, pp. 92–95). Increasing awareness of grizzly bear behavior, ecology, and biology, can enhance appreciation of the grizzly bear, increase public involvement, and correct common misconceptions about its temperament and feeding habitats. By identifying values common to certain user groups, I&E working groups can disseminate appropriate materials and provide workshops catered to these values, contributing to the continued coexistence between grizzly bears and humans. Additionally, I&E programs foster relationships and build trust between the general public and the government agencies implementing them by initiating communication and dialogue. Effective I&E programs have been an essential factor contributing to progress towards the recovery of the grizzly bear populations in the lower-48 States since its listing in 1975.

Servheen *et al.* (2004, p. 15) estimated that from 1980 through 2002, at least 36 percent (72 out of 196) of human-caused mortalities in the GYE may have been avoided if relevant I&E materials had been presented and used by involved parties. Educating back- and front-country users about the importance of securing potential bear attractants can reduce grizzly bear mortality risk. Similarly, adhering to hiking recommendations, such as making noise, hiking with other people, and hiking during daylight hours, can further reduce grizzly bear mortalities by decreasing the likelihood that hikers will encounter bears. Hunter-related mortalities may involve hunters defending their life because of carcasses that are left unattended or stored improperly. Grizzly bear mortalities also occur when hunters mistake grizzly bears for black bears. Many of these circumstances can be further reduced through I&E programs.

Another source of animosity towards grizzly bears is disagreement over land-use restrictions in place to enhance recovery of the species; effective I&E programs can address this too. Traditionally, stakeholders involved in resource extraction industries, such as loggers, miners, livestock operators, and hunting guides, were opposed to land-use restrictions that were perceived to place the needs of the grizzly bear above human needs (Kellert 1994, p. 48; Kellert *et al.* 1996, p. 984). Surveys of these user groups have shown that they tolerate large predators when they are not seen as direct threats to their economic stability or personal freedoms (Kellert *et al.* 1996, p. 985). To address the concerns of user groups who have objections to land use restrictions that accommodate grizzly bears, Federal and State agencies market the benefits to multiple species of restricting motorized access. For example, both Montana and Wyoming have recommendations for elk habitat security similar to those for grizzly bears (road densities of less than 0.6 km/km^2 (1 mi/mi^2)). This level of motorized access for elk habitat security meets the needs of a variety of wildlife species, while maintaining reasonable opportunities for public access.

I&E teams for the GYE, NCDE, SE/CYE, BE, and North Cascade IGBC Subcommittees and the IGBC Executive Committee coordinate the development, implementation, and dissemination of programs and materials to aid in preventative management of human-bear conflicts. I&E team members include the Service, State wildlife agencies, Tribal wildlife agencies, the NPS, and the USFS. These partners recognize that public I&E programs are a crucial key to preventing human-grizzly bear conflicts, which is evidenced by the fact that they have been actively involved in grizzly bear I&E outreach for over a decade.

In the GYE, all three States have been actively involved in I&E outreach for several decades, and their respective management plans contain chapters detailing efforts to continue current programs and expand them when possible. For example, the WGFD created a formal human-grizzly bear conflict management program in July 1990 and has coordinated an extensive I&E program since then. Similarly, since 1993, MFWP has implemented countless public outreach efforts to minimize human-bear conflicts, and the IDFG has organized and implemented education programs and workshops focused on private and public lands on the western periphery of the grizzly bear's range. To address public attitudes and knowledge levels, I&E programs present grizzly bears as a valuable public resource while acknowledging the potential dangers associated with them and ways to avoid conflicts. I&E programs are integral components of the 2016 GYE Conservation Strategy and will continue to be implemented by all partners whether the GYE grizzly bear is listed or not (YES 2016a, pp. 92–95).

In the NCDE, the State of Montana and Tribal entities recognize that public I&E programs are a crucial key to preventing human-grizzly bear conflicts. The State of Montana, CS&KT, and Blackfeet Nation have been actively involved in grizzly bear I&E outreach for over a decade, and their respective grizzly bear management plans contain chapters detailing efforts to continue current programs and expand them when possible (Servheen *et al.* 1981, pp. 17–29; Dood *et al.* 2006, pp. 31–38, 62–65; Blackfeet Tribal Business Council 2013, pp. 3–4, 9–10; NCDE

Subcommittee 2018, Chapter 4). Their management plans also acknowledge that public outreach is the most effective, long-term solution to human-grizzly bear conflicts and that I&E programs are paramount in driving successful coexistence between humans and bears in the NCDE. We have no independent data to confirm the success of the I&E programs, but we consider the increase in the NCDE grizzly bear population from 2004 to 2018 to be some evidence of success (Mace *et al.* 2012, p. 124; Costello *et al.* 2016, p. 2; MFWP, unpublished data), since this 2 to 3 percent annual growth rate occurred despite large increases in people living and recreating in the NCDE over the last 3 decades.

In the CYE, SE, BE, and North Cascades, I&E efforts include: public meetings; community events; informational posters, brochures, and bear identification sheets; bear-resistant containers; electric fencing; and funding of outreach by non-governmental agencies. The State of Montana contains detailed I&E efforts in its grizzly bear management plan (Dood *et al.* 2006, pp. 31–38, 62–65) and hired a bear conflict specialist for northwest Montana in 2007. A recent study documented the success of these efforts with a decrease in the level of human-caused grizzly bear mortality in the northwest Montana portion of the CYE after the hiring of the bear conflict specialist, supporting the success of these I&E programs (Proctor *et al.* 2018, p. 359). Further support of this success is the recent increase in the CYE grizzly bear population and the positive population trend since 2012 after a decade-long decline (Kasworm *et al.* 2020a, p. 40).

Public attitude surveys towards grizzly bears and their management have been conducted in both the North Cascades and CYE (Duda *et al.* 1996, entire; Canepa *et al.* 2008, entire). These surveys posed questions about public understanding and perception of grizzly bear biology and management and then were used to craft I&E programs to address and identified needs (Morgan *et al*. 2004, entire; Annis and Trimbo 2019, entire). The Grizzly Bear Outreach Program in the North Cascades is an example of a nongovernmental organization providing educational efforts in Washington with field representatives in small communities.

Food Storage Orders

Mandatory food storage orders on public lands decrease the chance of human-grizzly bear conflicts and reduce risks for both humans and grizzly bears. In addition, State and Federal I&E programs reduce human-grizzly bear conflicts on both private and public lands by educating the public about potential grizzly bear attractants and how to store them properly. Accordingly, the majority of grizzly bear budgets of the agencies responsible for managing grizzly bear populations in the lower-48 States is for human-grizzly bear conflict management, outreach, and education. The relationship between human food baiting by black bear hunters and subsequent conflict activity by bears may be an issue in areas of Idaho and Wyoming where baiting is allowed. Black bear baiting is limited and regulated by Idaho Department of Fish and Game (IDFG 2020, pp. 69–70) and Wyoming Fish and Game (WDFG 2020, pp. 3-2–3-6). Black bear baiting is not allowed in Montana.

In the GYE, food storage rules aimed at decreasing grizzly bear access to human foods are enforced on the 98 percent of lands inside the DMA managed by the USFS and NPS (USDA FS 2008, 2014a, 2014b, 2016, entire; YES 2016, pp. 84–85; GTNP 2019, p. 24; YNP 2019, pp. 34–35). In addition, food storage restrictions include most USFS lands and some Montana wildlife management areas where connectivity with the NCDE and/or BE are most likely to occur (USDA FS 2014b, entire; YES 2016, pp. 84–85; Montana Fish and Wildlife Commission 2019, pp. 5, 7–9).

In the NCDE, on NPS, USFS, and Tribal lands inside the recovery zone, Zone 1 including the DCAs, and Zone 2, food storage rules are aimed at decreasing grizzly bear access to human foods (NCDE Subcommittee 2018, Chapter 4; NPS 2010, p. 4; GNP 2019, pp. 12–18; Blackfeet Tribal Business Council 2018, p. 28; CS&KT 2018, p.10; USDA FS 2018d, pp. 9, 1-5, 1-17, 1-29, 1-40; USDA FS 2018e, p. 50). In addition, food storage orders occur on most State lands (Dood *et al.* 2006; ARM 12.8.201 and 12.8.210; DNRC 2010a, p. 4-436).

All three NFs (Idaho Panhandle, Lolo, and Kootenai) within the CYE and both NFs (Idaho Panhandle and Colville) in the SE have made food storage requirements mandatory in portions of the grizzly bear range (USDA FS 2011a, pp. 6–7; USDA FS 2015a, pp. 31, 33; USDA FS 2015b, pp. 31, 34; USDA FS 2018, p. 61).

In the BE recovery zone, there are no food storage orders on the NFs that manage nearly 100 percent of the BE recovery zone. The lack of mandatory food storage orders on USFS lands within the BE recovery zone may contribute to future grizzly bear mortality risk and inhibit natural recolonization.

In the North Cascades recovery zone, mandatory food storage orders are in effect in North Cascades NP (Title 36 CFR chapter 1, section 2.10(d) and section 2.2(a)(2)); however, there are no food storage orders on 75 percent of lands managed by the USFS. The lack of mandatory food storage orders on USFS lands within the North Cascades recovery zone may contribute to future grizzly bear mortality risk and inhibit restoration efforts.

Hazing Guidelines

As grizzly bear populations have expanded, more bears are using areas in or near human developments causing concern from the public. Because of these concerns, the Service developed guidelines on safe, legal hazing techniques to discourage grizzly bears from using areas near homes and other human-occupied areas (Service 2020, entire). The guidance describes techniques that the public may use to deter grizzly bears away from the immediate vicinity of a human-occupied residence or potential conflict area. The use of safe and legal hazing techniques prevents grizzly bears from becoming habituated to humans or conditioned to human foods, which can become a human-safety issue, and often results in removal of the bear. Successful hazing should result in fewer bears near homes, fewer human-bear conflicts, and ultimately, improved attitudes.

Summary of Conservation Efforts that reduce Human-Caused Mortality

In addition to the I&E programs, food storage orders, and hazing guidelines discussed above, the States and NGOs have implemented other programs to help reduce conflicts with the people that are directly affected by grizzly bears. These efforts include livestock carcass removal programs, electric fencing subsidies for apiaries and orchards, and sharing costs of bear-resistant garbage bins where appropriate. Moreover, annual reports are prepared by the IGBST for the GYE, MFWP for the NCDE, and the Service for the CYE and SE, analyzing the causes of conflicts, known and probable mortalities, and proposed management solutions (Servheen *et al.* 2004, pp. 1–29; DeBolt *et al.* 2018, pp. 84–89; Frey and Smith 2018, pp. 78–83; Gunther *et al.* 2018a, pp. 70–74; Gunther *et al.* 2018b, pp. 91–96; Gunther *et al.* 2018c, pp. 97–102; Hnilicka 2018, p. 90; Nicholson and Hendricks 2018, pp. 75–77; Wilmot 2018, p. 69; Costello and Roberts 2020, Appendix C; Kasworm *et al.* 2020a, p. 33–34; Kasworm *et al.* 2020b, p. 23). The responsible agencies have committed to continuing to use these data to identify where problems occur and compare trends in locations, sources, land ownership, and types of conflicts to inform proactive management of human-grizzly bear conflicts. The IGBST and Yellowstone Grizzly Coordinating Committee[9] (YGCC) implemented this adaptive management approach when the GYE grizzly bear population was delisted between 2007 and 2009. After high levels of mortality in 2008, the IGBST provided management options to the YGCC about ways to reduce human-caused mortality. In fall 2009, the YGCC provided updates on what measures they had implemented since the report was released the previous spring. These efforts, conducted through I&E and State fish and game agencies, included: increased outreach on the value of bear spray; development of a comprehensive encounter, conflict, and mortality database; and increased agency presence on USFS lands during hunting season (YGCC 2009, entire). In response to a recent increase in conflicts in the GYE and NCDE as their distributions expand, the IGBC and each ecosystem subcommittee is currently reevaluating recent sources of human-caused mortality and preventative measures. Based on the analysis provided above, we conclude that negative attitudes can be improved through I&E programs and proactive conflict reduction measures, such as food storage orders and hazing guidelines; negative attitudes are not currently limiting to grizzly bear populations.

Mortality Limits

Human-caused mortality is the primary factor affecting grizzly bears at both the individual and population levels. Understanding and managing for sustainable mortality levels is necessary to facilitate and maintain recovery.

Mortality limits in the GYE

In partnership with the States, other Federal Agencies, and Tribes in the GYE, we have developed a mortality management scheme to ensure sustainable mortality limits within the DMA and to maintain recovery within the GYE. The population inside the DMA has stabilized since 2002, with the model-averaged Chao2 population estimate for 2002–2014 being 674 bears (95% CI = 600–747). This stabilization over 13 years is strong evidence that the population is exhibiting density-dependent population regulation inside the DMA, which has recently been documented (van Manen *et al.* 2016, entire) and is further evidence that the population has achieved recovery within the DMA. The population in the DMA is managed to maintain the population around the long-term average population size for 2002–2014 of 674 bears (95% CI = 600–747) (using the model-averaged Chao2 population estimate), consistent with the revised

[9] The Yellowstone Grizzly Coordinating Committee replaces the Yellowstone Ecosystem Subcommittee (YES) upon delisting and implementation of the GYE Conservation Strategy. The YGCC replaced YES when grizzly bears in the GYE DPS were delisted between 2007 and 2009.

demographic recovery criteria (Service 2017, entire). Population growth inside the DMA has slowed and stabilized at this population size, and the long-term model-averaged Chao2 estimate of 674 bears represents a population level that is at or near carrying capacity in the core area of its range (van Manen *et al.* 2016, entire). The model-averaged Chao2 population estimator is used by the IGBST to annually estimate population size inside the DMA (YES 2016a, pp. 38–40), as this currently represents the best available science. By attempting to manage within the 95 percent confidence interval (600–747), in accordance with demographic recovery criterion #3, there is a sufficient buffer to ensure that recovery is achieved, while also acknowledging that populations fluctuate naturally and that it is not reasonable to manage to an exact population target. To achieve a population in the DMA that remains around the 2002–2014 average of 674, total mortality is limited to <7.6 percent for independent females when the population is at or below 674, with higher mortality limits when the population is higher than 674 (as per Table 9 in *Demographic Recovery Criterion 3 for the GYE*). A total mortality rate of 7.6 percent for independent females is the mortality level that the best available science shows results in population stability (IGBST 2012, entire). Annual estimates of population size in the DMA are derived each fall by the IGBST from the model-averaged Chao2 estimate of females with cubs-of-the-year (i.e., the model-averaged Chao2 population estimate). These annual estimates normally vary as in any wild animal population. Dependent on the annual population estimate, mortalities are managed on a sliding scale within the DMA as set summarized in Chapter 3 (Table 9).

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Total annual allowable mortality numbers are calculated each year by multiplying the total annual mortality rate by the size of each sex/age cohort, which varies with population size, from the previous year. Total mortality includes documented known and probable grizzly bear mortalities from all causes, including but not limited to: management removals, illegal kills, mistaken identity kills, self-defense kills, vehicle kills, natural mortalities, undetermined-cause mortalities, grizzly bear hunting, and a statistical estimate (Cherry *et al.* 2002, entire) of the number of unknown/unreported mortalities.

Mortality limits in the NCDE

In partnership with the States, other Federal Agencies, and Tribes in the NCDE, we manage human-caused mortalities as in demographic recovery criterion #3. Recently, the agencies agreed to also manage mortalities from all sources to support a greater than or equal to 90 percent estimated probability that the grizzly bear population within the DMA remains above 800 individuals, considering the uncertainty associated with the demographic parameters (NCDE Subcommittee 2018, Chapter 2; ARM 12.9.1403). In order to consider this uncertainty, the model that estimates the probability that the population is above 800 individuals incorporates the standard error associated with calculating survival rates for all age/sex classes (e.g., cubs, yearlings, independent males, and independent females) and reproductive parameters (e.g., proportion of females with cubs and litter size). The methods to determine thresholds for independent female survival, independent female mortality, and independent male mortality that allow achievement of this objective into the future are set forth in the NCDE Conservation Strategy (NCDE Subcommittee 2018, Chapter 2 and Appendix 3).

Population modeling based on vital rates from Costello *et al.* (2016, entire), indicates that the estimated probability that the NCDE grizzly bear population was greater than 800 bears was only 21 percent in 2004; increased to greater or equal to 90 percent in 2010; and has been greater or equal to 99 percent since 2015 (NCDE Subcommittee 2018, Chapter 2; Costello 2018, *in litt.*). Given the current rates and levels of uncertainty, managing the NCDE grizzly bear population with a greater than or equal to 90 percent estimated probability of being above 800 bears necessitates maintaining an estimated population size of approximately 950–1,000 bears. Larger estimated population sizes are needed if the level of uncertainty increases (NCDE Subcommittee 2018, Chapter 2).

As outlined in the NCDE Conservation Strategy (NCDE Subcommittee, Chapter 2), managers use a 6-year running average for independent female survival, independent female TRU mortality[10], and independent male TRU mortality to:

- Maintain an estimated annual survival rate of independent females within the DMA of at least 90 percent and a rate at or above the minimum level consistent with a projected probability of at least 90 percent that the population within the DMA will remain above 800 bears based on population modeling;
- Limit the annual estimated number of TRU mortalities of independent females within the DMA to a number that is no more than 10 percent of the number of independent females estimated within the DMA based on population modeling and a number that is at or below the maximum level consistent with a projected probability of at least 90 percent that the population within the DMA will remain above 800 bears based on population modeling;

[10] Total reported and unreported mortalities (TRU mortality) – an estimate of the total number of mortalities of independent bears within the DM, by sex, representing the sum of documented management removals, documented radio-marked deaths, and an estimate of other reported and unknown/unreported mortality calculated using the Cherry *et al.* (2002) method based on reported mortalities (excluding management removals and radio-marked removals) and the reporting rate observed among radio-marked bears.

- Limit annual estimated number of TRU mortalities of independent males within the DMA to a number that is no more than 15 percent of the number of independent males estimated within the DMA based on population modeling.

Managers need a number of population parameters to follow this process for calculating allowable mortality limits that meet the population objective of supporting a greater than or equal to 90 percent estimated probability that the grizzly bear population within the DMA remains above 800 individuals: (1) the 6-year running average for the annual survival rate of independent females; (2) annual mortalities for independent males and females in the DMA (i.e. TRUM); and (3) population estimates.

First, the 6-year running averages for the annual survival rate of independent females and the estimated number of TRU mortality for independent females and males within the DMA is calculated and reported annually by the Monitoring Team to the NCDE Subcommittee. Survival is estimated from current and previously collected (preceding five years) radio-telemetry data, using a known-fates statistical analysis that will also incorporate survival data from monitoring since 2004 (NCDE Subcommittee 2018, Appendix 2). Six-year running averages account for two breeding cycles and make estimates less sensitive to sampling variance and annual variability. Survival of independent females has been monitored and reported previously (Mace *et al.* 2012, p. 119; Costello *et al.* 2016, p. 1). Costello *et al.* (2016, pp. 43–44) reported a mean annual survival of 0.95 for all independent females during 2004–2013, and found no evidence for change in the annual rate during that period.

Second, the annual TRU mortalities for each sex in the DMA are calculated and reported annually by the Monitoring Team to the NCDE Subcommittee, and includes documented mortalities from all causes, including known and probable human-caused, natural, and undetermined causes. Estimated numbers of TRU mortality for independent females and males within the DMA have also been calculated and reported previously (Costello *et al.* 2016, p. 32; Costello and Roberts 2016, pp. 8–9; Costello and Roberts 2017, pp. 8–9).

Third, the population estimates used to calculate survival and mortality thresholds for the NCDE DMA are produced by a stochastic population modeling incorporating: (1) the estimated population size of 765 for the NCDE reported by Kendall *et al.* in 2004 (2009, p. 9); and (2) interagency monitoring data estimating vital rates for the population (Costello *et al*. 2016, p. 2). Costello *et al.* (2016, p. 2) estimated the annual population growth rate from 2004 to 2014 at of 2.3 percent and the median estimated population size for the NCDE in 2014 at 960 bears (95% CI = 837, 1,089). No change in vital rates was observed during 2014 to 2017, and updated analyses indicates the NCDE grizzly bear population size in 2019 was 1,068 individuals (95% CI= 890–1,283) (Costello 2019, *in litt.*; Costello 2020, *in litt.*).

Adherence to these survival and mortality thresholds for the DMA is evaluated by the Monitoring Team through continued demographic monitoring, application of stochastic population modeling to track size and trend, and management of mortality of independent female and independent male grizzly bears. The population modeling methods are set forth in detail in Appendices 1 and 2 of the NCDE Conservation Strategy (NCDE Subcommittee 2018) and currently represent the best available science.

Mortality Limits in the CYE and SE

For the CYE and SE, the mortality limits as set forth in demographic recovery criterion 3 of the Recovery Plan continue to apply (Service 1993, p. 33–34). These mortality limits apply within the recovery zone and a 10-mile buffer around the recovery zone. As discussed above in *Recovery Progress*, the mortality limits for the CYE and SE are that known, human-caused mortality cannot exceed 4 percent of the population estimate based on the most recent 3-year sum of females with cubs. No more than 30 percent shall be females. These mortality limits cannot be exceeded during any 2 consecutive years for recovery to be achieved. Although the Recovery Plan established a goal of zero human-caused mortality for the CYE and SE until the minimum population reached approximately 100 bears in the CYE and 90 bears in the SE, it also stated "In reality, this goal may not be realized because human-bear conflicts are likely to occur at some level within the ecosystem."

Mortality Limits in the BE

For the BE, the mortality limits as set forth in demographic recovery criterion 3 of the Recovery Plan Supplement continue to apply (Service 1996, p. 4). The mortality limits apply within the recovery zone and a 10-mile buffer around the recovery zone. As discussed above in *Recovery Progress*, the mortality limits for the BE are that known, human-caused mortality cannot exceed 4 percent of the population estimate based on the most recent 3-year sum of females with cubs. No more than 30 percent shall be females. These mortality limits cannot be exceeded during any 2 consecutive years for recovery to be achieved. Although the Recovery Plan established a goal of zero human-caused mortality for BE until the minimum population reached approximately 90 bears in the BE, it also stated "In reality, this goal may not be realized because human bear conflicts are likely to occur at some level within the ecosystem."

Mortality limits in the North Cascades

Sustainable levels of human-caused mortality were not established in the Recovery Plan Supplement for the North Cascades due to a lack of information for the ecosystem; however, the supplement established a goal of zero known, human-caused mortalities until the "population is large enough to offset some level of human-induced mortality" (Service 1997, pp. 3–4).

Legal Hunting

Legal hunting of grizzly bears has not been allowed in the lower-48 States, except the limited hunt in the NCDE during 1975–1991, since the grizzly bears in the lower-48 States were listed as a threatened species under the Act in 1975 (40 FR 331734, July 28, 1975).

Legal hunting of grizzly bears was allowed in the NCDE from 1975 until 1991, under a special rule authorizing take in the 1975 listing (40 FR 331734, July 28, 1975). During this time, recreational hunting accounted for 50 percent of human-caused mortality in the NCDE (124 of 249). The special rule allowing a limited hunt in the NCDE was removed in 1992 (57 FR 37478, August 19, 1992).

Independent of the Act, the States of Idaho, Montana, and Wyoming, and the Tribes have enacted regulatory mechanisms that require State or Tribal authorization for grizzly bear take, with illegal poaching remaining prosecutable under State and Tribal laws, since grizzly bears are designated as a game animal (IC 36-2-1; IDAPA 13.01.06.100.01(e); IC 36-1101(a); Idaho's MCA § 87-2-101(4); MCA 87-1-301; MCA 87-1-304; MCA 87-5-302; W.S. 23-1-101(a)(xii)(A); W.S. 23-3-102(a); FIR Tribal Ordinance 44D; Blackfeet Business Council 2018, p. 29; NCDE Subcommittee 2018, Chapter 6).

Summary of Human-Caused Mortality

Human-caused mortality includes illegal kills, defense of life and property mortality, accidental mortality, and management removals. Despite these mortalities, the GYE, NCDE, CYE, and SE grizzly bear populations have continued to increase in size and expand their current distribution (Pyare *et al.* 2004, pp. 5–6; Schwartz *et al*. 2006a, pp. 64–66; Schwartz *et al.* 2006b, p. 48; IGBST 2012, p. 34; Bjornlie *et al.* 2014a, p. 184; Costello *et al.* 2016, pp. 2, 10; Bjornlie and Haroldson 2019, pp. 25–28; Haroldson *et al.* 2020b, p. 13; Kasworm *et al.* 2020a, p. 38–40; Kasworm *et al.* 2020b, p. 26–27). Although humans are still directly or indirectly responsible for the majority of grizzly bear deaths, this source of mortality is mitigated through science-based management, monitoring, and outreach efforts. I&E programs reduce human-caused mortality by: (1) changing human perceptions and beliefs about grizzly bears; (2) educating recreationists and hunters on how to avoid encounters and conflicts, how to react during a bear encounter, how to use bear spray, and how to properly store food; and (3) educating black bear hunters on bear identification.

Monitoring agencies have committed to continuing to produce annual reports that analyze the causes of known and probable grizzly bear mortalities. Population monitoring data collected by the Federal, State, and Tribes is used to help identify where human-grizzly grizzly bear conflicts occur and compare trends in locations, sources, land ownership, and types of conflicts to inform proactive management of human-grizzly bear conflicts. Total mortality rates are managed consistent with recovery criteria and updated population objectives in the GYE and NCDE, with a goal of recovering and maintaining grizzly bear populations.

Natural Mortality

Mortality due to natural causes represents a relatively small portion of total mortality sources (GYE DMA: 8 percent; NCDE DMA: 3 percent; CYE: 23 percent; SE: 20 percent). Natural causes include avalanches, injuries, killing by other bears or wildlife species, old age, and starvation. Dependent cubs and yearlings are particularly vulnerable to natural mortality sources; however, detection of these events is difficult and we often do not know the specific cause.

Grizzly bears are sometimes killed by other grizzly bears or other species. These incidents are rarely documented, therefore the impact of predation on grizzly bear population dynamics is difficult to know. Intraspecific predation by adult grizzly bears on dependent young, subadults, or other adults (Stringham 1980, p. 337; Dean *et al.* 1986, pp. 208–211; Hessing and Aumiller 1994, pp. 332–335; McLellan 1994, p. 15; Schwartz *et al.* 2003a, pp. 571–572) occurs, but is rarely documented (Stringham 1980, p. 337). This type of intraspecific killing has only been observed among grizzly bears 27 times in the GYE between 2002 and 2019 (Haroldson 2019c, *in litt*., Haroldson 2020, *in litt.*) and 16 times in the NCDE between 1975 and 2019 (MFWP, unpublished data). Between 1980 and 2017, intraspecific predation has only been observed among grizzly bears twice in the SE and three times in the CYE; however, there have been 7 cubs in the CYE and 2 cubs in the SE lost to unknown causes (Kasworm 2018b, *in litt*.; Kasworm *et al.* 2020a, p. 33; Kasworm *et al.* 2020b, p. 23). There have been no documented cases of natural predation in the North Cascades since 1967; however, the last verified sighting in the North Cascades occurred in 1996. There have been no documented cases of natural predation in the BE, but until the last few years, there have been no verified sightings since the 1940s.

Grizzly bears are occasionally killed by other wildlife. Wolves and grizzly bears often scavenge similar types of carrion and, sometimes, will interact with each other in an aggressive manner. Since wolves were reintroduced into the GYE in 1995, we know of 339 wolf-grizzly bear interactions with 6 incidents in which wolf packs likely killed grizzly bear cubs-of-the-year and 2 incidents in which wolves likely killed adult female grizzly bears (Gunther and Smith 2004, pp. 233–236; Gunther 2014, *in litt*.). Although interactions have been observed, there are no documented instances in which wolves have killed grizzly bears in the NCDE (MFWP, unpublished data).

Overall, these types of aggressive interactions among grizzly bears or with other wildlife are rare and are an insignificant factor in population dynamics.

Although grizzly bears have been documented with a variety of bacteria and other pathogens, parasites, and disease, fatalities from disease are uncommon (LeFranc *et al.* 1987, p. 61) and do not appear to have population-level impacts on grizzly bears (Jonkel and Cowan 1971, pp. 31–32; Mundy and Flook 1973, p. 13; Rogers and Rogers 1976, p. 423). Researchers have found grizzly bears with brucellosis (type 4), clostridium, toxoplasmosis, canine distemper, canine parvovirus, canine hepatitis, and rabies (LeFranc *et al.* 1987, p. 61; Zarnke and Evans 1989, p. 586; Marsilio *et al.* 1997, p. 304; Zarnke *et al.* 1997, p. 474). However, based on nearly 40 years of research by the IGBST and MFWP, natural mortalities in the wild due to disease have never been documented (Craighead *et al.* 1988, pp. 24–84; IGBST 2005, pp. 34–35; Haroldson 2019c, *in litt.*; MFWP, unpublished data). Based on this absence in more than 50 years of data, we conclude that mortalities due to bacteria, pathogens, or disease are negligible components of total mortality for grizzly bears and are likely to remain an insignificant factor in population dynamics. Therefore, although disease may affect individuals, it does not significantly influence the resiliency of ecosystems.

Connectivity and Genetic Health

The isolated nature of the GYE and BE grizzly bear populations was identified as a potential threat when listing occurred in 1975 (40 FR 31734, July 28, 1975). The 1991, 1993, and 1999 findings of warranted but precluded for endangered status also identified the North Cascades, CYE, and SE, respectively, as small populations facing potential isolation (56 FR 33892, July 24, 1991; 58 FR 8250, February 12, 1993; 64 FR 26725, May 17, 1999). Although the 1993 Recovery Plan did not require connectivity for recovery of individual grizzly bear populations, we recognize that natural connectivity between grizzly bear populations will benefit long-term grizzly bear conservation through potential genetic exchange (Service 1993, pp. 23–25) and demographic augmentation of smaller isolated or female fragmented ecosystems (Proctor *et al.* 2005, p. 2414; Proctor *et al.* 2012, pp. 23–28). As shown in Figure 25, genetic diversity of small, isolated populations is influenced by connectivity which in turn is influenced by large intact blocks of land.

Small, isolated populations are at greater risk of loss of genetic diversity from inbreeding and genetic drift than larger connected populations, which can lead to decreased fitness and fecundity (Allendorf *et al.* 1991, p. 651; Burgman *et al.* 1993, p. 220), and reduced long-term viability. In addition, small populations are more susceptible to extinction due to genetic processes, human-caused mortality, and environmental processes such as poor food years, climate change, and habitat loss. Genetic diversity in small, isolated populations is typically maintained through genetic connectivity between populations and as few as one to two effective migrants per generation can maintain or enhance genetic diversity (Mills and Allendorf 1996, p. 1510, 1516; Newman and Tallmon 2001, pp. 1059–1061; Miller and Waits 2003, p. 4338).

Connectivity in grizzly bear populations should be examined in terms of both genetic and demographic health (Proctor *et al.* 2012, pp. 5, 26–28, 38–39). While male or female movements can enhance genetic diversity and reduce genetic fragmentation (i.e., provide genetic connectivity) (Miller and Waits 2003, pp. 4337–4338; Proctor *et al.* 2005, pp. 27–28), female movements are necessary to enhance population growth rate (i.e., provide demographic connectivity); this is particularly important for small populations (Proctor *et al.* 2012, pp. 5, 26–28). Demographic connectivity requires adequate habitat to support female residents in potential connectivity areas between ecosystems (McLellan and Hovey 2001, pp. 841–843; Servheen *et al.* 2001, p. 164; Proctor *et al.* 2005, pp. 2413–2415; Proctor *et al.* 2012, p. 35; Proctor *et al.* 2015, pp. 8–12; Proctor *et al.* 2018, pp. 356–361). Additional data are needed to determine thresholds for adequate habitat to facilitate genetic and demographic connectivity. However, Proctor *et al.* (2018, pp. 358–363) documented improved connectivity in identified linkage areas after the implementation of measures to reduce of human-caused mortality (i.e., attractant storage and motorized access reductions) and improve habitat security (i.e., motorized access reductions), which is particularly important for demographic connectivity as females will likely need to live in linkage areas.

Genetic health is typically assessed using a variety of metrics, including effective population size and genetic diversity (e.g., allelic richness, heterozygosity, inbreeding rate). Effective population size (N_e) is the size at which a hypothetical population begins losing genetic diversity at the same rate of the observed population (Kamath *et al.* 2015, p. 5507). To maintain short-term fitness (i.e., avoid inbreeding depression), Franklin (1980, pp. 140, 147) and Miller and Waits (2003, p. 4338) suggested that N_e should be greater than 50. Additionally, Franklin (1980, p. 147) suggested that an N_e of at least 500 is needed to maintain long-term evolutionary potential through additive genetic variance. These short- and long-term criteria are referred to as the "50/500 rule." Frankham *et al*. (2014, entire) reviewed the 50/500 rule of Franklin (1980, entire) and proposed an upward revision to at least 100/1,000, to which Franklin *et al*. (2014, entire) published a rebuttal stating that, although a larger effective population size is preferable, Frankham *et al*. (2014, entire) ignored the fact that natural selection operates on phenotypes and the 50/500 is still appropriate guidance. However, Franklin (1980, pp. 147–148) recognized that the 50/500 rule is imprecise, does not account for human management, and are broad guidelines when case-specific studies are not available. Reported ratios of N_e/N_c for grizzly bear populations vary widely from 0.04 to 0.6 (Allendorf *et al.* 1991, pp. 652–653; Paetkau *et al.* 1998, p. 424; Miller and Waits 2003, p. 4337; Schregel *et al.* 2012, pp. 3483–3484). For the GYE, ratios of N_e/N_c of 0.27 to 0.42 have been reported (Miller and Waits 2003, p. 4338; Kamath *et al.* 2015, p. 5513). Ratios of N_e/N_c vary between species and can even vary within a species; therefore, conclusions based on inference should be viewed cautiously (Jamieson and Allendorf 2012, p. 579).

Metrics to measure genetic diversity include allelic richness, heterozygosity, and inbreeding rate. Low heterozygosity values can be indicative of small and/or genetically isolated populations, which may reflect potential current or past population bottlenecks, whereas high heterozygosity values are indicative of genetic variability that is typically associated with larger and interconnected populations. Allelic richness (number of alleles/locus) is an index of genetic diversity, which reflects a population's long-term capacity to respond evolutionarily to selective pressures other than current ones. Inbreeding is a result of mating events among close relatives and may lead to expression of deleterious alleles, potentially affecting individual bears' ability to reproduce and survive at otherwise normal rates, which is referred to as "inbreeding depression." To maintain short-term fitness (i.e., evolutionary response), Franklin (1980, pp. 140) suggested that the rate of inbreeding should be less than 1 percent per generation, which is equivalent to an N_e of 50. Other demographic factors that can reassure biologists that there are not manifestations in the population of inbreeding depression include: healthy reproduction and survival, such as normal litter size, no evidence of disease, high survivorship, an equal sex ratio, normal body size and physical characteristics, and a stable to increasing population.

Connectivity and Genetic Health in the GYE

Effective population size and genetic diversity (e.g., allelic richness, heterozygosity, inbreeding rate), in addition to other indicators of genetic health (e.g., reproduction, survival), are monitored by the IGBST for the GYE grizzly bear population (in their entirety: Miller and Waits 2003; Haroldson *et al.* 2010; Kamath *et al.* 2015). As addressed in more detail below, recent data indicate an extremely low rate of inbreeding and an increase in the effective population size over the recent 25-year period of 1982 to 2007, substantially reducing the prospects of potential negative effects associated with isolation of the GYE population in the short term. These findings are likely a function of significant growth of the GYE grizzly population during the same 25-year period. Additionally, other measures of genetic health, such as heterozygosity and allelic richness, have not changed over the same 25-year time period of 1985 to 2010 (Kamath *et al.* 2015, p. 5512).

Effective Population Size: Two studies have estimated N_e for the GYE grizzly bear population during different time periods over the last century using various methods. Irrespective of the temporal and methodological differences between the Miller and Waits (2003, entire) and Kamath *et al.* (2015, entire) studies, both reported an increase in N_e over time, with the greatest increase indicated by the most contemporary data. Miller and Waits (2003, p. 4338) calculated maximum-likelihood estimates of N_e and found that N_e increased from ≈80 individuals across the period from the 1910s to the 1990s to more than 100 individuals during the late 1990s. Kamath *et al.* (2015, p. 5512) used a temporal-based method (variance effective population size or N_{ev}) to recalculate the data from Miller and Waits (2003, p. 4337) and found similar results (i.e., N_{ev} of ≈80 in the 1910s–1960s); however, they estimated an N_{ev} of ≈280 individuals for the more recent time period of 1982–2007, a 3- to 4-fold increase over the earlier period. In addition, Kamath *et al.* (2015, p. 5512) used the Estimator of Parentage Assignment method to estimate that the N_e for the GYE grizzly bear by this method was 469 (95% CI = 284–772) in 2007, a 4-fold increase from an EPA-based estimated N_e of 102 (95% CI = 64–207) in 1982 (Kamath *et al.* 2015, p. 5512). This increase in EPA-base N_e was evident regardless of the specified probability of parentage assignment used (i.e., 0.80 or 0.95), and is supportive of increases in population size, from approximately 136 to 312 individuals at the time of listing in 1975 (Cowan *et al.* 1974, pp. 32, 36; Craighead *et al.* 1974, p. 16; McCullough 1981, p. 175) to 571 individuals in 2007 using the model-averaged Chao2 estimator (Haroldson 2008, p. 10). Because the model-averaged Chao2 underestimates the number of bears, the population in 2007 was likely 30–40 percent higher than the 571 reported (Schwartz *et al.* 2008, figure 5; Cherry *et al.* 2007, p. 16). Kamath *et al.* (2015, p. 5514) noted that even for an isolated population such as the GYE grizzly bear population, increases in N_e will slow the loss of genetic variation over the long term (100–200 years) and thus will decrease the risk of inbreeding depression.

The estimated N_e levels from these studies reflect populations with extremely low risk of inbreeding depression, or similar adverse effects over the next few decades. To maintain short-term fitness (i.e., maintain response to natural selection and avoid inbreeding depression), Franklin (1980, pp. 140, 147) and Miller and Waits (2003, p. 4338) suggested that N_e should be greater than 50 individuals. Miller and Waits (2003, p. 438) conclude that "N_e is likely to be near or > 100 [and] … it is unlikely that genetic factors will have a substantial effect on the viability of the Yellowstone grizzly over the next several decades." The current estimates of EPA-based N_e of 280 to 469 grizzly bears in the GYE are sufficiently large for inbreeding avoidance (i.e., $N_e > 50$) over the short term, and are approaching, but not yet achieved levels of N_e that would support long-term genetic viability ($N_e > 500$) (Franklin *et al.*1980, pp. 140, 147; Kamath *et al.* 2015, p. 5517).

Genetic Diversity:

We use heterozygosity, allelic richness, and inbreeding rates to monitor genetic diversity in the GYE grizzly bear population. Given the isolated nature of the GYE population, it is anticipated that it will lose allelic richness and heterozygosity over time without genetic connectivity but evidence from multiple studies indicate this loss would be extremely small due to the large population size. Heterozygosity values for the GYE grizzly bear population have been relatively stable over the last few decades (heterozygosity = 0.60–0.61) (Haroldson *et al.* 2010, p. 4338; Kamath *et al.* 2015, p. 5512). When limited to 8 microsatellites common to Miller and Waits (2003, p. 4337) and corrected for differences in sample sizes, heterozygosity indices were stable from 1985 to 2010 (Kamath *et al.* 2015, p. 5512). Based on observed heterozygosity and year of birth of 1,130 grizzly bears in the GYE, Paetkau (2019, *in litt.*) calculated a rate of decline in heterozygosity of 0.0007 per year, implying a total loss of heterozygosity of 0.028 over the past 40 years, from 1979 to 2019. These heterozygosity values (0.6549) are slightly below average for 19 North American brow bear populations (Cronin *et al.* 2012, p. 875). They are lower than the NCDE (heterozygosity = 0.730) (Kendall *et al.* 2009, p. 12), which is connected to populations in Canada. However, heterozygosity values for the GYE are higher than the Selkirk Mountains (heterozygosity = 0.54), which was isolated for several decades but likely experienced greater genetic drift than the GYE due to its much smaller population size (Proctor *et al.* 2005, p. 2411; Proctor *et al.* 2012, pp. 12, 16, 33). They are also higher than the naturally isolated Kodiak brown bear (heterozygosity = 0.2985; see *Other Indicators* below for further discussion of the Kodiak brown bear) (Paetkau *et al.* 1998, p. 421; Proctor *et al.* 2012, pp. 12, 16).

Kamath *et al.* (2015, p. 5512) also demonstrated no statistical support for a decline in mean allelic richness (A) for the GYE grizzly bear population from 1985 to 2010 (A_{1985} = 4.65, A_{2010} = 4.52). When limited to 8 microsatellites common to Miller and Waits (2003, p. 4337) and corrected for differences in sample sizes, paired comparisons were similar across studies with no evidence of a decline (Kamath *et al.* 2015, p. 5512). These values fall within the range of allelic richness (2.13 to 8.13) for grizzly bear populations within North America (Paetkau *et al.* 1998, p. 421; Cronin and MacNeil 2012, p. 875).

The rate of inbreeding for the GYE grizzly bear population has been well below the 1 percent theoretical guidance set forth by Franklin (1980, p. 140), and has improved over the last several decades: Kamath *et al.* (2015, p. 5512) reported a 0.2 percent rate of inbreeding from 1985 to 2010, or approximately 0.1 percent per generation, an improvement from the 0.5 percent per generation estimated by Miller (2006, *in litt.*) based on an N_e approaching 100 in the late 1990s. These trends match those observed for the N_e estimates and strengthen overall inference of the contemporary genetic analyses by Kamath *et al.* (2015, entire).

Small, isolated populations are generally thought to be at greater risk of loss of genetic diversity and associated decreased fitness and fecundity (Allendorf *et al.* 1991, p. 651; Burgman *et al.* 1993, p. 220). However, there are examples of small and/or isolated brown bear populations, such as the one on Kodiak Island, Alaska, that has been isolated for thousands of years on an island similar in size (9,311 km^2 (3,595 mi^2)) to YNP (8,983 km^2 (3,468 mi^2)). The Kodiak Island population has one of the lowest documented heterozygosity (0.265) and allelic richness (2.13) values in brown bear populations worldwide, yet the population appears to be healthy and productive with an estimated annual population growth of 1.4 percent during 1995–2005, while supporting a sustainable harvest that has consistently yielded some of the largest bears in North America (Troyer and Hensel 1964, pp. 770–772; Barnes and Smith 1998, p. 6; Paetkau *et al.* 1998, p. 421; van Daele and Barnes 2010, entire). Low genetic diversity can have negative impacts, such as reducing the potential for immune responses against pathogens (Talbot *et al.* 2006, p. 29). The GYE population is smaller than the estimated population size for Kodiak brown bears (approximately 2,600 individuals) (Barnes and Smith 1998, p. 1), but genetic diversity in the GYE is more than double than values reported for Kodiak bears. No phenotypic signs (i.e., physically observable characteristics) of inbreeding have been documented in either population.

Connectivity

Genetic diversity in species consisting of disjunct populations is typically maintained through genetic connectivity between populations and as few as one to two effective migrants per generation can maintain or enhance genetic diversity (Mills and Allendorf 1996, p. 1510, 1516; Newman and Tallmon 2001, pp. 1059–1061; Miller and Waits 2003, p. 4338). An effective migrant is an individual that immigrates into an isolated population from a separate area, survives, breeds, and whose offspring survive. No effective migrants into the GYE have been detected to date; however, based on the 2018 estimates of occupied range for grizzly bears in the NCDE and GYE, and verified outlier observations, the likelihood of genetic connectivity through natural bear movement is better now than at any other time since listing in 1975. The Euclidean distance between NCDE and GYE grizzly bear occupied range in 2018 is 75 km (47 mi; Figure 28) (Bjornlie 2019, *in litt.*), a decrease of 47 km since 2006. In addition, there have been numerous confirmed sightings outside of occupied range between the two ecosystems, such as Big Hole Valley, and the Big Belt, Little Belt, Elkhorn, Deer Lodge, and Pioneer Mountains. Nonetheless, successful immigration events will likely remain rare due to distance and barriers unless current distributions continue to expand (Peck *et al*. 2017, pp. 15–16). Peck *et al*. (2017, entire) modeled potential male dispersal paths between the NCDE and GYE. These dispersal paths could be used to identify and prioritize conservation efforts that foster connectivity.

To document natural connectivity between the GYE and the NCDE, Federal, Tribal, and State agencies monitor bear movements with telemetry on the northern periphery of the GYE grizzly bear and the southern periphery of NCDE occupied range, and collect genetic samples from all captured or dead bears to document possible gene flow between the two ecosystems (MFWP 2013, p. 71; YES 2016a, pp. 52–54; NCDE Subcommittee 2018, pp. 29–30). An “assignment test” based on these genetic samples can detect a migrant, or their descendants, and identify the population from which it most likely originated based on their unique genetic signature (Paetkau *et al.* 1995, p. 348; Waser and Strobeck 1998, p. 43; Paetkau *et al.* 2004, p. 56; Proctor *et al.*

2005, pp. 2410–2412, Haroldson *et al.* 2010, p. 7). This technique also identifies offspring of reproduction between grizzly bears from the GYE and NCDE, or other source populations (Dixon *et al.* 2006, p. 158; Haroldson *et al.* 2010, p. 7). However, detection of a migrant or their descendants is dependent on the intensity of sampling efforts.

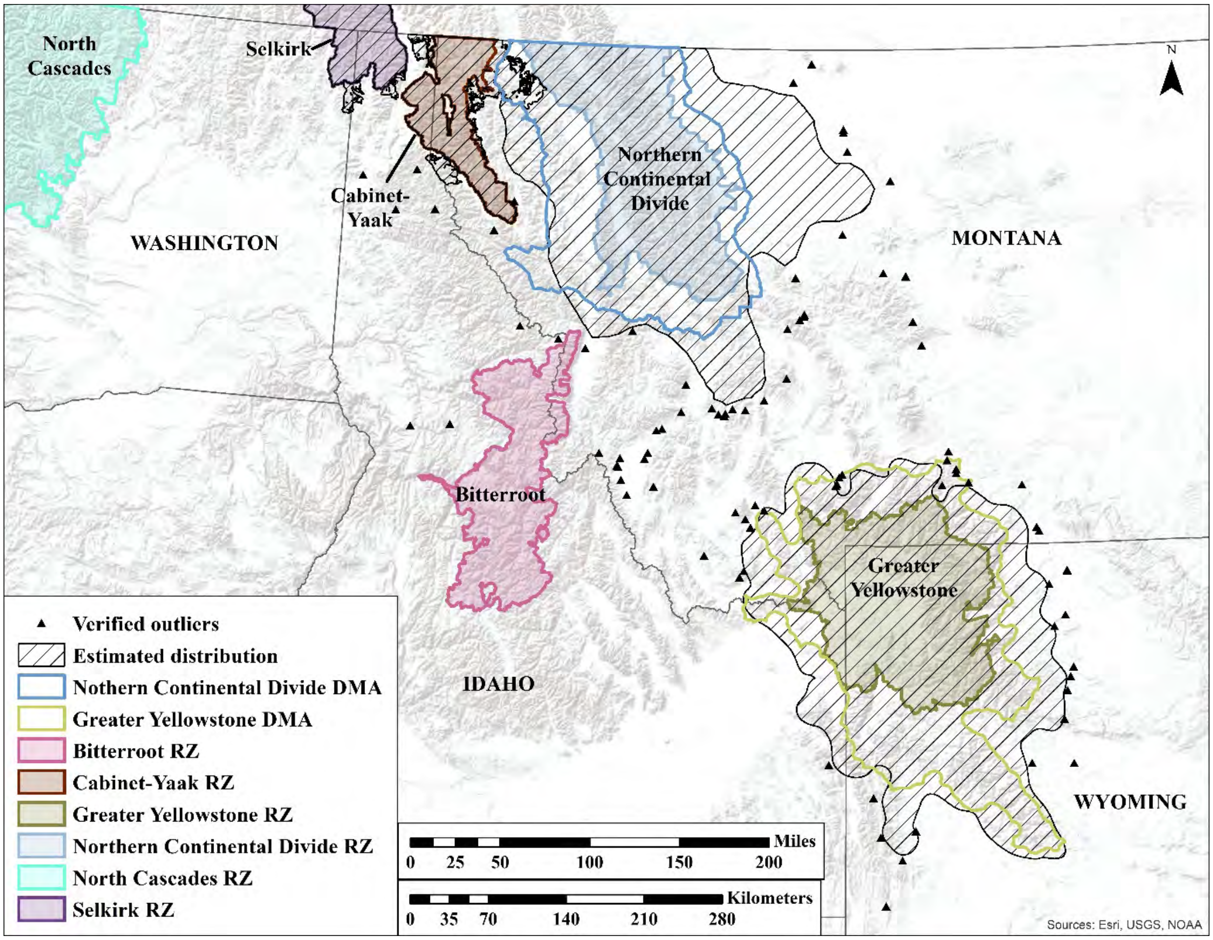

Figure 28. Estimated distribution of grizzly bears in the NCDE (2009-2018 data), GYE (2004-2018 data), CYE (2005-2019 data), and SE (2005-2019 data), and verified grizzly bear outlier observations between the ecosystems based on data through June 4, 2020.

In addition to monitoring gene flow and movements, the signatories to the 2016 GYE Conservation Strategy identified and committed to a protocol to encourage maintaining or enhancing landscape conditions that promote grizzly bear movement between the GYE and other ecosystems (YES 2016*a*, pp. 85–86). Connectivity between the GYE and the NCDE is a long-term goal for the State of Montana, as set out in their Grizzly Bear Management Plan for Southwestern Montana (MFWP 2013, pp. 41–44; NCDE Subcommittee 2018, pp. 20, 31). In addition, the Grizzly Bear Management Plan for Southwestern Montana indicates that increasing the likelihood of connectivity will be considered when relocating grizzly bears (MFWP 2016, pp. 4–5). If and when grizzly bears are documented to be present in areas between the NCDE management area and the DMA of the GYE, such as the Tobacco Root and Highland Mountains, maintaining their presence through reducing conflict related mortality would likely facilitate potential grizzly bear movements between the NCDE and GYE.

Additional mechanisms to promote natural connectivity include public outreach and education, attractant storage rules, highway crossing structures, and habitat protection (e.g., easements and conservation trust land acquisitions). Attractant storage rules on public lands between the GYE and other grizzly bear recovery zones in the NCDE and BE would help to reduce human-grizzly bear conflicts (see *Preventative Measures* for further details on attractant storage), increasing the likelihood that bears within connectivity corridors will survive. Highway planning can facilitate connectivity (YES 2016a, p. 85), where state transportation agencies are actively requesting information about grizzly bear data, including locations of highway-related mortalities and documented crossings, and information from state and federal wildlife agencies on proposed projects. Grizzly bears successfully used crossing structures in Alberta, with increasing use over time and a preference for larger structures in terms of height, width, and length (Clevenger and Waltho 2005, p. 453; Sawaya *et al.* 2014, p. 7). Distance to forest cover was also positively correlated with grizzly bear use of crossing structures, whereas human activity (i.e., traffic noise) was negatively correlated with use (Clevenger and Waltho 2005, p. 459). Lastly, the Service currently partners with several NGOs who work on conservation of important habitat linkage areas (see *Land Development* for further discussion). We do not consider connectivity to the east or south a relevant issue to the GYE grizzly bear population's long-term persistence because there are no extant populations in these directions to enhance the genetic diversity of the GYE population. However, we recognize the GYE grizzly bear population could be a possible source population to re-colonize the BE to the west and could provide an indirect connection to the NCDE.

Translocation

The current estimated effective population size of approximately 280 to 469 animals (Kamath *et al.* 2015, p. 5512) in the GYE is sufficiently large to avoid substantial accumulation of inbreeding depression and maintain genetic health over the short term. However, the Service recognizes that the long-term capacity of the GYE grizzly bear population to respond to future changes in selective pressures will improve by occasional gene flow (one to two effective migrants per generation (10–15 years) from nearby grizzly bear populations, such as the NCDE. Additionally, the Ninth Circuit concluded that adequate measures to ensure long-term genetic health are necessary (*Crow Indian Tribe v. United States*, 965 F.3d 662 (9th Cir. 2020).

Efforts mentioned above (I & E programs, attractant storage rules, highway crossing structures, and habitat protection) to facilitate natural connectivity between the NCDE and GYE will continue. These efforts, however, cannot ensure connectivity. Translocation of bears between these ecosystems could act as a precautionary measure to maintain or enhance genetic diversity (Miller and Waits 2003, p. 4338). Translocation has been successfully deployed in the CYE (Kasworm *et al*. 2020a, pp. 24–25). Kasworm *et al*. (2020a, pp. 24–25) documented reproduction of three of the 10 individuals that stayed in the target area and survived for more than 4 months after release (see *Augmentation Program in the CYE* below for further details).

Connectivity and Genetic Health in the NCDE

The NCDE grizzly bear population is genetically diverse, large enough to ensure genetic health, and genetically and demographically well connected to Canadian populations, and we have no reason to believe genetic health will affect the continued existence of the population. Nevertheless, genetic sampling and radio telemetry is ongoing and have also been used to examine movements, genetic diversity, and population structure within the NCDE grizzly bear population (in their entirety: Kendall *et al.* 2008; Kendall *et al.* 2009; Mace *et al.* 2012; Proctor *et al.* 2012; Mikle *et al.* 2016a; Morehouse *et al.* 2016).

Effective Population Size

Currently, no reliable effective population size estimates have been calculated for the NCDE grizzly bear population. Pierson *et al.* (2018b, entire), estimated that N_e in the NCDE ranged from 61 to 191, depending on the method used to estimate N_e. However, the authors note that N_e for the NCDE is underestimated because of substructuring within the population (i.e., reduced gene flow between subpopulations within the NCDE), this underestimation is particularly notable because estimates for N_e are higher inside GNP, a subpopulation of the NCDE, than the estimate for the entire NCDE (Pierson *et al.* 2018a, p. 7). In addition, several of the assumptions of estimating N_e, such as random mating, equal sex ratio, non-overlapping generations, and spatial structure, are violated in grizzly bear populations (Waples 2005, pp. 3349–3350; Waples and England 2011, pp. 633, 640; Neel *et al.* 2013, pp. 190, 194–196; Gilbert and Whitlock 2015, p. 2155).

Given that the NCDE has a current estimated population size of approximately 1,068 bears, if the NCDE were assumed to have the same N_e/N_c ratio as the GYE, its current N_e would be approximately 278–432 bears. However, we believe that the N_e is likely larger than this estimate because, unlike the GYE, the NCDE population is not geographically isolated from other bear populations, and has documented bear exchange with Canadian populations (Service 1993, p. 12; Kendall *et al.* 2009, pp. 3, 10, 12; Proctor *et al.* 2012, p. 28). The effective population size of the larger grizzly bear population to which the NCDE is connected likely has a N_e greater than 500; therefore, N_e is not considered a risk to the genetic health of the NCDE population.

Genetic Diversity

Measures of heterozygosity and allelic richness from the NCDE in 2004 (heterozygosity = 0.73, A = 8.6), are similar to those from undisturbed populations in Canada (heterozygosity ~ 0.68, A = 6.5) and Alaska (heterozygosity = 0.75, A = 7.6), leading to the conclusion that the NCDE population has high genetic diversity and is sufficiently connected to other bear populations (Paetkau *et al.* 1998, p. 421; Kendall *et al.* 2009, p. 12; Proctor *et al.* 2012, p. 12).

Fragmentation within the NCDE

Proctor *et al.* (2012, entire) used genetic information and movement data from radio-collared grizzly bears between 1979 and 2007, to assess fragmentation in grizzly bear populations in the U.S. and Canada (Figure 15). Data from radio-collared bears demonstrated that both male and female grizzly bears moved across the U.S.-Canadian border on the northern edge of the NCDE (Proctor *et al.* 2012, pp. 21, 25). Based on those movements and on recent measures of genetic diversity, there is currently little risk of significant reduction in the present high levels of genetic diversity (Proctor *et al.* 2012, p. 39).

Kendall *et al.* (2009, p. 10) identified six subpopulations in the NCDE that are a result of historically low levels of genetic interchange between these subpopulations; however, the difference in heterozygosity between the subpopulations was low. Subpopulation boundaries did not coincide with natural or anthropogenic geographic features and are most likely a result of multigenerational matrilinear assemblages (Støen *et al.* 2005, p. 6). The only suggestion of human-caused population fragmentation within the NCDE was on the western side of the U.S. Hwy. 2 / BNSF rail line corridor between GNP and USFS lands where historically mortality rates from vehicle and train collisions were higher compared to other areas of the ecosystem. However, the long-term trend in mortality as a result of train collisions has decreased as a result of mitigation measures that have been implemented by BNSF rail line (MFWP, unpublished data). Conversely, there was little genetic differentiation across the eastern portion of the corridor (Kendall *et al.* 2009, p. 10).

In recent years, connectivity within the ecosystem has mostly restored the genetic diversity across the NCDE. Genetic differentiation between subpopulations decreased when genetic data from 1976–1998, was compared to data from 1999–2006, a finding consistent with demographic recovery of the population (Kendall *et al.* 2009, p. 10). In addition, heterozygosity increased in 3 regions south of the Hwy. 2 corridor in the NCDE from 2004 to 2013 (2004: 0.69, 0.67, and 0.70; 2012: 0.76, 0.73, and 0.70) (Mikle *et al.* 2016b, supplementary table 3); these regions generally lined up with 3 of the subpopulations identified in Kendall *et al.* (2009, p. 4). While managers remain vigilant about the possible fragmenting effects of the U.S. Hwy. 2 corridor, frequent male and female movements have been documented across this corridor (Waller and Servheen 2005, pp. 992, 996), indicating that the current state of fragmentation along this corridor does not prevent demographic and genetic connectivity of grizzly bears within the NCDE (Waller and Servheen 2005, pp. 996–998).

Connectivity and Genetic Health in the CYE

Proctor *et al.* (2012, entire) used several metrics to evaluate the genetic status of grizzly bears in the CYE. They found that genetic diversity in the Yaak portion of the CYE was comparable to other healthy grizzly bear populations in North America. The sample size of native Cabinet bears was insufficient to include in the analysis. As discussed above, Miller and Waits (2003) recommended that effective population size remain above 100 animals in an isolated population to avoid negative, short-term genetic effects associated with small population size. Because habitat in the CYE recovery zone cannot support a grizzly bear population of this size, it is important to maintain connectivity with other populations. Female movement and reproduction provides demographic and genetic rescue to a population, whereas male movement and reproduction may only provide genetic rescue. Telemetry from collared animals indicates that grizzly bears move freely across the length of the international border from the CYE into and out of the Yahk grizzly bear population unit in B.C. immediately north of the international boundary (Kasworm *et al.* 2020a, p. 72–99). B.C. Hwy. 3 is a potential fracture area that divides the north and south Purcell Mountains. Data suggests that the Yaak River portion of the CYE ecosystem has experienced gene flow from B.C. grizzly bear populations. Using capture, telemetry, and DNA data, 14 individuals (11 males, 3 females) are known to have moved into the Yaak portion of the CYE from the NCDE, SE, and the North Purcells in Canada (north of Hwy. 3), not including augmentation bears. Reproduction was documented for 3 (2 males, 1 female) of these individuals, all from the North Purcells, resulting in 4 offspring in the CYE (Kasworm *et al.* 2020a, p. 32). No gene flow is known to have occurred from the NCDE or SE into the Yaak or Cabinets portions of the CYE. While there is evidence of movement into the Cabinets portion of the CYE from the Yaak, NCDE, and the SE, reproduction that would contribute to the genetic health of the population has not been documented for any emigrants (see *Augmentation Program in the CYE* below).

Of additional concern is population linkage between the Yaak and Cabinet portions of this recovery zone, which are split along Hwy. 2 (Proctor *et al.* 2012, p. 12; Kendall *et al.* 2016, pp. 320–321). The Yaak population is larger and connected to Canadian populations to the north, making it more genetically diverse than the Cabinet population (Proctor *et al.* 2012, p. 12; Kendall *et al.* 2016, pp. 320–321). Based on DNA analysis, only 3 individuals (all males) were detected on both sides of Hwy. 2 from 2012 to 2019 (Kendall *et al.* 2016, p. 325; Kasworm *et al.* 2020a, p. 32).

Moreover, while the Yaak portion of the recovery zone is connected with Canadian populations to the north, these Canadian populations are becoming increasingly fragmented from the rest of Canada by Canadian Hwy. 3 (Figure 15) (Proctor *et al.* 2012, pp. 17, 18, 33; Proctor *et al.* 2015, pp. 10–11). This highway is at least a partial barrier to demographic connectivity, as females only accounted for 13 percent (4 of 30) of all known migrant movements between population units in the transborder areas and adjacent U.S. recovery zones (Proctor *et al.* 2005, p. 2411; Proctor *et al.* 2012, p. 25; Proctor *et al.* 2015, pp. 10–11). Of the four females documented migrating between population units in Canada, two moved from areas entirely within Canada to areas that straddled the international border (i.e., the SE and NCDE) (Proctor *et al.* 2012, p. 25). These female migration movements demonstrate that limited demographic connectivity with Canadian populations exists while highlighting the importance of maintaining connectivity between U.S. and Canadian populations.

Maintaining or increasing current levels of genetic diversity in the CYE would help ensure genetic concerns do not become a threat in the future. Small population size makes this grizzly bear population more vulnerable to genetic, demographic, and environmental stochasticity. Natural connectivity would alleviate potential future genetic concerns, reduce extinction risk due to small population size, and increase this population's resilience to environmental and climate change impacts. Designation of the Salish DCA, with accompanying habitat protections, is designed to promote connectivity from the NCDE to the CYE over the 34–105 km (21–65 mi) distance between these areas.

Augmentation Program in the CYE

In the Cabinet Mountains portion of the CYE, researchers and managers have been augmenting the small population by introducing one to two grizzly bears a year from 1990–1994 and since 2005. All bears have originated from the NCDE or just north of the NCDE in B.C. Grizzly bear research indicated that only a small population remained (less than 15) in the Cabinet Mountains portion of the CYE as of 1988 (Kasworm and Manley 1988, p. 98). Concern over persistence of grizzly bear populations within this area resulted in a pilot program in 1990 that tested population augmentation techniques. Four subadult female bears with no history of conflicts with humans were captured in north fork of the Flathead in B.C. and moved to the Cabinet Mountains for release during 1990–1994 (Kasworm *et al.* 2013, p. 2). B.C. was selected as a source for augmentation bears because of the ability to capture non-conflict bears of appropriate age and sex; and similarity of habitat and food sources to the CYE (Service 1990, pp. 10, 23). By 2005, at least one augmentation bear was identified as remaining in the Cabinet Mountains and having reproduced (Kasworm *et al.* 2007, pp. 1263–1264). The success of the augmentation test program prompted additional augmentation between populations in the U.S. Beginning in 2005, in cooperation with MFWP, ten female bears and eight male bears were moved from the Flathead River to the Cabinet Mountains during 2005–2019 (Kasworm *et al.* 2020a, pp. 24–26). Of 22 bears released through 2019, 11 were known to have remained in the target area for more than a year. One of the individuals that left the area initially was recaptured and brought back and another individual returned to the target area a year after leaving. DNA analysis from hair corrals has been occurring since 2000 and from rub trees since 2012. Based on this analysis, one female is known to have produced at least 10 first generation, 16 second generation, and one third generation offspring. This female was a 2-year-old female that was released in 1993 as part of the augmentation program. Another female is known to have produced three offspring and a male is also known to have produced one offspring (Kasworm *et al.* 2020a, p. 31). Of 22 bears released through 2019, 8 are known to have left the target area (one was recaptured and brought back, two returned in the same year, and one returned a year after leaving), three were killed within 4 months of release, and one was killed 16 years after release (Kasworm *et al.* 2020a p. 25). Annual survival rates of augmentation bears (0.802) is lower than native subadult female CYE bears (0.847) (Kasworm *et al*. 2020a, pp. 37, 39).

Data collected since the 1988 population estimate now suggest the population may have been even smaller than the previously thought estimate of 15 or fewer individuals in 1988. However, this recent data also suggests that the number of grizzly bears in the Cabinet portion of the CYE has increased to 22–24 bears (Kendall *et al.* 2016, p. 314), almost exclusively through the augmentation effort and reproduction from those individuals (Kasworm *et al.* 2020a, p. 31). Genetic diversity in the Cabinet Mountains portion of this population remains a concern. Thirty-six offspring are known arising from five founders in this population. Twenty-six of these 36 individuals had the same father (Kasworm *et al*. 2020a, p. 31). This male died in 2019 and other males are expected to contribute offspring in succeeding generations. The augmentation program began transplanting males in 2010 and at least one of those individuals is known to have sired offspring. Male augmentation is expected to continue. Eight males from either the Yaak drainage, Selkirk Mountains, or NCDE are known to have traveled into and out of this area but no known reproduction has occurred (Kasworm *et al*. 2020a, p. 31). Most of these individuals are known to have died or left the area prior to any breeding opportunities.

Our assessment of genetic health of the CYE is predicated on the management goal of this entity being one population. While that may not be true at this moment, we have seen recent events toward reconnecting the Cabinets and Yaak portions through the monitoring of bear movements in the last decade. Where previously we saw no movement from the Yaak to the Cabinets during 1980–2010, we have documented several instances in the last 10 years (Kasworm *et al*. 2020a, p. 32). Though we have not yet seen any gene flow, we attempt to conservatively assess the genetic health of the CYE based on the Cabinets portion of this population and this lack of demonstrated gene flow.

While genetic issues may be a concern for this small population in the longer term, currently, demographic concerns outweigh those genetic concerns. Movement from other populations into the Yaak portion of this recovery area and the continued augmentation from the NCDE reduce the level of concern. Isolation of the CYE is more of a concern because of the small population size, but recent data indicate increasing movements by males and females and subsequent reproduction, resulting in limited, but increasing population connectivity, particularly in the Yaak portion of the CYE.

Connectivity and Genetic Health in the SE

Telemetry from collared animals indicates that grizzly bears move freely across the length of the international border in the SE (Kasworm *et al.* 2020b, p. 47–61). The area on the B.C. side of the border is the South Selkirk population unit. B.C. Hwy. 3 bisects this unit but numerous home ranges of collared bears cross this highway (9 males and 7 females, Kasworm *et al.* 2020b, p. 47–61).

Proctor *et al.* (2012, entire) used several metrics to evaluate the genetic status of grizzly bears in the U.S. and B.C. portions of the SE. They found genetic diversity was lower in the SE than in other grizzly bear populations in in the lower-48 States and Canada and that the SE grizzly bear population had likely been isolated in the recent past. Using capture, telemetry, and DNA data, seven individuals (6 males, 1 female) are known to have moved into the SE from the CYE and the North Purcells in Canada between 2000 and 2019 (Proctor *et al.* 2018, pp. 361, 363; Kasworm *et al.* 2020b, p. 22). Reproduction has been documented for two males from the North Purcells, resulting in nine offspring in the SE (Proctor *et al.* 2018, pp. 361, 363–365; Kasworm *et al.* 2020b, p. 22). These examples of migration into the SE, combined with an increase in expected heterozygosity from 0.54 (Proctor *et al.* 2005, p. 2411) to 0.57 (Proctor *et al.* 2018, p. 361). Thirteen of 15 loci tested (the same loci as used in Proctor *et al*. 2005a, p. 2410) increased in heterozygosity while two decreased (1 tailed, paired sample *t*-test, P = 0.07). Furthermore, 13 of 15 loci had an increased number of alleles, while 1 declined and another stayed the same (1 tailed paired sample *t*-test, $P < 0.001$) (Proctor *et al.*

2018, p. 361). These changes demonstrate that the SE is starting to increase connectivity with other grizzly bear populations.

The lower genetic diversity in the SE is likely a result of a bottleneck effect (Van Dyke 2003, pp 149–150). When the grizzly bear was listed in 1975, the SE recovery zone in the U.S. was thought to have only a few bears (Layser 1978, p. 78). These numbers gradually increased over the next 33 years to an estimated population of roughly 83 total animals in the U.S. and Canada in 2010 (25 of which were in the U.S.); however, the effects of such a small initial population size are evidenced by the lower genetic diversity values documented in 2007 (Proctor *et al.* 2012, pp. 12, 31).

Despite the lower levels of genetic diversity in the SE, there have been no detectable consequences on grizzly bear morphology, physiology, ecology, or biology related to these differences in genetic diversity as evidenced by normal litter size, little evidence of disease, an equal sex ratio, and normal physical characteristics such as body size and weight (Wakkinen and Kasworm 2004, pp. 71–72; Kasworm *et al*. 2020b, pp. 25–26, 40–41*in prep.*).

Because current levels of genetic diversity are not translating into any documented detectable deleterious effects, we do not consider genetic concerns to be a threat to grizzly bears in the SE. Because of the SE population's small size, its isolation is of more concern, but recent data indicate increasing connectivity and movements by both males and females. Maintaining or increasing current levels of genetic diversity in the SE would help ensure genetic concerns do not become a threat in the future. Small population size makes the SE grizzly bear population more vulnerable to genetic, demographic, and environmental stochasticity. Although connectivity has been documented in the SE, increased natural connectivity would alleviate potential future genetic concerns, reduce extinction risk due to small population size, and improve this population's resilience to environmental and climate change impacts.

Connectivity and Genetic Health in the BE

There is currently no known population in the BE and isolation is a concern for any future populations. However, at least five grizzly bears have been confirmed in areas immediately surrounding the recovery zone over the last 15 years. In addition, current distributions of grizzly bears in the GYE and NCDE continue to expand (NCDE and BE are only 7 km (4.3 mi) apart and multiple verified sightings have occurred between them and the BE. To date, all verified occurrences of grizzly bears entering the BE have been males and female immigration is also needed for natural recolonization. Female immigration is anticipated to be slower given their shorter dispersal distances and potential barriers (e.g., I-90). However, these examples indicate that connectivity between other ecosystems (CYE, SE, GYE, NCDE) and the BE is possible.

Connectivity and Genetic Health in the North Cascades

There is currently no known population in the North Cascades and natural recolonization is unlikely in the near future due to the low numbers of bears in nearby populations and the highly fragmented landscape in between (NPS and Service 2017, p. 5). However, if a population is established in the North Cascades, there are populations close enough that could provide a male immigrant, thereby ensuring long-term genetic fitness. There are at least three populations within long-distance dispersal range (67–176 km (42–109 mi)) (Blanchard and Knight 1991, pp. 50, 55; McLellan and Hovey 2001, p. 841; Peck *et al.* 2017, p. 2), from the North Cascades, including the Stein-Nahatlatch, Squamish-Lillooet, Garibaldi-Pitt Grizzly Bear Population Units in Canada.

Summary of Connectivity and Genetic Health

Genetic concerns are not an immediate threat to the GYE grizzly bear population (Miller and Waits 2003, p. 4338; Kamath *et al.* 2015, entire). First, as stated by Kamath *et al.* (2015, p. 5517), the current effective population size is sufficiently large to avoid accumulation of inbreeding depression, thereby reducing concerns regarding genetic factors affecting the viability of GYE grizzly bears. Second, the current level of genetic diversity in the GYE grizzly bear population coincides with robust demographic vital rates (i.e., reproduction, survival) that are fully comparable with other growing or stable brown bear populations in North America (van Manen 2016, *in litt.*). However, the GYE has been isolated for many generations, and could benefit from restoration of gene flow (Kamath *et al.* 2015, p. 5517).

For the GYE grizzly bear population, potential decreases in genetic diversity would occur gradually over decades due to long generational time and relatively large population size (Miller and Waits 2003, p. 4338). We remain confident that genetic monitoring, and translocation if necessary, will address the ability of future GYE bears to adapt evolutionarily (Hedrick 1995, p. 1004; Miller and Waits 2003, p. 4338). Reductions in conflict situations through attractant storage orders on public lands and other preventative measures (see *Preventative Measures* for further details), promotes genetic connectivity through natural movement. The IGBST monitors grizzly bear movements and observations, and the IGBST checks for the presence of alleles from grizzly bear populations outside the GYE grizzly bear (YES 2016a, pp. 52–54). The IGBST also monitors genetic diversity of the GYE grizzly bear population so that a possible reduction in genetic diversity will be detected and responded to accordingly with translocation of grizzly bears into the GYE originating from another population in the lower-48 States. In addition to possible translocations, measures described in the 2016 GYE Conservation Strategy are and will continue to be used to promote genetic connectivity through natural movements. These measures include habitat protections, population standards, mortality control, outreach efforts, and adaptive management.

Overall, the NCDE population is genetically and demographically well connected to Canadian populations; current levels of genetic diversity are sufficient to support healthy reproduction and survival; and the NCDE's current population size ensures genetic health. Accordingly, genetic health is not affecting the continued existence of the NCDE grizzly bear population and we do not expect that to change in the future. In fact, due to its good genetic health, the NCDE has served, and will continue to serve, as a source population for genetic and demographic rescue of other grizzly bear populations in the lower-48 States.

Recent data indicates increasing genetic connectivity and movements between populations within the lower-48 States and between these populations and populations Canada. However, because of the small populations sizes in the in CYE and SE, and the lack of known populations in the BE and North Cascades, isolation is still a potential future threat to the resiliency of these populations. To address this threat, interagency efforts are continuing to provide and maintain movement opportunities for grizzly bears, and reestablish natural connectivity and gene flow among all grizzly bear populations in the lower-48 States. To document natural connectivity, we monitor bear movements near the edges of all populations using a combination of radio-collared bears, non-invasive genetic sampling, and motion-triggered wildlife cameras, depending on available resources and opportunities. We also collect genetic samples from all captured or dead bears to document movements or gene flow between ecosystems. These monitoring efforts will continue in the future.

Food Resources

The lower-48 States is comprised of highly diverse landscapes containing a wide array of habitat types and bear foods. Plant communities vary from grasslands, grain fields, and hay fields at lower elevations to extensive conifer forests at mid-elevation to subalpine and alpine meadows at high elevations. Contraction of historical range could change the availability of highly energetic food resources, such as ungulates, army cutworm moths, and berries; that could influence grizzly bear reproduction, survival, or mortality risk (Mealey 1975, pp. 84–86; Pritchard and Robbins 1990, p. 1647; Craighead *et al.* 1995, pp. 247–252).

Grizzly bear diets are characterized by high variability among individuals, seasons, and years (Servheen 1981, p. 119–123,127–128; LeFranc *et al.* 1987, pp. 24–25; Mattson *et al.* 1991a, pp. 1621–1625; Mattson *et al.* 1991b, pp. 2433–2434; Schwartz *et al.* 2003a, pp. 568–569; Felicetti *et al.* 2004, pp. 496–499; Gunther *et al.* 2014, pp. 64–69). They display great diet plasticity and switch food habits according to which foods are most nutritious and available (Servheen 1981, pp. 119–123,127–128; Kendall 1986, pp. 12–18; Mace and Jonkel 1986, entire; Martinka and Kendall 1986, pp. 21–22; LeFranc *et al.* 1987, pp. 24–25; Aune and Kasworm 1989, pp. 64–72; Schwartz *et al.* 2003a, pp. 568–569; Gunther *et al.* 2014, pp. 65–69). Grizzly bears are successful omnivores, and in many areas almost entirely herbivorous (Kendall 1986, p. 12; Jacoby *et al.* 1999, pp. 924–927; Schwartz *et al.* 2003a, pp. 568–569; Teisberg *et al.* 2015, pp. 10–12). Grizzly bears will consume almost any food available, including living or dead mammals or fish, insects, worms, plants, human-related foods, and garbage (Mattson *et al.* 1991a, pp. 1621–1622; Mattson *et al.* 1991b, pp. 2433–2434; Schwartz *et al.* 2003a, pp. 568–569; Gunther *et al.* 2014; entire). In areas where animal matter is less available, berries, grasses, roots, bulbs, tubers, seeds, and fungi are important in meeting protein and caloric requirements (LeFranc *et al.* 1987, pp. 24–25; Schwartz *et al.* 2003a, pp. 568–569; Gunther *et al.* 2014, p. 65). It is hypothesized that grizzly bears frequently sample new foods in small quantities so that they have options in years when preferred foods are scarce (Mattson *et al.* 1991a, p. 1625). Annual changes in feeding strategy have been documented in GYE grizzly bears (Mattson *et al.* 1991a, entire).

Food Resources in the GYE

A comprehensive study of the GYE grizzly bear diet documented over 266 distinct plant and animal species ranging from grasses, fungi, berries, and seeds, to fish, carrion, and other meat sources (e.g., young and weakened animals) (Gunther *et al.* 2014, entire). Monitoring foods comprising such a diverse diet is challenging, which is why IGBST's current monitoring efforts have focused on four foods with relatively high energetic value and for which abundance (or use by bears) is relatively easy to measure: ungulates, spawning cutthroat trout, army cutworm moths, and whitebark pine seeds (Mealey 1975, pp. 84–86; Pritchard and Robbins 1990, p. 1647; Craighead *et al.* 1995, pp. 247–252). The discussion below assesses the potential influence of the availability of these four food sources on grizzly bears. Although we briefly discuss ungulates, cutthroat trout, and army cutworm moths, more details on the specific ways in which changes in these food sources could affect the GYE grizzly bear population are discussed in detail in the 2007 final rule (72 FR 14866, March 29, 2007, 14928–14933). Our analysis focuses on the potential impacts that the loss of whitebark pine could have on the GYE grizzly bear population.

Ungulates

Grizzly bears consume ungulates as winter-killed carrion in the early spring, kill calves opportunistically, consume hunter-killed carcasses or gut piles, and prey upon adults weakened during the fall breeding season. Although bison and elk are the primary ungulate species consumed by grizzly bears in the GYE, they also feed on mule deer, moose, pronghorn, and pronghorn sheep. Ungulate populations may be affected by: brucellosis (*Brucella abortus*) and the resulting management practices that can result in bison removal (however, brucellosis is not regulating in ungulate populations); chronic wasting disease; and decreasing winter severity. In addition, ungulate availability may be affected by competition with other top predators for ungulates as prey, including human hunters. Brucellosis does not affect bison as a food source for grizzly bears because it is not a threat to the long-term survival of the Yellowstone bison, and the subsequent removal program is managed to "maintain a wild, free-ranging population of bison" (NPS and USDA Animal and Plant Health Inspection Service 2000, p. 22). Chronic wasting disease is fatal to deer and elk but has not been detected in the GYE, and, as transmission is density-dependent (Schauber and Woolf 2003, pp. 611–612), chronic wasting disease would not result in local extinction of deer or elk populations. The availability of ungulate carcasses is not anticipated to be impacted by either of these diseases. The reintroduction of gray wolves (*Canis lupus*) to the GYE in 1995 has created competition between grizzly bears and wolves for carrion; however, there has been no documentation of negative influence on the GYE grizzly bear population (Servheen and Knight 1993, p. 36). Decreasing winter severity and length as a result of climate change could reduce spring carrion availability (Wilmers and Getz 2005, p. 574; Wilmers and Post 2006, p. 405). A reduction of winter-killed ungulates may be buffered by increased availability of meat to adult grizzly bears during the active season as a result of grizzly bears usually prevailing in usurping wolf-killed ungulate carcasses (Ballard *et al.* 2003, p. 262). The Yellowstone bison population size has remained within the Interagency Bison Management Plan's recommended range of 2,500 and 4,500 bison since 2000, with the exception of 2005 and 2007 when numbers exceed 4,500.

Cutthroat Trout

A decline in the Yellowstone cutthroat trout population has resulted from a combination of factors: the introduction of nonnative lake trout (*Salvelinus naymaycush*), a parasite that causes whirling disease (*Myxobolus cerebralis*), and several years of drought conditions in the Intermountain West (Koel *et al.* 2005, p. 10). Although there has been a corresponding decrease in grizzly bear use of cutthroat trout, only a small portion of the GYE grizzly bear population has access to this food resource (Haroldson *et al.* 2005, p. 175), and grizzly bears that fish in spawning streams only consume, on average, between 8 and 55 trout per year (Felicetti *et al.* 2004, p. 499).

Army Cutworm Moths

Army cutworm moths aggregate on remote, high-elevation talus slopes where grizzly bears forage on them from mid- to late summer. Moth sites are limited to the southeast corner of the GYE and only about 25 percent of grizzly bears use moth sites (Haroldson 2020, *in litt.*). Grizzly bears using moth sites could potentially be disturbed by backcountry visitors (White *et al.* 1999, p. 150), but this is currently not a major issue of concern due to the remoteness of these sites in the GYE (Nunlist 2020, pp. 83–90). Grizzly bear use of these sites is monitored by the WGFD and IGBST. Climate change may affect army cutworm moths by changing the distribution of plants that the moths feed on or the flowering times of the plants (Woiwod 1997, pp. 152–153). However, the GYE plant communities have a wide elevational range that would allow for distributional changes (Romme and Turner 1991, p. 382), and army cutworm moths display foraging plasticity (Burton *et al.* 1980, pp. 12–13).

Whitebark Pine

Background on whitebark pine: While we discussed notable declines in whitebark pine due to mountain pine beetle in the 2007 final rule, the data used to estimate population growth only went through 2002. The Ninth Circuit Court of Appeals questioned our conclusions about future population viability based on data gathered before the sharp decline in whitebark pine began (*Greater Yellowstone Coalition, Inc.* v. *Servheen, et al.*, 665 F.3d 1015, 1030 (9th Cir. 2011)). To assess vital rates for grizzly bears in the GYE since 2002, the IGBST completed a comprehensive demographic review using data from 2002–2011 (IGBST 2012, p. 7) and extensive analyses to determine if the decline in whitebark pine is driving observed changes in grizzly bear population vital rates (IGBST 2013, entire).

The threats to whitebark pine reported in our 2007 final rule and reiterated in our 12-month finding for whitebark pine (76 FR 42631; July 19, 2011) are currently being analyzed in an SSA. The 2011 12-month finding made the determination that whitebark pine is warranted for protected status under the Act, but that action is precluded by higher priority actions. This status is primarily the result of direct mortality due to white pine blister rust and mountain pine beetles but also less obvious impacts from climate change and fire suppression. For more details on the status of whitebark pine, please see the 2013 candidate notice of review (78 FR 70104; November 22, 2013).

Whitebark pine is a masting species, which means it produces large seed crops in some years and poor crops in other years. In the GYE, a good seed crop occurs approximately every 2 to 3 years. During years of low availability of whitebark pine seeds, human-grizzly bear conflicts tend to increase as bears use lower elevations for foraging, and those areas tend to be within less secure habitats (Gunther *et al.* 2004, pp. 13–15; Schwartz *et al.* 2010, pp. 661–662). Approximately six more independent females and six more independent males die across the ecosystem in poor versus good whitebark pine years (IGBST 2013, p. 25, figure 5). These mortalities are primarily due to defense of life encounters and management removals of conflict bears (Gunther *et al.* 2004, pp. 13–14; IGBST 2009, p. 4). Additionally, litter size and the likelihood of producing a litter may decrease slightly in years following poor whitebark pine crops (Schwartz *et al.* 2006b, p. 21). Therefore, an important question was whether decline of whitebark pine would make most years similar to those years with poor seed crops. In this section we will discuss the Food Synthesis Report, past studies on whitebark pine and grizzly bear mortality, density-dependent effects, and the GYE grizzly bear's high diet diversity.

Food Synthesis Report: Using data from 2002 to 2011, the IGBST documented an average annual population growth rate for the GYE grizzly bear population between 0.3 and 2.2 percent (IGBST 2012, p. 34). Although the population was still increasing in this more recent time period, it was increasing at a slower rate than in the previous time period (1983–2001) and coincided with the rapid decline of whitebark pine that began in the early 2000s. Therefore, the IGBST examined the potential influence of whitebark pine decline on the change in population growth rate. Because extrinsic, density-independent factors (e.g., availability of whitebark pine seeds) and intrinsic, density-dependent factors (i.e., a population with high bear density) can produce similar changes in population vital rates, the IGBST conducted several analyses to clarify and tease apart these two similar effects. The results of these analyses were summarized in a report titled "Response of Yellowstone grizzly bears to changes in food resources: a synthesis" (hereafter referred to as "the Food Synthesis Report") (IGBST 2013, entire). Regardless of whether these changes in population vital rates are being driven by declines in whitebark pine or are simply an indication of the population reaching high densities, the management response would be the same: to carefully manage human-caused mortality based on scientific monitoring of the population.

For this Food Synthesis Report, the IGBST developed a comprehensive set of research questions and hypotheses to evaluate grizzly bear responses to changes in food resources. Specifically, the IGBST asked eight questions:

(1) How diverse is the diet of GYE grizzly bears?
(2) Has grizzly bear selection of whitebark pine habitat decreased as tree mortality increased?
(3) Has grizzly bear body condition decreased as whitebark pine declined?
(4) Has animal matter provided grizzly bears with an alternative food resource to declining whitebark pine?
(5) Have grizzly bear movements increased during the period of whitebark pine decline (2000–2011)?
(6) Has home range size increased as grizzly bears sought alternative foods, or has home-range size decreased as grizzly bear density increased?

(7) Has the number of human-caused grizzly bear mortalities increased as whitebark pine decreased?
(8) Are changes in vital rates during the last decade associated more with decline in whitebark pine resources than increases in grizzly bear density?

The preliminary answers to these questions are contained in the Synthesis Report and the final results have been (or will be) published in peer-reviewed journals (in their entirety: Bjornlie *et al*. 2014a; Costello *et al*. 2014; Gunther *et al*. 2014; Schwartz *et al*. 2014a and 2014b; van Manen *et al.* 2016; Ebinger *et al.* 2016; Haroldson *et al.*, *in prep*.).

Key findings of the Synthesis Report and subsequent publications are summarized below. To address the first question about how diverse diets of grizzly bears in the GYE are, Gunther *et al.* (2014, entire) conducted an extensive literature review and documented over 260 species of foods consumed by grizzly bears in the GYE, representing four of the five kingdoms of life (for more information, please see *Nutritional Ecology*, above). Regarding the second research question, if whitebark pine seeds were highly selected over other fall foods, grizzly bears would continue to seek this food even if availability declined. However, Costello *et al.* (2014, p. 2013) found that grizzly bear selection of whitebark pine habitat and duration of use decreased between 2000 and 2011. Additionally, regarding the third research question, if grizzly bears were dependent on whitebark pine to meet their nutritional requirements, we would expect body condition to have decreased during that time. Schwartz *et al.* (2014a, p. 75) and the IGBST (2013, p. 18) found body mass and percent body fat in the fall had not changed from 2000 to 2010. When they examined trends in females only, the data showed a moderate decline in female body fat during the fall, starting around 2006 (Schwartz *et al*. 2014a, p. 72). However, they suggested it could be the result of small sample sizes (n = 2.6 bears/year) and noted the data for 2011 (not included in their published paper) showed an increase in fall body fat for females, ultimately cautioning that more data were needed before it could be determined if there was truly a trend (Schwartz *et al*. 2014a, p. 76). In the Food Synthesis Report, the IGBST revisited this previous analysis with data collected since 2010, and concluded that body condition was not different between poor and good years of whitebark pine production (IGBST 2013, p. 18). Furthermore, extending the female fall body fat data from Schwartz *et al.* (2014a, p. 73) by almost a decade (2011–2019) (IGBST, unpublished data), indicates a stable instead of decreasing trend.

In response to the fourth research question, in years with poor whitebark pine seed production, grizzly bears shifted their diets and consumed more meat (Schwartz *et al.* 2014a, p. 68). These results were consistent with previous findings (Mattson 1997, p. 169). Given these observations of diet shifts, Ebinger *et al.* (2016, p. 705) examined whether grizzly bear use of ungulate carcasses in the fall had increased during the period of whitebark pine decline. This was indeed the case, supporting the interpretation that responses to changing food resources were primarily behavioral. In response to the fifth and sixth questions, if overall food resources were declining, one would expect daily movements, fall movements, and home range sizes to increase if bears were roaming more widely in search of foods. However, movement rates did not change during 2000 to 2011, suggesting that grizzly bears were finding alternate foods within their home range as whitebark pine seeds became less available over the past decade (Costello *et al.* 2014, p. 2013). For females, home ranges actually decreased in size from the period before (1989–1999) to the period after (2007–2012) whitebark pine decline. This decrease was greater in areas with higher grizzly bear densities but showed no relationship with the amount of live whitebark pine in the home range (Bjornlie *et al*. 2014b, pp. 4–6). Male home ranges did not change in size (Bjornlie *et al.* 2014b, pp. 4–6). Finally, at the population level, bear density, but not whitebark pine decline, was associated with lower cub survival and reproductive suppression, factors contributing to the slowing of population growth since the early 2000s. Combined, these findings suggest that changes in population vital rates since the early 2000s are more indicative of the population approaching carrying capacity than a shortage of resources (van Manen *et al.* 2016, p. 310).

In response to the seventh question, while land managers have little influence on how calories are spread across the landscape, we have much more influence on human-caused mortality risk. Consistent with findings from earlier studies, the IGBST (2013, p. 24) found that grizzly bear mortalities increased in poor whitebark pine seed production years as compared to good whitebark pine seed production years. Assuming the poorest observed whitebark pine cone production, the IGBST (2013, p. 25) predicted an increase of 10 annual mortalities ecosystem-wide of independent females comparing 2000 with 2012, encompassing the period that coincided with whitebark pine decline (IGBST 2013, p. 25). The greatest increase in predicted mortality occurred outside the recovery zone, which may be partially attributable to range expansion and continued population increase (IGBST 2013, p. 25). However, increased mortality numbers during poor whitebark pine cone production years have not led to a declining population trend (IGBST 2012, p. 34), and total mortality will be maintained within the total allowable mortality limits set forth in tables 2 and 4.

In response to the eighth question, the IGBST found that while whitebark pine seed production can influence reproductive rates the following year, overall fecundity rates during the last decade (2002–2011) did not decline when compared with data from 1983–2001 (IGBST 2013, p. 32). This is important because fecundity rates are a function of both litter size and the likelihood of producing a litter, the two ways in which whitebark pine seed production may affect reproduction. Although Schwartz *et al.* (2006a, p. 21) found one-cub litters were more common in years following poor whitebark pine seed production, one-cub litters are still adequate for population growth. Furthermore, one-cub litters are still relatively uncommon following poor whitebark pine years, as evidenced by a very consistent average litter size around two cubs since the IGBST began reporting this metric. Fecundity and mean litter size did not change between the two monitoring periods (1983–2001 versus 2002–2011) examined by the IGBST even though the availability of whitebark pine seeds declined (IGBST 2013, pp. 33–34).

Past Studies on Whitebark Pine and Grizzly Bear Mortality: In contrast to previous studies that concluded increased mortality in poor whitebark pine cone production years led to population decline in those years (Pease and Mattson 1999, p. 964), the IGBST found the population did not decline despite increased mortality in poor whitebark pine cone production years. Therefore, we determined that the conclusions of Pease and Mattson (1999, p. 964) are inaccurate. First and foremost, estimating population growth for individual, non-consecutive years, as Pease and Mattson (1999, p. 962) did, is “not legitimate” and results in an “incorrect estimate” (Eberhardt and Cherry 2000, p. 3257). Even assuming their methods of separating out individual, non-consecutive years of data for a species whose reproduction and survival are inextricably linked to multiple, consecutive years (e.g., reproductive status in 1 year affects status in the following year), many other aspects of their analysis do not reflect the best available science. An important difference between Pease and Mattson (1999, p. 964) and other population growth rate estimates (Eberhardt *et al*. 1994, p. 362; Boyce 1995, entire; Schwartz *et al*. 2006b, p. 48; IGBST 2012, p. 34) is related to their treatment of conflict bears. Pease and Mattson (1999, p. 967) assumed that grizzly bears with any history of conflict would experience lower survival rates associated with conflict bears for the rest of their lives.

The findings of Schwartz *et al*. (2006b, p. 42) challenge this assumption, finding that while survival of conflict bears decreases during the year of the conflict and the next year, survival returns to approximately normal within 2 years. In other words, management-trapped bears often return to foraging on naturally occurring food sources without causing conflict. Another assumption made by Pease and Mattson (1999, p. 967) was that 73 percent of the GYE grizzly bear population were conflict bears, with correspondingly lower survival rates. However, Schwartz *et al*. (2006b, p. 39) found only about 28 percent of the GYE grizzly bear population were ever involved in conflicts. Together, these two erroneous assumptions by Pease and Mattson (1999, p. 967) resulted in a gross underestimation of population trend. Empirical trend data based on the two most recent decades of data refute their conclusions (Haroldson *et al.* 2020b, p. 18). As a result, we do not consider Pease and Mattson (1999, entire) to be the best available science.

Earlier studies suggested that increased grizzly bear mortalities in poor whitebark pine cone production years are a result of bears roaming more widely in search of foods and exposing themselves to higher mortality risk in roaded habitats at lower elevations. However, Costello *et al.* (2014, p. 2014) showed that grizzly bears did not roam over larger areas or canvass more area within their fall ranges as whitebark pine declined rapidly starting in the early 2000s, and suggested bears found alternative foods within their fall ranges. Furthermore, Bjornlie *et al.* (2014b, p. 4) found that home range size has not increased after whitebark pine declined. In addition, Schwartz *et al.* (2010, p. 662) found that when bears use lower elevations in poor whitebark pine seed production years, it is the amount of secure habitat that determines mortality risk: in both good and poor whitebark pine seed years, survival is determined primarily by levels of secure habitat. Therefore, our approach of maintaining these levels of secure habitat on Federal lands, which comprise 98 percent of lands within the recovery zone and 59 percent of suitable habitat outside the recovery zone, provides effective mitigation against any impacts the decline of whitebark pine may have on this grizzly bear population because the mechanism driving the increased mortality risk is secure habitat, not the presence or absence of whitebark pine, or their seed production.

While there was some concern that the rapid loss of whitebark pine could result in mortality rates similar to those experienced after the open-pit garbage dumps were closed in the early 1970s (Schwartz *et al.* 2006b, p. 42), we now know this has not been the case. This is most likely due to the fact that whitebark pine has never been a spatially or temporally predictable food source on the landscape like the open-pit garbage dumps were. The dumps were open year-round and provided high-calorie foods the entire time. They were in the exact same location every year and for the entire season. Grizzly bears congregated at these known locations in large numbers and in very close proximity to each other and to people. None of these circumstances are true for grizzly bears foraging on whitebark pine seeds.

Density-Dependent Effects: Evidence suggests that observed changes in population vital rates were driven by density-dependent effects and have resulted in a relatively flat population trajectory (van Manen 2016, *in litt.*). van Manen *et al.* (2016, entire) found cub survival, yearling survival, and reproductive transition (i.e., transition probability[11]) from no young to cubs all changed from 1983 to 2012, with lower rates evident during the last 10 years of that time period. Cub survival and reproductive transition were negatively associated with an index of grizzly bear density, indicating greater declines of those parameters where bear densities were higher. Their analysis did not support a similar relationship with estimates of decline in whitebark pine tree cover. Moreover, changes in vital rates started in the late 1990s and early 2000s (van Manen *et al.* 2016, pp. 307–308), which preceded the beginning and peak time period of whitebark pine decline. The results of van Manen *et al.* (2016, entire) support the interpretation that slowing of population growth during the last decade was associated more with increasing grizzly bear density than the decline in whitebark pine.

GYE Grizzly Bears' High Diet Diversity: GYE grizzly bears have high diet diversity (Gunther *et al.* 2014, p. 65) and use alternate foods in years of low whitebark pine seed production (Schwartz *et al.* 2014a, pp. 75–76). Nearly one third of grizzly bears in the GYE do not have whitebark pine in their home range, so they do not use this food (Costello *et al.* 2014, p. 2013). Grizzly bears in the GYE that do use whitebark pine are accustomed to successfully finding alternative natural foods in years when whitebark pine seeds are not available, and body mass and body fat are not different between good and poor whitebark pine seed years (Schwartz *et al.* 2014a, pp. 72–73, 75).

Grizzly bears are resourceful omnivores that will make behavioral adaptations regarding food acquisition (Schwartz *et al.* 2014a, p. 75). Diets of grizzly bears vary among individuals, seasons, years, and where they reside within the GYE (Mealey 1980, pp. 284–287; Mattson *et al.* 1991a, pp. 1625–1626; Felicetti *et al.* 2003, p. 767; Felicetti *et al.* 2004, p. 499; Koel *et al.* 2005, p. 14; Costello *et al.* 2014, p. 2013; Gunther *et al.* 2014, pp. 66–67), reflecting their ability to find adequate food resources across a diverse and changing landscape. In other nearby areas such as the NCDE (100 miles north of the GYE), whitebark pine has been functionally extinct as a bear food for at least 40 years (Kendall and Keane 2001, pp. 228–232), yet the NCDE grizzly bear population has continued to increase and thrive with an estimated 765 bears in 2004, and a subsequent average 2.3 percent annual rate of growth (Kendall *et al.* 2009, p. 9; Costello *et al.* 2016, p. 2; Costello 2018, *in litt.*). Similarly, although whitebark pine seed production and availability of cutthroat trout in the Yellowstone Lake area varied dramatically over the last 3 decades due to both natural and human-introduced causes (Reinhart and Mattson 1990, pp. 345–349; Podruzny *et al*. 1999, pp. 134–137; Felicetti *et al.* 2004, p. 499; Haroldson *et al*. 2005, pp. 175–178; Haroldson 2015, p. 47; Teisberg *et al*. 2014, pp. 375–376), the GYE grizzly bear population has continued to increase and expand during this time period despite these changes in foods (Schwartz *et al.* 2006a, p. 66; IGBST 2012, p. 34; Bjornlie *et al.* 2014a, p. 184).

[11] Transition probability: The probability of a transition for an adult female (greater than 3 years old) among reproductive states. The possible reproductive states are: no young, with cubs-of-the-year, or with 2-years-olds. Ten potential reproductive transitions are biologically feasible.

The GYE grizzly bear population has been coping with the unpredictable nature of whitebark pine seed production for millennia. Grizzly bears are not dependent upon whitebark pine seeds for survival, nor do they have a diet that is specialized on consumption of these seeds. Whitebark pine seed production can influence reproductive and survival rates; however, decline of whitebark pine seed production has not caused a negative population trend, as evidenced by a relatively constant population size within the DMA since the early 2000s; rather there is greater evidence of an increasing trend in recent years (Haroldson *et al.* 2020b, pp. 13, 18). As articulated in the Food Synthesis Report by the IGBST (IGBST 2013, pp. 32–35) and supporting studies (in their entirety: Bjornlie *et al*. 2014b; Costello *et al.* 2014; Gunther *et al.* 2014), the demonstrated resiliency to declines in whitebark pine seed production and other high-calorie foods such as cutthroat trout shows that changes in food resources are not likely to become substantial impediments to the long-term persistence of the GYE grizzly bear population.

Food Resources in the NCDE

The NCDE is comprised of a highly diverse landscape containing a wide array of habitat types and bear foods. Plant communities vary from short grass prairie, grain fields, and hay fields on the eastern foothills to extensive conifer forests at mid-elevation to subalpine and alpine meadows at high elevations. In the NCDE, historical grizzly bear presence was less common in prairie habitats (i.e., those areas outside the DMA) and was associated with rivers and streams where grizzly bears used bison carcasses as a major food source (Rollins 1935, p. 191; Wade 1947, p. 444; Burroughs 1961, pp. 57–60; Herrero 1972, pp. 224–227; Stebler 1972, pp. 297–298; Mattson and Merrill 2002, pp. 1128–1129). Most of the shortgrass prairie on the east side of the Rocky Mountains has been converted into agricultural land (Woods *et al.* 1999, entire), and high densities of traditional food sources (i.e., bison) are no longer available due to land conversion and human occupancy of urban and rural lands. Traditional food sources such as bison and elk have been reduced and replaced with domestic livestock such as cattle, sheep, chickens, goats, pigs, and beehives, which can become anthropogenic food sources for grizzly bears. Historically, grizzly bears on the prairie also fed on grasses, berries, and forbs commonly associated with riparian areas, which they continue to do today (Herrero 1972, p. 224; Stebler 1972, p. 299).

Grizzly bears are successful omnivores, and in many areas of the NCDE are almost entirely herbivorous (Kendall 1986, p. 12; Jacoby *et al.* 1999, pp. 924–927; Schwartz *et al.* 2003a, pp. 568–569; Teisberg *et al.* 2015, pp. 10–12). Using observed ratios of stable isotopes in food items, it is possible with sufficient sample sizes to infer information about assimilated diets of grizzly bears (Robbins *et al*. 2004, pp. 162–164). Stable isotope analysis indicates that grizzly bear consumption of animal matter has remained relatively constant within the NCDE over the last several decades. Animal matter comprises a larger percentage of adult male grizzly bear diets (60%), than adult females (35%), and subadults (46%) (Teisberg *et al.* 2015, p. 10). There was high variation across the ecosystem with bears on the southwestern, southern, and eastern periphery having higher levels of dietary animal matter and bears in the northwestern and interior periphery having lower levels of dietary animal matter (Teisberg *et al.* 2015, see figure 2). Grizzly bears on the East Front consumed the highest proportions of animal matter at 71 percent while the lower Swan River and lower South Fork of the Flathead had the lowest proportions of animal matter at 21 percent (Teisberg *et al.* 2015, p. 11). These findings are consistent with previous studies completed in the 1980's, 1990's, and early 2000's (Aune and Kasworm 1989, pp. 64–72; Jacoby *et al.* 1999, pp. 924–927; Mowat and Heard 2006, pp. 477–482), and indicate that NCDE grizzly bear consumption of animal matter has not varied greatly throughout the decades.

Upon den emergence, bears in the NCDE may search avalanche chutes for animal carcasses from descending to lower elevations seeking newly emerging vegetation. From den-emergence until early summer, grizzly bears typically subsist on the roots of sweet vetches (*Hedysarum* spp.), biscuit root (*Lomatium* spp.), glacier lilies (*Erythonium grandiflorum*) and western spring beauty (*Claytonia lanceolata*); berries from the previous year's crop of bearberry (*Arctostaphylos uva-ursi*); vegetation from grasses, sedges, cow parsnip (*Heracleum* spp.), and angelica (*Angelica* spp.); and deer (*Odocoileus* spp.), elk (*Cervus canadensis*), or domestic livestock in the form of neonate fawns or calves and carrion resulting from winter related die-off and calving season mortality (Servheen 1981, pp. 99–102; Kendall 1986, pp. 15–16; Mace and Jonkel 1986, p. 108; Martinka and Kendall 1986, p. 22; LeFranc *et al.* 1987, pp. 111–114; Aune and Kasworm 1989, pp. 65–66). During summer, before berry crops are available, bears in the NCDE may eat the roots of western spring beauty and glacier lilies and the vegetation of *Ligusticum* species, sweet cicely (*Osmorhiza* spp.), grasses, *Equisetum* species, cow parsnip (*Heracleum lanatum*), and *Angelica* species (LeFranc *et al.* 1987, pp. 111–114; Aune and Kasworm 1989, pp. 65–66; McLellan and Hovey 1995, p. 708). Consumption of insects, especially ants, peaks during summer months. Many bears also begin to feed on army cutworm moths (*Euxoa auxiliaris*) in GNP from late June through mid-September (White *et al.* 1998, p. 223). In the Mission Mountains, grizzly bears may feed on army cutworm moths and ladybird beetles (*Coccinnella* spp.) from the beginning of July through the end of August (Chapman *et al.* 1955, entire; Servheen 1983, p. 1031). Grizzly bears have also been observed feeding on army cutworm moths in the Scapegoat Wilderness (Sumner and Craighead 1973, p. 21) and the Rocky Mountain Front of Montana (Aune and Kasworm 1989, p. 70). Once berries become available, bears in the NCDE may consume huckleberries (*Vaccinium* spp.), soap berries (*Shepherdia canadensis*), service berries (*Amelanchier alnifolia*), hawthorn berries *(Crataegus douglasii*), and choke cherries (*Prunus* spp.); and to a lesser degree alderleaf buckthorn berries (*Rhamnus alnifolia)* and mountain ash berries (*Sorbus* spp.) (Servheen 1981, p. 101; Kendall 1986, pp. 12, 15–16; Mace and Jonkel 1986, p. 108; Martinka and Kendall 1986, p. 21; LeFranc *et al.* 1987, p. 111; McLellan and Hovey 1995, pp. 706–707). The amount and species of berries in bear diets vary annually based on annual fruit production and distributions (McLellan and Hovey 1995, pp. 706–707).

During late summer to fall, bears in the NCDE may continue to eat berries but will also consume more animal matter (mostly from hunter gut piles and hunter wounded animals) and the roots/bulbs/corms of sweet vetches and biscuit roots (Kendall 1986, pp. 15–16; Mace and Jonkel 1986, p. 108; Martinka and Kendall 1986, p. 22; LeFranc *et al.* 1987, pp. 112–114; Aune and Kasworm 1989, pp. 64–72; McLellan and Hovey 1995, pp. 706–708). While the roots of sweet vetches are used by grizzly bear populations in Canada, Alaska, GNP, and the northern reaches of the lower-48 States during spring and fall (Hamer and Herrero 1987a, p. 205; LeFranc *et al.* 1987, pp. 112–114; McLellan and Hovey 1995, pp. 706–708; Munro *et al.* 2006, p. 1115), where *Hedysarum* is less common in the southern and eastern edges of the recovery zone, grizzly bears can consume biscuit roots and glacier lily bulbs instead (LeFranc *et al.* 1987, pp. 112–114; Aune and Kasworm 1989, pp. 64–72).

Prior to the spread of white pine blister rust (*Cronartium ribicola*) in the NCDE, grizzly bears opportunistically fed on whitebark pine seeds in the late summer through fall, primarily in the Whitefish Mountain range and along the Rocky Mountain Front (Shaffer 1971, pp. 39, 76, 78; Mace and Jonkel 1986, pp. 107–109; Aune and Kasworm 1989, pp. 64–72; Kendall and Arno 1990, pp. 264–265; Schwartz *et al.* 2003a, pp. 568–569). By the early to mid-1990's however, 42 to 58 percent of all trees surveyed were dead and 48 to 83 percent of the remaining live trees surveyed showed signs of blister rust infection within the NCDE (Kendall and Keane 2001, pp. 228–232). By 2006, nearly 75 percent of whitebark pine trees were dead and of the remaining live trees, 90 percent were affected by blister rust (Fiedler and McKinney 2014, p. 290). Due to this widespread mortality from blister rust, whitebark pine has been functionally extinct as a food resource for grizzly bears for the past 40 years (Kendall and Keane 2001, pp. 228–232). Despite this loss, during this same period, the NCDE grizzly bear population thrived and increased from as few as 300 grizzly bears in 1986 to an estimated 765 bears in 2004 (Kendall *et al.* 2009, p. 9), and a subsequent average 2–3 percent annual growth rate (Mace *et al.* 2012, p. 124; Costello *et al.* 2016, p. 2).

Body fat content is measured for captured grizzly bears in the NCDE (Teisberg 2020, *in litt.*). As noted in the GYE, CYE, and SE, body fat varies by month, exhibiting a trend that is presumably dependent on denning and availability and quality of foods consumed during the active season (Schwartz *et al.* 2014, p. 72; Kasworm *et al.* 2020a, pp. 61–63). For data from 2010–2017, adult males had significantly higher body fat content than subadult grizzly bears and adult females (Teisberg 2020, *in litt.*). Body fat content for NCDE grizzly bears also differed by month. October–November body fat values were significantly higher than those in all other months, and September fat values were higher than those in June and July. Upon den emergence, grizzly bears continue to lose body fat and start gaining fat as early as July. Body fat content is highest in the fall period prior to hibernation, suggesting that habitat and food resources are available to allow for body fat gain. In addition, fall levels for females are well above the minimum pre-denning body fat to produce cubs suggested by Robbins *et al.* (2012, p. 543).

Food Resources in the CYE and SE

The CYE and SE are both within the Rocky Mountains and are characterized by a Pacific maritime-continental climate, with wet, forested mountains. Mixed coniferous and deciduous tree stands are interspersed with riparian shrub fields and wet meadows along major drainages. Mixed shrub fields contain many species of berries, including huckleberries (*Vaccinium* spp.), buffaloberry (*Sheperdia canadensis*), and mountain ash (*Sorbus scopulina*). Understory and non-forested include graminoid parks. The small size of the CYE and SE provide a narrower range of habitats than the NCDE and GYE, and as a result may limit the diversity of foods available. In addition, its densely forested habitats may support less dense populations of ungulates and therefore less available as a food source.

In the CYE, seasonal consumption of food resources was estimated based on scat analysis (Kasworm *et al.* 2020a, p. 56). Upon den emergence in April and May, graminoids (i.e., grasses and sedges) and meat, presumably from winter-killed deer and moose, constituted 40 percent of the dry mater consumed. The use of forbs, such as cow parsnip, clover (*Trifolium* spp.), and dandelion (*Taraxacum officinale*) increased in June but grasses and sedges were still the main food resource. As graminoids begin to cure in July they provide less digestible nutrition and the amount of grasses and sedges decreased while forbs increased, mainly cow parsnip. Grizzly bears began to feed upon berries (huckleberry, whortleberry, and serviceberry) and insects (mainly ants) in July as they became available. Berries were the primary food consumed in August and September; however, consumption of animal matter (elk, deer, moose) began to increase in September and was the primary food consumed in October. This consumption correlates with the hunting season and consumption may involve entrails left by hunters or wounded animals. The SE has similar vegetation types and we assume that food habitats are similar to that in the CYE.

Stable isotope analysis was used to investigate the proportion of animal matter and vegetation in grizzly bear diets in the CYE and SE (Kasworm *et al.* 2020a, pp. 55–56*in prep.*; Kasworm *et al.* 2020b, p. 38). In the CYE, grizzly bears in the Yaak contained nearly 22 percent animal matter whereas grizzly bears in the Cabinets contained only about 13 percent. In addition, males in the Cabinets made greater use of animal matter than females (24 percent and 10 percent animal matter, respectively). Grizzly bears in the SE consumed less animal matter than the in CYE with an estimated 12 percent animal matter. Both males and females exhibited a shift in diet from spring to fall, consuming nearly double the animal matter in the fall.

Body fat content is measured for captured grizzly bears in the CYE and SE (Kasworm *et al.* 2020a, pp. 61–63). As noted in the GYE and NCDE, body fat varies by month, exhibiting a trend that is presumably dependent on denning and availability and quality of foods consumed during the active season (Schwartz *et al.* 2014, p. 72). Male and female grizzly bears did not differ in their body fat content. Upon den emergence, grizzly bears continue to lose body fat and start gaining fat as early as July. Body fat content is highest in the fall period prior to hibernation, suggesting that habitat and food resources are available to allow for body fat gain. In addition, fall levels for females are well above the minimum pre-denning body fat to produce cubs suggested by Robbins *et al.* (2012, p. 543).

Food Resources in the BE

The climate in the BE varies from warm and dry in the southern portion to cool and moist in subalpine areas. Low elevations are predominately grasslands, which with increasing elevation give way to open ponderosa pine types, subalpine fir and several types of lodgepole pine, and near-alpine habitat at the highest elevational areas. Plentiful ungulates, including elk, mule deer, and white-tailed deer, occur throughout the BE during summer and fall (Service 2000, p. 3-11). Davis and Butterfield (1991, p. entire) did a comprehensive evaluation of habitat centered around the Frank Church-River of No Return Wilderness north of the Salmon River, the Selway-

Bitterroot Wilderness, and Roadless areas north of the Selway-Bitterroot Wilderness mostly in the North Fork Clearwater drainage to the crest of the Mallard Larkins Mountains. In the area they evaluated, a wide variety of vegetation types were identified that were well distributed throughout the area and are comparable to occupied habitat in other grizzly bear ecosystems (Davis and Butterfield 1991, pp. 29–320. They concluded that these habitats would support adequate sources of known grizzly bear foods, including elk and deer, small mammals, herbaceous vegetation and tubers, and fruits and nuts (Davis and Butterfield 1991, pp. 32–40). The southern part of the BE recovery zone is drier and less productive and was not included in the analysis done by Davis and Butterfield (1991, entire). The final EIS for Grizzly Bear Recovery in the BE concluded that although the forb and berry production in these dry habitats is relatively low, the southern half of the BE recovery zone contains substantial stands of whitebark pine as well as populations of elk and deer that can provide food for grizzly bears (Service 2000, p. 3-20). Hogg *et al.* (1999; Service 2000, p. 3-23) determined that bear foods in the form of primary and secondary berries are present in biologically significant amounts in both the northern and southern portions of the ecosystem, but generally decline in abundance moving from north to south. In contrast, whitebark pine tend to follow the opposite pattern with greater abundance and distribution south of the Salmon River and a general decline through the northern portions of the BE (Service 2000, Appendix 21, Figure 6-15).

The diet of grizzly bears that recolonize the BE will likely differ somewhat from historical diets. Current runs of anadromous fish would no longer provide a readily abundant food source and would be supplemental at best; however, other fish species such as cutthroat trout and kokanee salmon may provide supplemental food for grizzly bears (Brostrom 1996, as cited in Service 2000, p. 3-16). Prior to the most recent outbreak of mountain pine beetle, Keane and Arno (1996, p. 52) estimated whitebark pine to be at 20–40 percent of historical levels because of mortality from white pine blister rust. Davis and Butterfield (1991, p. 39) concluded that Whitebark pine is still consistently present in the non-riparian subalpine habitats and may still be an important fall food source for grizzly bears that recolonize the BE. However, more recent data from the national forest inventory data suggests that blister rust and mountain pine beetle infestation rates have led to increased mortality of whitebark pine and subsequently reduced the availability of whitebark pine seeds since 2000 (Goeking and Izlar 2018, p. 4) to a level comparable to that in the GYE. However, data are currently not available to assess potential local impacts to availability to grizzly bears in the BE as a food resource.

Food Resources in the North Cascades

The North Cascades provides a variety of habitat types from temperate rainforests of the west side to the dry ponderosa pine forests and sage-steppe on the east side. The area provides a range of elevations from low elevation old growth forest to subalpine meadows to alpine environments. Grizzly bears in ecosystems with similar food economies to the North Cascades have been shown to rely heavily on herbaceous vegetation, graminoids, forbs, berries, and roots, depending on the season (McLellan and Hovey 1995, pp. 706–708; Munro *et al.* 2006, p. 1115). In these similar habitat types in west-central Alberta, upon den emergence in early spring, grizzly bears dig for roots before beginning to hunt ungulates in late May and early June. Avalanche chutes, common on the west side of the North Cascades, have been identified as important spring food sources for grizzly bears in a number of studies (Waller and Mace 1997, pp. 1034–1037; Ramcharita 2000, p. 15; McLellan and Hovey 2001, pp. 96–97). Avalanche chutes provide spring and summer forage species as well as potential avalanche mortalities (carrion) in the spring (Waller and Mace 1997, p. 1034–1037). As herbaceous vegetation begins to green up, the predominant food items include grass-like plants and forbs. Grizzly bears shift to eating berries as they become available later in the summer. At the end of the berry producing period, grizzly bears again shift to consuming roots and ungulates prior to reentering their dens (McLellan and Hovey 2001, pp. 96–97). Data from the CYE (Kasworm *et al.* 2020a, p. 56), may be indicative of potential grizzly bear food habitats in the central and west side of the Cascade Mountains due to the similar Pacific maritime climate.

In addition, Almack *et al.* (1993, entire) and Gaines *et al.* (1994, entire) produced vegetation cover maps of the study area according to vegetation structure (e.g., forest, shrub, barren rock, etc.) and community composition. Analysis of the vegetation maps indicate that 100 of the 124 plant species known to be grizzly bear foods in other ecosystems exist in the study area. In addition, they found that ungulates were dispersed relatively evenly throughout the study area. Results led both teams to conclude that sufficient vegetative grizzly bear foods are readily available in the North Cascades, and the occurrence of wildlife prey species could sustain a grizzly bear population (in their entirety: Almack *et al.* 1993; Gaines *et al.* 1994; Lyons *et al.* 2018).

Several salmon species occur in the North Cascades, although current distribution is limited to streams on the western slope of the North Cascades and occur at much lower levels than what was historically available. Most bears would not have access to salmon and would likely feed almost exclusively on terrestrial foods. However, grizzly bears introduced into the North Cascades with no history of salmon consumption may be susceptible to salmon poisoning disease (Robbins *et al*. 2018, entire). Salmon poisoning disease is a potentially fatal condition caused by infective bacterium. Ongoing studies, including prevalence in the recovery area, are looking into whether this could be an impediment to grizzly bear recovery in the North Cascades.

Summary of Food Resources

There are no indications that the availability of foods, other than whitebark pine nuts, cutthroat trout, and salmon, or the diets of grizzly bears have changed in the NCDE, CYE, SE, BE, and North Cascades in the last several decades. Although grizzly bears in the GYE have experienced a decline in the availability of whitebark pine nuts and cutthroat trout, bears are finding sufficient alternative food resources to maintain body condition. While salmon abundance is reduced in the BE and North Cascades compared to historical numbers, several studies have concluded that there are sufficient alternative foods to maintain grizzly bear populations in those ecosystems. We anticipate that grizzly bears will be able to adapt to any future potential changes in individual food sources because of the great plasticity of grizzly bear diets and the range of available foods. Thus, the highly omnivorous and flexible diet of grizzly bears will enable the species to adapt to future changes in food availability. It is also clear that grizzly bears can compensate for changes in the availability of food as long as there are sufficient large intact, blocks of land. In addition, the varying climate, topography, and vegetative conditions encompassed in the ecosystems provide a variety of habitats and foods for grizzly bears to consume.

Potential Effects of Climate Change

We evaluated observed or likely environmental changes resulting from ongoing and projected changes in climate. Effects related to climate change may result in a number of changes to grizzly bear habitat, including a reduction in snowpack levels, which may shorten the denning season (Leung *et al.* 2004, pp. 93–94), shifts in denning times (Craighead and Craighead 1972, pp. 33–34; Van Daele *et al.* 1990, p. 264; Haroldson *et al.* 2002, pp. 34–35), shifts in the abundance and distribution of some natural food sources (Rodriguez *et al.* 2007, pp. 41–42), and changes in fire regimes (Nitschke and Innes 2008, p. 853; McWethy *et al.* 2010, p. 55).

Background on Climate Change

As defined by the Intergovernmental Panel on Climate Change (IPCC), the term “climate” refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2013a, p. 1450). The term “climate change” thus refers to a change in the state of the climate that can be identified by changes in the mean or the variability of relevant properties, which persists for an extended period, typically decades or longer, due to natural conditions (e.g., solar cycles), or human-caused changes in the composition of the atmosphere or in land use (IPCC 2013a, p. 1450).

Scientific measurements spanning several decades demonstrate that changes in climate are occurring. In particular, warming of the climate system is unequivocal, and many of the observed changes in the last 60 years are unprecedented over decades to millennia (IPCC 2013b, p. 4). The current rate of climate change may be as fast as any extended warming period over the past 65 million years and is projected to accelerate in the next 30 to 80 years (National Research Council 2013, p. 5). Thus, rapid climate change is adding to other sources of extinction pressures, such as land use and human-caused mortality, which will likely place extinction rates in this era among just a handful of the severe biodiversity crises observed in Earth’s geological record (American Association for the Advancement of Sciences 2014, p. 17).

Examples of various other observed and projected changes in climate and associated effects and risks, and the bases for them, are provided for global and regional scales in recent reports issued by the IPCC (in their entirety: 2013b, 2014), and similar types of information for the United States and regions within it are available via the National Climate Assessment (Melillo *et al.* 2014, entire). Results of scientific analyses presented by the IPCC show that most of the observed increase in global average temperature since the mid-20th century cannot be explained by natural variability in climate and is “extremely likely” (defined by the IPCC as 95–100 percent likelihood) to be due to the observed increase in greenhouse gas concentrations in the atmosphere as a result of human activities, particularly carbon dioxide emissions from fossil fuel use (IPCC 2013b, p. 17).

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of greenhouse gas emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions. Model results yield very similar projections of average global warming until about 2030, and thereafter the magnitude and rate of warming vary through the end of the century depending on the assumptions about population levels, emissions of greenhouse gases, and other factors that influence climate change. Thus, absent extremely rapid stabilization of greenhouse gas emissions at a global level, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by human actions regarding greenhouse gas emissions (IPCC 2013b, p. 19; IPCC 2014, entire).

Global climate projections are informative, and, in some cases, the only or the best scientific information available for us to use. However, projected changes in climate and related impacts can vary substantially across and within different regions of the world (in their entirety: IPCC 2013b, 2014), and within the U.S. (Melillo *et al.* 2014, entire). Therefore, we use “downscaled” projections when they are available and have been developed through appropriate scientific procedures, because such projections provide higher resolution information that is more relevant to spatial scales used for analyses of a given species (see Glick *et al*. 2011, pp. 58–61, for a discussion of downscaling).

The hydrologic regime in the Rocky Mountains has changed and is projected to change further (Bartlein *et al.* 1997, p. 786; Cayan *et al.* 2001, p. 411; Leung *et al.* 2004, p. 75; Stewart *et al.* 2004, pp. 223–224; Pederson *et al.* 2011, p. 1666). The western United States may experience milder, wetter winters with warmer, drier summers and an overall decrease in snowpack (Leung *et al.* 2004, pp. 93–94; Joyce *et al.* 2018, pp. 20–22). While some climate models do not demonstrate significant changes in total annual precipitation for the western United States (Duffy *et al.* 2006, p. 893), an increase in “rain on snow” events is expected (Leung *et al.* 2004, p. 93; McWethy *et al.* 2010, p. 55). The amount of snowpack and the timing of snowmelt may also change, with an earlier peak stream flow each spring (Cayan *et al.* 2001, p. 410; Leung *et al.* 2004, p. 75; Stewart *et al.* 2004, pp. 223–224). Although there is some disagreement about changes in the water content of snow under varying climate scenarios (Duffy *et al.* 2006, p. 893), reduced runoff from decreased snowpack could translate into decreased soil moisture in the summer (Leung *et al.* 2004, p. 75). However, Pederson *et al.* (2011, p. 1682) found that increased spring precipitation in the northern Rocky Mountains is offsetting these impacts to total annual stream flow from expected declines in snowpack thus far.

A vulnerability assessment of the North Cascades was conducted recently by The North Cascadia Adaptation Partnership, a collaborative group with members from USFS, NPS, and the University of Washington (Littell and Raymond 2014, entire). The USFS analyzed historical climate data in conjunction with global climate models to project what changes in the climate are likely to occur in the Pacific Northwest. In addition, the Climate Impacts Group at the University of Washington developed datasets of downscaled climate and hydrologic projections to support the vulnerability assessments, which estimated an average regional temperature increase of 2.1°C by 2040 and 3.8°C by 2080. The highest relative increases in temperature are projected to occur during summer months (Littell *et al.* 2011, p. 35). While a change in precipitation was predicted, magnitude and direction varied between models. Increases in average temperature are almost certain to decrease the regional snowpack in extent and duration (Elsner *et al.* 2010, p. 225–226; Mote 2003, p. 280).

Climate change is likely to alter physical and hydrologic conditions in the North Cascades in a way that will create shifts in vegetation communities in the area (Littell *et al.* 2010, entire). Using dynamic models that consider climate change, current vegetation community composition, and plant tolerances, Rogers *et al.* (2011, entire) predicted shifts in vegetation biomes for three different climate scenarios. The results indicate that alpine tundra, which provides early and late season habitat for grizzly bears, may nearly disappear from the North Cascades and the total area of subalpine forest may decrease. The specific effects of climate change on grizzly bears in the North Cascades are unknown. However, research in Alberta, Canada has shown that higher temperatures and earlier snow melt have contributed to improved food resources for grizzly bears (Nielsen *et al*. 2013, pp. 9–10). Grizzly bears historically ranged as far south as northern Mexico and are both habitat and food generalists. Grizzly bears will consume almost anything available including vegetation, living or dead mammals or fish, insects, and human garbage (Knight *et al*. 1988, pp. 123–124; Mattson *et al*. 1991a, pp. 1625–1626; Schwartz *et al*. 2003a, pp. 568–569).

Climate change could also change the habitat as a result in changes in disturbance patterns such as wildfires. However, depending on their size and severity, fires may only have short term adverse effects on grizzly bears while providing more long-term benefits. For example, “recently burned areas are generally avoided by bears for the first few years after a fire while vegetation recovers, but once vegetation recovers, food resources generally become plentiful and these areas often become highly used habitats by bears” (Hamer and Herrero 1987b, p. 185; Apps *et al*. 2004, p. 147). Additionally, Ransom *et al*. (2018, pp. 25–26) concluded that despite predicted increases in growing season length, winter and spring water availability, wildfire, and decreases in snowpack, grizzly bears will likely persist due to their adaptive capacity and ability to change their movements to accommodate shifting food resources.

Potential Impacts from Climate Change on Denning

Because timing of den entry and emergence is at least partially influenced by food availability and weather (Craighead and Craighead 1972, pp. 33–34; Van Daele *et al.* 1990, p. 264), less snowpack would likely shorten the denning season as foods become available later in the fall and earlier in the spring. In the GYE, Haroldson *et al.* (2002, pp. 34–35) reported later den entry dates for male grizzly bears, corresponding with increasing minimum November temperatures from 1975 to 1999. This increased time outside of the den could increase the potential for conflicts with humans (Servheen and Cross 2010, p. 4). To monitor climate change impacts, den entry and exit times are recorded annually for research bears in the GYE, NCDE, CYE, and SE, and these provide a basis for comparison of data. Upon restoration or natural recolonization of grizzly bears into the BE and North Cascades, den entry and exit times would be recorded annually for research bears in these areas as well. As discussed in *Human-Caused Mortality* discussion, above, any possible increase in grizzly bear mortality risk is not expected to significantly affect ecosystem resiliency because of management of grizzly bear mortalities to sustainable levels within each ecosystem.

Potential Impacts from Climate Change on Food Sources

Effects related to climate change could create temporal and spatial shifts in grizzly bear food sources (Rodriguez *et al.* 2007, pp. 41–42; Roberts *et al.* 2014, entire; Prevéy *et al.* 2020, entire). Changes in plant communities have already been documented, with species' ranges shifting farther north and higher in elevation due to environmental constraints (Walther *et al.* 2002, pp. 390–391; Walther 2003, pp. 172–175; Walther *et al.* 2005, p. 1428) and increases in outbreaks of insects that reduce survival (Bentz *et al.* 2010, entire). A net loss in forested areas is anticipated as forest contraction occurs more rapidly than forest expansion, with an expected increase in productivity in montane, subalpine, and alpine areas and a decrease in productivity in lower elevation, warmer, and drier sites (Whitlock *et al.* 2017, p. 165). It is unclear whether avalanche chutes, an important habitat component to grizzly bears, will decrease, possibly as a result of decreased snowpack, or increase, as a result of increases in "rain on snow" events that may decrease the stability of snowpack. Changes in vegetative food distributions also may influence other mammal distributions, including potential prey species such as ungulates (White *et al.* 2018, entire). While the extent and rate to which individual plant species will be impacted is difficult to foresee with any level of confidence (in their entirety: Walther *et al.* 2002; Fagre *et al.* 2003), there is general consensus that grizzly bears are flexible enough in their dietary needs that they will not be impacted directly by ecological constraints such as shifts in food distributions and abundance (Servheen and Cross 2010, p. 4; IGBST 2013, p. 35). However, research in Alberta, Canada has shown that higher temperatures and earlier snow melt have contributed to improved food resources for grizzly bears (Nielsen *et al.* 2013, p. 9). Grizzly bears historically ranged as far south as northern Mexico and are both habitat and food generalists. Grizzly bears will consume almost anything available including vegetation, living or dead mammals or fish, insects, and human garbage (Knight *et al.* 1988, p. 123; Mattson *et al.* 1991a, entire; Schwartz *et al.* 2003a, pp. 568–569).

Potential Climate Change Impacts on Fire Regimes

Fire regimes can affect the abundance and distribution of some vegetative bear foods (e.g., grasses, berry-producing shrubs) (LeFranc *et al.* 1987, p. 150). For instance, fires can reduce canopy cover, which usually increases berry production. However, on steep south or west slopes, excessive canopy removal due to fires or vegetation management may decrease berry production through subsequent moisture stress and exposure to sun, wind, and frost (Simonin 2000, entire). Fire frequency and severity may increase with late summer droughts predicted under climate change scenarios (Nitschke and Innes 2008, p. 853; McWethy *et al.* 2010, p. 55). Increased fire frequency has the potential to improve grizzly bear habitat, with low to moderate severity fires being the best. For example, fire treatment most beneficial to huckleberry shrubs is that which results in damage to stems, but does little damage to rhizomes (Simonin 2000, entire). High-intensity fires may reduce grizzly bear habitat quality immediately afterwards by decreasing hiding cover and delaying regrowth of vegetation. However, depending on their size and severity, fires may only have short term adverse effects on grizzly bears while providing more long-term benefits. For example, fire plays an important role in maintaining an open forest canopy, shrub fields, and meadows that provide for grizzly bear food resources, such as increased production of forbs, root crops, and berries (Hamer and Herrero 1987b, pp. 183–185; Blanchard and Knight 1996, p. 121; Apps *et al.* 2004, p. 148; Pengally and Hamer 2006, p. 129). Because grizzly bears have shown resiliency to changes in vegetation resulting from fires, we do not expect altered fire regimes predicted under most climate change scenarios to have significant negative impacts on grizzly bear survival or reproduction, despite the potential effects on vegetation.

Summary of Effects of Climate Change

Most grizzly bear biologists in the United States and Canada do not expect habitat changes predicted under climate change scenarios to directly threaten grizzly bears (Servheen and Cross 2010, p. 4). Climate change may even make habitat more suitable and food sources more abundant (Servheen and Cross 2010, Appendix D). Timing and frequency of human-grizzly bear interactions and conflicts may change (Servheen and Cross 2010, p. 4). We expect that conservation plans and strategies and mortality limits will limit negative effects of climate change on grizzly bears.

Catastrophic Events

Here we analyze a number of possible catastrophic events including fire, volcanic activity, and earthquake. Volcanic activity is most relevant for the GYE given their geographic location; however, fires and earthquakes are the most plausible stressor to all of the ecosystems given their geographic location.

Fire

Fire is a natural part of all grizzly bear ecosystems. Even though fire frequency and severity may increase with late summer droughts predicted under climate change scenarios (Nitschke and Innes 2008, p. 853; McWethy *et al.* 2010, p. 55; Whitlock *et al.* 2017; pp. 123–131, 216, XXXII), increased frequency of low to moderate severity fires has the potential to improve grizzly bear habitat. Grizzly bears have evolved with fire as part of the natural landscape, and they are capable of adapting to changing ecological conditions. Wildfires have both positive and negative impacts on grizzly bears, but often provide significant long-term benefits by maintaining natural ecosystem processes (YNP 2005, p. 47). For instance, fires can reduce canopy cover, which usually increases berry production (LeFranc *et al.* 1987, p. 150; Simonin 2000, entire; Proctor *et al.* 2017, pp. 49, 51). Negative impacts of fire on berry production have been noted on steep south or west slopes, however, where excessive canopy removal may decrease berry production through subsequent moisture stress and exposure to sun, wind, and frost (Simonin 2000, entire).

Twentieth century forest management, which included extensive wildfire suppression efforts, promoted heightened potential for a large fire event. In 1988, the largest wildfires in YNP's recorded history, burned a total of 3,213 km^2 (1,240 mi^2) or 36 percent of the Park. However, large mobile species such as grizzly bears and their ungulate prey were not meaningfully adversely affected. Surveys after the 1988 fires found that 345 elk, 36 deer, 12 moose, 6 black bears, and 9 bison died in GYE as a direct result of the conflagration (YNP 2011, p. 3). Blanchard and Knight (1990, p. 592) found that the 1988 fire resulted in the probable deaths of only a few grizzly bears and no increase in bear home range sizes or daily movement rates during or after the fire. Immediately after the fires had passed, grizzly bears moved into the burned areas to feed on the increased availability of burnt ungulate carcasses, roots, ants, and newly emerged grasses and forbs. Although some grizzly bears avoided burned sites in the year after the fire (1989), use of burned areas in subsequent years (1990 to 1992) suggested that fires increased production of forbs and roots and were, therefore, beneficial to grizzly bears (Blanchard and Knight 1996, pp. 120–121). The period of most robust grizzly bear growth (4 to 7 percent) occurred shortly after the 1988 fires, through the entire decade of the 1990s. YNP's fire management policy (YNP 2014, entire) indicates natural wildfires should be allowed to burn, so long as parameters regarding fire size, weather, and potential danger are not exceeded. Those fires that do exceed the standards set forth in the fire management policy, as well as all human-caused fires, are to be suppressed (YNP 2014, entire). NFs manage natural wildfires to allow them to play their "natural ecological role" while "minimizing negative effects to life, investments and valuable resources" (USDA FS 2005, p. 11; USDA FS 2011c, pp. 3–4; USDA FS 2012, p. 2; USDA FS 2015d, p. 8). Future fires are likely in grizzly bear ecosystems and while the other ecosystems have yet to experience a wildfire of a similar scale, we agree with the YNP conclusion (YNP 2005, Appendix H) that grizzly bears are adaptable and will benefit from fires in the long term. Wildfires often lead to an increase in ungulate food supplies and an increase in ungulate numbers. While minor, localized, short-term impacts are likely, fire is not a major concern for grizzly bear ecosystems in the lower 48-States.

Volcanic Activity

Of the six ecosystems, only the GYE is potentially at risk from volcanic activity. The GYE has experienced several large volcanic eruptions in the past 2.1 million years. Super eruptions occurred 2.1 million, 1.3 million, and 640,000 years ago (Lowenstern *et al.* 2005, pp. 1–2). Such a similar event would devastate the GYE. While one could argue "we are due" for such an event, scientists with the Yellowstone Volcano Observatory maintain that they "see no evidence that another cataclysmic eruption will occur at Yellowstone in the foreseeable future… [and that] recurrence intervals of these events are neither regular nor predictable" (Lowenstern *et al.* 2005, p. 6). Such an event is not likely within the 30 to 45-year timeframe for this SSA.

Slightly more probable is a nonexplosive lava flow eruption or a hydrothermal explosion. There have been 30 nonexplosive lava flows in YNP over the last 640,000 years, most recently 70,000 years ago (Lowenstern *et al.* 2005, p. 2). During such an eruption, flows ooze slowly over the surface, moving a few hundred feet per day for several months or several years (Lowenstern *et al.* 2005, p. 2). Any renewed volcanic activity at YNP would most likely take this form (Lowenstern *et al.* 2005, p. 3). In general, such events would have localized impacts and be far less devastating than a large eruption (although such an event could also cause fires; fire as a stressor is discussed above). Hydrothermal explosions, triggered by sudden changes in pressure of the hydrothermal system, also occasionally affect the region. More than a dozen large hydrothermal explosion craters formed between 14,000 and 3,000 years ago (Lowenstern *et al.* 2005, p. 4). The largest hydrothermal-explosion crater documented in the world is along the north edge of Yellowstone Lake in an embayment known as Mary Bay; this 2.6-km (1.5-mi) diameter crater formed about 13,800 years ago (Lowenstein *et al.* 2005, p. 4). We do not consider either nonexplosive lava flow eruptions or a hydrothermal-explosion likely to occur within the 30 to 45-year timeframe for this analysis. However, even if one did occur, the impact to grizzly bears would likely be localized, temporary, and not a significant concern for grizzly bear populations, and within the GYE only.

Earthquakes

Earthquakes also occur within the region and can impact the surrounding environment through fire damage, rockslides, ground cracks, and changes in ground water (Pardee 1926, entire). The most notable earthquake in YNP's recent history was a magnitude 7.5 in 1959 (Lowenstern *et al.* 2005, p. 3). Similarly, a magnitude 6.5 earthquake hit within YNP in 1975 (Lowenstern *et al.* 2005, p. 3). The 1959 earthquake killed 28 people, most of them in a massive landslide triggered by the quake (Lowenstern *et al.* 2005, p. 3). The highest magnitude earthquake originating within the NCDE in recent history was a 6.9 magnitude earthquake in Townsend, Montana, in 1925 (Pardee 1926, entire), and seismic effects from other high magnitude earthquakes have also occurred within the NCDE (Lowenstern *et al.* 2005, p. 3). Most earthquakes in the CYE, SE, BE, and North Cascades have been a lower than 3.5 magnitude (Earthquake Tracker 2020), however larger earthquakes have occurred, and there is a potential that large earthquakes will occur in the future. Although massive landslides and other earthquake-related impacts could also affect wildlife, as with other potential catastrophic events, the impact of a large earthquake to grizzly bears would be localized, temporary, and are not a significant concern for grizzly bear populations.

Summary of Catastrophic Events

We considered catastrophic and stochastic (random probability) events that might reasonably occur in the each of the ecosystems within the 30 to 45-year future, to the extent possible. Most catastrophic events discussed above are unpredictable and unlikely to occur within the biologically meaningful timeframe for our SSA. Other events that might occur within the future would likely cause only localized and temporary impacts that would not significantly reduce the resiliency of any of the six ecosystems.

Conservation Efforts

The following existing regulatory mechanisms are specifically considered and discussed as they relate to the stressors under each relevant discussion, affecting grizzly bears in the lower-48 States. Under *Habitat-Related Effects*:

- 2016 Conservation Strategy for the Grizzly Bear in the Greater Yellowstone Ecosystem and the Appendices (YES 2016a, 2016b);
- Conservation Strategy for the Grizzly Bear in the Northern Continental Divide Ecosystem (NCDE Subcommittee 2018);
- 2006 Forest Plan Amendment for Grizzly Bear Habitat Conservation for the Greater Yellowstone Area National Forests (USDA FS 2006a, 2006b);

- 2011 Forest Plan Amendments for Motorized Access Management within the Selkirk and Cabinet-Yaak Grizzly Bear Recovery Zones for the Kootenai, Lolo, and Idaho Panhandle National Forests (USDA FS 2011b);
- 2015 Revision of the Land Management Plan for the Kootenai National Forest (USDA FS 2015a);
- 2015 Revision of the Land Management Plan for the Idaho Panhandle National Forest (USDA FS 2015b);
- 2019 Colville National Forest Land Management Plan (USDA FS 2019);
- 2000 Conservation Agreement between Stimson Lumber Company, Colville National Forest, and the Service (Service 2001);
- 1997 interim Forest direction for the North Cascades Federal land management agencies,
- Final Environmental Impact Statement for the Forest Plan for the Flathead National Forest (USDA FS 2018a);
- Final Environmental Impact Statement for the Forest Plan Amendments: Incorporating Habitat Management Direction for the Northern Continental Divide Ecosystem Grizzly Bear Population for the Helena-Lewis and Clark, Kootenai, and Lolo National Forests (USDA FS 2018b);
- Blackfeet Forest Management Plan (Blackfeet Nation 2008);
- Flathead Indian Reservation Forest Management Plan (CS&KT 2000);
- Final Environmental Impact Statement for the Montana Department of Natural Resources and Conservation Forested Trust Lands Habitat Conservation Plan (DNRC 2010a, 2010b);
- Administrative Rules of Montana 36.11.433 and 12.9.1401;
- Wilderness Act of 1964;
- The 2001 Roadless Rule;
- Glacier National Park Superintendent's Compendium implemented under the National Park System Organic Act (GNP 2019). The Organic Act of 1916, 16 U.S.C. Section 1, created the NPS and assigned it the responsibility to manage the NPs. The Organic Act requires the NPS to manage park units to conserve scenery, natural and historic objects within parks, and wildlife, and to provide for their enjoyment in a manner that leaves them unimpaired for the enjoyment of future generations;
- Yellowstone National Park (YNP 2020, *in prep.*) and Grand Teton National Park Compendia (GTNP and JDR 2019) implemented under the National Park Service Organic Act.
- Bureau of Land Management's Record of Decision for the Garnet Resource Management Plan and the Environmental Impact Statement (BLM 1986);
- Bureau of Land Management's Draft Resource Management Plan and Environmental Impact Statement for the Missoula Field Office (BLM 2019a); and
- Bureau of Land Management's Draft Lewistown Resource Management Plan (BLM 2019b).

Under *Human-Caused Mortality*:

- 2016 Conservation Strategy for the Grizzly Bear in the Greater Yellowstone Ecosystem and the Appendices (YES 2016a, 2016b);

- Conservation Strategy for the Grizzly Bear in the Northern Continental Divide Ecosystem (NCDE Subcommittee 2018);
- 2011 Forest Plan Amendments for Motorized Access Management within the Selkirk and Cabinet-Yaak Grizzly Bear Recovery Zones for the Kootenai, Lolo, and Idaho Panhandle National Forests (USDA FS 2011b);
- 2015 Revision of the Land Management Plan for the Kootenai National Forest (USDA FS 2015a);
- 2015 Revision of the Land Management Plan for the Idaho Panhandle National Forest (USDA FS 2015b);
- 2018 Colville National Forest Land Management Plan (USDA FS 2018).
- Grizzly Bear Management Plan for Western Montana (Dood *et al.* 2006);
- Flathead Indian Reservation Grizzly Bear Management Plan (Servheen *et al.* 1981);
- Bear Management Plan and Guidelines for Bear Management on the Blackfeet Indian Reservation (Blackfeet Tribal Business Council 2013);
- Blackfeet National Fish and Wildlife Code (Blackfeet Tribal Business Council 2018);
- Administrative Rules of Montana 12.9.1401 and 12.9.1403.
- State of Idaho Yellowstone Grizzly Bear Management Plan (Idaho's Yellowstone Grizzly Bear Delisting Advisory Team 2002);
- Proclamation of the Idaho Fish and Game Commission Relating to the Limit of the Take of Grizzly Bear in the Greater Yellowstone Ecosystem (Idaho Fish and Game Commission 2016);
- Grizzly Bear Management Plan for Southwestern Montana (MFWP 2013);
- Montana Hunting Regulations for Grizzly Bear (MFWP 2016);
- Montana Fish and Wildlife Commission Resolution approving the Tri-State Memorandum of Agreement (July 13, 2016);
- Wyoming Grizzly Bear Management Plan (WGFD 2016);
- Wyoming Game and Fish Commission (2016) Chapter 67 Grizzly Bear Management Regulation; and
- Memorandum of Agreement Regarding the Management and Allocation of Discretionary Mortality of Grizzly Bears in the Greater Yellowstone Ecosystem (Wyoming Game and Fish Commission *et al.* 2016).

Cumulative Effects

Many of the stressors faced by grizzly bears are interrelated and could be synergistic, or act cumulatively. When stressors act synergistically, or in concert with one another, the potential combined effects on the species are called cumulative effects. Principal stressors discussed above include habitat loss through road building and the resulting increased human access to grizzly bear habitat, human-caused mortality of grizzly bears, and the legal mechanisms that direct habitat and population management. The principal stressors assessed in previous sections may cumulatively impact individual grizzly bear populations beyond the scope of each individual stressor. For example, expected increases in human populations across the Western United States and climate change both have the potential to increase grizzly bear conflicts and human-caused mortality (Servheen and Cross 2010, entire). Historically, each of these factors impacted grizzly bears in each of the ecosystems and cumulatively acted to reduce their range and abundance over time.

We note that by using the SSA framework, we have not only analyzed individual effects of stressors on individuals, ecosystems, and the lower-48 States, but we have also analyzed their potential cumulative effects. Because the SSA uses metrics for demographics, distribution, and diversity, the effect of multiple stressors is inherent in the assessment and helps to assess how populations and ultimately the species responds cumulatively to the interactive effects of stressors and conservation efforts included in the future scenarios (Smith *et al.* 2018, p. 6). We incorporate the cumulative effects into our analysis when we characterize the current and future condition of the species across six ecosystems. Our assessment of the current and future conditions encompasses and incorporates the stressors individually and cumulatively. Our current and future condition assessment is iterative because it accumulates and evaluates the effects of all the factors that may be influencing the subspecies, including negative influences from stressors and positive influences from conservation efforts. We evaluate potential effects from these influences consistently across the same subset of habitat and demographic needs for the subspecies, both currently and into the future. Because the SSA framework considers not just the presence of the factors, but also to what degree they collectively influence risk to the entire species, our assessment integrates the cumulative effects of the factors and replaces a standalone cumulative effects analysis.

It is important to recognize that grizzly bears are a "conservation reliant" species (Scott *et al.* 2005, p. 384; Scott *et al.* 2010, pp. 92, 95). "Even when management actions succeed in achieving biological recovery goals, maintenance of viable populations of many species will require continuing, species-specific intervention. Such species are "conservation reliant'" (Scott *et al.* 2010, p. 91). As a "conservation reliant" species, grizzly bears will require ongoing management and conservation efforts to remain recovered.

While stressors on grizzly bear persistence are numerous and challenging to conservation, our experience demonstrates that if human-caused mortality can be sufficiently limited, it is possible for large carnivore conservation to be compatible with them (Linnell *et al.* 2001, p. 48). We consider estimates of population trend (i.e., "lambda") to be the ultimate metric to assess cumulative impacts to the population. Population trend reflects all of the various stressors on the population. This calculation reflects total mortality, changes in habitat quality, changes in population density, change in current range, displacement effects, and so forth. Despite the various stressors discussed above, the best available data indicate that, due to ongoing conservation efforts in the GYE, NCDE, CYE, and SE, grizzly bear population trends in these ecosystems are stable or increasing, and range extent has continued to expand. In addition, the likelihood of natural recolonization of the BE is better now than at any point since listing. Natural recolonization of the North Cascades is unlikely in the near future due to the low numbers of bears in nearby populations and the highly fragmented landscape in between. Ongoing conservation efforts have ameliorated the multiple negative effects so that these populations are currently stable or increasing. As long as conservation efforts continue, we do not consider existing threats substantial, either individually or cumulatively.

Summary of Cause-and-Effects

We evaluated the following stressors (we provide the relevant listing factors under the Act for reference only):

(1) Effects due to habitat destruction and modification (Factor A);
(2) Human-caused mortality (Factors B and E);
(3) Disease (Factor C);
(4) Natural predation (Factor C);
(5) Effects due to genetic health (Factor E);
(6) Effects due to changes in food resources (Factor E);
(7) Effects due to climate change (Factor E);
(8) Effects due to catastrophic events (Factor E); and
(9) Cumulative effects.

We summarize each of these stressors by ecosystem below.

Summary of Cause-and-Effects in the GYE

The primary factors related to past habitat destruction and modification have been reduced through changes in management practices that have been formally incorporated into regulatory documents. In the GYE, maintenance of the 1998 baseline values for secure habitat, developed sites on public lands, and livestock allotments inside the recovery zone will adequately reduce the multitude of stressors on grizzly bear habitat such that they do not become threats to the GYE grizzly bear population in the future. We expect many of these stressors to continue to occur at some level, but assuming that current regulatory mechanisms remain in place, these stressors are currently sufficiently reduced so that they affect only a small proportion of the population.

The GYE NFs and NPs will continue to implement and maintain the 1998 baseline. Together, these two Federal agencies manage 98 percent of lands within the GYE recovery zone and 88 percent of all suitable habitat within the DMA. Suitable habitat outside the recovery zone provides additional ecological resiliency and habitat redundancy to allow the population to respond to environmental changes. Habitat protections specifically for grizzly bear conservation are not necessary here because other regulatory mechanisms that limit development and motorized use are already in place for 59 percent of suitable habitat outside the recovery zone (e.g., Wilderness Areas, WSAs, and IRAs). These and other conservation measures discussed in the USFS's ROD (2006b, pp. 4–6) ensure threats to the GYE grizzly bear population's habitat outside the recovery zone will not become substantial enough to reduce resiliency.

Human-caused mortality, mainly "indiscriminate illegal killing" and management removals historically reduced the resiliency of all ecosystems. Since the 1975 listing, the GYE grizzly bear population has tripled in size and range (Eberhardt *et al.* 1994, pp. 361–362; Knight and Blanchard 1995, pp. 2–11; Boyce *et al.* 2001, pp. 1–11; Schwartz *et al.* 2006b, p. 48; Pyare *et al.* 2004, pp. 5–6; Schwartz *et al.* 2006a, pp. 64–66; IGBST 2012, p. 34; Bjornlie and Haroldson 2019, pp. 25–28l; Haroldson *et al.* 2020b, p. 13). Inside the DMA, the population has been stable to slightly increasing since 2002 and is exhibiting density-dependent population regulation (van Manen *et al.* 2016, entire). Although humans are still directly or indirectly responsible for most grizzly bear deaths, this source of mortality is reduced through science-based management, State regulations, careful population monitoring, and education and outreach efforts. Since 1975, no grizzly bears have been removed from the GYE for commercial, recreational, scientific, or education purposes. In the future, although the States may choose to institute carefully regulated grizzly bear hunting outside of the National Parks, it would be within scientifically determined sustainable levels to maintain the population in the long term and would not occur if other sources of human-caused mortality were excessive. While human-caused mortality will continue to occur, State regulatory mechanisms limit total mortality to sustainable levels detailed in Table 9.

The importance of continued regulatory mechanisms and effective wildlife management infrastructure to large carnivore conservation cannot be understated, as described under *Habitat Destruction and Modification* and *Human-Caused Mortality* (see Linnell *et al.* 2001, p. 348). Regulatory mechanisms in place include NP Superintendent's Compendia, the USFS Amendment for Grizzly Bear Habitat Conservation for the GYE NFs, and State and Tribal commission regulations controlling mortality as described under *Habitat Destruction and Modification* and *Human-Caused Mortality*. The management infrastructure is already in place and described in the 2016 GYE Conservation Strategy. Because the signatory agencies to the 2016 GYE Conservation Strategy are the same agencies that have been managing grizzly bear habitat, population, and monitoring for the last 40 years, the management transition would be minimal. Existing regulatory mechanisms ensure the GYE grizzly bear population will continue to meet the recovery criteria and maintain resiliency.

The GYE grizzly bear population has experienced population growth and range expansion since 1975 (Pyare *et al.* 2004, pp. 5–6; Schwartz *et al*. 2006a, pp. 64–66; Schwartz *et al.* 2006b, p. 48; IGBST 2012, p. 34; Bjornlie and Haroldson 2019, pp. 25–28l; Haroldson *et al.* 2020b, p. 13), and potential threats from disease, predation, genetic health, changes in food resources, climate change, and catastrophic events have not manifested themselves such that they negatively affect the long-term trajectory of the. Essentially, the management response to all these potential threats would be to limit human-caused mortality through conflict prevention and management as well as managing discretionary mortality. Because of the manageable nature of these potential threats through conflict prevention and response efforts and the large amount of suitable, secure habitat within the GYE, we do not expect these other natural or manmade factors to become threats to the GYE grizzly bear population.

Many of the stressors faced by grizzly bears are interrelated and could cumulatively impact the GYE grizzly bear population through excessive grizzly bear mortality. While these numerous stressors on grizzly bear persistence are challenging to conservation, our experience demonstrates it is possible for large carnivore conservation to be compatible with them as long as regulatory mechanisms remain in place (Linnell *et al*. 2001, p. 48), particularly given the rigorous scientific monitoring protocols established for the GYE grizzly bear population. There will always be stressors that influence individuals, and potentially ecosystems, but if these are not causing the population to decline, we do not consider them to reduce resiliency.

Summary of Cause-and-Effects in the NCDE

The primary factors related to past destruction and modification of grizzly bear habitat have been reduced through changes in management practices that have been formally incorporated into regulatory documents. Maintenance of the baseline values for secure core habitat, developed sites on public lands, and livestock allotments inside the recovery zone will adequately mitigate the stressors on grizzly bear habitat. We expect many of the threats discussed under *Habitat Destruction and Modification* to continue to occur at some level, but they are sufficiently reduced so they affect only individuals or a small proportion of the population.

The NCDE NFs and GNP, which manage 78 percent of lands within the recovery zone, will continue to implement and maintain the baseline. The BLM, FIR, and DNRC have implemented habitat protections on an additional 13 percent of lands within the recovery zone. The USFS, BLM, BIR, FIR, and DNRC have put habitat protections in place in Zone 1 that protect 47 percent of lands and provide additional ecological resiliency and habitat redundancy to allow the population to respond to environmental changes (in their entirety: CS&KT 2000; Blackfeet Nation 2008; DNRC 2010a, 2010b; USDA FS 2018c, 2018d, and 2018e; BLM 2019a, 2019b). These and other conservation measures discussed in the NCDE Conservation Strategy (NCDE Subcommittee 2018, entire) ensure threats to the NCDE grizzly bear population's habitat will not become substantial enough to reduce resiliency of this ecosystem.

When grizzly bears were listed in 1975, we identified human-caused mortality, mainly "indiscriminate illegal killing" and management removals, as threats to the population under *Human-Caused Mortality*. In response, we implemented demographic recovery criteria in the 1982 Recovery Plan (Service 1982, pp. 59–81). These criteria were then updated in the 1993 Recovery Plan to maintain a minimum population size and a well-distributed population and to establish total mortality limits based on scientific data and direct monitoring of the population (Service 1993, pp. 61–79). Since implementing these criteria, the NCDE grizzly bear population has more than doubled in size (from approximately 300 to 1,068 grizzly bears) and range (from 24,800 km^2 (9,600 mi^2) to 63,924 km^2 (24,681 mi^2)) (Dood *et al.* 1986, p. 166; Service 1993, pp. 11–12; Kendall *et al.* 2009, p. 3; Mace *et al.* 2012, p. 124; Costello *et al.* 2016, p. 2; Costello and Roberts 2019, p. 10; Costello 2020, *in litt.*; MFWP, unpublished data). The population in the NCDE has grown at a rate of 2.3 percent annually since 2004 (Costello *et al.* 2016, p. 2; Costello 2018, *in litt.*).

Although humans are still directly or indirectly responsible for the majority of grizzly bear deaths, this source of mortality is being effectively mitigated through science-based management, State and Tribal regulations, careful population monitoring, and outreach efforts. In addition, recent levels of human-caused mortality have not precluded an annual population growth rate of 2.3 percent since 2004 (Costello *et al.* 2016, p. 2; Costello 2018, *in litt.*). Since 1975, no grizzly bears have been removed from the NCDE for commercial, scientific, or education purposes. Legal hunting was allowed in the State of Montana under a special exception from 1975 until 1991, but no grizzly bears have been removed from the NCDE for recreational purposes since 1991. Although the State of Montana may choose to institute carefully regulated grizzly bear hunting outside of GNP and the BIR and FIR, it would be within scientifically determined sustainable levels to maintain the population in the long term and would not occur if other sources of human-caused mortality were excessive. Overall, the NCDE

Conservation Strategy and existing regulatory mechanisms include provisions to ensure discretionary mortality will be limited to sustainable levels and ensure resiliency is maintained

The importance of regulatory mechanisms and effective wildlife management infrastructure to large-carnivore conservation cannot be overstated, as described under *Habitat Destruction and Modification, and Human-Caused Mortality* (see Linnell *et al.* 2001, p. 348). The regulatory mechanisms that are now in place or will be in place before publication of any final rule include: (1) as described under *Habitat Destruction and Modification*: GNP's Superintendent's Compendium; the USFS revised Flathead NF Plan; the USFS Plan Amendments to Incorporate Habitat Management for the NCDE Grizzly Bear Population on the Helena-Lewis and Clark, Kootenai, and Lolo NFs; BLM's Garnet Resource Management Plan; BLM's Draft Lewistown Resource Management Plan; BLM's Draft Resource Management Plan and EIS Statement for the Missoula Field Office; the Blackfeet Forest Management Plan; the FIR Forest Management Plan; DNRC's HCP; ARM 36.11.433 and 12.9.1401; the Wilderness Act of 1964; and the 2002 Roadless Rule; and (2) as described under *Human-Caused Mortality*: the Grizzly Bear Management Plan for Western Montana; the FIR Grizzly Bear Management Plan; the Bear Management Plan and Guidelines for Bear Management on the BIR; the Blackfeet National Fish and Wildlife Code; and ARM 12.9.1401 and 12.9.1403. The management infrastructure to maintain habitat conditions and limit mortality is or will be in place, as described in the NCDE Conservation Strategy, prior to any final rule. Because the signatory agencies to the NCDE Conservation Strategy are the same agencies that have been managing grizzly bear habitat, population, and monitoring for the last 40 years, the management transition would be minimal. Regulatory mechanisms that currently exist ensure the NCDE grizzly bear population will continue to meet the recovery criteria and maintain resiliency.

The NCDE grizzly bear population has experienced population growth and range expansion since 1993 (Dood *et al.* 1986, p. 164; Kendall *et al.* 2009, p. 3; Mace *et al.* 2012, p. 124; Costello *et al.* 2016, p. 2; Costello 2018, *in litt.*; Costello and Roberts 2019, p. 10; MFWP, unpublished data), in spite of potential threats from disease, predation, genetic health, potential changes in food resources, climate change, and catastrophic events. Many of these are infrequent and unpredictable and are not currently a significant concern for the NCDE population.

Many of the threats faced by grizzly bears are interrelated and could cumulatively impact the NCDE grizzly bear population through excessive grizzly bear mortality. While these numerous stressors on grizzly bear persistence are challenging to conservation, our experience demonstrates it is possible for large-carnivore conservation to be compatible with them (Linnell *et al.* 2001, p. 48), particularly given the rigorous scientific monitoring protocols established for the NCDE grizzly bear population. There will always be stressors to the NCDE grizzly bear population, but if these are not causing the population to decline, we do not consider them currently to be significant threats to the long-term persistence of the population.

Summary of Cause-and-Effects in the CYE, SE, BE, and North Cascades

When grizzly bears were listed in 1975, we identified habitat destruction and modification, isolation, and human-caused mortality, mainly "indiscriminate illegal killing" and management removals, as threats to the population. The States of Idaho, Montana, and Washington have regulations, independent of the Act, that make it illegal to kill a grizzly bear other than in defense of life (ARM 14.9.1403; IDAPA 13.01.06.100.01(e); Washington Administrative Code 220-610-010). Human-caused mortality will continue to be the limiting factor, but it can be managed within levels that prevent population decline. Human-caused mortality has been reduced to levels that have allowed the CYE population to increase at a rate of 0.9 percent annually (Kasworm *et al.* 2020a, p. 39) and the SE to increase 2.5 percent annually (Kasworm 2020b, pp. 26–27). There is currently no known population in either the BE or the North Cascades. However, because of the small population sizes in the in CYE and SE, isolation is still a potential threat to the resiliency of these grizzly bear populations. Trans-boundary connectivity has been observed in the NCDE and limited demographic and genetic connectivity has been observed between Canadian populations and the SE and Yaak portion of the CYE. While gene flow has not yet been documented between the CYE and SE, movements between the CYE, SE, BE, and NCDE, and between the CYE, SE, and NCDE and Canada have increased. In addition, the estimated distribution of the NCDE grizzly bear population is within 7 km (4.3 mi) of the BE recovery zone and there are multiple verified sightings between the GYE and NCDE distributions and the BE (figure 2).

Standards currently exist only in the CYE and SE recovery zones and BORZ are managed under a "no net loss" policy (in their entirety: USDA FS 2011a, 2015a, 2015b, 2018). Inter-ecosystem connectivity could be enhanced by higher female survival rates in linkage areas, as research indicates female occupancy in these intervening linkage areas is necessary for demographic connectivity (Proctor *et al.* 2015, pp. 8–11; Proctor *et al.* 2018, pp. 356–364). These standards should reduce human-caused mortality risk. Standards are not yet in place in the two unoccupied recovery zones, the BE and North Cascades. We do not view the lack of standards in the BE as a threat, however, because it is 98 percent Wilderness. In the North Cascades, approximately 64 percent of the public lands are designated Wilderness or IRAs and existing regulatory mechanisms regulate the remaining Federal lands under a "no net loss" policy for secure core habitat. However, existing motorized access levels are unknown on USFS lands and we are unable to assess the adequacy of existing levels. Further monitoring of the population and cause-specific mortality will determine the success of the current "no net loss" policy. Habitat protections within the CYE and SE and in potential connectivity areas in the form of easements and purchases have protected additional lands. Because habitat in the BE, CYE, North Cascades, and SE may only support relatively small grizzly bear populations, connectivity with other grizzly bear populations, including Canada, is necessary for their long-term conservation.

The principle land management agency in the CYE and SE, the USFS, amended forest plans with regulatory requirements for food storage orders requiring forest users to keep foods and attractants inaccessible to bears (in their entirety: USDA FS 2011a, 2015a, 2015b, 2018). Food storage orders should reduce human-caused mortality risk. There are no food storage orders within the BE recovery zone. In the North Cascades, food storage orders are in effect in North Cascades NP, but not on 75 percent of land managed by the USFS within the North Cascades recovery zone. The lack of mandatory food storage orders within the North Cascades and BE recovery zones may contribute to future grizzly bear mortality risk and inhibit restoration efforts or natural recolonization. As grizzly bear distribution expands, food storage orders in areas outside the recovery zones would likely facilitate connectivity.

Effective I&E programs have been an essential factor in the progress towards recovery of the CYE, SE, NCDE, and GYE grizzly bear populations since its listing in 1975, and have likely played a crucial supporting role to the success of other grizzly bear management strategies implemented for the population. In addition, I&E programs in the BE and North Cascades lay the foundation for restoration of grizzly bears in these two ecosystems.

Chapter 6: Current Condition

In this chapter, we describe the current condition of the grizzly bear in the lower-48 States in terms of resiliency, redundancy, and representation. We do this by evaluating the current condition of the habitat and demographic factors that we identified as needs in Chapter 4. In Chapter 5, we summarized our evaluation of potential stressors and conservation efforts that influence the condition for each ecosystem. The stressors that influence current resiliency of ecosystems include sources of human-caused mortality in all six ecosystems, and motorized access in the BE, CYE, SE, and North Cascades ecosystems. As also summarized in Chapter 5, a variety of conservation measures help reduce the influence of these stressors on ecosystem resiliency.

We begin our evaluation of current condition with a description of the methodology that we used to evaluate resiliency consistently across all six ecosystems. We developed a categorical model, called a condition category table, to calibrate resiliency in terms of stochastic risk based on the condition of two habitat factors and six demographic factors. We then used this table to evaluate resiliency for each ecosystem and summarized our evaluation of current condition for the grizzly bear in terms of the 3Rs.

Methodology to Evaluate Current and Future Condition

As summarized in Chapter 4, we identified large intact bocks of land, cover, high-caloric foods, and dens as habitat needs for the grizzly bear in the lower-48 States. For demographic needs, we identified connectivity, adequate fecundity and survival, genetic diversity, population trend, and abundance as ecosystem-level needs for resiliency. For our analysis of current and future condition, we selected a subset of these needs, two habitat factors and six demographic factors that are most influential to ecosystem resiliency and that we could measure relatively consistently across all six ecosystems. The two habitat factors and six demographic factors that we used to evaluate condition were:

- **Natural, high-caloric foods**, as measured by available data on body fat, stable isotope analyses, and where available, the direct monitoring of food sources;
- **Large intact blocks of land**, as measured by the status of meeting habitat standards, where applicable, and the existence of other protections that influence the security of habitats;
- **Adult female survival**, as measured by estimates of survival rates using data from radio-collared individuals;
- **Abundance,** as measured by progress toward meeting **Population Targets** outlined in relevant conservation plans, and the **Number of Bears**. While the overall number of bears is most important to resiliency, we also evaluated population targets to acknowledge that some recovery zones are small in size (and therefore rely on connectivity to larger populations nearby) and carrying capacity is more limited;
- **Population trend**, as measured using long-term trend data available for each ecosystem;
- **Fecundity,** as measured by occupancy of BMUs by reproductive females;

- **Inter-ecosystem connectivity,** or natural connectivity between ecosystems, as measured by monitoring data on immigration. Natural connectivity can facilitate a small population to become self-sustaining, an objective of the recovery plan (Service 1993, p. 15); and
- **Genetic diversity,** as measured by the effective population size, heterozygosity, allelic richness, inbreeding rates, as available for each ecosystem.

We describe each of these habitat and demographic factors needed by individuals and ecosystems in more detail in Chapters 2 and 4.

We then developed a categorical model, called a condition category table, for these two habitat and six demographic factors, to calibrate our evaluation of resiliency in terms of a plausible range of stochastic risk, from highest to lowest risk, for each factor (Table 14). The categories we used to describe resiliency are high, moderate, low, very low, and functionally extirpated, which represent relative levels of stochastic risk for each factor, with high being the most resilient, and functionally extirpated being the least resilient, based on the condition of the factor as described in the table's rows. For the two habitat factors (high-caloric foods and large intact blocks of land), and one demographic factor (population trend), resiliency categories did not include a 'very low' score due to evaluation metrics.

We used a condition category table to calibrate our understanding of resiliency and to evaluate the condition of each habitat and demographic factor for each ecosystem. As we considered the condition, we used metrics that were available consistently for all ecosystems, including compiled information from peer-reviewed literature, surveys and reports, and input from scientific experts. For several factors, other accurate metrics exist (e.g., carrying capacity to measure population target); however, we did not have accurate estimates of those metrics for all ecosystems and therefore used different metrics commonly available to evaluate condition. Throughout our evaluation, we considered the life history and ecology of grizzly bear in the lower-48 States, as summarized in Chapter 2, data on the current distribution and trends, as summarized in Chapter 2, and our cause-and-effect analysis of stressors and conservation efforts, as summarized in Chapter 5. The SE recovery zone extends into Canada, but we analyzed the SE for the lower-48 States portion only where possible; however, there are some demographic factors that are assessed for the entire recovery zone and we note where this is the case.

To calculate an overall score for resiliency, we assigned weighted values to the resiliency categories and then calculated a weighted average using the formula in Figure 29. We assigned 4 to high, 3 to moderate, 2 to low, 1 to very low, and 0 to the functionally extirpated category. We weighted the demographic factor for abundance, the number of bears, three times, due to its relative importance to the resiliency of each ecosystem and to balance its weight proportionally to four other demographic factors. Adult female survival and fecundity influence the number of bears, population trend reflects changes in the number of bears, and population target is a different metric of the same factor (number of bears) (Figure 29). Population target is an objective or threshold from existing plans and conservation strategies, and considers biological and social factors; it does not represent carrying capacity.

We based the overall condition score thresholds on the difference between the highest and lowest possible condition scores, divided into five equal intervals. A weighted average of 3.2 or greater was classified as a High Condition; 2.4–3.19 a Moderate Condition; 1.6–2.39 a Low Condition; 0.8–1.59 a Very Low Condition; and less than 0.79 a Functionally Extirpated (X) Condition (Figure 29). For any ecosystem, if the demographic factor for abundance, the number of bears, received a Functionally Extirpated Condition (X), then the overall resiliency for the ecosystem is categorized as Functionally Extirpated (X), regardless of the condition category assigned to any of the other habitat or demographic factor. This methodology allowed us to summarize the condition of habitat factors needed by individuals to breed, feed, and shelter, to the demographic factors needed by ecosystems to be resilient, to the redundancy and representation needed by the lower-48 States to withstand catastrophes and adapt to environmental change. In general, ecosystems with higher resiliency have a greater probability of persistence over the next 30 to 45 years than ecosystems with lower resiliency.

$$\begin{aligned}\boldsymbol{Overall\ Resiliency} &= (\boldsymbol{High\ Caloric\ Foods} \\ &+ \boldsymbol{Large\ Intact\ Blocks\ of\ Land} \\ &+ \boldsymbol{Adult\ Female\ Survival} \\ &+ \boldsymbol{Population\ Target} + \boldsymbol{3} \\ &* (\boldsymbol{Number\ of\ Bears}) \\ &+ \boldsymbol{Population\ Trend} \\ &+ \boldsymbol{Fecundity} \\ &+ \boldsymbol{InterEcosystem\ Connectivity} \\ &+ \boldsymbol{Genetic\ Diversity})/\boldsymbol{11}\end{aligned}$$

Calculation of Thresholds for Overall Resiliency Condition

Max Score	4	
Intervals	0.8	
	Min	**Max**
High (4)	3.2	4
Moderate (3)	2.4	3.2
Low (2)	1.6	2.4
Very Low (1)	0.8	1.6
Extirpated – X (0)	0.0	0.8

Figure 29. Formula and thresholds used to calculate an overall score for resiliency for each ecosystem based on our evaluation of condition for the two habitat factors and six demographic factors.

Table 14. Condition category table (categorical model) used to evaluate resiliency in terms for the six ecosystems of grizzly bear in the lower-48 States, in terms of two habitat factors and six demographic factors.

Resiliency Categories	Habitat Factors		Demographic Factors						
				Abundance					
	Natural, High-Caloric Foods	**Large, intact blocks of land**	**Adult Female Survival**	**Population Target**	**Number of Bears (3x)**	**Population Trend**	**Fecundity**	**Inter-Ecosystem Connectivity**	**Genetic Diversity**
Evaluation Metrics	Body fat data, stable isotope analysis, and/or direct monitoring of food sources	Status of meeting various habitat standards; existence of other protections that ensure habitat security	Estimate survival rates using peer-reviewed methodology[12]	Recovery criteria and/or Conservation Strategies indicate population target; the methods we use to estimate the number of bears depends on the ecosystem	The methods we use to estimate the number of bears varies by ecosystem	The method we use to estimate population trend varies by ecosystem and reflects the long-term trend	A BMU is occupied by a reproductive female at least once in a 6-year window	Monitor immigration into ecosystems during the most recent generational interval (10 to 15 years) (through radio-collared bears, DNA sampling, marked individuals)	Effective population size, heterozygosity, allelic richness, inbreeding rates
High (4)	Diverse, high-caloric, natural foods are not limiting	Availability of secure habitat is sufficient to meet individual needs	Survival rate is above 0.93	At or above target	More than 800 bears	Lambda greater than 1	All BMUs within the recovery zone are occupied	Females have immigrated and bred (demonstrating demographic connectivity)	Sufficient for long-term fitness
Moderate (3)	Diverse, high-caloric, natural foods are somewhat limiting	Availability of secure habitat to meet individual needs is somewhat limiting	Survival rate is between 0.90–0.93	80–99 percent of target	400–799 bears	Lambda is stable or slightly declining (between 0.98 and 1)	70–99% of the BMUs within the recovery zone are occupied	Males have immigrated and bred (demonstrating genetic connectivity)	Sufficient for short-term fitness
Low (2)	Diverse, high-caloric, natural foods are limiting	Availability of secure habitat to meet individual needs is limiting	Survival rate is below 0.90	50–79 percent of target	91–399 bears	Lambda is below 0.98	50–69% of the BMUs within the recovery zone are occupied	Evidence of an immigrant that has established a home range within the ecosystem but no documented breeding	Sufficient for short-term fitness, but with high levels of inbreeding
Very Low (1)				Less than 50 percent of the target and has evidence of reproduction.	Fewer than 90 bears and a known population		Less than 50% of the BMUs are occupied	Immigrant is documented within the ecosystem but no evidence of home range establishment or breeding	Insufficient for short-term or long-term fitness
Extirpated (0)	Diverse, high-caloric, natural foods are absent	There is no secure habitat	No known population	No known population	No known population	No known population	No BMUs occupied	No connectivity	No known population

[12] Data from radio-collared individuals is currently used to estimate survival rates.

Current Condition: Resiliency

Table 15 summarizes the current demographic data in each ecosystem for five of the demographic factors used to evaluate resiliency.

Table 15. Summary of current data for five demographic factors used to evaluate resiliency. Values are point estimates and do not reflect sampling errors associated with estimates.

	Adult Female Survival	**Fecundity** BMUs occupied with breeding females	**Population Trend**	**Population Target***	**Number of Bears**
NCDE	0.94	22 out of 23 BMUs occupied	1.023	Above target of 800	1,068
GYE	0.94	18 out of 18 BMUs occupied	1.003–1.022	Above target of 674	737
CYE	0.94	12 out of 22 BMUs occupied	1.009	Below target of 100	55 to 60 bears
SE	0.91	8 out of 10 BMUs occupied	1.025	Below target of 90 (including Canada)	Minimum of 53 bears (in U.S.)
BE	0	0	0	Below target of 280	X
North Cascades	0	0	0	Below target of 200	X

Table 16 presents our evaluation of current condition for grizzly bears in the six ecosystems in the lower-48 States. Currently, there are two ecosystems with high resiliency (NCDE and GYE), one ecosystem with moderate resiliency (SE), and one ecosystem with low resiliency (CYE). Two ecosystems (BE and North Cascades) are currently in a functionally extirpated condition, with no resiliency. There may be one or more individuals in the BE, however there is no known population, so it currently is in a functionally extirpated condition. We summarize our evaluation of current condition for ecosystem below.

*Table 16. Current condition for six ecosystems for grizzly bear in the lower-48 States, evaluated used the condition category table for resiliency. *Overall Current Condition was calculated as the weighted average of all factors, with "number of bears" weighted three times due to its importance to resiliency. High=4, Moderate = 3, Low=2, Very Low=1, and Functionally Extirpated (X) = 0, with score thresholds as Moderate= 2.4–3.19, Low= 1.6–2.39, Very Low=0.8–1.59; and less than 0.79 = Functionally Extirpated (X) Condition. An X in number of bears results in an overall condition of X, regardless of the other factors. In general, ecosystems with higher resiliency have a greater probability of persistence over the next 30 to 45 years, based on their ability to withstand stochastic events, than ecosystems with lower resiliency.*

CURRENT CONDITION										
	Habitat Factors		Demographic Factors							
Ecosystem	Natural, High-Caloric Foods	Large, intact blocks of land	Adult Female Survival	Abundance		Population Trend	Fecundity	Inter-Ecosystem Connectivity	Genetic Diversity	RESILIENCY*
				Population Target	Number of Bears (3x)					
NCDE	High	High	High	High	High	High	Moderate	High	High	**High**
GYE	High	High	High	High	Moderate	High	High	X	Moderate	**High**
CYE	Moderate	Moderate	High	Low	Very Low	High	Low	Moderate	Low	**Low**
SE	Moderate	Moderate	Moderate	Moderate	Very Low	High	Moderate	Moderate	Moderate	**Moderate**
BE	Moderate	Moderate	X	X	X	X	X	Very Low	X	**X**
North Cascades	Moderate	Moderate	X	X	X	X	X	X	X	**X**

Current Condition in the NCDE

Overall Current Condition: HIGH

High-Caloric Foods: HIGH

- High-caloric foods are readily available and diverse.

Large Intact Blocks of Land: HIGH

- A variety of land protections influence the current condition of these habitat factors (Chapters 2 and 5).

Adult Female Survival: HIGH

- Adult female survival = 0.94.

Fecundity: MODERATE

- Females with cubs occupy 22 of the 23 BMUs in the NCDE, which falls just short of the requirement for a high fecundity condition that all BMUs be occupied by a reproductive female at least once in a 6-year window. However, we note that due to its forested habitats, which make surveying females with cubs challenging, this factor is difficult to measure in the NCDE, so moderate condition for fecundity could be an underestimate. Additionally, one BMU in the NCDE is entirely a Wilderness area that is not actively monitored, which also suggests that a moderate condition could be an underestimate for fecundity in the NCDE.

Population Trend: HIGH

- Population growth rate = 1.023.

Population Target: HIGH

- Estimated number of individuals = 1,068 individuals (target for the lower 90% confidence bound, considering sampling uncertainty associated with demographic parameters = 800). Given current rates and levels of uncertainty, managing for a population with a ≥90% estimated probability of being above 800 bears requires maintaining an estimated population size of approximately 950–1,000 bears.

Number of Bears: HIGH

- Large population size increases population fitness.

Genetic Diversity: HIGH

- Due to high population size and relatively high levels of heterozygosity and allelic richness (Kendall *et al.* 2008, pp. 1698–1704; Kendall *et al.* 2009, pp. 9–12; Mace *et al.* 2012, pp. 124–125; Proctor *et al.* 2012, pp. 33–34; Mikle *et al.* 2016a, pp. 4–6; Morehouse *et al.* 2016, pp. 1160–1163).

Inter-Ecosystem Connectivity: HIGH

- Female grizzly bears have entered the NCDE from Canada and bred (Proctor *et al.* 2012, entire).

Current Condition in the GYE

Overall Current Condition: HIGH

High-Caloric Foods: HIGH

- High-caloric foods are readily available and diverse.

Large Intact Blocks of Land: HIGH

- A variety of land protections influence the current condition of these habitat factors (Chapters 2 and 5).

Adult Female Survival: HIGH

- Adult female survival = 0.94.

Fecundity: HIGH

- Females with cubs occupy 18 of 18 BMUs.

Population Trend: HIGH

- Population growth rate = 1.003–1.022 (IGBST 2012, p. 34). The population trajectory that includes the most recent data are based on Chao2 estimates of females with cubs for the period 2002 to 2019, which indicates a relatively constant population size for this reproductive segment of the population within the DMA, but with some evidence in recent years of an increasing trend (Haroldson *et al.* 2020b, p. 13).

Population Target: HIGH

- Population size = 737 individuals (target = 674, Service 2017, p. 5) inside the DMA (Haroldson *et al.* 2020b, p. 13), as estimated by conservative model-averaged Chao2 method (Schwartz 2008, entire).

Number of Bears: MODERATE

- 737 individuals falls short of the 800 individuals needed for high condition for the number of bears, however this is likely an underestimate due to the way that the population size is estimated (Cherry et al. 2007, entire; Schwartz *et al.* 2008, figure 5).

Genetic Diversity: MODERATE

- Heterozygosity is moderate and the population remains isolated.

Inter-Ecosystem Connectivity: FUNCTIONALLY EXTIRPATED

- Population is currently isolated, but given the increased distributions of the GYE and NCDE and the increasing number of verified sightings in between these distributions (Figure 22), if current trends continue we expect that natural immigration into the GYE will occur in the future and improve the condition of inter-ecosystem connectivity.

Current Condition in the CYE

Overall Current Condition: LOW

High-Caloric Foods: MODERATE

- The CYE is smaller than the GYE and NCDE, with a narrower range of habitats, which may limit the diversity of foods available. Few alternatives to huckleberries exist in the CYE, and its forested habitats may make ungulates less available as a food source. Although foods are less diverse in the CYE, individuals have body fat levels to indicate that natural, high-caloric foods are not limiting.

Large Intact Blocks of Land: MODERATE

- Large intact blocks of land are somewhat limiting in the CYE. Although there are large protected areas within the CYE recovery zone (with 44 percent designated as Wilderness or IRAs), additional protections outside the recovery zone, and recent conservation efforts on private lands, motorized route densities have not yet met habitat standards established for the CYE recovery zone.

Adult Female Survival: HIGH

- Adult female survival = 0.94.

Fecundity: LOW

- Females with cubs occupy 12 of 22 BMUs. Likely a result of the very low abundance in terms of the number of bears. We expect that over time, if the population trend and adult female survival rates remain high in the CYE, the population in this ecosystem will likely expand, which would improve the condition of fecundity and abundance.

Population Trend: HIGH

- Population growth rate = 1.009.

Population Target: LOW

- The population target of 100 for the CYE is not currently being met.

Number of Bears: VERY LOW

- 55 to 60 individuals (Kasworm *et al*. 2020a, p. 40). This low estimate likely reflects the fact that the CYE is a smaller ecosystem that is still slowly recovering from being close to historical extirpation, particularly in the Cabinets portion of the CYE.

Genetic Diversity: LOW

- The low rating is driven by the Cabinets portion of the CYE. Though we have documented some movement and gene flow from the Purcells north of Hwy. 3 into the Yaak, we have only recently detected movement by males but no gene flow into the Cabinets. Potential inbreeding and a small population size, but evidence of connectivity suggests there is short-term genetic fitness in the CYE.

Inter-Ecosystem Connectivity: MODERATE

- Males have immigrated into the Yaak portion of the CYE and subsequently bred, but we have only detected movements into or out of the Cabinets portion (Kasworm *et al.* 2020a, p. 32; Proctor *et al.* 2018, p. 363). Emigration out of the CYE has occurred and may benefit other ecosystems.

Current Condition in the SE

The recovery zone extends into Canada, therefore, some of the demographic information (i.e., female survival and population trend) we have is based on the entire recovery zone (so includes bears in Canada).

Overall Current Condition: MODERATE

High-Caloric Foods: MODERATE

- Foods are less diverse in the SE, likely due to its small size and narrower range of habitats. The SE is also forested, which may reduce the availability of ungulates as a food source. Although high-caloric foods are somewhat limiting in the SE, body fat levels indicate that individuals are relatively healthy.

Large Intact Blocks of Land: MODERATE

- The SE contains a limited amount of protected areas inside the recovery zone (3 percent designated or recommended Wilderness) and motorized route densities do not yet meet applicable habitat standards, although they are close. There have been recent conservation efforts on private lands in Canada and there are some regulations that manage motorized access outside the recovery zone. However, motorized access standards have not been fully implemented, and motorized route densities somewhat limit the availability of large intact blocks of land in the SE.

Adult Female Survival: MODERATE

- Adult female survival rate = 0.91 (Kasworm *et al*. 2020b, p. 24).

Population Trend: HIGH

- Population growth rate = 1.025.

Population Target: MODERATE

- The population target of 100 bears, including Canada, is not currently being met.

Number of Bears: VERY LOW

- A minimum of 53 individuals in the U.S. portion. Small population size decreases population fitness. Some individuals in the U.S. minimum population estimate have home ranges that crossed the international border, for which an updated population estimate is in progress. An estimate of 83 bears for the international population was made in 2010 (Proctor *et al.* 2012, p. 31).

Fecundity: MODERATE

- Eight of the 10 BMUs had sightings of females with young (Kasworm *et al*. 2020b, p. 12). Likely a function of the very low number of bears in the SE. We expect that if the SE population continues to expand and maintains a positive population trend, females with cubs will occupy more of the BMUs, which would improve the condition of fecundity and abundance in the SE.

Genetic Diversity: MODERATE

- Heterozygosity values in the SE, as measured in the trans-boundary population, remain low, due to the small number of bears, historical bottleneck, and past isolation. However, heterozygosity has increased some in the past decade with increased immigration and breeding from other populations (Proctor *et al.* 2018, p. 361).

Inter-Ecosystem Connectivity: MODERATE

- Males have been observed moving into the SE from other ecosystems (Kasworm *et al.* 2020b, p. 22*in prep.*). Emigration out of the SE has occurred and may benefit other ecosystems.

Current Condition in the BE

Overall Current Condition: FUNCTIONALLY EXTIRPATED

- There is at least one known bear near the recovery zone, but no known population.

High-Caloric Foods: MODERATE

- High-caloric foods are less diverse in the drier southern part of the BE.

Large Intact Blocks of Land: MODERATE

- Approximately 98 percent of the BE recovery zone is designated Wilderness, but condition is Moderate because motorized access standards have not been developed for the recovery zone or for adjacent areas to the north and east, where female occupancy is necessary for natural recolonization of the BE.

Adult Female Survival: FUNCTIONALLY EXTIRPATED

Fecundity: FUNCTIONALLY EXTIRPATED

Population Trend: FUNCTIONALLY EXTIRPATED

Population Target: FUNCTIONALLY EXTIRPATED

- The population target of 280 bears (Service 2000, p. ii) is not currently being met.

Number of Bears: FUNCTIONALLY EXTIRPATED

- There is no known population but in 2019, a collared bear dispersed from the CYE into the BE recovery zone and returned north to the CYE to den. Four additional grizzly bears have been confirmed in areas immediately surrounding the recovery zone over the last 15 years, indicating that connectivity is possible.

Genetic Diversity: FUNCTIONALLY EXTIRPATED

Inter-Ecosystem Connectivity: Very LOW

- Despite its relative isolation from other ecosystems, recent sightings suggest that inter-ecosystem connectivity is currently very low for the BE. In 2019, at least one bear from the CYE spent time in the BE recovery zone, and there have been multiple, verified sightings to the north and west of the recovery zone, one of which is known to have originated from the SE. There have also been verified sightings in potential connectivity areas between all four occupied ecosystems, although it is unknown for every case from what ecosystem the individuals originated. Numerous conservation easements on private lands and the purchase of land by land trusts have increased the potential for future natural recolonization of the BE from other ecosystems. For example, in the GYE, more than 2,800 km^2 (1,080 mi^2) of privately owned land are protected by easements or owned by land trusts in potential connectivity areas between the GYE and the BE. In the NCDE, more than 600 km^2 (230 mi^2) of privately owned land are protected by easements or owned by land trusts in the Ninemile DCA in Zone 1, which borders the northeast boundary of the BE. More than 700 km^2 (270 mi^2) of privately owned land are protected by easements or owned by land trusts in areas that border the GYE and the NCDE and could connect to the BE. While these conservation measures are helpful for connectivity, and the distance between the BE and NCDE is small (7 km (4.3 mi)), significant impediments remain in place (e.g., I-90) that act to slow down immigration. To date all verified occurrences of grizzly bears entering the BE have been males and female immigration is also needed for natural recolonization. Female immigration is anticipated to be slower given their shorter dispersal distances and potential barriers (e.g., I-90).

Current Condition in the North Cascades Ecosystem

Overall Current Condition: FUNCTIONALLY EXTIRPATED

High-Caloric Foods: MODERATE

- Berries and herbaceous material are the primary foods available; ungulate food sources are less available.

Large Intact Blocks of Land: MODERATE

- For the BMUs in the North Cascades, there is a habitat standard of "no net loss" of secure habitat developed from a 1997 baseline. Federal land managers have met this baseline; however, we have not evaluated whether this 1997 "no net loss" approach provides an adequate amount of secure habitat for a healthy grizzly bear population. Approximately 63 percent of the North Cascades ecosystem is designated Wilderness or IRAs. Therefore, although the North Cascades has protected areas and meets its "no net loss" approach, uncertainty associated with the adequacy of the baseline means that the condition of large intact blocks of land is currently moderate for the North Cascades. We note that the North Cascades ecosystems likely has sufficient habitat resources to support a population (Servheen *et al*. 1991, p. 6; Almack *et al*. 1993, pp. 21–22; Gaines *et al*. 1994; Lyons *et al.* 2018, p. 30).

Adult Female Survival: FUNCTIONALLY EXTIRPATED

Fecundity: FUNCTIONALLY EXTIRPATED

Population Trend: FUNCTIONALLY EXTIRPATED

Population Target: FUNCTIONALLY EXTIRPATED

- The population target of 200 bears (NPS and Service 2017, p. 5) is not currently being met.

Number of Bears: FUNCTIONALLY EXTIRPATED

Genetic Diversity: FUNCTIONALLY EXTIRPATED

Inter-Ecosystem Connectivity: FUNCTIONALLY EXTIRPATED

- Although the North Cascades is currently isolated, we note that it is within the dispersal distance of existing populations in the United States or Canada, and inter-ecosystem connectivity could improve in the future, which in turn could then improve the condition of the other demographic factors. There are several populations within the long-distance dispersal range (67–176 km (42–109 mi)) (Blanchard and Knight 1991, pp. 50, 55; McLellan and Hovey 2001, p. 841; Peck *et al.* 2017, p. 2), in Canada (Stein-Nahatlatch, Squamish-Lillooet, Garibaldi-Pitt Grizzly Bear Population Units);inter-ecosystem connectivity is plausible.

Although the BE and North Cascades currently do not support populations and are in overall functionally extirpated condition, I&E programs provide an important foundation for the potential future restoration of grizzly bears in these two ecosystems. The I&E team for the North Cascades and BE IGBC Subcommittee coordinates the development, implementation, and dissemination of programs and materials to aid in preventative management of human-bear conflicts. I&E team members include the Service, State fish and game agencies, Tribal wildlife agencies, the NPS, and the USFS. These partners recognize that public I&E programs are crucial in preventing human-grizzly bear conflicts, which is evidenced by the fact that they have been actively involved in grizzly bear I&E outreach for over a decade. I&E efforts include: public meetings; community events; informational posters, brochures, and bear identification sheets; bear-resistant containers; electric fencing; and funding of outreach by non-governmental agencies. In contrast to these I&E efforts, there are currently no food storage orders on the NFs in the BE, which manage nearly 100 percent of the BE recovery zone. Similarly, there are currently no food storage orders on the 75 percent of lands within the North Cascades recovery zone that are managed by the USFS; mandatory food storage orders are in effect in North Cascades NP (Title 36 CFR chapter 1, section 2.10(d) and section 2.2(a)(2). The lack of mandatory food storage orders on USFS lands within the North Cascades and BE recovery zones could reduce potential future improvements in the condition of the demographic factors for these ecosystems.

Summary of Current Resiliency

Currently, the NCDE and GYE have high resiliency. The SE has moderate resiliency and the CYE has low resiliency. Resiliency of the NCDE and GYE is currently high due to the generally high and moderate conditions for the habitat and demographic factors that influence resiliency (Figure 30). Despite high population trends and high and moderate adult female survival, both the CYE and SE currently have very low numbers of bears, although this factor could improve as bears reproduce and expand in the future. Despite the moderate condition of habitats, without known populations, the BE and North Cascades are currently in functionally extirpated condition, and therefore have no resiliency.

Current Condition: Redundancy

Redundancy describes the number and distribution of ecosystems, such that the greater the number and the wider the distribution of the ecosystems, the better able grizzly bear in the lower-48 States can withstand catastrophic events. Grizzly bears in the lower-48 States currently occupy four ecosystems, with two ecosystems with high resiliency, one with moderate resiliency, and one with low resiliency. Two ecosystems are currently in functionally extirpated condition, with no resiliency, so do not contribute to redundancy. The four ecosystems are currently distributed from north to south and east to west as illustrated in Figure 30.

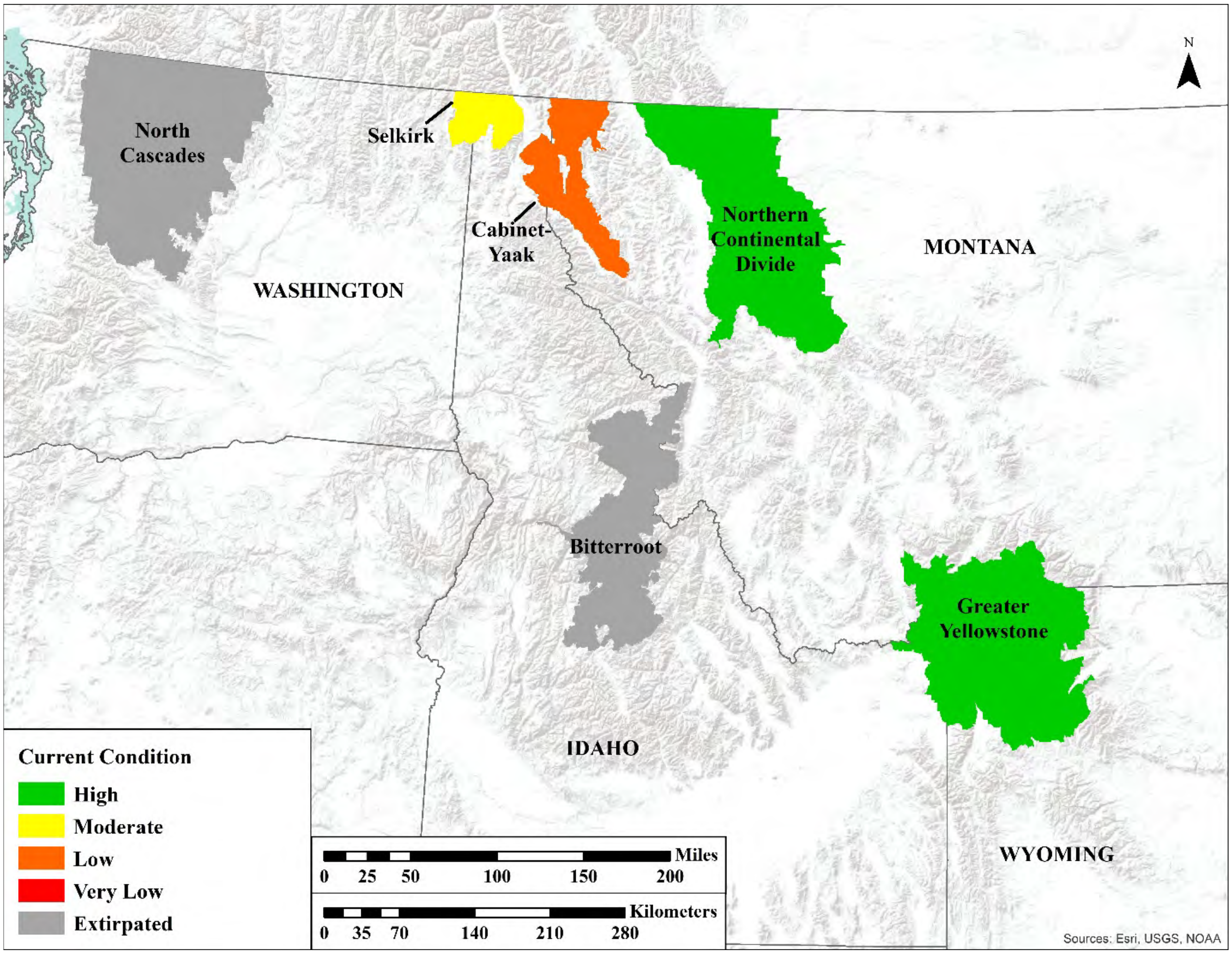

Figure 30. Map of the overall current condition for the six grizzly bear ecosystems in the lower-48 States, in terms of resiliency, redundancy, and representation. Colors represent the current resiliency for each ecosystem, based on the current condition of two habitat factors and six demographic factors for each ecosystem. Ecosystems with higher levels of resiliency are at less risk from environmental and demographic stochasticity. Currently, the Greater Yellowstone (GYE) and Northern Continental Divide (NCDE) ecosystems have high resiliency, the Selkirk ecosystem (SE) has moderate resiliency, and the Cabinet-Yaak ecosystem (CYE) has low resiliency. The North Cascades and Bitterroot (BE) ecosystems are in a functionally extirpated condition currently, so have no resiliency. Four ecosystems (GYE, NCDE, SE, and CYE) distributed as illustrated on the map contribute to redundancy and these ecosystems feature a diversity of ecological types used by the grizzly bear for representation.

Current Condition: Representation

Representation describes the breadth of ecological, genetic, behavioral, and morphological diversity across the six ecosystems. Representation is currently captured by ecological diversity inherent within the four resilient ecosystems (Figure 30, above). For example, the GYE, contained in the Middle Rockies ecoregion, is dominated by forested, mountainous habitat, and dry sagebrush to the east and south, and includes hydrothermal features and other unique geologic features. The NCDE includes parts of the Great Plains, Middle Rockies, and Northern Rockies ecoregions, and habitat varies from wet forested lands west of Glacier Park to much drier habitat to the east, including prairie grasslands. The CYE and SE are both contained within the Rocky Mountains, and are characterized by wet, forested mountains. The BE is primarily contained in the Idaho Batholith ecoregion, and contains mountainous regions, canyons, dry, partly wooded mountains, grasslands, high glacial valleys, and hot dry canyons. The North Cascades is composed of high, rugged mountains, and has a high concentration of active glaciers.

Summary of Current Condition

Of the six ecosystems, two ecosystems currently have high resiliency, one ecosystem has moderate resiliency, and one ecosystem has low resiliency. Two ecosystems are currently in functionally extirpated condition, with no resiliency. The four resilient ecosystems, the NCDE, GYE, CYE, and SE, contribute to redundancy as they are distributed north to south and east to west across the lower-48 States, and the ecological diversity inherent within these ecosystems contributes to representation (Figure 30, above).

Chapter 7: Future Conditions

In Chapter 6 we described the current condition for the grizzly bear in the lower-48 States in terms of resiliency, redundancy, and representation. In this chapter, we consider how the viability of the grizzly bear in the lower-48 States could change from its current condition in the future. To evaluate future condition, we used the same methodology used to evaluate current condition, but instead considered the plausible conditions for the two habitat factors and six demographic factors projected into the future under a range of plausible scenarios. We developed future scenarios to capture the range of uncertainty associated with how stressors and conservation efforts could influence viability in the future.

We evaluated future condition for the grizzly bear 30 to 45 years into the future. We selected this timeframe because it captures approximately two to three generation intervals for grizzly bear. A generation interval is the approximate time that it takes a female grizzly bear to replace herself in the population. Given the longevity of grizzly bears, two to three generation intervals represent a time period during which a complete turnover of the population would have occurred; any positive or adverse changes in the status of the population would be evident. Additionally, this timeframe considers the possibility that USFS land management plans, which may provide important conservation measures to reduce potential stressors, could go through at least one revision. Below we discuss our future scenarios and evaluation of future condition under each scenario.

Future Scenarios

Future scenarios allow us to explore a range of possible future conditions for the grizzly bear in the lower-48 States, given the uncertainty in both the stressors it may face, the potential response to those stressors, and the potential for possible conservation efforts to improve future conditions. For all scenarios, we assumed that stressors and conservation efforts in Canada remain the same and that climate change would not impact grizzly bears within the 30 to 45-year timeframe considered under all future scenarios. For this assessment, we developed five scenarios that capture a range of plausible, future possibilities for the grizzly bear and its habitats, based largely on the conservation efforts and other mechanisms that influence resiliency of ecosystems that we described in Chapter 5. Scenarios are qualitative in nature, include a high level of uncertainty, and are intended to discuss general impacts of potential future stressors and conservation actions. Although there may be different probabilities associated with our future scenarios, all five of our scenarios are equally plausible for the purposes of our SSA analysis. The future scenarios that we used to evaluate condition for the grizzly bear in the lower-48 States are (see Table 17 below for further details):

- **Future Scenario 1 – Significantly Decreased Conservation**: Under this scenario, conservation actions decrease significantly, largely through the termination or non-renewal of plans or regulations, and rate of private land development increases dramatically;
- **Future Scenario 2 – Decreased Conservation**: Under this scenario, conservation actions decrease, but not as significantly as Scenario 1, due to decreased effectiveness

and implementation of conservation actions and mechanisms, and rate of private land development increases;

- **Future Scenario 3 – Continuation of Conservation:** Under this scenario, conservation actions continue at their same rate, magnitude, and effectiveness as current condition, and rate of private land development remains the same;
- **Future Scenario 4 – Increased Conservation:** Under this scenario, conservation actions increase or improve, and rate of private land development decreases; and
- **Future Scenario 5 – Significantly Increased Conservation:** Under this scenario, conservation actions increase significantly, and rate of private land development decreases dramatically.

Table 17 details the five future scenarios in terms of the expected outcome for stressors and conservation actions under the range from significantly decreased conservation to significantly increased conservation. We describe the causes-and-effects for the sources, stressors, activities, and conservation actions in more detail in Chapter 5.

Table 17. Five future scenarios used to evaluate future condition for the six grizzly bear ecosystems in the lower-48 States.

Source, Stressor, Activity, or Conservation Action	SCENARIO 1: Significantly decreased conservation	SCENARIO 2: Decreased conservation	SCENARIO 3: Continuation of current levels of conservation	SCENARIO 4: Increased conservation	SCENARIO 5: Significantly increased conservation
Funding	No assurances that conservation actions and mechanisms will continue and there is a significant decrease in funding. There is also a reduction in research and conflict management.	Slight decrease in funding across the board.	Same long-term average and distribution of funding sources for conservation actions and monitoring.	Slight increase in funding across the board.	Assurances in place that funding for conservation programs, monitoring, and personnel will continue indefinitely. There is an increase in funding for conservation and management to areas where bears are expanding, in addition to increases in funding across all areas (within and outside ecosystems) for conflict prevention and I&E programs. There is also increased funding for research on stressors and the effectiveness of conservation actions and efforts (improved adaptive management).
Motorized Access	All the regulations/management plans currently enforcing motorized access standards are eliminated, new road building occurs, and there is a significant increase in motorized access.	Loss of some IRAs and all motorized access standards decrease (OMRD and TMRD). There is an increase in motorized access.	Management plans, regulations, and protections enforcing and influencing levels of motorized access remain in place.	Motorized access standards increase (OMRD and TMRD). There is a decrease in motorized access in grizzly bear habitat.	There is a significant decrease in motorized access in key habitats. There are new/additional regulations limiting motorized access in connectivity areas. Some IRAs become Wilderness areas. Increased funding could support underpasses/overpasses/fencing to reduce stressors from roads and highways.
Trains	Carcasses and grain spills are not removed from the tracks. Existing fencing along tracks is not effectively maintained. The HCP with BNSF is not finalized and/or not renewed. The HCP is not expanded to cover all appropriate areas as grizzly bear populations expand.	HCP with BNSF is implemented but not renewed, and voluntary conservation measures that reduce the impact/potential of train collisions are not implemented.	Voluntary conservation measures that reduce the impact/potential of train collisions continue to be implemented. However, all carcasses and spills are not promptly removed, and there is insufficient fencing.	All carcasses and grain spills are cleaned from the tracks and rights of way promptly. There is increased fencing to keep livestock off the tracks and existing fencing is effectively maintained. The HCP with BNSF is finalized and fully implemented	In addition to prompt clean-up of carcasses and spills, increased fencing, and a final HCP with BNSF, the conservation measures in the HCP expand throughout all recovery areas, as appropriate. The HCP is also renewed regularly. There is improved effectiveness and implementation of other conservation actions to reduce the impacts of train collisions, such as noise deterrents, electric fencing on trestles.
Livestock (Federal Allotments)	Increase in the number of livestock on federal lands (increase in the number of active allotments and/or density of livestock).	Less effectiveness of and compliance with permit conditions (e.g., food storage orders, carcass removals). Transition allotments to more vulnerable types of livestock (e.g., sheep). Implement less effective animal husbandry practices that increase the potential for conflict.	Current grazing practices on Federal allotments stay the same. Livestock operations continue to use existing active allotments (numbers, distribution, type of livestock, and management of livestock stay the same).	Maintain current number of allotments. Increased effectiveness of and compliance with permit conditions (e.g., food storage orders, carcass removals). Transition current allotments to less vulnerable types of livestock. Implement improved animal husbandry practices to reduce potential for conflict.	Close high-conflict livestock allotments to reduce the number of livestock on federal lands.
Livestock Operations (Private Lands)	Increase in the number of livestock on private lands, change the type of livestock to more vulnerable livestock, and decrease the quality of husbandry on livestock operations on private lands.	Decreased effectiveness and implementation of animal husbandry practices that reduce potential for conflict with livestock on private lands.	The amount and type of livestock on private lands stays the same, in the same locations. Grazing occurs on the same schedule. Current implementation and effectiveness of animal husbandry practices stay the same.	Improved effectiveness and implementation of animal husbandry practices that reduce potential for conflict with livestock on private lands.	Decrease in the number of livestock on private lands, change the type of livestock to less vulnerable livestock, and increase the quality of husbandry.

Source, Stressor, Activity, or Conservation Action	SCENARIO 1: Significantly decreased conservation	SCENARIO 2: Decreased conservation	SCENARIO 3: Continuation of current levels of conservation	SCENARIO 4: Increased conservation	SCENARIO 5: Significantly increased conservation
Unsecured Attractants	All existing regulations controlling securing of attractants are removed and there are no new regulations.	Regulatory mechanisms promoting securing of attractants (e.g., food storage orders) become less effective (either less restrictive or less enforcement).	All food storage orders currently on federal, state, tribal, and private lands stay in place. All other current attractant storage regulations stay in place. There are no food storage orders in the North Cascades, BE, or connectivity areas.	Additional food storage orders are implemented so they exist on all public lands in all ecosystems.	Regulations or standards are implemented to secure all attractants on public and private lands in all ecosystems.
Developed Sites	Existing management plans change to allow for increases in developed sites, and these increases are significant.	Existing management plans change to allow for increases in developed sites, but these increases are in lower quality habitat areas, and they are consolidated near existing development.	There is no increase in developed sites in the GYE recovery zone. There are no increases in developed sites in the NCDE recovery zone, beyond the allowed increases (1 increase per BMU per decade). There are no restrictions on developed sites in the CYE, BE, SE, or North Cascades but development continues to occur at a minimal rate on USFS lands.	There is no increase in developed sites in the GYE recovery zone. In the NCDE recovery zone, sideboards on the allowed increases are clarified. There are restrictions on developed sites in the other recovery zones.	There is no increase in developed sites in all ecosystems and connectivity areas.
Federal Land Protections (i.e., wilderness)	All non-designated wilderness areas (e.g., recommended, proposed, WSAs) lose this status and are no longer managed as wilderness.	Some of the non-designated wilderness areas (e.g., recommended, proposed, WSAs) lose this status and are no longer managed as wilderness.	Current wilderness areas remain designated as wilderness and non-designated wilderness areas (e.g., recommended, proposed, WSAs) are managed as wilderness.	Some proposed and recommended wilderness and WSAs become designated as wilderness (especially in the CYE).	All proposed and recommended wilderness and WSAs become designated as wilderness (especially in the CYE).
IRAs	All IRAs disappear.	There is a decrease in the number of IRAs and/or an increase in the number of motorized trails within the IRAs.	The number of IRAs stays the same. The level of motorized trails within IRAs stays the same.	There is a reduction in the number of motorized trails within the IRAs.	All IRAs are converted to Wilderness areas.
Forest Plans and National Park Management Plans	The standards that benefit grizzly bears in some (but not all) Forest Plans are eliminated. NPS changes some of their standards so that they are less effective. There are no standards in the connectivity areas.	Standards that benefit grizzly bears in some Forest Plans revised to allow for more motorized access, and allow for increases in other activities (e.g., recreation, timber harvest).	Standards and protections in USFS and NPS land management plans that benefit grizzly bears stay the same. Standards that currently exist in some of the connectivity areas remain in place.	Improvement and expansion of standards that benefit grizzly bears in USFS and NPS management plans, especially where new bears are detected.	There are habitat management standards that benefit grizzly bears in USFS and NPS management plans in all ecosystems, and in connectivity areas, improving the security of habitat.
State and Tribal Plans	There are no State and Tribal management plans for habitat and mortality management, either because they are not finalized or they lapse and are not renewed.	Less effective State and Tribal plans for habitat and mortality management.	If needed, existing State and Tribal plans can sustainably manage mortality. These plans also provide habitat standards in important areas.	Existing State and Tribal plans are renewed and have legally binding regulatory mechanisms to manage mortality and habitat in a few ecosystems. State and/or tribal conservation improves issues related to mistaken identity killing by black bear hunters.	State and Tribal plans are finalized and expanded with legally binding regulatory mechanisms to manage mortality and habitat in all ecosystems.
Private Land Development Rate	Rate of private land development increases dramatically.	Rate of private land development increases.	Rate of private land development remains the same.	Rate of private land development decreases.	Rate of private land development decreases dramatically.
Translocation, augmentation, or human-facilitated restoration of bears	Human-facilitated restoration of bears in extirpated ecosystems does not occur. Bears do not move naturally into the CYE, and augmentation does not continue. There are no translocations into the GYE even if needed for long-term genetic health.	CYE augmentation does not continue. Translocations into the GYE occur if necessary.	Continuation of current augmentation program in the CYE. We would translocate bears into the GYE, if needed for long-term genetic health.	Bears are successfully reintroduced into the North Cascades. CYE augmentation continues. We would translocate bears into the GYE, if needed for long-term genetic health.	Bears are successfully reintroduced into the North Cascades and in the BE. There is enough natural movement that augmentation of the CYE is no longer needed. There is enough natural movement into the GYE that translocation is no longer needed.

Future Condition: Resiliency, Redundancy, and Representation

Using the same methodology that we used to evaluate current condition, we projected the resiliency for the six ecosystems 30 to 45 years into the future. First, we projected the future condition for the two habitat factors and six demographic factors that we identified as needs in Chapter 5, for each future scenario. Then, we used the same weighted average to calculate an overall resiliency score for each ecosystem under each scenario. In general, ecosystems with higher resiliency have a greater probability of persistence, based on their ability to withstand stochastic events, than ecosystems with lower resiliency. After evaluating resiliency, we then we evaluated redundancy and representation for each future scenario.

As we evaluated the future condition of fecundity under the five future scenarios, we considered the uncertainty associated with how this demographic factor is measured. Fecundity may be underestimated, because detecting breeding females depends on how and where surveys occur, and on the overall survey effort. As a result, we used our best professional judgement to project the future condition of fecundity assuming no issues with measuring. Our evaluations therefore reflect the actual projected condition for fecundity, not what measurement techniques would likely detect. Similarly, because inter-ecosystem connectivity is measured within a 10 to 15-year window, we projected whether immigrants move between ecosystems between years 2040 and 2050.

We also highlight uncertainty associated with measuring a population target for the SE. Although grizzly bears in the lower-48 States is the subject of our SSA, the demographic information we have for the SE is for the whole recovery zone, which includes a small portion of Canada. Therefore, our evaluation of conditions for the SE may overestimate conditions, because we must rely on data that includes individuals in Canada. Below, we summarize our evaluation of future conditions under each of the five future scenarios.

Future Scenario 1 – Significantly Decreased Conservation

Future Scenario 1 is a pessimistic scenario. Under Scenario 1, conservation decreases significantly, due largely to a significant revisions to the current regulatory framework, decrease in funding for conservation actions and other mechanisms, research, and conflict management tools that reduce habitat loss, increase the potential for conflicts and increase human-caused mortality. Under this scenario, motorized access increases significantly, as new roads are constructed, and all regulations and management plans that enforce motorized access standards disappear. IRAs also disappear. Existing regulations that reduce habitat loss and human-caused mortality from unsecured attractants, developed sites, livestock operations, and trains disappear. The rate of development of private lands increases dramatically. Augmentation and translocation efforts do not occur. Additionally, all non-designated Wilderness areas lose their designations and are no longer managed as Wilderness (Table 17, above).

With a significant decrease in conservation under Scenario 1, there are subsequent decreases in resiliency across the habitat and demographic factors (Figure 31 and Table 18). Both the NCDE and GYE decrease in overall resiliency from high to moderate, the SE declines from moderate to very low, and the CYE declines from low to very low. Although resiliency decreases, redundancy and representation remain the same under Scenario 1, with four ecosystems distributed similarly to current condition across their ecosystem types.

Table 18. Future conditions for habitat and demographic factors, 30 to 45 years under Future Scenario 1, where conservation decreases significantly.

FUTURE CONDITION SCENARIO 1 – SIGNIFICANTLY DECREASED CONSERVATION										
	Habitat Factors		**Demographic Factors**							
	Natural, High-Caloric Foods	**Large, intact blocks of land**	**Adult Female Survival**	**Abundance**		**Population Trend**	**Fecundity**	**Inter-Ecosystem Connectivity**	**Genetic Diversity**	**Future Resiliency**
				Population Target	**Number of Bears**					
NCDE	High	Moderate	Low	Moderate	Moderate	Low	Moderate	High	High	**Moderate**
GYE	High	Moderate	Low	Low	Moderate	Low	Moderate	X	Low	**Moderate**
CYE	Moderate	Low	Low	Very Low	Very Low	Low	Very Low	Very Low	Very Low	**Very Low**
SE	Moderate	Low	Low	Very Low	Very Low	Low	Very Low	Very Low	Low	**Very Low**
BE	Moderate	Low	X	X	X	X	X	X	X	**X**
North Cascades	Moderate	Moderate	X	X	X	X	X	X	X	**X**

Natural high-caloric foods remain high or moderate for all ecosystems under Scenario 1, due in part to the large amount of Wilderness and National Parks within the NCDE and GYE, which help ensure that a diversity of food sources would continue to be available to the grizzly bear into the future. However, as conservation declines significantly under Scenario 1, large intact blocks of land decline from high to moderate for the NCDE and GYE, and from moderate to low in the CYE, SE, and BE, but remains moderate for the North Cascades. In the NCDE and GYE, large intact blocks of land shifts from high to moderate as motorized access increases, but the quantity of Wilderness Areas and National Parks that remain in these ecosystems and also the North Cascades, helps ensure that the condition of this habitat factor does not fall below moderate. Despite also having large amounts of designated Wilderness areas that are not expected to change under Scenario 1, large intact blocks of land in the BE declines from moderate to low given a reduction in the IRAs that reduce motorized access in the important connectivity areas in the northern part of the ecosystem. Large intact blocks of land in the CYE and SE are low under this scenario due also to increases in motorized access. Conditions also worsen in the CYE and SE because these ecosystems lack large Wilderness areas or National Parks to help reduce motorized access and sources of human-caused mortality.

Under Scenario 1, there are overall declines in condition for most of the demographic factors for the four ecosystems that are currently resilient (NCDE, GYE, CYE, and SE). Under this scenario, significant reductions in conservation actions that address unsecured attractants and other sources of human-caused mortality lead to increased mortality and hence declines in adult female survival, abundance, population trend, and fecundity. Without effective management of human-caused mortality, such as a HCPs, to help reduce human-caused mortality along railroads, the population target in the NCDE shifts from high to moderate under Scenario 1. The NCDE could lose 50 individuals or more per year without these conservation actions, so its future population target is moderate. The decline in future condition related to population target in the GYE, from high to low, is more dramatic than the NCDE, given increased mortality and declines in an ecosystem that currently has fewer grizzly bears.

Fecundity remains moderate in the NCDE under Scenario 1, due to the quantity of wilderness areas and National Parks, which help reduce motorized access and other sources of human caused mortality such that at least 70 percent of the BMUs will likely be occupied. Fecundity in the GYE declines from high to moderate, as at least one BMU in this ecosystem would not likely be occupied as a result of significantly decreased conservation, more than likely in the southwest corner of YNP where occupancy is often relatively low. Fecundity in the CYE and SE also declines due to the significantly decreased conservation under this scenario.

Under Scenario 1, inter-ecosystem connectivity remains high in the NCDE, because we assumed that conservation efforts would remain the same in Canada, regardless of reduced conservation in the lower-48 States. If Canadian conservation efforts remain the same under this scenario, individuals could continue to move into the NCDE from Canada. Even with significantly reduced conservation, at least one female grizzly bear would likely move down from Canada into the NCDE and successfully breed, so inter-ecosystem connectivity remains high in the NCDE. Inter-ecosystem connectivity for the CYE and SE drops from moderate to very low under Scenario 1, as increases in motorized access and human-caused mortality reduces the quality of habitats and discourages immigrating females from establishing new home ranges.

Finally, under Scenario 1, genetic diversity remains high in the NCDE, due to moderate abundance. However, in the GYE, CYE, and SE genetic diversity declines as abundance declines due to increasing human caused mortality. Additionally, augmentation efforts in the CYE cease under this scenario, which would decrease the size and genetic health of this ecosystem. Genetic diversity in the SE is currently moderate, with lower heterozygosity than the other ecosystems, and as human caused mortality increases under this scenario and reduces immigration of individuals, abundance decreases, which reduces genetic diversity. In general, under Scenario 1, increased human caused mortality could exacerbate declines in genetic diversity across all four ecosystems.

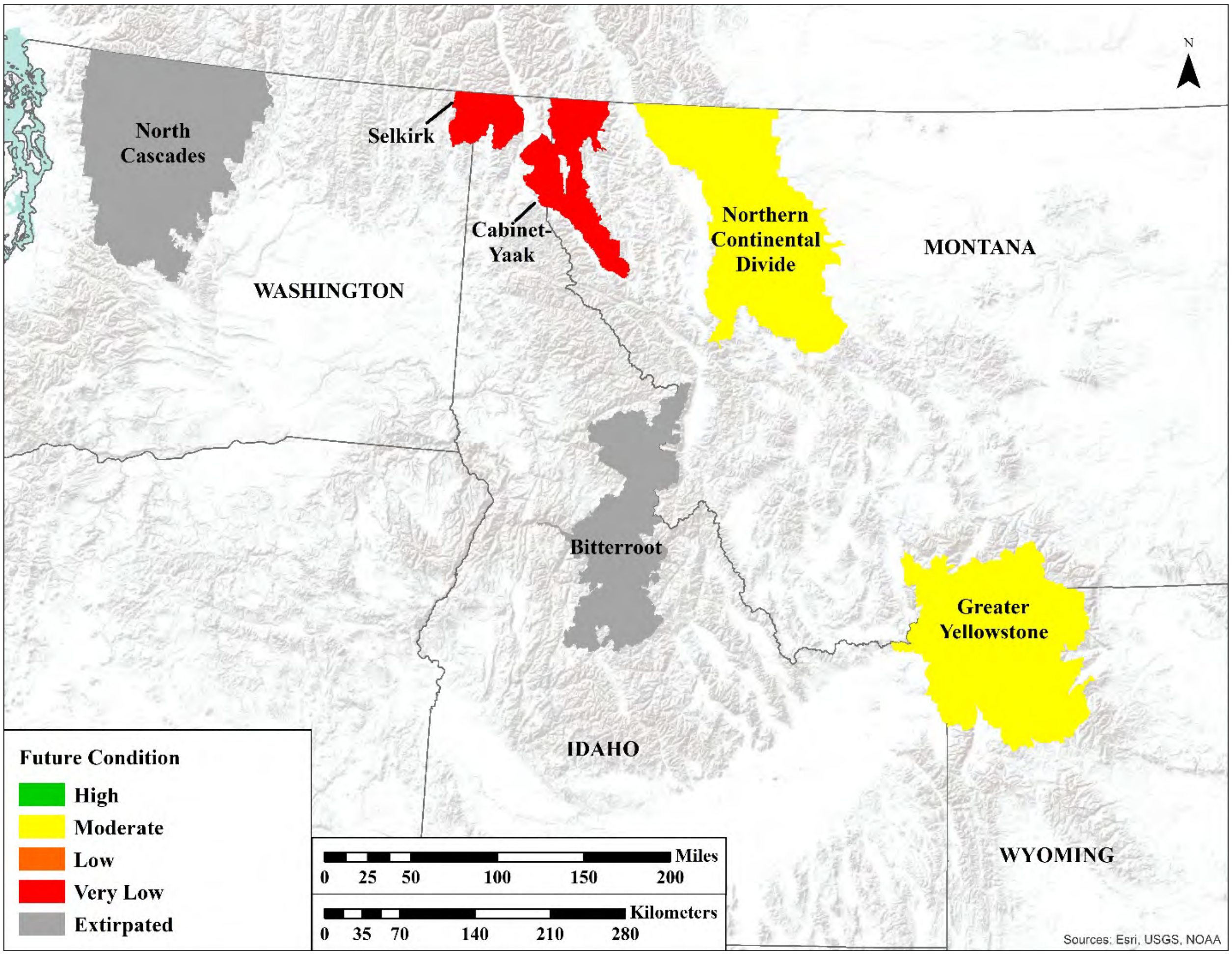

Figure 31. Map of future Scenario 1 – Significantly decreased conservation 30 to 45 years into the future, which illustrates the 3Rs under this scenario.

Future Scenario 2 – Decreased Conservation

Like Scenario 1, Future Scenario 2 is a pessimistic scenario. Under Scenario 2, there is a decrease in conservation under future Scenario 2, but the decrease is not as significant. Under Scenario 2, overall declines result from slight, not significant, decreases in funding levels and in the quantity and effectiveness of conservation actions and regulations, but some efforts remain. As a result, motorized access increases as existing regulatory mechanisms remain in place, but are less effective, and the potential for conflict increases. There are no augmentations in the CYE, but translocation occurs in the GYE, as needed. There is a slight decline in the number of protected areas, as some areas are no longer managed as wilderness. The rate of development on private land increases.

With a decrease in conservation under Scenario 2, potential decreases in overall resiliency are less severe than under Scenario 1. Under Scenario 2, both the NCDE and GYE remain in high overall resiliency, the CYE remains in low resiliency, but the SE drops from moderate to low overall resiliency (Table 19 and Figure 32). Redundancy and representation remain the same as current conditions.

Table 19. Future conditions for habitat and demographic factors, 30 to 45 years under Future Scenario 2, where conservation decreases.

FUTURE CONDITION SCENARIO 2 – DECREASED CONSERVATION											
	Habitat Factors		Demographic Factors								
				Abundance							
	Natural, High-Caloric Foods	Large, intact blocks of land	Adult Female Survival	Population Target	Number of Bears	Population Trend	Fecundity	Inter-Ecosystem Connectivity	Genetic Diversity	Future Resiliency
NCDE	High	Moderate	Moderate	Moderate	High	Moderate	Moderate	High	High	**High**
GYE	High	Moderate	Moderate	Low	Moderate	Moderate	Moderate	X	Moderate	**High**
CYE	Moderate	Moderate	Moderate	Very Low	Very Low	Moderate	Low	Low	Low	**Low**
SE	Moderate	Moderate	Moderate	Very Low	Very Low	Moderate	Low	Moderate	Moderate	**Low**
BE	Moderate	Moderate	X	X	X	X	X	Very Low	X	**X**
North Cascades	Moderate	Moderate	X	X	X	X	X	X	X	**X**

As conservation is reduced under Scenario 2, natural high-caloric foods remain the same as current condition for all ecosystems, but large intact blocks of land shift from high to moderate for the NCDE and GYE due to increases in motorized access, but remain moderate for the CYE and SE.

Despite the reduced conservation, abundance as related to the population target and the number of bears, both remain high for the NCDE under Scenario 2. However, we note that this could be an overestimate, as the number of bears is likely to hover around the threshold between high and moderate condition for both of these measures of abundance. In general, reduced conservation could increase human-caused mortality, and reduce abundance in the NCDE, but we have some uncertainty regarding the magnitude of this reduction under this scenario. Population trends for the NCDE, GYE, CYE, and SE are moderate under this scenario, as population trends are currently high for all four ecosystems.

Under Scenario 2, inter-ecosystem connectivity for the BE remains very low, not functionally extirpated. Even with reduced conservation measures under this scenario, which would increase human-caused mortality in the SE, CYE, and NCDE, we believe that at least one individual could wander into the BE between years 2040 and 2050. Therefore, inter-ecosystem connectivity is very low. Genetic diversity stays the same for all four ecosystems under Scenario 2.

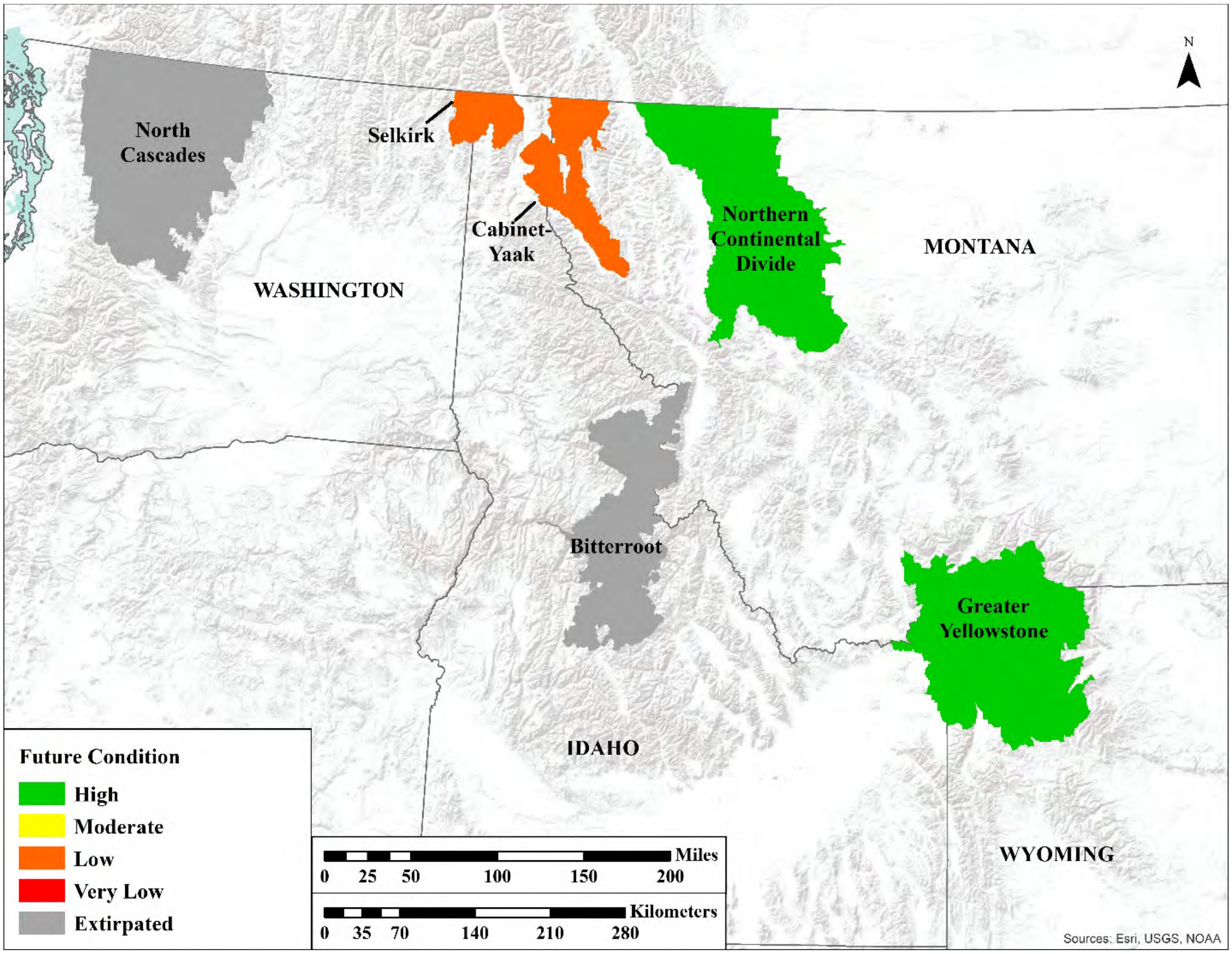

Figure 32. Map of future Scenario 2 –Decreased conservation 30 to 45 years into the future, which illustrates the 3Rs under this scenario.

Future Scenario 3 – Continuation of Conservation

Future Scenario 3 is a continuation scenario, where all stressors and conservation efforts continue at their same rate and magnitude 30 to 45 years into the future. The current levels of funding and effectiveness and implementation of conservation actions and mechanisms stay the same under this scenario. As a result, the NCDE and GYE remain in overall high resiliency, the SE stays moderate, but the CYE improves in overall resiliency from low to moderate (Table 20 and Figure 33). Redundancy and representation remain the same as current conditions.

Table 20. Future conditions for habitat and demographic factors, 30 to 45 years under Future Scenario 3, where conservation continues at the same rate and effectiveness as current condition.

FUTURE CONDITION SCENARIO 3 – CONTINUATION OF CONSERVATION										
	Habitat Factors		Demographic Factors							Future Resiliency
				Abundance			Fecundity			

	Natural, High-Caloric Foods	Large, intact blocks of land	Adult Female Survival	Population Target	Number of Bears	Population Trend		Inter-Ecosystem Connectivity	Genetic Diversity	
NCDE	High	High	High	High	High	High	Moderate	High	High	**High**
GYE	High	High	High	High	Moderate	High	High	Moderate	High	**High**
CYE	Moderate	Moderate	High	Moderate	Very Low	High	Moderate	Moderate	Moderate	**Moderate**
SE	Moderate	Moderate	High	High	Low	High	Moderate	Moderate	Moderate	**Moderate**
BE	Moderate	Moderate	X	X	X	X	X	Low	X	**X**
North Cascades	Moderate	Moderate	X	X	X	X	X	X	X	**X**

Habitat factors remain the same under Scenario 3 for all ecosystems. Despite ongoing conservation, large intact blocks of land remain moderate for the SE and CYE by virtue of their smaller size relative to the NCDE and GYE. However, there are increases in condition for specific demographic factors, particularly in the CYE and SE, under this scenario, as continued conservation continues to allow demographic factors to improve over time. Most notably in the SE, adult female survival improves from moderate to high under this scenario, as 30 to 45 years of additional implementation of motorized access conservation efforts help achieve secure habitat goals for each BMU. Population targets in the CYE and SE improve, from low to moderate and moderate to high, respectively, as abundance increases with ongoing conservation. With an additional 30 years of implementing conservation efforts at their current rate and effectiveness, we expect there could be at least an additional 10 individuals in the SE, for 90 total, which would meet the population target for this ecosystem, so the abundance as related to the population target would be high.

If conservation continues as described under Scenario 3, inter-ecosystem connectivity for the GYE improves from a functionally extirpated to a moderate condition. Individuals moving south from the NCDE are already very close to the GYE, and we expect that within 30 to 45 years, as the ecosystems continue to grow, supported by ongoing conservation, it is likely that at least one male would enter the GYE, establish a home range, and breed. We are confident that with ongoing conservation, an individual could naturally immigrate into the GYE within 30 to 45 years, therefore inter-ecosystem connectivity is moderate for the GYE under Scenario 3. We have documented several bears in and near the BE over the last several years, however a breeding population is needed to overcome a functionally extirpated status. A population is defined as at least two different female grizzly bears with young or one female seen with different litters in two different years in an area geographically distinct (separate) from other grizzly bears populations (Service 2000, pp. 3-14–15). Female dispersal movements are much more limited than males, and we believe it is unlikely that a breeding population will be established in the next 30 to 45 years. Because this criterion is unlikely to be met in the next 30 to 45 years; the population is classified as Functionally Extirpated.

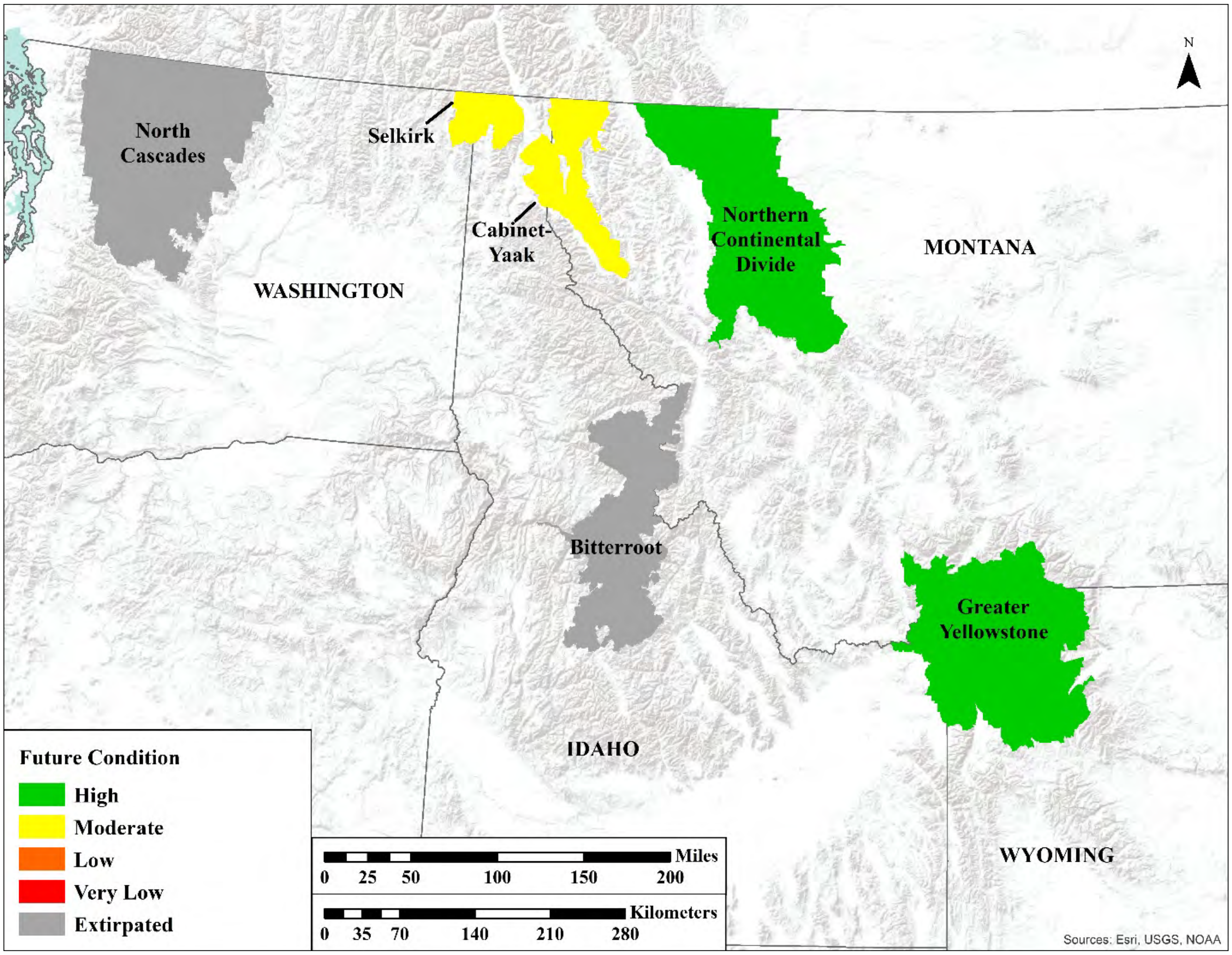

Figure 33. Map of future Scenario 3 –Continued conservation 30 to 45 years into the future, which illustrates the 3Rs under this scenario.

Future Scenario 4 – Increased Conservation

Future Scenario 4 is the first of two optimistic scenarios. Under Scenario 4, conservation increases, as funding increases and the mechanisms that reduce motorized access and human caused mortality increase or are more effective. Rates of development on private lands decrease and there are increases in the amount designated Wilderness and IRAs. Under this scenario, individuals are successfully moved into the North Cascades, augmentations continue into the CYE, and translocations occur in the GYE, as needed.

Under Scenario 4, redundancy and representation improve, as both the BE and North Cascades shift from their currently functionally extirpated conditions with no resiliency to low resiliency. The NCDE and GYE remain in overall high resiliency, the SE remains moderate, and the CYE improves from low to moderate resiliency (Table 21 and Figure 34). Risk from potential catastrophic events is now spread across six instead of four ecosystems (redundancy) with additional ecological diversity gained at the northwestern and central extents of the overall range (representation) (Figure 34).

Table 21. Future conditions for habitat and demographic factors, 30 to 45 years under Future Scenario 4, where conservation increases.

FUTURE CONDITION SCENARIO 4 – INCREASED CONSERVATION										
	Habitat Factors		**Demographic Factors**							**Future Resiliency**
	Natural, High-Caloric Foods	**Large, intact blocks of land**	**Adult Female Survival**	**Abundance**		**Population Trend**	**Fecundity**	**Inter-Ecosystem Connectivity**	**Genetic Diversity**	
				Population Target	**Number of Bears**					
NCDE	High	High	High	High	High	High	High	High	High	**High**
GYE	High	High	High	High	High	High	High	Moderate	High	**High**
CYE	Moderate	Moderate	High	Moderate	Low	High	Moderate	Moderate	Moderate	**Moderate**
SE	Moderate	Moderate	High	High	Low	High	Moderate	High	Moderate	**Moderate**
BE	Moderate	Moderate	Moderate	Very Low	Very Low	Moderate	Very Low	Low	Very Low	**Low**
North Cascades	Moderate	Moderate	Low	Very Low	Very Low	Moderate	Very Low	Very Low	Very Low	**Low**

Despite the increased conservation under Scenario 4, natural high-caloric foods and large intact blocks of land remain the same as current condition. Without additional Wilderness areas and IRAs, large intact blocks of land remain moderate for the CYE and SE. Additionally, habitat conditions remain relatively the same for both the North Cascades and BE under this scenario.

Under Scenario 4, demographic factors for the BE and North Cascades begin to improve from their currently functionally extirpated condition to moderate in the BE and low in the North Cascades. In the BE, improvements in conservation measures associated with mistaken identity kills by black bear hunters help improve adult female survival in the BE under this scenario. Local support for reintroduction in the North Cascades increases and a population is established via reintroduction. Natural recolonization in the BE under this scenario improves population trend in these ecosystems to moderate. We expect that successful reintroduction into the North Cascades would result in a positive population trend, as it would be unlikely that all the individuals would die. Reintroduction moves bears in the North Cascades under this scenario, but subadult female survival is low because reintroduced bears have wandered, which has increased human-caused mortality as demonstrated in the Cabinet Mountains augmentation effort (Kasworm *et al*. 2020a, p. 37). Abundance in the CYE and SE improves under this condition, with targets of 90 individuals achieved due to decreases motorized access, ongoing augmentation in the CYE, and a positive population trend. Additionally, with increased conservation, inter-ecosystem connectivity improves for the GYE, SE, and North Cascades.

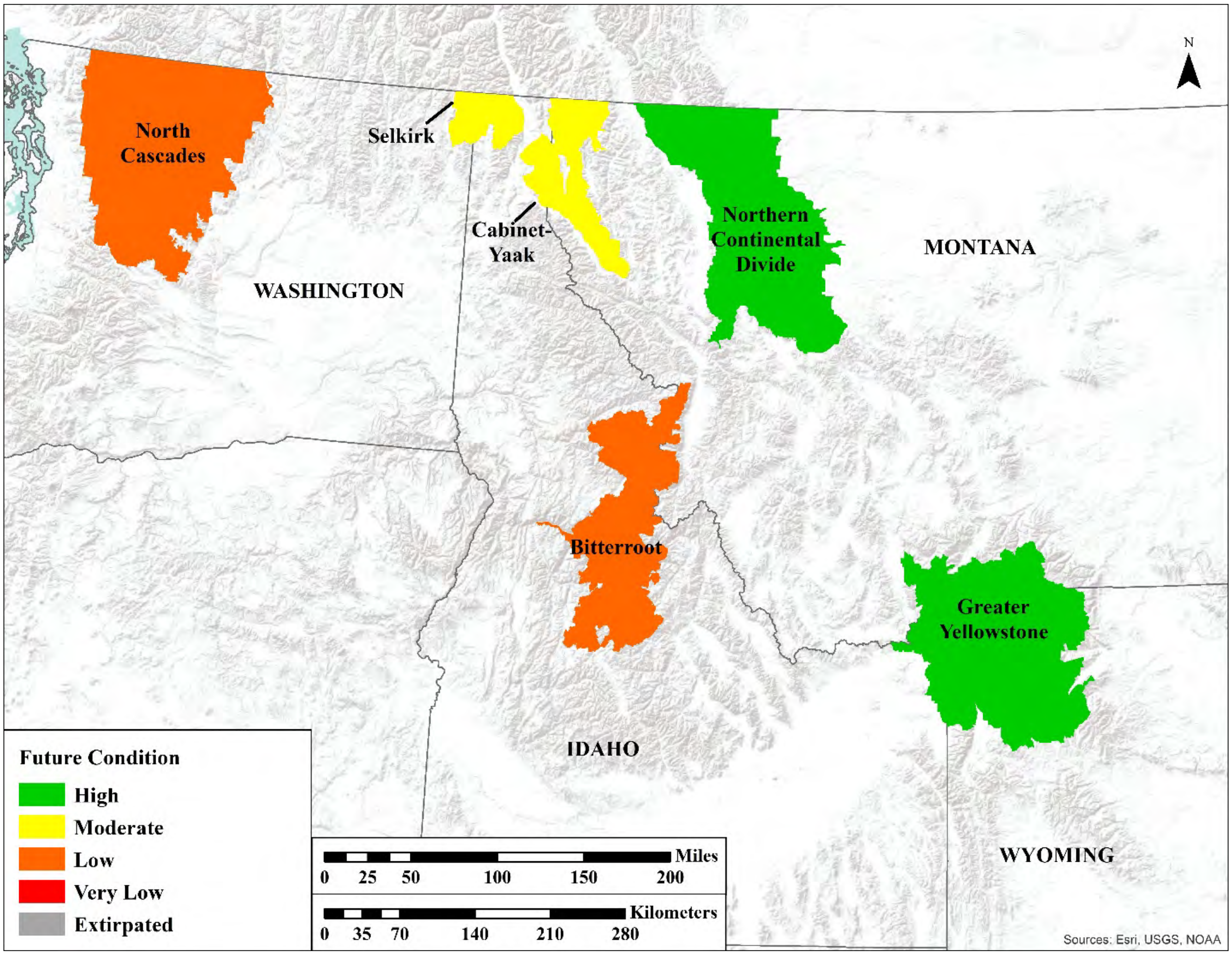

Figure 34. Map of future Scenario 4 –Increased conservation 30 to 45 years into the future, which illustrates the 3Rs under this scenario.

Future Scenario 5 – Significantly Increased Conservation

Future Scenario 5 is an optimistic scenario under which conservation increases significantly. Tolerance and acceptance also significantly increase, and there is general acceptance of grizzly bears persisting in all ecosystems and the importance of connectivity. As a result, resiliency, redundancy, and representation improve. Under this scenario, the NCDE and GYE stay in high overall resiliency, but the CYE and SE improve to high overall resiliency. The BE and North Cascades have low overall resiliency under this scenario (Table 22 and Figure 35).

Table 22. Future conditions for habitat and demographic factors, 30 to 45 years under Future Scenario 5, where conservation increases significantly.

FUTURE CONDITION SCENARIO 5 – SIGNIFICANTLY INCREASED CONSERVATION										
	Habitat Factors		Demographic Factors							
	Natural, High-Caloric Foods	Large, intact blocks of land	Adult Female Survival	Abundance: Population Target	Abundance: Number of Bears	Population Trend	Fecundity	Inter-Ecosystem Connectivity	Genetic Diversity	Future Resiliency
NCDE	High	High	High	High	High	High	High	High	High	**High**
GYE	High	High	High	High	High	High	High	Mod (look at Lori's map)	High	**High**
CYE	Moderate	High	High	High	Low	High	Moderate	High	High	**High**
SE	Moderate	High	High	High	Low	High	High	High	High	**High**
BE	High	High	Moderate	Very Low	Very Low	High	Very Low	Moderate	Low	**Low**
North Cascades	Moderate	High	Moderate	Very Low	Very Low	High	Very Low	Very Low	Low	**Low**

Conditions under Scenario 5 generally improve similarly to conditions under Scenario 4, but with additional increases in genetic diversity and population trend. The condition for high-caloric foods remains consistent from current to future conditions for all six ecosystems, except for an improvement in condition for the BE from moderate to high under Scenario 5, where conservation increases significantly. This improvement in high-caloric foods for the BE under Scenario 5 results from an increase in secure habitats as IRAs become Wilderness, and conservation actions are implemented that could benefit ungulates as a food source. Local support for reintroduction in the BE and North Cascades increases and a population is established via reintroduction. In the BE and North Cascades, adult female survival improves from functionally extirpated to moderate, not to high, as a result of the inherently low survival rates for reintroduced individuals that tend to wander. Under this scenario, the CYE would likely reach the population target of 100 individuals, especially given the ecosystem's currently positive population trend. However, fecundity in the CYE is moderate due to the uneven distribution of females across the ecosystem, and it will take additional time for fecundity to reach a high condition.

With significantly increased conservation, inter-ecosystem connectivity in the North Cascades could improve if individuals from B.C. move into this ecosystem; therefore, the condition of this factor is very low under this scenario. Genetic health of the CYE would improve with an increase in abundance and improved connectivity with Canada and the SE.

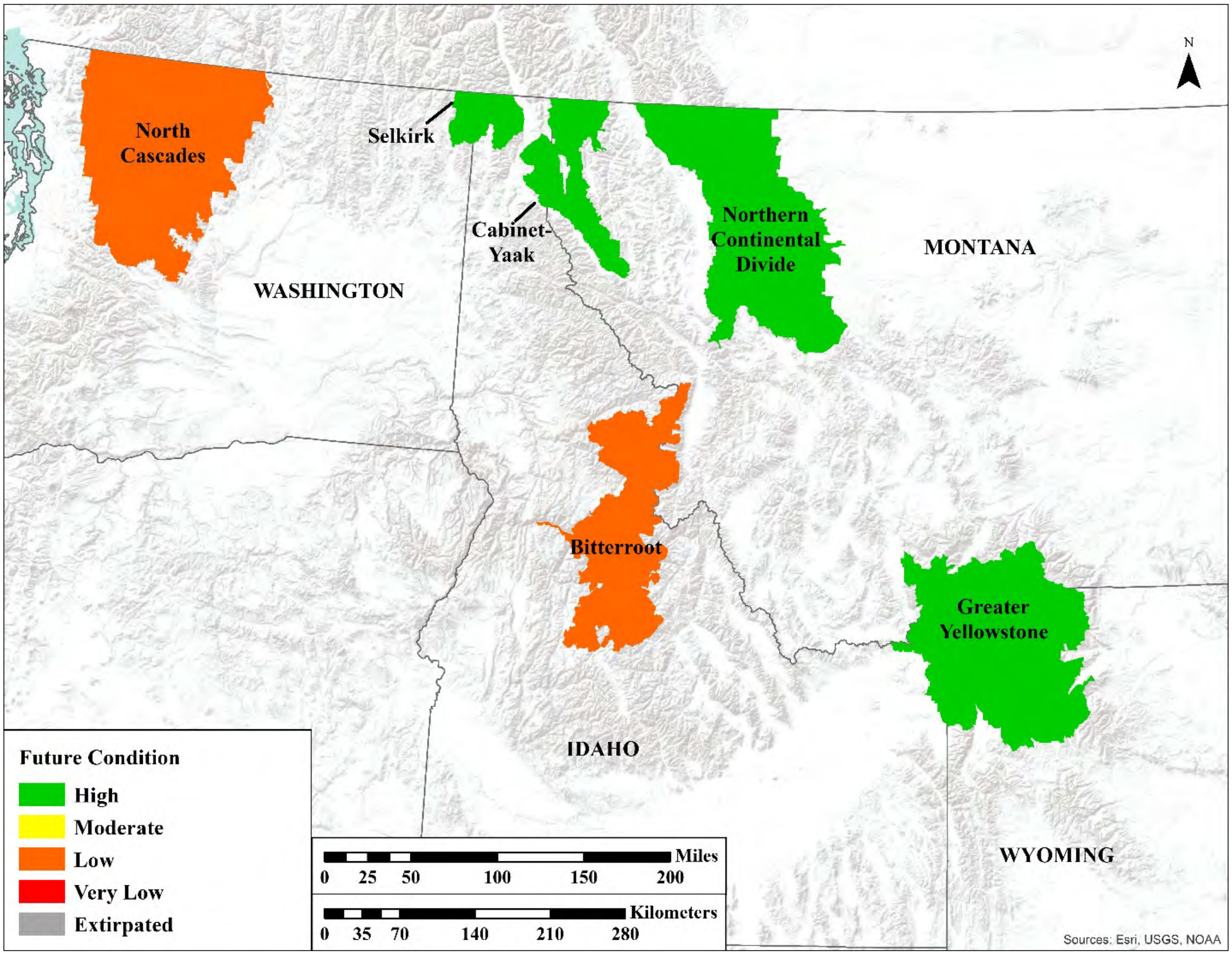

Figure 35. Map of future Scenario 5 –Significantly Increased conservation 30 to 45 years into the future, which illustrates the 3Rs under this scenario.

Chapter 8: Synthesis of Current and Future Condition

For this SSA of grizzly bear in the lower-48 States, we evaluated the current and future conditions in terms of resiliency, redundancy, and representation. Resiliency describes risk associated with stochastic events, redundancy with catastrophic events, and representation describes risk associated with long-term environmental change. We used future scenarios to capture a range of plausible futures and uncertainty associated with the future.

Currently, there are two ecosystems with high resiliency, one ecosystem with moderate resiliency, and one ecosystem with low resiliency (Table 23). Within 30 to 45 years in the future, there are improvements and reductions in resiliency across the ecosystems depending on the scenario; with reductions in resiliency under Scenario 1, the most pessimistic scenario where conservation efforts decline significantly and improvements in resiliency under Scenario 5, the most optimistic scenario where conservation efforts improve significantly. If conservation efforts stay the same, as under Scenario 3 the continuation scenarios, the CYE improves from low to moderate resiliency. Under this continuation scenario, the NCDE and GYE stay in high resiliency and the SE retains moderate resiliency. Under the optimistic scenarios where conservation efforts increase under Scenarios 4 and 5, the BE and North Cascades improve from functionally extirpated conditions with no resiliency to low resiliency, which also represents an increase in redundancy and representation. To summarize changes in resiliency from current to future conditions, there is less risk from stochastic events if conservation efforts continue or improve, but there is greater risk from stochastic events if conservation efforts decrease (Table 23).

Table 23. Current and future resiliency for the six ecosystems for the grizzly bear in the lower-48 states.

CURRENT AND FUTURE RESILIENCY						
	Current Condition	***Future Scenario 1*** ↓↓ ***Conservation***	***Future Scenario 2*** ↓ ***Conservation***	***Future Scenario 3*** ***Continuation Conservation***	***Future Scenario 4*** ↑ ***Conservation***	***Future Scenario 5*** ↑↑ ***Conservation***
NCDE	High	Moderate	High	High	High	High
GYE	High	Moderate	High	High	High	High
CYE	Low	V Low	Low	Moderate	Moderate	High
SE	Moderate	V Low	Low	Moderate	Moderate	High
BE	X	X	X	X	Low	Low
North Cascades	X	X	X	X	Low	Low

Currently, redundancy for the grizzly bear is described as four ecosystems, the NCDE, GYE, CYE, and SE, as they are distributed from north to south and east to west across the lower-48 States. Catastrophic risk is spread across these four ecosystems and their ecological diversity contributes to representation. Two ecosystems, the BE and North Cascades have no populations, are not resilient, so do not currently contribute to redundancy or representation. In 30 to 45 years, redundancy is maintained across the future scenarios and never falls below the four, currently resilient ecosystems as they are distributed. Although redundancy stays the same from now to the future, if conservation efforts decrease, as under Scenarios 1 and 2, resiliency decreases, and the four ecosystems are at greater risk to stochastic events. But if conservation efforts increase, as under Scenarios 4 and 5, resiliency in the BE and North Cascades improves, as does redundancy, as the number and distribution of ecosystems increases from four to six ecosystems. This improvement in redundancy reduces risk to the grizzly bear from catastrophic events (Table 24 and Figure 36). To summarize redundancy across the future scenarios, catastrophic risk to the grizzly bear stays the same if conservation efforts continue at their current rate and effectiveness, but catastrophic risk decreases with increased conservation as the BE and North Cascades improve to low resiliency. Representation stays the same with a continuation and decreases in conservation efforts, but ecological diversity increases if conservation efforts increase with resilient BE and North Cascades ecosystems.

Our SSA characterizes the viability for the grizzly bear in the lower-48 States, or its ability to sustain populations in the wild over time, based on the best scientific understanding of its current and future abundance, distribution, and diversity. Based on our assessment of the 3Rs, currently and 30 to 45 years into the future, viability for the grizzly bear in the lower-48 States improves slightly if conservation efforts continue at their current rate and levels of effectiveness. If conservation efforts declines, viability also decreases. If conservation efforts increase, viability improves.

Table 24. Summary of current and future viability in terms of resiliency, redundancy, and representation for the six ecosystems of grizzly bear in the lower-48 States.

VIABILITY: CURRENT AND FUTURE 3Rs						
	Current Condition	***Future Scenario 1*** ↓↓ ***Conservation***	***Future Scenario 2*** ↓ ***Conservation***	***Future Scenario 3*** ***Continuation Conservation***	***Future Scenario 4*** ↑ ***Conservation***	***Future Scenario 5*** ↑↑ ***Conservation***
Resiliency	2 High 1 Moderate 1 Low 2 Extirpated	2 Moderate 2 Very Low 2 Extirpated	2 High 2 Low 2 Extirpated	2 High 2 Moderate 2Extirpated	2 High 2 Moderate 2 Low	4 High 2 Low
Redundancy	4 ecosystems, as distributed	4 ecosystems, as distributed	4 ecosystems, as distributed	4 ecosystems, as distributed	6 ecosystems, as distributed	6 ecosystems, as distributed
Representation	Ecological diversity across 4 ecosystems	Ecological diversity across 4 ecosystems	Ecological diversity across 4 ecosystems	Ecological diversity across 4 ecosystems	Ecological diversity across 6 ecosystems	Ecological diversity across 6 ecosystems

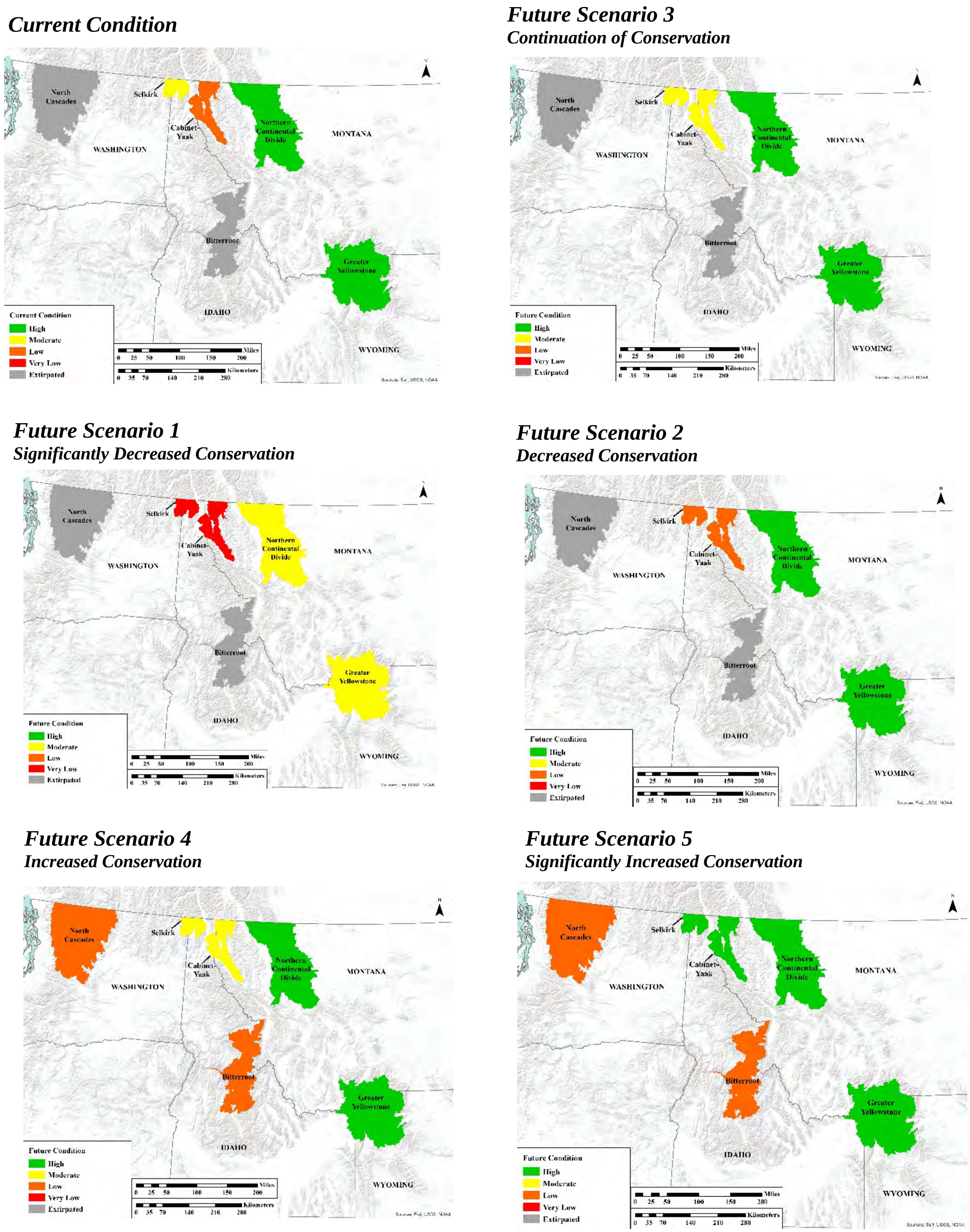

Figure 36. Current and future (30 to 45 years) conditions for resiliency, redundancy, and representation for grizzly bear in the lower-48 States.

Literature Cited

Ake, K. 2017. Background information on NCDE GBCS developed recreation increase of one overnight site per BMU per decade. Planning record exhibit 00671. Flathead National Forest.

Alaska Department of Fish and Game. 2020. Brown/grizzly bear hunting in Alaska: Life history. Available at: http://www.adfg.alaska.gov/index.cfm%3Fadfg=brownbearhunting.main. Accessed July 1, 2020.

Allen, L. R. 2011. A review of grizzly bear recurring use areas associated with the Selkirk and Cabinet-Yaak Ecosystems. USDA Forest Service, Idaho Panhandle National Forest.

Allendorf, F. W., R. B. Harris, and L. H. Metzgar. 1991. Estimation of effective population size of grizzly bears by computer simulation. Pages 650–654 in E.C. Dudley, editor. The unity of evolutionary biology: proceedings of the fourth international conference of systematic and evolutionary biology. Dioscorides Press, Portland, Oregon, USA.

Almack, J. A., W. L. Gaines, R. H. Naney, P. H. Morrison, J. R. Eby, G. F. Wooten, M. C. Snyder, S. H. Fitkin, and E. R. Garcia. 1993. North Cascades grizzly bear ecosystem evaluation. Final Report to the Interagency Grizzly Bear Committee.

American Association for the Advancement of Sciences. 2014. What We Know: The Reality, Risks and Response to Climate Change. The AAAS Climate Science Panel.

Anderson, C. R., Jr., M. A. Ternent, and D. S. Moody. 2002. Grizzly bear-cattle interactions on two grazing allotments in northwest Wyoming. Ursus 13:247–256.

Apps, C. D., B. N. McLellan, J. G. Woos, and M. F. Proctor. 2004. Estimating grizzly bear distribution and abundance relative to habitat and human influence. Journal of Wildlife Management 68:138–162.

Aune, K. and W. Kasworm. 1989. Final report East Front grizzly bear study. Montana Department of Fish, Wildlife, and Parks. 332 pages.

Ballard, W. B., L. N. Carbyn, and D. W. Smith. 2003. Wolf interactions with non-prey. Pages 259–271 *in* L. D. Mech and L. Boitani, editors. Wolves: ecology, behavior, and conservation. The University of Chicago Press, Chicago, Illinois, USA.

Barnes, V. G., Jr., and R. B. Smith. 1998. Estimates of brown bear abundance on Kodiak Island, Alaska. Ursus 10:1–9.

Bartlein, P. J., C. Whitlock, and S. L. Shafer. 1997. Future climate in the Yellowstone National Park region and its potential impact on vegetation. Conservation Biology 11:782–792.

Bentz, B. J., J. Regniere, C. J. Fettig, E. M. Hansen, J. L. Hayes, J. A. Hicke, R. G. Kelsey, J. F. Negron, and S. J. Seybold. 2010. Climate change and bark beetles in the western United States and Canada: direct and indirect effects. Bioscience 60:602–613.

Bjornlie, D. D., and M. A. Haroldson. 2019. Grizzly bear occupied range in the Greater Yellowstone Ecosystem, 1990-2018. Pages 25–28 *in* F. T. van Manen, M. A. Haroldson, and B. E. Karabensh, editors. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 2018. U.S. Geological Survey, Bozeman, Montana, USA.

Bjornlie, D. D., D. J. Thompson, M. A. Haroldson, C. C. Schwartz, K. A. Gunther, S. L. Cain, D. B. Tyers, K. L. Frey, and B. C. Aber. 2014*a*. Methods to estimate distribution and range extent of grizzly bears in the Greater Yellowstone Ecosystem. Wildlife Society Bulletin 38:182–187.

Bjornlie, D. D. F. T. van Manen, M. R. Ebinger, M. A. Haroldson, D. J. Thompson, and C. M. Costello. 2014*b*. Whitebark pine, population density, and home-range size of grizzly bears in the Greater Yellowstone Ecosystem. PLOS ONE 9:1–8.

Blackfeet Nation. 2008. Blackfeet Reservation forest management plan, 2009–2023. Browning, Montana, USA.

Blackfeet Tribal Business Council. 2013. Bear management plan and guidelines for bear management on the Blackfeet Indian Reservation.

Blackfeet Tribal Business Council. 2018. Blackfeet Nation fish and wildlife code: Fish and game rules to govern fishing, hunting and trapping on the Blackfeet Indian Reservation.

Blanchard, B. M. 1978. Grizzly bear distribution in relation to habitat areas and recreational use: Cabin Creek – Hilgard Mountains. M.S. Thesis, Montana State University, Bozeman, Montana, USA.

Blanchard, B. M., and R. R. Knight. 1990. Reactions of grizzly bears, *Ursus arctos horribilis*, to wildlife in Yellowstone National Park, Wyoming. The Canadian Field Naturalist 104:592–594.

Blanchard, B. M., and R. R. Knight. 1991. Movements of Yellowstone grizzly bears. Biological Conservation 58:41–67.

Blanchard, B. M., and R. R. Knight. 1996. Effects of wildfire on grizzly bear movements and food habits. Ecological Implications of Fire in Greater Yellowstone: Proceedings of the second biennial Conference on the Greater Yellowstone Ecosystem, September 19-21, 1993, Yellowstone National Park, Wyoming. International Association of Wildland Fire.

Boulanger, J., M. Cattet, S. E. Nielsen, G. Stenhouse, and J. Cranstone. 2013. Use of multi-state models to explore relationships between changes in body condition, habitat and survival of grizzly bears *Ursus arctos horribilis*. Wildlife Biology 19:274–288.

Boulanger, J., and G. B. Stenhouse. 2014. The impact of roads on the demography of grizzly bears in Alberta. PLoS One 9:e115535. DOI: 10.1371/journal.one.0115535.

Boyce, M. S. 1995. Population viability for grizzly bears (*Ursus arctos horribilis*): A critical review. A report to the Interagency Grizzly Bear Committee Funded by the National Fish and Wildlife Foundation and the U.S. Fish and Wildlife Service.

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.

Bureau of Land Management. 1986. Record of decision for the Garnet resource management plan and the environmental impact statement. Butte District, Montana, USA.

Bureau of Land Management. 2019a. Draft resource management plan and environmental impact statement. Missoula Field Office, Missoula, Montana, USA.

Bureau of Land Management. 2019b. Draft Lewistown resource management plan. Lewistown, Montana, USA.

Burgman, M. A., S. Ferson, and H. R. Akcakaya. 1993. Risk assessment in conservation biology. Chapman and Hall, London, England.

Burroughs, R. D. 1961. Bears and raccoons. Pages 52–69 *in* The natural history of the Lewis and Clark expedition. Michigan State University Press, Lansing, Michigan, USA.

Burton, R. L., K. J. Starks, and D. C. Peters. 1980. The Army Cutworm. Bulletin B-749. Agricultural Experiment Station, Division of Agriculture, Oklahoma State University, Stillwater, Oklahoma, USA. 35 pp.

Canepa, S., K. Annis, and W. Kasworm. 2008. Public opinion and knowledge survey of grizzly bears in the Cabinet-Yaak Ecosystem. Cabinet-Yaak and Selkirk Mountains Subcommittee of the Interagency Grizzly bear Committee, Missoula, Montana, USA.

Carroll, C., J. A. Vucetich, M. P. Nelson, D. J. Rohlf, and M. K. Philips. 2010. Geography and recovery under the U.S. Endangered Species Act. Conservation Biology 24:395–403.

Cayan, D. R., S. A. Kammerdiener, M. D. Dettinger, J. M. Caprio, and D. H. Peterson. 2001. Changes in the onset of spring in the western United States. Bulletin of the American Meteorological Society 82:399–415.

Chao, A. 1989. Estimating population size for sparse data in capture-recapture experiments. Biometrics 45:427–438.

Chapman, J. A., J. I. Romer, and J. Stark. 1955. Ladybird beetles and army cutworm adults as food for grizzly bears in Montana. Ecology 36: 156–158.

Chapman, S. S., S. A. Bryce, J. M. Omernik, D. G. Despain, J. ZumBerge, and M. Conrad. 2004. Ecoregions of Wyoming (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,400,000). Available at http://www.epa.gov/wed/pages/ecoregions/wy_eco.htm

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 numbers of females with cubs-of-the-year in the Yellowstone grizzly bear population. Journal of Agriculture, Biological, and Environmental Statistics 12: 1–21.

Christensen, A. G., and M. J. Madel. 1982. Cumulative effects analysis process: grizzly habitat component mapping. Kootenai National Forest.

Clevenger, A. P., and N. Waltho. 2005. Performance indices to identify attributes of highway crossing structures facilitating movement of large mammals. Biological Conservation 121:453–464.

Colinvaux, P. 1986. Ecology. John Wiley and Sons, Inc. New York, New York, USA.

Confederated Salish and Kootenai Tribes (CS&KT). 1997. Mission mountains tribal wilderness management plan.

Confederated Salish and Kootenai Tribes (CS&KT). 2000. Flathead Indian Reservation forest management plan. Pablo, Montana, USA.

Confederated Salish and Kootenai Tribes (CS&KT). 2018. Hunting, fishing, and recreation regulations for members of the Confederated Salish and Kootenai Tribes, 2018–2019 season. Polson, Montana, USA.

Cooley, C., M. Haroldson, and C. Costello. 2018. Grizzly Bear Mortality Overview. Presentation to the Interagency Grizzly Bear Committee.

Costello, C. M. 2017. Summary of data for USFWS Grizzly Bear Recovery Plan criteria for the NCDE grizzly bear. Montana Fish, Wildlife & Parks, unpublished data.

Costello, C. M., and L. Roberts. 2016. Northern Continental Divide Ecosystem grizzly bear population monitoring annual report – 2015. Montana Fish, Wildlife & Parks, Kalispell, Montana, USA.

Costello, C. M., and L. Roberts. 2017. Northern Continental Divide Ecosystem grizzly bear population monitoring annual report – 2016. Montana Fish, Wildlife & Parks, Kalispell, Montana, USA.

Costello, C. M., and L. Roberts. 2018. Northern Continental Divide Ecosystem grizzly bear population monitoring annual report – 2017. Montana Fish, Wildlife & Parks, Kalispell, Montana, USA.

Costello, C. M., and L. Roberts. 2019. Northern Continental Divide Ecosystem grizzly bear population monitoring annual report, 2018. Montana Fish, Wildlife & Parks, Kalispell, Montana, USA.

Costello, C. M., and L. Roberts. 2020. Northern Continental Divide Ecosystem grizzly bear population monitoring annual report, 2019. Montana Fish, Wildlife & Parks, Kalispell, Montana, USA.

Costello, C. M., F. T. van Manen, M. A. Haroldson, M. R. Ebinger, S. L. Cain, K. A. Gunther, and D. D. Bjornlie. 2014. Influence of whitebark pine decline on fall habitat use and movements of grizzly bears in the Greater Yellowstone Ecosystem. Ecology and Evolution 4:2004–2018.

Costello, C. M., R. D. Mace, and L. Roberts. 2016. Grizzly bear demographics in the Northern Continental Divide Ecosystem, 2004–2014: Research results & techniques for management of mortality. Montana Fish, Wildlife and Parks, Helena, Montana, USA.

COSEWIC. 2012. COSEWIC assessment and status report on the grizzly bear *Ursus arctos* western population in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Canada.

Cowan, I. M., D. G. Chapman, R. S. Hoffmann, D. R. McCullough, G. A. Swanson, and R. B. Weeden. 1974. Report of the Committee on the Yellowstone grizzlies. National Academy of Sciences Report.

Craighead, F. C., Jr. and J. J. Craighead. 1972. Grizzly bear prehibernation and denning activities as determined by radiotracking. Wildlife Monographs 32:1–35.

Craighead, F. L., D. Paetkau, H. V. Reynolds, C. Strobeck, and E. R. Vyse. 1998. Use of microsatellite DNA analyses to infer breeding behavior and demographic processes in an arctic grizzly bear population. Ursus 10:323–327.

Craighead, J. J. 1980. A proposed delineation of critical grizzly bear habitat in the Yellowstone region. A monograph presented at the Fourth International Conference on Bear Research and Management, Kalispell, Montana, USA. Monograph Series Number 1.

Craighead, J. J. and J. A. Mitchell. 1982. Grizzly bear. Pages 515–556 *in* Wild mammals of North America: biology, management, and economics. The Johns Hopkins University Press, Baltimore, Maryland, USA.

Craighead, J.J., J. R. Varney, and F. C. Craighead Jr. 1974. A population analysis of the Yellowstone grizzly bears. Bulletin 40, Montana Forest and Conservation Experiment Station, University of Montana, Missoula, Montana, USA.

Craighead, J. J., K. R. Greer, R. R. Knight, and H. Ihsle Pac. 1988. Grizzly bear mortalities in the Yellowstone ecosystem, 1959–1987. Montana Fish, Wildlife, and Parks, Helena, Montana, USA. 103 pp.

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.

Cronin, M. A., and M. D. MacNeil. 2012. Genetic relationships of extant brown bears (*Ursus arctos*) and polar bears (*Ursus maritimus*). Journal of Heredity 103:873–881.

Dean, F. C., L. M. Darling, and A. G. Lierhaus. 1986. Observations of intraspecific killing by brown bears, Ursus arctos. Canadian field naturalist 100:208–211.

DeBolt, B., Z. Turnbull, L. Ellsbury, M. Boyce, S. Stephens, D. Lasseter, P. Quick, Z. Gregory, and D. J. Thompson. 2018. Human-grizzly bear conflicts in Wyoming. Pages 84–89 *in* F. T. van Manen, M. A. Haroldson, and B. E. Karabensh, editors. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 2017. U.S. Geological Survey, Bozeman, Montanan, USA.

Dixon, J. D., M. K. Oli, M. C. Wooten, T. H. Eason, J. W. McCown, and D. Paetkau. 2006. Effectiveness of a regional corridor in connecting two Florida black bear populations. Conservation Biology 20:155–162.

Dood, A. R., R. D. Brannon, and R. D. Mace. 1986. Management of grizzly bears in the Northern Continental Divide Ecosystem, Montana. Transcripts of the 51st North American Wildlife & Natural Resources Conference:162–177.

Dood, A. R., S. J. Atkinson, and V. J. Boccadori. 2006. Grizzly bear management plan for western Montana. Montana Fish, Wildlife & Parks, Bozeman, Montana, USA.

Duda, M. D., K. C. Young, T. E. Graham, R. S. Sipes, and S. J. Bissel. 1996. Washington residents’ opinions on grizzlybear recovery in the North Cascades Mountains. Responsive Management, Harrisonburg, Virginia, USA.

Duffy, P. B., R. W. Arritt, J. Coquard, W. Gutowski, J. Han, J. Iorio, J. Kim, L.-R. Leung, J. Roads, and E. Zeledon. 2006. Simulations of present and future climates in the western United States with four nested regional climate models. Journal of Climate 19:873–895.

Earthquake Tracker. 2020. Available at: https://earthquake.usgs.gov/earthquakes/. Accessed July 6, 2020.

Eastern Shoshone and Northern Arapaho Tribes. 2009. Grizzly bear management plan for the Wind River Reservation. Shoshone and Arapaho Tribal Fish and Game Department. Ethete, Wyoming, USA.

Eberhardt, L. L. 1977. Optimal policies for conservation of large mammals, with special reference to marine ecosystems. Environmental Conservation 4:205–212.

Eberhardt, L. L. 2002. A paradigm for population analysis of long-lived vertebrates. Ecology 83:2841–2854.

Eberhardt, L. L. and S. Cherry. 2000. Demography of the Yellowstone grizzly bears: Comment. Ecology 81:3256–3259.

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 72:360–63.

Ebinger, M. R., M. A. Haroldson, F. T. van Manen, C. M. Costello, D. D. Bjornlie, D. T. Thompson, K. A. Gunther, J. K. Fortin, J. E. Teisberg, S. R. Pils, P. J. White, S. L. Cain, P. Cross. 2016. Detecting grizzly bear use of ungulate carcasses using global positioning system telemetry and activity data. Oecologia 181: 695–708.

Edwards, M. A., A. E. Derocher, K. A. Hobson, M. Branigan, and J. A. Nagy. 2011. Fast carnivores and slow herbivores: differential foraging strategies among grizzly bears in the Canadian Arctic. Oecologia 165:877–889.

Elsner, M. M., L. Cuo, N. Voisin, J. S., Deems, A. F. Hamlet, J. A. Vano, K. E. B. Mickelson, S. Y. Lee, and D. P. Lettenmaier. 2010. Implications of 21st century climate change for the hydrology of Washington State. Climate Change 102:225–260.

Fagre, D. B., D. L. Peterson, and A. E. Hessl. 2003. Taking the pulse of mountains: Ecosystem responses to climatic variability. Climatic Change 59:263–282.

Felicetti, L. A., C. C. Schwartz, R. O. Rye, M. A. Haroldson, K. A. Gunther, D. L. Phillips, and C. T. Robbins. 2003. Use of sulfur and nitrogen stable isotopes to determine the importance of whitebark pine nuts to Yellowstone grizzly bears. Canadian Journal of Zoology 81:763–770.

Felicetti, L. A., C. C. Schwartz, R. O. Rye, K. A. Gunther, J. G. Crock, M. A. Haroldson, L. Waits, C. T. Robbins. 2004. Use of naturally occurring mercury to determine the importance of cutthroat trout to Yellowstone grizzly bears. Canadian Journal of Zoology 82:493–501.

Fiedler, C. E., and S. T. McKinney. 2014. Forest structure, health, and mortality in two rocky mountain whitebark pine ecosystems: implications for restoration. Natural Areas Journal 34:290–299.

Folk, G. E., Jr., A. Larson, and M. A. Folk. 1974. Physiology of hibernating bears. Ursus 3:373–380.

Forman, R. T. T., and L. E. Alexander. 1998. Roads and their major ecological effects. Annual Review of Ecology and Systematics 29:207–231.

Fortin, J. K., C. C. Schwartz, K. A. Gunther, J. E. Teisberg, M. A. Haroldson, M. A. Evans, and C. T. Robbins. 2013. Dietary adjustability of grizzly bears and American black bears in Yellowstone National Park. Journal of Wildlife Management 77:270–281.

Fortin, J. K., K. D. Rode, G. V. Hilderbrand, J. Wilder, S. Farley, C. Jorgensen, and B. G. Marcot. 2016. Impacts of human recreation on brown bears (*Ursus arctos*): A review and new management tool. PLoS One 11:e0141983. Doi:10.1371/journal.pone.0141983.

Frankham, R. 1995. Effective population size/adult population size ratios in wildlife: a review. Genetic Research, Cambridge 66:95–107.

Frankham, R., C. J. Bradshaw, and B. W. Brook. 2014. Genetics in conservation management: revised recommendations for the 50/500 rules, Red List criteria and population viability analyses. Biological Conservation 170:56–63.

Franklin, I. R. 1980. Evolutionary change in small populations. Pages 135-140 *in* Conservation Biology: An evolutionary-ecological Perspective. M. E. Soule' and B. A. Wilcox, Eds. Sinauer Associates, Sunderland.

Franklin, I. R., F. W. Allendorf, and I. G. Jamieson. 2014. The 50/500 rule is still valid – Rely to Frankham et al. Biological Conservation 176:284–285.

French, S. P., M. G. French, and R. R. Knight. 1994. Grizzly bear use of army cutworm moths in the Yellowstone ecosystem. Ursus 9:389–399.

Frey, K. L., and J. Smith. 2018. Human-grizzly bear conflicts in Montana. Pages 78–83 *in* F. T. van Manen, M. A. Haroldson, and B. E. Karabensh, editors. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 2017. U.S. Geological Survey, Bozeman, Montanan, USA.

Gaines, W. L., R. H. Naney, P. H. Morrison, J. R. Eby, G. F. Wooten, and J. A. Almack. 1994. Ursus 9:533–547.

Gilbert, K. J., and M. C. Whitlock. 2015. Evaluating methods for estimating local effective population size with and without migration. Evolution 69:2154–5166.

Glacier National Park. 1999. General Management Plan. Flathead and Glacier Counties, Montana, USA.

Glacier National Park. 2019. Superintendent's Compendium. West Glacier, Montana, USA.

Glick, P., B. A. Stein, and N.A. Edelson, editors. 2011. Scanning the conservation horizon: a guide to climate change vulnerability assessment. National Wildlife Federation; Washington, DC.

Goeking, S. A., and D. K. Izlar. 2018. *Pinus albicaulis* Engelm. (whitebark pine) in mixed-species stands throughout its US range: broad-scale indicators of extent and recent decline. Forests 9:doi:10.3390/f9030131.

Grand Teton National Park and John D. Rockefeller, Jr. Memorial Parkway. 2019. 2019 Superintendent's Compendium.

Graves, T., and V. Reams, editors. 2001. Record of the snowmobile effects on wildlife: Monitoring protocols workshop. April 10–12, 2001, Denver, CO, USA.

Greater Yellowstone Area Grizzly Bear Habitat Modeling Team. 2018. Appendix A: 2017 Grizzly bear habitat monitoring report. Pages 108–127 *in* F. T. van Manen, M. A. Haroldson, and B. E. Karabensh, editors. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 2017. U.S. Geological Survey, Bozeman, Montanan, USA.

Gunther, K. A. 1994. Bear management in Yellowstone National Park, 1960-93. Pages 549–560 *in* Bears: their biology and management. Proceedings of the 9th international conference on bear research and management, Missoula, Montana USA.

Gunther, K. A. 2018. Yellowstone National Park Recreational Use. Pages 66–68 *in* F. T. van Manen, M. A. Haroldson, and B. E. Karabensh, editors. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 2017. U.S. Geological Survey, Bozeman, Montanan, USA.

Gunther, K. A. and D. W. Smith. 2004. Interactions between wolves and female grizzly bears with cubs in Yellowstone National Park. Ursus 15:232–238.

Gunther, K. A., M. A. Haroldson, K. Frey, S. L. Cain, J. Copeland, and C. C. Schwartz. 2004. Grizzly bear-human conflicts in the Greater Yellowstone ecosystem, 1992–2000. Ursus 15:10–22.

Gunther, K. A., R. R. Shoemaker, K. L. Frey, M. A. Haroldson, S. L. Cain, F. T. van Manen, and J. K. Fortin. 2014. Dietary breadth of grizzly bears in the Greater Yellowstone Ecosystem. Ursus 25:60–72.

Gunther, K. A., T. C. Wyman, and E. Reinertson. 2018a. Human-grizzly bear conflicts in Yellowstone National Park. Pages 70–74 *in* F. T. van Manen, M. A. Haroldson, and B. E. Karabensh, editors. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 2017. U.S. Geological Survey, Bozeman, Montanan, USA.

Gunther, K. A., T. C. Wyman, and E. Reinertson. 2018b. Human-grizzly bear interactions in Yellowstone National Park. Pages 91–96 *in* F. T. van Manen, M. A. Haroldson, and B. E. Karabensh, editors. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 2017. U.S. Geological Survey, Bozeman, Montanan, USA.

Gunther, K. A., E. Reinertson, and T. C. Wyman. 2018c. Visitor compliance with bear spray and hiking group size bear safety recommendations in Yellowstone National Park. Pages 97–102 *in* F. T. van Manen, M. A. Haroldson, and B. E. Karabensh, editors. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 2017. U.S. Geological Survey, Bozeman, Montanan, USA.

Hall, E. R. 1984. Geographic variation among brown and grizzly bears (*Ursus arctos*) in North America. University of Kansas Museum of Natural History, Special Publication 13.

Hamer, D., and S. Herrero. 1987a. Grizzly bear food and habitat in the front ranges of Banff National Park, Alberta. Bears: Their Biology and Management 7:199–213.

Hamer, D., and S. Herrero. 1987b. Wildfire's influence on grizzly bear feeding ecology in Banff National Park, Alberta. Bears: Their Biology and Management 7:179–186.

Harding, L. and J. A. Nagy. 1980. Responses of grizzly bears to hydrocarbon exploration on Richards Island, Northwest Territories, Canada. Pages 277–280 *in* Bears: their Biology and Management. Proceedings of the 4th International Conference on Bear Research and Management, Kalispell, Montana.

Haroldson, M. A. 2008. Assessing trend and estimating population size from counts of unduplicated females. Pages 9–14 *in* C. C. Schwartz, M. A. Haroldson, and K. West, editors. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 2007. U.S. Geological Survey, Bozeman, Montana, USA.

Haroldson, M. A. 2015. Whitebark pine cone production. Pages 46–47 *in* F. T. van Manen, M. A. Haroldson, and S. C. Soileau, editors. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 2014. U.S. Geological Survey, Bozeman, Montana, USA.

Haroldson, M. A., M. Clapham, C. C. Costello, K. A. Gunther, K. C. Kendall, S. D. Miller, K. E. Pigeon, M. E. Proctor, K. D. Rode, C. Servheen, G. B. Stenhouse, and F. T. van Manen. 2020a. Brown bear (*Ursus arcots*; North America). *In Press*. V. Penteriani and M. Melletti, editors. Bears of the World: Ecology, Conservation and Management. Cambridge University Press.

Haroldson, M. A., and K. Frey. 2009. Estimating sustainability of annual bear mortalities. Pages 20–25 *in* C. C. Schwartz, M. A. Haroldson, and K. West, editors. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 2008. U.S. Geological Survey, Bozeman, Montana, USA.

Haroldson, M. A., and K. Frey. 2013. Estimating sustainability of annual grizzly bear mortalities. Pages 27–31 *in* F. T. van Manen, M. A. Haroldson, and S. C. Soileau, editors. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 2013. U.S. Geological Survey, Bozeman, Montana, USA.

Haroldson, M. A., and K. Frey. 2020. Estimating number of females with cubs. Pages 28–34 *in* F. T. van Manen, M. A. Haroldson, and B. E. Karabensh, editors. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 2019. U.S. Geological Survey, Bozeman, Montana, USA

Haroldson, M. A., K. A. Gunther, D. P. Reinhart, S. R. Podruzny, C. Cegelski, L. Waits, T. Wyman, and J. Smith. 2005. Changing numbers of cutthroat trout in tributary streams of Yellowstone Lake and estimates of grizzly bears visiting streams from DNA. Ursus 16: 167–180.

Haroldson, M. A., B. E. Karabensh, and F. T. van Manen. 2020b. Estimating number of females with cubs. Pages 12–18 *in* F. T. van Manen, M. A. Haroldson, and B. E. Karabensh, editors. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 2019. U.S. Geological Survey, Bozeman, Montana, USA.

Haroldson, M. A., C. C. Schwartz, K. C. Kendall, K. A. Gunther, D. S. Moody, K. Frey, and D. Paetkau. 2010. Genetic analysis of individual origins supports isolation of grizzly bears in the Greater Yellowstone Ecosystem. Ursus 21:1–13.

Haroldson, M. A., M. A. Ternent, K. A. Gunther, and C. C. Schwartz. 2002. Grizzly bear denning chronology and movements in the Greater Yellowstone Ecosystem. Ursus 13:29–37.

Haroldson, M. A., F. T. van Manen, M. R. Ebinger, M. D. Higgs, D. L. Bjornlie, K. A. Gunther, K. L. Frey, S. L. Cain, B. C. Aber. In prep. Trends in causes and distribution, and effects of whitebark pine production on grizzly bear mortality in the Greater Yellowstone Ecosystem.

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 44–55 *in* C.C. Schwartz, M.A. Haroldson, G.C. White, R.B. Harris, S. Cherry, K.A. Keating, D. Moody, and C. Servheen, eds. 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, R. D. Mace, and M. A. Haroldson. 2011. Study design and sampling intensity for demographic analyses of bear populations. Ursus 22:24–36.

Healy, K., T. Guillerme, S. Finlay, A. Kane, S. B. A. Kelly, D. McLean, D. J. Kelly, I. Donohue, A. L. Jackson, and N. Cooper. 2014. Ecology and mode-of-life explain lifespan variation n birds and mammals. Proceedings of the Royal Society B 281:20140298. http://dx.doi.org/10.1098/rspb.2014.0298.

Hedrick, P. W. 1995. Gene flow and genetic restoration: The Florida panther as a case study. Conservation Biology 9:996–1007.

Hegg, S. J., K. Murphy, and D. Bjornlie. 2010. Grizzly bears and snowmobile use: a summary of monitoring a grizzly den on Togwotee Pass. Yellowstone Science 18:23–28.

Herrero, S. 1972. Aspects of evolution and adaptation in American black bears (*Ursus americanus* Pallas) and brown and grizzly bears (*U. arctos* Linné) of North America. Pages 221–231 *in* Bears: their biology and management. Proceedings of 2nd International Conference on Bear Research and Management, Calgary, Alberta, Canada.

Hessing, P. and L. Aumiller. 1994. Observations of conspecific predation by brown bears, Ursus arctos, in Alaska. Canadian Field Naturalist 108:332–336.

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 of Zoology 77:132–138.

Hnilicka, P. 2018. Human-grizzly bear conflicts on the Wind River Reservation. Page 90 *in* F. T. van Manen, M. A. Haroldson, and B. E. Karabensh, editors. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 2017. U.S. Geological Survey, Bozeman, Montanan, USA.

Holling, C. S. 1978. Adaptive environmental assessment and management. John Wiley and Sons, New York, New York, USA.

Hornocker, M. G. 1962. Population characteristics and social and reproductive behavior of the grizzly bear in Yellowstone National Park. M.S. thesis, Montana State University, Bozeman, Montana, USA.

Idaho Department of Fish and Game. 2011. Fish & Game launches online bear ID training. Press release.

Idaho Department of Fish and Game. 2020. Idaho big game 2020 seasons & rules.

Idaho Department of Lands (IDL) and Idaho Department of Fish and Game (IDFG). 2012. Road closure agreement: Priest Lake, Pend Oreille and Kootenai Valley areas. Memorandum of Agreement.

Idaho Fish and Game Commission. 2016. Proclamation of the Idaho Fish and Game Commission relating to the limit of the take of grizzly bear in the Greater Yellowstone Ecosystem. August 8, 2016.

Idaho's Yellowstone Grizzly Bear Delisting Advisory Team. 2002. State of Idaho Yellowstone grizzly bear management plan.

Interagency Grizzly Bear Committee. 1998. Taskforce Report: grizzly bear/motorized access management.

Interagency Grizzly Bear Study Team. 2005. Reassessing 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.

Interagency Grizzly Bear Study Team. 2006. Supplement to Reassessing sustainable mortality limits for the Greater Yellowstone Ecosystem grizzly bear. USGS, Northern Rocky Mountain Science Center, Montana State University, Bozeman, Montana, USA.

Interagency Grizzly Bear Study Team. 2009. Yellowstone mortality and conflicts reduction report. USGS, Northern Rocky Mountain Science Center, Bozeman, Montana, USA.

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. USGS, Northern Rocky Mountain Science Center, Bozeman, Montana, USA.

Interagency Grizzly Bear Study Team. 2013. Response of Yellowstone grizzly bears to changes in food resources: a synthesis. Report to the Interagency Grizzly Bear Committee and Yellowstone Ecosystem Subcommittee. Interagency Grizzly Bear Study Team, U.S. Geological Survey, Northern Rocky Mountain Science Center, Bozeman, Montana, USA.

Intergovernmental Panel on Climate Change (IPCC). 2013a. Annex III: Glossary [Planton, S. (ed.)]. *In*: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Intergovernmental Panel on Climate Change (IPCC). 2013b. Summary for Policymakers. *In*: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, New York, USA.

Intergovernmental Panel on Climate Change. 2014. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Summary for Policymakers. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. URL: *http://ipcc-wg2.gov/AR5/images/uploads/IPCC_WG2AR5_SPM_Approved.pdf*

Jacoby, M. E., G. V. Hilderbrand, C. Servheen, C. C. Schwartz, S. M. Arthur, T. A. Hanley, C. T. Robbins, and R. Michener. 1999. Trophic relations of brown and black bears in several western North American ecosystems. Journal of Wildlife Management 63: 921–292.

Jamieson, I. G., and F. W. Allendorf. 2012. How does the 50/500 rule apply to MVPs? Trens in Ecology and Evolution 27:578–584.

Johnson, C. J., M. S. Boyce, C. C. Schwartz, and M. A. Haroldson. 2004. Modeling survival: application of the Andersen-Gill model to Yellowstone grizzly bears. Journal of Wildlife Management 68:966–978.

Jonkel, C. 1980. Grizzly bears and livestock. Western Wildlands 6:11–14.

Jonkel, C. J., and I. M. Cowan. 1971. The black bear in the spruce-fir forest. Wildlife Monographs 27.

Jope, K. L. 1985. Implications of grizzly bear habituation to hikers. Wildlife Society Bulletin 13:32–37.

Joyce, L. A., M. Talbert, D. Sharp, and J. Stevenson. 2018. Historical and projected climate in the Northern Rockies Region. Pages 17–22 *in* J. E. Halofsky and D. L. Peterson, editors. Climate Change and Rocky Mountain Ecosystems.

Jerina, K., and M. Adamič. 2008. Fifty years of brown bear population expansion: effects of sex-biased dispersal o rate of expansion and population structure. Journal of Mammalogy 89:1491–1501.

Judd, S. L., R. R. Knight, and B. M. Blanchard. 1986. Denning of grizzly bears in the Yellowstone National Park area. Pages 111–117 *in* Bears: their biology and management. Proceedings of the 6th International Conference on Bear Research and Management, Grand Canyon, Arizona, USA.

Juliusson, L, and J. Fortin-Noreus. 2020. Grizzly bear secure core/habitat analysis for the San Juan and Sierra Nevada Mountains' historical range. U.S. Fish and Wildlife Service, Lakewood, Colorado, USA.

Kamath, P.L., M.A. Haroldson, G. Luikart, D. Paetkau, C. Whitman, and F.T. van Manen. 2015. Multiple estimates of effective population size for monitoring a long-lived vertebrate: an application of Yellowstone grizzly bears. Molecular Ecology 24:5507–5521.

Kasworm, W. F., and T. L. Manley. 1988. Grizzly bear and black bear ecology in the Cabinet Mountains of northwest Montana. Montana Fish, Wildlife and Parks.

Kasworm, W. F., and T. L. Manley. 1990. Road and trail influences on grizzly bears and black bears in northwest Montana. International Conference on Bear Research and Management 8:79–84.

Kasworm, W. F., T. G. Radandt, J. E. Teisberg, M. Proctor, and C. Servheen. 2013. Cabinet-Yaak grizzly bear recovery area 2012 research and monitoring progress report. U.S. Fish and Wildlife Service, Missoula, Montana, USA.

Kasworm, W. F., T. G. Radandt, J. E. Teisberg, A. Welander, M. Proctor, and H. Cooley. 2020a. Cabinet-Yaak grizzly bear recovery area 2019 research and monitoring progress report. U.S. Fish and Wildlife Service, Missoula, Montana, USA.

Kasworm, W. F., T. G. Radandt, J. E. Teisberg, A. Welander, M. Proctor, and H. Cooley. 2020b. Selkirk Mountains grizzly bear recovery area 2019 research and monitoring progress report. U.S. Fish and Wildlife Service, Missoula, Montana, USA.

Kasworm, W. F, and T. J. Their. 1993. Cabinet-Yaak Ecosystem grizzly bear and black bear research 1992 progress report. U.S. Fish and Wildlife Service, Missoula, Montana, USA.

Kasworm, W. F, and T. J. Their. 1994. Cabinet-Yaak Ecosystem grizzly bear and black bear research 1993 progress report. U.S. Fish and Wildlife Service, Missoula, 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.

Kellert, S. R. 1994. Public attitudes toward bears and their conservation. Pages 43–50 *in* Bears: their biology and management. Proceedings of the 9th international conference on bear research and management, Missoula, Montana USA.

Kellert, S. R., M. Black, C. R. Rush, and A. J. Bath. 1996. Human culture and large carnivore conservation in North America. Conservation Biology 10:977–990.

Kendall, K. C. 1986. Grizzly and black bear feeding ecology in Glacier National Park, Montana. Progress Report. Science Center, Glacier National Park, West Glacier, Montana, USA.

Kendall, K. C., and R. E. Keane. 2001. Whitebark pine decline: infection, mortality, and population trends. Pages 221–242 *in* Tomback, D. F., S. F. Arno, and R. E. Keane, editors. Whitebark pine communities: ecology and restoration, Island Press, Washington D.C., USA.

Kendall, K. C., and S. F. Arno. 1990. Whitebark pine—an important but endangered wildlife resource. Pages 264–273 *in* W. C. Schmidt and K. J. McDonald, compilers. Proceedings—Symposium on whitebark pine ecosystems: ecology and management of a high-mountain resource. Bozeman, Montana, USA.

Kendall, K. C., A. C. Macleod, K. L. Boyd, J. Boulanger, J. A. Royle, K. F. Kasworm, D. Paetkau, M. F. Proctor, K. Annis, and T. A. Graves. 2016. Density, distribution, and genetic structure of grizzly bears in the Cabinet-Yaak Ecosystem. Journal of Wildlife Management 80:314–331.

Kendall, K. C., J. B. Stetz, J. Boulanger, A. C. Macleod, D. Paetkau, and G. C. White. 2009. Demography and genetic structure of a recovering grizzly bear population. Journal of Wildlife Management 73:3–17.

Kendall, K. C., J. B. Stetz, D. A. Roon, L. P. Waits, J. B. Boulanger, and D. Paetkau. 2008. Grizzly bear density in Glacier National Park, Montana. Journal of Wildlife Management 72:1693–1705.

Kerns, B. K., S. J. Alexander, and J. D. Bailey. 2004. Huckleberry abundance, stand conditions, and use in western Oregon: evaluating the role of forest management. Economic Botany 58: 668–678.

Knight, R. R. 1980. Biological considerations in the delineation of critical habitat. Pages 1–3 *in* Bears: their biology and management. Proceedings of the 4th international conference on bear research and management, Kalispell, Montana USA.

Knight, R. R. and B. M. Blanchard. 1995. Yellowstone grizzly bear investigations: Annual report of the Interagency Grizzly Bear Study Team, 1994. National Biological Service, Bozeman, Montana, USA.

Knight, R. R. and L. L. Eberhardt. 1985. Population dynamics of Yellowstone grizzly bears. Ecology 66:323–334.

Knight, R. R. and S. L. Judd. 1983. Grizzly bears that kill livestock. Pages 186–190 *in* Bears: their biology and management. Proceedings of the 4th international conference on bear research and management, Kalispell, Montana.

Knight, R. R., B. M. Blanchard, and L. L. Eberhardt. 1988. Mortality patterns and populations 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., B. M. Blanchard, and P. Schullery. 1999. Yellowstone bears. Pages 50–75 *in* T.W. Clark, A.P. Curlee, S.C. Minta, and P.M. Kareiva, editors. Carnivores in ecosystems: The Yellowstone experience. Yale University Press, New Haven, Connecticut, USA.

Koel, T. M., P. E. Bigelow, P. D. Doepke, B. D. Ertel, and D. L. Mahoney. 2005. Nonnative lake trout result in Yellowstone cutthroat trout decline and impacts to bears and anglers. Fisheries 30:10–19.

Koford, C. B. 1969. The last of the Mexican grizzly bear. IUCN Bulletin 2:95.

Krebs, C. J. 2009. Ecology—the experimental analysis of distribution and abundance. Benjamin Cummings, San Francisco, California, USA.

Lamb, C. T., G. Mowat, A. Reid, L. Smit, M. Proctor, B. N. McLellan, S. E. Nielsen, and S. Boutin. 2017. Effects of habitat quality and access management on the density of a recovering grizzly bear population. Journal of Applied Ecology 55:1406–1417.

Lande, R. 1988. Genetics and demography in biological conservation. Science 241:1455–1460.

Layser, E. F. 1978. Grizzly bears in the southern Selkirk Mountains. Northwest Science 52:77–91.

LeFranc, M. N. Jr., M. B. Moss, K. A. Patnode, and W. C. Sugg III, editors. 1987. Grizzly bear compendium. The National Wildlife Federation, Washington, D.C., USA.

Leopold, A. S. 1967. Grizzlies of the Sierra del Nido. Pacific Discovery 20:30–32.

Leung, L. R., Y. Qian, X. Bian, W. M. Washington, J. Han, and J. O. Roads. 2004. Mid-century ensemble regional climate change scenarios for the western United States. Climatic Change 62:75–113.

Lewis, J. C. 2019. Periodic status review for the grizzly bear. Washington Department of Fish and Wildlife, State of Washington, USA.

Lindenmayer, D. B., and J. Fischer. 2006. Habitat Fragmentation and Landscape Changes: An Ecological and Conservation Synthesis. Island Press, Washington, USA.

Linnell, J. D. C., J. E. Swenson, R. Andersen, and B. Barnes. 2000. How vulnerable are denning bears to disturbance? Wildlife Society Bulletin 28:400–413.

Linnell, J. D. C., J. E. Swenson, R. Andersen. 2001. Predators and people: conservation of large carnivores is possible at high human densities if management policy is favourable. Animal Conservation 4:345–349.

Littell, J. S., M. M. Elsner, G. Mauger, E. Lutz, A. F. Hamlet, and E. Salathé. 2011. Regional climate and hydrologic change in the northern U.S. Rockies and Pacific Northwest: Internally consistent projections of future climate for resource management. Climate Impacts Group, University of Washington, College of the Environment, Seattle, Washington, USA.

Littell, J. S., E. E. Oneil, and D. McKenzie. 2010. Forest ecosystems, disturbance, and climatic change in Washington State, USA. Climatic Change 102:129–158.

Littell, J. S., and C. L. Raymond. 2014. Climate and climate change in the North Cascades Range. Pages 25–44 *in* C. L. Raymond, D. L. Peterson, and R. M. Rochefort, editors. General Technical Report PNW-GTR-892. USDA Forest Service, Portland, Oregon, USA.

Lowenstern, J. B., R. L. Christiansen, R. B. Smith, L. A. Morgan, and H. Heasler. 2005. Steam explosions, earthquakes, and volcanic eruptions – what's in Yellowstone's future? U.S. Geological Survey Fact Sheet 2005-3024.

Lyons, A. L., W. L. Gaines, P. H. Singleton, W. F. Kasworm, M. F. Proctor, and J. Begley. 2018. Spatially explicit carrying capacity estimates to inform species specific recovery objectives: grizzly bear (*Ursus arctos*) recovery in the North Cascades. Biological Conservation 222:21–32.

Mace, R. D., and C. J. Jonkel. 1986. Local food habits of the grizzly bear in Montana. Pages 105–110 *in* Bears: their biology and management. Proceedings of the 6th international conference on bear research and management, Grand Canyon, Arizona, USA.

Mace, R. D., and J.S. Waller. 1996. Grizzly bear distribution and human conflicts in Jewel Basin Hiking Area, Swan Mountains, Montana. Wildlife Society Bulletin 24:461–467.

Mace, R. D., and J.S. Waller. 1997a. Final Report: grizzly bear ecology in the Swan Mountains, Montana. Montana Fish, Wildlife & Parks, Helena, Montana, USA.

Mace, R. D., and J.S. Waller. 1997b. Spatial and temporal interaction of male and female grizzly bears in northwestern Montana. Journal of Wildlife Management 61:39–52.

Mace, R. D., and L. L. Roberts. 2011. Northern Continental Divide Ecosystem grizzly bear population monitoring annual report – 2009 and 2010. Montana Fish, Wildlife & Parks, Kalispell, Montana, USA.

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 33:1395–1404.

Mace, R. D., D. W. Carney, T. Chilton-Radandt, S. A. Courville, M. A. Haroldson, R. B. Harris, J. Jonkel, B. McLellan, M. Madel, T. L. Manley, C. C. Schwartz, C. Servheen, G. Stenhouse, 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.

Marsilio, F. P-G Tiscar, L. Gentile, H. U. Roth, G. Boscagli, M. Tempsesta, and A. Gatti. 1997. Serologic survey for selected viral pathogens in brown bears from Italy. Journal of Wildlife Diseases 33:304–307.

Martinka, C. J., and K. C. Kendall. 1986. Grizzly bear habitat research in Glacier National Park, Montana. USDA Forest Service General Technical Report Proceedings: Grizzly Bear Habitat Symposium. Missoula, Montana, USA.

Mattson, D. J. 1990. Human impacts on bear habitat use. Pages 33–56 *in* Bears: their biology and management. Proceedings of the 8th international conference on bear research and management, Victoria, British Columbia, Canada.

Mattson, D. J. 1997. Use of ungulates by Yellowstone grizzly bears *Ursus arctos*. Biological Conservation 81:161–177.

Mattson, D. J. and C. Jonkel. 1990. Stone pines and bears. Pages 223–236 *in* Proceedings—Symposium on whitebark pine ecosystems: Ecology and management of a high-mountain resource. General Technical Report INT 270 USDA Forest Service.

Mattson, D. J. and R. R. Knight. 1991. Effects of access on human-caused mortality of Yellowstone grizzly bears. Interagency Grizzly Bear Study Team Report, Bozeman, Montana, USA. 13 pages.

Mattson, D. J. and T. Merrill. 2002. Extirpations of grizzly bears in the contiguous United State, 1850–2000. Conservation Biology 16:1123–1136.

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. Pages 259–273 *in* Bears: their biology and management. Proceedings of the 7th International Conference on Bear Research and Management, Williamsburg, Virginia, USA.

Mattson, D. J., B. M. Blanchard, and R. R. Knight. 1991a. Food habits of Yellowstone grizzly bears, 1977–1987. Canadian Journal of Zoology 69:1619–1629.

Mattson, D. J., C. M. Gillin, S. A. Benson, and R. R. Knight. 1991b. Bear feeding activity at alpine insect aggregations in the Yellowstone ecosystem. Canadian Journal of Zoology 69:2430–2435.

Mattson, D. J., B. M. Blanchard, and R. R. Knight. 1992. Yellowstone grizzly bear mortality, human habituation, and whitebark pine seed crops. Journal of Wildlife Management 56:432–442.

Mattson, D. J., S. Herrero, R. G. Wright, and C. M. Pease. 1996. Science and management of Rocky Mountain grizzly bears. Conservation Biology 10:1013–1025.

McCullough, D. R. 1981. Population dynamics of the Yellowstone grizzly bear. Pages 173-196 in Fowler, C. W. and T. D. Smith, editors. Dynamics of large mammal populations, John Wiley and Sons, New York, New York, USA.

McGrath C. L., A. J. Woods, J. M. Omernik, S. A. Bryce, M. Edmondson, J. A. Nesser, J. Shelden, R. C. Crawford, J. A. Comstock, and M. D. Plocher. 2002. Ecoregions of Idaho (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,350,000). Available at http://www.epa.gov/wed/pages/ecoregions/id_eco.htm.

McLellan, B. N. 1989. Dynamics of a grizzly bear population during a period of industrial resource extraction, II: mortality rates and causes of death. Canadian Journal of Zoology 67:1861–1864.

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. Eighth international conference on bear research and management monograph series number 3.

McLellan, B. N. 2015. Some mechanisms underlying variation in vital rates of grizzly bears on a multiple use landscape. Journal of Wildlife Management 79:749–765.

McLellan, B. N., and F. W. Hovey. 1995. The diet of grizzly bears in the Flathead River drainage of southeastern British Columbia. Canadian Journal of Zoology 73:704–712.

McLellan, B. N., M. F. Proctor, D. Huber, and S. Michel (IUCN SSC Bear Specialist Group). 2016. Brown bear (*Ursus arctos*) isolated populations (supplementary material to *Ursus arctos* redlisting account). The IUCN Red List of Threatened Species 2016.

McLellan, B. N. and D. M. Shackleton. 1988. Grizzly bears and resource-extraction industries: effects of roads on behaviour, habitat use and demography. Journal of Applied Ecology 25:451–460.

McLellan, B. N. and D. M. Shackleton. 1989a. Immediate reactions of grizzly bears to human activities. Wildlife Society Bulletin 17:269–274.

McLellan, B. N. and D. M. Shackleton. 1989b. Grizzly bears and resource-extraction industries: habitat displacement in response to seismic exploration, timber harvesting and road maintenance. Journal of Applied Ecology 26:371–380.

McLellan, B. N., and F. W. Hovey. 2001. Natal dispersal of grizzly bears. Canadian Journal of Zoology 79:838–844.

McLellan, B. N., F. W. Hovey, R. D. Mace, J. G. Woods, D. W. Carney, M. L. Gibeau, W. L. Wakkinen, and W. F. Kasworm. 1999. Rates and causes of grizzly bear mortality in the interior mountains of British Columbia, Alberta, Montana, Washington, and Idaho. Journal of Wildlife Management 63:911–920.

McLoughlin, P. D., S. H. Ferguson, and F. Messier. 2000. Intraspecific variation in home range overlap with habitat quality: a comparison among brown bear populations. Evolutionary Ecology 14: 39–60.

McWethy, D. B., S. T. Gray, P. E. Higuera, J. S. Litell, G. T. Pederson, A. J. Ray, and C. Whitlock. 2010. Climate and terrestrial ecosystem change in the U.S. Rocky Mountains and Upper Columbia Basin: Historical and future perspectives for natural resource management. U.S. Department of the Interior, National Park Service Natural Resource Report NPS/GRYN/NRR–2010/260, Fort Collins, Colorado, USA.

Mealey, S.P. 1975. The natural food habits of free-ranging grizzly bears in Yellowstone National Park, 1973–1974. M. S. thesis, Montana State University, Bozeman, Montana, USA.

Mealey, S.P. 1980. The natural food habits of grizzly bears in Yellowstone National Park, 1973–1974. Bear: Their Biology and Management 4:281–292.

Melillo, J.M., T.C. Richmond, and G.W. Yohe, editors. 2014. Climate change impacts in the United States: he third national climate assessment. U.S. Global Change Research Program.

Merriam, C. H. 1922. Distribution of grizzly bears in U.S. Outdoor Life L:1–2.

Merrill, T., D. J. Mattson, R. G. Wright, and H. B. Quigley. 1999. Defining landscapes suitable for restoration of grizzly bears *Ursus arctos* in Idaho. Biological Conservation 87:231–248.

Mikle, N., T. A. Graves, R. Kovach, K. C. Kendall, and A. C.Macleod. 2016a. Demographic mechanisms underpinning genetic assimilation of remnant groups of a large carnivore. Proceedings of the Royal Society B 283:20161467.

Mikle, N., T. A. Graves, R. Kovach, K. C. Kendall, and A. C.Macleod. 2016b. Electronic Supplement: Demographic mechanisms underpinning genetic assimilation of remnant groups of a large carnivore. Proceedings of the Royal Society B 283:20161467.

Miller, C. R. and L. P. Waits. 2003. The history of effective population size and genetic diversity in the Yellowstone grizzly (*Ursus arctos*): Implications for conservation. Proceedings of the National Academy of Sciences 100:4334–4339.

Miller, S. D. 1990. Denning ecology of brown bears in southcentral Alaska and comparisons with a sympatric black bear population. International Conference on Bear Research and Management 8:279–287.

Mills, L. S. 1995. Edge effects and isolation: red-backed voles on forest remnants. Conservation Biology 9:395–403.

Mills, L. S., and F. W. Allendorf. 1996. The one-migrant-per-generation rule in conservation and management. Conservation Biology 10:1509–1518.

Ministry of Forests, Lands and Natural Resource Operations (MFLNRO). 2012. British Columbia grizzly bear population estimate for 2012.

Montana Department of Natural Resources and Conservation (DNRC). 2010a. Habitat Conservation Plan final EIS, Volume I. Missoula, Montana, USA.

Montana Department of Natural Resources and Conservation (DNRC). 2010b. Habitat Conservation Plan final EIS, Volume II. Missoula, Montana, USA.

Montana Department of Natural Resources and Conservation (DNRC). 2011. Record of Decision: Forested state trust lands final habitat conservation plan and environmental impact statement. Missoula, Montana, USA.

Montana Department of Transportion and Montana Fish, Wildlife and Parks (MFWP). 2020. Memorandum of agreement for coordination of wildlife and transportation issues between Montana Department of Transportaion and Montana Fish, Wildlife and Parks.

Montana Fish and Wildlife Commission Resolution. 2016. Passed July 13, 2016.

Montana Fish and Wildlife Commission. 2019. Fish and wildlife commission rules for public use of Montana's wildlife management areas, wildlife habitat protection areas, and fisheries conservation areas.

Montana Fish, Wildlife & Parks (MFWP). 2013. Grizzly bear management plan for southwestern Montana. MFWP, Helena, Montana, USA.

Montana Fish, Wildlife & Parks (MFWP). 2016. Grizzly Bear Montana hunting regulations.

Montana Fish, Wildlife & Parks (MFWP). 2018. Fish and wildlife commission rules for public use of Montana's wildlife management areas, wildlife habitat protection areas, and fisheries conservation areas.

Morehouse, A. T., T. A. Graves, N. Mikle, and M. S. Boyce. 2016. Nature vs. nurture: evidence for social learning of conflict behaviour in grizzly bears. PLoS ONE 11:e0165425. Doi:10.1371/journal.pone.0165425.

Morgan, C. P., J. Davis, T. Ford, and N. Laney. 2004. Promoting understanding: The approach of the North Cascades Grizzly Bear Outreach Project. Ursus 15:137–141.

Mote, P. W. 2003. Trends in temperature and precipitation in the Pacific Northwest during the Twentieth Century. Northwest Science 77:271–282.

Mowat, G., and D. C. Heard. 2006. Major components of grizzly bear diet across North America. Canadian Journal of Zoology 84:473–489.

Mundy, K. R. D. and D. R. Flook. 1973. Background for managing grizzly bears in the National Parks of Canada. Canadian Wildlife Services Report Number 22.

Munro, R. H. M., S. E. Nielsen, M. H. Price, G. B. Stenhouse, and M. S. Boyce. 2006. Seasonal and diel patterns of grizzly bear diet and activity in west-central Alberta. Journal of Mammalogy 87:1112–1121.

National Park Service. 2006. Management Policies 2006. Washington, D.C., USA.

National Park Service. 2010. Bear Management Plan: Glacier National Park. West Glacier, Montana, USA.

National Park Service. 2012. Ross Lake National Recreation Area general management plan. North Cascades National Park Complex, Seattle, Washington, USA.

National Park Service. 2018a. Glacier National Park annual park recreation visitation.

National Park Service. 2018b. Glacier National Park overnight stays.

National Park Service and USDA Animal and Plant Health Inspection Service. 2000. Record of decision for final environmental impact statement and bison management plan for the state of Montana and Yellowstone National Park. 75 pp.

National Parks Service and U.S. Fish and Wildlife Service. 2017. Draft grizzly bear restoration plan / environmental impact statement: North Cascades Ecosystem.

National Research Council. 2013. Abrupt impacts of climate change: anticipating surprises. Committee on Understanding and Monitoring Abrupt Climate Change and Its Impacts; Board on Atmospheric Sciences and Climate; Division on Earth and Life Studies. The National Academies Press, Washington, D.C., USA.

Neel, M. C., K. McKelvey, N. Ryman, M. W. Lloyd, R. Short Bull, F. W. Allendorf, M. K. Schwartz, and R. S. Waples. 2013. Estimation of effective population size in continuously distributed populations: there goes the neighborhood. Heredity 111:189–199.

Nelson, R. A. 1980. Protein and fat metabolism in hibernating bears. Federation Proceedings 39:2955–2958.

Newman, D., and D. A. Tallmon. 2001. Experimental evidence for beneficial fitness effects of gene flow in recently isolated populations. Conservation Biology 15:1054–1063.

Nicholson, J. M., and C. Hendricks. 2018. Human-grizzly bear conflicts in Idaho. Pages 75–77 *in* F. T. van Manen, M. A. Haroldson, and B. E. Karabensh, editors. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 2017. U.S. Geological Survey, Bozeman, Montanan, USA.

Nielsen, S. E.,M. R. L. Cattet, J. Boulanger, J. Cranston, G. J. McDermid, A. B. A. Shafer, and G. B. Stenhouse. 2013. Environmental, biological and anthropogenic effects on grizzly bear body size: temporal and spatial considerations. BMC Ecology 13. http://www.biomedcentral.com/1472-6785/13/31.

Nielsen, S. E., G. B. Stenhouse, and M. S. Boyce. 2006. A habitat-based framework for grizzly bear conservation in Alberta. Biological Conservation 130:217–229.

Nitschke, C. R., and J. L. Innes. 2008. Climatic change and fire potential in south-central British Columbia, Canada. Global Change Biology 14:841–855.

Northern Continental Divide Ecosystem (NDCE) Subcommittee. 2018. Conservation strategy for the grizzly bear in the Northern Continental Divide Ecosystem.

Nowak, R.M. and J.L. Paradiso. 1983. Walker’s Mammals of the World, 4th edition. The Johns Hopkins University Press, Baltimore, Maryland, USA.

Nunlist, E. A. 2020. Grizzly bears and humans at two moth aggregation sites in Wyoming. M.Sc. thesis, Montana State University, Bozeman, Montana, USA.

Omernik, J. M. 1987. Ecoregions of the conterminous United States. Annals of the Association of American Geographers 77:118–125.

Omernik, J. M. 1995. Ecoregions: a spatial framework for environmental management. Pages 49–62 *in* Davis, W. S., Simon, T. P., editors. Biological assessment and criteria: tools for water resource planning and decision making. Lewis Publishing, Boca Raton, Florida, USA.

Orme, M. L. and R. G. Williams. 1986. Coordinating livestock and timber management with the grizzly bear in situation 1 habitat, Targhee National Forest. Pages 195–203 *in* G. P. Contreras and K. E. Evans, compilers. Proceedings—grizzly bear habitat symposium. U.S. Forest Service General Technical Report INT-207.

Paetkau, D., L. P. Waits, P. L. Clarkson, L. Craighead, E. Vyse, R. Ward, and C. Strobeck. 1998. Variation in genetic diversity across the range of North American brown bears. Conservation Biology 12:418–429.

Paetkau, D., W. Calvert, I. Stirling, and C. Strobeck. 1995. Microsatellite analysis of population structure in Canadian polar bears. Molecular Ecology 4:347–354.

Paetkau, D., R. Slade, M. Burden, and A. Estoup. 2004. Genetic assignment methods for the direct, real-time estimation of migration rate: a simulation-based exploration of accuracy and power. Molecular Ecology 13:55–65.

Pardee, J. T. 1926. The Montana earthquake of June 27, 1925. Shorter Contributions to General Geology.

Pease, C. M. and D. J. Mattson. 1999. Demography of the Yellowstone grizzly bears. Ecology 80:957–975.

Peck, C. P., F. T. van Manen, C. M. Costello, M. A. Haroldson, L. A. Landenburger, L. L. Roberts, D. D. Bjornlie, and R. D. Mace. 2017. Potential paths for male-mediated gene flow to and from an isolated grizzly bear population. Ecosphere 8:e01969.

Pederson, G. T., S. T. Gray, T. Ault, W. Marsh, D. B. Fagre, A. G. Bunn, C. A. Woodhouse, and L. J. Graumlich. 2011. Climatic controls on the snowmelt hydrology of the northern Rocky Mountains. Journal of Climate 24:1666–1687.

Peek, J. M., M. R. Pelton, H. D. Picton, J. W. Schoen, and P. Zager. 1987. Grizzly bear conservation and management: a review. Wildlife Society Bulletin 15:160–169.

Pengelly, I., and D. Hamer. 2006. Grizzly bear use of pink hedysarum roots following shrubland fire in Banff National Park, Alberta. Ursus 17:124–131.

Pierson, J. C., T. A. Graves, S. C. Banks, K. C. Kendall, and D. B. Lindenmayer. 2018a. Relationship between effective and demographic population size in continuously distributed populations. Evolutionary Applications 2018:1–14. DOI: 10.1111/eva.12636.

Pierson, J. C., T. A. Graves, S. C. Banks, K. C. Kendall, and D. B. Lindenmayer. 2018b. Supplement: Relationship between effective and demographic population size in continuously distributed populations. Evolutionary Applications. DOI: 10.1111/eva.12636.

Podruzny, S. R., D. P. Reinhart, and D. J. Mattson. 1999. Fire, red squirrels, whitebark pine, and Yellowstone grizzly bears. Ursus 11:131–138.

Podruzny, S. R., S. Cherry, C. C. Schwartz, and L. A. Landenburger. 2002. Grizzly bear denning and potential conflict areas in the Greater Yellowstone Ecosystem. Ursus 13:19–28.

Prevéy, J. S., L. E. Parker, C. A. Harrington, C. T. Lamb, and M. F. Proctor. 2020. Climate change shifts in habitat suitability and phenology of huckleberry (*Vaccinium membranaceum*). Agricultural and Forest Meteorology 280:107803.

Pritchard, G. T. and C. T. Robbins. 1990. Digestive and metabolic efficiencies of grizzly and black bears. Canadian Journal of Zoology 68:1645–1651.

Proctor, M. F., W. F. Kasworm, K. M. Annis, A. G. MacHutchon, J. E. Teisberg, T. G. Radandt, and C. Servheen. 2018. Conservation of threatened Canada-USA trans-border grizzly bears linked to comprehensive conflict reduction. Human-Wildlife Interactions 12:348–372.

Proctor, M., C. Lamb, and G. MacHutchon. 2017. The grizzly dance between berries and bullets: relationships among bottom-up food resources and top-down mortality risk on grizzly bear populations in southeast British Columbia. Trans-border Grizzly Bear Project. Kaslo, British Columbia, Canada.

Proctor, M. F., B. N. McLellan, G. B. Stenhouse, G. Mowat, C. T. Lamb, and M. S. Boyce. 2015. Effects of roads and motorized human access on grizzly bear populations in British Columbia and Alberta, Canada. Ursus 30:article e2. DOI: 10.2192/Ursus-D-18-00016.2.

Proctor, M. F., B. N. McLellan, C. Strobeck, and R. M. R. Barclay. 2004. Gender-specific dispersal distances of grizzly bears estimated by genetic analysis. Canadian Journal of Zoology 82:1108–1118.

Proctor, M., B. N. McLellan, C. Strobeck, and R. Barclay. 2005. Genetic analysis reveals demographic fragmentation of grizzly bears yielding vulnerably small populations. Proceedings of the Royal Society, London 272:2409–2416.

Proctor, M. F., D. Paetkau, B. N. McLellan, B. B. Stenhouse, K. C. Kendall, R. D. Mace, W. F. Kasworm, C. Servheen, C. L. Lausen, M. L. Gibeau, W. L. Wakkinen, M. A. Haroldosn, G. Mowat, C. D. Apps, L. M. Ciarniello, R. M. R. Barclay, M. S. Boyce, C. C. Schwartz, and C. Strobeck. 2012. Population fragmentation and inter-ecosystem movements of grizzly bears in western Canada and the northern United States. Wildlife Monographs 180:1–46.

Proctor, M., C. Servheen, W. Kasworm, and T. Radandt. 2007. Transborder Purcell and Selkirk Mt. grizzly bear project: Annual report 2007.

Pyare, S., S. Cain, D. Moody, C. Schwartz, and J. Berger. 2004. Carnivore re-colonization: reality, possibility and a non-equilibrium century for grizzly bears in the southern Yellowstone Ecosystem. Animal Conservation 7:1–7.

Ransom, J. L., M. Krosby, and A. Lyons. 2018. Climate change implications for grizzly bears (*Ursus arctos*) in the North Cascades Ecosystem. Natural Resource NOCA/NRR – 2018/1814. National Park Service Fort Collins, Colorado, USA.

Rausch, R. L. 1963. Geographic variation in size of North American brown bears, *Ursus arctos* L., as indicated by condylobasal length. Canadian Journal of Zoology 41:33–45.

Redford, K. H., G. Amato, J. Baillie, P. Beldomenico, E. L. Bennett, N. Clum, R. Cook, G. Fonseca, S. Hedges, F. Launay, S. Lieberman, G. M. Mace, A. Murayama, A. Putman, J. G. Robinson, H. Rosenbaum, E. W. Sanderson, S. N. Stuart, P. Thomas, and J. Thorbjarnarson. 2011. What does it mean to conserve a (vertebrate) species? BioScience 61:39–48.

Reinhart, D. P. and D. J. Mattson. 1990. Bear use of cutthroat trout spawning streams in Yellowstone National Park. Pages 343–350 *in* Bears: their biology and management. Proceedings of the 8th international conference on bear research and management, Victoria, British Columbia, Canada.

Reynolds, P. E., H. V. Reynolds, and E. H. Follmann. 1986. Responses of grizzly bears to seismic surveys in northern Alaska. Pages 169–175 *in* Bears: their biology and management. Proceedings of the 6th international conference on bear research and management, Grand Canyon, Arizona, USA.

Robbins, C. T., M. Ben-David, J. K. Fortin, and O. L. Nelson. 2012. Maternal condition determines birth date and growth of newborn bear cubs. Journal of Mammalogy 93:540–546.

Robbins, C. T., C. C. Schwartz, an L. A. Felicetti. 2004. Nutritional ecology of ursids: a review of newer methods and management implications. Ursus 15:161–171.

Robbins, C. T., N. L. Woodford, G. G. Clyde, C. Minor, O. L. Nelson, M. M. Brewer, P. H. Khalife, and J. R. Hawley. 2018. Salmon poisoning disease in grizzly bears with population recovery implications. Journal of Wildlife Management: DOI: 10.1002/jwmg.21502.

Roberts, D. R., S. E. Nielsen, and G. B. Stenhouse. 2014. Idiosyncratic responses of grizzly bear habitat to climate change based on projected food resource changes. Ecological Applications 24:1144–1154.

Rode, K. D., and C. T. Robbins. 2000. Why bears consume mixed diets during fruit abundance. Canadian Journal of Zoology 78:1640–1645.

Rodriguez, C., J. Naves, A. Fernandez-Gil, J. R. Obeso, and M. Delibes. 2007. Long-term trends in food habits of relict brown bear population in northern Spain: the influence of climate and local factors. Environmental Conservation 34:36–44.

Rogers, B. M, R. P. Neilson, R. Drapek, J. M. Lenihan, J. R. Wells, D. Bachelet, and B. E. Law. 2011. Impacts of climate change on fire regimes an carbon stocks of the U.S. Pacific Northwest. Journal of Geophysical Research 116:doi:10.1029/2011JG001695.

Rogers, L. L. and S. M. Rogers. 1976. Parasites of bears: a review. Pages 411–430 *in* Bears: their biology and management. Proceedings of the 3rd international conference on bear research and management, Binghamton, New York, USA.

Rollins, P. A. 1935. The discovery of the Oregon Trail – Robert Stuart's narratives of his overland trip eastward from Astoria in 1812–13. Charles Scribner's Sons, New York, New York, USA.

Romme, W. H., and M. G. Turner. 1991. Implications of global climate change for biogeographic patterns in the Greater Yellowstone Ecosystem. Conservation Biology 5: 373–386.

Roosevelt, T. 1907. Good hunting: In pursuit of big game in the West. Harper & Brothers, New York, New York, USA.

Sahlén, E., O.-G. Støen, and J. E. Swenson. 2011. Brown bear den site concealment in relation to human activity in Sweden. Ursus 22:152–158.

Sawaya, M. A., S. T. Kalinowski, and A. P. Clevenger. 2014. Genetic connectivity for two bear species at wildlife crossing structures in Banff National Park. Proceedings of the Royal Society B 281:20131705.

Schallenberger, A., and C. J. Jonkel. 1980. Rocky Mountain east front grizzy studies, 1979. Annual Report #3, Border Grizzly Project Special Report No. 39, University of Montana, Missoula, Montana, USA.

Schauber, E. M., and A. Woolf. 2003. Chronic wasting disease in deer and elk: a critique of current models and their application. Wildlife Society Bulletin 31: 610–616.

Schneider, B. 1977. Where the grizzly walks. Mountain Press Publishing Company, Missoula, Montana, USA.

Schoen, J. W., L. R. Beier, J. W. Lentfer, and L. J. Johnson. 1987. Denning ecology of brown bears on Admiralty and Chichagof Islands. Ursus 7:293–304.

Schregel, J., A. Kopatz, S. B. Hagen, H. Brøseth, M. E. Smith, S. Wikan, I. Wartiainen, P. E. Aspholm, J. Aspi, J. E. Swenson, O. Makarova, N. Polikarpova, M. Schneider, P. M. Knappskog, M. Ruokenen, I. Kojola, K. F. Torronen, P. I. Danilov, and H. G. Eiken.

2012. Limited gene flow among brown bear populations in far Northern Europe? Genetic analysis of the east-west border population in the Pasvik Valley. Molecular Ecology 21:3474–3488.

Schwartz, C. C., J. K. Fortin, J. T. Teisberg, M. A. Haroldson, C. Servheen, C. T. Robbins, and F. T. van Manen. 2014*a*. Body and diet composition of sympatric black and grizzly bears in the Greater Yellowstone Ecosystem. Journal of Wildlife Management 78:68–78.

Schwartz, C. C., M. A. Haroldson, S. Cherry, and K. A. Keating. 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. 2006a. Distribution of grizzly bears in the Greater Yellowstone Ecosystem in 2004. Ursus 17:63–66.

Schwartz, C. C., M. A. Haroldson, G. C. White, R. B. Harris, S. Cherry, K. A. Keating, D. Moody, and C. Servheen, eds. 2006b. 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. 2010. Hazards Affecting Grizzly Bear Survival in the Greater Yellowstone Ecosystem. Journal of Wildlife Management 74:654–667.

Schwartz, C. C., K. A. Keating, H. V. Reynolds, III, V. G. Barnes, Jr., R. A. Sellers, J. E. Swenson, S. D. Miller, B. N. McLellan, J. Keay, R. McCann, M. Gibeau, W. F. Wakkinen, R. D. Mace, W. Kasworm, R. Smith, and S. Herrero. 2003b. Reproductive maturation and senescence in the female brown bear. Ursus 14:109–119.

Schwartz, C. C., S. D. Miller, and M. A. Haroldson. 2003a. Grizzly/brown bear. Pages 556–586 *in* G. Feldhamer, B. Thompson, and J. Chapman, editors. Wild mammals of North America: biology, management, and conservation. Johns Hopkins University Press, Baltimore, Maryland, USA.

Schwartz, C. C., J. E. Teisberg, J. K. Fortin, M. A. Haroldso , C. Servheen, C. T. Robbins, and F. T. van Manen. 2014*b*. Use of isopic sulfur to determine whitebark pine consumption by Yellowstone bears: a reassessment. Wildlife Society Bulletin. doi: 10.1002/wsb.426

Scott, J. M., D. D. Goble, A. M. Haines, J. A. Wiens, and M. C. Neel. 2010. Conservation-reliant species and the future of conservation. Conservation Letters 3:91–97.

Scott, J. M., D. D. Goble, J. A. Wiens, D. S. Wilcove, M. Bean, and T. Male. 2005. Recovery of imperiled species under the Endangered Species Act: the need for a new approach. Frontiers in Ecology and the Environment 3:383–389.

Servheen, C. 1981. Grizzly bear ecology and management in the Mission Mountains, Montana. Ph.D. dissertation, University of Montana, Missoula, Montana, USA.

Servheen, C. 1983. Grizzly bear food habits, movements, and habitat selection in the Mission Mountains, Montana. Journal of Wildlife Management 47:1026–1035.

Servheen, C. 1989. The management of the grizzly bear on private lands: some problems and possible solutions. Bear-People Conflicts – Proceedings of a Symposium on Management Strategies. Northwest Territories Department of Renewable Resources.

Servheen, C. 1990. The status and conservation of the bears of the world. 32 pages. Eighth international conference on bear research and management monograph series number 2.

Servheen, C. 1998. Conservation of small bear populations through strategic planning. Ursus 10:67–73.

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.

Servheen, C. 2001. Revision in the way we record human-caused mortalities. Letter from Christopher Servheen on behalf of the Interagency Grizzly Bear Study Team, NCDE Technical Team, Wayne Wakkinen, and Wayne Kasworm. Missoula, Montana, USA.

Servheen, C., and M. Cross. 2010. Climate change impacts on grizzly bears and wolverines in the northern U.S. and transboundary Rockies: Strategies for conservation. Report on a workshop held September 13–15, 2010, in Fernie, British Columbia, Canada.

Servheen, C., A. Hamilton, R. Knight, and B. McLellan. 1991. Report of the technical review team: evaluation of the Bitterroot and North Cascades to sustain viable grizzly bear populations. A report to the Interagency Grizzly Bear Committee. U.S. Fish and Wildlife Service, Boise, Idaho, USA.

Servheen, C., M. Haroldson, K. Gunther, K. Barber, M. Brucino, M. Cherry, B. DeBolt, K. Frey, L. Hanauska-Brown, G. Losinski, C. Schwartz, and B. Summerfield. 2004. Yellowstone mortality and conflicts reduction report. Presented to the Yellowstone Ecosystem Subcommittee April 7, 2004.

Servheen, C., R. Klaver. 1983. Grizzly bear dens and denning activity in the Mission and Rattlesnake Mountains, Montana. International Confererence on Bear Research and Management 5:201–207.

Servheen, C., R. W. Klaver, and J. J. Claar. 1981. Flathead Indian Reservation grizzly bear management plan. Confederated Salish & Kootenai Tribal Council and Bureau of Indian Affairs, Flathead Agency, Montana, USA.

Servheen, C., and R. R. Knight. 1993. Possible effects of a restored gray wolf population on grizzly bears in the Greater Yellowstone Area. Scientific Monograph 22: 28–37.

Servheen, C., and L. C. Lee. 1979. An assessment of the grizzly bear population size and status, and a description of important grizzly use sites in the Finley Logging Unit, Flathead Reservation, Montana. No. C50-C-1420-4988 for the Bureau of Indian Affairs, Flathead Agency.

Servheen, C., and R. Shoemaker. 2010. Bitterroot Mountains bear DNA and camera survey: 2008-2009. U.S. Fish and Wildlife Service, Missoula, Montana, USA.

Servheen, C., J. S. Waller, and P. Sandstrom. 2001. Identification and management of linkage zones for grizzly ears between the large blocks of public lands in the Northern Rocky Mountains. Pages 161–179 *in* C. L. Irwin, P. Garrett, and K. P. McDermott, editors. Proceedings of the 2001 Inernational Conference on Ecology and Transportation. Center for Transportation and the Environment, North Carolina State University, Raleigh, North Carolina, USA.

Shaffer, M. L., and M. A. Stein. 2000. Safeguarding our precious heritage. Pages 301–321 *in* B. A. Stein, L. S. Kutner, and J. S. Adams, editors. Precious heritage: the status of biodiversity in the United States. Oxford University Press, New York, New York, USA.

Shaffer, S. C. 1971. Some ecological relationships of grizzly bears and black bears of the Apgar Mountains in Glacier National Park, Montana. M.Sc. thesis, University of Montana, Missoula, Montana, USA.

Simonin, K., compiler. 2000. Effects of fall burning on a big huckleberry shrubfield near Mount Adams, Washington. In: Vaccinium membranaceum. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available at: <http://www.fs.fed.us/database/feis/plants/shrub/vacmem/all.html> [Accessed 2014, June 19].

Smith, D. R., N. L. Allan, C. P. McGowan, J. A. Szymanski, S. R. Oetker, and H. M. Bell. 2018. Development of a species status assessment process for decisions under the U.S. Endangered Species Act. Journal of Fish and Wildlife Management 9:302–320.

Stebler, A. M. 1972. Conservation of the grizzly- ecologic and cultural considerations. Pages 297–303 *in* Bears: their biology and management. Proceedings of the 2nd international conference on bear research and management, Calgary, Alberta, Canada.

Stewart, I. T., D. R. Cayan, and M. D. Dettinger. 2004. Changes in snowmelt runoff timing in western North America under a ‘business as usual’ climate change scenario. Climatic Change 62:217–232.

Støen, O.-G., E. Bellemain, S. Sæbø, and J. E. Swenson. 2005. Kin-related spatial structure in brown bears *Ursus arctos*. Behavioral Ecology and Sociobiology 59:191–197.

Storer, T. I. and L. P. Tevis. 1955. California grizzly. University of Nebraska Press, Lincoln, Nebraska, USA.

Stringham, S. F. 1980. Possible impacts of hunting on the grizzly/brown bear, a threatened species. Pages 337–349 *in* Bears: their biology and management. Proceedings of the 4th international conference on bear research and management, Kalispell, Montana, USA.

Stringham, S. F. 1990. Grizzly bear reproductive rate relative to body size. International Conference on Bear Research and Management 8:433–443.

Summerfield, B., W. Johnson, and D. Roberts. 2004. Trends in road development and access management in the Cabinet-Yaak and Selkirk bear recovery zones. Ursus 15: Workshop Supplement:115–122.

Sumner, J., and J. J. Craighead. 1973. Grizzly bear habitat survey in the Scapegoat Wilderness, Montana.

Swenson, J. E., F. Sandegren, S. Brunberg, and P. Wabakken. 1997. Winter den abandonment by brown bears, *Ursus arctos*: causes and consequences. Wildlife Biology 3:35–38.

Swenson, J. E., F. Sandegren, and A. Söderberg. 1998. Geographic expansion of an increasing brown bear population: evidence for presaturation dispersal. Journal of Animal Ecology 6:819–826.

Talbot, S. L., J. R. Gust, G. K. Sage, A. Fischbach, K. Amstrup, W. Leacock, and L. Van Daele. 2006. Genetic characterization of brown bears of the Kodiak Archipelago. Final Report to Kodiak National Wildlife Refuge. U.S. Fish and Wildlife Service, Kodiak, Alaska.

Teisberg, J. E., M. A. Haroldson, C. C. Schwartz, K. A. Gunther, J. K. Fortin, C. T. Robbins. 2014. Contrasting past and current numbers of bears visiting Yellowstone cutthroat trout streams. The Journal of Wildlife Management 78: 369–378.

Teisberg, J. E., M. J. Madel, R. D. Mace, C. W. Servheen, and C. T. Robbins. 2015. Diet composition and body condition of Northern Continental Divide grizzly bears. Final Report.

Trevino, J. C., and C. Jonkel. 1986. Do grizzly bears still live in Mexico? International Conference on Bear Research and Management 6:11–13.

Troyer, W. A., and R. J. Hensel. 1964. Structure and distribution of a Kodiak bear population. Journal of Wildlife Management 28:769–772.

U.S. Census Bureau, Population Division. 2005. State interim population projections by age and sex: 2004–2030. *Total population for regions, divisions, and states: 2000 to 2030*. Retrieved December 1, 2006 from http://www.census.gov/population/www/projections/projectionsagesex.html

U.S. Fish and Wildlife Service. 1982. Grizzly bear recovery plan. Denver, Colorado, USA.

U.S. Fish and Wildlife Service. 1990. Record of Decision and Final Environmental Assessment: Grizzly bear population augmentation test, Cabinet-Yaak Ecosystem. Missoula, Montana, USA.

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

U.S. Fish and Wildlife Service. 1995. Biological Opinion on the proposed Amendment #19 to the Flathead Forest Plan. Helena, Montana, USA.

U.S. Fish and Wildlife Service. 1996. Bitterroot Ecosystem recovery plan chapter - supplement to the grizzly bear recovery plan. Missoula, Montana, USA.

U.S. Fish and Wildlife Service. 1997. North Cascades Ecosystem recovery plan chapter—supplement to the grizzly bear recovery plan. Missoula, Montana, USA.

U.S. Fish and Wildlife Service. 2000. Final environmental impact statement: Grizzly bear recovery in the Bitterroot Ecosystem. Missoula, Montana, USA.

U.S. Fish and Wildlife Service. 2001. Biological Opinion for Stimson ANILCA access easement project. Spokane, Washington, USA.

U.S. Fish and Wildlife Service. 2002. Biological Opinion on Greater Yellowstone Ecosystem snowmobile use consultation. Helena, Montana, USA.

U.S. Fish and Wildlife Service. 2004. National environmental policy act scoping report for the Burlington Northern and Santa Fe Railway Company grizzly bear habitat conservation plan. Helena, Montana, USA.

U.S. Fish and Wildlife Service. 2007a. Supplement: Revised Demographic Recovery Criteria for the Yellowstone Ecosystem. Missoula, Montana, USA.

U.S. Fish and Wildlife Service. 2007b. Supplement: Habitat-based Recovery Criteria for the Yellowstone Ecosystem. Missoula, Montana, USA.

U.S. Fish and Wildlife Service. 2007c. Final Conservation Strategy for the Grizzly Bear in the Greater Yellowstone Area. Missoula, Montana, USA.

U.S. Fish and Wildlife Service. 2013. Draft Revised Supplement: Revised Demographic Recovery Criteria for the Yellowstone Ecosystem. Missoula, Montana, USA.

U.S. Fish and Wildlife Service. 2016. USFWS species status assessment framework. Version 3.4

U.S. Fish and Wildlife Service. 2017. Grizzly Bear Recover Plan Supplement: Revised Demographic Recovery Criteria for the Greater Yellowstone Ecosystem. Missoula, Montana, USA.

U.S. Fish and Wildlife Service. 2018. Supplement: Habitat-based Recovery Criteria for the Northern Continental Divide Ecosystem. Missoula, Montana, USA.

U.S. Fish and Wildlife Service. 2020. Grizzly bear hazing guidelines: guidance for livestock owners, homeowners and the general public. Missoula, Montana, USA.

USDA and USDOI. 1983. Memorandum of Agreement to establish the Interagency Grizzly Bear Committee.

USDA Forest Service. 1986a. The Lolo National Forest Plan. Lolo National Forest.

USDA Forest Service. 1986b. Forest Plan. Flathead National Forest.

USDA Forest Service. 1986c. Interagency grizzly bear guidelines. United States Forest Service, Washington, D.C., USA.

USDA Forest Service. 1997. Grizzly bear recovery – North Cascades Ecosystem. Wenatchee, Okanogan, and Mt. Baker Snoqualmie NFs.

USDA Forest Service. 2004. Forest plan amendments for grizzly bear conservation for the greater Yellowstone area National Forests draft environmental impact statement.

USDA Forest Service. 2005. Caribou-Targhee National Forest Fire Management Plan.

USDA Forest Service. 2006a. Forest plan amendment for grizzly bear habitat conservation for the greater Yellowstone area National Forests, final environmental impact statement.

USDA Forest Service. 2006b. Forest plan amendment for grizzly bear habitat conservation for the greater Yellowstone area National Forests final environmental impact statement, Record of Decision.

USDA Forest Service. 2006c. Gallatin National Forest Travel Management Plan—Record of Decision and Final Environmental Impact Statement. Gallatin National Forest, Bozeman, Montana, USA.

USDA Forest Service. 2008. Occupancy and use Restrictions. Caribou-Targhee National Forest order number 04-15-0063.

USDA Forest Service. 2011a. Final supplemental environmental impact statement: Forest plan amendments for motorized access management within the Selkirk and Cabinet-Yaak grizzly bear recovery zones. Kootenai, Lolo, and Idaho Panhandle National Forests. Lincoln, Sanders, Bonner, Boundary, and Pend Oreille counties, Montana, Idaho, and Washington, USA.

USDA Forest Service. 2011b. Record of decision: Forest plan amendments for motorized access management within the Selkirk and Cabinet-Yaak grizzly bear recovery zones. Kootenai, Lolo, and Idaho Panhandle National Forests. Lincoln, Sanders, Bonner, Boundary, and Pend Oreille counties, Montana, Idaho, and Washington, USA

USDA Forest Service. 2011c. Fire management amendment to the Gallatin National Forest Plan. Decision notice and finding of no significant impact (FONSI) and finding of no significant amendment. Gallatin National Forest.

USDA Forest Service. 2012. Shoshone National Forest Fire Management Plan.

USDA Forest Service. 2014a. Occupancy and use Restrictions. Custer Gallatin National Forest order number 01-14-11-00-02.

USDA Forest Service. 2014b. Forest supervisor's order requiring safe storage, possession, and handling of food and attractants. Beaverhead-Deerlodge National Forest.

USDA Forest Service. 2015a. Land management plan, 2015 revision, Kootenai National Forest.

USDA Forest Service. 2015b. Land management plan, 2015 revision, Idaho Panhandle National Forest.

USDA Forest Service. 2015c. Okanogan-Wenatchee National Forest Forestwide travel analysis report.

USDA Forest Service. 2015d. Bridger-Teton National Forest fire management plan.

USDA Forest Service. 2016. Occupancy and use Restrictions. Bridger-Teton National Forest order number 04-03-330 and Shoshone National Forest order number 16-001.

USDA Forest Service. 2018a. Volume 2—Final environmental impact statement for the land management plan. Flathead National Forest. Kalispell, Montana, USA.

USDA Forest Service. 2018b. Volume 3—Final environmental impact statement for the forest plan amendments: Incorporating habitat management direction for the Northern Continental Divide Ecosystem grizzly bear population. Helena-Lewis and Clark, Kootenai, and Lolo National Forests. Helena, Libby, and Missoula, Montana, USA.

USDA Forest Service. 2018c. Final record of decision for the Flathead National Forest land management plan. Flathead, Lake, Lewis and Clark, Lincoln, Missoula, and Powell Counties, Montana, USA.

USDA Forest Service. 2018d. Records of decision for the forest plan amendments to incorporate habitat management direction for the Northern Continental Divide Ecosystem grizzly bear population. Helena-Lewis and Clark, Kootenai, and Lolo National Forests, Montana, USA.

USDA Forest Service. 2018e. Flathead National Forest land management plan. Flathead, Lake, Lewis and Clark, Lincoln, Missoula, and Powell Counties, Montana, USA.

USDA Forest Service. 2019. Colville National Forest land management plan. Ferry, Pend Oreille, and Stevens Counties, Washington, USA.

USDA Forest Service. 2020a. Selkirk/Cabinet-Yaak grizzly bear recovery zones 2019 annual monitoring summary report. Colville, Idaho Panhandle, Kootenai, and Lolo National Forests.

USDA Forest Servic. 2020b. USDA Forest Service National Visitor Use Monitoring. Available at: apps.fs.usda.gov/nvum/. Accessed on June 19, 2020.

Van Daele, L. J., and V. G. Barnes. 2010. Management of brown bear hunting on Kodiak Island, Alaska. Scandinavian Bear Conference, Orsa, Sweden, January 2010.

Van Daele, L. J., V. G. Barnes, and R. B. Smith. 1990. Denning characteristics of brown bears on Kodiak Island, Alaska. Pages 257–267 *in* Bears: their biology and management. Proceedings of the 8th International Conference on Bear Research and Management, Victoria, British Columbia, Canada.

Van Dyke, F. 2003. Conservation Biology: Foundations, Concepts, Applications. McGraw-Hill Higher Education.

Van Manen, F. T., M. R. Ebinger, M. A. Haroldson, R. B. Harris, M. D. Higgs, S. Cherry, G. C. White, and C. C. Schwartz. 2014. Re-evlaution of Yellowstone grizzly bear population dynamics not supported by empirical data: response to Doak & Cutler. Conservation Letters 7:323–331.

van Manen, F. T., M. A. Haroldson, D. D. Bjornlie, M. R. Ebinger, D. J. Thompson, C. M. Costello, and G. C. White. 2016. Density dependence, whitebark pine decline, and vital rates of grizzly bears. Journal of Wildlife Management 80: 300–313.

Vandermeer, J. H. and D. E. Goldberg. 2003. Population ecology: First principles. Princeton University Press, Princeton, New Jersey. USA.

Wade, M., editor. 1947. The journals of Francis Parkman. Harper and Brothers Publishers, New York, New York, USA.

Wakkinen, W. L., and W. F. Kasworm. 2004. Grizzly bear and road density relationships in the Selkirk and Cabinet-Yaak recovery zones. Report.

Wakkinen, W. L., and W. F. Kasworm. 2004. Demographics and population trends of grizzly bears in the Cabinet-Yaak and Selkirk Ecosystems of British Columbia, Idaho, Montana, and Washington. Ursus 15: Workshop Supplement: 65–75.

Waller, J. S., and C. S. Miller. 2015. Decadal growth of traffic volume on US Highway 2 in northwestern Montana. Intermountain Journal of Sciences 21:29–37.

Waller, J. S., and C. Servheen. 2005. Effects of transportation infrastructure on grizzly bears in northwestern Montana. Journal of Wildlife Management 69:985–1000.

Walther, G-R. 2003. Plants in a warmer world. Perspectives in Plant Ecology, Evolution, and Systematics 6:169–185.

Walther, G-R., E. Post, P. Convey, A. Menzel, C. Parmesan, T. J. C. Beebee, J.-M. Fromentin, O. Hoegh-Guldberg, and F. Bairlein. 2002. Ecological responses to recent climate change. Nature 416:389–395.

Walther, G-R., S. Berger, and M. T. Sykes. 2005. An ecological 'footprint' of climate change. Proceedings of the Royal Society B 272:1427–1432.

Waples, R. S. 2005. Genetic estimates of contemporary effective population size: to what time periods do the estimates apply? Molecular Ecology 14:335–3352.

Waples, R. S., and P. R. England. 2011. Estimating contemporary effective population size on the basis of linkage disequilibrium in the face of migration. Genetics 189:633–644.

Waser, P. M., and C. Strobeck. 1998. Genetic signatures of interpopulation dispersal. Trends in Ecology and Evolution 13:43–44.

Waser, P. M., and W. T. Jones. 1983. Natal philopatry among solitary mammals. The Quarterly Review of Biology 58:355–390.

Washington Department of Fish and Wildlife (WDFW). 2019. 2019 big game hunting seasons & regulations pamphlet corrections.

Weaver, J., R. Escano, D. Mattson, T. Puchlerz, and D. Despain. 1986. A cumulative effects model for grizzly bear management in the Yellowstone ecosystem. Pages 234–246 in G. Contreras and K. Evans, compilers. Proceedings: grizzly bear habitat symposium. USDA Forest Service General Technical Report INT-207.

Wells, S. M., L. B. McNew, D. B. Tyers, F. T. van Manen, and D. J. Thompson. 2018. Grizzly bear depredation on grazing allotments in the Yellowstone Ecosystems. Journal of Wildlife Management. DOI: 10.1002/jwmg.21618.

Wyoming Game and Fish Department (WGFD). 2016. Wyoming grizzly bear management plan. Wyoming Game and Fish Department. Available at https://wgfd.wyo.gov/WGFD/media/content/PDF/Wildlife/Large%20Carnivore/GB-Mgmt-Plan-Approved-5-11-2016.pdf.

White, D. Jr., K. C. Kendall, and H. D. Picton. 1998. Grizzly bear feeding activity at alpine army cutworm moth aggregation sites in northwest Montana. Canadian Journal of Zoology 76:221–227.

White, D. Jr., K. C. Kendall, and H. D. Picton. 1999. Potential energetic effects of mountain climbers on foraging grizzly bears. Wildlife Society Bulletin 27:146–151.

White, E. M., J. M. Bowker, A. E. Askew, L. L. Langner, J. R. Arnold, and D. B. K. English. 2016. Federal outdoor recreation trends: effects on economic opportunities. General Technical Report PNW-GTR-945. Pacific Northwest Research Station, USDA Forest Service.

White, K. S., D. P. Gregovich, and T. Levi. 2018. Projecting the future of an alpine ungulate under climate change scenarios. Global Change Biology 24:1136–1149.

Whitlock, C., W. F. Cross, B. Maxwell, N. Silverman, and A. A. Wade. 2017. 2017 Montana climate assessment. Montana State University and University of Montana, Montana Institute on Ecosystems. Bozeman and Missoula, Montana, USA.

Wilmers, C. C., and E. Post. 2006. Predicting the influence of wolf-provided carrion on scavenger community dynamics under climate change scenarios. Global Change Biology 12:403–409.

Wilmers, C. C., and W. M. Getz. 2005. Gray wolves as climate change buffers in Yellowstone. Plos Biology 3:571–576.

Wilmot, K. R. 2018a. Grand Teton National Park Recreational Use. Page 65 *in* F. T. van Manen, M. A. Haroldson, and B. E. Karabensh, editors. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 2017. U.S. Geological Survey, Bozeman, Montanan, USA.

Wilmot, K. R. 2018b. Human-grizzly bear conflicts in Grant Teton National Park. Page 69 *in* F. T. van Manen, M. A. Haroldson, and B. E. Karabensh, editors. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 2017. U.S. Geological Survey, Bozeman, Montanan, USA.

Woiwod, I. P. 1997. Detecting the effects of climate change on Lepidoptera. Journal of Insect Conservation 1:149–158.

Wolf, S., B. Hartl, C. Carroll, M. C. Neel, and D. N. Greenwald. 2015. Beyond PVA: why recovery under the Endangered Species Act is more than population viability. BioScience 65:200–207.

Woodroffe, R. 2000. Predators and people: using human densities to interpret declines in large carnivores. Animal Conservation 3:165–173.

Woodroffe, R. and J. R. Ginsberg. 1998. Edge effects and the extinction of populations inside protected areas. Science 280:2126–2128.

Woods, A. J., J. M. Omernik, J. A. Nesser, J. Shelden, and S. H. Azevedo. 1999. Ecoregions of Montana (color poster with map, descriptive text, summary tables, and photographs). Reston, Virginia, U.S. Geological Survey (map scale 1:1,500,000). Available at http://www.epa.gov/wed/pages/ecoregions/mt_eco.htm

Wright, W. H. 1909. The grizzly bear: The narrative of a hunter-naturalist. C. Scribner's Sons, New York, New York, USA.

Wyoming Game and Fish Commission, Wyoming Game and Fish Department, Montana Fish and Wildlife Commission, Montana Fish, Wildlife and Parks, Idaho Fish and Game Commission, and Idaho Department of Fish and Game. 2016. Memorandum of agreement regarding the management and allocation of discretionary mortality of grizzly bears in the Greater Yellowstone Ecosystem.

Wyoming Game and Fish Commission. 2016. Chapter 67: Grizzly bear management regulation.

Wyoming Game and Fish Department. 2020. Chapter 3: Black bear hunting seasons.

Yahner, R. H. 1988. Changes in wildlife communities near edges. Conservation Biology 2:333–339.

Yellowstone Ecosystem Subcommittee (YES). 2016*a*. 2016 Conservation Strategy for the Grizzly Bear in the Greater Yellowstone Ecosystem. Missoula, Montana, USA.

Yellowstone Ecosystem Subcommittee (YES). 2016*b*. Appendices to the 2016 Conservation Strategy for the Grizzly Bear in the Greater Yellowstone Ecosystem. Missoula, Montana, USA.

Yellowstone Grizzly Bear Coordinating Committee (YGCC). 2009. Meeting minutes from the October 28, 2009 YGCC meeting in Jackson, Wyoming, USA.

Yellowstone National Park. 2005. 2004 Update of the 1992 Fire Management Plan: Programmatic Biological Assessment: Appendix I. National Park Service, U.S. Department of the Interior, Yellowstone National Park.

Yellowstone National Park. 2011. Wildland fire in Yellowstone. Yellowstone Science. National Park Service, U.S. Department of the Interior, Yellowstone National Park. Website accessed 30 October 2011.

Yellowstone National Park. 2014. 2014 Fire Management Plan. National Park Service, U.S. Department of the Interior, Yellowstone National Park.

Yellowstone National Park. 2019. 2019 Yellowstone National Park Superintendent's Compendium. Yellowstone National Park, Wyoming, USA.

Zager, P., C. Jonkel, and J. Habeck. 1983. Logging and wildfire influence on grizzly bear habitat in northwestern Montana. Pages 124–132 *in* Bears: their biology and management. Proceedings of the 5th International Conference on Bear Research and Management, Madison, Wisconsin, USA.

Zarnke R. L., R. Gamble, R. A. Heckert, and J. Ver Hoef. 1997. Serologic survey for *Trichinella* spp. in grizzly bears from Alaska. Journal of Wildlife Diseases 33:474–479.

Zarnke, R. L. and M. B. Evans. 1989. Serologic survey for infectious canine hepatitis virus in grizzly bears (*Ursus arctos*) from Alaska, 1973 to 1987. Journal of Wildlife Diseases 25:568-573.

In litteris

Ake, K. 2018a. Email from Kathy Ake, GIS Specialist Flathead National Forest to Jennifer Fortin-Noreus, USFWS Wildlife Biologist on May 3, 2018.

Ake, K. 2018b. Email from Kathy Ake, GIS Specialist Flathead National Forest to Jennifer Fortin-Noreus, USFWS Wildlife Biologist on June 29, 2018.

Ake, K. 2018c. Email from Kathy Ake, GIS Specialist Flathead National Forest to Jennifer Fortin-Noreus, USFWS Wildlife Biologist on September 24, 2018.

Ake, K. 2019a. Email from Kathy Ake, GIS Specialist Flathead National Forest to Jennifer Fortin-Noreus, USFWS Wildlife Biologist on September 3, 2019.

Ake, K. 2019b. Email from Kathy Ake, GIS Specialist Flathead National Forest to Jennifer Fortin-Noreus, USFWS Wildlife Biologist on September 24, 2019.

Bjornlie, D. 2019. Calculations of the distance between the GYE and NCDE grizzly bear populations. April 19, 2019.

Costello, C. 2018. Email from Cecily Costello, MFWP Grizzly Bear Research Biologist to Jennifer Fortin-Noreus, USFWS Wildlife Biologist on August 1, 2018.

Costello, C. 2019. Email from Cecily Costello, MFWP Grizzly Bear Research Biologist to Jennifer Fortin-Noreus, USFWS Wildlife Biologist on May 13, 2019.

Costello, C. 2020. Email from Cecily Costello, MFWP Grizzly Bear Research Biologist to Jennifer Fortin-Noreus, USFWS Wildlife Biologist on January 17, 2020.

Fortin-Noreus, J. K. 2019. Calculations for estimated distributions and boundaries. April 8, 2019.

Gunther, K. 2014. Email from Kerry Gunther, YNP Bear Management Program Leader to Rebecca Shoemaker, USFWS Policy Biologist on July 7, 2014.

Gustine, D. 2019. Email from David Gustine, GTNP Wildlife Chief to Hilary Cooley, USFWS Grizzly Bear Recovery Coordinator on February 12, 2019.

Haroldson, M. 2017. Email from Mark Haroldson, USGS Grizzly Bear Study Team to Jennifer Fortin-Noreus, USFWS Wildlife Biologist on March 9, 2017.

Haroldson, M. 2019*a*. Email from Mark Haroldson, USGS Grizzly Bear Study Team to Jennifer Fortin-Noreus, USFWS Wildlife Biologist on May 2, 2019.

Haroldson, M. 2019*b*. Summary of documented and probable mortalities for independent females and males during 2002–2018 from Mark Haroldson, USGS Grizzly Bear Study Team to Jennifer Fortin-Noreus, USFWS Wildlife Biologist on May 7, 2019.

Haroldson, M. 2019*c*. Email from Mark Haroldson, USGS Grizzly Bear Study Team to Jennifer Fortin-Noreus, USFWS Wildlife Biologist on June 18, 2019.

Haroldson, M. 2019*d*. Email from Mark Haroldson, USGS Grizzly Bear Study Team to Jennifer Fortin-Noreus, USFWS Wildlife Biologist on June 18, 2019.

Haroldson, M. 2020. Email from Mark Haroldson, USGS Grizzly Bear Study Team to Jennifer Fortin-Noreus, USFWS Wildlife Biologist on November 9, 2020.

Jackson, S. 2019. Email from Scott Jackson, USFS National Carnivore Program Leader to Jennifer Fortin-Noreus, USFWS Wildlife Biologist on May 22, 2019.

Juliusson, L. 2019. Email from Lara Juliusson, USFWS Spatial Ecologist to Jennifer Fortin-Noreus, USFWS Wildlife Biologist on May 5, 2019.

Kasworm, W. 2018a. Email from Wayne Kasworm, USFWS Wildlife Biologist to Jennifer Fortin-Noreus, USFWS Wildlife Biologist on April 16, 2018.

Kasworm, W. 2018b. Email from Wayne Kasworm, USFWS Wildlife Biologist to Jennifer Fortin-Noreus, USFWS Wildlife Biologist on September 6, 2018.

Kasworm, W. 2020. Email from Wayne Kasworm, USFWS Wildlife Biologist to Jennifer Fortin-Noreus, USFWS Wildlife Biologist on April 27, 2020.

Landenburger, L. 2014. Edits and updates received from Lisa Landenburger, USGS Grizzly Bear GIS Database Coordinator.

Mace, R. 2012. Email from Rick Mace, MFWP Research Biologist to Chris Servheen, USFWS Grizzly Bear Recovery Coordinator on May 3, 2012.

Manley, T. 1993. Security Areas – Typed Notes from Tim Manley, MFWP Bear Specialist to Jennifer Fortin-Noreus, USFWS Wildlife Biologist.

Miller, C. 2006. Email from Craig Miller to Chris Servheen, USFWS Grizzly Bear Recovery Coordinator on January 25, 2006.

Paetkau, D. 2019. Letter from David Paetkau, Wildlife Genetics International, to Mark Haroldson, Interagency Grizzly Bear Study Team on December 16, 2019.

Rice, R. 2019. Email from Richard Rice, RO Range/Noxious Weed Program Manager, R2 Rocky Mountain Region, USDA Forest Service to Jennifer Fortin-Noreus, USFWS Wildlife Biologist on June 26, 2019.

Roberts, L. 2018. Email from Lori Roberts, MFWP Wildlife Research Technician to Jennifer Fortin-Noreus, USFWS Wildlife Biologist on April 30, 2018.

Vaculik, L. 2019. Email from Leslie Vaculik, Forest Service Petroleum Engineer-Leasable Minerals to Jennifer Fortin-Noreus, USFWS Grizzly Bear Recovery Program Wildlife Biologist on April 26, 2019.

van Manen, F. 2016. Edits and updates received from Frank van Manen, IGBST Leader.

van Manen, F. 2020. Email from Frank van Manen, IGBST Leader to Jennifer Fortin-Noreus, USFWS Grizzly Bear Recovery Program Wildlife Biologist on June 8, 2020.

Appendix A: Grizzly Bear Secure Core/Habitat Analysis for the San Juan and Sierra Nevada Mountains' Historical Range

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October 20, 2020

Introduction and Goals

This document describes the process and data used to analyze secure core area for grizzly bears within the San Juan and Sierra Nevada Mountains' historical range, as well as the results of that analysis. We report secure core using the definition from the Northern Continental Divide Ecosystem and secure habitat using the definition from the Greater Yellowstone Ecosystem. We report secure core as the percentage of federal, state, or tribal lands within the analysis area with no motorized routes, more than 500 meters from an open or gated motorized route, and at least 2,500 acres in size. In addition, we report secure habitat as the percentage of federal, state, or tribal lands within the analysis area with no motorized routes, more than 500 meters from an open or gated motorized route, and at least 10 acres in size. We lacked data for high-use trails in the San Juan and Sierra Nevada Mountains to analyze core areas as defined for the Cabinet-Yaak, Selkirk, and North Cascades Ecosystems.

GIS Layers Used:

This section describes the best available GIS data used in this analysis.

Surface Management Agency

Surface management agency (SMA) is authoritative spatial data from the Bureau of Land Management (BLM) representing land management across the U.S. We acquired the latest SMA from BLM, published 2017-11-03. As this layer has been known to include significant area overlaps, which can lead to double counting, we performed a quality control test within the areas of the San Juan and Sierra Nevada Mountains and found that overlaps were negligible.

San Juan Mountains Historical Range Analysis Area

An initial challenge to conducting this analysis was describing an analysis area for the San Juan Mountains, which has no official mapped boundary. To do this, we began by selecting the U.S. Forest Service (USFS) San Juan National Forest (NF) polygon in the BLM's Surface Management Agency layer, and then moved outward from this polygon and selected contiguous Federal lands. We used mapped mountain peaks described on Wikipedia as being within the San Juan Mountains to help delineate where the San Juan Mountains end. We used the extent of the selected polygons as a boundary, and limited the northern and southern USFS extent by stopping the area into the Rio Grande NF on the north at U.S. Highway 50 and by stopping the area into the Santa Fe NF on the south at U.S. Highway 64. Both U.S. 50 and U.S. 64 in these National Forests were included in the analysis. We left all non-Federal lands found within the analysis area on edges and interstitial to Federal lands. Federally managed lands within the San Juan mountains' historical range are made up of BLM, USFS, and U.S. Bureau of Reclamation (USBR) lands.

Sierra Nevada Mountains Historical Range Analysis Area

We were able to locate an official analysis area for the Sierra Nevada Mountains defined as part of the USFS's EcoMap project (https://data.fs.usda.gov/geodata/edw/datasets.php?xmlKeyword=Ecomap**)**. We reviewed this area in relation to the historical range of the grizzly bear and concluded that the boundaries of the region that the USFS defined were appropriate for use as an analysis area. Federally managed lands within the Sierra Nevada mountains' historical range are made up of BLM, USFS, National Park Service (NPS), U.S. Bureau of Reclamation (USBR), U.S. Fish and Wildlife Service (USFWS), and Department of Defense (DOD) lands.

Roads

We used road and trails data from the U.S. Census Bureau TIGER 2018 All Roads line file (https://www2.census.gov/geo/tiger/TGRGDB18/tlgdb_2018_a_us_roads.gdb.zip). These data include the best available data from a federal data steward. The All Roads line file includes all primary, secondary, local neighborhood, and rural roads, city streets, vehicular trails (4wd), ramps, service drives, alleys, parking lot roads, private roads for service vehicles (logging, oil fields, ranches, etc.), bike paths or trails, bridle/horse paths, walkways/pedestrian trails, and stairways. We selected the following road types from the data for use in secure core analysis using the codes MTFCC IN ('S1100' , 'S1200' , 'S1400' , 'S1500' , 'S1630' , 'S1640' , 'S1730' , 'S1740', 'S1780').

- Alley
- Local neighborhood road, rural road, city street
- Parking lot road
- Primary road
- Private road for service vehicles (logging, oil fields, ranches, etc.)
- Ramp
- Secondary road
- Service drive usually along a limited access highway
- Vehicular trail (4WD)

Population Density by Block

The best available data for population density at a census block level is based on the 2010 census. We pulled these data from the Census Bureau, and joined it to the tlgdb_2015_a_us_block layer available at https://www2.census.gov/geo/tiger/TGRGDB18/tlgdb_2018_a_us_block.gdb.zip. We then calculated persons per square km for each block.

BLM and USFS Sheep Allotments

The U.S. Forest Service makes their range allotment data available nationally. We downloaded the June 2018 update of this layer (https://catalog.data.gov/dataset/range-allotment-feature-layer). The field "Sheep" in the layer describes if a particular allotment is allotted for sheep grazing. BLM also makes their allotment data available nationally (https://gis.blm.gov/EGISDownload/LayerPackages/BLM_National_Grazing_Allotments.zip) and we downloaded the November 2018 update of this layer. Unfortunately, BLM does not provide information on grazing type in these data, so we used the BLM's online RAS system (https://reports.blm.gov/reports/RAS/) to pull sheep grazing data for all of the field offices and populate a new field called "RAS_AuthUse20190510" in the BLM allotment data to indicate a specific allotment was allotted for sheep. We then merged the USFS and BLM sheep allotment data and dissolved to remove overlaps (BLM_USFS_Sheep_Allotments_SNMtns_dis and BLM_USFS_Sheep_Allotments_SJMtns_dis)

Analysis

Secure Core and Secure Habitat Calculations

Grizzly bear secure core and secure habitat analyses utilizes a buffering process to determine contiguous areas that are a distance of greater than 500 meters away from roads. Secure core are core areas managed as federal, tribal, or state lands that are at least 2,500 acres in size. Secure habitat are core areas managed as federal, tribal, or state lands that are at least 10 acres in size. We also wanted to understand the amount of area within these secure core/habitat areas that were authorized for sheep grazing by BLM or the USFS, or were in areas with populations greater than 50 persons per kilometer within census blocks. We used the following process to calculate secure core in the western U.S.

- We clipped the roads and BLM surface management layers to the western U.S. (RoadsClpWesternStatesAlbSubset)
- Because of the large size of this data set and processing limitations, we split it into four parts and then buffered each line file by 500 meters and dissolved the results.
  - Final_FinalRoadsBuff500_Part1_dis
  - Final_FinalRoadsBuff500_Part2_dis
  - Final_FinalRoadsBuff500_Part3_dis
  - Final_FinalRoadsBuff500_Part4_dis
- We then unioned the four files together with a polygon file representing all areas in the western U.S. Prior to this step and then coded a field called "Core" with "Non Core" for the road buffers, and "Core" for the western states. This created a polygon file with information about which polygons were made up non core area and which were made up core area based on distance from roads. We then added a field called "Final Core" and assigned all polygons a designation of core or non core based on the original "Core" fields (WestwideSecureCore).
- To further speed processing, we clipped the Westwide core layer (WestwideSecureCore), the BLM surface management layer, the density per square km by block layer, and the BLM and USFS sheep allotments layers to the San Juan and Sierra Nevada Mountains analysis area layers.
- We then unioned the core layers for each analysis area to the BLM surface management layer and calculated a new field called "ManagementCore" indicating those areas that were federal, state, or tribal areas or not. Using this field and the "Final Core" field we lastly calculated a field called "CoreByMgmt", which allowed us to code for core

managed by federal, state, or tribal agencies (federally managed core), core not managed by these agencies (non federally managed core), and non core
    - SanJuanMtnsStudyArea and
    - SierraNevadaMtnsStudyArea
- We next dissolved on the “CoreByMgmt” field (without multipart features checked). We then recalculated acres and added a new field called “FinalSecCore” to calculate contiguous acreages of secure core (federal, state and tribal lands with core >= 2,500 acres in size)) and secure habitat (federal, state and tribal lands with core >= 10 acres in size)
    - SanJuanMtnsStudyAreaDis_20201006
    - SierraNevadaMtnsStudyAreaDis_20201006
- Finally, we unioned these layers with the population per sq. km. by block, sheep allotment, and BLM surface management layers and recalculated acreages to create tabular output that could be used in a pivot table to summarize the findings of the analysis
    - SanJuanMtnsStudyArea_Final20201006 and SanJuanMtnsStudyArea_Final20201006.XLSX
    - SierraNevadaMtnsStudyArea_Final20201006 and SierraNevadaMtnsStudyArea_Final20201006.XLSX

Results

Secure Core Acreages and Maps for the San Juan Mountains

The tables and maps below show the breakdown of acres of secure core and non secure core areas for the San Juan historical range analysis area. These areas are also tabulated by surface management, within sheep allotments, and by census blocks with a population of 50 or more people / square mile.

San Juan Mountains Historical Range		
Habitat	**Acres**	**Percent Analysis Area**
Secure Core	**3,447,488**	**52.62**
Federal	3,381,062	51.61
State Government	40,594	0.62
Tribal Lands	25,832	0.39
Non-Secure Core	**3,103,845**	**47.38**
Federal	1,812,869	27.67
Local Government	33,102	0.51
Private	1,171,934	17.89
State Government	50,226	0.77
Tribal Lands	35,714	0.55
Total Analysis Area	**6,551,333**	

Table 1. San Juan Mountains Historical Range; Habitat areas by surface management.

San Juan Mountains Historical Range		
Habitat within Sheep Allotments	**Acres**	**Percent Analysis Area**
Secure Core	281,795	4.30
Non-Secure Core	177,639	2.71

Table 2. San Juan Mountains Historical Range; Habitat area within BLM or USFS sheep allotments.

San Juan Mountains Historical Range		
Habitat with Population >= 50 people / sq. mile	**Acres**	**Percent Analysis Area**
Secure Core	38	0.001
Non-Secure Core	32,765	0.500

Table 3. San Juan Mountains Historical Range; Habitat areas with population of 50 or more people per square mile.

Figure 1. San Juan Mountains secure core and surface management.

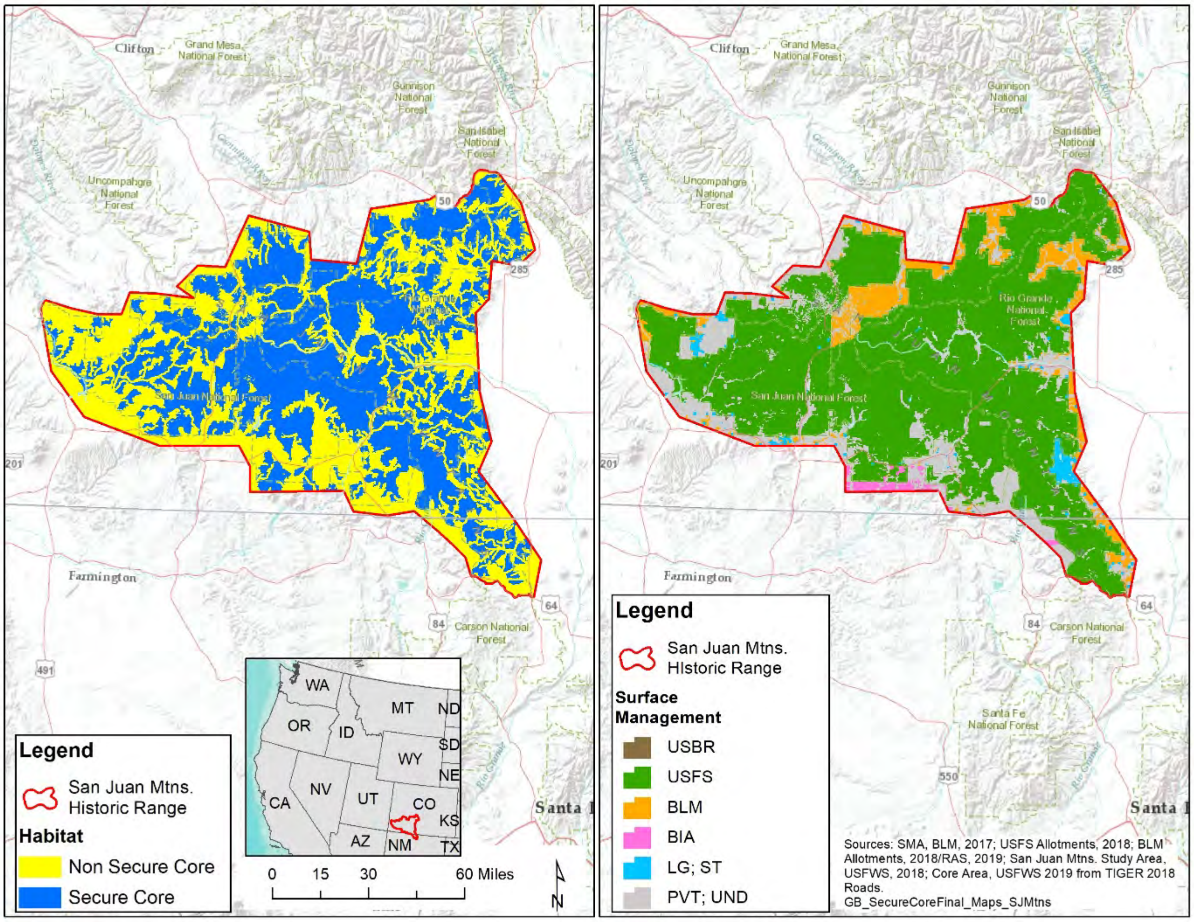
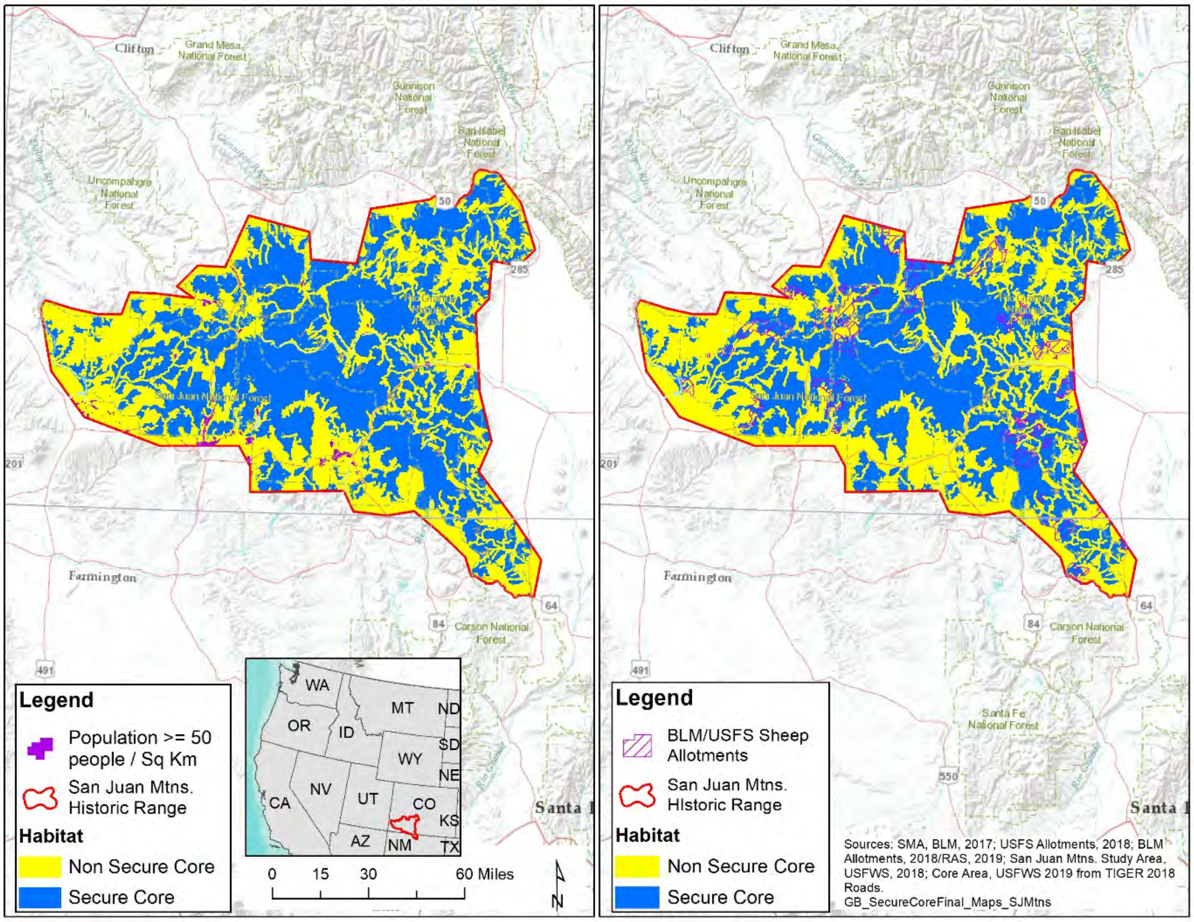


Figure 2. San Juan Mountains high population and sheep allotments in secure core and non secure core areas.



Secure Habitat Acreages and Maps for the San Juan Mountains

The tables and maps below show the breakdown of acres of secure habitat and non secure habitat areas for the San Juan historical range analysis area. These areas are also tabulated by surface management, within sheep allotments, and by census blocks with a population of 50 or more people / square mile.

San Juan Mountains Historical Range		
Habitat	**Acres**	**Percent Analysis Area**
Secure Habitat	**3,677,890**	**56.14**
Federal	3,595,912	54.89
State Government	48,958	0.75
Tribal Lands	33,020	0.50
Non-Secure Habitat	**2,873,440**	**43.86**
Federal	1,598,017	24.39
Local Government	33,103	0.51
Private	1,171,933	17.89
State Government	41,862	0.64
Tribal Lands	28,526	0.44
Total Analysis Area	**6,551,330**	

Table 4. San Juan Mountains Historical Range; Habitat areas by surface management.

San Juan Mountains Historical Range		
Habitat within Sheep Allotments	**Acres**	**Percent Analysis Area**
Secure Habitat	302,989	4.62
Non-Secure Habitat	156,445	2.39

Table 5. San Juan Mountains Historical Range; Habitat area within BLM or USFS sheep allotments.

San Juan Mountains Historical Range		
Habitat with Population >= 50 people / sq. mile	**Acres**	**Percent Analysis Area**
Secure Habitat	169	0.003
Non-Secure Habitat	32,634	0.501

Table 6. San Juan Mountains Historical Range; Habitat areas with population of 50 or more people per square mile.

Figure 3. San Juan Mountains secure habitat and surface management.

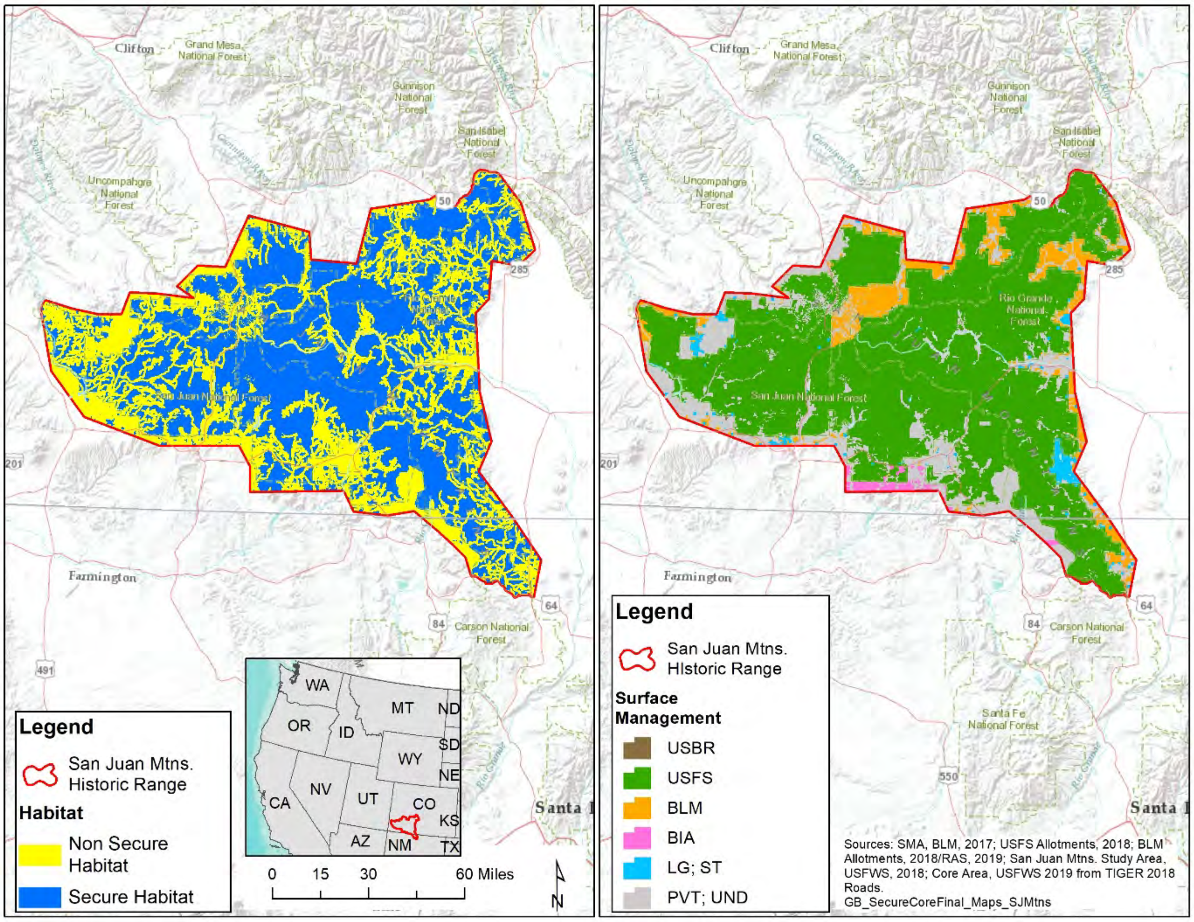
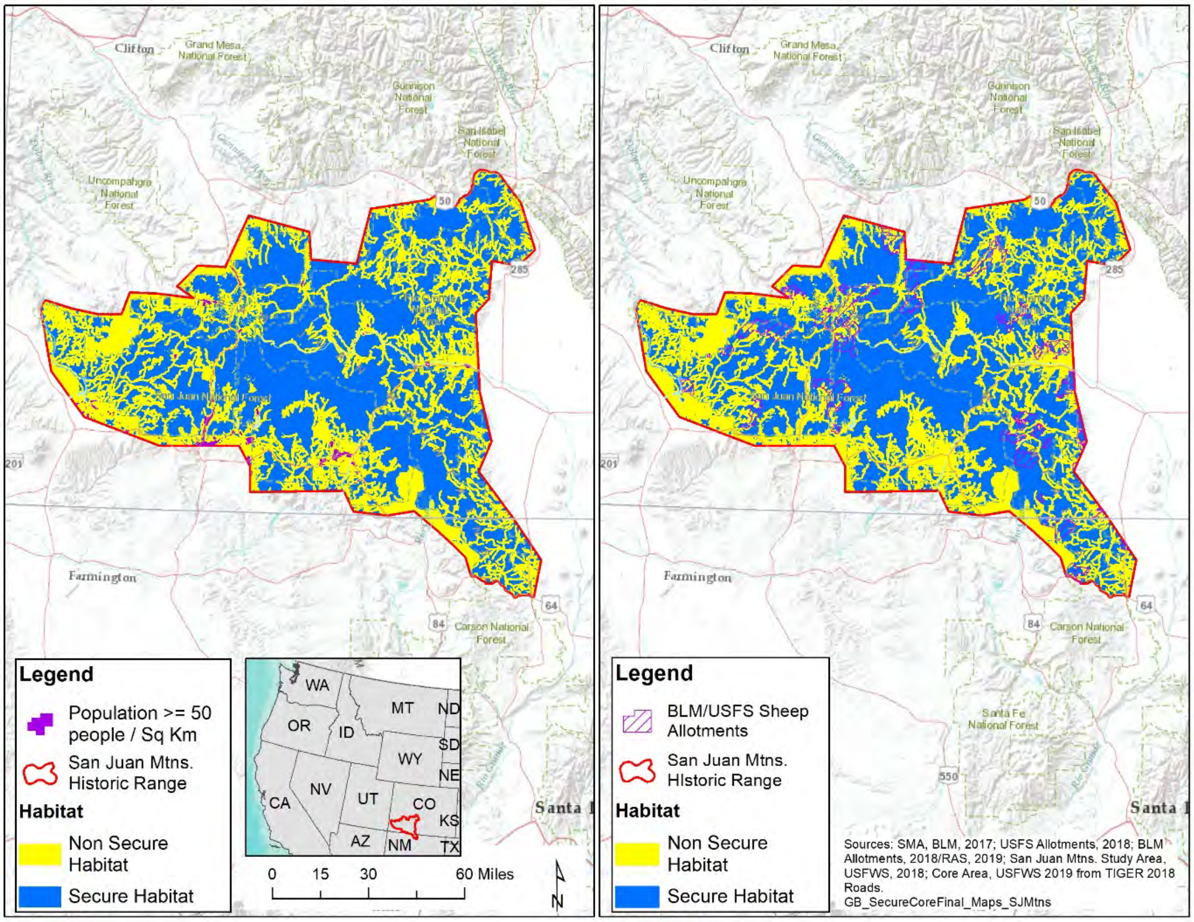


Figure 4. San Juan Mountains high population and sheep allotments in secure habitat and non secure habitat areas.



Secure Core Acreages and Maps for the Sierra Nevada Mountains

The tables and maps below show the breakdown of acres of secure core and non secure core (including areas not 500 m from an open or gated motorized route and "core; non secure," areas that are greater than 500 m from an open or gated motorized route but are not 2,500 acres in size) for the Sierra Nevada historical range analysis area. These areas are also tabulated by surface management, within sheep allotments, and by census blocks with a population of 50 or more people / square mile.

Sierra Nevada Mountains Historical Range		
Habitat	**Acres**	**Percent Analysis Area**
Secure Core	**5,591,258**	**43.07**
Federal	5,566,680	42.88
State Government	15,382	0.12
Tribal Lands	9,196	0.07
Non-Secure Core	**7,389,539**	**56.93**
Federal	4,158,418	32.04
Local Government	40,667	0.31
Private	3,106,631	23.93
State Government	66,771	0.51
Tribal Lands	17,052	0.13
Total Analysis Area	**12,980,797**	

Table 7. Sierra Nevada Mountains Historical Range; Habitat areas by surface management

Sierra Nevada Mountains Historical Range		
Habitat within Sheep Allotments	**Acres**	**Percent Analysis Area**
Secure Core	117,084	0.90
Non-Secure Core	264,280	2.04

Table 8. Sierra Nevada Mountains Historical Range; Habitat area within BLM or USFS sheep allotments

Sierra Nevada Mountains Historical Range		
Habitat with Population >= 50 people / sq. mile	**Acres**	**Percent Analysis Area**
Secure Core	525	0.004
Non-Secure Core	314,090	2.42

Table 9. Sierra Nevada Mountains Historical Range; Habitat areas with population of 50 or more people per square mile

Figure 5. Sierra Nevada Mountains secure core and surface management.

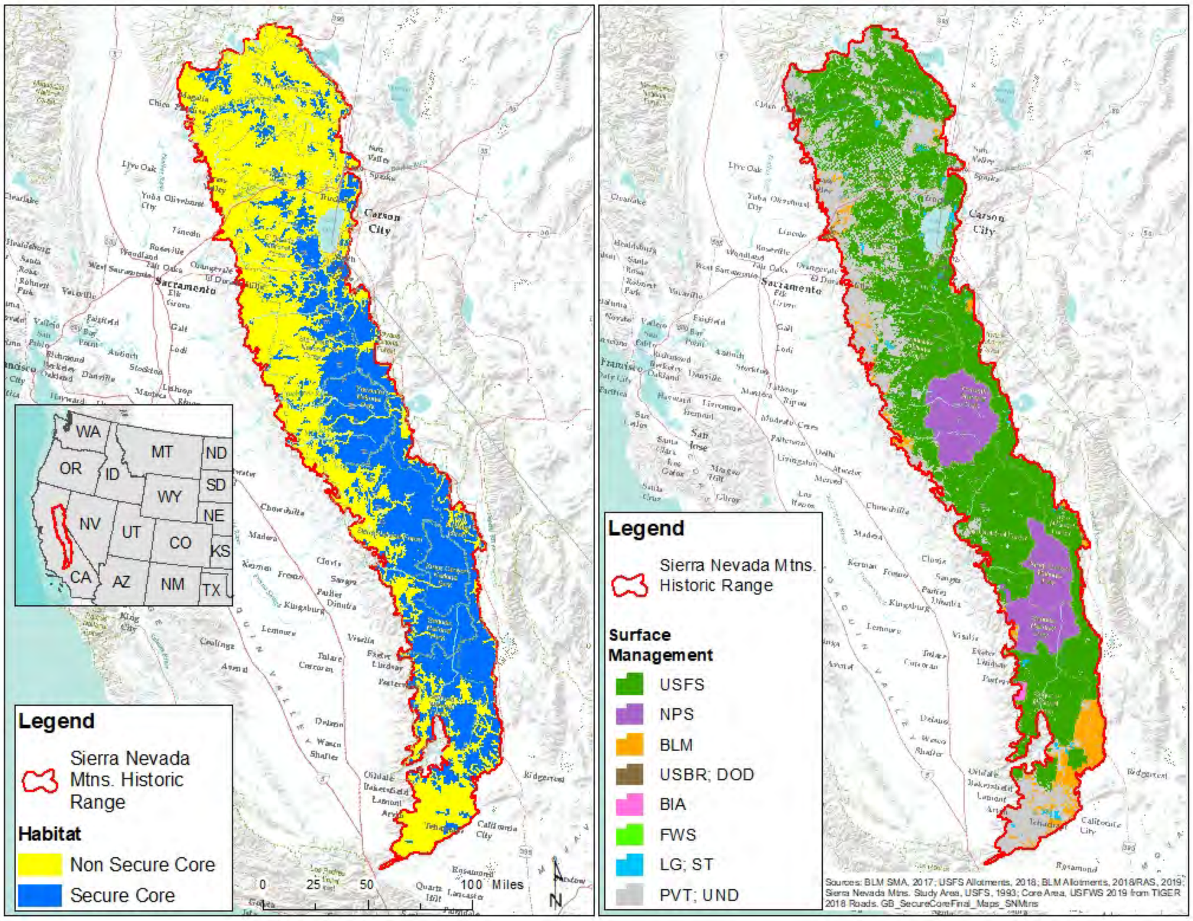
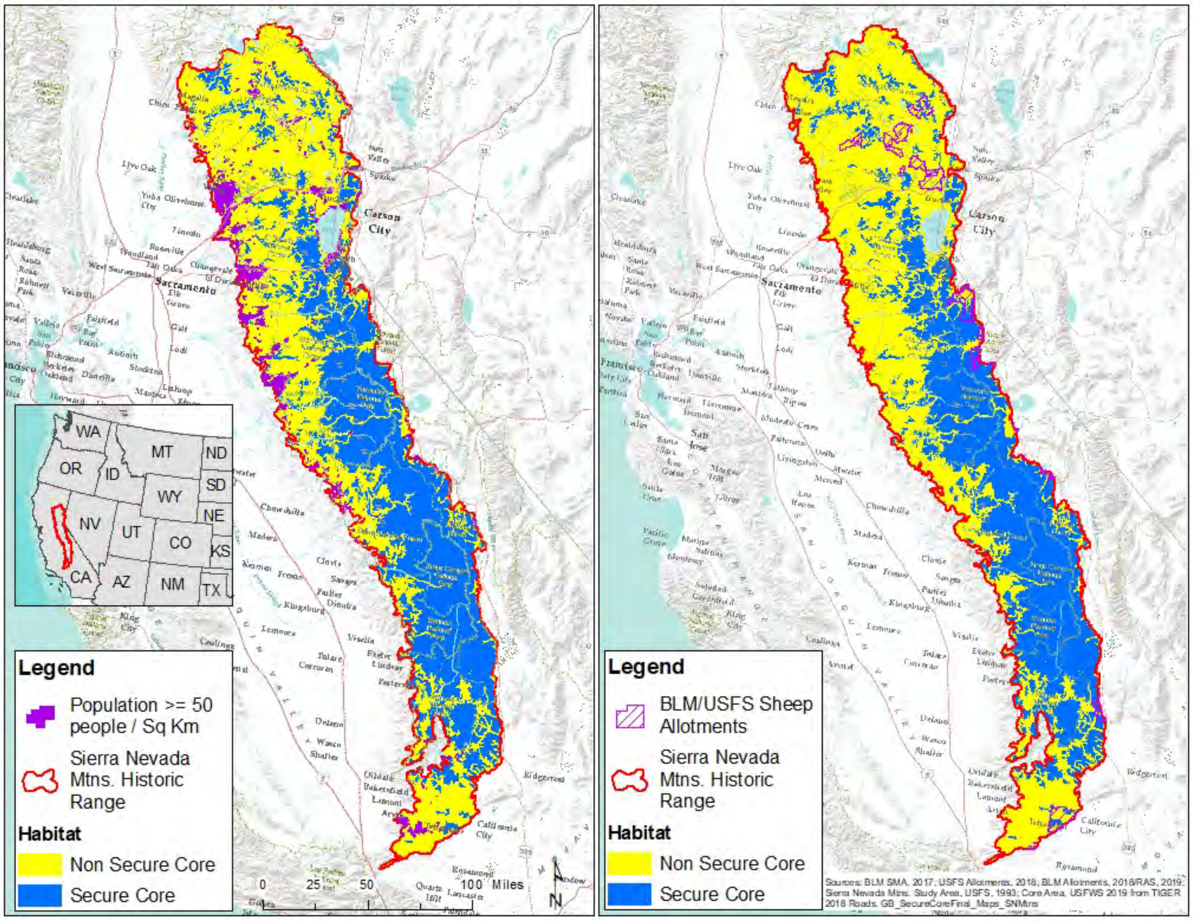


Figure 6. Sierra Nevada Mountains high population and sheep allotments in secure core and non secure core areas.



Secure Habitat Acreages and Maps for the Sierra Nevada Mountains

The tables and maps below show the breakdown of acres of secure habitat and non secure habitat (including areas not 500 m from an open or gated motorized route and "core; non secure," areas that are greater than 500 m from an open or gated motorized route but are not 10 acres in size) for the Sierra Nevada historical range analysis area. These areas are also tabulated by surface management, within sheep allotments, and by census blocks with a population of 50 or more people / square mile.

Sierra Nevada Mountains Historical Range		
Habitat	**Acres**	**Percent Analysis Area**
Secure Habitat	**6,134,441**	**47.26**
Federal	6,098,860	46.98
State Government	24,333	0.19
Tribal Lands	11,248	0.09
Non-Secure Habitat	**6,846,355**	**52.74**
Federal	3,626,236	27.94
Local Government	40,667	0.31
Private	3,106,631	23.93
State Government	57,820	0.45
Tribal Lands	15,000	0.12
Total Analysis Area	**12,980,796**	

Table 10. Sierra Nevada Mountains Historical Range; Habitat areas by surface management

Sierra Nevada Mountains Historical Range		
Habitat within Sheep Allotments	**Acres**	**Percent Analysis Area**
Secure Habitat	151,007	1.16
Non-Secure Habitat	230,357	1.77

Table 11. Sierra Nevada Mountains Historical Range; Habitat area within BLM or USFS sheep allotments

Sierra Nevada Mountains Historical Range		
Habitat with Population >= 50 people / sq. mile	**Acres**	**Percent Analysis Area**
Secure Habitat	1,1510	0.01
Non-Secure Habitat	313,105	2.41

Table 12. Sierra Nevada Mountains Historical Range; Habitat areas with population of 50 or more people per square mile

Figure 7. Sierra Nevada Mountains secure habitat and surface management.

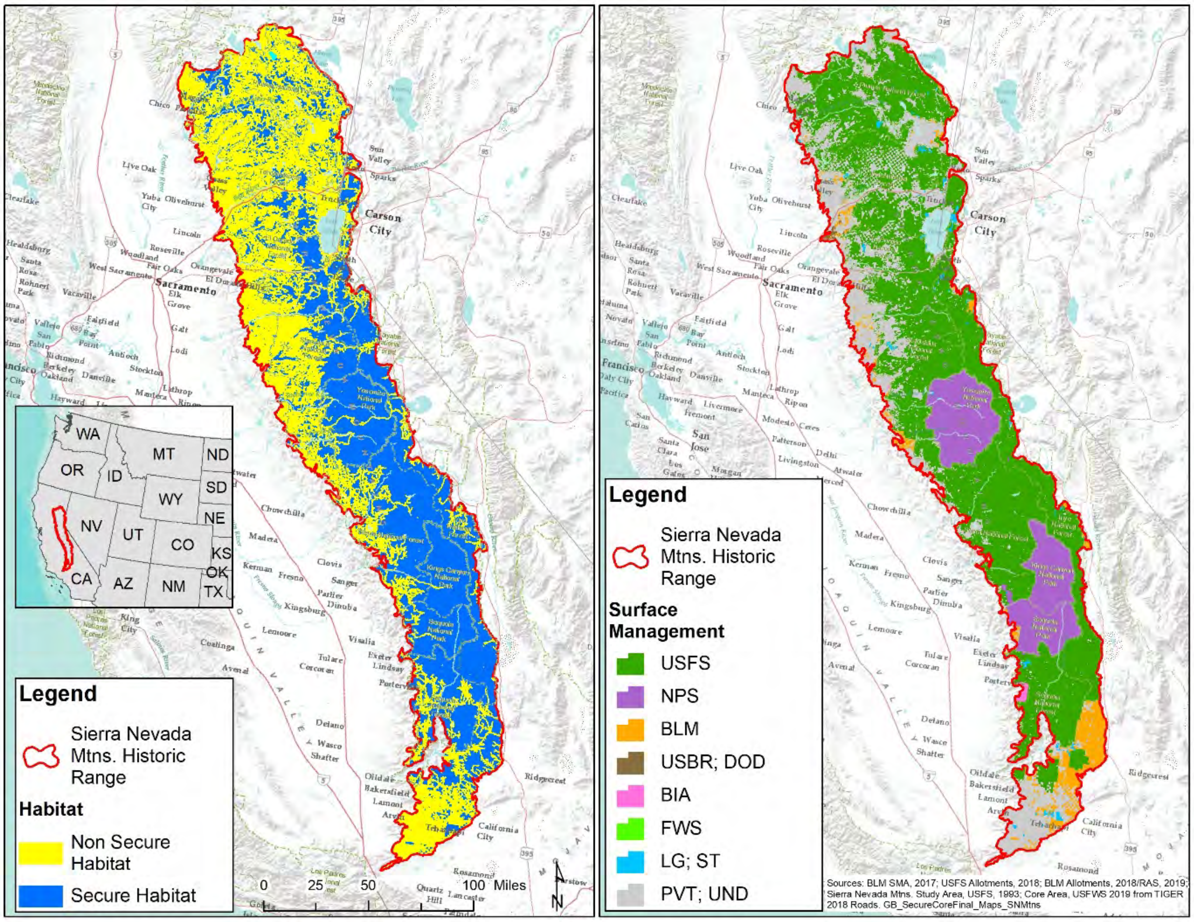
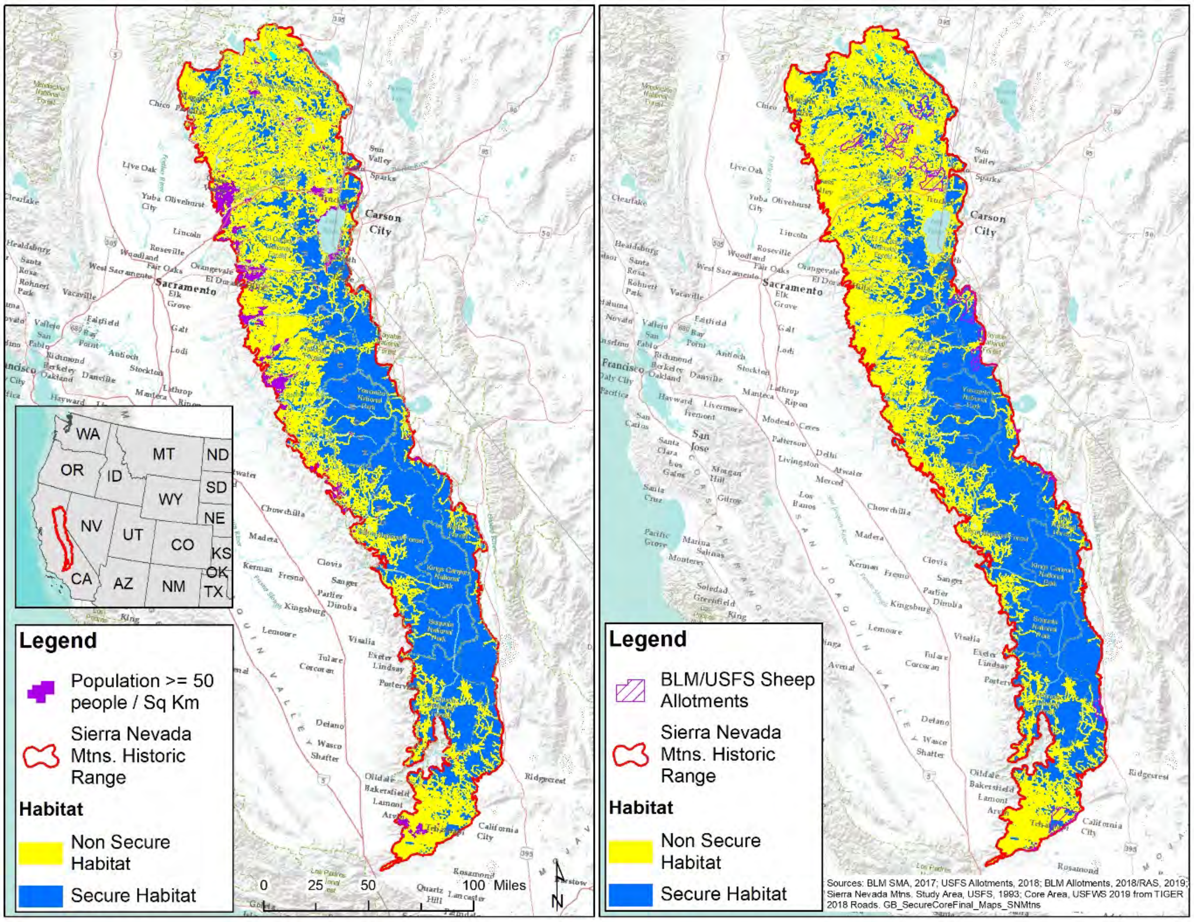


Figure 8. Sierra Nevada Mountains high population and sheep allotments in secure habitat and non secure habitat areas.



Appendix B. Secure Habitat Background

The Interagency Grizzly Bear Committee Taskforce Report on Grizzly bear/motorized access management was first released in 1994 and revised in 1998 (in their entirety: IGBC 1994, 1998). Management of motorized access is one of the most influential factors affecting habitat security for wildlife, including grizzly bears (Mattson *et al.* 1987; Mace and Manley 1993; USFWS 1993; Christensen *et al.* 1993). The Taskforce Report recognized that by managing motorized access, the following grizzly bear management objectives can be met (IGBC 1998, p. 1):

- Minimize human interactions and potential grizzly bear mortality;
- Minimize displacement from important habitats;
- Minimize habituation to humans; and
- Provide relatively secure habitat where energetic requirements can be met.

Historically, management of motorized use has been primarily accomplished through restriction of certain types of motorized use on established access routes. In addition to open and total road densities, the presence of core areas, areas free of motorized traffic and high levels of human use, are important to the management of human access (IGBC 1998, p. 1). The Taskforce Report recommended three parameters, with definitions and methods of measurement, to provide for a consistent approach to motorized access management between and within grizzly bear ecosystems: (1) open motorized route density, (2) total motorized route density, and (3) core areas (IGBC 1998, p. 1). Motorized route densities are calculated using a moving window analysis and are reported as the percentage of the analysis area with greater than 1 mi/mi^2 open motorized routes and 2 mi/mi^2 total motorized routes. Core areas are reported as the percentage of the analysis area that are greater than 500 m (1,650 ft) from any open motorized route or high-use non-motorized route and in place for at least 10 years. The Taskforce did not recommend minimum size for core areas. The Taskforce Report recognized that each ecosystem subcommittee would apply these recommendations based on ecosystem-specific information and recommend ecosystem specific habitat conditions that should be maintained to provide habitat security.

There is no published method to deductively calculate minimum habitat values required for a healthy and recovered population. Grizzly bears are long-lived, opportunistic omnivores whose food and space requirements vary depending on a multitude of environmental and behavioral conditions and on variation in the experience and knowledge of each individual bear. Grizzly bear home ranges overlap and change seasonally, annually, and with reproductive status. These characteristics make the development of habitat criteria complicated. We established criteria for the GYE and NCDE by assessing the habitat features that were compatible with a stable to increasing grizzly bear population in the past, and then used these habitat conditions as threshold values that must be maintained to ensure a healthy population (i.e., a "no net loss" or baseline approach), as suggested by Nielsen *et al.* (2006, p. 227). Because of the inability to calculate minimum habitat values for a recovered population, we use a "no net loss" approach by assessing what habitat factors are compatible with a stable to increasing grizzly bear population.

Greater Yellowstone Ecosystem (GYE)

The Service, in cooperation with the IGBC, held a workshop in 1997 to allow interested parties to present their ideas on the habitat needs for grizzly bear recovery and discuss proposals for habitat-based recovery criteria. Information gathered at the workshop was considered in drafting the habitat criteria for the Greater Yellowstone Area that were first released for public comment in 1999. These same criteria were included in the draft Conservation Strategy that was released for public comment in 2000. After analysis of public comment led to development of the habitat standards in the 2007 Conservation and the Recovery Plan Supplement: Habitat-based Recovery Criteria for the Yellowstone Ecosystem.

The 1998 baseline for habitat standards was chosen because the levels of secure habitat and developed sites on public lands remained relatively constant in the 10 years preceding 1998 (USDA FS 2004, pp. 140–141), and the selection of 1998 ensured that habitat conditions existing at a time when the population was increasing at a rate of 4 to 7 percent per year (Schwartz *et al.* 2006b, p. 48) would be maintained. In addition to measures for motorized routes and secure core habitat, as recommended in the Taskforce Report, the baseline sets measures for developed recreation sites and livestock allotments. The overall habitat goal is to maintain habitat conditions at or improved upon baseline conditions, with limited exceptions as set forth in the YES Conservation Strategy (YES 2016a).

For the GYE, secure habitat refers to those areas with no motorized access that are at least 10 acres (0.31 km^2 (0.016 mi^2)) in size and more than 500 m (1,650 ft) from a motorized access route (open or gated) or recurring helicopter flight line (USDA FS 2004, p. 18). Our definition of secure habitat includes areas as small as 10 acres (0.31 km^2 (0.016 mi^2)) in size because both the IGBST and YES concluded that all secure habitats are important for grizzly bears in the GYE, regardless of size, particularly in peripheral areas. Research by Schwartz *et al*. (2010, p. 661) supported this conclusion and demonstrated a direct link between this definition and grizzly bear survival in the GYE. If the minimum size of secure habitat was enlarged, the end result would be that thousands of acres of secure habitat would no longer be considered secure and would, therefore, not be subject to the "no net loss" standard. By using a smaller minimum acreage requirement, we are not excluding any of the larger blocks of secure habitat. Non-motorized trails were not excluded from secure core because research indicates that non-motorized trails do not significantly affect grizzly bear survival, and that survival is better explained by the absence of motorized routes (Schwartz *et al*. 2010, p. 659).

Northern Continental Divide Ecosystem (NCDE)

In a study of female grizzly bears in the South Fork of the Flathead River in the NCDE, female home ranges averaged 19 percent total road density >2 mi/mi^2, 19 percent open road density >1 mi/mi^2, and 68 percent core area (Manley 1993, *in litt.*). This level of secure core habitat was determined to be necessary for successfully reproducing adult female grizzly bears (Manley 1993, *in litt.*). As a result, Amendment 19 was used as a habitat management strategy for the Flathead National Forest (USFWS 1995, entire). Amendment 19 included no net increase in TMRD density greater than >2 mi/mi^2, no net increase in OMRD greater than >1 mi/mi^2, and no net decrease in the amount or size of security core. Furthermore, it established objectives: to limit OMRD densities of >1 mi/mi^2 to no more than 19 percent of a BMU subunit; to limit TMRD densities of >2 mi/mi^2 to no more than 19 percent of a BMU subunit; and to provide security core areas that equal or exceed 60 percent of each BMU subunit in 5 years and 68 percent in 10 years.

Significant efforts made by the USFS led to the majority of the BMU subunits in the NCDE meeting the Amendment 19 objectives. Monitoring of the NCDE grizzly bear population show that the number of bears substantially exceed the minimum population size goal stated in the 1993 Recovery Plan (391 bears) (Service 1993, p. 62), the population is well distributed throughout the Recovery Zone, and the population has expanded its geographic distribution well beyond the Recovery Zone boundary (Kendall *et al.* 2009; Mace *et al.* 2012; Costello *et al.* 2016), even though not every BMU subunit meets the 19-19-68 percentage objective of Amendment 19. Based on updated NCDE grizzly bear population data and our understanding about grizzly bear responses to human activities and management, in 2009 a Conservation Strategy Technical Team was appointed by the NCDE Subcommittee and began to re-evaluate habitat standards for the NCDE grizzly bear population. A draft Conservation Strategy was released in 2013 for public comment and peer review. The NCDE Subcommittee re-assembled the Conservation Strategy Team and finalized the Conservation Strategy in 2018.

Based on an estimated growth rate for the NCDE grizzly bear population of 2–3 percent annually from 2004–2011, the NCDE Subcommittee decided to establish habitat conditions in December 31, 2011, as a reasonable and conservative baseline that would likely support a robust, stable to increasing grizzly bear population. In addition to measures for motorized routes and secure core habitat, as recommended in the Taskforce Report, the baseline sets measures for developed recreation sites and livestock allotments. The overall habitat goal is to maintain habitat conditions at or improved upon baseline conditions, with limited exceptions as set forth in the NCDE Conservation Strategy (NCDE Subcommittee 2018)

For the NCDE, secure core habitat is defined as those areas on Federal lands within the analysis area more than 500 m (1,650 ft) from a motorized access route and at least 2,500 acres (10.1 km^2 (3.9 mi^2)) in size, and in place for 10 years (Service 2018, pp. 5, 12). The 2,5000 acre (10.1 km^2 (3.9 mi^2)) minimum size for secure core habitat is based on the 1994 IGBC Guidelines that state minimum size will be recovery zone specific and that "the minimum size for the core area(s) be that area necessary to support a female grizzly bear for 24 hours of foraging." Information and research specific to the NCDE indicated that 83 percent of documented locations of radio-collared females were in habitat that did not have motorized access that were usually at least 2,200 acres in size (USFWS 1997). Non-motorized trails were not excluded from secure core because research indicates that non-motorized trails do not significantly affect grizzly bear survival, and that survival was better explained by the absence of motorized routes (Schwartz *et al*. 2010, p. 659).

Cabinet-Yaak (CYE) and Selkirk Ecosystems (SE)

Wakkinen and Kasworm (1997, entire) created road density and core area maps for the CYE and SE based on the definitions set forth in the Taskforce Report. Based on female grizzly bear radio telemetry data, they determined the proportion of home ranges with >2 mi/mi^2 total road density, >1 mi/mi^2 open road density, and the amount of core area are appropriate access management standards for the CYE and SE (Wakkinen and Kasworm 1997, p. 22). The female home ranges averaged 26 percent total road density >2 mi/mi^2, 33 percent open road density >1 mi/mi^2, and 55 percent core area. No minimum core area size was determined because of the small sample size (Wakkinen and Kasworm 1997, p. 23). Wakkinen and Kasworm (1997, pp. 24–25) speculated that differences in the percentage of core areas within home ranges between the NCDE and the CYE and SE may be due to the lack of larger core areas available in the CYE and SE, different computer software to conduct the analysis, and/or differences in levels of human use on roads between the ecosystems. The recommendations by Wakkinen and Kasworm (1997, pp. 24–25) for OMRD, TMDR, and core area were incorporated into the Forest Plan Amendments for the Motorized Access Management within the Selkirk and Cabinet-Yaak Grizzly Bear Recovery Zones (USDA FS 2011, entire).

North Cascades Ecosystem

Core areas for the North Cascades are defined as those areas greater than 500 m (1,650 ft) from any open motorized route or high-use non-motorized route, as set forth by the Taskforce Report (USDA FS 1997, entire). The North Cascades Ecosystem Subcommittee agreed to a phased approach to identify and protect “core area” (USDA FS 1997, p. 1). The Federal land management agencies agreed to manage for “no net loss” of core area until “seasonal habitat has been defined, mapped and its availability evaluated” (USDA FS 1997, p. 3). In addition, they identified the need to do further work to define “high use non-motorized trails” for the North Cascades (USDA FS 1997, p. 1).

Bitterroot Ecosystem (BE)

Ecosystem specific data are not available, and motorized access and core area standards have not yet developed for the BE.

Appendix C. Methods Used to Measure Population Trends and Annual Estimates

Wildlife managers and population ecologists monitor a number of factors to gauge the status of a population and make scientifically informed decisions. These measures include population size, population trend, density, and current range. While population size is a well-known and easily understood metric, it only provides information about a population at a single point in time. Wildlife managers often want to know how a population is changing over time and why. As managers and technical experts review new techniques or approaches for potential adoption, they should consider the technique's cost, field sampling logistics, utility to managers, and the ability to retroactively apply population estimates to previous years of data are considered.

Greater Yellowstone Ecosystem (GYE)

The IGBST uses four independent methods to estimate population trend: (1) the model-averaged Chao2 method, which is also used to estimate population size; (2) Mark-Resight estimator (i.e., capture-recapture data (IGBST annual reports)); (3) population projections from known-fate analysis (in their entirety: Schwartz *et al*. 2006b; IGBST 2012); and (4) population reconstruction (minimum number of known live) based on capture and mortality records (IGBST, unpublished data).

Model-Averaged Chao2 Population Estimator: The model-averaged Chao2 population estimator is currently the best available science to derive annual estimates of total population size in the GYE. The basis for the estimation is an annual count of female grizzly bears with cubs-of-the-year, based on sightings on aerial surveys and ground observations. Those sightings are clustered into those estimated to be from the same family group (i.e., female with cubs-of-the-year) using a "rule set" to avoid duplicate counts, primarily based on spatial, temporal, and litter size criteria (Knight *et al.* 1995). In clustering the observations, a balance must be obtained between overestimating or underestimating the actual number of unique females with cubs-of-the-year. The rule set was constructed to be conservative (i.e., reduce Type I errors or mistakenly identifying sightings of the same family as different families). Using the frequencies of sightings of unique females with cubs-of-the-year obtained from application of the rule set, an annual estimate of the total number of females with cubs-of-the-year is calculated using the Chao2 estimator, a bias-corrected estimator that is robust to differences in sighting probabilities among individuals (Chao 1989; Keating *et al.* 2002; Cherry *et al.* 2007). In the final step, the annual estimate of total number of females with cubs-of-the-year is combined with those of previous years to assess trend. Changes in numbers of females with cubs-of-the-year are representative of the rate of change for the entire population, but additional process variation comes from the proportion of females that have cubs-of-the-year.

Annual estimates of females with cubs-of-the-year based on Chao2 have been reported by IGBST since 2005, accompanied by the derivation of total population estimates. The model-averaged Chao2 estimates of females with cubs-of-the-year and derived total population estimates have been applied and reported by the IGBST since 2007.

Other Methods: The known-fate analysis method is the IGBST's primary method for estimating population trend. The known-fate analysis method uses estimates of vital rates derived from radio-monitoring a representative sample of grizzly bears in the GYE (e.g., see Schwartz *et al*. 2006b; IGBST 2012). Those vital rates include annual survival rates for independent male and female grizzly bears, age of first reproduction, litter size, and survival of dependent young (i.e., cubs of the year and yearlings) that accompany their radio-marked mothers. The estimated number of unique females with cubs-of-the-year used in the Chao2 method do not enter into those population projections and thus represent an independent data source. However, IGBST can also estimate trend using the Chao2-corrected annual counts of unique females with cubs. Although not a primary IGBST method for assessing trend, a is that the trend for this observable segment of the population (i.e., females with cubs-of-the-year) is representative of trend for the entire population.

In order to derive an annual population estimate (rather than calculation of population trend), the IGBST uses both the end point for the model-averaged result of the linear and quadratic regressions of the Chao2-corrected counts, combined with vital rates estimates from the known-fate analyses (see IGBST 2012, p. 39).

Northern Continental Divide Ecosystem (NCDE)

In the NCDE, the population trend is estimated using two methods: (1) a deterministic life table analysis; and (2) individual-based, stochastic population modeling (Costello *et al.* 2016, p. 69). The population estimate is based on a genetic capture/recapture study conducted in 2004 (Kendall *et al.* 2009, entire) and subsequent estimates of population trend (Costello *et al.* 2016, p. 16).

Deterministic life table analysis: The deterministic life-table analysis approach involves estimates of vital rates, does not incorporate uncertainty, and is a female-only rate. It computes the deterministic asymptomatic rate of population growth (lambda; λ) using a standard, dynamic life table and solving iteratively for *r* (i.e., the intrinsic rate of growth). Costello *et al.* (2016, p. 69) estimated λ using "three point estimates of independent female survival: (1) maximum (0.951), obtained when unknown-fate females were censured; (2) minimum (0.943), obtained when unknown-fate females were assumed dead; and (3) the mean of those two estimates (0.947).

Individual-based, stochastic population modeling: Individual-based, stochastic population modeling is based on vital rates all sex/age classes and the uncertainty associated with each vital rate. This estimate uses RISKMAN to stochastically model population growth based on estimated recruitment rates, dependent bear survival rates, and independent bear survival rates for both males and females (Costello *et al.* 2016, p. 69).

Genetic capture/recapture population estimate: In 2004, a noninvasive genetic sampling effort was conducted within occupied areas of the NCDE (Kendall *et al.* 2009, entire). DNA data was included from hair traps, bear rubs, and physical captures to construct individual bear encounter histories in a Huggins-Pledger closed mark-recapture model to estimate population size. Lured hair traps were systematically distributed using a grid of 7x7 km cells across estimated occupied areas. Within each cell placement of the hair snare was based on evidence of ear activity, presence of natural travel routes, seasonal vegetation characteristics, and indices of recent wildfire severity. Bears naturally rub on trees, power poles, wooden signs and fence posts, and barbed wire fences, and thus did not require the use of lure. Physical capture information included bears handled for research or management or that were identified during other hair sampling studies from 1975-2007.

Cabinet-Yaak and Selkirk Ecosystems (CYE and SE)

In the CYE and SE the population trend is determined by female survival and fecundity rates determined through radio collar monitoring (Kasworm *et al.* 2020a, pp. 38–40, Kasworm *et al.* 2020b, pp. 26–27). Bootstrapping techniques are used to estimate lambda and associated confidence intervals (Hovey and McLellan 1996, entire).

Annual CYE population estimates are obtained by applying the rate of growth to a 2012 population estimate (Kasworm *et al* 2020a, p. 40). The 2012 estimate was developed from a mark-recapture effort using hair traps and rub trees (Kendall *et al*. 2016, entire). Kasworm *et al.* (2020a, p. 29) also estimate a minimum number of individuals identified in annual collared bear monitoring, captures, hair sampling, and trail camera photographs, minus any known mortality.

In the SE, population estimates are obtained by applying the rate of growth to a 2002 population estimate (Kasworm *et al.* 2020b, pp. 26-27). The 2002 estimate was developed from a mark recapture effort using hair corrals in the B.C. portion of the SE in 2002 (Proctor *et al.* 2007, p. 3). Kasworm *et al*. (2020b, p. 19) also estimate a minimum number of individuals identified in annual collared bear monitoring, captures, hair sampling, and trail camera photographs, minus any known mortality.

The 1993 Recovery Plan details a method to calculate a minimum population estimate based on a 6-year average of unduplicated females with cubs to stabilize the averaged based on a 3-year reproductive cycle. The 6-year average of females with cubs is multiplied by three to estimate the number of adult females in the population given that on average, either 28 percent (CYE) or 33 percent (SE) of the population is made of adult females. The minimum number of females with cubs likely underestimates the actual number because reporting efficiency of females with cubs is estimated to be 60 percent. The proportion of adult females in the population is based on the proportion adults: subadults in the population and the sex ratio of males: females for both subadults and adults. The minimum population size is calculated by dividing 6-year average observed females with cubs by 0.6 then dividing by the adult female proportion of the population

(Service 1993, pp. 83–84, 101–102; Kasworm *et al.* 2020a, p. 16.; Kasworm *et al.* 2020b, pp. 12–13).

Appendix D. Suitable Habitat in the GYE

For the purposes of this biological report, "suitable habitat" is considered the area within the larger GYE ecosystem capable of supporting grizzly bear reproduction and survival now and in the future. Suitable habitat is generally associated with mountains and forested lands that are primarily owned and managed by Federal agencies. We defined "suitable habitat" for grizzly bears as areas having three characteristics:

(1) Being of adequate habitat quality and quantity to support grizzly bear reproduction and survival;
(2) Being contiguous with the current distribution of GYE grizzly bears such that natural recolonization is possible; and
(3) Having low mortality risk as indicated through reasonable and manageable levels of grizzly bear mortality.

Our definition and delineation of suitable habitat is built on the widely accepted conclusions of extensive research that grizzly bear reproduction and survival is a function of both the biological needs of grizzly bears and remoteness from human activities, which minimizes mortality risk for grizzly bears (Craighead 1980, pp. 8–11; Knight 1980, pp. 1–3; Peek *et al.* 1987, pp. 160–161; Merrill *et al.* 1999, pp. 233–235; Schwartz *et al.* 2010, p. 661).

Our first criteria in defining suitable habitat involved analyzing land cover types. Mountainous areas provide hiding cover, the topographic variation necessary to ensure a wide variety of seasonal foods, and the steep slopes used for denning (Judd *et al.* 1986, pp. 114–115; Aune and Kasworm 1989, pp. 29–58; Linnell *et al.* 2000, pp. 403–405). Higher elevation, mountainous regions in the GYE (Omernik 1987, pp. 118–125; Omernik 1995, pp. 49–62; Woods *et al.* 1999, entire; McGrath *et al.* 2002, entire; Chapman *et al.* 2004, entire) contain high-energy foods such as whitebark pine seeds (Mattson and Jonkel 1990, p. 223; Mattson *et al.* 1991*a*, p. 1623) and army cutworm moths (Mattson *et al.* 1991*b*, 2434; French *et al.* 1994, p. 391). For our analysis of suitable habitat, we considered the Middle Rockies ecoregion, within which the GYE is contained (Omernik 1987, pp. 120–121; Woods *et al.* 1999, entire; McGrath *et al.* 2002, entire; Chapman *et al.* 2004, entire), to meet grizzly bear biological needs providing food, seasonal foraging opportunities, cover, and denning areas (Mattson and Merrill 2002, p. 1125).

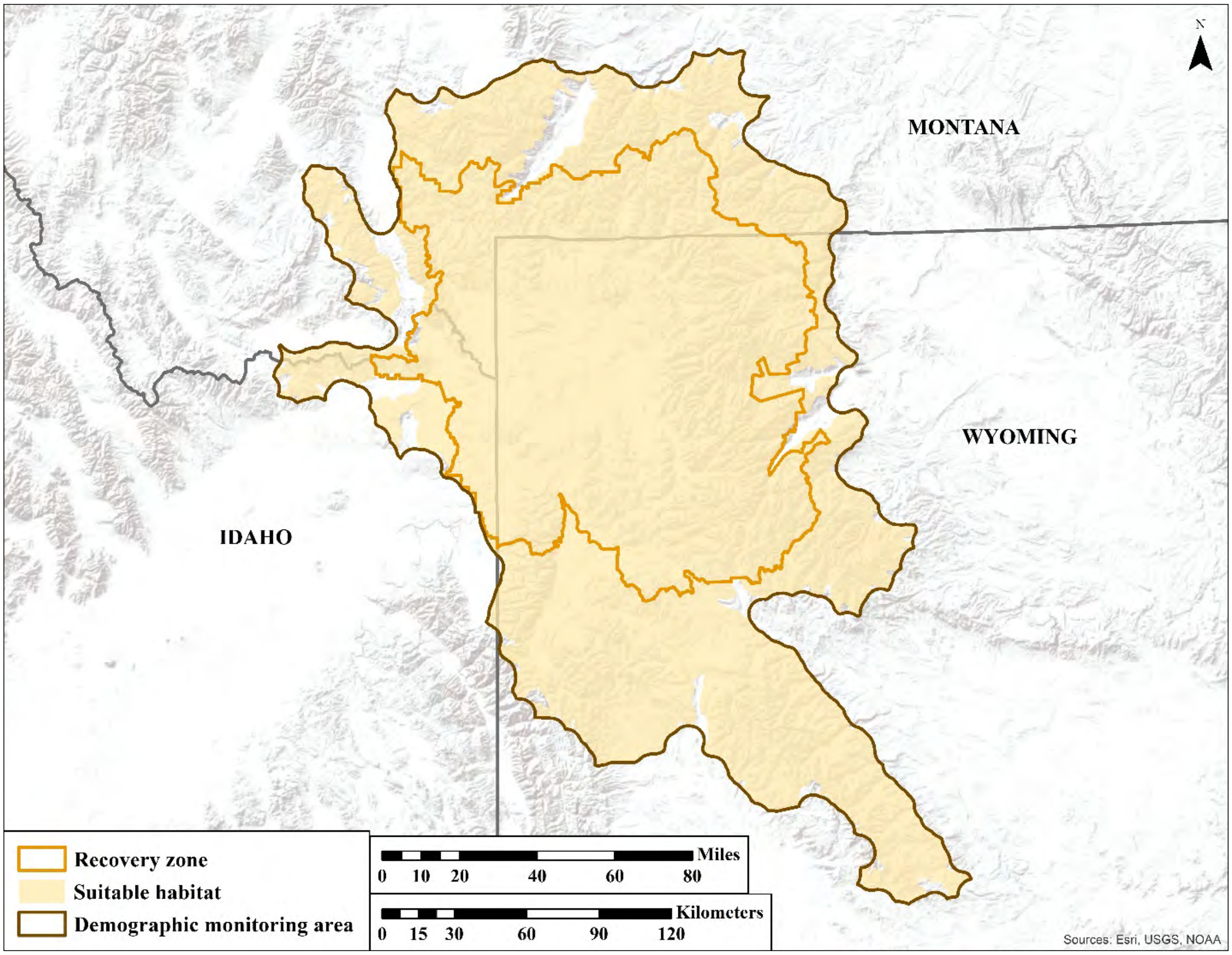


Figure 37. Map of the Greater Yellowstone Ecosystem (GYE). Boundaries are shown for: (1) the recovery zone; (2) the Demographic Monitoring Area; and (3) biologically suitable habitat.

Although grizzly bears historically occurred throughout the area of the larger GYE ecosystem (Stebler 1972, pp. 297–298), today many of these habitats are not biologically suitable for grizzly bears. For example, we did not include drier sagebrush, prairie, or agricultural lands within our definition of suitable habitat because these land types no longer contain adequate food resources (i.e., bison) to support grizzly bears. While there are records of grizzly bears in eastern Wyoming near present-day Sheridan, Casper, and Wheatland, even in the early 19th century, indirect evidence suggests that grizzly bears were less common in these eastern prairie habitats than in mountainous areas to the west (Rollins 1935, p. 191; Wade 1947, p. 444). Grizzly bear presence in drier, grassland habitats was associated with rivers and streams where grizzly bears used bison carcasses as a major food source (Burroughs 1961, pp. 57–60; Herrero 1972, pp. 224–227; Stebler 1972, pp. 297–298; Mattson and Merrill 2002, pp. 1128–1129). Most of the short-grass prairie on the east side of the Rocky Mountains has been converted into agricultural land (Woods *et al.* 1999, entire), and high densities of traditional food sources are no longer available due to land conversion and human occupancy of urban and rural lands. Traditional food sources such as bison and elk have been reduced and replaced with domestic livestock such as cattle, sheep, chickens, goats, pigs, and beehives, which can become anthropogenic sources of prey for grizzly bears. While food sources such as grasses and berries are abundant in some years in the riparian zones within which the bears travel, these are not reliable every year and can only support a small number of bears. These nutritional constraints and the potential for human-bear conflicts limit the potential for a self-sustaining population of grizzly bears to develop in the prairies, although we expect some grizzly bears to live in these areas. Because wild bison herds no longer exist in these areas, and are mainly contained within YNP in the GYE, they are no longer capable of contributing in a meaningful way to the overall status of the GYE grizzly bear.

Bears in these peripheral areas (i.e., prairie habitats) will not establish self-sustaining, year-round populations due to a lack of suitable habitat, land ownership patterns, and the lack of traditional, natural grizzly bear foods (i.e., bison). Instead, bears in these peripheral areas will likely always rely on the GYE grizzly bear population inside the DMA as a source population. Grizzly bears in these peripheral areas are not biologically necessary to the GYE grizzly bear population and a lack of occupancy outside the DMA boundaries in peripheral areas will not impact the resiliency of the GYE grizzly bear population. Grizzly bear recovery in these portions of the species' historical range is unnecessary, because there is more than enough suitable habitat to support a viable grizzly bear population as set forth in the demographic recovery criteria. Therefore, additional recovery efforts in these areas are beyond what is required by the Act.

Our second criteria in defining suitable habitat involved analyzing human-caused mortality risk, as this can impact which habitat might be considered suitable. Some human-caused mortality is unavoidable in a dynamic system where hundreds of bears inhabit large areas of diverse habitat with several million human visitors and residents. The negative impacts of humans on grizzly bear survival and habitat use are well documented (Harding and Nagy 1980, p. 278; McLellan and Shackleton 1988, pp. 458–459; Aune and Kasworm 1989, pp. 83–103; McLellan 1989, pp. 1862–1864; McLellan and Shackleton 1989b, pp. 377–378; Mattson 1990, pp. 41–44; Mattson and Knight 1991, pp. 9–11; Mace *et al.* 1996, p. 1403; McLellan *et al.* 1999, pp. 914–916; White *et al.* 1999, p. 150; Woodroffe 2000, pp. 166–168; Boyce *et al.* 2001, p. 34; Johnson *et al.* 2004, p. 976; Schwartz *et al.* 2010, p. 661). These effects range from temporary displacement to actual mortality. Grizzly bear persistence in the contiguous United States between 1920 and 2000 was negatively associated with human and livestock densities (Mattson and Merrill 2002, pp. 1129–1134).

As human population densities increase, the frequency of encounters between humans and grizzly bears also increases, resulting in more human-caused grizzly bear mortalities due to a perceived or real threat to human life or property (Mattson *et al.* 1996, pp. 1014–1015). Similarly, as livestock densities increase in habitat occupied by grizzly bears, depredations follow. Although grizzly bears frequently coexist with cattle without depredating them, when grizzly bears encounter domestic sheep, they usually are attracted to such flocks and depredate the sheep (Jonkel 1980, p. 12; Knight and Judd 1983, pp. 188–189; Orme and Williams 1986, pp. 199–202; Anderson *et al.* 2002, pp. 252–253). If repeated depredations occur, managers either relocate the bear or remove it (i.e., euthanize or place in an approved American Zoological

Association facility) from the population, resulting in such domestic sheep areas becoming population sinks (areas where death rates exceed birth rates) (Knight *et al.* 1988, pp. 122–123). Because urban sites and sheep allotments possess high mortality risks for grizzly bears, we did not include these areas as suitable habitat (Knight *et al.* 1988, pp. 122–123). Based on 2000 census data, we defined urban areas as census blocks with human population densities of more than 50 people per km^2 (129 people per mi^2) (U.S. Census Bureau 2005, entire). Cities within the Middle Rockies ecoregion, such as West Yellowstone, Gardiner, Big Sky, and Cooke City, Montana, and Jackson, Wyoming, were not included as suitable habitat. There are large, contiguous blocks of sheep allotments in peripheral areas of the ecosystem in the Wyoming Mountain Range, the Salt River Mountain Range, and portions of the Wind River Mountain Range on the Bridger Teton and the Targhee NFs (Figure 37).

This spatial distribution of sheep allotments on the periphery of suitable habitat results in areas of high mortality risk to bears within these allotments and a few small, isolated patches or strips of suitable habitat adjacent to or within sheep allotments. Due to the negative "edge effects" of this distribution of sheep allotments on the periphery of current grizzly bear range, our analysis did not classify linear strips and isolated patches of habitat as suitable habitat. These strips and patches of land possess higher mortality risks for grizzly bears because of their enclosure by and/or proximity to areas of high mortality risk. 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, pp. 3–4; Yahner 1988, pp. 335–337; Mills 1995, p. 396). Edge effects are exacerbated in small habitat patches with high perimeter-to-area ratios (i.e., those that are longer and narrower) and in wide-ranging species such as grizzly bears because they are more likely to encounter surrounding, unsuitable habitat (Woodroffe and Ginsberg 1998, p. 2126).

Finally, dispersal capabilities of grizzly bears were considered in our determination of which potential habitat areas might be considered suitable. For example, because the Bighorn mountain range is disjunct from other suitable habitat and current grizzly bear distribution, our analysis did not classify the Bighorn Mountains as suitable habitat within the GYE. The Bighorn Mountains comprise 6,341 km^2 (2,448 mi^2) of habitat that is classified as part of the Middle Rockies ecoregion, but are separated from the current grizzly bear distribution by approximately 100 km (60 mi) of a mosaic of private and BLM lands primarily used for agriculture, livestock grazing, and oil and gas production (Chapman *et al.* 2004, entire). Although there is a possibility that individual bears may emigrate from the GYE to the Bighorn Mountains occasionally, this dispersal distance exceeds the average dispersal distance for both males (30 to 42 km (19 to 26 mi)) and females (10 to 14 km (6 to 9 mi)) (McLellan and Hovey 2001, p. 842; Proctor *et al.* 2004, p. 1108). Without constant emigrants from suitable habitat, the Bighorn Mountains will not support a self-sustaining grizzly bear population.

Some areas that do not meet our definition of suitable habitat may still be used by grizzly bears (Schwartz *et al.* 2002, p. 209; Schwartz *et al.* 2006b, pp. 64–66). The records of grizzly bears in these unsuitable habitat areas are generally due to recorded human-grizzly bear conflicts or to transient animals. These areas are defined as unsuitable due to the high risk of mortality resulting from these human-grizzly bear conflicts. These unsuitable habitat areas may contain grizzly bears but do not support grizzly bear reproduction or survival because bears that repeatedly come into conflict with humans or livestock are usually either relocated or removed from these areas.

According to the criteria in defining suitable habitat, the GYE contains approximately 46,905 km^2 (18,110 mi^2) of suitable grizzly bear habitat (Figure 37). The Service concluded that this amount of suitable habitat is sufficient to meet all habitat needs of a recovered grizzly bear population and provide ecological resiliency to the population through the availability of widely distributed, high-quality habitat that will allow the population to respond to environmental changes

Appendix E. Winter Recreation

Grizzly bears are easily awakened in the den (Schwartz *et al.* 2003a, p. 567), and it is important to consider the potential impact from winter recreation. Disturbance of grizzly bears in the den can result in cub abandonment or early den exit, which could kill a grizzly (if they leave before food is readily available). However, information regarding impacts of winter recreation on grizzly bears is limited. We found no studies in the peer-reviewed literature documenting the effects of snowmobile use on any denning bear species and no records of litter abandonment by grizzly bears in the lower-48 States due to snowmobiling information; the information that is available is based on opportunistic sightings and small sample sizes (in their entirety: Service 2002; Hegg *et al.* 2010). The one documented observation of snowmobiling at a known den site in the lower-48 States found the bear did not abandon its den, even though snowmobiles were operating directly on top of it (Hegg *et al.* 2010, p. 26). This, however, is only an opportunistic observation and is based on a sample size of one. We found no records of litter abandonment or den abandonment by grizzly bears in the lower-48 States due to snowmobiling activity (in their entirety: Service 2002; Hegg *et al.* 2010; Roberts 2018, *in litt.*).

Swenson *et al.* (1997, entire) monitored 13 different grizzly bears for at least 5 winters each and documented 18 instances of den abandonment, 12 of which were related to human activities. Four of these instances were hunting related (i.e., gunshots fired within 100 m (328 ft) of the den), two occurred after "forestry activity *at* the den site," one had moose and dog tracks within 10 m (33 ft) of a den, one had dog tracks *at* the den site, one had ski tracks within 80 to 90 m (262 to 295 ft) from a den, one had an excavation machine working within 75 m (246 ft) of a den, and two were categorized as "human related" without further details (Swenson *et al.* 1997, p. 37). Swenson *et al.* (1997) found that most den abandonment (72 percent) occurred early in the season before pregnant females give birth. However, there still may be a reproductive cost of these early den abandonments: 60 percent (sample size of 5) of female bears that abandoned a den site before giving birth lost at least one cub whereas only 6 percent (sample size of 36) of pregnant females that did not abandon their dens lost a cub in or near their den (Swenson *et al.* 1997, p. 37).

There are no data or information suggesting winter recreational use is negatively affecting grizzly bear populations in the lower-48 States, yet because the potential for disturbance and impacts to reproductive success exists, monitoring will continue to support adaptive management decisions about winter recreation use in areas where disturbance is documented or likely to occur.

Inside the GYE

In the GYE, the one documented observation of snowmobile use at a known den site found the bear did not abandon its den, even though snowmobiles were operating directly on top of it (Hegg *et al.* 2010, p. 26). Additionally, monitoring of den occupancy for 3 years on the Gallatin NF in Montana did not document any den abandonment (USDA FS 2006c, entire). In one rare instance of possible den disturbance, four backcountry skiers in GTNP reported seeing a collared grizzly bear close to where he had been denned three weeks earlier based on VHF locations from flights (Gustine 2019, *in litt.*). Of the 479 grizzly bear mortalities that occurred between 2002 and 2018, only 2 occurred between 1 December and 28 February. One of the mortalities was a radio-collared, 20-year-old male that died in January from natural causes in YNP, most likely from maladies associated with old age. The second mortality was a collared individual that likely died in an avalanche.

The Forest Plan Amendment includes guidance that, inside the recovery zone, localized area restrictions are to be used to mitigate any conflicts during denning or after bear emergence in the spring. Bears tend to den in remote areas with characteristics that are not conducive to snowmobiling (i.e., steep, forested habitats). Suitable denning habitat is well distributed on the forests, and much of the general grizzly bear denning habitat identified in the Forest Plan Amendment Final EIS as being open to snowmobiling is not actually used by snowmobiles because of its steep and forested nature (USDA FS 2006a, p. 92). For example, 85.2 percent of the known dens in the GYE are located in areas where snowmobile use does not occur and, of the 13.9 percent of dens that do occur in areas open to snowmobiling, only 0.8 percent are classified as high potential for snowmobile use (Haroldson 2017, *in litt.*).

Inside the NCDE

Bears tend to den in remote areas with characteristics that are not conducive to snowmobiling (i.e., steep, forested habitats). Suitable denning habitat is well distributed on the forests, and under current forest plans, approximately 6 percent of USFS lands are both open for snowmobiling and are modeled denning habitat (Ake 2019b, *in litt.*). Forest Plans within the NCDE include direction that, inside the recovery zone, there will be no net increase in the area or miles or routes designated for over-snow vehicle use during the den emergence period (USDA FS 2018a, p. 181; USDA FS 2018b, p. 15). This measure will reduce the potential impacts to females with cubs whom have high energetic costs and often spend several days to a few weeks near the den after emergence. In addition, snowmobiling is not allowed inside Glacier National Park or in designated Wilderness on USFS lands, which constitutes approximately 34 percent of the recovery zone.

Inside the CYE, SE, BE, and North Cascades

There have been no documented cases of grizzly bears abandoning dens as a result of snowmobiling or other winter recreational activities in the CYE or SE (Kasworm 2018a, *in litt.*). The BE and North Cascades have not had a known population in recent decades.