Exhibit 13

The Grizzly Bear Promised Land

Past, Present & Future of Grizzly Bears in the Bitterroot, Clearwater, Salmon & Selway Country

David J. Mattson, Ph.D.

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The Grizzly Bear Recovery Project

P.O. Box 2406,
Livingston,
Montana

Table of Contents

1. Introduction 2
1.a. Overview 2
1.b. Scope and Intent 4
2. Deep History 6
2.a Arrival & Evolutionary Decent 6
2.b. Ancient Diet and Lifeways 7
3. Pre-European Holocene 11
3.a. Changes in Climate and Vegetation 11
3.b. Availability of Meat from Marine and Terrestrial Sources 14
4. The Arrival of Europeans 19
4.a. Setting the Stage, *circa* 1800 20
4.b. Extirpations 24
5. Prospects and Potential 30
5.a. What the Models Show 30
5.b. How Much Will Be Enough? 32
6. Prospective Diets 35
6.a. Grizzly Bear Diets in the Northern Rocky Mountains 35
6.b. What About Salmon? 39
6.c. Modern Dietary Economies 40
6.d. Foods on the Nez Perce-Clearwater National Forests 43
7. Security and Coexistence Infrastructure 49
7.a. Prospective Conflicts on the Nez Perce-Clearwater National Forests 50
7.b. Habitat Security Standards 53
7.c. Habitat Security on the Nez Perce-Clearwater National Forests 56
8. Fragmentation 60
9. The Future 63
9.a. Environmental Changes 64
9.b. Changes in Bear Foods 67
9.c. The Future with Humans 69
10. Summary of Conclusions 73
11. References 76

1. Introduction

Idaho has some of the most extensive tracts of remote wild country in the contiguous United States, including 21,690 km^2 of designated Wilderness Areas, 39,928 km^2 of inventoried roadless or wilderness study areas, and 3,472 km^2 of other protected areas. Even so, barring peripheral areas along its northern and eastern borders and the recent appearance of a few colonizers, Idaho has no grizzly bears (*Ursus arctos*). Yet the potential is enormous. John Craighead and Chuck Jonkel—esteemed grizzly bear researchers of their day—recognized this potential as far back as the early 1970s, and helped convince the U.S. Fish & Wildlife Service to specifically reference wildlands of central Idaho in its initial 1975 rule protecting grizzly bears under the U.S. Endangered Species Act (ESA)[1]. The Service later designated portions of these vacant wildlands as a Recovery Area in 1982[2].

I arrived in Idaho during 1972 to pursue undergraduate studies at the University of Idaho—shortly before grizzly bears received ESA protections. It didn't take long for my imagination to be fired by initial forays into Idaho's backcountry, and then for me to make the connection with grizzly bears after starting to work for the Interagency Grizzly Bear Study Team in 1979. My interest in bringing grizzly bears back to central Idaho led me to collaborate with Troy Merrill on projects modeling potential suitable habitat, including one effort we reported in a paper published during 1999[3] in the midst of efforts by the Fish & Wildlife Service to reintroduce grizzlies into the Bitterroot Recovery Area[4].

Decades have passed, but my attention has returned to Idaho after spending the last several years grappling with issues surrounding grizzly bear restoration and recovery in the contiguous United States. These efforts have brought the obvious into focus. The wildlands of central Idaho are a lynchpin—an absolutely critical piece of geography with enormous potential, as well as a fascinating past. This report hopefully brings Idaho into appropriate focus for grizzly bear recovery efforts.

But first, a thumbnail sketch—an overview—of what I cover in this report, and a brief description of my scope and intent.

1.a. An Overview

At the time of European colonization, the area that would eventually become Idaho supported thriving populations of grizzly bears everywhere except perhaps in arid lower-elevation shrublands along the Snake River (Figure 1). Although this basic fact has been contested during recent decades by people focused on advancing political and ideological agendas, the supporting circumstantial and direct evidence for the presence of several thousand grizzly bears in Idaho is incontestable.

The diets, densities, and behaviors of ancestral Idaho grizzly bears must have been diverse. Although there is scant direct evidence for this assertion—largely because Europeans who left written records

[1] https://ecos.fws.gov/docs/federal_register/fr65.pdf

[2] U.S. Fish & Wildlife Service (1982). Grizzly bear recovery plan. Fish & Wildlife Reference Unit, Denver, Colorado. https://www.biodiversitylibrary.org/item/137553#page/4/mode/1up

[3] Merrill, T., Mattson, D. J., Wright, R. G., & Quigley, H. B. (1999). Defining landscapes suitable for restoration of grizzly bears *Ursus arctos* in Idaho. Biological Conservation, 87(2), 231-248.

[4] https://www.federalregister.gov/documents/2000/11/17/00-29531/record-of-decision-concerning-grizzly-bear-recovery-in-the-bitterroot-ecosystem; U.S. Fish & Wildlife Service (2000). Grizzly bear recovery in the Bitterroot Ecosystem: Final environmental impact statement. U.S. Fish & Wildlife Service, Missoula, Montana.

focused almost exclusively on their exploits killing grizzly bears rather than on bear behaviors—historical and contemporary variation in abundance and types of bears foods provides a compelling circumstantial basis for reconstructing the life-ways of grizzly bears in Idaho.

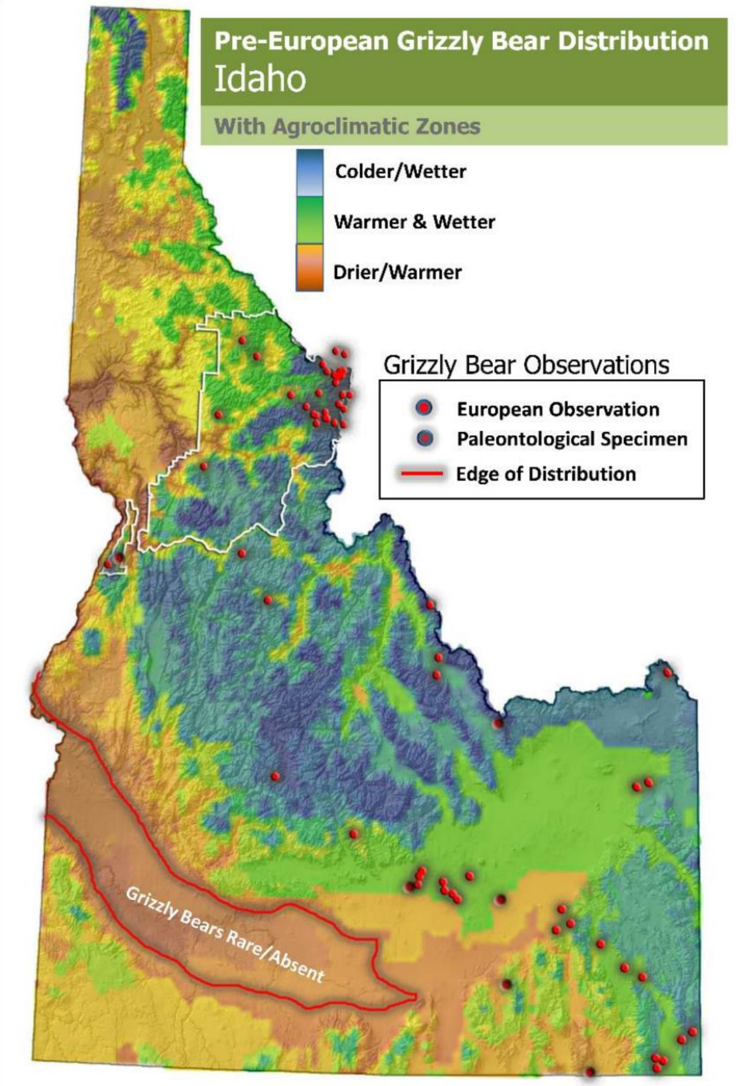

Figure 1. This map shows the physical environment of Idaho around the time of first European contact along with evidence of grizzly bear distribution outside of currently occupied areas in the Selkirk Mountains of far northern Idaho. A color-coded scheme for agroclimate zones is overlain on shaded relief to provide a snap-shot of the topographic and climatic diversity of Idaho. Agroclimate zones (from Godfrey 1999) represent potential vegetal productivity as a function of temperature and precipitation. Sources for grizzly bear observations and specimens can be found in the captions of Figures 5 and 9, below. The white line delineates the current Nez Perce-Clearwater National Forests.

Grizzly bear habitats in Idaho are indeed diverse, a reflection of diverse climates, landscapes, vegetation, and even configurations of river drainages (Figure 1). At higher latitudes, inland rain forests typified by western hemlock (*Tsuga heterophylla*) and western red cedar (*Thuja plicata*) continue to sustain abundant fruit-bearing shrubs and other vegetal foods. Grasslands of the Palouse prairie farther south and west once supported herds of bison (*Bison bison*). Higher-elevation mountains of central Idaho host abundant whitebark pine (*P. albicaulis*)—a source of fat-rich seeds. Farther south, austere shrub steppe vegetation carpeting the Snake River plains encompasses enclaves of roots such as biscuitroot (*Lomatium cous*)—and at one time also supported scattered herds of bison. Last but not least, basins drained by the Columbia River were once host to teaming populations of anadromous salmonids, including steelhead trout (*Oncorhynchus mykiss*) and multiple runs of chinook salmon (*Oncorhynchus tshawytscha*) throughout much of central Idaho, and coho salmon (*Oncorhynchus kisutch*) in lower reaches of the Clearwater and Snake Rivers.

Yet despite abundant and diverse bears foods, grizzly bears virtually disappeared from Idaho within a short 120-year period—between roughly 1830 and 1950. By 1950, only a handful of grizzlies survived in the Selkirk Mountains of the far northwestern corner of the state. The reason for this sudden demise is no mystery. Grizzly bears were slaughtered by newly-arrived Europeans at every opportunity, whether during chance encounters or as a result of deliberate pursuit. At the most fundamental level, grizzly bears almost disappeared from Idaho because of trauma and blood loss caused by high-velocity projectiles delivered from firearms held mostly by white men. At the most esoteric level, grizzly bears nearly vanished because of intolerance sustained by narratives of Manifest Destiny that ostensibly entitled believers to cleanse landscapes of all impediments to profitable exploitation.

Although the ultimate cause of grizzly bear extirpations is incontestable, the rapid and nearly complete loss of grizzlies from Idaho still poses a mystery. Most of Idaho has always been rugged, wild, roadless, and unpopulated by humans. Regions of comparable remoteness elsewhere sustained grizzly bears throughout periods of intensive persecution by Europeans—including areas that would later be called the Greater Yellowstone and Northern Continental Divide Ecosystems. But not the wilds of central Idaho.

Something unique happened in Idaho involving humans, bears, and bear habitats that led to the loss of grizzly bears in an area that, on the face of it, seems ideal for sustaining large populations of these animals. In fact, central Idaho has so much self-evident potential that the Selway-Bitterroot portion was the only area identified for recovery of grizzly bears by the U.S. Fish & Wildlife Service in the absence of grizzly bears[5]. Moreover, modeling of potential grizzly bear habitat since designation of the Selway-Bitterroot Ecosystem Recovery Area in 1982 has shown that there is perhaps as much potential outside the Recovery Area as there is inside, and that central Idaho occupies an area critical to achieving meaningful connectivity among grizzly bear populations in the Greater Yellowstone, Northern Continental Divide, Cabinet-Yaak, and Selkirk Ecosystems.

1.b. Scope and Intent

This report contains information relevant to understanding the past history, present conditions, and future prospects of grizzly bears and grizzly bear habitat in Idaho south of the Selkirk and Cabinet-Yaak Ecosystems, with an emphasis on pivotal landscapes encompassed by the 16,109 km^2 Nez Perce-Clearwater National Forests (Figure 1). This single National Forest unit, administratively combined from the Clearwater National Forest and Nez Perce National Forest in 2012, is comparable in size to that of our largest grizzly bear Recovery Areas[6], and is also at the crossroads of colonization by grizzly bears dispersing from the Selkirk, Cabinet-Yaak, and Northern Continental Divide Ecosystems.

I also focus here on unravelling the mystery of grizzly bear extirpations during the late 1800s and early 1900s, which is critical to any realistic assessment of current and future prospects for grizzlies in central Idaho for the region encompassing the St. Joe River drainage south to the Snake River Plains. Without understanding why grizzly bears disappeared in the first place, any evaluation of recovery potential and related recovery challenges is certain to be compromised.

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[5] U.S. Fish & Wildlife Service (1982). Grizzly bear recovery plan. Fish & Wildlife Reference Unit, Denver, Colorado. https://www.biodiversitylibrary.org/item/137553#page/4/mode/1up

[6] https://www.fws.gov/mountain-prairie/es/grizzlybear.php

I contend, moreover, that a full appreciation of Idaho's grizzly bears is not possible without a meaningful understanding of deep history—prospectively going back to the Pleistocene. Grizzly bears were a prominent presence on Idaho's landscapes for thousands of years, very likely pre-dating the Last Glacial Maximum, which began roughly 26,500 years ago. Although their ancient remains are intrinsically scarce, grizzly bears no doubt survived rapid environmental changes during the late Pleistocene and early Holocene, the rigors of the hot-dry Altithermal, and the bounteous conditions thereafter…up until the arrival of Europeans.

In what follows, I do not claim to be comprehensive, but rather parsimonious, although with occasional indulgent interludes where I dig more deeply into topics that intrigue me. Nor is what follows definitive, although I aspire to offer an analysis that is more contextual, complete, and relevant than any I have encountered elsewhere, including the U.S. Fish & Wildlife Service's compendious plan for reintroducing grizzlies into the Selway-Bitterroot Ecosystem[7].

I hope to populate an ecological canvas with evidence-based depictions of what we once had, and could yet again have again, in a landscape so rich with potential that I have been inspired to call it "The Grizzly Bear Promised Land."

[7] U.S. Fish & Wildlife Service (2000). Grizzly bear recovery in the Bitterroot Ecosystem: Final environmental impact statement. U.S. Fish & Wildlife Service, Missoula, Montana.

2. Deep History

For my purposes here, Deep History is encompassed by the Late Pleistocene, which lasted from roughly 26,500 to 11,700 years ago, although only the latter half of this period is relevant to the history of grizzly bears in North America and, more recent yet, the history of grizzly bears in ancestral Idaho. The Pleistocene is the epoch of Ice Ages, the last of which marked the arrival of grizzly bears—equivalent to brown bears—in North America.

2.a. Arrival and Evolutionary Decent

Grizzly bears first arrived in North America during the Late Pleistocene, perhaps as early as 70,000 years ago (Barnes et al. 2002). These first colonizers came from Siberia across the Bering Land Bridge when Europe, Asia, and North America formed a super-continent that emerged out of shallower oceans created by capture of ocean water in massive continental ice sheets of the Northern Hemisphere. This arrival predated onset of the Last Glacial Maximum (LGM) roughly 26,500 years ago, and the related blockage of free passage from Beringia to mid-latitudes by coalescence of the Cordilleran and Laurentide Ice Sheets.

Although reconstruction of ice sheet margins prior to the LGM is intrinsically problematic—simply because much of the direct evidence was erased by subsequent ice sheet growth—the best available modeling based on terrain features and climate simulations suggests that there was an ephemeral ice-free corridor south from Beringia to mid-latitudes of North America roughly 40,000 years ago (Kleman et al. 2010, Batchelor et al. 2019). As a bottom line, grizzlies must have somehow gotten south because the remains of a bear were found near what is now Edmonton, Alberta, dating to around 27,000-30,000 years ago (Matheus et al. 2004), consistence with more circumstantial genetic evidence suggesting that viable populations of grizzly bear existed south of the continental ice sheet throughout the LGM (Miller et al. 2006, Davis et al. 2011).

All of this is noteworthy because, up until the remains of the Edmonton grizzly were found and recent genetic analyses were published, the prevailing consensus was that grizzlies first arrived at mid-latitudes roughly 13,000 years ago, after an ice-free corridor had opened during terminal melt of the Cordilleran and Laurentide Ice Sheets (e.g., Kurtén & Anderson 1980). Of more specific relevance here, the best available evidence suggests that grizzly bears roamed Idaho's ancestral landscape for perhaps as long as 40,000 years rather than a mere 13,000 years.

Equally notable, the grizzly bears that roamed mid-latitudes of North America during the LGM and the subsequent 40 millennia were—and continue to be—evolutionarily unique. All of the grizzlies in what was to become the contiguous United States and adjacent portions of Canada and Mexico were of a single evolutionary lineage called Clade 4[8]. Clade 4 grizzlies belonged to one of three clades and

[8] Clades are commonly defined as a natural group of organisms descended from a common ancestor, able to be differentiated genetically, denoting a distinct evolutionary history. Clades are explicitly relational and expressive of evolution, which makes them more tractable than earlier approaches based on subspecies, which are less explicitly relational and require unambiguous demarcations. Because of this implicit need for clearly demarked boundaries, the concept of subspecies—and even species—has been beset by controversy, as has application to specific taxa. In the case of *Ursus arctos*, this sort of contention is evident in the fact that at one time C. Hart Merriam defined 84 "species" of grizzlies in North America alone (Merriam 1918), subsequently winnowed down to two (Rausch

subclades comprising the first wave of bears colonizing eastern Beringia—before the LGM (Barnes et al. 2002). The other two clades represented by these colonists were 2 and 3c. All three of these clades arose in eastern Asia (Tumendemberel et al. 2019). Of importance to this story, Clade 4 grizzlies have since disappeared everywhere on Earth with the exception of a small isolate on the Japanese island of Hokkaido and at mid-latitudes of North America (Davis et al. 2011, Hirata et al. 2017). Similarly, Clade 3c grizzlies are entirely extinct, whereas Clade 2 bears are currently represented only by populations on Admiralty, Baranof, and Chichagof Islands in Alaska. By contrast, the big evolutionary winners among grizzlies in North America belong to Clades 3a and 3b, which emigrated across the Bering Land Bridge to eastern Beringia as the LGM was waning between 25,000 and 15,000 years ago, and currently occupy all of Alaska and northern Canada as well as most of British Columbia and Alberta (Barnes et al. 2002, Davis et al. 2011).

The grizzly bears that occupied Idaho for millennia—and continue to hold on in Idaho's portions of the Selkirk, Cabinet-Yaak, and Yellowstone ecosystems—are members of a unique evolutionary and biogeographic lineage that has disappeared virtually everywhere else on Earth.

2b. Ancient Diets and Life-ways

Whereas modern genetic variation can provide reliable insights into evolutionary histories, and preserved remains can provide definitive evidence of primordial distributions, reconstructions of ancient diets and life-ways are necessarily based on circumspect extrapolations of often circumstantial evidence. In other words, reconstructions of pre-historic diets and lifeways are necessarily speculative, but ideally achieving veracity through maximal leveraging of scant direct evidence, knowledge of contemporary ecological relations, and reconstructions of paleo-environments.

Regardless of the specific geography, remains of *Ursus arctos* are rare. Remains with retrievable organic material are rarer still. Even so, enough such remains have been retrieved from higher latitudes to provide some direct evidence of proportionately how much meat and vegetation were in the diets of Pleistocene grizzly bears occupying frigid steppe tundra or mixed tundra-woodland environments[9]. As a modality, Pleistocene grizzlies in such environments were relatively carnivorous (e.g., Rey-Iglesia et al. 2019), more so than is typical of contemporary grizzly bear diets in temperate and boreal environments outside of areas supporting anadromous salmon (Hilderbrand et al. 1999, Jacoby et al. 1999, Mowat & Heard 2006). Even so, there is also evidence that grizzlies in some areas, for example eastern Beringia, France, and northern Spain, were omnivorous much like contemporary brown and grizzly bears (Bocherans et al. 2004, Fox-Dobbs et al. 2008, Garcia-Vázquez et al. 2018, Rey-Iglesia et al. 2019).

During the Pleistocene, variation in grizzly bear diets was very likely shaped not only by differences in abundance of foods, by also by divergences in assemblages of competitors and predators. It is a truism of ecology that this trio of factors largely configures animal foraging behaviors.

1963), and then expanded back to nine (Hall 1984), none of which correlated well with genetic differences, evolutionary descent, or historical biogeography.

[9] Consumption of vegetation and meat from terrestrial and marine sources can be estimated from judicious interpretation of concentrations and ratios of isotopic nitrogen ($\delta^{15}N$) and carbon ($\delta^{13}C$) in organic remains, as in this case.

Despite the fact that grizzly bears are currently the largest terrestrial carnivore in the Northern Hemisphere, barring perhaps the Siberian tiger (*Panthera tigris*), during the Pleistocene grizzlies were not dominant. They shared space with a number of very large carnivores, some of which lived in prides or packs, including giant short-faced bears (*Arctodus simus*), lions (*Panthera spelaea* and *P. atrox*), saber-toothed cats (*Smilodon fatalis*), scimitar-toothed cats (*Homotherium serum*), cave hyenas (*Crocuta crocuta spelaea*), and dire wolves (*Canis dirus*). Of these, short-faced bears, cave hyenas, and dire wolves would have been formidable competitors for scavenging opportunities. All but perhaps dire wolves would have been potential predators.

In light of this, it makes sense that grizzly bears would have been more carnivorous in areas without any of the species that could dominate scavenging opportunities (e.g., dire wolves, cave hyenas, and short-faced bears), as in western Beringia (Rey-Iglesia et al. 2019); and more herbivorous in areas where these competing species were present, as in eastern Beringia (with short-faced bears) and France and Spain (with cave hyenas) (Bocherans et al. 2004, Garcia-Vázquez et al. 2018, Rey-Iglesia et al. 2019).

It is not clear how much of the meat that grizzlies ate during the Pleistocene was from predation or scavenging, but given the numbers of large-bodied herbivores occupying grassland and woodland environments of that time[10], it is likely that much of their meat was obtained by scavenging kills made by other carnivores or animals that died of causes such as starvation, disease, and exposure (see Mattson 1997). And unit area concentrations of biomass on large herbivores during the Pleistocene were not only remarkable, but also far more than might be expected based on contemporary concentrations (Zhu et al. 2018).

Of specific relevance to ancient Idaho, Pleistocene grizzly bears shared much of this area with large carnivores that would have been potential predators as well as fierce competitors, including short-faced bears, American lions, scimitar-toothed cats, and saber-toothed cats (Figure 2). As a consequence, grizzly bears probably needed to carefully negotiate a potentially lethal landscape, and would have likely availed themselves of scavenging opportunities only during fleeting safe intervals when they managed to find carrion before other dominant scavengers did. Even so, these opportunities might have been relatively common given the abundance of large-bodied herbivores (Figure 2), including Columbian mammoths, bison, camels (*Camelops hesternus*), giant ground sloths (*Megalonyx jeffersoni*), horses (*Equus conversidens* and *E. ferus*), and helmeted muskox (*Bootherium bombifrons*).

That having been said, Pleistocene grizzly bears in ancestral Idaho were probably distinctly omnivorous, including a substantial number of bears that likely relied predominately on roots, fruits, and other vegetation. If so, this begs the question of what specific vegetal foods would have been staples in the relatively arid environments that typified ice-age Idaho (Dyke 2005). Although there is virtually no direct evidence of changes in landscape-level abundance of grizzly bear foods through the millennia, there is some basis in models and judicious extrapolation from current distributions for inferring what some of the major vegetal bear foods in ancestral Idaho might have been. Regarding

[10] For example, bison (*Bison priscus*, *B. latifrons*, and *B. antiquus*), mammoths (*Mammuthus primigenius* and *M. columbi*), aurochs (*Bos primigenius*), and woolly rhinos (*Coelodonta antiquitatis*) (Kurtén 1968, Kurtén & Anderson 1980).

Late-Pleistocene Distributions **Mega-Fauna**

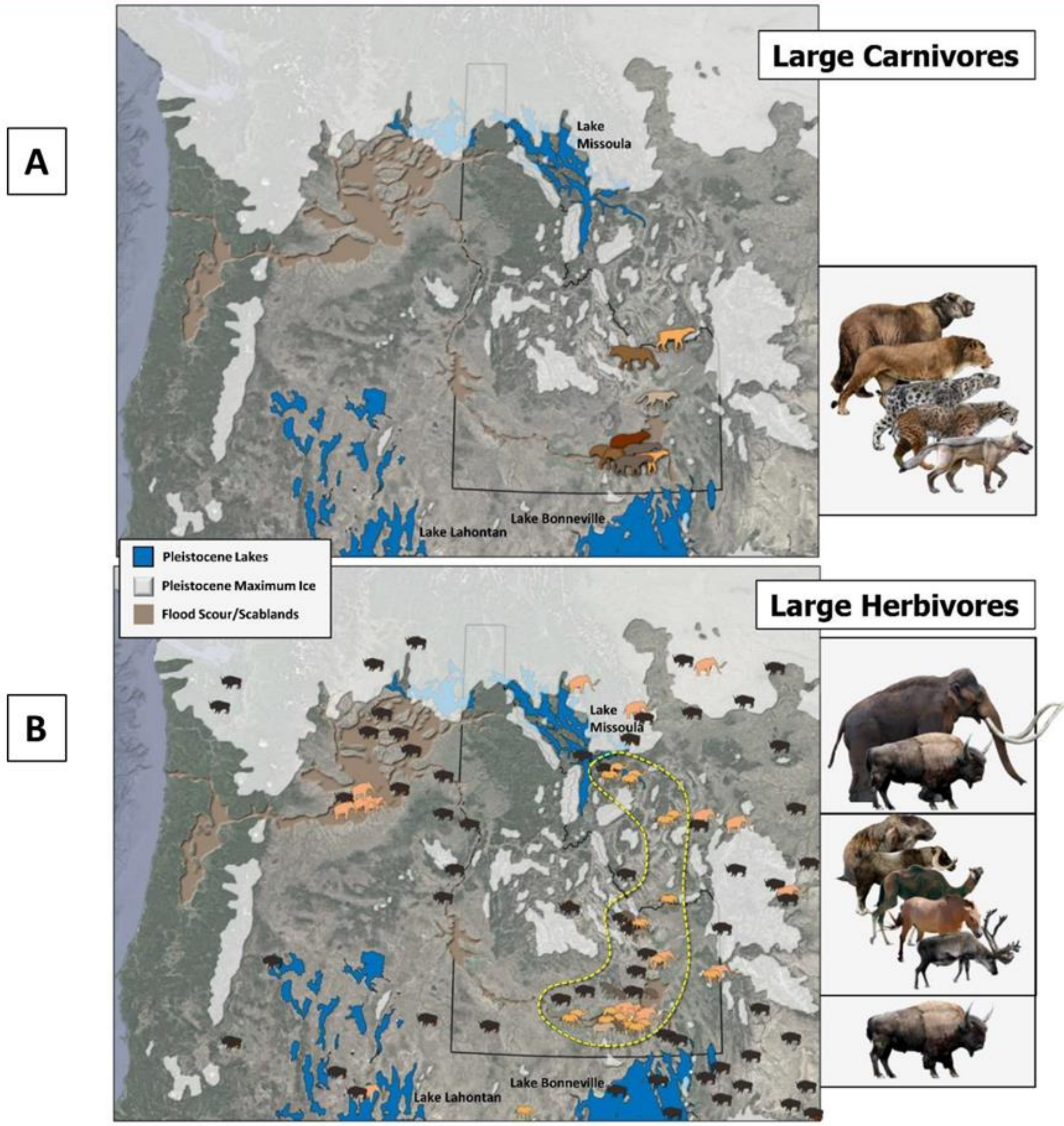


Figure 2. These two maps summarize key facets of the environment occupied by grizzly bears in the Pacific Northwest during the Late Pleistocene, roughly 40,000-10,000 years ago. Both maps show defining geophysical features, including the maximum extent of glacial ice, both in the form of mountain glaciers and continental ice-sheets (in dusky white, from Pierce [2003], Dyke [2004]); the maximum extent of glacial lakes, featuring Lakes Lahontan, Bonneville, and Missoula (in blue, from Matsubara & Howard [2009], Hanson et al. [2012]); and the extent of areas subject to scour (e.g., scablands) from outbursts of Lakes Missoula and Bonneville (in beveled tan, from Hanson et al. [2012], O'Connor et al. [2020]). Map (**A**) shows locations of remains from large carnivores, including, as illustrated from top to bottom, the giant short-faced bear (*Arctodus simus*), American lion (*Panthera leo atrox*), simitar-toothed cat (*Homoterium serum*), saber-toothed cat (*Smilodon fatalis*), and dire wolf (*Canis dirus*). Map (**B**) shows locations of—also as illustrated top to bottom—mammoths (predominantly *Mammuthus columbi*), bison (predominantly *Bison antiquus*), Jefferson's ground sloth (*Megalonyx jeffersonii*), helmeted muskox (*Bootherium bombifrons*), western camel (*Camelops hesternus*), horses (*Equus* sp.), and caribou (*Rangifer tarandus*). The yellow dashed line delineates a region with maximum density and diversity of remains from large herbivores. Locations were obtained from the Neotoma Paleoecology Database (https://www.neotomadb.org/), augmented by locations of bison from Grayson (2006a). Idaho is outlined in black.

this latter point, the distribution of Yellowstone foods and related grizzly bear foraging on them provides a relevant benchmark.

More specifically, there are a handful of plants that Yellowstone grizzly bears exploit predominantly in high-elevation cold environments, comparable to environments that were probably more widespread at lower elevations during the Pleistocene south of the Cordilleran Ice Sheet. These notably include biscuitroot (*Lomatium cous*), horsetail (*Equisetum arvense*), and whitebark pine (*Pinus albicaulis*): the roots of the first, the stems of the second, and the fat-rich seeds of the third (Mattson 2000, Mattson et al. 2004; https://www.allgrizzly.org/pleistocene-holocene-diet). The probable importance of whitebark pine is given greater weight by recent modeling showing that whitebark pine would likely have been abundant during the LGM in lower-elevation areas such as the Snake River plain (Robert & Hamann 2015). Insofar as important fruits are concerned, the most likely candidate is buffaloberry or soopolallie (*Shepherdia canadensis*). Although regional evidence is scant, the widespread contemporary consumption of buffaloberries by grizzlies in drier boreal and subarctic environments[11] implicate the potential importance of these fruits to bears during the Pleistocene.

Grizzly bears in Pleistocene Idaho were, first, probably relegated to using marginal habitats, foods, and temporal windows as means of avoiding other predatory carnivores; second, obtained meat primarily by scavenging large-bodied herbivores in amounts likely to constitute an important food for many bears; and, third, despite this, relied primarily on vegetal foods for the bulk of their diet, with whitebark pine seeds also of prominent importance.

[11] For example, Hamer & Herrero (1987), MacHutcheon & Wellwood (2003), and Munro et al. (2006).

3. The Pre-European Holocene

The Holocene is conventionally considered to start around 11,700 years ago, marking the end of the Pleistocene and the advent of our current warmer epoch. Even so, the Holocene got off to a rocky start punctuated by wild swings in climate driven partly by melt of the continental ice sheets—which in North America lasted up until roughly 6,000 years ago (Dyke 2004). Early outflow of melt water around 13,000 years ago from Lake Agassiz likely cooled the north Atlantic and sent the Earth back into a mini-ice age called the Younger Dryas (Leydet et al. 2018; although arguments have been fielded implicating an extraterrestrial impact as a trigger[12]). Several millennia later, accelerated ice melt coupled with release of water from Lake Agassiz by catastrophic failure of ice dams again shut down a strengthening Gulf Stream and plunged the Earth back into yet another cold episode (Matero et al. 2017). These oscillations in climate triggered rapid changes in vegetation (as per in Figure 3) that dramatically reconfigured North America's fauna. Among the most dramatic changes was extirpation of almost all of North America's large herbivores and carnivores in a relatively brief period between 12,000 and 10,000 years ago (Faith & Surovell 2009)—an event partly driven by burgeoning populations of highly efficient human hunters. In North America, the largest terrestrial carnivore left standing was the grizzly bear. The largest remaining herbivore was the bison. One of the most notable features of the Holocene was the relationship between these two surviving members of the Pleistocene mega-fauna that lasted up until Europeans nearly eliminated both in what was to become the western United States (see: https://www.allgrizzly.org/the-bison-factor).

3.a. Changes in Climate and Vegetation

There are numerous proxies for changes in paleoclimates, but perhaps one of the best is changes in vegetation. Since the end of the Pleistocene, variations in relative and absolute concentrations of pollen from different plant genera and families captured by sediments in the bottoms of wetlands have provided a tableau of change. Thanks largely to studies by Cathy Whitlock and her students, we have a comprehensive palynological history from in and near the northern U.S. Rocky Mountains, which gives a rich and nuanced view of how climates and vegetation varied during the Holocene, with implications for grizzly bear foods and grizzly bear populations.

Figure 3 summarizes results from the many palynological studies undertaken in the northern U.S. Rocky Mountains[13]. The main patterns, regardless of elevation or latitude, are an initial colonization of recently deglaciated or periglacial environments by a woodland of Engelmann spruce (*Picea engelmannii*), with grasses, sedges, and forbs below, happening later—as would be expected—in areas that were deglaciated later (Figure 3b); and a substantial increase in cover of Douglas-fir (*Pseudotsuga menziesii*), western larch (*Larix occidentalis*), sagebrush (*Artemisia* sp.), and drier grasslands during the long-lasting hot dry period called the Altithermal that dominated the middle of the Holocene between roughly 10,500 and 6,000 years ago. Forests characteristic of present times bracketed this period, with the exception of areas to the north and west that experienced delayed

[12] For more on the controversy surrounding the Younger Dryas impact hypothesis, see Petaev et al. (2013), Moore et al. (2017), Wolboch et al. (2018a, 2018b), and Holliday et al. (2020).

[13] Sources for Figure 3b are Mack et al. (1978a, 1978b, 1978c), Whitlock 1992, and Power et al. (2011); for Figure 3c are Mehringer et al. (1977, 1985), Karsian (1995), and Brunelle et al. (2005); and for Figure 3d, Mack et al. (1983), Dorener & Carrera (2001), Whitlock et al. (2011), and Alt et al. (2018).

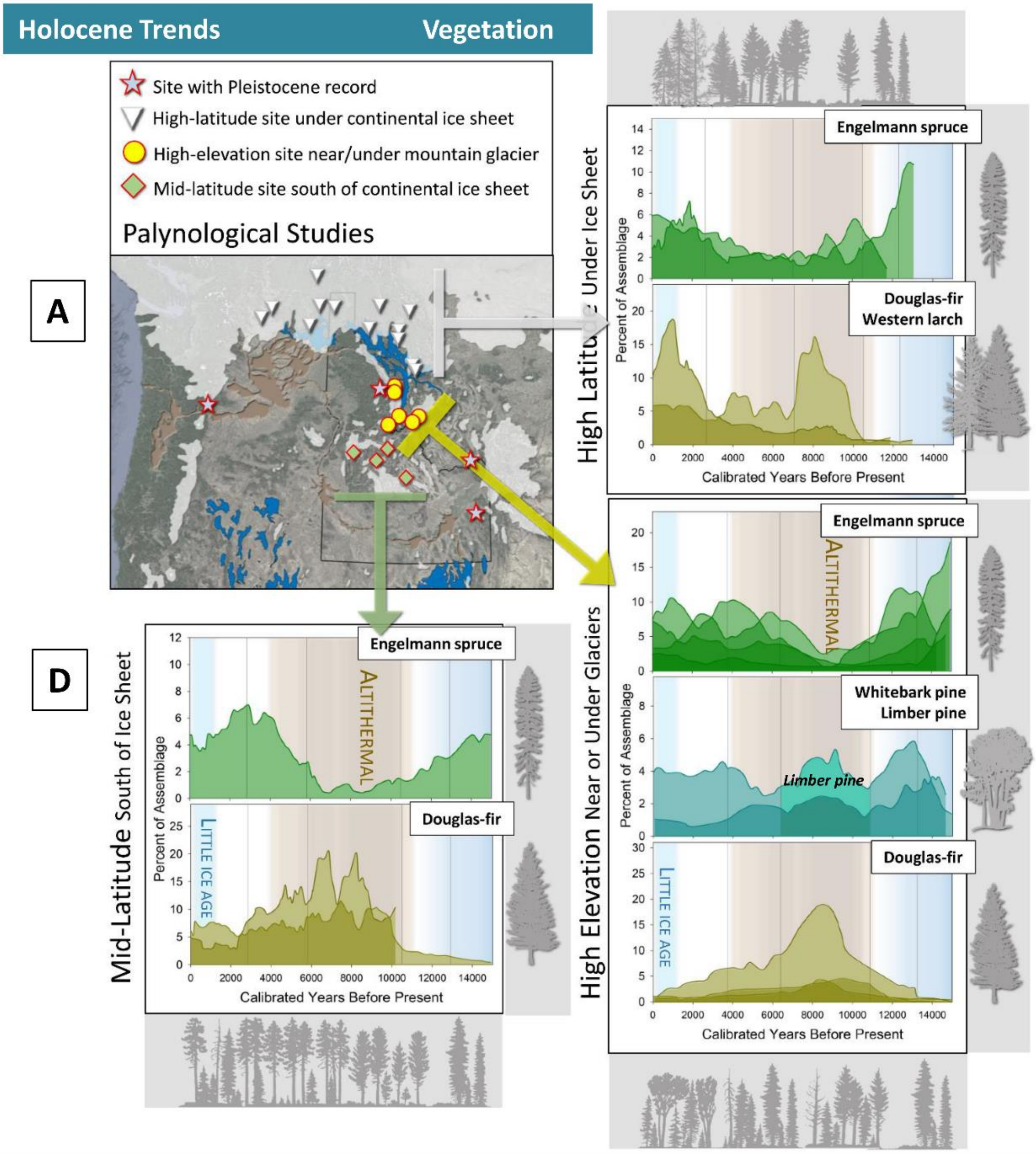


Figure 3. These panels illustrate major trends in vegetation during the Holocene and Late-Pleistocene (14,000-0 years before present) based on studies of pollen deposits in wetlands (i.e., palynology). The map in (**A**) shows the locations of studies from which results were summarized for (**B**) higher latitudes that were under the continental ice-sheets; (**C**) lower-latitude sites at high elevations; and (**D**) mid-latitude sites at moderate to low elevations. The study sites denoted by stars include records spanning the last glacial maximum. Trends in relative abundance of trees species that signify changes in environmental conditions are shown in each panel: Engelmann spruce (*Picea engelmannii*) at top of each; Douglas-fir (*Pseudotsuga menziesiii*) and western larch (*Larix occidentalis*)—that produce indistinguishable pollen—at bottom; and whitebark and limber pines (*Pinus albicaulis & P. flexilis*) in the middle of (**C**). Trends from each study site are overlain within each of the three strata, with greater overlap denoted by darker hues. The silhouetted profiles above, below, and to the side illustrate either changes in vegetation structure and composition or featured tree species. Background areas shaded progressively darker brown in each panel denote periods of greater warmth and drought, culminating during the Altithermal; areas shaded blue denote colder periods, beginning with emergence from glacial conditions.

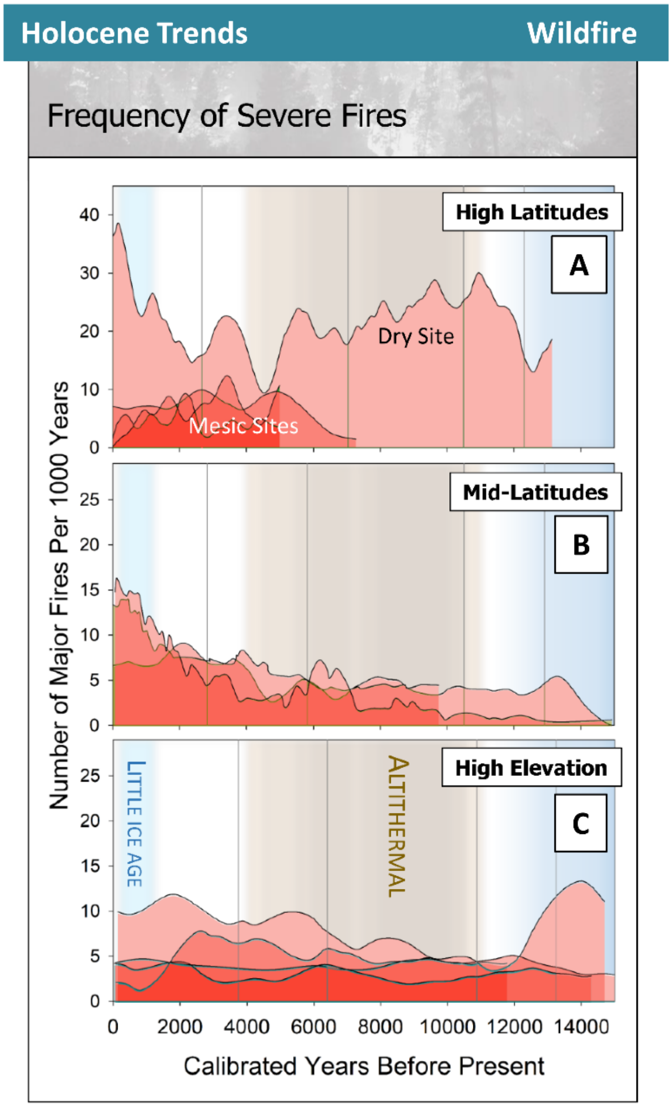


Figure 4. These panels show trends in frequency of wildfires during the Holocene and late Pleistocene, 14,000-0 years before present. These records are based on either depositions of charcoal in wetlands or depositions of sediment in alluvial fans, both of which signify major stand-replacing upland fires. The locations of studies used as sources for these records are shown in figure 3a. The strata shown here, in (**A**)-(**C**), are the same as used in figure 3 to illustrate regional trends in vegetation. Strata-specific records from individual study sites are overlain in each panel, with darker hues denoting greater overlap of results. The record in (**A**) from a drier lower-elevation site in Montana is differentiated from sites farther north in wetter areas typified by the presence of western hemlock (*Tsuga heterophylla*) and grand fir (*Abies grandis*). Background areas shaded progressively darker brown in each panel denote periods of greater warmth and drought, culminating during the Altithermal; areas shaded blue denote colder periods, beginning with emergence from glacial conditions. Vertical gray lines denote major changes in vegetation structure and composition in each stratum.

colonization by tree species adapted to wetter maritime climates and with limited migration potential—such as western hemlock (*Tsuga heterophylla*) and western red-cedar (*Thuja plicata*).

Other patterns are noteworthy, especially for reconstructing changes in amounts of vegetal bear foods. Figure 3c shows relatively constant abundance of 5-needled hapoxylon pines throughout the Holocene—which for much of this Epoch have been widespread in the northern U.S. Rocky Mountains (see Figure 5a). These pines include not only whitebark pine, an important source of bear food, but also limber pine (*Pinus flexilis*) which is only rarely exploited by bears for food and also fares better than whitebark pine under warmer drier conditions (Minore 1979). Although the pollen of these two species cannot be reliably differentiated, the pulse of hapoxylon pollen during the Altithermal was very likely not from whitebark pine but rather from limber pine (e.g., Whitlock et al. 2011, Iglesias et al. 2018), consistent with increased concentrations of Douglas-fir and western larch pollen.

As might be expected, the frequency of wildfires extensive enough and hot enough to leave traces of charcoal in wetland sediments has also changed substantially during the Holocene, but not always as might be expected from changes in ambient temperatures and precipitation. In fact, with the exception of intrinsically drier sites that have always been typified by grassy woodlands (Figure 4a), large fires tended to be less frequent during the Altithermal, especially in contrast to more recent millennia (Figure 4). The last 3,000-4,000 years have seen a substantial increase in fire activity in most areas, presumably because wetter conditions have promoted more productive forests and increased accumulation of large fuels (Brunelle et al. 2005). The other notable pattern was a pulse of more frequent fires early in the sediment record during the Younger Dryas period between 14,000 and 13,000 years ago, coincident with the emergence of Engelmann spruce and whitebark pine woodlands—possibly linked to global repercussions of an extraterrestrial impact (see footnote 12).

The Altithermal was probably a stressful period for grizzly bears caused by hot-dry conditions that reduced amounts of vegetal foods—including the abundance of whitebark pine—for perhaps as long as 3,500 years. By contrast, the generally cooler and wetter conditions that followed the Altithermal not only resulted in greater herbaceous productivity, but also an increased frequency of forest fires that likely resulted in greater amounts of available fruit on shrub species such as huckleberry (*Vaccinium membranaceum*) and buffaloberry—both of which tend to flourish in more open conditions—and thus in the wake of forest fires, with maximum amounts of fruit produced 20-40 years afterwards[14].

3.b. Availability of Meat from Marine and Terrestrial Sources

The amount of meat in contemporary grizzly bear diets varies substantially from one location to another as a predictable function of access to anadromous salmonids and high densities of large-bodied herbivores (Mowat & Heard 2006). As a proxy, consumption of meat from terrestrial sources is positively correlated with colder, drier climates in less rugged terrain (Mowat et al. 2006, Niedziałkowska et al. 2019)—which during pre-European times correlated in turn with higher densities of ungulates such as bison, caribou (*Rangifer tarandus*), and even elk (*Cervus canadensis*).

Of the ungulates, there is compelling evidence that, given equal availability, grizzly and brown bears preferentially consume meat from the largest-bodied species, notably moose and bison (Mattson 1997, 2017; Green et al. 1997). Of these two species, meat from moose is acquired mostly by outright predation (Gassaway et al. 1992, Mattson 1997, Dahle et al. 2013) whereas meat from bison is acquired primarily by scavenging (Green et al. 1997; Mattson 1997, 2017). Observations by early European travelers provide further evidence that, wherever bison were historically available, they were likely a locally importance source of food for grizzly bears (e.g., Burroughs 1961; https://www.allgrizzly.org/the-bison-factor).

All of this is relevant to determining where and when meat was prominent in diets of grizzly bears occupying Idaho during the early and middle Holocene—and from what sources. Runs of anadromous salmon colonizing Holocene habitats that had been previously scoured or otherwise made inhospitable during the Pleistocene (Waples et al. 2008; see Figure 2) almost certainly rapidly emerged as important sources of meat for grizzlies, as was the case for native peoples (Campbell & Butler 2010). Bison and perhaps elk were also very likely important sources of meat for grizzly bears in lower elevation steppes.

Figure 5 shows distributions of these meat resources during the Holocene, featuring salmonids in Figure 5a and bison and elk in Figure 5b. These figures also show locations of grizzly bear remains from

[14] See Martin (1979, 1983), Hamer (1996), Anzinger (2002), and Proctor et al. (2018)

Holocene Distributions — Meat Resources

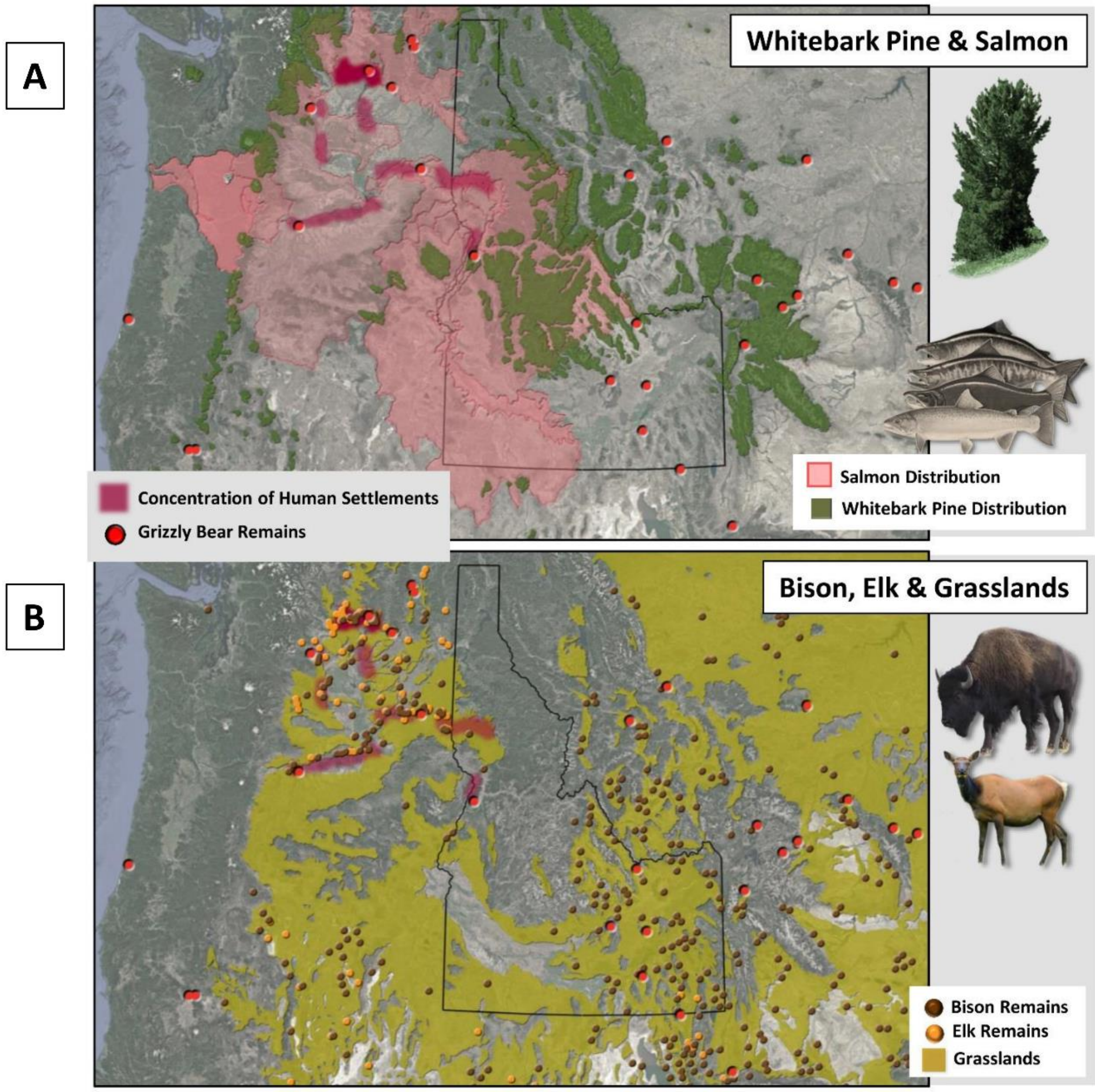


Figure 5. These two maps show major configurations of habitat as well as distributions of major grizzly bear foods during the Holocene, 10,000-350 years before present, exclusive of fruit-producing shrubs and herbaceous foods (see figure 7). Areas with high concentrations of human settlement in the Columbia River Basis are also shown in lavender (from Chatters [1995]) along with locations of Holocene remains of grizzly bears from archeological and paleontological study sites, shown as large red dots (from Lyman [1986] and the Neotoma Paleoecology Database (https://www.neotomadb.org/). The distribution of salmon in (**A**) is from NOAA 5-year status reviews published during 2016 for each of the protected anadromous salmonids in the Pacific Northwest (NOAA National Marine Fisheries Service, 2016a-2016d), with darker pink denoting greater overlap in distributions. The distribution of whitebark pine (*Pinus albicaulis*) in (**A**) is from the Whitebark Pine Foundation (https://whitebarkfound.org/wp-content/uploads/2019/05/WBP_April23_2019_1.jpg), with refinements based on interpretations from Google Earth imagery. Map (**B**) shows the distribution of non-forest vegetation types with a comparative abundance of perennial grasses (in dusky green, from US Environmental Protection Agency, state-specific Level III and IV ecoregion maps; https://www.epa.gov/eco-research/level-iii-and-iv-ecoregions-state), together with Holocene locations of elk (orange dots) and bison (dark-brown dots). Elk and bison locations are from the Neotoma Paleoecology Database augmented by locations from Bailey (2016), Dixon & Lyman (1996), Grayson (2006a), Grayson & Fisher (2009), and Lyman (2004, 2016).

archeological and paleontological sites dated to the pre-European Holocene (as red dots), suggesting that grizzlies were indeed widespread in the Pacific northwest.

The occurrence of numerous runs of spawning salmonids throughout drainages of the Columbia River suggest that fish were probably an important source of food for grizzlies in a large portion of ancestral Idaho, especially in tributaries to the Snake River. However, humans introduce an important proviso. There is circumstantial evidence suggesting that native peoples may have limited access by grizzly bears to concentrated riparian food resources well before the arrival of Europeans (Mattson et al. 2005). Hence both maps show concentrations of human settlements, many of which date back to the middle Holocene. However, even if humans interfered with grizzly bear access to spawning salmon, this would have likely applied only to lower-elevation reaches of the Columbia and Snake Rivers (Figure 5a), leaving grizzly bears a free hand along spawning streams in central and southwestern portions of central Idaho.

Bison, in particular, and elk, to a lesser extent, were clearly widespread and in some place relatively abundant during the Holocene at lower elevations of the Pacific Northwest (Figure 5b). This possibility wasn't given much credence at one time, but a conclusive body of historical, archeological, and paleontological evidence has emerged showing that bison were common, especially in the Columbia Basin, southeastern Idaho, and adjacent northwestern Utah (see the caption of Figure 5 for sources). Elk were likewise relatively common in the Columbia Basin. Even though this rapidly changed with the arrival of Europeans, grizzly bears almost certainly had access to meat from bison and perhaps elk during most the Holocene throughout the extensive shrub steppe environments in and around ancestral Idaho—barring the height of the Altithermal.

Figures 6a-c shows trends in meat resources for grizzly bears in the Pacific Northwest during the Holocene—specifically remains of bison and different proxies for abundance of spawning salmon. As has been documented pretty much everywhere at mid-latitudes in North America, bison reached a nadir of abundance during the hot-dry Altithermal (https://www.allgrizzly.org/the-bison-factor). Populations exploded thereafter, in the Pacific Northwest delayed until around roughly 1,500 years ago, coincident with the comparatively cool-wet Little Ice Age (Figure 6c). The pattern for salmon was quite different, with apparent abundance during the last 7,000 years peaking during the Altithermal and then again at roughly 3,000 and 1,300 years ago, with several measures suggesting a significant decline that began with onset of the Little Ice Age but accelerated 500 years ago—around 1500 A.D. Put together, these patterns suggest that the offset abundances of bison and salmon may have allowed for compensatory diet shifts by grizzly bears, although direct evidence for such shifts is lacking.

Insofar as the human factor is concerned, all of the reconstructions of human population size that I've encountered for North America, the northern U.S. Rocky Mountains, and the Pacific Northwest also suggest that the Altithermal was a challenging if not brutal time for people (e.g., Figure 6e)—perhaps less so in the Pacific Northwest where people had access to spawning salmon (Figure 6d). Human populations were at undisputed lows during the Altithermal and experienced a steady if not dramatic upturn beginning between 4,000 and 3,000 years ago, but with the onset of a dramatic *decline* beginning around 1500 A.D., coincident with the arrival of European diseases and the devastating impacts that followed (Hutchinson & Hall 2020). Of specific relevance to grizzlies, at the same time that they were challenged by the Altithermal climate and a dearth of foods from terrestrial sources,

Holocene Trends **Meat Resources & Humans**

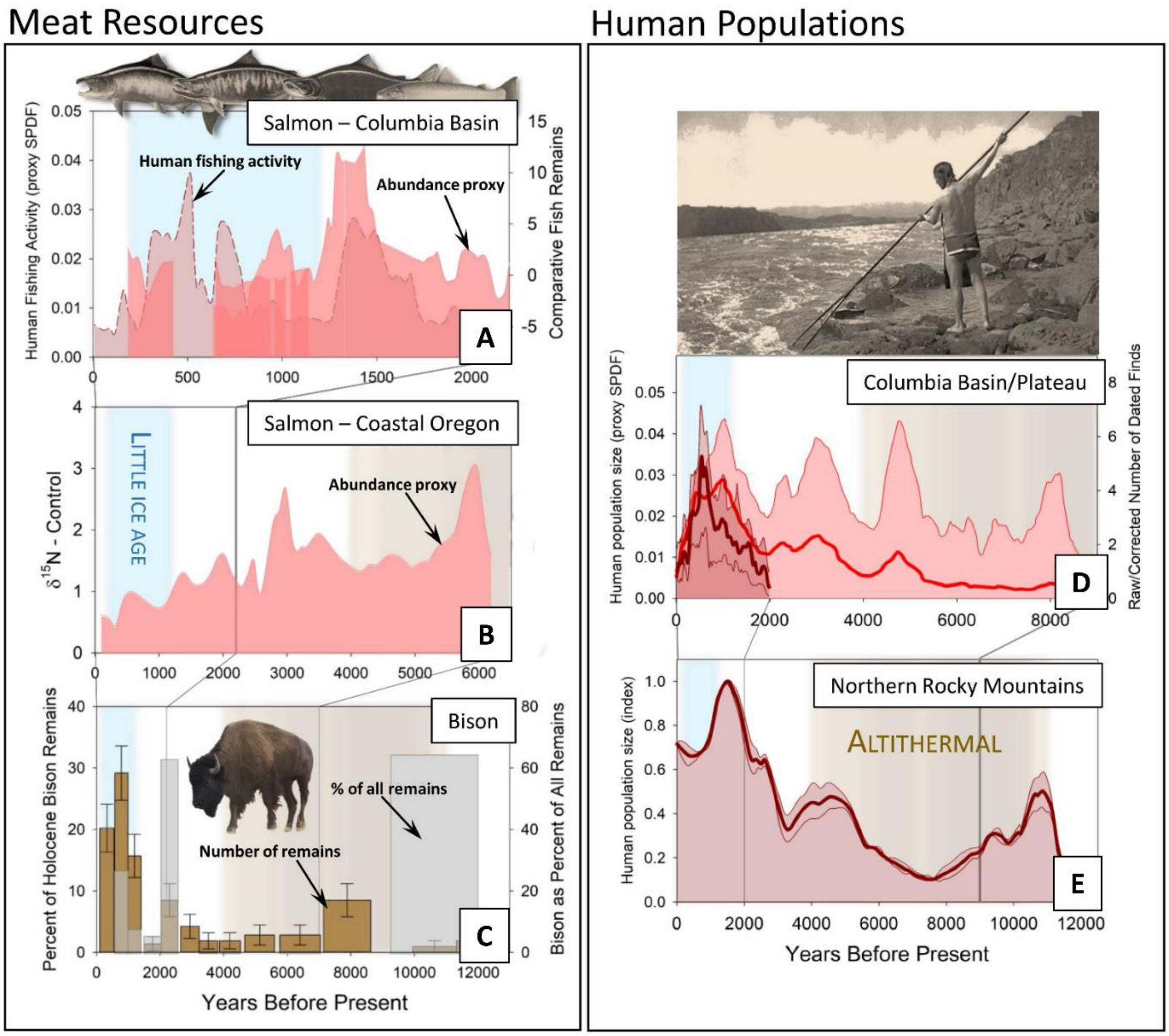


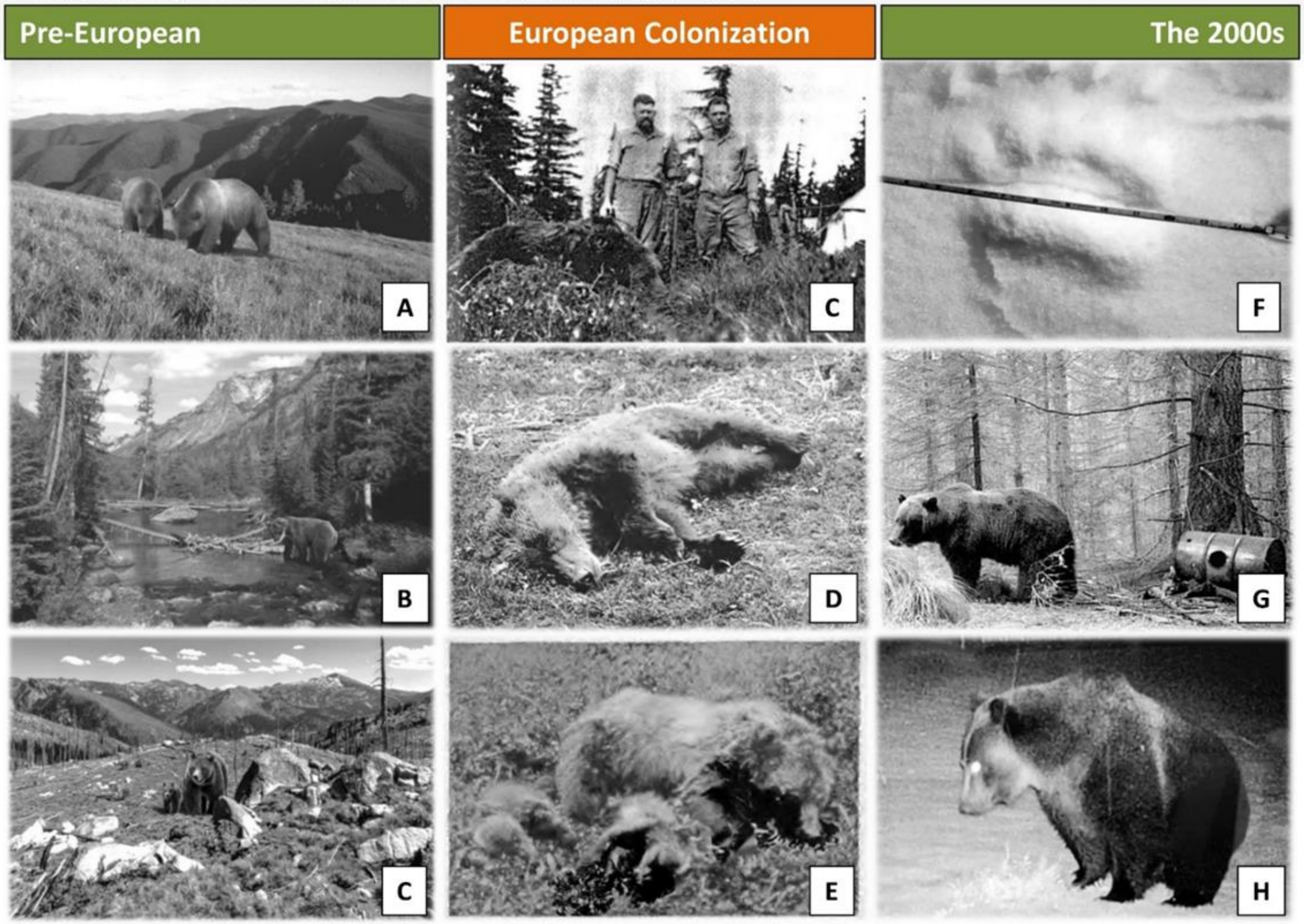
Figure 6. These graphics show Holocene trends in either (**A**-**C**) sources of dietary meat or (**D**-**E**) numbers of humans in the Pacific Northwest. The trend lines in (**A**) show a proxy for relative abundance of salmon based on fish remains in sediment cores (Finney et al. 2002) together with levels of human fishing activity at Kettle Falls along the Columbia River (from Hutchinson & Hall [2020]). Panel (**B**) shows a proxy for abundance of salmon going back 6,000 years based on nitrogen inputs from salmon reckoned as the difference between $\delta^{15}N$ inputs in lake systems with and without spawning salmon (Gavin et al. 2018). Panel (**C**) shows two different representations of bison abundance in the Columbia and Great Basins. The dark-brown bars show the distribution of dated bison remains *among* Holocene time-periods (from Stutte 2004) whereas the lighter gray bars show the *proportion of all remains* from larger mammals *during a given time period* that were attributable to bison (Lyman 2004). Panel (**D**) shows trends in proxies for human populations in the Columbia River Basin, with the longer time-line based on radiocarbon-dated archeological finds both corrected (pink) and uncorrected (red) for presumed decay in detection probabilities (Chatters 1995), together with a proxy for a shorter timeline corresponding with that shown in panel (**A**) (from Hutchinson & Hall [2020]). Panel (**E**) shows yet another proxy for human populations in the ancestral Bighorn Basin of the U.S. northern Rocky Mountains spanning the entire Holocene (Kelly et al. 2013) based on models driven by climate and radiocarbon-dated records. The darker burgundy lines in (**D**) and (**E**) are central tendencies of estimates whereas the bounding finer lines are 95th percentile confidence or credibility intervals. Background areas shaded progressively darker brown in each panel denote periods of greater warmth and drought, culminating during the Altithermal; areas shaded blue denote colder periods.

competition from and predation by humans was also lessening, which may have allowed grizzlies greater access to spawning salmon in lower-elevation stream and river reaches.

Grizzly bears in most parts of ancestral Idaho probably had access to abundant meat during the Holocene either from spawning anadromous salmonids or from large-bodied herbivores such as bison and elk, with these two sources complementary in both time and space. The challenges to grizzlies posed by humans, at least up until the arrival of European horses[15] and then Europeans themselves, tended to be spatially concentrated along specific reaches of the Columbia and Salmon Rivers, leaving bears ample access to salmon in mountainous areas of central Idaho. There may even have been a brief Edenic time for grizzlies that lasted a couple of centuries between when European diseases took their toll on indigenous human populations and lethal Europeans arrived in person.

[15] See Haines (1938) and Worcester (1945) for a review and Secoy (1992) for a map of the spread of horses and firearms in North America after arrival of Europeans. Horses fundamentally changed the lives and economies of native peoples, in ways that probably increased their impacts on bison as well as their lethality to grizzly bears (Flores 1991; Hämäläinen 2003, 2008; Isenberg 2020).

Box 1. This triptych of photos is illustrative of three eras of relations between grizzly bears and people in *The Grizzly Bear Promised Land*. Photos (A)-(C) are somewhat fanciful reconstructions of grizzly bears in pre-European times set against real backgrounds in the region: (A) near the crest of the Sapphire Mountains east of the Bitterroot Valley; (B) along a small spawning stream tributary to the Selway River; and (C) along Beaver Ridge in the Bitterroot Mountains. Photos (C)-(E) are emblematic of the slaughter that accompanied European colonization. Photos (D) and (E) were taken by William Wright during the late 1800s, representative of the dozens he alone killed during a few decades. Photo (C) shows one of the last grizzly bears killed during the early 1900s in the Clearwater drainage—on Wallow Mountain. Photos (F)-(H) are emblematic of recent colonization by grizzly bears, including a track found near Grangeville, Idaho, during 2020; (G) a grizzly photographed during 2019 near a bait set to attract black bears in the same area; and (H) a grizzly bear photographed during 2020 in the backyard of a residence near Lolo Hot Springs in Montana.



4. The Arrival of Europeans

The arrival of Europeans in North America triggered complex, multi-faceted, and ultimately cataclysmic changes for humans, animals, and plants that had occupied the continent in relative isolation since closure of the Bering Land Bridge roughly 11,000 years ago (Jakobbson et al. 2017). Although native peoples and grizzly bears had endured environmental upheavals of the Pleistocene-Holocene transition, as well as rigors of the subsequent Altithermal period, both were nearly extirpated in what was to become the United States by diseases, economic disruptions, mass migrations, violence, and environmental changes unleashed by European colonists. Native peoples and grizzly bears in nascent Idaho were no exception, although the catastrophe unfolded here later than in most other places.

The verifiable history of Europeans in the area that was to become Idaho began with passage of the Lewis & Clark expedition during 1805 down the Lochsa and Clearwater Rivers, followed by occasional incursions of fur trappers between 1812 and 1840 that led to establishment during the early 1830s of small European settlements at Fort Boise and Fort Hall in southern Idaho[16]. Missions followed shortly after during the mid-1830s in northern Idaho. The first small settlements of Mormons were established in southern Idaho during the 1850s. But these intrusions by Europeans were of little consequence compared to the massive impacts associated with operation of the Oregon Trail between 1843 and 1868, with annual traffic peaking at around 24,000 people during 1848-1857 (Unruh 1993). These concentrations of heavily-armed hungry transients along the Snake River Plain are unambiguously implicated in early extirpations of bison and elk in this region. But the biggest impacts on grizzly bears were probably unleashed by a flood of miners into the Clearwater, Boise, and Salmon River drainages that began during 1860-1863 and resulted in the near overnight establishment of cities with thousands of people in previously remote areas.

By the 1870s and 1880s agricultural settlements were widespread in southern Idaho, on the Palouse Prairie, and in more accessible and verdant portions of the Clearwater and Coeur d'Alene River drainages in the north. By 1910, there were numerous cattle and over 3,000,000 sheep in Idaho, mostly in southern portions of the state (U.S. Census of Agriculture, https://www.nass.usda.gov/AgCensus/). Sheep numbers only dropped significantly by 1940—to roughly 1,300,000 animals. Meanwhile, another explosion of mining activity had occurred in the Coeur d'Alene drainage during the late 1870s and early 1880s centered on silver mining in the Wallace and Mullan areas.

Impacts of Europeans in nascent Idaho likely unfolded in pulses organized around different episodes of colonization and exploitation with different geographic foci. Traffic on the Oregon Trail probably unleashed an early devastation of fauna on the Snake River Plain during the 1840s-1860s. Miners flooded remote mountains of central and north-central Idaho during 1860s-1880s. Agriculture followed during the 1870s and 1880s, most dramatically on the Palouse Prairie where a native grassland that had previously supported bison was almost completely converted to non-native wheat. Barring the effects of subsequent dams on the Columbia and Snake Rivers, perhaps the most severe environmental impacts caused by European colonization played out during a remarkably brief 40-year period.

4.a. Setting the Stage, *circa* 1800

It is difficult to estimate how many grizzly bears live in a given area under the best of circumstances. Even so, a ballpark estimate of how many grizzly bears likely roamed Idaho at the time of first contact with Europeans is potentially useful. If nothing else, this kind of estimate serves as a baseline for determining how many bears were lost—and how many we could potentially still have. Perhaps the

[16] My sources for this brief summary of Idaho history include a number of books devoted to the topic. Some of the earliest include Bancroft (1890) and Hailey (1910). These books along with Wells (1983) and Western Mining History https://westernmininghistory.com/ also cover the history of mining in Idaho.

best approach to such a calculation is to summarize contemporary density estimates for unexploited grizzly bear populations and then judiciously apply averaged densities to areas with approximately the same intrinsic productivity—which is the approach I've taken here[17].

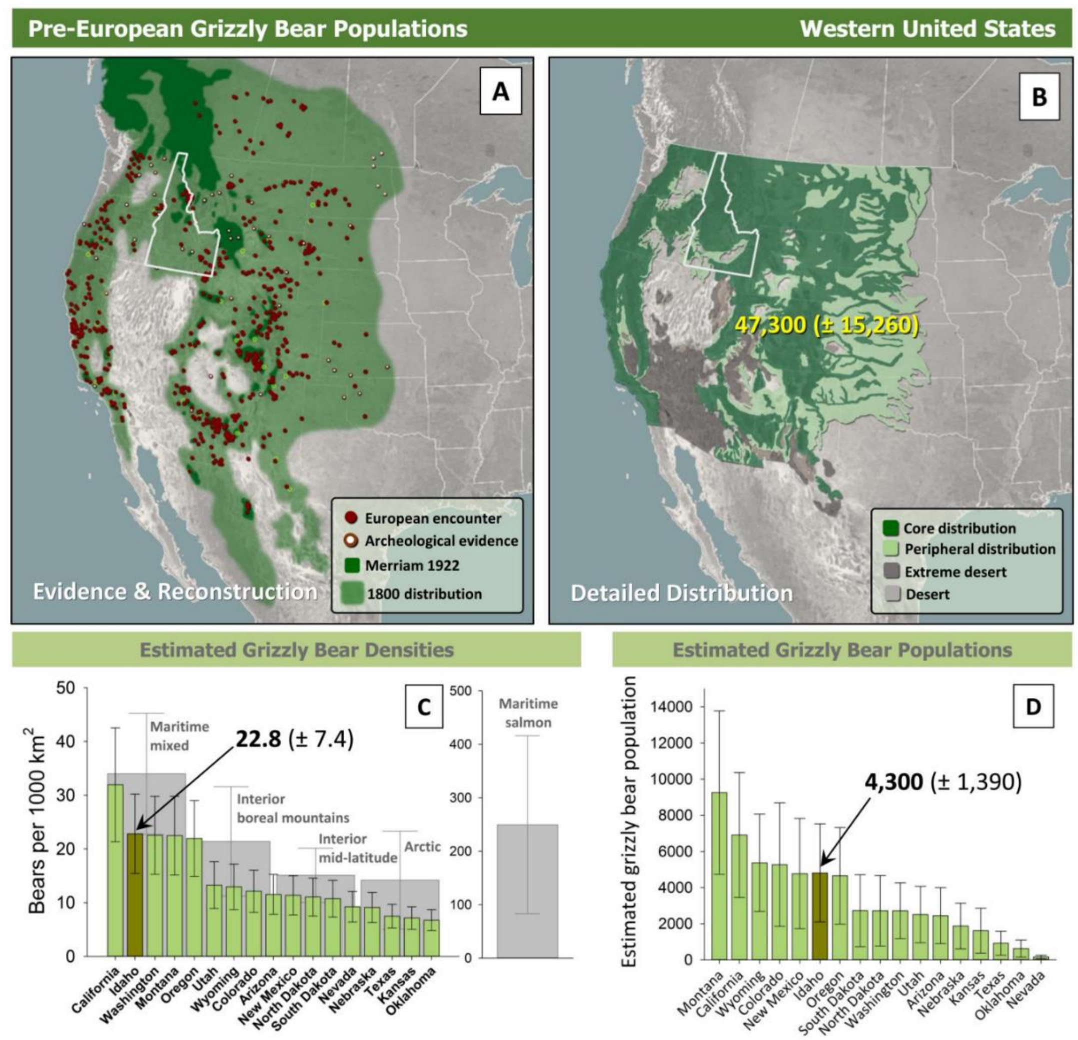


Figure 7. Map (**A**) shows the estimated distribution of grizzly bears *circa* 1800 along with supporting evidence. Solid dots represent documented encounters by Europeans; orange dots, archeological grizzly bear remains dating *ca.* 500-1000 years before present (see Mattson [2020a] for sources); and dark green, estimated distribution circa 1910 (from Merriam [1922], Leopold [1959, 1967], and Trevino & Jonkel [1986]). Map (**B**) shows a detailed reconstruction of grizzly bear distribution circa 1800, including core and peripheral distributions based on ecoregions and climate; estimated total population of grizzly bears is shown based on details in (D) (see Mattson [2020a] for sources). The future state of Idaho is outlined in white in both maps. The bar graph in (**C**) shows estimated contemporary densities of grizzly bears in portions of ecoregions relatively unaffected by humans (light gray bars) as a basis for estimating total numbers of grizzly bears in the contiguous United States *circa* 1800, stratified by core and peripheral habitat (see Mattson [2020a] for sources). Light green bars represent estimated densities of grizzly bears in each state, accounting for core and peripheral habitat. The bars in (**D**) are proportional to estimated numbers of grizzly bears in each state of the contiguous U.S. *circa* 1800 based on density estimates and relative amounts of core and peripheral habitats. Estimates for Idaho in (**C**) and (**D**) are shown as dark green bars.

[17] I lack the space here to provide a comprehensive list of references or grizzly bear density estimates, so the best I can do is refer readers to this web page-- https://www.allgrizzly.org/bear-density --where I've posted a document with relevant details, most raw data coming from Mowat et al. (2013).

The results of these calculations are shown in Figure 7, where I show Idaho in context of other future western states, including in Figure 7a a reconstruction of grizzly bear distribution based on recorded encounters between Europeans and grizzly bears, augmented by locations of grizzly bear remains documented at archeological sites; in Figure 7b, a representation of grizzly bear habitat differentiated by whether it likely supported core or peripheral grizzly bear populations[18]; and in Figures 7c and 7d, resulting estimates of average grizzly bear densities as well as total population sizes on a per state basis, realizing that none of these states existed in 1800. Figure 1 also shows an approximation of grizzly bear distribution in Idaho circa 1800.

These results suggest that ancestral Idaho supported one of the highest densities of grizzly bears in the future western United States (approximately 23 bears per 1000km^2), second only to California, yielding a total population estimate (roughly 4,300 grizzlies) comparable to that of other second tier states, including Wyoming, Colorado, New Mexico, and Oregon. The map in Figure 7b is also consistent with the agroclimate zones depicted in Figure 1, suggesting that the Snake River Plain was marginal—or "peripheral"—habitat for grizzly bears compared to everywhere else in the future state of Idaho.

In addition to having some estimate of grizzly bear numbers to work with, another salient benchmark is the approximate nature and distribution of grizzly bear dietary economies in Idaho at the time of European contact. Figure 8 shows my best attempt at reconstructing these economies for most of the northern U.S. Rocky Mountains, including all but the southern-most portion of Idaho.

Far northern Idaho and adjacent northwestern Montana were probably typified by a dietary economy based on consumption of fruit and forbs (see Figures 15 and 16 for relevant details)—likely the default consequence of a dearth of spawning anadromous salmon, whitebark pine, and bison as it was the more affirmative consequence of a comparatively wet maritime climate and resulting lush vegetation (see Figure 1). Farther south, central and southwestern Idaho were almost certainly characterized by a salmon-based economy (see Hilderbrand et al. 1999), but grading from wetter areas to the north, where fruit was also a staple, to drier colder areas farther to the south and east, where whitebark pine seeds were probably a prominent food. Further south and east yet, outside the distribution of anadromous salmonids, grizzly bears likely exhibited what I call a "mixed-mountain" dietary economy. This economy would have been typified by varied consumption of various foods, but with whitebark pine seeds, fruit, roots (e.g., biscuitroot and yampa [*Perideridia gairdneri*]), and bison prominent[19]—with army cutworm moths (*Euxoa auxilliaris*)[20] and cutthroat trout (*Oncorhynchus clarki*)[21] potentially also locally important. Finally, farther east yet, on the Great Plains, grizzly bear diets likely transitioned to dominance by meat from bison plus fruit from species typical of this environment, including

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[18] I based this determination for the most part on maps of U.S. Environmental Protection Agency Level III and IV Ecoregions (https://www.epa.gov/eco-research/level-iii-and-iv-ecoregions-state) cross-walked to a somewhat subjective reckoning of whether each of the ecoregion types would have more likely supported higher versus lower densities of grizzly bears.
[19] See https://www.allgrizzly.org/pre-european-diets-i and https://www.allgrizzly.org/pre-european-diets-ii
[20] For more about grizzly bear consumption of army cutworm moths, see this web page: https://www.mostlynaturalgrizzlies.org/army-cutworm-moths
[21] For more about grizzly bear consumption of cutthroat trout, see this web page: https://www.mostlynaturalgrizzlies.org/cutthroat-trout

serviceberry (*Amelanchier alnifolia*), chokecherry (*Prunus virginiana*), and plums (*P. americana*)[22]. Parenthetically, an expression of this bison-based economy might have also existed in upper elevations of the Snake River Plain (as per Figure 5).

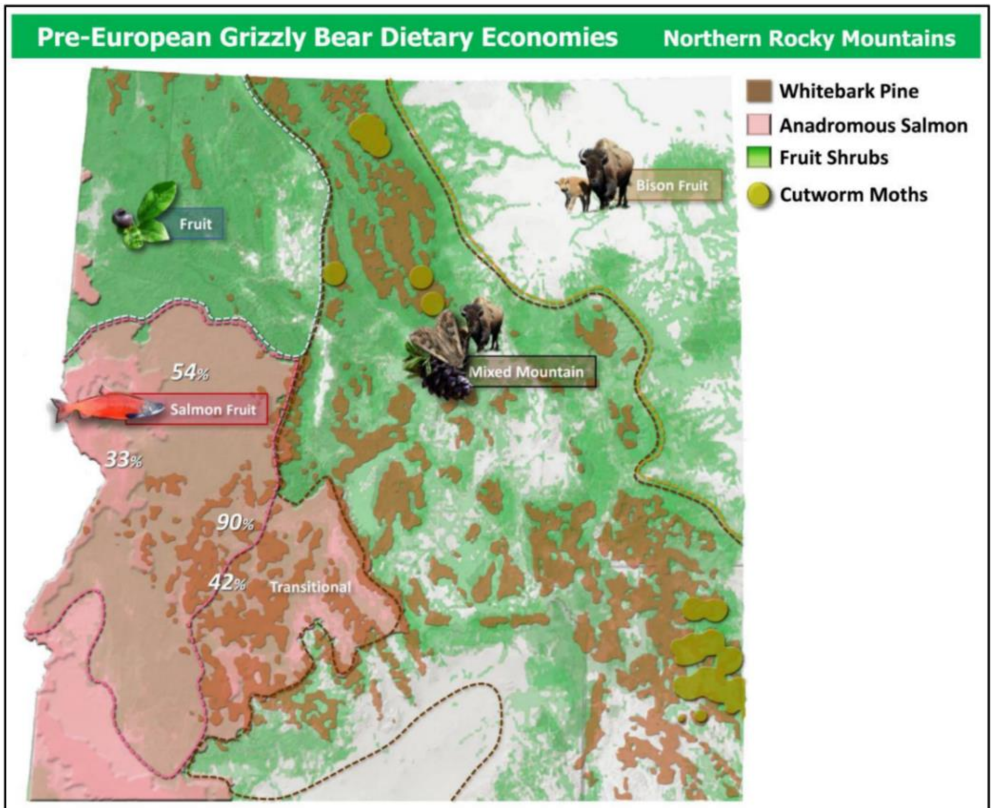


Figure 8. This map shows the distributions of four grizzly bear dietary economies at the time of first contact with Europeans in and near what was to become the northern Rocky Mountains of the United States. Each dietary economy is labeled and delineated by a different-colored dashed line that accounts for the distribution of grizzly bears as well as transitions to other dietary economies that are not labeled. This map represents the synthesis of information from Mattson (2020a). Distributions of spawning salmon are from U.S. Department of Commerce (2013a,b) and Idaho Department of Fish & Game (2018). White italicized percentages are estimates of metabolized energy obtained from salmon, with each number corresponding to an individual grizzly bear. Estimates were based on analysis of isotopes obtained from grizzly bear remains recovered from museum collections (Hilderbrand et al. 1996). Distribution of huckleberry is from Prevéy et al (2020). Distributions of other important fruit-producing shrubs are from Ironside & Mattson (2014). Distribution of whitebark pine is from Crookston, *Plant Species and Climate Profile Predictions*. Distributions of army cutworm moth aggregation sites are from Chapman et al. (1955), Craighead et al. (1982), Aune & Kasworm (1989), Mattson et al. (1991a), White et al. (1998), and Robison (2009).

The future state of Idaho almost certainly supported several thousand grizzly bears at the time of European contact, with highest bear densities likely occurring in portions of the state north of the Snake River Plain. Central and northern ancestral Idaho were probably more productive environments for grizzly bears compared to the arid and semi-arid Snake River Plain, largely as a consequence of abundant fruit, anadromous salmonids, and whitebark pine. Central portions of the Snake River Plain may have only supported significant numbers of grizzly bears when bison roamed this region prior to the 1830s-1840s.

[22] See https://www.allgrizzly.org/pre-european-diets-ii and https://www.allgrizzly.org/the-bison-factor

4.b. Extirpations

Grizzly bears in Idaho were extirpated from over 90% of the state by newly arrived Europeans in a startlingly brief 100-year period, between roughly 1850 and 1950 (see Figure 9 for a mapped synopsis of these extirpations). The proximal causes were trauma caused by bullet wounds, injuries from massive spring-loaded traps, and toxicity from poisons laced into baited carcasses. Grizzly bears whose ancestors had lived in the newly-defined area of Idaho for perhaps 40,000 years were shot, trapped, and poisoned at every turn as part of a sanctioned eradication effort.

Behind all this was unqualified intolerance of large carnivores justified by well-honed narratives that ascribed virtue to these extirpations as means of removing obstacles to civilization and otherwise cleansing the Earth in preparation for a superior European culture. There is ample evidence of this cultural program in the many journals and recollections of Europeans who traveled through and settled in the Rocky Mountains, although perhaps best documented in specific reference to grizzly bears by authors such as Storer & Tevis (1955; for California) and Brown (1985; for the Southwest), but also by Robinson (2005) generally for the history of government subsidized programs to eliminate predators.

In some respects, the cause(s) of grizzly bear extirpations in Idaho are pretty straight-forward, with perhaps nothing left to be explained.

But the *pattern* of extirpations begs a number of questions (Figure 10). Most prominently, why did grizzly bears disappear from the extensive remote mountainous region between the Snake River Plains and the St. Joe River drainage at the neck of Idaho's panhandle? Most of this area is currently roadless, and much of it is designated Wilderness Area. It is remarkably rugged. The question is thrown into even sharper relief by the fact that viable populations of grizzly bears managed to survive persecution by Europeans in areas comparably remote and rugged, notably in the current Greater Yellowstone and Northern Continental Divide Ecosystems. Why did grizzly bears survive in these areas, but not in central and north-central Idaho? What was different? Why did grizzly bears disappear from their last stronghold in the Clearwater-Lochsa River drainage when their numbers (*c*. 40) were not that dissimilar from populations that survived in the Selkirk (*c*. 20) and Cabinet (*c*. 25) Mountains as well as in the Yaak region (*c*. 30) of far northwestern Montana (Figure 9b)?

The maps in Figure 10 highlight the most prominent geospatial anomalies, as well as providing cause to dismiss the ready invocation of densities of resident humans as an explanation for extirpations. Humans were not that numerous in central Idaho, although the nature of their presence and interactions with grizzlies was perhaps singular, especially in contrast to the ancestral Greater Yellowstone and Northern Continental Divide Ecosystems.

The history of invasion and occupancy by Europeans, together with unique configurations of habitats and foods, provide clues to why early extirpations of grizzly bears happened in an otherwise wild remote landscape. As shown in Figure 11a, the area of anomalous grizzly bear extirpations coincided with where spawning anadromous salmon were a staple food for grizzly bears. These extirpations also coincided with areas where there were early intrusions by miners into the mountainous areas of central and north-central Idaho between the 1860s and 1880s (Figure 11b).

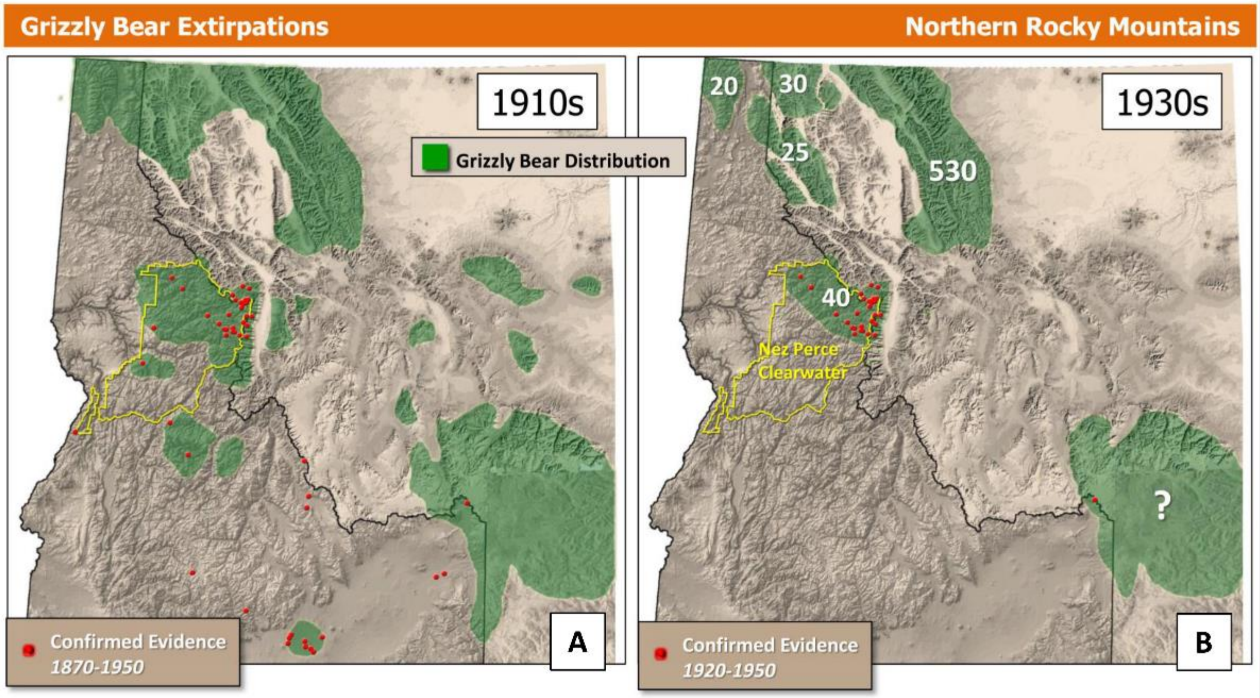


Figure 9. These two maps show documented locations (as red dots) as well as estimated total distributions (in green) of grizzly bears in the U.S. Northern Rocky Mountains during two time periods that encompass the period of terminal grizzly bear extirpations in this region. The boundary of the future Nez Perce-Clearwater National Forests is shown in yellow . The estimated distribution of grizzly bears in (A) is from Merriam (1922); individual locations are from Merriam (1891), Wright (1909), Mills (1919), Cochrell (1970), Smith (1973), Space (1981), Moore (1996), and collections held by the Smithsonian National Museum of National History. The distribution of grizzly bears in (B) was estimated by interpolating between 1910s and 1970s distributions ; the latter estimated from U.S. Forest Service (1933), Layser (1972, 1978), Kasworm (1985), U.S. Fish & Wildlife Service (1982), and Moore (1996). Population estimates in (B) are from Forest-specific estimates of game populations in U.S. Forest Service (1933).

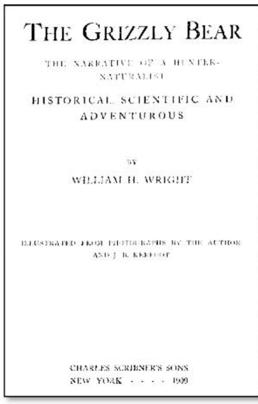
As a general—even axiomatic—proposition, grizzly bears are killed by humans as a joint function of how frequently they encounter people and the likelihood that these encounters will be lethal to the involved bears (Mattson et al. 1996a). There is no doubt that encounters with Europeans during the 1800s and early 1900s were almost always lethal for grizzlies, which meant that persistence of grizzly bear populations largely became a function of conditions that minimized the likelihood they would encounter people in the first place.

Not surprisingly, the most prominent driver of contact is numbers of people in a given area (Mattson & Merrill 2002). But local distributions of bear foods are also important, especially if they attract grizzlies to areas where they are more likely to encounter people, whether they be few or many. Aside from anthropogenic foods, the native foods that most often brought bears into contact with Europeans during the 1800s were bison carcasses, by being concentrated in riparian areas used as primary travel routes by people, and spawning salmonids, by being concentrated in streams confined to valley bottoms, which were likewise used by people for both travel and habitation (Mattson & Merrill 2002). By contrast, grizzly bears survived best during the late 1800s and early 1900s in areas where whitebark pine seeds were a principal food (Mattson & Merrill 2002).

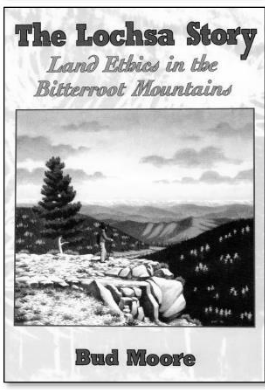
Whitebark pine is exploited by grizzly bears in rugged high-elevation areas that are infrequently occupied or visited by people (Mattson et al. 1994). As a result, grizzly bears that forage on the seeds

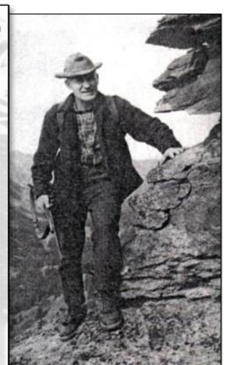
Documenting Extirpations of Grizzly Bears in the Bitterroot and Clearwater Country

Box 2. William Wright (1856-1934) and Bud Moore (1917- 2010) probably contributed more than anyone else to documenting the pre-extirpation ecology of grizzly bears in Bitterroot Mountains and north-central Idaho as well as the final demise of grizzlies in this area. Photos of both men are below, along with illustrative quotes from each of their books. The covers of their seminal books are also shown at left.



Page 74
"I accordingly fired at the small bear, and hitting him square in the shoulder, he dropped promptly and without a murmur, but he dropped into the pool. Before the other one on the log had time to make much of an investigation I hit him near the same place, but a little further back, and he made for the shore. I paid no attention to him, as I knew that he was fatally wounded and would not go far, and slapping my third cartridge in place, I turned to look for the third bear, but all I could see was the swaying of the bushes where he had disappeared. The second one shot went some fifty yards after reaching the bank, when he fell, and was quite dead when I got to him."





Page 278
"The last track I saw was along the Spruce Creek Fork of the Brushy in 1946. There was no life in its wake. The mud had dried around the imprint of the big paw and its long claws in what seemed to me an attempt by nature to preserve some sign of the last of the great bear's passing. That year the Idaho Fish and Game Department, for the first time, closed the season for hunting grizzlies. But it was already too late."

of whitebark pine end up being attracted to *de facto* refuges from humans where they in turn have a greater likelihood of surviving (Mattson et al. 1992, Pease & Mattson 1999). As a result, grizzly bear populations with access to whitebark pine have a greater likelihood of persisting (Mattson & Merrill 2002).

All of this is relevant to interpreting the early extirpations of grizzly bears in central portions of Idaho, especially between 1860 and 1909. Spawning salmon were almost certainly an important food in this region that attracted grizzlies to predictable places at predictable times, all located in valley bottoms where people were more likely to be active. Of even greater relevance, this spatial and temporal predictably would have made grizzlies acutely vulnerable to people deliberately setting out to kill them (as described by Wright 1909; also see Box 2). Compounding this dynamic, prospectors in Idaho are described as visiting virtually every corner of even the most remote regions in their quest for exploitable mineral deposits (Wells 1983)—a pattern that differentiated them from people intent on pursuing a living in agriculture. Many of the mining claims, mines, and mining camps were, moreover, located deep in the mountains (Figure 11b) where they would have functioned as bases of operations offering hunters, prospectors, and miners easier access to grizzly bears.[23] The concurrent and subsequent establishment of scattered remote homesteads along the main stem and tributaries of the Salmon and Boise Rivers, many sustained by subsistence hunting and income from trapping (e.g., Smith 1973), almost certainly did not help.

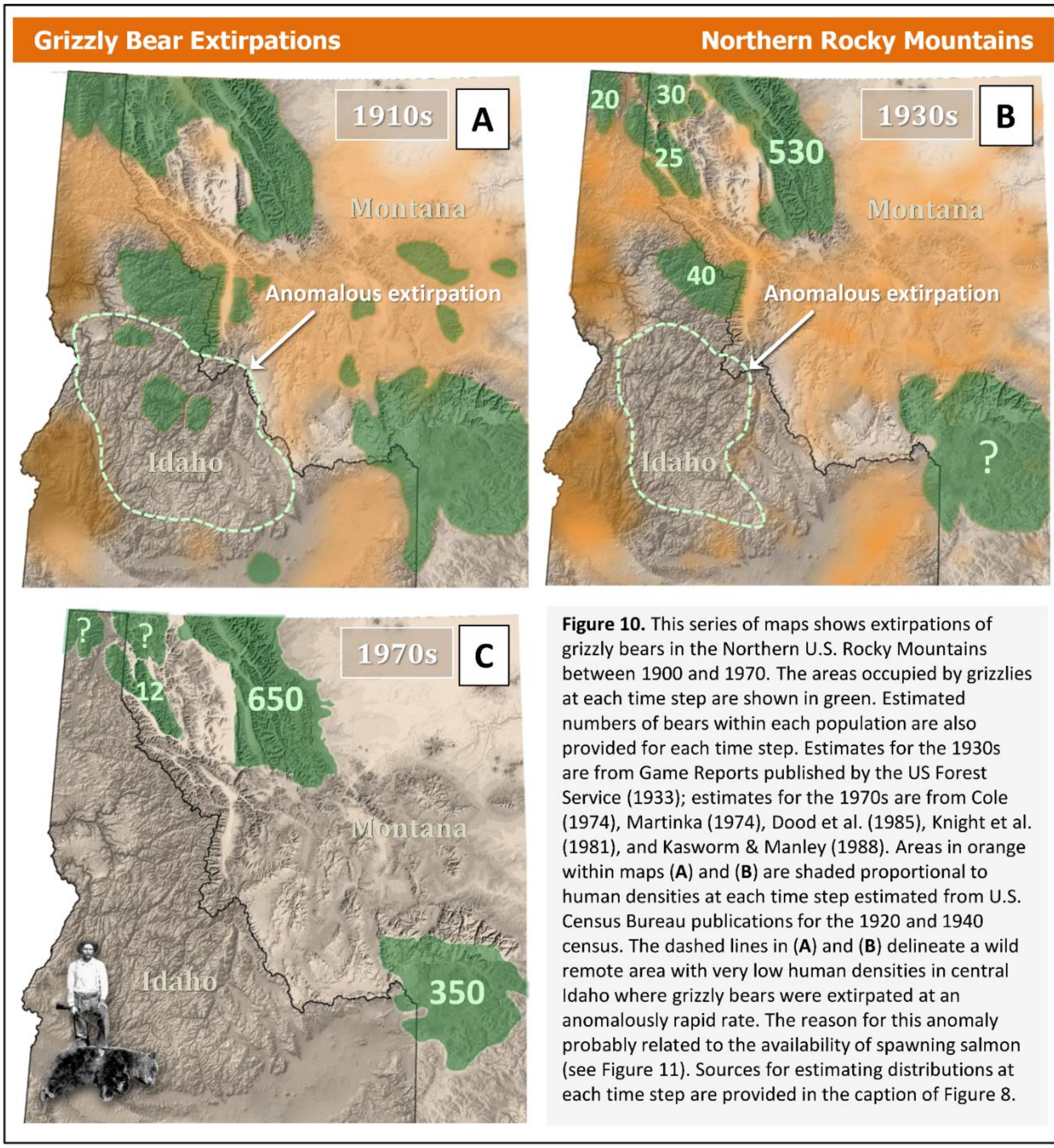


Figure 10. This series of maps shows extirpations of grizzly bears in the Northern U.S. Rocky Mountains between 1900 and 1970. The areas occupied by grizzlies at each time step are shown in green. Estimated numbers of bears within each population are also provided for each time step. Estimates for the 1930s are from Game Reports published by the US Forest Service (1933); estimates for the 1970s are from Cole (1974), Martinka (1974), Dood et al. (1985), Knight et al. (1981), and Kasworm & Manley (1988). Areas in orange within maps (**A**) and (**B**) are shaded proportional to human densities at each time step estimated from U.S. Census Bureau publications for the 1920 and 1940 census. The dashed lines in (**A**) and (**B**) delineate a wild remote area with very low human densities in central Idaho where grizzly bears were extirpated at an anomalously rapid rate. The reason for this anomaly probably related to the availability of spawning salmon (see Figure 11). Sources for estimating distributions at each time step are provided in the caption of Figure 8.

[23] Interestingly—and for somewhat inexplicable reasons—some of the last grizzly bears to be killed in southern Idaho occupied areas in and near Craters of the Moon. According to records kept by the Smithsonian National Museum of Natural History, three bears were killed during 1917, one during 1922, two during 1923, and one during 1928 in this relatively small area thanks to the collecting and predator control efforts of Luther Goldman (of the Bureau of Biological Survey), Carlos McIntosh, G. W. Bryson, R. Williams, L. Twichel, S. Driggs, and J. Moran—egged on from afar by C. Hart Merriam (Merriam 1904). What were grizzlies eating in this area? Clues are offered by Luther Goldman and Harold Stearns who each respectively observed that focal foods at the time seemed to be livestock (Goldman 1922) and biscuitroot (or "parsley," *Lomatium cous*; Stearns 1928).

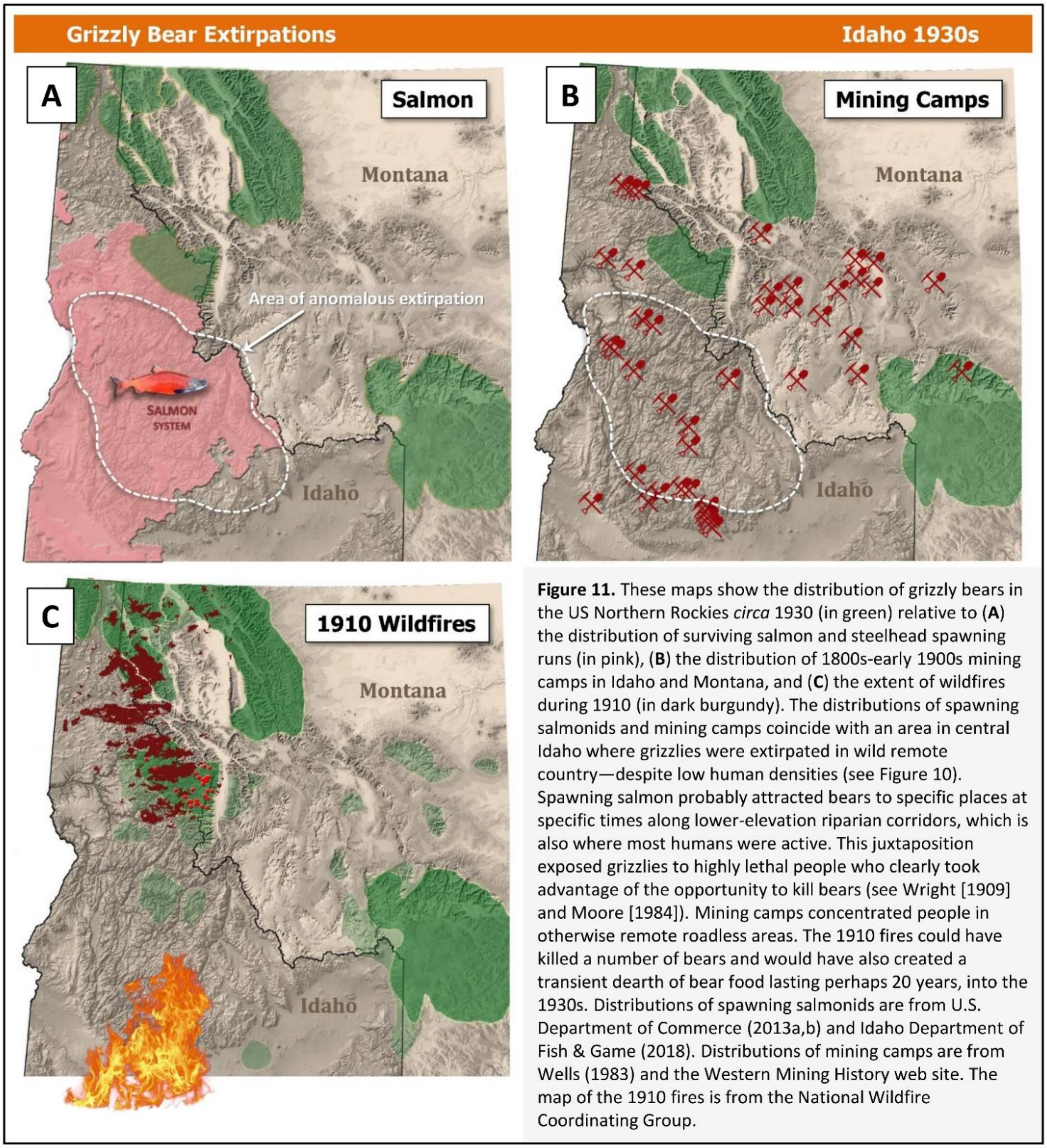


Figure 11. These maps show the distribution of grizzly bears in the US Northern Rockies *circa* 1930 (in green) relative to (**A**) the distribution of surviving salmon and steelhead spawning runs (in pink), (**B**) the distribution of 1800s-early 1900s mining camps in Idaho and Montana, and (**C**) the extent of wildfires during 1910 (in dark burgundy). The distributions of spawning salmonids and mining camps coincide with an area in central Idaho where grizzlies were extirpated in wild remote country—despite low human densities (see Figure 10). Spawning salmon probably attracted bears to specific places at specific times along lower-elevation riparian corridors, which is also where most humans were active. This juxtaposition exposed grizzlies to highly lethal people who clearly took advantage of the opportunity to kill bears (see Wright [1909] and Moore [1984]). Mining camps concentrated people in otherwise remote roadless areas. The 1910 fires could have killed a number of bears and would have also created a transient dearth of bear food lasting perhaps 20 years, into the 1930s. Distributions of spawning salmonids are from U.S. Department of Commerce (2013a,b) and Idaho Department of Fish & Game (2018). Distributions of mining camps are from Wells (1983) and the Western Mining History web site. The map of the 1910 fires is from the National Wildfire Coordinating Group.

But there is a final peculiarity. Why did grizzly bears disappear from their last enclave in north-central Idaho in upper reaches of the Clearwater River drainage between 1910 and 1950? On the one hand, there were so few grizzlies left here that a few chance events could have led to their demise. Yet comparably small populations of grizzly bears managed to persist in three other areas—the Yaak region and in the Cabinet and Selkirk Mountains. Aside from on-going human-caused attrition, there are not many obvious candidates to explain the disappearance of grizzlies in the Clearwater country—except for two.

Wildfire is not often thought of as a hazard for grizzly bears. Yet there was one wildfire event that no doubt affected the last enclave of grizzly bears in the Clearwater drainage—the unprecedented fires of 1910. These fires were so explosive and so large that they killed nearly 90 people and injured hundreds more (Egan 2009; see the map in Figure 11c for the extent of these fires). Given how rapidly these massive fires spread during just a few days, it is easy to imagine that some grizzly bears fell victim as well, not only in the Clearwater country, but also in the nearby Cabinet Mountains of northwestern Montana. But aside from this, many spawning streams would have likely been impaired by sediment pollution during subsequent erosion events[24], and vegetal bear foods would have been eliminated for at least a few years after, with recovery of fruit crops probably not occurring until 20-40 years later[25] during the 1930s-1950s.

The other factor that would have likely harmed grizzly bears in the Clearwater drainage during their final decades was construction of the Lewiston Dam in 1927 near Lewiston, Idaho. The dam impaired steelhead trout runs and essentially barred passage of chinook salmon farther upstream into the reaches yet occupied by grizzlies (Davis et al. 1986). At the same time, domestic sheep were being grazed in the Lochsa River and Clearwater River drainages as means of capitalizing on the forage that flourished in open conditions following the 1910 fires. Sheep would have been a prime and easily obtained alternative food for grizzly bears trying compensate for short-falls in salmon and fruit, with the unfortunate consequence of triggering persecution by sheep-herders intent on preventing or retaliating for depredations (Moore 1984).

It is probably not by coincidence that the last plausible evidence of grizzlies in the Clearwater country was documented during 1946 (Moore 1984, 1996).

Extirpations of grizzly bears from Idaho by newly-arrived Europeans were rapid, widespread, and anomalous, with some anomalies plausibly explained by the concentration of grizzlies near lethal people in pursuit of spawning salmon, but with prospects of mineral-related wealth also sending people into even the most remote refuges left to grizzlies. The massive wildfires of 1910 and the near end of chinook salmon spawning runs might have contributed to delivering a *coup de grâce* to the last grizzlies left in the Clearwater country.

[24] There is a compendious body of research on how wildfires of varying intensities and sizes can differentially affect influx of sediments as well as other hydrologic conditions in spawning streams. A few relevant references include Ice et al. (2004), Rieman et al. (2012), and Riley et al. (2015).

[25] For more on successional patterns of relevance to fruit production see: https://www.mostlynaturalgrizzlies.org/habitat-associations

5. Prospects and Potential

By 1970 there was no verifiable evidence of grizzly bears living anywhere in Idaho between the Selkirk Mountains in the far north and the Targhee National Forest in the far southeast, despite a peculiar reference to the presence of grizzlies in the Clearwater River drainage in the U.S. Fish & Wildlife's 1975 rule that gave ESA protections to this species[26]. Regardless, the vast wildlands of this region begged for the presence of grizzly bears, either lurking in some hidden corner, or somehow resurrected by ESA protections. This self-evident potential led the U.S. Fish & Wildlife Service to designate the Selway-Bitterroot Wilderness Area and its neighborhood as the only grizzly bear Recovery Area in the contiguous United States without resident grizzly bears (U.S. Fish & Wildlife Service 1982). The Recovery Area was subsequently enlarged to include the Frank Church-River of No Return Wilderness Area during an effort in the late 1990s to reintroduce grizzlies. This effort led to a compendious Environmental Impact Statement (U.S. Fish & Wildlife Service 2000) that has since been purged from all offical sources as a result of political fall-out from this failed undertaking[27]. But the redrawn Recovery Area boundaries survived as did recognition of the ample potential of this region.

5a. What the Models Show

With the passage of time, modeling methods have improved to a point where useful spatially-explicit representations of suitable grizzly bear habitat can be made. Among the first was Merrill et al. (1999), who tackled projections for Idaho (Figure 12a). Modeled estimates of potential grizzly bear densities and population sizes followed, with one by Boyce & Waller (2003) specifically for the Selway-Bitterroot Recovery Area—subsequently more or less replicated by Mowat et al. (2013). These two estimates came in at around 300-500 bears (Figure 12b), far more than potential population sizes estimated for Cabinet-Yaak Recovery Area (Mattson & Merrill 2004, Mowat et al. 2013).

But this isn't the whole picture. Modeling efforts that liberated themselves from the confines of Recovery Area boundaries drawn by the U.S. Fish & Wildlife Service—largely for political reasons—showed much greater potential (e.g., Merrill et al. 1999; Carroll et al. 2001, 2003; Merrill 2005; Craighead et al. 2005) encompassing almost all of the roadless wildlands of north-central, central, and southern Idaho (Figure 12a). Importantly, these models considered not only remoteness from humans, but also habitat productivity—absent any consideration of meat resources such as elk and spawning salmonids. An estimate of potential numbers of grizzlies for this more expansive representation of potential suitable habitat suggests that between 500 and 1,100 grizzlies could live in portions of Idaho that are remote enough, productive enough, and also contiguous enough to support grizzlies (as per Merrill 2005). The pivotal Nez Perce-Clearwater National Forests alone could probably support between 250 and 500 grizzlies (Figure 12).

Even in the wake of all this modeling, a question still remained. Could grizzly bear actually make it to this Grizzly Bear Promised Land absent the heavy intervening hand of a reintroduction effort? Other

[26] 40 FR 31734-31736, July 28, 1975; "verifiable" is the key word here, as typically used by the U.S. Fish & Wildlife Service to mean that confirmation requires either a carcass, DNA evidence, or an irrefutable photograph. Tracks are considered to be intrinsically suspect. Even so, investigators such as Melquist (1985) and Groves (1987) provide credible evidence that grizzly bears were present in north-central Idaho during the 1970s and 1980s.
[27] The fraught history of this effort has been covered by authors such as Smith (2003), Dax (2015), and Nadeau (2020)—with varying degrees of veracity, bias, and self-reference.

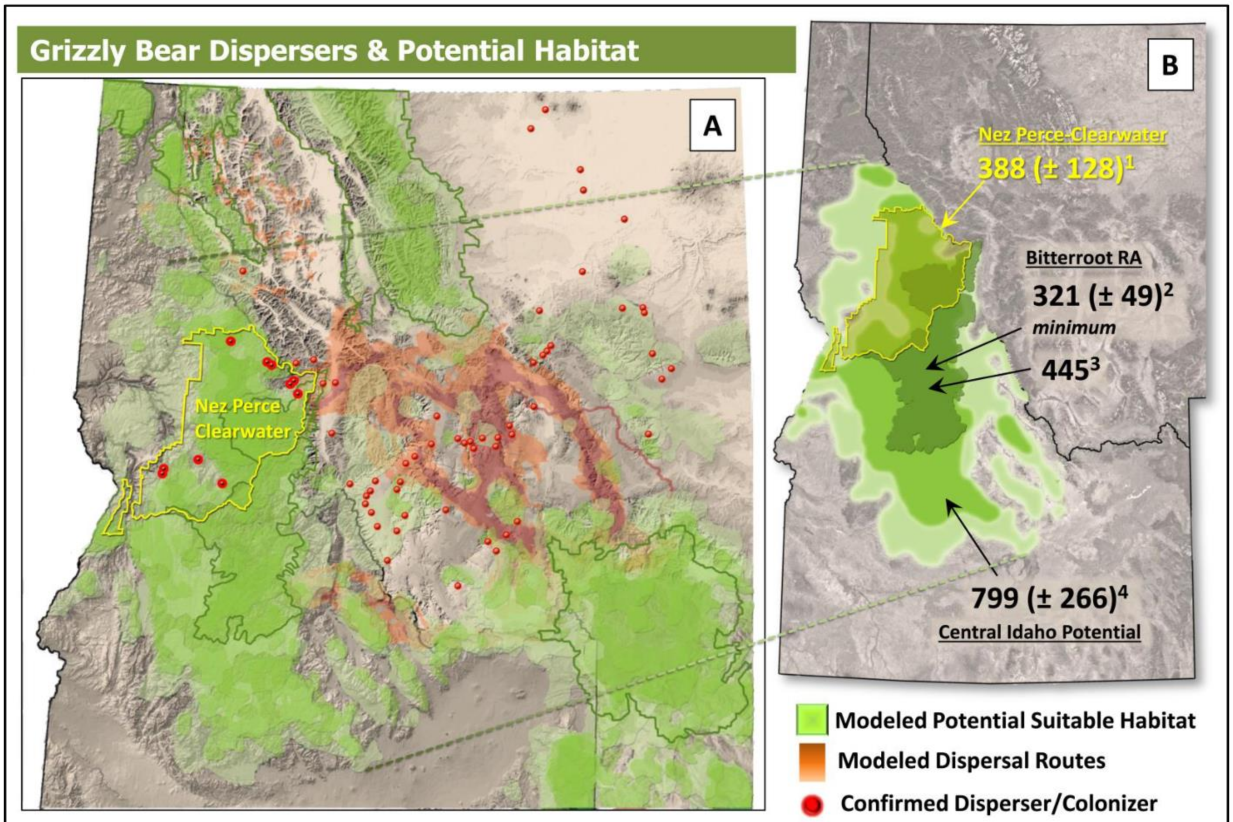


Figure 12. Map (**A**) shows the distribution of potential suitable habitat (in shades of green) and potential dispersal routes (in shades of orange) for grizzly bears in the U.S. Northern Rocky Mountains along with the distribution of dispersing/colonizing grizzly bears documented since 2005 (red dots). Potential suitable habitat is based on models that incorporate habitat productivity and remoteness from humans, with darker green indicating greater replication of results (from Merrill et al. [1999]; Carroll et al. [2001, 2003]; Merrill & Mattson [2003]; Mattson & Merrill [2004]; Merrill [2005]; and Craighead et al. [2005]). Dispersal routes were modeled by Walker & Craighead (1997), Servheen et al. (2001), Proctor et al. (2015), and Peck et al. (2017). Documented locations of dispersers/colonizers are from Groves (1987), Nokkentved (2007), Costello et al. (2014, 2019), Barker (2020), Backus (2020), Phillips (2020), Angelamontana (2020), and Kasworm et al. (2020). Map (**B**) shows estimated potential population sizes for grizzly bears in north-central and central Idaho relative to different delineations. Estimates for the Bitterroot Recovery Area (in darkest green) are from Boyce & Waller (2003)[2] and Mowat et al. (2013)[3]. The estimate for potential suitable habitat in central Idaho by Merrill et al. (1999)[4] was obtained by applying average densities of unexploited grizzly bear populations in interior North America to areas delineated in light-green (low density) and medium-green (moderate density), respectively (from Figure 7). The estimate for the Nez Perce-Clearwater National Forests (in yellow)[1] was obtained using the same methods.

modeling has attempted to answer this question, although grizzly bears themselves have provided an even more definitive response. Figure 12a shows the results of various efforts to model "dispersal" habitat for grizzlies, most usefully by Walker & Craighead (1997). These results, together with models of potential suitable habitat, showed potential connections between the Cabinet-Yaak Ecosystem to the north, the Northern Continental Divide Ecosystem to the northeast, and the Greater Yellowstone Ecosystem to the east.

But these are only models. Verified observations of dispersers have shown that grizzly bears are, in fact, making the journy (Figure 12a). Perhaps most surprising, at least one grizzly bear made it as far south as the breaks of the Salmon River drainage in the Nez Perce National Forest. But all of these dispersers are probably male bears—certainly that's the case for all of the dispersers of known sex.

This gender bias is not surprising given that the average dispersal distance of young males (55 km, averaged over 7 studies) is 5-times farther than the average dispersal distance of females (11 km, averaged over 6 studies)[28]—which translates into a considerable time lag between when female and male bears show up in an area. It may be several decades before female grizzlies arrive in central Idaho, but they will get here provided they survive hazardous encounters with highways, agricultural lands, roaded landscapes, human settlements, and hunters.

5b. How Much Will Be Enough?

A political calculus that gives priority to the backward-looking politics of Idaho (as described by Smith [2003]) would suggest that ambitions for grizzly bears should be confined to the current Selway-Bitterroot Recovery Area—a logical culmination of the political calculus that led to drawing these boundaries in the first place. However, there are practical consequences for following such a course, especially when one considers the likelihood that any population of naturally-established grizzly bears might persist for an evolutionarily meaningful period of time within such bounds.

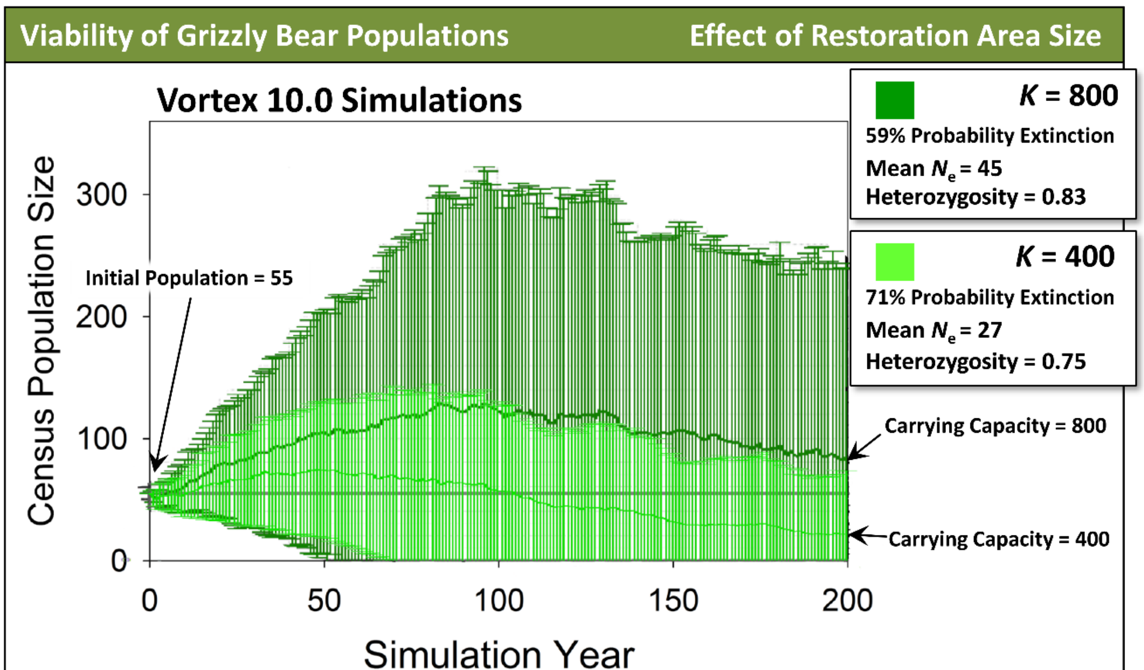


Figure 13. The graphic above shows the results of simulations run with Vortex 10 (Lacy et al. 2018) in which the effect of carrying capacity on population viability is explored with all other set parameters equal, including an initial population size of 55. One simulation was run with carrying capacity set at 800 (dark green), which approximates conditions where all of the suitable habitat identified by Merrill et al. (1999) was candidate for restoration of grizzly bears in central Idaho (see Figure 12a). The other simulation was run with carrying capacity set at 400 (light green), which approximates conditions where recovery of grizzly bears is confined to the existing Recovery Area defined by the Selway-Bitterroot and Frank Church-River of No Return Recovery Areas (see Figure 12b). Under the second scenario, extinction probability is 20% higher, ending population sizes an average 34% lower, and loss of genetic heterozygosity 11% greater compared to the first scenario. The bars for each set of simulations are Standard Deviations of population size at each time step. Population parameters were taken from the Northern Continental Divide Ecosystem grizzly bear population (Mace et al. 2012, Costello et al. 2014) with intrinsic rate of growth (λ) set at approximately 1 and with no emigration or immigration.

[28] These figures were calculated from Blanchard & Knight 1991; McLellan & Hovey (2001); Proctor et al. (2004, 2012), Støen et al. (2006); Zedrosser et al. (2007); and Lamb et al. (2020).

At the most basic level, the parameters for such a consideration devolve down to the prospective carrying capacity (also known among academics as *k*) of the current Recovery Area, in contrast to the prospective carrying capacity for a more liberated assessment of potential suitable habitat, as per Merrill (2005).

With these two basic parameters in hand, I undertook an evaluation of prospective population persistence for grizzly bears that naturally established themselves in central and north-central Idaho—in one scenario limited to the 400 bears and in the other limited to 800 bears (Figure 13). I input plausible demographic parameters from a nearby ecosystem (the Northern Continental Divide) into a well-established bit of software used to estimate population viability (Vortex) to project what would likely happen with plausible environmental variation as well as the the occasional perturbations introduced by inevitable catastrophes. I also considered the effects of genetic heterozygosity, a key determinant of long-term (100s of years) viability. The results are shown in Figure 13.

Even with an equal initial numbers of bears, effective population size (N_e)[29] under a scenario with k = 800 was nearly twice that under a scenario with k = 400, although in both scenarios census population sizes (N) struggled to exceed roughly 20% of ostensible carrying capacity (k). A predictable toll was taken not only by environmental variation, but also by periodic catastropes—which are an inevitable part of real life. Perhaps surprisingly, probabilities of extinction were high under both scenarios, and reached an alarming 71% when carrying capacity was limited to 400 grizzlies.

These results are consistent with the current scientific consensus regarding long-term population viability, realistically defined as what's required to achieve roughly 99% probability of persistence (versus 29-41% probability, as per the two scenarios in Figure 13) for a period of approximately 40 generations (Reed et al. 2003, Frankham & Brook 2004, Reed & McCoy 2013), which for grizzly bears, with average generation lengths of approximately 10 years, equates to around 400 years—twice the time considered here. This consensus suggests that for a species such as the grizzly bear, with a low reproductive rate and a low N_e:N ratio, around 2,500-9,000 animals in a contiguous inter-breeding population are needed to attain long-term, evolutionarily meaningful, viability[30].

This population goal is clearly not attainable within the confines of potential suitable habitat modeled for grizzly bears in Idaho (as per Figure 12b). However, a contiguous population of thousands of bears is feasible if the geographic scope is expanded beyond state and international boundaries to include consideration of occupied as well as potential suitable habitat inclusive of the Greater Yellowstone ecosystem, central and north-central Idaho, northwest Montana, the Northern Continental Divide ecosystem, and contiguous portions of southeastern British Columbia and southwestern Alberta (as

[29] Effective population size is almost always less than census population size. Very simplistically, N_e is the number of breeding individuals in a population—which excludes juveniles, females accompanied by younger offspring, and unsuccessful male breeders—which, when small, has predictable effects on genetic diversity through processes such as inbreeding, purging, genetic mutation, and genetic drift.

[30] The following authors provide an entrée into supporting scientific literature: Lande (1995), Reed et al. (2003), Cardillo et al. (2004, 2005), Frankham (2005), Brook et al. (2006), O'Grady et al. (2006), Traill et al. (2007), and Frankham et al. (2014).

per Proctor et al. [2012] and Apps et al. [2016]). Figure 14b offers a visual representation of what this potential would look like if realized, in contrast to the current distribution of grizzly bears in the contiguous United States. This more encompassing vision not only accommodates the dispersal and colonization by grizzly bears that has alread happened (Figure 14b), but also throws into relief imperatives to preserve as well as restore connectivity among current populations and areas such as central and north-central Idaho that have such self-evident potential.

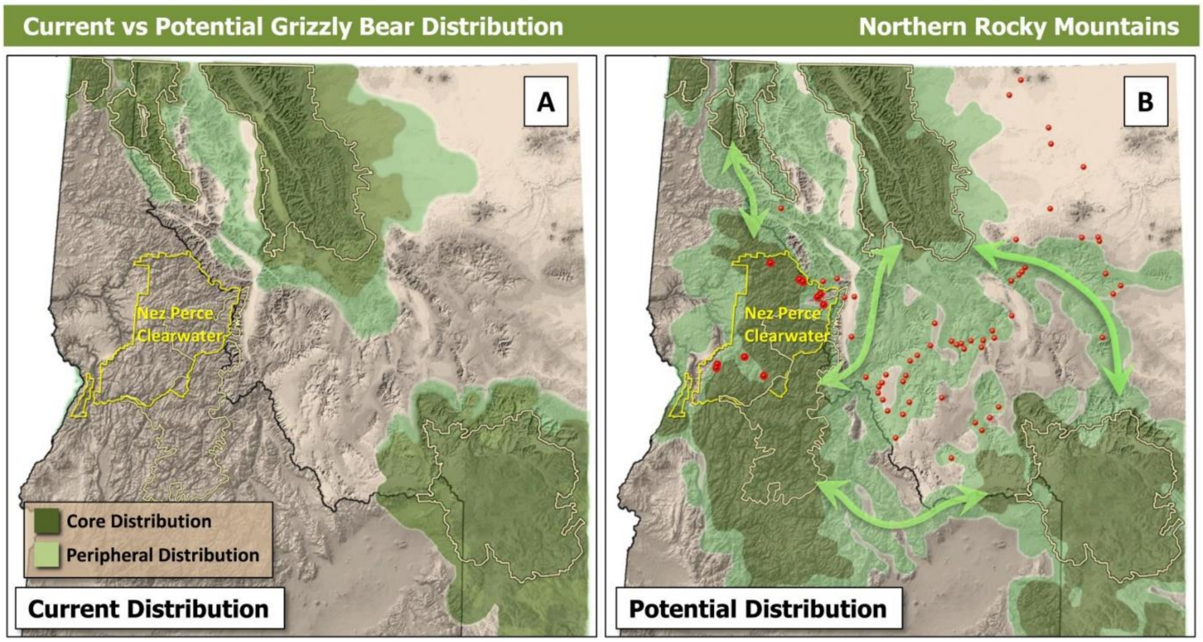


Figure 14. Map (**A**) shows the estimated current distribution of grizzly bears in the U.S. Northern Rocky Mountains, with core distributions denoted by dark green and peripheral distributions denoted by light green (from Costello et al. [2019]; Kasworm et al. [2019, 2020]; and Van Manen et al. [2019]). Map (**B**) shows the estimated potential distribution of grizzly bears in the Northern Rockies with full occupancy of potential suitable habitat shown in Figure 11a. The red dots in (**B**) are dispersing/colonizing grizzly bears documented between 2005 and 2018 (see Figure 12 caption for sources). The green arrows show main connectors between ecosystems. The Nez Perce-Clearwater National Forests are delineated in yellow.

Vacant wildlands of central and north-central Idaho have the potential to support as many as 1,000 grizzly bears which, if realized, would offer significantly greater odds of population persistence compared to if grizzlies were confined to the current Selway-Bitterroot Recovery Area. However, long-term viability will require a contiguous interbreeding population of several thousand grizzly bears, which could be achieved if current populations were connected by on-going colonization of interstitial potential suitable habitat throughout the northern Rockies into Canada.

6. Prospective Diets

During the public debate surrounding plans to reintroduce grizzly bears into the Selway-Bitterroot Recovery Area, contention arose over whether there would be enough food for bears to eat in this region. At the time, this issue seemed a bit inane given that there are ample black bears (*Ursus americanus*) here—eating essentially the same foods that grizzlies will eat—and that brown bears in Asia (the same species as grizzlies) occupy environments of the Gobi Desert, Tibetan Plateau, and nearby Pamir Mountains that are far more austere than any in central Idaho. Closer to home, grizzlies living in the harsh unproductive arctic regions of North America are also instructive.

Even so, this debate served to highlight the entirely reasonable question of whether anadromous salmon would play a role in grizzly bear recovery, and also catalyzed efforts to more explicitly evaluate grizzly bear habitat in this region. Several models offered relatively esoteric representations of habitat productivity based on coarse-grain proxies for vegetation patterns (notably Merrill et al. [1999] and Boyce & Waller [2003]). Early on, the Craighead Wildlife-Wildlands Institute (CWWI), among others, tackled assessment of prospective bear foods at the level of species and habitat types (Scaggs 1979, Butterfield & Almack 1985), later translated into modeled distributions of key vegetal foods by CWWI (Hogg et al. 2000). However, with the exception of passing references by Butterfield & Almack (1985) and Davis et al. (1986), none of these efforts explicitly considered animal foods, which play an important role in the diets of grizzly and brown bears throughout the northern Hemisphere (Mowat & Heard 2006, Niedziałkowska et al. 2019).

In this section I tackle the issue of clarifying temporal-spatial configurations of prospective grizzly bear diets, inclusive of animals as well as plants, not only in the Selway-Bitterroot Recovery Area, but also throughout Idaho's potential suitable habtiat. I devote considerable space to factors that will likely shape grizzly bear diets in pivotal landscapes of the Nez Perce-Clearwater National Forests, not only because this area is critical to recovery efforts, but also for the practical reason that much relevant information has been generated during recent efforts to update and revise the official Plan for these forests (e.g., Nez Perce-Clearwater National Forests (2014a, 2014b, 2019a, 2019b).

Why the lengthy focus here on foods and diets? Diets offer important insights, not only regarding where and when grizzly bears will be active, but also why, with relevance to anticipating and preventing human-bear conflicts. Diets are also essential grounding for any explanation of historical extirpation dynamics (Section 4b) as well as projections of what the future might hold (Section 9).

6.a. Grizzly Bear Diets in the Northern Rocky Mountains

There is still no subsitute for looking at the contents of fecal matter (i.e., scats) to obtain high-resolution information about what bears eat—often to the level of species. Even though poking around in feces has become *passé* among wildlife researchers more enamored with the latest Bayesian modeling methods than with the details of bear behaviors, there have been enough feces-based food habits studies in the various ecosystems of the nothern U.S. Rockies to allow for judicious extrapolations of grizzly bear diets to vacant habitats in Idaho.

Seasonal results of the five most relevant and comprehensive food habitats studies are summarized in Figure 15, ordered from farthest north and west in Figure 15a (the Cabinet-Yaak ecosystem) to farthest south and east in Figure 15e (the Greater Yellowstone ecosystem). These seasonal fractions

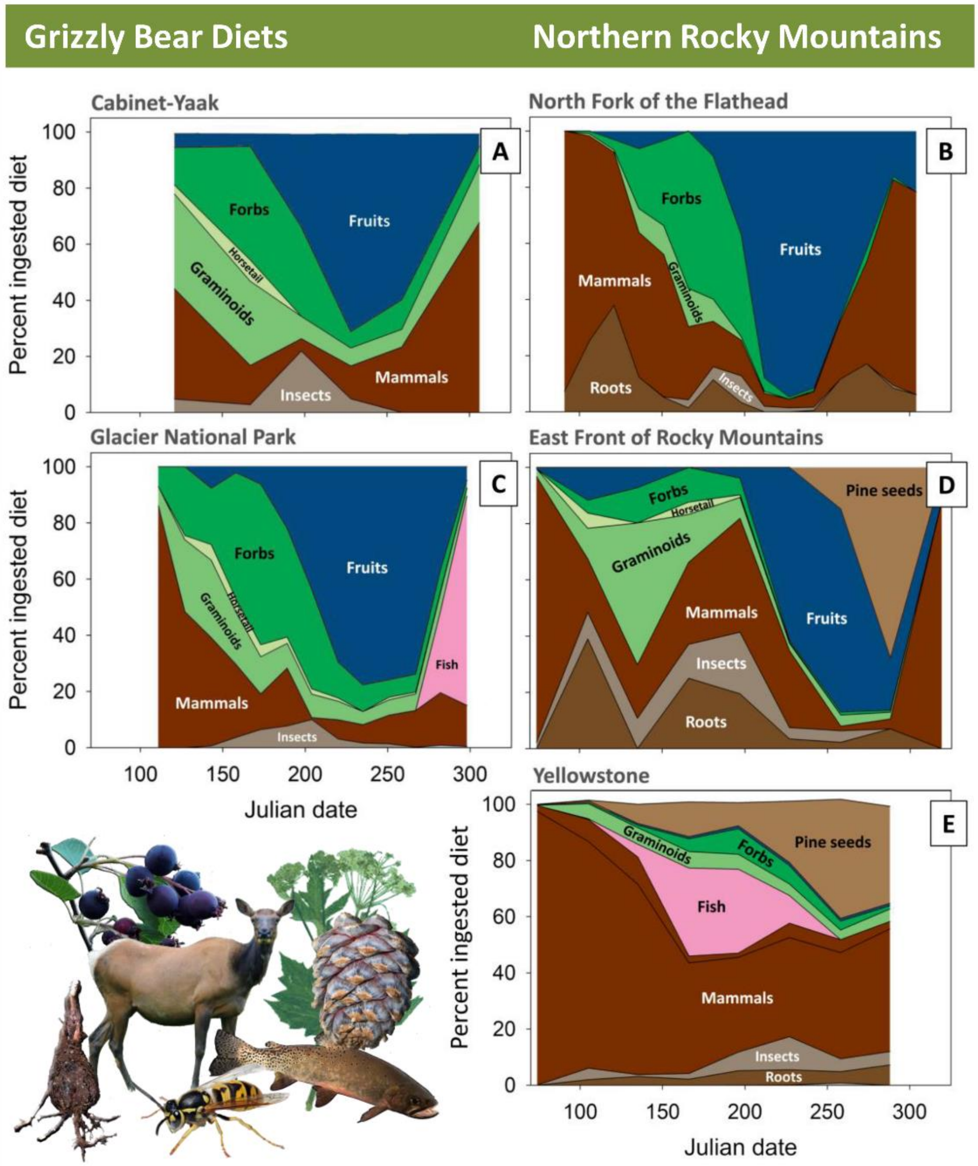


Figure 15. This series of graphics shows seasonal trends in fractional composition of ingested diets for grizzly bears in 5 different study areas to the north, east, and south of central Idaho: (**A**) the Cabinet-Yaak ecosystem (Kasworm et al. 2018); (**B**) the North Fork of the Flathead River spanning the U.S.-Canadian border (McLellan & Hovey 1995); (**C**) Glacier National Park (Kendall 1986); (**D**) the East Front of the Rocky Mountains in Montana (Aune & Kasworm 1989); and (**E**) the Yellowstone ecosystem (Mattson et al. 1991b). Different colors denote different major food groups. Month-specific fractions are estimated from fecal analysis and corrected for differential passage through the gut to calculate relative ingested volumes (Hewitt & Robbins 1996; Mattson et al. 2004).

represent estimates of *ingested* diets, obtained by applying correction factors to fecal contents that account for the differential attrition of foods with passage through the digestive tract (as per Hewitt & Robbins [1996]). As might be expected, the greatest corrections are for meat from fish and mammals and the smallest are for fibrous vegetation—reflecting orders-of-magnitude differences in digestibilities of these foods.

There are a few major themes of relevance to central and nort-central Idaho. First, fruit will almost certainly be a critically important food in most regions, but moreso farther north, with greatest fruit consumption occurring during July and August[31]. Second, perhaps surprisingly, meat from mammals will also be important regardless of the locale, eaten primarily during the spring and fall, but of proportionately greater prominance in drier areas farther south[32]. Third, whitebark pine seeds will probably be heavily consumed wherever healthy stands of mature cone producing trees survive, with most of these seeds eaten during September-October[33]. Finally, of the grazed foods, forbs[34] will be comparatively more important in areas with greater maritime climatic influence farther north, whereas grasses and sedges (i.e. "graminoids") will be more important in areas with continental climates farther south and east—with the bulk of grazing throughout the region occurring during late spring and early summer.

Figure 16 more expressly deals not only with geospatial differences in diets of grizzly bear in the northern U.S. Rockies, but also underlying patterns in distributions of key foods and habitats. The pie diagrams in each panel represent the fractional composition of annual diets, which accounts not only for differential passage of foods through the gut, but also for seasonal differences in population-level feeding activity (as per Roth [1980] and Mattson et al. [1991b]). The dietary portions of relevance to the underlying distributions in each panel are highlighted different colors: blue for fruit, with the darkest blue denoting the modeled distribution of fruit-bearing shrubs by Hogg et al. (2000; Figure 16a); reddish-brown for ungulates, but additionally with highly productive spring habitats shown in shades of green (Figure 16b); brown for whitebark pine, with the darkest brown denoting the modeled distribution of this species by Hogg et al. (Figure 16c); and pink for fish (Figure 16d), which I address below. Idaho's potential suitable grizzly bear habitat is also shown in each of these panels.

The patterns are relatively straight-forward. Fruit-bearing shrubs tend to be more abundant and diverse farther to the north and west, reflected in fruits comprising 33% to 42% of the entire annual grizzly bear diet in these regions; meat from terrestrial sources becomes more prominent farther south, notably in the Greater Yellowstone ecosystem, which is consistent with the greater extent of elk winter ranges in areas subject to more continental climates in drier portions of Idaho; and the

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[31] In north and central regions huckleberry (*Vaccinium membranaceum*) will predictably be a mainstay augmented by mountain ash (*Sorbus* sp.); with proportionately greater consumption of serviceberry (*Amelanchier alnifolia*), chokecherry (*Prunus viriginiana*), and hawthorn (*Crataegus* sp.) farther south; and consumption of buffaloberry (*Shepherdia canadensis*) wherever conditions are auspicious; see https://www.mostlynaturalgrizzlies.org/fruit

[32] White-tailed deer (*Odocoileus virginianus*) are a comparatively more important source of meat in areas with greater maritime climatic influence, often obtained during the fall by scavenging remains left by hunters; elk (*Cervus canadensis*) are important wherever there are large populations, but especially in more open environments with drier climates; consumption of bison (*Bison bison*) is unique to the Yellowstone region; moose (*Alces alces*), although rarely abundant, are preferentially exploited by grizzlies (Mattson 1997). Exploitation of cattle is increasingly common in agricultural areas recently colonized by grizzly bears; see Mattson (2017) and https://www.mostlynaturalgrizzlies.org/spatial-patterns-1

[33] For more details, see https://www.mostlynaturalgrizzlies.org/whitebark-pine

[34] Most notably, cow parsnip (*Heracleum sphondylium*), angelica (*Angelica arguta*), sweet cicely (*Osmorhiza occidentalis*), dandelion (*Taraxacum officinale*) and clover (*Trifolium* sp.); see the caption of Figure 15 for references.

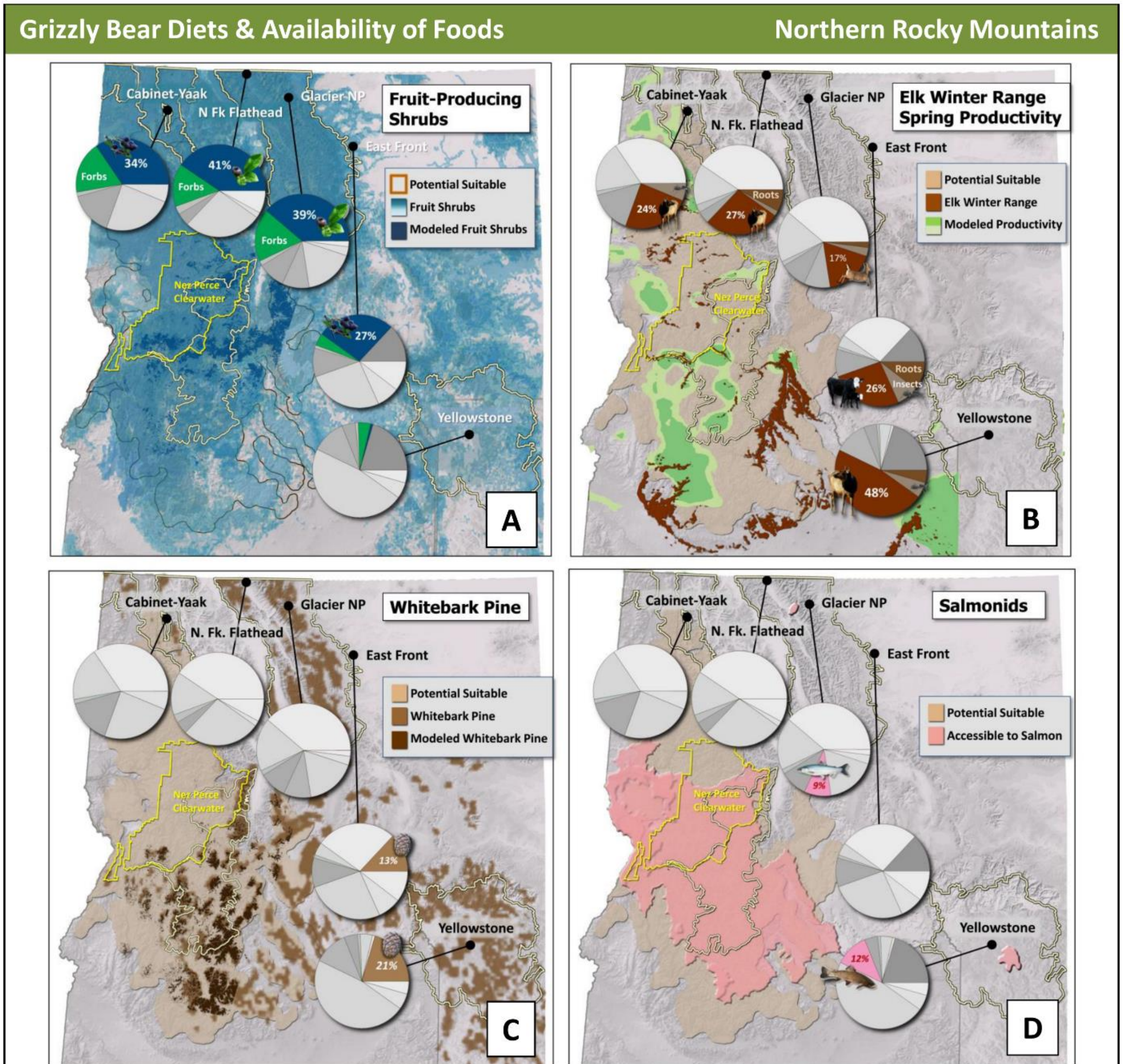


Figure 16. This series of graphics shows fractional composition of total ingested diets for grizzly bears in 5 different study areas (sources in Figure 15) shown as pie diagrams with featured foods highlighted in each panel. These estimated fractions not only account for differential passage of food through the gut (as per in Figure 12), but also seasonal variation in population-wide levels of feeding (Roth 1980, Mattson et al. 1991b, Haroldson et al. 2002, Mattson 2020b). Consumption and availability of different foods or food groups are highlighted in each panel: (**A**) fruits and forbs (e.g., *Heracleum spondophyllum, Angelica arguta*), characteristic of wetter regions with a maritime-influenced climate; (**B**) ungulates, most of which are characteristically exploited during spring (see Figure 12), featuring elk winter range and estimated spring habitat productivity; (**C**) whitebark pine (*Pinus albicualis*), a common source of bear food in areas with more pronounced continental climates; and (**D**) spawning salmonids, historically including kokanee (*Oncorhynchus nerka*) in Glacier National Park and cutthroat trout (*O. clarkii*) in Yellowstone National Park. Modeled distributions of fruit-producing shrubs in (A) are from Hogg et al. (1999; the darkest blue), Ironside et al. (2014), and Prevéy et al. (2020). Distribution of Idaho's elk winter range in (**B**) is from Bergen et al. (2016), shown juxtaposed with modeled spring habitat productivity from Merrill et al. (1999). Distribution of whitebark pine in (C) is from Crookston *Plant Species and Profile Predictions*, with darkest brown showing the distribution modeled by Hogg et al. (1999). Locations where bears exploited salmonids in Glacier and Yellowstone in (**D**) are from Shea (1973) and Reinhart & Mattson (1990), respectively. The extent of current spawning habitat for chinook salmon (*O. tshawytscha*) and steelhead (*O. mykiss*) is from U.S. Department of Commerce (2013a,b) and Idaho Department of Fish & Game (2018).

abundance of whitebark pine increases to the south and east, reflected in substantial fractions of whitebark pine seeds in grizzly bear diets in Yellowstone and along the East Front of Montana's Rocky Mountains. Not surprisingly, aside from the spring scavenging opportunities offered by elk carrion (see Green et al. [1997]), spring vegetal productivity in Idaho tends to be concentrated in warmer lower-elevation areas that only roughly correlate with the distribution of elk winter ranges.

Roughly translated for unoccupied grizzly bear habitat in Idaho: fruit will undoubtedly be a prominent if not dominate source of energy and nutrients north of the Salmon River, but also potentially in an arc further south stretching from central portions of the Frank Church-River of No Return Wilderness Area southwest through the Boise River drainage; meat from elk in particular will likely be proportionately more important south of the Salmon River compared to north; and whitebark pine seeds are likely to be important in grizzly bear diets, but only south of the Salmon River, especially farther east in and near the Sawtooth, Lost River, and Lemhi Mountain Ranges. This last projection is tentative given that most mature whitebark pine may have died in this region during recent decades from an outbreak of native mountain pine beetles (*Dendroctonus ponderosae*; Macfarlane et al. [2013]) and the progressive spread of a highly lethal non-native disease (white pine blister rust, *Cronartium ribicola*; Retzlaff et al. [2016]; for more see: https://www.mostlynaturalgrizzlies.org/recent-trends).

The current distributions of major bear foods together with diets documented for grizzly bears in nearby ecosystems provide ample basis for anticipating what grizzlies would likely eat in different parts of central and north-central Idaho, ranging from a dominance of fruit and forbs to the north, to greater contributions of elk and whitebark pine seeds to the south—with salmon and trout of possible importance in between.

6.b. What About Salmon?

All of this still begs the question: What about salmon? The answer largely depends on the on-going toll taken on anadromous salmonids by dams along the Columbia and Snake Rivers, but some insight can also be gained by considering what we know about relations between grizzly bears and fish in the Glacier and Yellowstone ecosystems. Panel D in Figure 16 certainly drives home the point that anadromous salmonids could be significant in the future diets of grizzly bears if for no other reason than the extent of overlap between potential suitable grizzly bear habitat and drainages still open to spawning salmon or steelhead. Perhaps even more important, consequential portions of central and north-central Idaho still support comparatively healthy runs of anadromous salmonids as well as larger-bodied non-anadromous fish (for example, bull trout [*Salvelinus confluentus*] and kokonee [*Oncorhynchus nerka*]).

Almost all of the fish consumed by grizzly bears in Glacier and Yellowstone Parks were comparatively small-bodied (usually 0.4-0.9 kg), which may explain why in both environments bears preferentially fished smaller streams with higher volumetric densities of spawners (Reinhart & Mattson 1990, Mattson & Reinhart 1997)[35], consistent with William Wright's observations that grizzly bears in central

[35] Of parenthetical relevance, both species have been essentially eliminated as important bear foods during recent decades, primarily as a result of actions taken by people. For more on the reasons behind these declines, see Spencer et al. (1991, 1999), Ellis et al. (2011), and Devlin et al. (2017) for Flathead Lake kokanee, and see https://www.mostlynaturalgrizzlies.org/trends for Yellowstone Lake's cutthroat trout.

Idaho tended to concentrate along smaller streams to fish for spawning salmon (Wright 1909). In Glacier, nearly all of the fish consumed by grizzlies were non-native kokonee salmon from Flathead Lake that spawned during late fall in the shallow waters of McDonald Creek, below McDonald Lake, where they were not only vulnerable to bears, but also to a number of other predators, including a remarkable concentration of bald eagles (*Haliaeetus leucocephalus*; Shea 1973, Martinka 1974). In Yellowstone, almost all of the fish consumed by grizzly bears were cutthroat trout (*Oncorhynchus clarkii*) captured during late spring and early summer while spawning in streams tributary to Yellowstone Lake[36].

The point of all this is that contemporary grizzly bears in the northern U.S. Rockies have made substantial use of smaller-bodied trout and landlocked salmon, contigent on having access to smaller streams that supported high volumetric densities of spawners. Fish don't necessarily need to be large (for example, >1-2 kg), although large size would predictably play to a bear's advantage. But abundance is probably crucial, although the comparative importance of size and abundance is unclear.

Given the large sizes of adult chinook salmon, steelhead trout, and even bull trout—all often >4 kg—fishing by grizzly bears could probably be sustained in headwaters of the Clearwater and Salmon Rivers by even modest spawning runs—which could, in turn, result in salmonids playing a significant role in the diets of grizzly bears in central and north-central Idaho.

6.c. Modern Dietary Economies

In this concluding short section about prospective grizzly bear diets in central and north-central Idaho, I offer a synoptic and somewhat speculative view of contemporary dietary economies in occupied and potential suitable grizzly bear habitat of the northern U.S. Rocky Mountains (Figure 17). A dominant theme is the transition from a fruit and forb-dominated economy farther north and west to what I call a "mixed mountain agricultural" economy to the south and east. The first economy is self-explanatory, although the second probably is not.

Mixed Mountain Agricultural allows for a diminished although still noteworthy dietary role for whitebark pine seeds, while acknowledging an increasing role for agricultural foods, notably livestock, but also including grain crops and honey from beehives. These agricultural elements have largely arisen from grizzly bears colonizing both public lands with grazing allotments as well as private lands subject to various agricultural uses (as described for the Northern Continental Divide ecosystem by Mattson [2019a]). Meat from elk is also prominent in this economy as are, in places, army cutworm moths (*Euxoa auxilliaris*).

Army cutworm moths are heavily consumed by grizzlies in areas with extensive tracts of tundra and high-elevation talus (Mattson et al. 1991a, White et al. 1998). Cutworm moths concentrate in alpine areas during the summer to feed at night on nectar of tundra flowers. During the day they seek refuge in talus slopes, which is where grizzly bears excavate them—potentially consuming as many as 40,000 per day. The most notable concentrations of this feeding behavior are in the Absaroka Mountains of

[36] For more on relations between Yellowstone grizzlies and cutthroat trout, see: https://www.mostlynaturalgrizzlies.org/cutthroat-trout and https://www.mostlynaturalgrizzlies.org/spatial-arrangements

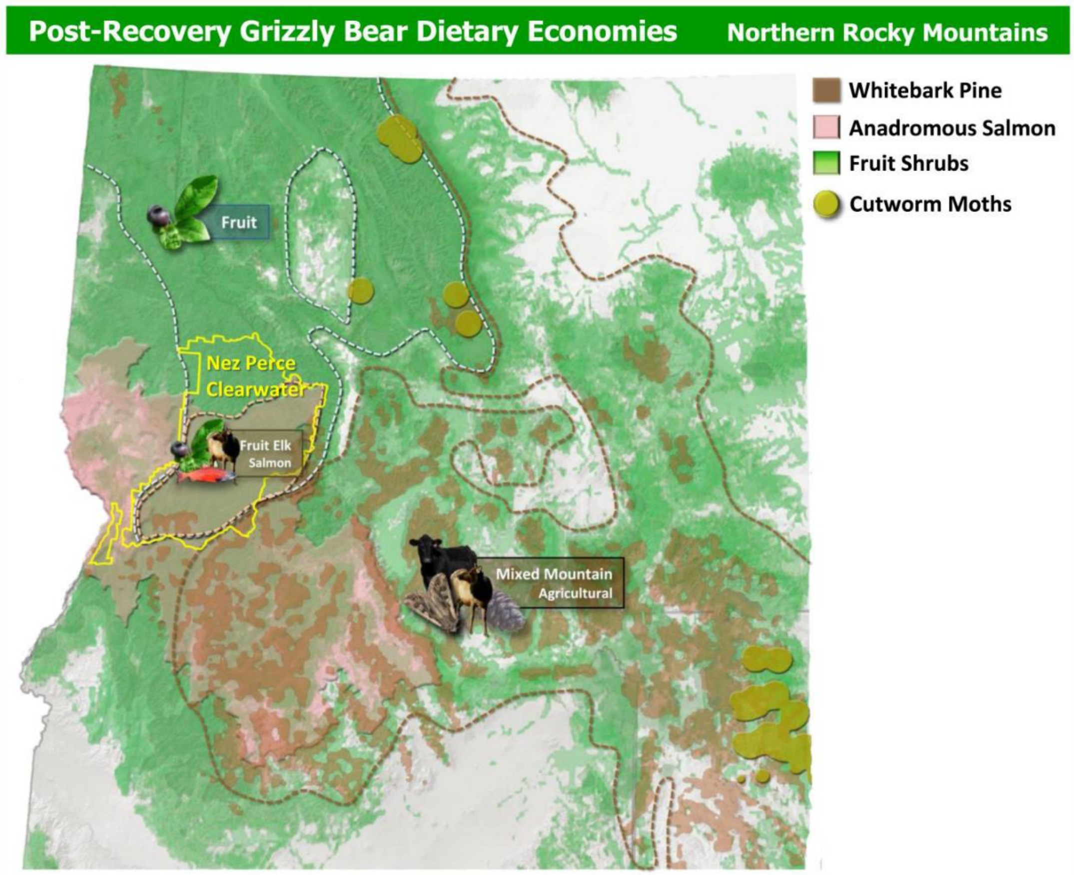


Figure 17. This map shows the extent of contemporary grizzly bear dietary economies in the U.S. Northern Rocky Mountains, inferred from information summarized in Figures 9, 15, and 16) and superimposed on the estimated availability of key grizzly bear foods, as per Figure 8. Each dietary economy is delineated by a different-colored dashed line, with the boundary of the Nez Perce-Clearwater National Forests shown in yellow. The dietary economies for central Idaho are largely speculative absent grizzly bear-specific data for this region. Even so, the diets of grizzly bears in this area promise to be unique relative to diets documented elsewhere in the Northern Rockies given the potential availability of spawning salmonids, juxtaposed with whitebark pine and numerous elk in the south and abundant fruit in the north.

Wyoming and in eastern portions of Glacier National Park[37]. Although concentrations of cutworm moths have not yet been found in Idaho, the possibility that they exist, and that at some future date grizzly bears might eat them, warrants further investigation, especially in the Bitterroot, Sawtooth, Little Lost River, and Lemhi Mountain Ranges of east-central and southern Idaho.

What stands out, though, is the somewhat confused denotation of a dietary economy in southern portions of the Nez Perce-Clearwater National Forests typified, not only by the transition from Fruit-Forb to Mixed Mountain Agricultural economies, but also by the potential role of spawning salmonids

[37] For more on grizzly bear consumption of army cutworm moths see: https://www.mostlynaturalgrizzlies.org/army-cutworm-moths

in grizzly bear diets. In other words, this area stands out as having a dietary economy that could be unique for grizzly bears, not only in the northern U.S. Rocky Mountains, but also, perhaps, globally.

Much has changed between 1800 and now in the tableau of grizzly bear foods (see Figure 8 juxtaposed with Figure 17). With the exception of a remnant in Yellowstone National Park (Mattson 1997, Green et al. 1997), the bison-based dietary economy has entirely disappeared, along with the bison, replaced by an economy centered on anthropogenic foods that engender conflict between bears and people. Whitebark pine is diminished everywhere and, in areas to the north and west, functionally extirpated as a bear food by white pine blister rust (Retzlaff et al. 2016). The distribution of spawning habitat for anadromous salmonids has been truncated in Idaho by high dams on the Snake River above Hells Canyon. Surviving salmon and steelhead populations elsewhere in Idaho have been dramatically reduced by impediments posed by numerous dams on the lower Columbia and Snake Rivers[38]. Even so, much bear food remains, with the fruit and forb-based dietary economy of north-central Idaho essentially intact.

6.d. Foods on the Nez Perce-Clearwater National Forests

The stakes are high for grizzly bear conservation on the Nez Perce-Clearwater National Forests, self-evidently because these jurisdictions encompass a critical geography that is host to essentially all of the recent colonization of central Idaho's wildlands by grizzly bears dispersing from the Northern Continental Divide ecosystem and Selkirk and Cabinet Mountains. As important, on-going revision of the Forest Plan for these newly-consolidated adminstrative units will determine whether there is meaningful consideration given to recovery and conservation of grizzly bears, especially in the codification of security standards as well as measures for preventing and managing human-bear conflicts. However, crafting such provisions requires understanding where, when, and why grizzly bears are likely to be active—which is ultimately rooted in knowing something about the spatial and temporal configuration of bear foods. Hence, this section focuses on bear foods and habitats of the Nez Perce-Clearwater National Forests[39], organized around spatial and temporal patterns shown in Figures 18 and 20, respectively.

The map in Figure 18a features spring habitats, including a comprehensive representation of spring productivity and predicted bear activity produced by Boyce & Waller (2003) for the Selway-Bitterroot Wilderness Area. Absent such a map for the rest of the Forests, elk winter ranges (shown as reddish-brown) offer a good proxy for where grizzly bears will likely be active during the spring, both because winter ranges tend to be in lower-elevation areas with advanced spring phenology, and because grizzlies predictably seek scavenging opportunities here (Green et al. 1997).

The implications of this are straight-forward. During spring, grizzly bears will likely be concentrated at low elevations throughout the Forests, coincident with the location of passable roads and trails and associated human activity. The result will be ample opportunity for displacement, conflict, and human-caused grizzly bear mortality early in the bears' active season.

[38] https://en.wikipedia.org/wiki/List_of_dams_in_the_Columbia_River_watershed

[39] I don't show peripheral and highly fragmented Forest Service lands on the Palouse Ranger District to the northwest largely because *prima facie* there is little secure habitat for grizzly bears.

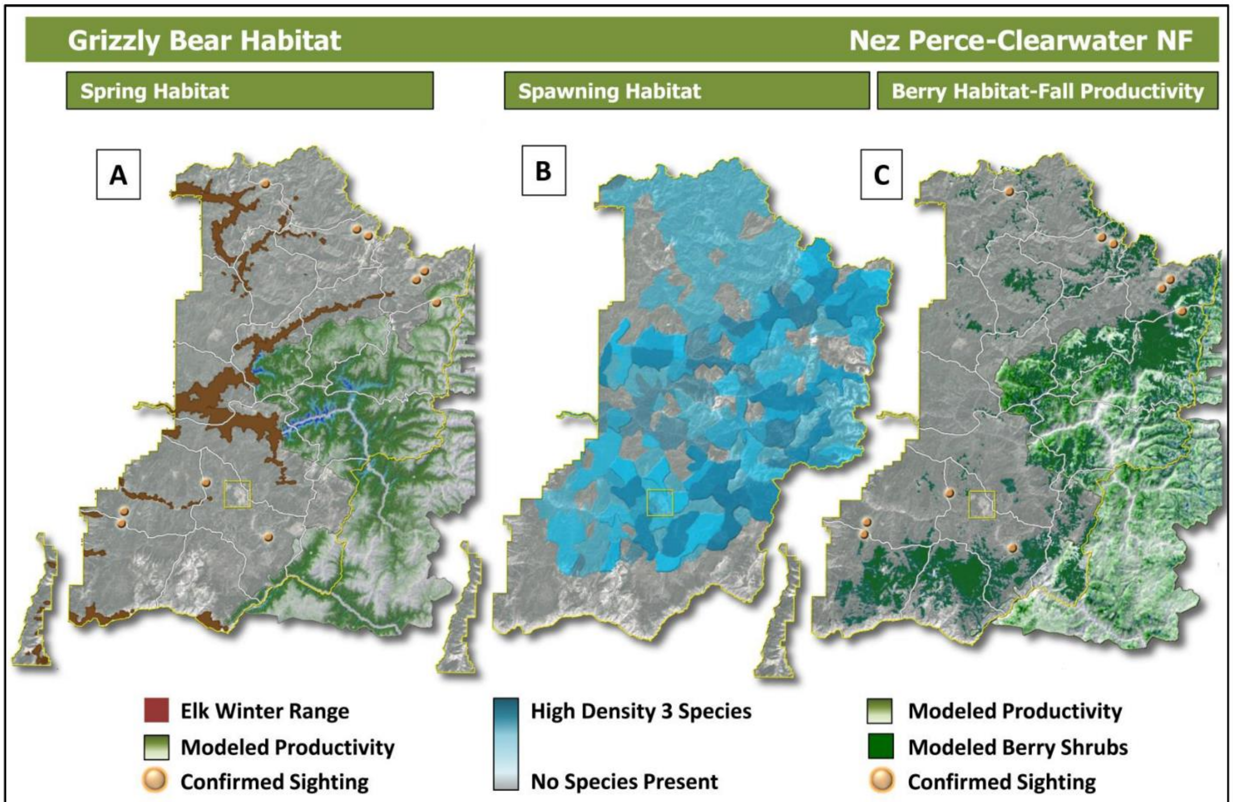


Figure 18. These maps show the seasonal distributions of key grizzly bear foods, habitats, or modeled habitat productivity for the Nez Perce-Clearwater National Forests. Spring and fall foods and habitat are featured given the importance of foods consumed during hyperphagia (mid-July through October) to reproductive success of grizzly bears (e.g., Hertel et al. 2018) and the potential of spring foods to concentrate bears near people at lower elevations. Confirmed grizzly bear sightings or sign (from Figure 12) are also shown as brown dots. Map (**A**) shows the distribution of elk winter ranges (Nez Perce-Clearwater National Forests (2019: Elk Habitat Effectiveness 3.2-3.4-16), where spring scavenging opportunities are likely to be concentrated (Green et al. 1997), together with spring habitat productivity modeled for the Selway-Bitterroot and Frank Church-River of No Return Wilderness Areas by Boyce & Waller (2003). Map (**B**) features the distribution of sub-watersheds supporting healthy populations of anadromous steelhead and spring-summer spawning chinook as well as resident bull trout (*Salvelinus confluentus*; from the Draft Clearwater Subbasin Assessment [Ecovista et al. 2003]). Darker blue denotes areas where a greater number of salmonids are present in "stronghold" habitats. Map (**C**) shows, darkest green, the distribution of fruit –producing shrubs modeled by Hogg et al. (1999)—including *Amelanchier alnifolia*, *Prunus virginiana*, *Sambucus* sp., *Shepherdia canadensis*, *Sorbus scopulina*, and *Vaccinium membranaceum*—overlain on predicted fall grizzly bear habitat productivity and use from Boyce & Waller (2003).

The maps in Figures 18b and 18c feature foods and habitats of likely importance to grizzly bears during summer and fall, including spawning salmonids and modeled productivity based primarily on the distribution of fruit-producing shrubs. As in Figure 18a, modeled fall habitat productivity and associated probabilities of bear activity in Figure 18c are restricted to the Selway-Bitterroot Wilderness Area, although the modeled aggregate distribution of fruit-producing shurbs (from Hogg et al. [1999]) is shown in dark green for the entire Forests. The blue in Figure 18b denotes watersheds of the Clearwater drainage that are strongholds for spawning steelhead, chinook salmon, or bull trout, with darkest blue denoting watersheds that support healthy runs of all three species. Information for watersheds draining into the Salmon River is notably absent.

Taken together, Figures 18b and 18c suggest that grizzly bears will likely concentrate during summer and fall at middle to higher elevations of the Forests, with much of the most productive habitat encompassed by the Selway-Bitterroot and Gospel Hump Wilderness Areas. Notable exceptions to this pattern include a swath of abundant fruit-producing shrubs and spawner strongholds east of Elk City and at upper elevations of the Salmon River Breaks, as well as another swath along and immediately below the divide between the Clark Fork River and North Fork of the Clearwater River.

Wildfires 1980-2016

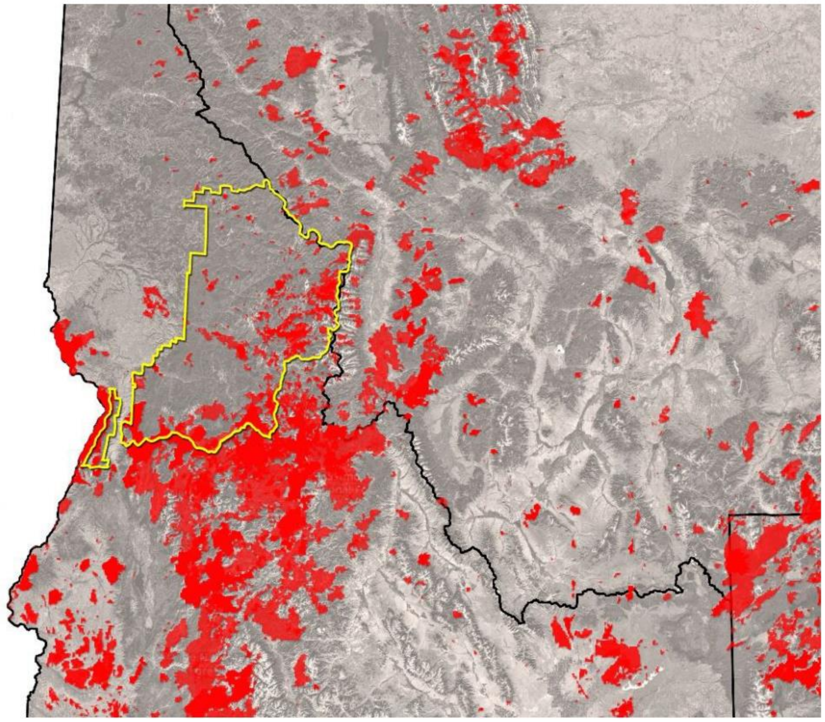


Figure 19. The map above shows, in red, the cumulative extent of wildfires that burned during 1980-2016. This timeframe is relevant to grizzly bears and grizzly bear foods because fruit production tends to peak roughly 20-40 or even 60 years post-fire on species such as huckleberry and buffaloberry (Martin [1979, 1983]; Hamer [1996]; Proctor et al. [2018]; and https://www.mostlynaturalgrizzlies.org/habitat-associations) This map highlights the extent to which areas south of the Salmon River Breaks have burned, sometime repeatedly, in contrast to areas farther north, including much of the Nez Perce-Clearwater National Forests, shown delineated in yellow. Parenthetically, fire intervals <40-60 years are predictably detrimental to fruit-producing shrubs and related availability of fruit for bears to eat, which could have affected fruit production in some parts of south-central Idaho. Fire perimeters are from National Interagency Fire Center, https://data-nifc.opendata.arcgis.com/datasets/interagency-fire-perimeter-history-all-years

The concentration of summer-fall foods and habitats in Wilderness Areas on the Nez Perce-Clearwater Forests is auspicious, at least insofar as conflicts with humans is concerned, but with an important proviso. Wilderness Areas do not provide any insurance against deaths resulting from mistaken identificiations by black bear hunters or from conflicts with big game hunters during the fall—both of which plausibly threaten grizzly bears in remote Forest Service jurisdictions (see Section 7.a.).

Insofar as decadal trends are concerned, there is little explicit information about changes in abundance of key vegetal foods during the last 60-70 years, although, as I mention in Section 4.b. above, there is good reason to suspect that a period of abundant fruit production followed in the wake of the 1910 fires, probably peaking during the 1930s-1960s. A comparative dearth of wildfires since then on the Nez Perce-Clearwater National Forests—at least in contrast to areas south of the Salmon River Breaks—has probably led to a slow decline in Forest-wide fruit production outside of some recently-burned areas in the Selway-Bitterroot Wilderness Area (Figure

19) and a handful of harvest units on intrinsically productive sites that were minimally scarified and subsequently secured from human access by road closures[40].

In contrast to vegetal foods, there is a substantial amount of information available regarding trends in fish and elk populations on the Nez Perce-Clearwater Forests, not only because humans exploit these animals for food and trophies, but also because of the iconic status of threatened Pacific Northwest steelhead and salmon. Figures 20a and 20b show the result of my efforts to cobble together information from multiple sources on trends in numbers of salmonids and elk in the Clearwater River drainage.

Dams on the Columbia and Snake Rivers led to major if not catastrophic declines in numbers of "wild" chinook salmon and steelhead, with perhaps the greatest impact on fall runs of chinook. Severe declines that culminated during the 1980s have since been offset to a small extent by heroic efforts to improve passage structures on dams (Idaho Department of Fish & Game 2019), with an upsurge in populations during the 2000s that has recently—unfortunately—dramatically reversed (https://stateofsalmon.wa.gov/statewide-data/salmon/dashboard/).

Parenthetically, I also show numbers of kokanee salmon resident to Dworshak Reservoir in Figure 20a. These introduced landlocked salmon spawn upstream from the Reservoir in smaller streams tribuary to the North Fork of the Clearwater River, where they would potentially be available to grizzly bears. On a related note, a number of watersheds upstream from Dworhak are also strongholds for bull trout (as per Figure 18b), opening up the possibility that runs of both species could offset some of the harm caused by 1973 closure of Dworshak Dam to fish resources that were historically available to bears in upper reaches of the North Fork of the Clearwater.

Meat from elk is important to grizzly bears wherever there are significant numbers of elk for bears to exploit (https://www.mostlynaturalgrizzlies.org/spatial-patterns-1). This will probably be a factor for grizzlies colonizing the Nez Perce-Clearwater National Forests given the historical abundance of elk in the region. However, as Figure 20b shows, elk numbers have varied dramatically since at least the 1940s as a consequence of both hunter harvest and habitat changes (Peek et al. 2020). At least in the Lochsa drainage, peak elk numbers during the 1950s almost certainly resulted from favorable habitat conditions entrained by the 1910 wildfires (see Figure 11; Peek et al. [2020]). Declines during the

[40] The topic of whether and to what extent grizzly bears benefit from timber harvest through the stimulation of food production is contentious. It is also complicated by the fact that bears must choose to venture into harvest units, usually near roads, to benefit from any food that might be there. Even so, there is substantial body of scientific research that has delved into the comparative use of natural and human-created successional habitats by grizzly bears. There is no ambiguity in this research about the consistently strong positive selection by grizzlies for shrublands and timbered-shrublands roughly 40-50 years or even longer post-fire (see also Martinka [1976], McLellan [2015], Proctor et al. [2018a]). McLellan (2015) also observed that large wildfires in productive uplands are highly beneficial to grizzly bears, consistent with the long history of grizzly bears intensively exploiting huckleberries in the Apgar Mountains of Glacier National Park (Shaffer 1971, Martinka 1976). By contrast, observed selection of cutting units is vagarious, and more often strongly negative than even modestly positive. This result holds even when controlling for the effects of roads (e.g., Waller & Mace 1997; McLellan & Hovey 2001b; Apps et al. 2004, 2016; Proctor & Kasworm 2020), and is consistent with the results of Proctor et al. (2018a) regarding distribution of productive huckleberry patches in southeastern British Columbia: ""We found 74% of huckleberry patches were not in cut blocks. The ~26% of huckleberry patches that were in cut blocks occurred where the proportion of our focal area in cut blocks was only 18%."

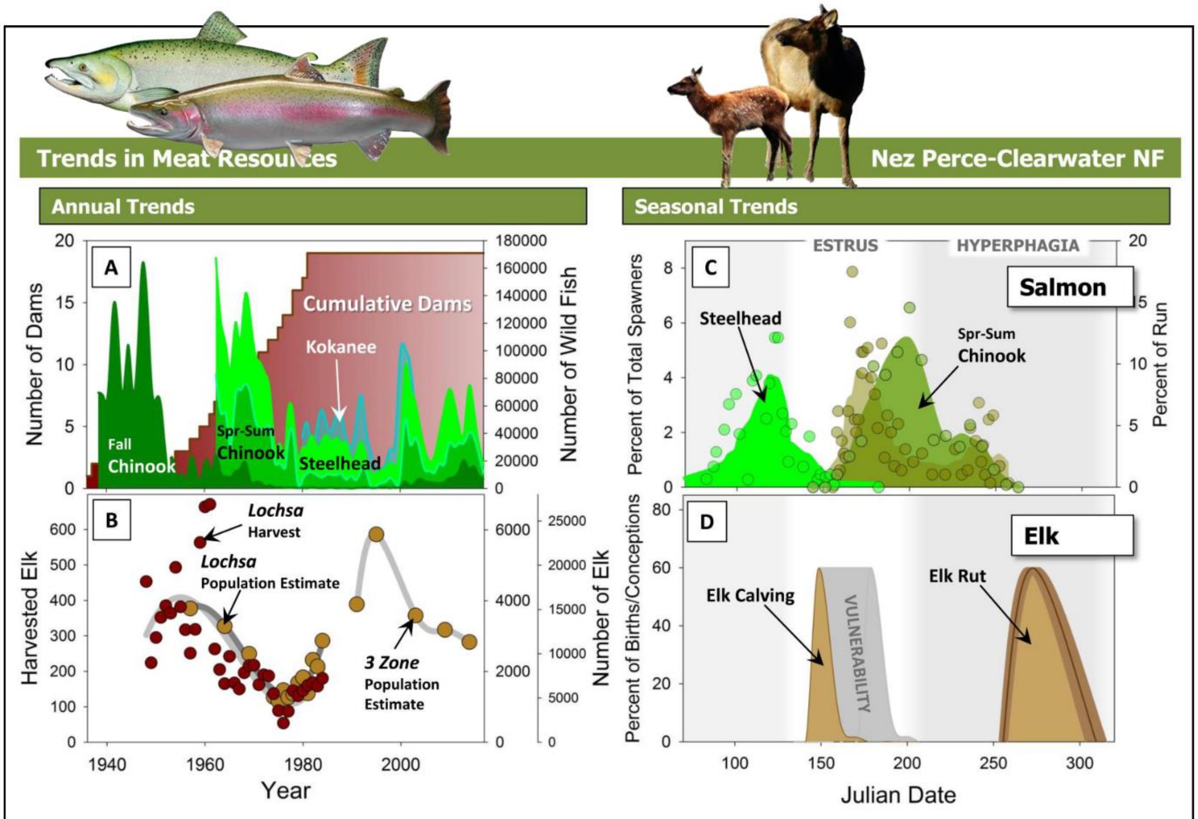


Figure 20. These time series graphs show annual trends (**A**-**B**) and seasonal availability (**C**-**D**) of meat resources for bears on the Nez Perce-Clearwater National Forests. Graph (**A**) shows trends in availability of wild-spawning (vs hatchery-raised) salmon of different species and seasonal runs in the Snake River drainage relative to cumulative closure of dams along the Columbia River system below the Snake River and along the Snake River up through the Salmon and Clearwater drainages. Dam closure dates are from Wikipedia *List of Dams in the Columbia River Watershed*. Estimates of spawner numbers are from Irving & Bjornn (1981), West Coast Chinook Salmon Biological Review Team (1997), Stark (2006), and Idaho Department of Fish and Game (2019). Graph (**B**) shows trends in indicators of elk abundance . The earlier time series, 1948-1984, shows estimates of total elk numbers (brown dots) and elk hunter harvest (burgundy dots) for the Lochsa River drainage (from Schlegel [1986a] and Peek et al. [2020]). The later time series, 1995-2018, shows estimates of total elk numbers for the Lolo, Dworshak, and Elk City Zones from Idaho Department of Fish & Game *Elk. Progress Reports*, 1990-2020. Graph (**C**) shows characteristic seasonal trends in numbers of spawning steelhead and spring-summer chinook salmon in tributary streams of the Forests (for steelhead adapted from Stark et al. [2016] using data for Fish Creek; for chinook from data collected at the Imnaha River by Hoffnagle et al. [2008] and South Fork Salmon River by Sullivan et al. [2018]). Graph (**D**) shows the distribution of elk calving dates (from Schlegel 1986b) and subsequent period of vulnerability during which most black bear mortality has historically occurred (White et al. 2010), along with the approximate duration and intensity of the fall elk rut (based on Noyes et al. [2002]).

1960s-1970s were probably caused in turn by deteriorating habitat conditions associated with succession of shrubfields to closed forest, with declines compounded by the effects of black bear predation on elk calves (White et al. 2010, Peek et al. 2020). More recent trends for Idaho Fish & Game's Lolo, Dwoshak, Selway, and Elk City Elk Management Zones, inclusive of the Nez Perce-Clearwater Forests, suggest that elk numbers recovered during the 1990s, only to decline again during the late 1990s and early 2000s, although elk in the last three of these Zones still number >11,000 (e.g., Idaho Department of Fish & Game, 2018 Elk Progress Report, https://collaboration.idfg.idaho.gov/WildlifeTechnicalReports/Elk%20Statewide%20FY2018.pdf).

The other temporal pattern of obvious importance to grizzly bears colonizing the Nez Perce-Clearwater Forests is seasonal availability of meat resources, summarized in Figures 20c and 20d for anadromous salmon and elk, respectively. Availability of anadromous salmon to bears is predictably dictated almost exclusively by when salmon spawn, which for steelhead peaks during April-May and, for spring-summer runs of chinook salmon peaks during July-August. Functional availability of elk, whether as carrion or prey, is largely dictated by numbers of animals dying from disease and starvation on winter ranges and available to scavengers primarily during April-May; the two-month-long period of calving and subsequent peak vulnerability of calves to predation beginning roughly during mid-May; and vulnerability of bull elk to predation during and after the September rut (Mattson 1997). When put together, these complementary seasonal patterns suggest that meat, whether from fish or elk, should be availabe to grizzly bears on the Nez Perce-Clearwater Forests throughout the bears' active season. This alone makes the environment here potentially unique among Grizzly Bear Recovery Zones in the contiguous United States.

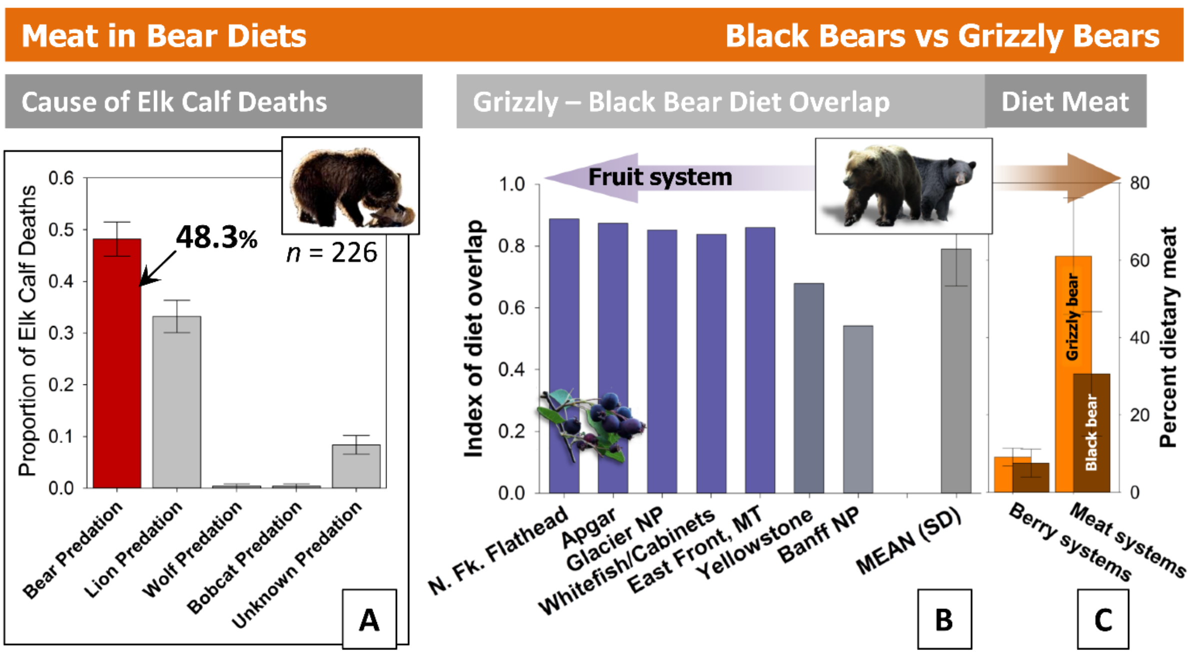


Figure 21. These graphics show information relevant to projecting the role of meat from large herbivores such as elk in the diets of grizzly bears in central Idaho, with an emphasis on the Nez Perce-Clearwater National Forests. The bar graph in (**A**) shows proportional causes of elk calf deaths documented during two time periods and in three different study areas on the Nez Perce-Clearwater National Forests (the Lochsa and North and South Forks of the Clearwater River; from Schegel [1986b] and Zager & White [2003]). Black bear predation accounted for 48% of deaths. The bar graph in (**B**) shows the overlap in diet between black and grizzly bears in 7 Rocky Mountain study areas, where an index of 1.0 indicates complete overlap and an index of 0.0 indicates no overlap. The study areas are ordinated from environments where fruit and forbs are dominate in diets, farthest left, to study areas where meat, whitebark pine seeds, and roots are increasingly important, farthest right (calculated from Shaffer [1971], Hamer & Herrero [1983], Aune & Kasworm [1989], Raine & Kansas [1990], McLellan & Hovey [1995], Fortin et al. [2007], Kasworm et al. [2018]). The bar graph in (**C**) shows average fractions of meat in black and grizzly bear diets, differentiating areas where fruit and forbs dominate the diet from areas where meat is a major source of energy and nutrients (from sources in [**B**] plus Jacoby et al. [1999], McLellan [2011], and Schwartz et al. [2013]).

One final observation is warranted regarding prospective exploitation of elk by grizzly bears on the Nez Perce-Clearwater Forests. A remarkably consistent pattern has been documented wherever grizzly and black bears coexist. On average, grizzly bears eat more meat, with the disparity between black and grizzly bears increasing the greater the reliance of both on animal versus plant resources. As the bar graph in Figure 21c shows, differences between the species are negligable in ecosystems where both species are reliant primarily on fruit and forbs, as in northwestern Montana and adjacent southeastern British Columbia (Figure 21b; Mattson et al. [2005]). By contrast, there is an average two-fold or more difference in meat consumption by black and grizzly bears in ecosystems with continental climates and more available meat.

There is already a long history of concern about how predation on elk calves by black bears and mountain lions (*Puma concolor*) affect elk populations in Idaho (e.g., Unsworth et al. 1993), with black bears accounting for the bulk of documented predation (Figure Figure 21a). There is increasing evidence that predation on elk calves can indeed have population-level effects (Raithel et al. 2007, Luckas et al. 2019), including on the Nez Perce-Clearwater Forests (White et al. 2010). Given these patterns, it is noteworthy that grizzly bears can be highly efficient predators on elk calves (e.g., French & French 1990, Gunther & Renkin 1990) and, in the case of some individual bears, even efficient predators on adult elk and moose (Gasaway et al. 1992, Mattson 1997, Dahle et al. 2013). This ability to predate on adult and calf ungulates allows grizzly bears to adopt a more predatory strategy inter-annually (Mattson 1997) as well as on a longer-term basis (Barber-Meyer et al. 2008, Middleton et al. 2013) when alternate foods are in short supply, and for some adult male grizzlies to adopt dietary strategies centered almost exclusively on eating meat—much of it obtained by predation (Mattson 1997, 2000; Schwartz et al. 2014).

Differences in exploitation of meat from ungulates by black and grizzly bears has potential implications for elk and even moose on the Nez Perce-Clearwater Forests. Grizzly bears establishing themselves in this region will very likely end up eating more meat compared to sympatric black bears. Whether this will be a consequence of grizzly bears usurping a meat-eating niche from black bears or simply eating more meat given the same available resources can't be reliably foreseen, largely because we have never had the opportunity to study diets of black bears before and after colonization by grizzly bears. Even so, whatever effects black bear predation may currently be having on elk populations will not be lessened with the arrival and establishment of grizzly bears.

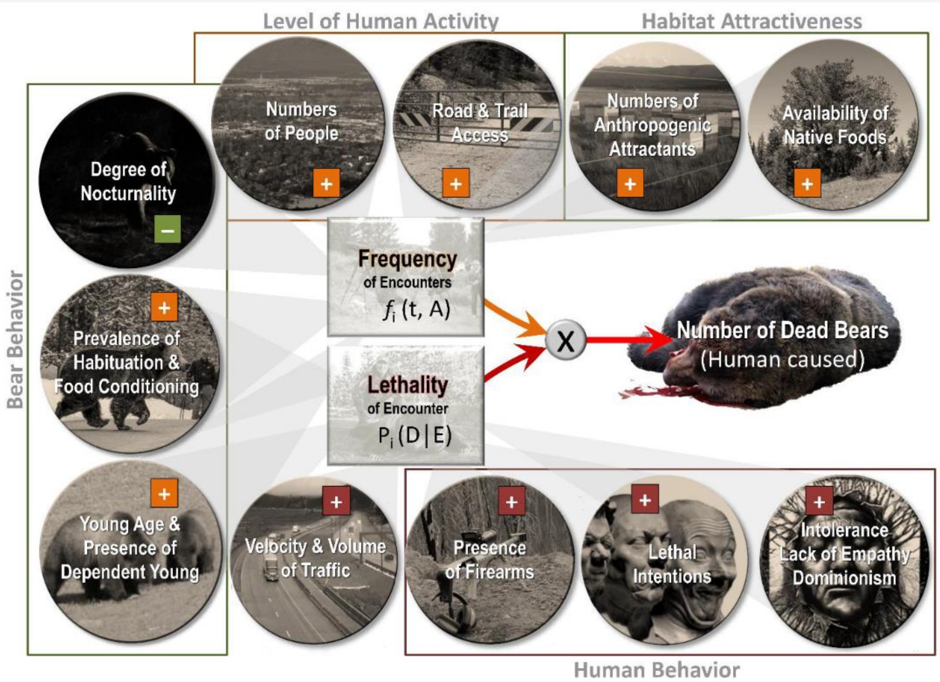
There are clearly ample foods for grizzly bears on the Nez Perce-Clearwater National Forests, including potentially substantial amounts of meat from either salmonids or elk throughout the bears' active season. During summer and fall, distributions of key foods will likely attract grizzlies to comparatively secure habitat, much of it in designated Wilderness Areas, whereas during spring productive habitats will probably attract grizzlies to lower elevations where conflicts with humans will be likely. Other conflicts could arise over foreseeable impacts of grizzly bear predation on iconic elk populations that some people see as existing primarily to provide a harvestable surplus for humans to kill.

7. Conflicts and Habitat Security

Relations with humans will continue to determine the fates of grizzly bears in the contiguous United States. Humans armed with firearms, traps, or poisons are highly lethal predators, evident even during modern times by the fact that 70-90% of adult and adolescent grizzly bear deaths are caused by humans[41]—even with protections afforded by the Endangered Species Act. Put another way, grizzly bears will or will not survive depending upon whether they have refuges from people or are attracted by human-associated foods into areas and situations that catalyze lethal conflict. But perhaps even more important, peoples' tolerance of bears as well as their willingness to accommodate them will determine where grizzlies can live and in what numbers.

Conceptualizing Factors That Determine How Many Grizzlies People Kill

Box 3. A conceptual model of factors driving the rate at which humans kill grizzly bears is potentially useful for assessing and managing threats to grizzlies, reducing conflicts, and developing a coexistence infrastructure. The model below builds on initial efforts by Mattson et al. (1996a, 1996b) while preserving the basic premise that bears are axiomatically killed by humans as a function of how often they encounter people and the likelihood that any given encounter will be lethal. Broadly speaking, frequency of encounter is dictated by levels of human activity, the attractiveness of habitats used by people, and bear behaviors, whereas encounter lethality is ultimately dictated by human worldviews, manifest by peoples' choices and behaviors.



One way of conceptualizing human-caused grizzly bear mortality is to deconstruct the rate at which people kill grizzlies into two components: (1) frequency of contact between the two species, and (2) the likelihood that any given encounter will be lethal for the involved bear (Mattson et al. 1996a, 1996b). In other words, the frequency and lethality of encounters with humans will jointly dictate the

[41] These percentages are based on the fates of radio-collared grizzly bears (e.g., McLellan et al. 1999, Wakkinen & Kasworm 2004, Schwartz et al. 2006, Mace et al. 2012, and Costello et al. 2016), which mitigates biases that otherwise arise from variation in the likelihood that deaths from different causes will be detected by humans absent some sort of real-time monitoring (Mattson 1998).

rate at which adult and adolescent grizzly bears are killed by people, with grizzlies potentially able to thrive despite frequent encounters with people, but only as long as those encounters are benign—as in National Parks. By contrast, where people are highly lethal, grizzlies will only survive if they have access to extensive areas free of human activity—as was the case during the 1800s and early 1900s (Mattson & Merrill 2002). Box 3 visualizes this conceptualization, along with key factors that drive frequency and lethality of contact.

Trade-offs between frequency and lethality of contact are relevant to assessing what measures are needed to sustain grizzly bears in places such as the Nez Perce-Clearwater National Forests, and whether or not these measures make major impositions on people. If even a handful of people are intolerant and disinclined to practice reasonable management of anthropogenic attractants, then conservation of grizzly bears will probably require large tracts of land free of human activity and access. If people are more uniformly willing to accommodate grizzly bears and engage in prudent behaviors, then there will be many fewer restrictions on access and activity (Mattson et al. 1996a). The choice is ours, individually and collectively, albeit constrained by fundamental worldviews (Kellert et al. 1996).

7.a. Prospective Conflicts on the Nez Perce-Clearwater National Forests

Management of lands and wildlife on the Nez Perce-Clearwater National Forests currently provides no explicit protections for grizzly bears, despite eastern portions of these Forests being in an officially designated Recovery Area (Nez Perce-Clearwater National Forests 2019a, 2019b). At best, protections are provided by Sections 7 and 9 of the Endangered Species Act (ESA)[42], but contingent on land and wildlife managers bothering to invoke these provisions—something notably absent from official deliberations for decades. State wildlife and federal land managers have essentially been given *carte blanche* by the U.S. Fish & Wildlife Service in matters related to the protection of grizzly bears and grizzly bear habitat.

These deficiencies are evident in the latest proposed revision of the the Nez Perce-Clearwater National Forests Plan, which perpetuates a regime that gives only parenthetical consideration to the appearance of colonizing grizzly bears and obligations incurred under the ESA (Nez Perce-Clearwater National Forests 2019a, 2019b). A meaningful reckoning with these obligations has yet to occur. More specifically, and in reference to Box 3, there is no explicit consideration given to management of anthropogenic attractants or people's behaviors and behavioral intentions—especially the practices of elk and black bear hunters.

Anthropogenic attractants have a long history of being at the center of conflicts between people and grizzly bears, perhaps best documented for Yellowstone National Park, where management transitioned from maintaining open pit garbage dumps that served as ecocenters for grizzlies; to aburpt closure of these dumps, with a dramatic spike in grizzly bear mortality after bears deprived of their traditional food source turned to exploiting other anthropogenic foods; to, during the past 15 years, a period of quietude resulting in part from thorough sanitation of the Park and nearby gateway communities (Schullery 1992, Craighead et al. 1995, Gunther et al. 2004).

[42] Endangered Species Act of 1973 (16 U.S.C. 1531-1544, 87 Stat. 884)

The threat posed by garbage and other anthropogenic foods to grizzly bears and grizzly bear recovery led managers to make sanitation efforts a centerpiece of the first Interagency Grizzly Bear Guidelines published in 1986 (Interagency Grizzly Bear Committee 1986). Since then, virtually every National Forest with documented grizzly bear occupancy has issued Forest-wide orders designed to limit availability of human foods to grizzlies, whether garbage, fresh food, or even hunter-killed big game carcasses (for example, Northern Continental Divide Ecosystem Flathead, Lewis & Clark, and Helena National Forests [2000], Kootenai National Forest [2011], and Custer-Gallatin National Forest [2014]).

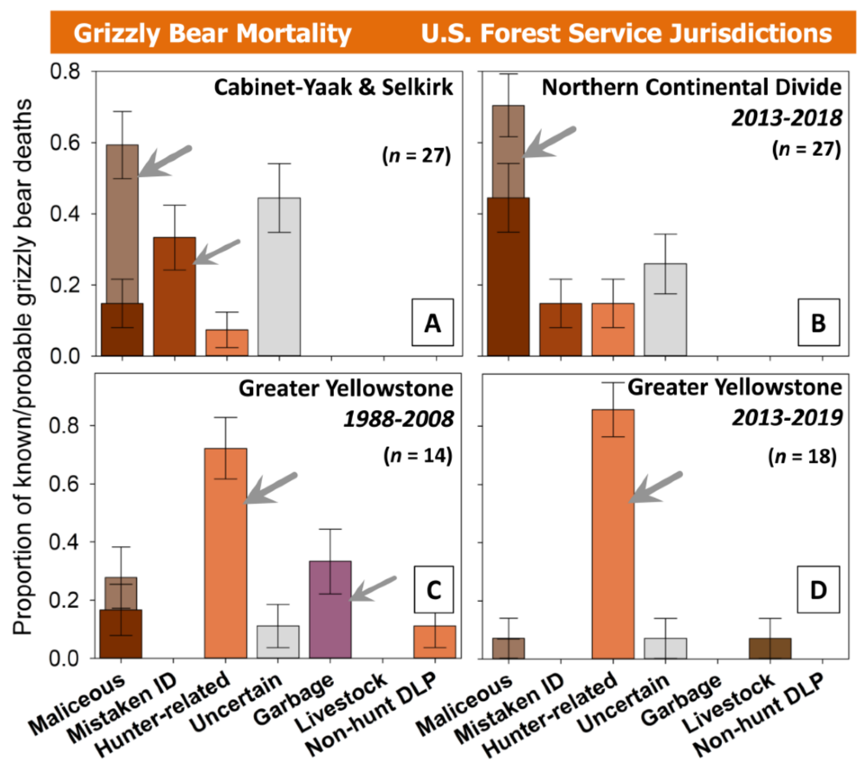


Figure 22. This series of four bar graphs shows the proportional composition of human-caused grizzly bear mortalities on Forest Service jurisdictions in (**A**) the Cabinet-Yaak (CYE) and Selkirk (SE) Ecosystems, combined; (**B**) the Northern Continental Divide Ecosystem (NCDE); and the Greater Yellowstone Ecosystem (GYE) during (**C**) years prior to major losses of whitebark pine (1988-2008) compared to (**D**) years after losses culminated in 2010 (2013-2019). Gray arrows in each graph identify prominent causes. Mortalities attributable to malicious causes are shown in two ways: including only those definitively determined to be deliberate poaching or illegal kills (dark burgundy); versus definite determinations plus other human-caused deaths that occurred under questionable circumstances implicating malicious intent or unwarranted human reactions (narrower brown bars). These latter mortalities are also differentiated and shown as gray bars labeled "uncertain." Jurisdictions of mortalities were determined from databases covering 1983-2014 (CYE and SE), 1998-2018 (NCDE), and 1988-2014 (GYE) obtained through federal Freedom of Information Act requests and Montana Open Documents requests. Information from these databases were augmented by information contained in *Cabinet-Yaak Grizzly Bear Recovery Area Research and Monitoring Progress Reports* for 2015-2019 and online databases of GYE mortalities maintained by the Interagency Grizzly Bear Study Team (https://www.usgs.gov/science/interagency-grizzly-bear-study-team?qt-science_center_objects=4#qt-science_center_objects).

These orders require that all human foods and garbage be stored in bear resistant containers, hard-sided vehicles, or hung from a tree at least 10' off the ground and 4' from the trunk at a safe distance from campsites. Considerable emphasis has been placed on disposition and storage of hunter-killed animals in National Forests of the Yellowstone ecosystem, aided by an aggressive program to install back-country "bear poles" designed to support the weight of big game carcasses hoisted a safe distance off the ground (e.g., Shoshone National Forest, Carcass Storage Order, 36 CFR 261.58[s]).

None of this holds for the Nez Perce-Clearwater National Forests, which currently do not have a Forest-wide food or carcass storage order in place. The Clearwater National Forest did make some uneven attempts during the early 2000s to distribute and maintain bear-resistant garbage dumpsters at front-country Forest Service facilities. However a recent inventory of this infrastructure at 40 campgrounds and other sites by the non-profit group, Friends of the Clearwater, documented problematic accumulations of refuse and widespread lack of maintenance that rendered the affected bear-resistant dumpsters ineffective.

The comparative lack of grizzly bear deaths related to conflicts over garbage on Forest Service jurisdictions in other grizzly bear ecosystems—especially since 2013—is testimony to both the effectiveness and importance of sanitation efforts (Figure 22). But the summaries of grizzly bear mortalities shown in Figures 22c and 22d highlight a major cause that has clearly not been adequately addressed in the Greater Yellowstone ecosystem, with potential relevance to the Nez Perce-Clearwater Forests: deaths attributable to encounters with big game hunters.

This cause has long been dominant on Forest Service jurisdictions in the Yellowstone region, largely because of the numerous problematic encounters that occur between grizzlies and elk hunters during September-November, many of which turn lethal for the involved bears. Some of these encounters are close-quarter surprises, although most involve bears contesting elk carcasses in the field or in backcountry camps. There is even evidence that grizzly bears actively seek out hunter-killed elk (Haroldson et al. 2004), plausibly because of the nutritional value of gut piles and other carcass remains (Mattson et al. 2004). This persisting problem motivated several agency-sponsored reports that recommended measures to reduce grizzly bear-hunter conflicts[43] (among them, Interagency Grizzly Bear Study Team [2000] and Servheen et al. [2009]), but to little avail given that most of the recommendations were not widely implemented—all of which is relevant to the Nez Perce-Clearwater National Forests given the extent of elk hunting in these jurisdictions (Nez Perce-Clearwater National Forests 2019b: Section 3.2.3.4).

The other category of hunting-related bear mortality that has clear relevance to conditions on the Nez Perce-Clearwater Forests is the frequency with which grizzly bears are killed by black bear hunters as a result of mistaken identification—a non-trivial cause of grizzly bears deaths in western portion of the Northern Continental Divide ecosystem as well as in the Cabinet-Yaak and Selkirk Recovery Areas (Figure 22a,b). Although bear identification programs are mandated for black bear hunters by Montana's Department of Fish, Wildlife, & Parks (https://fwp.mt.gov/hunt/education/bear-identification), deaths of grizzlies from mistaken identifications continue, which calls into question the effectiveness of such educational efforts. But of particular relevance to conditions in north-central Idaho, one of the first grizzlies known to have ventured into the Clearwater drainage since the 1940s was killed over bait during 2007 as the result of misidentification by an out-of-state black bear hunter (Nokkentved 2007).

And finally, of the conflict-related grizzly bear deaths, those arising from depredations of livestock on Forest Service grazing allotments are noteworthy. Although this cause has not been prominent in occupied grizzly bear Recovery Areas during recent decades, it was common-place up through the 1970s in the Yellowstone ecosystem, and has emerged yet again as a major cause since 2010 (Wells et

[43] Practices that could reduce lethal conflicts between bears and hunters include carrying non-lethal self-protection such as pepper spray (Herrero & Higgins 1998; Smith et al. 2008, 2020); securing carcasses and other attractants at hunting camps (see above); not leaving carcasses unattended overnight; not hunting late in the day; hunting in parties of least two; being better educated about grizzly bear behavior; and not archery hunting in areas occupied by grizzly bears.

al. 2019). Prior to the 1980s, domestic sheep were the victims of most grizzly bear depredation (Johnson & Griffel 1982, Jorgensen 1983, Knight & Judd 1983), although depredations on cattle date back to before the 1940s (Murie 1948). Depredations on sheep were virtually eliminated after sustained efforts by non-governmental organizations and the Forest Service led to the retirement or conversion of most sheep grazing allotments in areas occupied by grizzly bears[44]. But since then depredations on cow calves have increased exponentially as grizzlies colonize grazing allotments on the periphery of the Yellowstone ecosystem (Wells et al. 2019) and turn increasingly to eating meat (Schwartz et al. 2014, Ebinger et al. 2016).

Although only a comparatively small part of the Nez Perce-Clearwater Forests is allocated to grazing allotments—almost all in western portions of the Nez Perce Forest—the situation is radically different on the Salmon-Challis and Boise National Forests south of the Salmon River (https://idl.maps.arcgis.com/apps/View/index.html?appid=3f449b10713748eb90f2dd386751d28a). Conflicts over grizzly bear depredations on cattle and sheep are clearly a major potential issue in these southerly areas, but also a potential problem on the Nez Perce Forest, despite blithe dismissal in the 2019 Forest Plan Revision Draft EIS (Section 3.2.3.3) of any challenges for grizzly bear conservation associated with management of allotments.

Because of inattention to conflict prevention by state wildlife and federal land managers, current conditions on the Nez Perce-Clearwater Forests are ripe for grizzly bear-human conflicts over unsecured garbage and food; conflicts over livestock depredations; conflicts with big game hunters; and mortalities caused by black bear hunters mistaking a grizzly for a black bear. All of this promises to leave managers scrambling to deal with grizzly bear mortalities arising from foreseeable conflicts.

7.b. Habitat Security Standards

Perhaps the most attention-getting feature of Figures 22a and 22b is the predominance of poaching as a cause of grizzly bear deaths on Forest Service jurisdictions in the Selkirk and Cabinet-Yaak Ecosystems as well as on the west side of the Northern Continental Divide Ecosystem. I use "poaching" here in a broad sense to include, not only documented instances, but also cases where circumstantial evidence suggests illegality or just simply an unwarranted lethal response by someone to an encounter with a grizzly bear that was subsequently not reported to wildlife managers. Broadly speaking, these categories are unified by a predisposition on the part of involved people to respond lethally to encounters with grizzlies—often in ways that transgress or challenge legal boundaries. Put another way, these categories speak to underlying intolerance and fear, which is a problematic cocktail when mixing people with grizzly bears.

Poaching throws into sharp relief the challenge of preventing grizzly bear mortality and promoting grizzly bear recovery when there are significant numbers of lethal people in a local human population. As I suggest earlier (Box 3), the only means of addressing this problem, other than through aggressive law enforcement, is by limiting frequency of contact between bears and people of unpredictable predispositions. And the primary way of doing this, at least on public lands, is through limitations on

[44] Notable non-governmental organizations involved in this effort include the National Wildlife Federation, Wild Sheep Foundation, and Wyoming Wildlife Federation. Most of the buy-outs and retirements were to benefit bighorn sheep (*Ovis canadensis*), but with substantial collateral benefit for grizzly bears.

access—an externalized burden created by intolerant people, but borne by everyone, regardless of their attitudes towards grizzlies.

Given that there is little reason to expect major differences between the attitudes of people living in north-central and central Idaho and people living in the Selkirk, Cabinet-Yaak, and western Continental Divide ecosystems, restrictions on access are necessarily a paramount consideration in conservation of grizzly bears on jurisdictions such as the Nez Perce-Clearwater National Forests. With this consideration in mind, provisions offered by the revised Forest Plan Draft EIS for management of road access on these Forests warrant close scrutiny.

At this point its probably worth emphasizing the extent to which human-caused grizzly bear deaths are associated with roads and, as a logical correlate, with landscapes intensively managed for extraction of timber. I don't intend here to plumb the depths of the ample scientific research showing a concentration of grizzly bear deaths near—i.e., within 500-m of—roads, along with related population-level impacts. For a recent synthesis of road-related impacts on grizzly bears, see Proctor et al. (2018b, 2020). Reckoned in other geospatial terms, a large body of scientific research shows that, not only do road densities need to be <0.5 km/km^2, but also that additional portions of a grizzly bear's home range need to be entirely free of road access to ensure survival rates that sustain population growth (e.g., Proctor et al. 2018a).

But, for those who remain doubters, Figure 23b offers a map view of how grizzly bear mortalities correlate spatially with areas prioritized by the Forest Service for timber production and associated dense road networks in the Cabinet-Yaak and Northern Continental Divide ecosystems. Even on the basis of visual inspection, the association is striking. Grizzly bears die disproportionately more often in landscapes devoted to the industrial production of timber compared to landscapes without roads. Of relevance to prospects for grizzly bears in north-central Idaho, substantial portions of the Idaho Panhandle and Nez Perce-Clearwater National Forests have been provisionally relegated to timber production (Figure 23a). The gauntlet is daunting.

The impacts of roads and associated human activities are often encapsulated by grizzly bear managers into calculations of percent "secure" habitat. These calculations are done at the scale of individual Bear Management Units (BMUs) that are approximately the size of a female grizzly bear's life—around 900-km^2 (see Box 4). BMUs are used as spatial constraints for reckoning changes in secure habitat associated with the construction or retirement of roads. This approach serves to insure that the impacts of the road infrastruture are reckoned at a scale that is meaningful to individual bears. It debars, for example, using road closures on one side of a National Forest to "offset" road construction on the other side when the intervening distance is far greater than any one bear would likely move.

Reckonings of habitat security by grizzly bear managers in different grizzly bear ecosystems have long been marked by a number of peculiarities, most of which defy logic and the best available science. Initial approaches to assessing habitat security accounted for all types of human activities, road-bound or not, and for intersections of these activities with habitats of different attractiveness (e.g., Mattson et al. 1986, 2004; Weaver et al. 1986). However, this more replete approach was later abandoned and replaced by a simplified caricature that only accounted for roads—without any consideration of traffic levels—and did not account for differences in quality or attractiveness of intersected habitats. Unfortunately, this particular conception of "security", as a reckoning of both displacement and mortality risk for grizzly bears, is at odds with almost all of the credible research produced during the

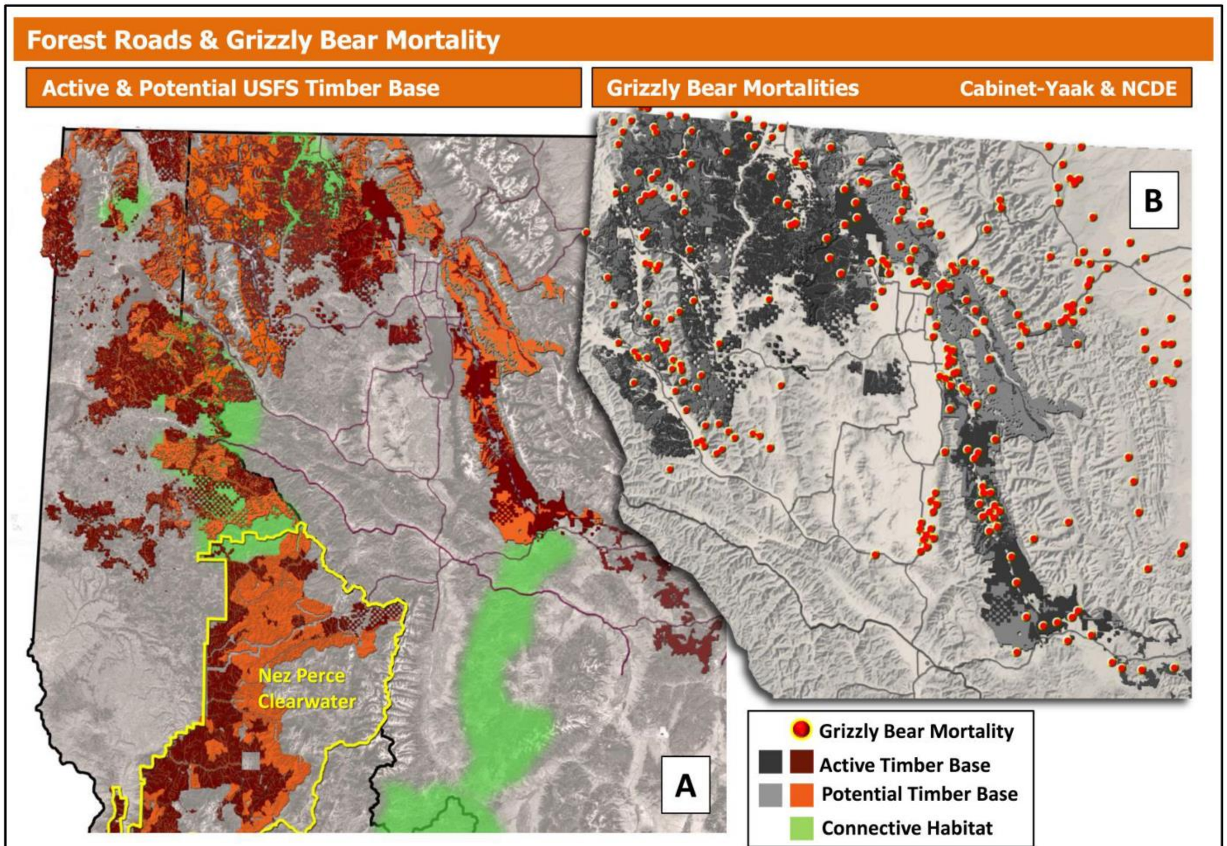


Figure 23. Map (**A**) shows areas suitable for timber harvest (in burgundy) and harvestable for other resource objectives (orange), for the Nez Perce-Clearwater National Forests (delineated in yellow), the Panhandle National Forests, Kootenai National Forest, Flathead National Forest, and Helena National Forest (from Forest Plans for each of the last four, and from the Draft EIS for the Nez Perce-Clearwater National Forests: Alternative W). The green in map (**A**) corresponds with the most promising connective habitat identified in Figures 12 & 14. Map (**B**) renders areas suitable for forest harvest in shades of black and white, with locations of grizzly bear mortalities shown as red dots, 1998-2018 in the Northern Continental Divide Ecosystem and 1983-2018 for the Cabinet-Yaak Ecosystem. Locations of mortalities are from databases covering 1983-2014 (CYE) and 1998-2014 (NCDE) obtained through federal Freedom of Information Act requests and Montana Open Documents requests. Locations from these databases were augmented by map locations from *Northern Continental Divide Ecosystem Grizzly Bear Population Monitoring Team Annual Reports* and *Cabinet-Yaak Grizzly Bear Recovery Area Research and Monitoring Progress Reports* for 2015-2019. Lands managed for some level of timber harvest are featured because of the close spatial correlation with road systems. Map (**B**) illustrates the extent to which grizzly bear mortalities are disproportionately associated with these lands; map (A) shows the extent of these lands in areas north and east of potential suitable grizzly bear habitat in central Idaho, exclusive of the Lolo National Forest.

last two decades showing, for example, that jurisdiction matters (as as surrogate for human lethality); that traffic levels on roads and trails matter; that diel timing of human activity matters; that people on foot have impacts; that the presence of attractants matters; and that the juxtapose of human facilities with bear habitats also powerfully configures impacts[45]. The upshot is that official calculations of "security" are a very crude as well as scientifically-indefensible representation of reality.

[45] A sampler of this research includes Mattson et al. (1987), Mace & Waller (1996), Mace et al. (1999), Merrill et al. (1999), Benn & Herrero (2002), Chruszcz et al. (2003), Merrill & Mattson (2003), Mattson & Merrill (2004), Apps et al. (2004, 2016), Johnson et al. (2004), Nielsen et al. (2004, 2010), Waller & Servheen (2005), Suring et al. (2006), Ciarniello et al. (2007), Roever et al. (2008), Graham et al. (2010), Schwartz et al. (2010), Northrup et al. (2012), Boulanger & Stenhouse (2014), Proctor et al. (2015, 2018a), Lamb et al. (2017, 2018, 2020), Ladle et al. (2019), and Mattson (2019b).

Setting this fundamental problem aside for the moment, there are additional inexplicable peculiarities that bedevil official calculations of habitat security for grizzly bears in different ecosystems. But first, a little more background. Calculations in all ecosystems are founded on the premise that "secure" habitat is defined by any area >500-m from a road, in some ecosystems contingent on the resulting isolated patches be of a minimum size. Additional standards impose limitations on the percentages of any given BMU that can have road densities exceeding 1 mile/mile^2 and 2 mile/mile^2. All of these benchmarks have some degree of scientific support (Proctor et al. 2018a, 2020).

However, these more-or-less valid benchmarks are called into question by vagarous specifications that inexplicably differ from one grizzly bear ecosystem to another. For example, the aspirational goal for habitat security in BMUs of the Yellowstone ecosystem is 75% (Yellowstone Ecosystem Subcommittee 2016). In the Northern Continental Divide ecosystem (NCDE), the goal is 68% (Northern Continental Divide Ecosystem Subcommittee 2020). In the Cabinet-Yaak ecosystem it is 55% (Kootenai National Forest 2015). Even standards set for portions of BMUs with greater than 1 and 2 miles/mile^2 are vagarious. In the Cabinet-Yaak ecosystem the respective percentages allowed for in each category are 33 and 26, whereas in the NCDE the percentages are 19 and 19—42% and 27% lower—despite the fact that the acutely vulnerable Cabinet and Yaak grizzly bear populations are 30-40-times smaller than the NCDE population (Costello & Roberts 2019, Kasworm et al. 2019). And so on.

Disregard for the best available science together with inexplicable variation in security standards among ecosystems complicate any assessment of whether conditions on the Nez Perce-Clearwater National Forests provide adequate security for grizzly bears—which is further complicated by being nested within the larger issue of what's needed at a broader scale to insure population viability (see Section 5.b. above). But these sorts of complications do not debar an evaluation of landscape conditions and useful comparisons with other ecosystems.

7.c. Habitat Security on the Nez Perce-Clearwater National Forests

The first challenge posed by any useful assessment of habitat security for grizzly bears on the Nez Perce-Clearwater National Forests is partitioning this large expanse into areas that logically comport with the scale of grizzly bear movements; i.e., Bear Management Units. Although I am not in a position to create authoritative boundaries, I am well-acquainted with the conceptual underpinnings. I was one of three people who literally stood around a table in 1983 drawing boundaries on a paper map for the first grizzly bear BMUs in the Greater Yellowstone Ecosystem, and was also involved in developing the initial logic and conceptualization for BMUs (as per Weaver et al. [1986], Mattson & Knight [1991], and Dixon [1997]), later applied to other grizzly bear ecosystems. Parenthetically, the maps showing seasonal distributions of habitat productivity in Figure 18 were vital to informing my delineations of provisional BMUs on the Nez Perce-Clearwater Forests given that BMUs ideally encompass habitats sufficient to support resident grizzlies year-round. The results of my effort are shown in Box 4.

With these boundaries in hand, it is possible to determine what portions of each candidate BMU are "secure," at least in the broadest sense of being outside areas with road densities >1 mile/mile^2 and >2 miles/mile^2. My crude calculations were complicated by not having access to the Nez Perce-Clearwater Forests GIS containing exact geospatial coordinates for all linear access features. Even so, calculations of road densities have been completed for evaluations of watershed conditions (Ecovista et al. 2003) and elk habitat security (Nez Perce Clearwater National Forests [2019b]: Section 3.2.3.4), shown in Figures 24a and 24b, overlain on boundaries of provisional BMUs (in white).

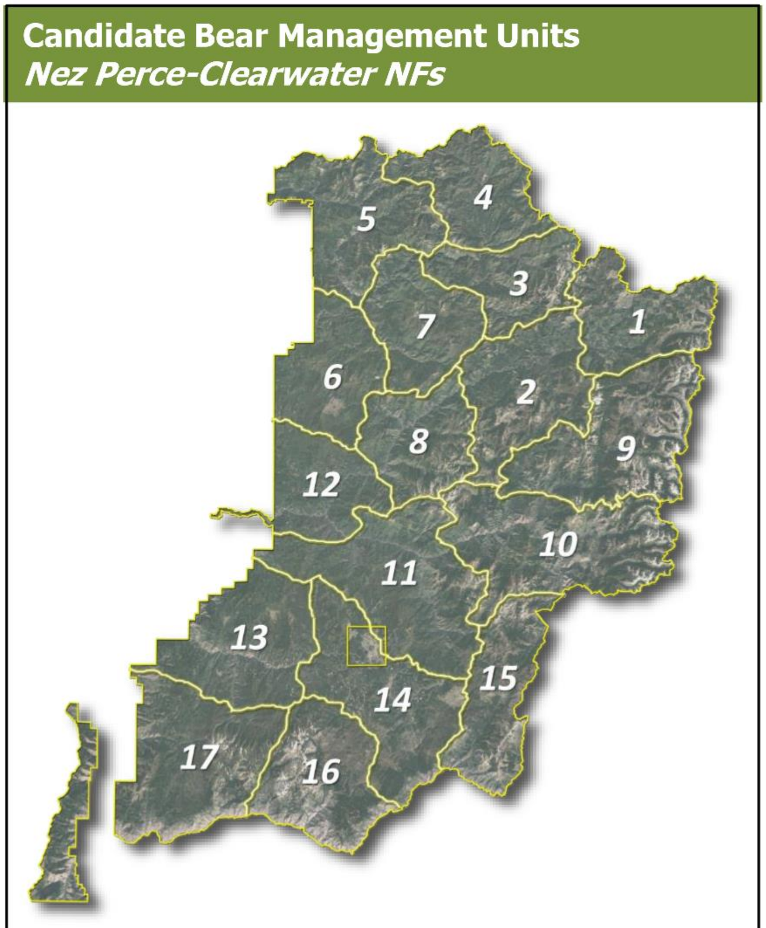


Figure 24. This map shows candidate Bear Management Units (BMU) delineated for the Nez Perce-Clearwater National Forests (yellow lines) and given provisional numeric identifiers. BMUs approximate the size of a female grizzly bear life range (Weaver et al. 1986, Mattson & Knight 1991, Dixon 1997) and, to the extent possible, are delineated to encompass high-quality spring and summer-fall habitat (see Figure 18).

The extact demarcations of watershed and elk security area boundaries differ, as do the bins for representing road densities, but the maps from each analysis show the same broad patterns. Road densities are uniformly high in western portions of both Forests, but also along lower-elevation portions of the North Fork of the Clearwater, in the area of interspersed Forest Service and private lands near Lolo Pass, and in a swath extending east through Elk City up to the Selway-Bitterroot Wilderness Area[46].

A crude estimate of habitat security for grizzly bears within each BMU can obtained by combining and averaging road density calculations for watersheds and elk security areas, and then using these averages to calculate the percentage of each BMU outside of areas with 1 mile/mile^2 and 2 miles/mile^2 road densities. These percentages are shown for each BMU in Figure 24c, ranging from 4-22% in the most heavily compromised BMUs (1, 6, 12, 13, and 14) to nearly 100% in those that are least compromised (3, 8, 9, and 10).

[46] Parenthetically, the importance of spatial partitioning at the scale of BMUs is highlighted the by the analysis of road densities presented in the Nez Perce-Clearwater National Forests Revised Plan, Draft EIS in Section 3.2.3.3. The Forest Service analysis encompasses portions of the Clearwater Forest south to the southern boundary of the Lochsa River, outside of the Selway-Bitterroot Wilderness Area, partitioned into two large areas, each equivalent to 4-5 of the BMUs shown in Box 4 and Figure 24. These large strata mask areas with exceptionally high road densities, yielding average road densities for each of 0.9-1.1 mile/mile^2. Yet these extensive strata contain home range-sized areas where road densities exceed 2 or even 4-5 miles/mile^2—where habitat security is substantially deficient.

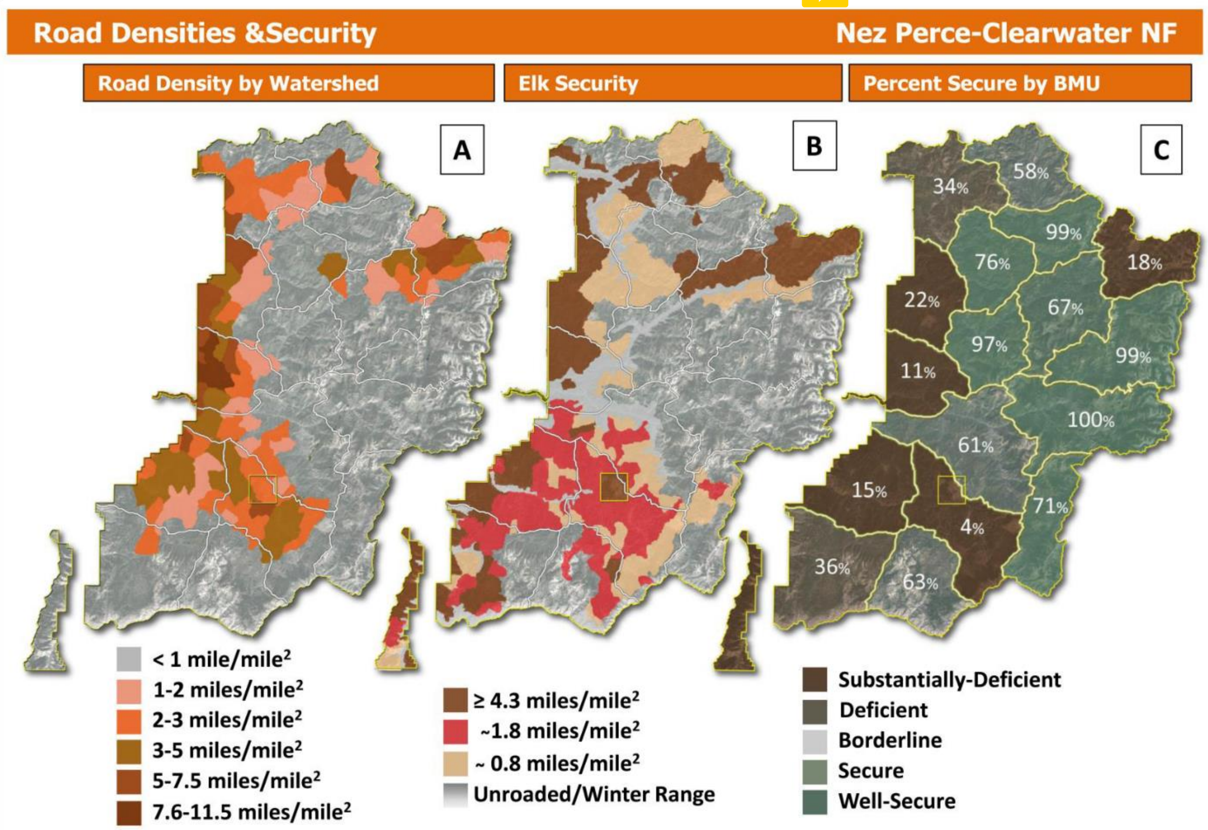


Figure 25. These maps show configurations of habitat security for grizzly bears on the Nez Perce-Clearwater National Forests, with an emphasis on road densities. Map (**A**) shows road densities averaged for sub-watersheds on portions of the Forests contained within the Clearwater River drainage (from the Draft Clearwater Subbasin Assessment [Ecovista et al. 2003]). Map (B) shows elk security areas differentiated by whether management objectives are 25, 50, or 75% security. Colors correspond with approximate road densities associated with each objective. Road densities averaged for the entire analysis areas were 1.1. miles/mile^2 for the North Fork and 0.9 miles/mile^2 for the Lochsa (Nez Perce-Clearwater National Forest 2019: 3.2 3.3-84). When corrected to estimate densities within roaded areas (areas shaded burgundy and beige), average densities were 4.3 miles/mile^2 for the North Fork and 2.9 miles/mile^2 for the Lochsa. Map (**C**) shows provisional Bear Management Units (BMUs) delineated by yellow lines and shaded to identify those that exceeded (dark burgundy) or were likely to exceed (light burgundy) security standards. BMUs were delineated to be around 900 km^{2}in size (based on life range criteria used to delineate BMUs in the Greater Yellowstone Ecosystem [Weaver et al. 1986, Mattson & Knight 1991, Dixon 1997]), follow topographic and drainage boundaries, and, if possible, encompass high-value spring and fall habitat (Weaver et al. [1986]; geospatial configurations are from Figure 24).

Without context or points of reference these percentages are difficult to interpret, other than in their denotation of the obvious: a higher precentage is better than a lower one. However, comparison with conditions in other grizzly bear ecosystems can provide insight into whether the Nez Perce-Clearwater National Forests currently provide security that is adequate for recovering a grizzly bear population. Figure 25 shows a summary of habitat security for BMUs along with habitat security standards for three occupied ecosystems (the Greater Yellowstone, Northern Continental Divide, and Cabinet-Yaak) as points for reference for a comparable summary of security for provisional BMUs on the Nez Perce-Clearwater Forests. This comparison offers noteworthy benchmarks given that the Yellowstone and NCDE grizzly bear populations are large and faring relatively well (Costello & Roberts 2019, Van Manen et al. 2019), whereas the Cabinet and Yaak populations are small and acutely vulnerable (Kasworm et al. 2019).

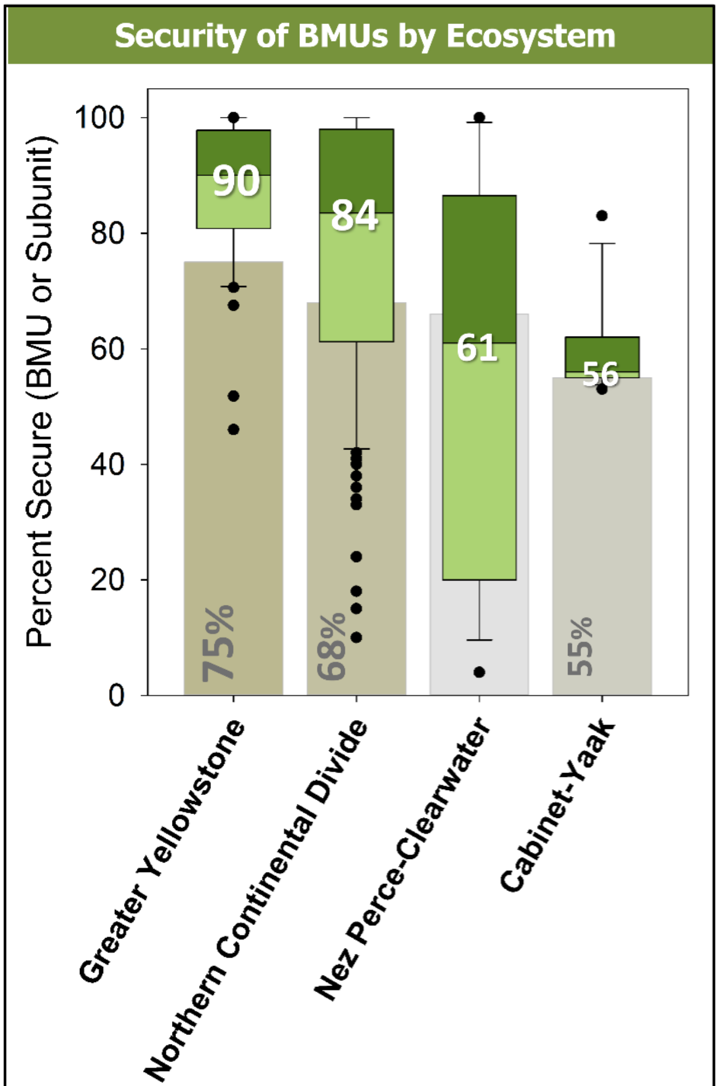


Figure 26. This graph combines bars (in shades of light dusky green) and box plots (in shades of darker green) to depict differences in security standards (secure % by Bear Management Unit [BMU]) and realized percent security by Grizzly Bear Recovery Area, including candidate BMUs on the Nez Perce-Clearwater National Forests. The bars denote standards, with standards also shown as percentages. The box plots show realized security on a BMU or BMU-Subunit basis. The numbers within each box plot are median percent security for each Ecosystem. Data are from Van Manen et al. (2019):115-116; NCDE Conservation Strategy, Appendix 3:27-29; Kootenai NF Plan Monitoring & Evaluation Report (2013):16-17; and, for the Nez Perce-Clearwater National Forests, from Figure 25c.

There are a few noteworthy take-aways from the comparison shown in Figure 25. The security of provisional BMUs on the Nez Perce-Clearwater Forests varies enormously, but inclusive of BMUs with levels comparable to that of the upper range for BMUs in the Greater Yellowstone and Northern Continental Divide ecosystems. On the other hand, median habitat security for the Forests is comparable to that in the Cabinet-Yaak ecosystem, suggesting that when viewed as a whole, the Nez Perce-Clearwater Forests are, at best, only marginally secure and, because of that, warranting major improvement.

Revisiting points I made in Sections 7.a. and 7.b., above, there is an imperative to reduce road access on the Nez Perce-Clearwater National Forests, not only because median levels of habitat security for grizzly bears are subpar, but also because measures to prevent conflicts are inadequate and likelihood of poaching and other illegal killing is comparatively high. In other words, heightened odds of prospectively lethal confrontions between humans and grizzly bears increases the need to reduce levels of contact through restrictive management of road access.

8. Fragmentation

Fragmentation of grizzly bear populations has long been a concern of managers, dating back to when ESA protections were first given to grizzlies. Although there are no explicit provisions in current government plans or strategies for securing connectivity among extant populations, the desirability of connectivity has nonetheless been routinely extolled not only by grizzly bear managers[47], but also by grizzly bear researchers, notably Walker & Craighead (1997), Craighead (1998), Proctor et al. (2004, 2005, 2012, 2015), Craighead et al. (2005), and Peck et al. (2017). Fragmentation potentially threatens the persistence of grizzly bears in the contiguous United States by reducing numbers of breeding individuals in any given population; decreasing genetic diversity through impaired gene flow and increased inbreeding and purging (Miller & Waits 2003, Lino et al. 2019); and lessening the likelihood of demographic rescue of one population by another when environmental catastrophes strike (Cosgrove et al. 2018, Millon et al. 2019).

These concerns have resulted in several investigations designed to indentify not only the location, nature, and severity of fracture zones for grizzly bear populations in the transboundary United States-Canada Rocky Mountains (Proctor et al. 2004, 2005, 2012, 2015; Waller & Servheen 2005; Graves et al. 2011; Graves 2012), but also the location of potential connective habitat at both coarse and fine scales (Gore et al. 2001, Servheen et al. 2001, Walker & Craighead 1997, Craighead & Olenicki 2006, Cushman et al. 2013, Peck et al. 2017).

In every instance, fracture zones were identified with major transportation corridors typified by heavily-trafficked highways and higher densities of human occupancy—notably along the Highway 2/Burlington Northern Santa Fe (BNSF) corridor through the Northern Continental Divide (NCDE) and Cabinet-Yaak Ecosystems; the Highway 200/Montana Rail Link corridor along the southwestern margin of the Cabinet Mountains; Highway 93 through Flathead, Mission, and Bitterroot Valleys along the west side of the NCDE and east side of the Selway-Bitterroot Ecosystem; and, most notably, Interstate Highway 90 (I-90), separating the Northern Continental Divide, Cabinet-Yaak, and Selkirk Ecosystems to the north from the Greater Yellowstone and Selway-Bitterroot Ecosystems to the south (Rutherford et al. 2014).

The map in Figure 27a shows the location of major fracture zones defined by the federal highway system. The width of red buffers is proportional to average daily traffic volume, most dramatically in and near the urban and exurban areas centered on Kalispell and Missoula in Montana and Coeur d'Alene and Boise in Idaho. The fracture zones of greatest relevance to recolonization of north-central Idaho by grizzly bears are I-90 between Missoula and Coeur d'Alene and Highway 93 south through the Bitterroot Valley (Servheen et al. 2001), although Highway 12 through the heart of the Clearwater National Forest is also of potential concern (Gore et al. 2001) given the extent to which Highway 2 through the NCDE has historically impeded movements of grizzly bears from north to south (Waller & Servheen 2005, Mikle et al. 2016).

[47] For example, U.S. Fish & Wildlife Service (1993, 2011), Servheen & Sandstrom (1993), Gore et al. (2001), Servheen et al. (2001), Montana Fish, Wildlife & Parks (2013), Yellowstone Ecosystem Subcommittee (2016), Northern Continental Divide Ecosystem Subcommittee (2020)

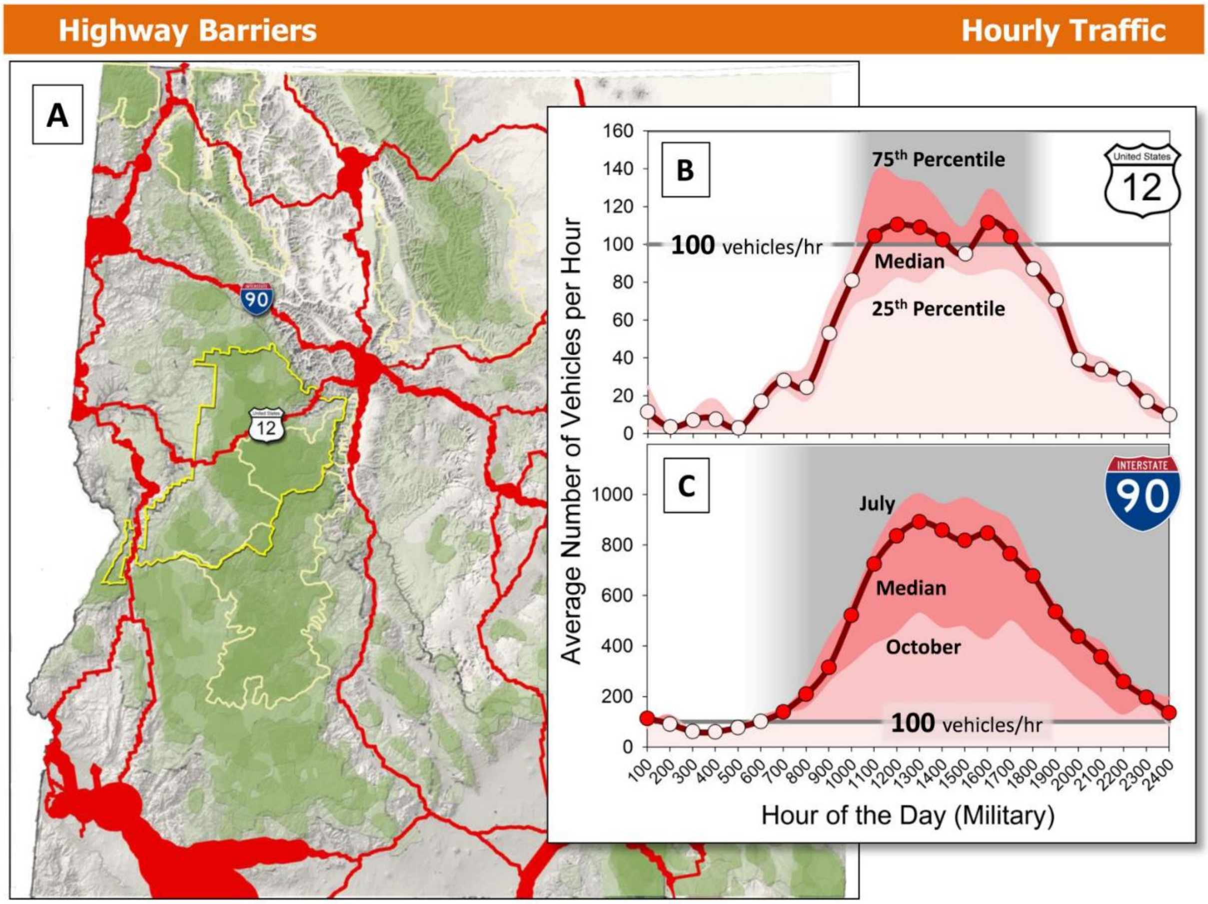


Figure 27. These graphics portray the spatial and temporal configuration of barriers posed to grizzly bear dispersal by major highways in the U.S. Northern Rocky Mountains, with an emphasis on highways located between central Idaho and source populations to the north. Map (**A**) shows major U.S. highways in red, with the width of red at any given point proportional to estimated daily traffic averaged for the entire year (U.S. Department of Transportation…(2016)). Interstate-90 to the immediate north of the Nez Perce-Clearwater National Forests (delineated in yellow) is featured because it is the most prominent barrier south and west of the Cabinet-Yaak, Selkirk, and Northern Continental Divide grizzly bear populations (Servheen et al. 2001). U.S. Highway 12 is also featured because it is the only potential highway-related barriers for grizzly bears moving north and south once bears have established in potential suitable habitat of central and north-central Idaho. Figures (**B**) and (**C**) show median hourly traffic for May-October for Highway 12 (**B**) and Interstate 90 (**C**) (Montana Department of Transportation, TCDC) relative to a threshold of 100 vehicles per hour. Waller & Servheen (2005) found that when traffic exceeded this threshold along US Highway 2 in Montana, highway crossings by grizzly bear dropped to near 0. Times of day when traffic likely poses an absolute barrier to bears are shaded gray for each highway. The red and pink-shaded area above and below the median in (**B**) represents 25th and 75th precentiles of traffic measured during various years, May-September. The shaded areas in (**C**) represent hourly traffic during 2019 for months with the greatest and least average daily traffic—July and October, respectively.

Inset Figures 27b and 27c provide visual depictions of the extent to which Interstate-90 and Higway 12 likely impede grizzly bear movements, drawing heavily on research along the Highway 2/BNSF corridor showing that grizzly bear crossings dropped to essentially nil when traffic exceeded roughly 100 vehicles per hour (Waller & Servheen 2005). The inset graphs show average or median traffic levels by time of day for different seasons, with times of day when median levels exceed 100 vehicles per hour shaded gray. The take-away from these graphs is that grizzly bears have ample opportunity to cross

Highway 12 in the Clearwater drainage between roughly 6 pm in the afternoon and 8 am in the morning, whereas opportunities to cross I-90 are restricted to between roughly 2 am and 6 am.

However, these hours only bracket periods during which *most* bears would likely attempt to cross a section of open road. Other opportunities clearly exist for grizzly bears with less aversion to attempt—and potentially survive—such a crossing, or for bears to safely cross through underpasses, overpasses, and drainage culverts. The fact that some bears have successfully navigated the seemingly impenetrable barrier posed by Interstate-90 is evident in the fact that at least four grizzlies have made the journey from either the Selkirk Ecosystem, Cabinet Mountains, or the Northern Continental Divide Ecosystem south across I-90 to north-central Idaho or the adjacent Bitterroot Mountains (see Section 5). Although the question has not been explicitly addressed, it seems plausible that, despite heavy traffic, I-90 near the Idaho-Montana border is more easily crossed by grizzly bears compared to Highway 93 in the Bitterroot Valley simply because the Bitterroot Valley has so many more human residences and associated opportunities for conflict—as evidenced by a young male grizzly that had its journey south from the NCDE abruptly terminated in 2018 when it chose to forage in a golf course near Stevensville, Montana (Backus 2018).

Natural colonization of north-central Idaho by grizzly bears will clearly depend on successful immigration of grizzly bears from the Selkirk, Cabinet-Yaak, and Northern Continental Divide Ecosystems. However, this on-going process will predictably proceed at a slow pace because of hazards created by I-90 to the north and human settlements in the Bitterroot Valley to the east. As much as natural colonization will depend on creation of *in situ* conditions that foster survival of newly-arrived grizzlies, it will also depend on making I-90 and the Bitterroot Valley more permeable to migrants. Fortunately, there is no shortage of knowledge and experience about how to do this, whether related to highway crossing structures[48] or human-grizzly bear coexistence[49].

[48] The research by Tony Clevenger and his colleagues has been perhaps the most notable contribution to refining design and effectiveness of highway crossing structures for grizzly bears (Clevenger & Waltho 2000, 2005; Clevenger et al. 2002; Ford et al. 2009, 2017; Sawaya et al. 2013), augmented by recent work along Highway 93 in Montana's Mission Valley (Hardy et al. 2007, Huijser et al. 2016, Andis et al. 2017).

[49] For example, see Primm & Wilson (2004), Wilson & Clark (2007), Clark et al. (2013), Clark & Rutherford (2014), Wilson et al. (2014), Miller et al. (2016), and Van Eeden et al. (2018).

9. The Future

Grizzly bears in the Northern Rockies face major environmental changes of a magnitude not seen since the Late Pleistocene and early and middle Holocene, but unfolding at a much faster pace[50]—faster even than the whipsaw changes of the Younger Dryas or 8.2k Episode (see Sections 2 and 3); faster perhaps than at any period in Earth's history other than during catastrophes triggered by impacts of extra-terrestrial objects; and of a severity that will likely rival the end-Permian early-Triassic transition that triggered mass extinctions[51].

These phenomenal environmental changes will challenge grizzly bears, although deep history would suggest not fatally—at least for the species as a whole. Grizzlies have managed to survive extreme environments served up by global change during the last million years or so. But grizzlies will be affected—through changes in the types, abundance, and nutritional quality of available foods[52] with prospectively orders-of-magnitude effects on bear densities[53]. At the very least, distributions and behavioral strategies of grizzly bears will be affected through changes in distributions of preferred foods and increases in potential heat stress[54].

But, even more importantly, the near future will be different in ways unlike any epoch in the past. The world occupied by grizzly bears in western North America will also be occupied by a non-trivial number of people who are armed to the teeth—disproportionately older, rural-dwelling, white males (Parker et al. 2017)—and who see themselves as entitled to dominate, use, or kill as they please. This statement may come across as being politically incorrect, nonetheless it is overwhelmingly supported by scientific research[55]. More hopefully, broader trends in human attitudes suggest that increasing

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[50] The scientific literature on the rapidity of climate warming and related ecological consequences is overwhelming. A couple of seminal papers and reports include Loarie et al. (2009), Burrows et al. (2011), LoPresti et al. (2011), Halpern et al. (2019), Oreskes et al. (2019), and Shukla et al. (2019). Even the most optimistic projections have been bleak, but recent evidence suggests that warming has, in fact, been remarkably fast since the 1970s when reckoned against an increasingly reliable specification of 1850-1950 temperatures (Li et al. 2020), and well on track to the worst-case RCP8.5 scenario of global warming (Schwalm et al. 2020).

[51] Ward (2007) provides an accessible introduction to the end-Permian environment and related extinctions. The essay that is linked at the end of this sentence provides an overview specifically in reference to grizzly bears as well as a link within (at the end) to a downloadable pdf with a list of references for those who want to dig deeper: https://www.grizzlytimes.org/single-post/2019/07/20/through-the-climate-looking-glass-into-grizzly-wonderland

[52] See Mattson et al. (2004) for a summary of the digestibilities and nutritional content of characteristic bear foods, all of which can vary by orders of magnitude.

[53] Miller et al. (1997) and Mowat et al. (2013) summarize orders of magnitude differences in North American grizzly bear densities that are directly linked to habitat productivity, with greatest differences between coastal regions where bears have access to anadromous salmon and interior regions without, but also with 10-fold or more differences in densities of interior grizzly bear populations.

[54] There is an increasing body of science offering insight into how climate change will likely affect bears, including through changes in regional configurations of productive habitat (Roberts et al. 2014, Su et al. 2018, Zhen et al. 2018, Penteriani et al. 2019, Dai et al. 2019), effects on phenology and productivity of bear foods (Holden et al. 2012, Carlson 2017, Deacy et al. 2017, Laskin et al. 2019), and effects on thermoregulatory (Pigeon et al. 2016a, Sawaya et al. 2016, Zhang et al. 2018, Schneider et al. 2020, Rogers et al. 2021) and denning behaviors (Pigeon et al. 2016b, Johnson et al. 2017, Delgado et al. 2018, Fowler et al. 2019, González-Bernardo et al. 2020).

[55] This essay https://www.grizzlytimes.org/single-post/2018/07/15/entrusting-grizzlies-to-a-basket-of-deplorables provides numerous links to articles that report research delving into social and psychological dynamics of political conservatism, especially as consolidated around an ideological agenda of social dominance, intolerance, authoritarianism, and allegiance to Donald Trump. This essay https://www.grizzlytimes.org/single-

Climate in the Clearwater Drainage

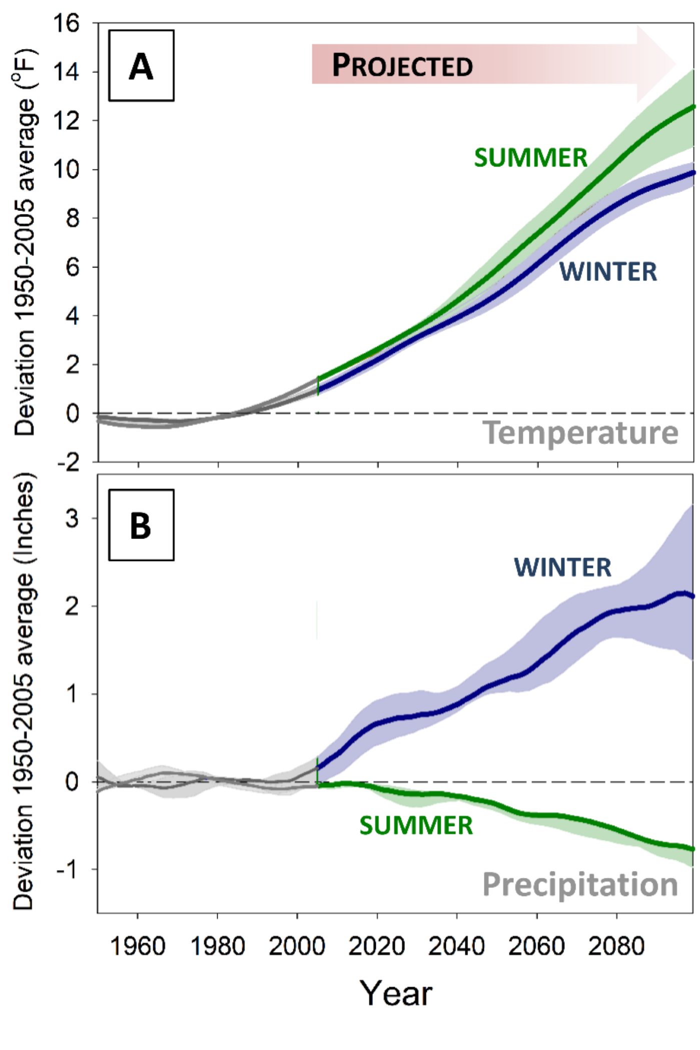

Figure 28. These two graphs show past (pre-2005) and projected future trends in average (A) temperature and (B) precipitation in Clearwater Country, Idaho, inclusive of the Clearwater River drainage (from the Applied Science Climate Lab and UW Hydro Groups' *The Climate Toolbox,* which provides county-resolution summaries of past and future climate). The graphs show trends in deviance of means and upper and lower quartiles from 1950-2005 averages. The blue-shaded lines and envelopes defined by quantile deviances show winter trends whereas the green-shaded lines and envelopes shows summer trends.

numbers of people see themselves and other animals as fellow inhabitants of a biosphere that is increasingly threatened (see Kellert & Wilson [1995], Kellert [1996], and Manfredo et al. [2020a] for insight into these trends).

The following two sections attempt to bring sharper focus to near-future projections for the northern U.S. Rocky Mountains, featuring not only on environmental change, but also prospective changes in human numbers and attitudes. The magnitude and nature of foreseeable environmental changes during the next 50-100 years will place a mounting burden on people to reconfigure attitudes and institutions if the rich biota of the Northern Rockies is to survive—including grizzly bears.

9.a. Environmental Changes

The climate of areas that could potentially support grizzlies in Idaho will change during the next 50-100 years, accelerating trends that have been evident since the 1970s. Figure 28 features projected climate changes for Clearwater County, Idaho—emblematic of what the future holds for potential suitable grizzly bear habitat throughout Idaho, as well as for the current locus of grizzly bear colonization in the Clearwater River drainage.

Foreseeable changes in seasonal temperatures are not subtle (Figure 28a), with projected increases of a staggering 12°F (6.7°C) during summer and 10°F (5.6°C) during winter. This change is tantamount to transporting the winter temperatures of St. George, Utah, and

post/2018/10/18/basket-of-deplorables-revisited-grizzly-bears-at-the-mercy-of-wyoming elaborates on how these social-psychological dynamics have been manifest more recently in relations with grizzly bears.

summer temperatures of Moab, Utah, roughly 9° latitude north to Moscow, Idaho. Although this projection is based on the International Panel on Climate Change's (IPCC's) worst-case RCP8.5 scenario, this prognosis is warranted by our current climate trajectory (Schwalm et al. 2020) and apparent inability, globally, to adequately curb greenhouse gas emissions (see Blanco et al. [2014] and Friedlingstein et al. [2020]).

Projected Changes in Stored Ecosystem Moisture

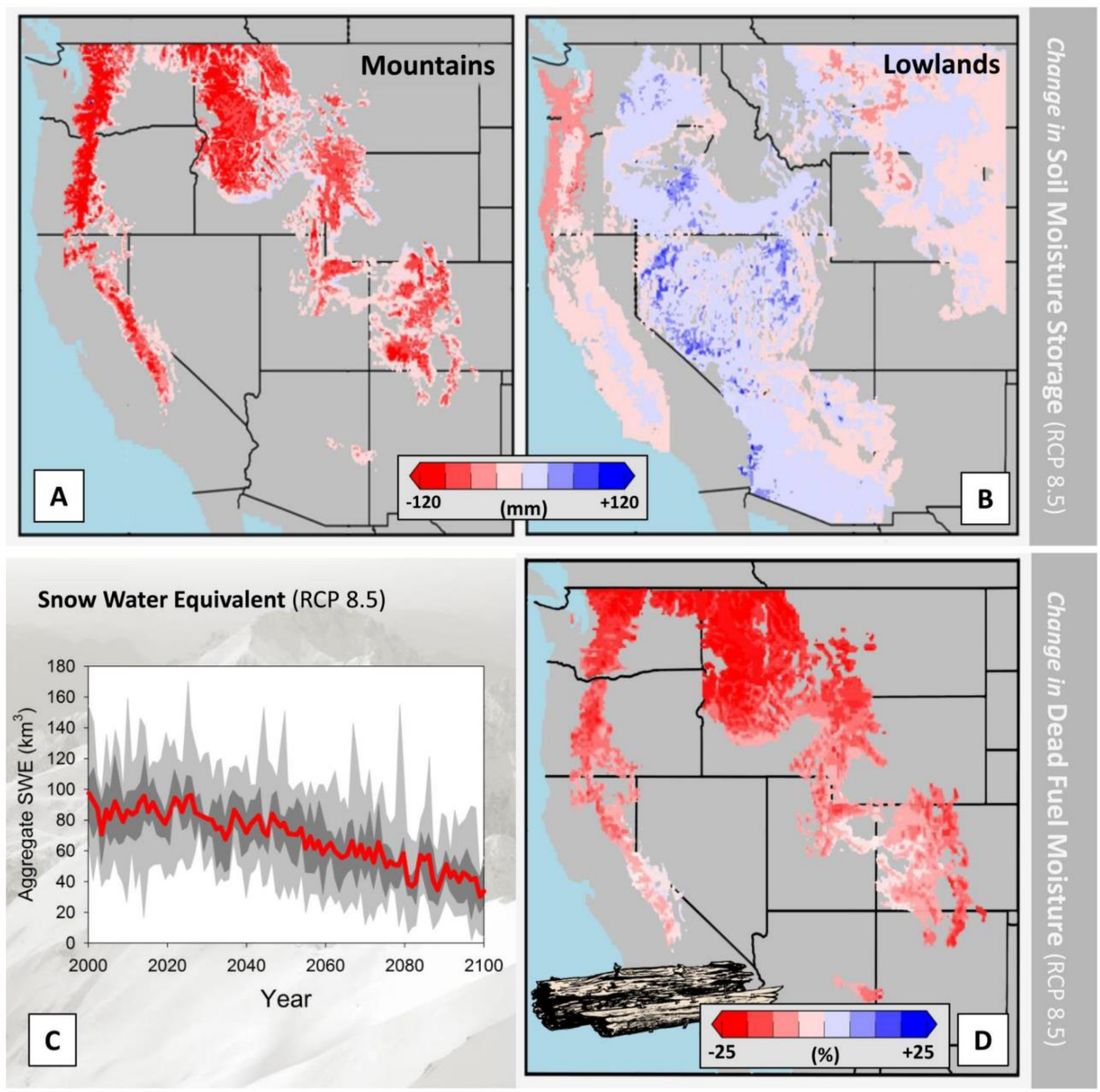

Figure 29. These four graphics show projected changes in moistures conditions during the next 80 years, with direct relevance to the ignition and spread of forest wildfires, including soil moisture storage (A) in mountainous and (B) in lowland areas, and related changes in (D) moisture content of woody fuels. Increases in moisture relative to current normals are shown as progressively darker shades of blue; comparative drying is shown as progressively darker shades of red. Figure (C) shows projected changes in moisture delivered and stored as snow (snow water equivalent), which is a direct driver of soil and fuel moisture in mountain areas. All of these graphics are adapted from Gergel et al. (2017).

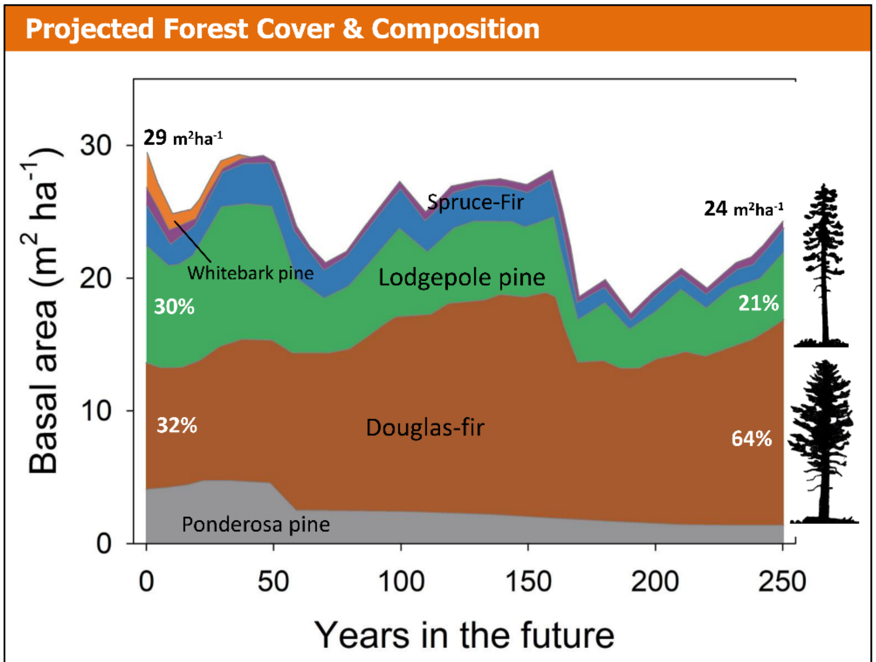

Figure 30. Climate change will interact in sometimes complex ways with wildfire, disease, and outbreaks of insects to shape forest composition and cover in the northern U.S. Rock Mountains. This graphic shows a 250-year projection for a watershed in the Bitterroot mountains simulating the effects of a warming climate, increasing wildfire frequency, outbreaks of mountain pine beetles (*Dendroctonus ponderosae*), and spread of white pine blister rust (*Cronartium ribicola*; Loehman et al. 2018). Total forest basal area in this watershed is projected to decrease by around 17%, although the biggest changes will be in forest composition, notably a doubling in the proportional representation of Douglas-fir (*Psuedotsuga menziesii*) and the disappearance of whitebark pine (*Pinus albicaulis*).

Projected changes in precipitation are not as dramatic, but still substantial, with a marked divergence in seasonal trends (Figure 28b). Winters will likely get wetter, although to an uncertain extent, whereas summers will more certainly get drier. The effects of sustantially warmer winter weather will have major impacts on the proportion of precipitation falling as rain versus snow, with loss of snow-dominated winter weather projected for almost all watersheds in the Columbia River Basin during the next 60-80 years (Mantua et al. 2010, Hamlet et al. 2013).

As a consequence, peak streamflows will occur earlier (e.g., Hamlet et al. 2013 U.S. Department of the Interior, Bureau of Reclamation 2016), accompanied by increasing stream temperatures and increased frequency of flood events (e.g., Mantua et al. 2010, Tohver et al. 2014, U.S. Environmental Protection Agency Region 10 2020).

But the synergistic impacts of drier hotter summers and proportionally reduced snowfall will not be limited to hyrologic regimes. Perhaps self-evidently, the water content (i.e., SWE), spatial extent, and seasonal duration of snow packs will decline substantially (Figure 29c; Hamlet et al. 2013, Gergel et al. 2017, Dalton & Fleishman 2021). The derivative effects of these changes will be reduced summer moisture storage and content of both soils and dead fuels in mountain areas (Figures 29a and 29d; Gregel et al. 2017), with resulting increases in the frequency and extent of wild fire, albeit it with some opportunities for limited mitigation (Barbero et al. 2015, Holden et al. 2018, Halofsky et al. 2020).

All of this will lead to inevitable effects on vegetation cover and composition, with a predictable shift to fire-adapted drought-tolerance species. Although there is not room here to summarize the compendious research on this topic (although, see Halofsky et al. [2018, 2020] and Halofsy & Peterson [2018] for summaries), Figure 30 is illustrative of prospective changes. The projections in this figure are based on simulations that include the effects of climate warming, wildfire, white pine blister rust (*Cronartium ribicola*), and mountain pine beetle (*Dendroctonus ponderosae*) for a watershed of the Bitterroot River drainage (Keane et al. 2015). The modeled dynamics result in a proportional increase of Douglas-fir—which is particularly well-adapted to frequent wildfire—along with an unsurprising loss of cold-adapted species (whitebark pine, subalpine fir, and Engelmann spruce) and a decrease in overall forest basal area. But, then, this is only the tip of the proverbial iceberg.

Dramatic increases in temperatures together with diminished snowpacks and substantial summer-time drying will predictably lead to deteriorating hydrologic regimes and increasingly frequent wildfires throughout most of Idaho. These and other environmental changes will almost certainly translate into foreseeable impacts on foods that are currently important to grizzly bears in Idaho's potential suitable habitat.

9.b. Changes in Bear Foods

First and foremost, the extent of environments hospitable to fruit-producing shrubs will likely shrink—including for huckleberry (*Vaccinium memberanaceum*), serviceberry (*Amelanchier alnifolia*), buffaloberry (*Shepherdia canadensis*), and chokecherry (*Prunus virginiana*). Figure 31 shows where climates suitable for these four species are projected to persist in and near the northern U.S. Rocky Mountains (Ironside & Mattson 2014, Prevéy et al. 2020). In all of the panels except for huckleberry, areas of likely persistence are shown in green, whereas areas of likely loss are shown in yellow. In the case of huckleberry, persistence is show in shades of blue and loss in shades of brown. As a point of reference, the boundary of the Nez Perce-Clearwater National Forests is also shown.

In a nutshell, greatest losses are projected for chokecherry and serviceberry whereas least losses are projected for buffaloberry. Of particular relevance to north-central and central Idaho, huckleberry will likely persist only in the highest-elevation areas; chokecherry will likely disappear altogether from most areas; whereas significant portions of the Nez Perce-Clearwater Forests will likely form a notable refugium for serviceberry. One important point that emerges from these projections is that persistence and loss of will not be a simple matter of species migrating up in elevation. Responses will likely be more complex than that, driven by interactions of species-specific adaptations to shifting seasonal climatic regimes. Even so, the overall picture is one of net losses in abundance of fruit-producing shrubs that are currently important to grizzly bears.

Insofar as anadromous salmonids are concerned, the scientific literature on how climate change will directly or indirectly affect species in the Pacific Northwest is so voluminous that NOAA's Northwest Fisheries Science Center devotes a 30 to 60 page-long publication each year to reviewing what was produced the year before (i.e., *Impacts of climate change on salmon in the Pacific Northwest: A review of the scientific literature published in*…). Needless to say there are many nuances and complexities.

Even so, there is an emerging consensus about fundamentals, notably reported in Crozier et al. (2019, 2020). According to the ranking system used by Crozier et al. (2019), 10 of 11 distinct population segments (DPSs) of chinook salmon are rated as being highly or very highly vulnerable to the impacts of climate change, whereas all 11 DPSs of steelhead are rated as being either highly or moderately vulnerable. More specifically for the Salmon and Clearwater River drainages, steelhead populations in almost all reaches are judged to be highly sensitive and exposed to either worsening thermal or flow regimes (Wade et al. 2013), although a more replete reckoning of vulnerability suggests that there are amplifying concerns related to genetic impoverishment (Wade et al. 2017). The upshot is that, although not as threatened by climate change as populations in middle reaches of the Columbia Basin, salmon and steelhead in Idaho will likely be diminished.

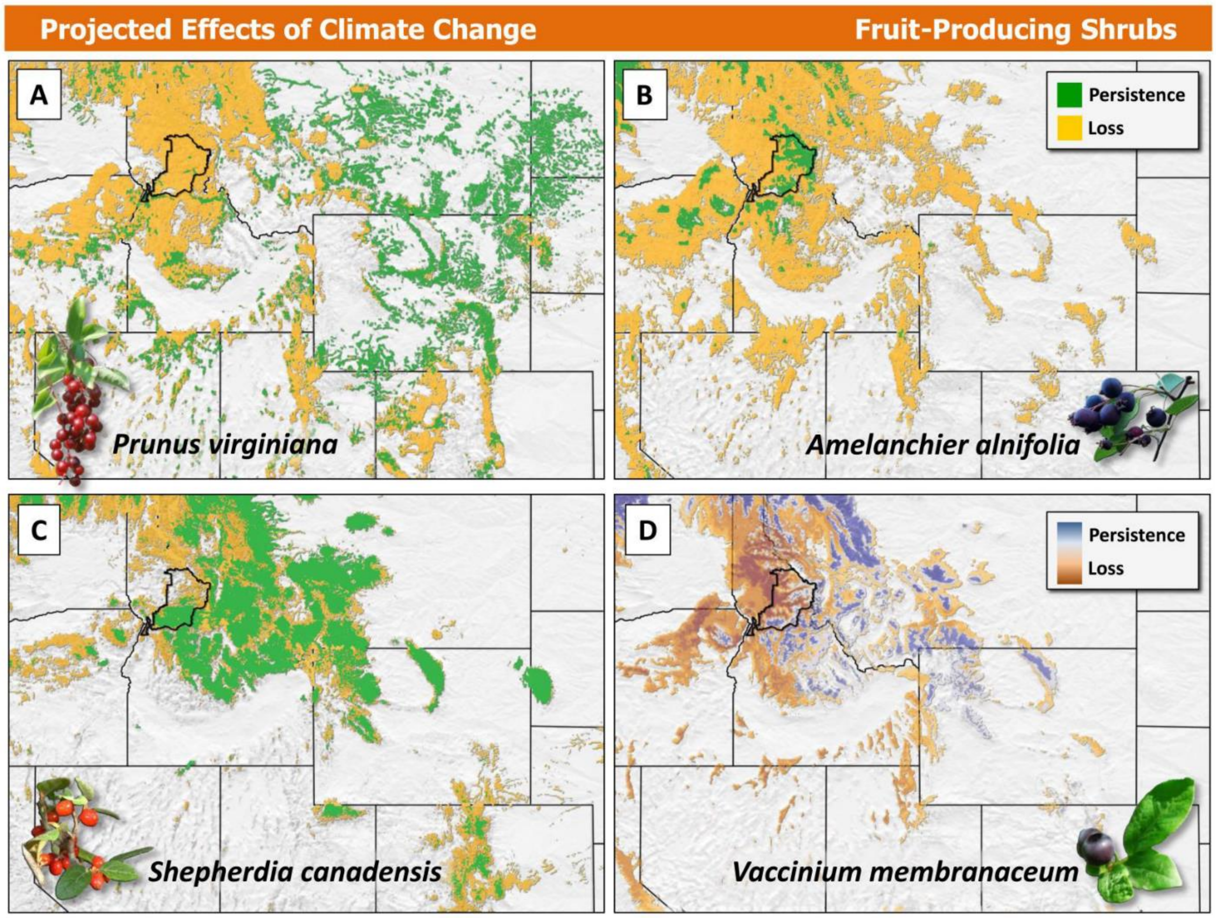

Figure 31. These maps show projected changes in distributions of four shrubs that are currently the source of most fruit eaten by grizzly bears in the U.S. Northern Rocky Mountains. Projections are based on anticipated changes in climate and related changes in climate envelope for each species, but without accounting for effects of altered fire regimes or changing abundance of pollinators. Projections in (**A**)-(**C**) are shown relative to a cutpoint above which the species' climate envelope has a >50% chance of persisting (green) and below which the envelope is unlikely to persist (yellow) by the end of 2050 (from Ironside & Mattson [2014]). Projections in (**D**) are shown in terms of increased or decreased joint probability of both shrub presence and fruit production for huckleberry during the next 80 years (adapted from Prevéy et al. [2020]). The boundary of the Nez Perce-Clearwater National Forests is shown as a thick black line in each of the panels.

Finally, and without being exhaustive, whitebark pine will almost certainly disappear during the next 100 years as an important bear food in central Idaho. There is a veritable cottage industry of research projecting the future of high-elevation haunts for whitebark pine, few of which have improved on an original prognosis by Romme & Turner (1991) showing a >90% attrition in the distribution of whitebark pine in the Yellowstone ecosystem due to climate warming. The numerous projections since then, deploying progressively more sophisticated models, have shown the same basic result (for example, Coops & Waring 2011, Chang et al. 2014, Smith-McKenna et al. 2014, Case & Lawler 2016)—which is much the same as has been shown for alpine habitats destined to be figuratively pushed off the mountain-tops (Diaz & Eischeid 2007, Rehfeldt et al. 2012, Hansen et al. 2015). As important, the devastation caused by a climate-driven mountain pine beetle outbreak in the Yellowstone ecosystem during 2000-2009 revealed how quickly whitebark pine could be functionally extirpated as a bear food (Macfarlane et al. 2013).

Other changes in the natural environment are foreseeable, including an abbreviation of the season and attrition of sites where succulent forbs are available for bears to graze. But one prospectively consequential change involves meat from terrestrial sources. A pattern has emerged in the Greater Yellowstone and Northern Continental Divide Ecosystems typified by increased consumption of meat by grizzly bears in places or at times when other high-quality foods are not abundant. In the past this occurred in the Yellowstone Ecosystem during years when whitebark pine seeds were scarce (Mattson 1997). But during the last few decades, with essentially permanent losses of whitebark pine in both the Yellowstone and eastern portions of the Northern Continental Divide Ecosystems, grizzly bears have substantially increased their consumption of meat, often as a result of colonizing peripheral areas populated by livestock (Mattson 2017, 2019a). In the NCDE, meat accounts for nearly 90% of ingested energy and nutrients for grizzlies occupying the High Plains (Mace & Roberts 2012).

Emerging patterns in the Yellowstone and Northern Continental Divide Ecosystems foreshadow a future in which additional vegetal foods are lost and grizzly bears switch to alternate high-quality foods that catalyze local changes in distribution—a future in which meat from terrestrial sources plays a prominent dietary role (see the dietary economies in Figure 17), as it likely did at lower elevations in Idaho during the late Pleistocene and early to middle Holocene (Sections 2.b. and 3.b.). If this future comes to pass, it will put human-bear relations increasingly to the test, especially when there are conflicts with livestock producers subject to depredation losses or hunters jealous of their prepogatives to kill harvestable elk.

9.c. The Future With Humans

Within the next 40 years there will almost certainly be more people living near and recreating in areas occupied by grizzly bears. However, if current drivers and past trends continue to hold, growth in human populations will not be geographically uniform. Figure 32 provides a summary of trends and projections broken down, not only by grizzly bear ecosystems, but also by counties within each ecosystem that have experienced the most and least growth during the last 40 years—between 1980 and 2020. Perhaps not surprisingly, populations of rural counties dependent on agriculture and extractive industries have grown very little, whereas populations of “amenity-rich” counties have exploded, especially in and near the Northern Continental Divide and Yellowstone Ecosystems. Interestingly, the fastest growing counties near the Selkirk, Cabinet-Yaak, and Selway-Bitterroot Ecosystems have grown at a significantly slower pace, but with potentially substantial increases in human populations projected for the next 40 years.

There is little reason to expect that the divergence in population gains between amenity-rich counties and the rest will change, largely because there is little reason to anticipate that drivers of growth will change. Past population increases have been linked to nearness of airports, interstate highways, universities, hubs of entrepreneurial activity, and destination resorts such as ski areas—more so even than to the presence of protected areas and dramatic scenery in the figurative backyard, although both also help (Rasker & Hansen 2000; Gude et al. 2006; Rasker et al. 2009, 2013). This configuration of drivers serves to explain not only low rates of population growth in counties dependent on extractive industries, but also lower rates of population growth in Valley and Ravallii counties compared to Missoula, Lewis & Clark, Flathead, Gallatin, and Teton (Wyoming) counties.

Projected Changes in Human Populations

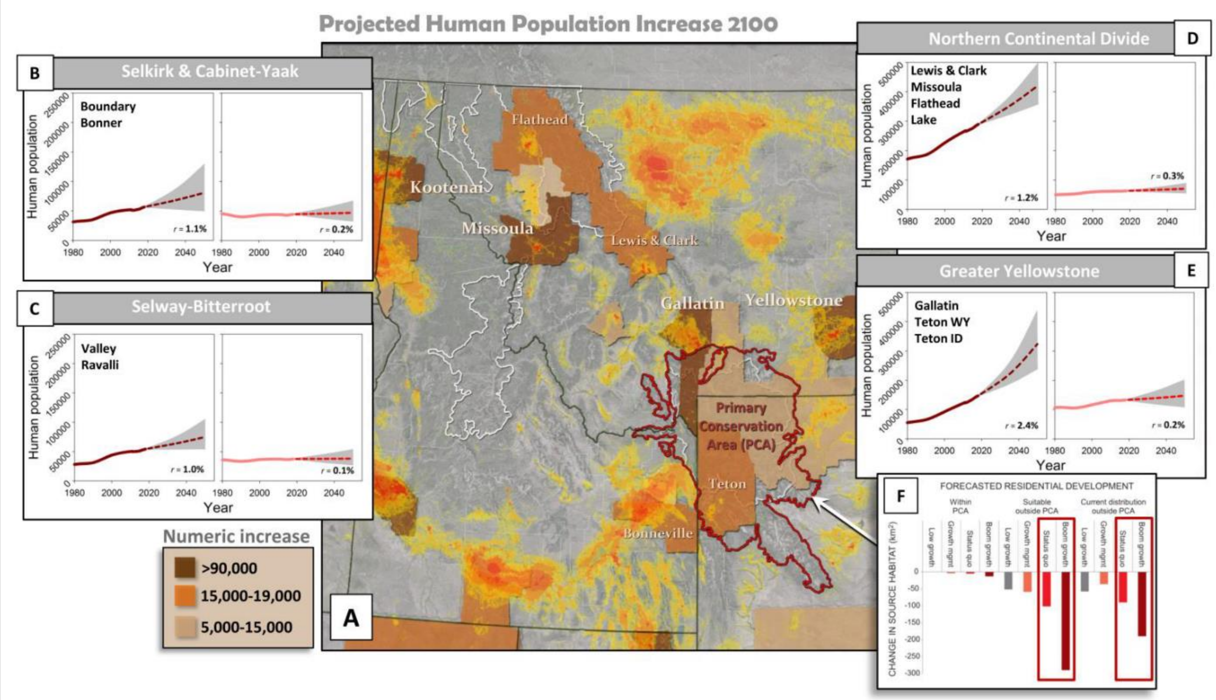

Figure 32. This set of graphics summarizes past and projected trends in human populations in the northern U.S. Rocky Mountains, 1980-2060, differentiated by counties encompassing different grizzly bear ecosystems, delineated by white lines. In addition, counties are differentiated for each ecosystem by those that are the fastest growing (left panel of each pair) versus the remainder (right panel). Human populations in and near (B) the Selkirk, (B) Cabinet-Yaak, and (C) Selway-Bitterroot Ecosystem have grown much slower than human populations in the (D) Northern Continental Divide and (E) Greater Yellowstone Ecosystems—a trend that is projected to for the next 40 years. (A) Counties that are projected to have the greatest numeric increases are shown in various shades of brown, with those colored darkest (Kootenai, Idaho; and Missoula and Gallatin, Montana), projected to gain >90,000 people during the next two decades. The impacts of this projected growth are shown for the Greater Yellowstone area in (F), including potential losses of 300-km^2 of source habitats for grizzly bears (Schwartz et al. 2012). The current human footprint, including impacts of human infrastructure and permanent conversions to agriculture, is shown in shades of orange (Leu et al. 2008; map data from Databasin, uploaded by Conservation Biology Institute). Historical trends in human populations are from U.S. Census Bureau; projected trends are from Hauer (2019).

Regardless of the locus of population increases, there are additional important nuances and dynamics. People who live in amenity-rich counties don't stay there. They typically travel regionally to recreate, and those who are most likely to participate in backcountry recreation fit the demographic profile of people disproportionately immigrating into amenity-rich counties of the northern U.S. Rockies[56]. All of these patterns have likely led to increasing rather than decreasing frequencies of contact between grizzly bears and people, regardless of where people have specifically been inclined to settle.

Even so, potential suitable grizzly bear habitat in Idaho is characterized by an auspicious configuration of formally protected and *de facto* protected wildlands, including Wilderness Areas, Wilderness Study Areas, and Inventoried Roadless Areas (IRAs)—all of which predictably mitigate against intrusions by

[56] Cordell (2012) and Mockin et al. (2012) provide useful summaries of participation in different outdoor recreational activities, not only by demographic group (i.e., age, sex, race, ethnicity, income, and region), but also over time. Young white people with even modest amounts of disposable income are the most likely of all groups to be active in the backcountry, especially in the Rocky Mountain region. Not surprisingly, this demographic accounts for much of the immigration into the northern U.S. Rocky Mountains during the last 20 years.

Roadless Areas & Suitable Grizzly Bear Habitat

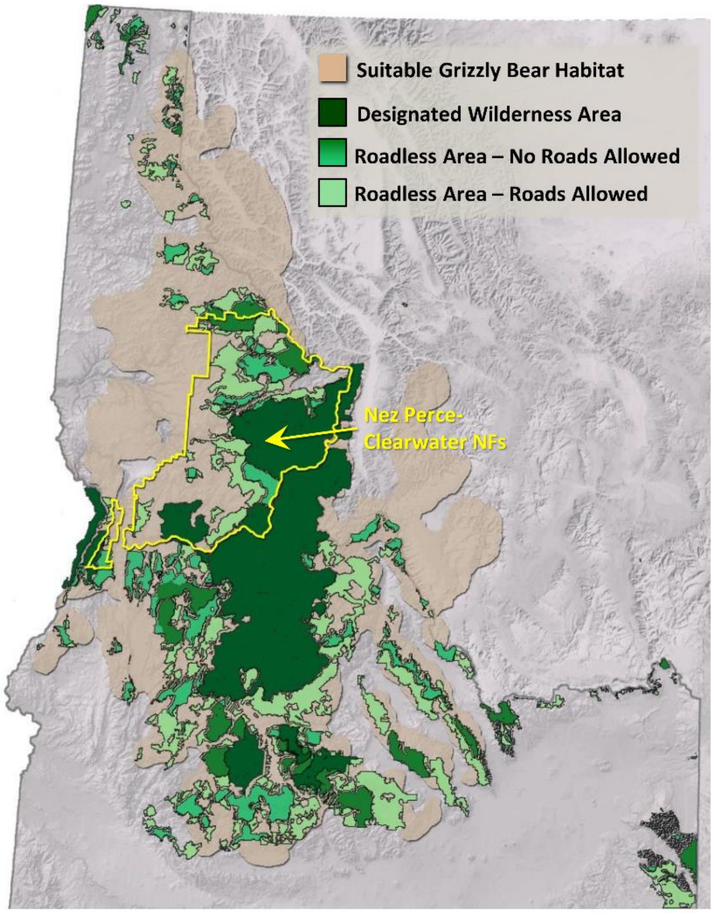

Figure 33. This map shows the extent of potential suitable habitat in Idaho, including contiguous areas in Montana (beige; see Figure 12) along with designated Wilderness Areas (darkest green), Inventoried Roadless Areas (IRAs) where road construction and maintenance are prohibited (medium shades of green), and IRAs where road construction and maintenance are allowed (lightest green). Maps of IRAs follow 2001 delineations and are from https://www.fs.usda.gov/detail/roadless/2001roadlessrule/maps/statemaps/?cid=fsm8_037707

people, especially beyond the likely distance of a day-hike or mountain bike foray. The map in Figure 33 provides a visual summary of the remarkable extent of these wildlands in Idaho. Insofar as grizzly bear conservation is concerned, the *status quo* turns out to be auspicious—unlike in much of the western United States. But this favorable situation will only provide future benefits if it is conserved, and much of that conservation will be contingent on whether and to what extent Wilderness Study Areas and IRAs are given permanent meaningful protections. In other words, preservation of these roadless wildlands offers perhaps the best means of offsetting foreseeable impacts of increasing regional human populations on recovering grizzly bear populations in north-central and central Idaho.

But perhaps even more important, human attitudes, values, and perspectives will matter. The newcomers who have fueled population growth have brought pursuits, behaviors, employments, and worldviews with them that differ from those of long-time residents (Shumway & Otterstrom 2001, Hansen et al. 2002, Ghose 2004). More specifically—as Manfredo et al. (2009) put it—they tend to be more "mutualistic" as opposed to personally identified with domination; or, as Kellert (1996) earlier characterized it, more likely to anthropomorphize animals and be concerned about their welfare rather than invested in using and dominating them. And those who are invested in domination and use also tend to be more lethal to wildlife, especially predators such as mountain lions (*Puma concolor*; Mattson & Ruther 2012).

The upshot is that proportionately fewer of those fueling human population growth in the northern U.S. Rockies are likely to kill grizzly bears compared to longer-term residents embued with traditional rural values espousing domination and use of wildlife, largely as a consequence of the differential prevalence of “domination” and “mutualism” values (Manfredo et al. 2020a). Or, as framed in Box 3 on page 49, grizzly bears stand a decent chance of weathering increasing numbers of encounters with people because each encounter, on average, will likely be less lethal for the involved bear.

But the key part of this equation is lethality, which derives not only from the attitudes being brought by newcomers, but also by shifting attitudes among longer-term residents. And there are indications that longer-term residents, as well as those identified with the cultures of hunting and ranching, are not becoming less but rather more lethal.

A major driver of prospective increases in lethality among hunters and rural residents is plausibly rooted in resentment—resentment of changes in culture, demographics, political privilege, and economic configurations being catalyzed by the influx of newcomers. These resentments and associated backlash and “revolts” are well-documented and well-scrutinized (for example, see Krannich & Smith [1998], Ulrich-Schad & Duncan [2018] and Berlet & Sunshine [2019]). But the link to grizzly bears—and other large carnviores—is plausibly through the extent to which those who identify with traditional lifeways and values identify newcomers with alien mutualistic orientations towards wildlife. In other words, resentment of newcomers and the changes they represent likely translates into resentment of the animals these newscomers value—especially large carnviores such as grizzly bears and wolves (*Canis lupus*; Nie 2003).

The result is plausibly a backlash among many hunters, ranchers, and other long-time rural residents against large carnivores that they identify with newcomers (e.g., Manfredo et al. 2017). In other words, real bears become “symbol bears” (Primm 2000), with symbolic loadings rather than objective realities driving people’s behaviors. Hence the likely prevalence of poaching as a cause of grizzly bear deaths in the Selkirk, Cabinet-Yaak, western Northern Continental Divide Ecosystems (see Section 7.a.)—in rural counties typified by stagnating extractive industries and dominated demographically by politically conservative people without a college education, who also happen to be white (U.S. Census Bureau; U.S. Federal Election Commission); i.e., those who are most inclined to feel “left behind” in the New West (Wuthnow 2018).

Relations with humans will continue to dictate whether grizzly bears survive and thrive in the northern U.S. Rocky Mountains, including in the wildlands of Idaho. Yet relations with people have become increasingly typified by volatile dynamics at the juncture of human population increases, socio-economic change, political conflict, and unstable attitudes. The future of grizzlies will likely depend on whether human resentments and population increases are offset by the preservation of wild places and continued emergence of benevolent attitudes towards large carnivores.

10. Summary of Conclusions

Deep History

The grizzly bears that occupied Idaho for millennia—and continue to hold on in Idaho's portions of the Selkirk, Cabinet-Yaak, and Yellowstone ecosystems—are members of a unique evolutionary and biogeographic lineage that has disappeared virtually everywhere else on Earth.

Grizzly bears in Pleistocene Idaho were probably relegated to using marginal habitats, foods, and temporal windows as means of avoiding other predatory carnivores and obtained meat primarily by scavenging large-bodied herbivores in amounts likely to constitute an important food for many bears. Despite this, most grizzlies probably relied primarily on vegetal foods for the bulk of their diet, with whitebark pine seeds also of prominent importance.

Pre-European Holocene

The Altithermal was probably a stressful period for grizzly bears caused by hot-dry conditions that reduced amounts of vegetal foods—including the abundance of whitebark pine—for perhaps as long as 3,500 years. By contrast, the generally cooler and wetter conditions that followed the Altithermal not only resulted in greater herbaceous productivity, but also an increased frequency of forest fires that likely resulted in greater amounts of available fruit on shrub species such as huckleberry and buffaloberry—both of which tend to flourish in more open conditions—and thus in the wake of forest fires.

Grizzly bears in most parts of ancestral Idaho probably had access to abundant meat during the Holocene either from spawning anadromous salmonids or from large-bodied herbivores such as bison and elk, with these two sources complementary in both time and space. The challenges to grizzlies posed by humans, at least up until the arrival of European horses and then Europeans themselves, tended to be spatially concentrated along specific reaches of the Columbia and Salmon Rivers, leaving bears ample access to salmon in mountainous areas of central Idaho. There may even have been a brief Edenic time for grizzlies that lasted a couple of centuries between when European diseases took their toll on indigenous human populations and lethal Europeans arrived in person.

The Arrival of Europeans

The future state of Idaho almost certainly supported several thousand grizzly bears at the time of European contact, with highest bear densities likely occurring in portions of the state north of the Snake River Plain. Central and northern ancestral Idaho were probably more productive environments for grizzly bears compared to the arid and semi-arid Snake River Plain, largely as a consequence of abundant fruit, anadromous salmonids, and whitebark pine. Central portions of the Snake River Plain may have only supported significant numbers of grizzly bears when bison roamed this region prior to the 1830s-1840s.

Impacts of Europeans in nascent Idaho likely unfolded in pulses organized around different episodes of colonization and exploitation with different geographic foci. Traffic on the Oregon Trail probably unleashed an early devastation of fauna on the Snake River Plain during the 1840s-1860s. Miners flooded remote mountains of central and north-central Idaho during 1860s-1880s. Agriculture followed during the 1870s and 1880s, most dramatically on the Palouse Prairie where a native grassland that had previously supported bison was almost completely converted to non-native wheat. Barring the effects of subsequent dams on the Columbia and Snake Rivers, perhaps the most severe environmental impacts caused by European colonization played out during a remarkably brief 40-year period.

Extirpations of grizzly bears from Idaho by newly-arrived Europeans were rapid, widespread, and anomalous, with some anomalies plausibly explained by the concentration of grizzlies near lethal people in pursuit of spawning salmon, but with prospects of mineral-related wealth also sending people into even the most remote refuges left to grizzlies. The massive wildfires of 1910 and the near end of chinook salmon spawning runs might have contributed to delivering a *coup de grâce* to the last grizzlies left in the Clearwater country.

Prospects and Potential

Vacant wildlands of central and north-central Idaho currently have the potential to support as many as 1,000 grizzly bears which, if realized, would offer significantly greater odds of population persistence compared to if grizzlies were confined to the Selway-Bitterroot Recovery Area. However, long-term viability will require a contiguous interbreeding population of several thousand grizzly bears, which could be achieved if current populations were connected by on-going colonization of interstitial potential suitable habitat throughout the northern Rockies into Canada.

Prospective Diets

Much has changed between 1800 and now in the tableau of grizzly bear foods. Whitebark pine is diminished everywhere and, in areas to the north and west, functionally extirpated as a bear food by white pine blister rust. The distribution of spawning habitat for anadromous salmonids has been truncated in Idaho by high dams on the Snake River above Hells Canyon. Surviving salmon and steelhead populations elsewhere in Idaho have been dramatically reduced by impediments posed by numerous dams on the lower Columbia and Snake Rivers. Even so, much bear food remains, with the fruit and forb-based dietary economy of north-central Idaho essentially intact.

The current distributions of major bear foods together with diets documented for grizzly bears in nearby ecosystems provide ample basis for anticipating what grizzlies would likely eat in different parts of central and north-central Idaho, ranging from a dominance of fruit and forbs to the north, to greater contributions of elk and whitebark pine seeds to the south—with salmon and trout of possible importance in between.

Given the large sizes of adult chinook salmon, steelhead trout, and even bull trout—all often >4 kg—fishing by grizzly bears could probably be sustained in headwaters of the Clearwater and Salmon Rivers by even modest spawning runs—which could, in turn, result in salmonids playing a significant role in the diets of grizzly bears in central and north-central Idaho.

There are clearly ample foods for grizzly bears on the Nez Perce-Clearwater National Forests, including potentially substantial amounts of meat from either salmonids or elk throughout the bears' active season. During summer and fall, distributions of key foods will likely attract grizzlies to comparatively secure habitat, much of it in designated Wilderness Areas, whereas during spring productive habitats will probably attract grizzlies to lower elevations where conflicts with humans will be likely. Other conflicts could arise over foreseeable impacts of grizzly bear predation on iconic elk populations that some people see as existing primarily to provide a harvestable surplus for humans to kill.

Security and Coexistence Infrastructure

Because of inattention to conflict prevention by state wildlife and federal land managers, current conditions on the Nez Perce-Clearwater Forests are ripe for grizzly bear-human conflicts over unsecured garbage and food; conflicts over livestock depredations; conflicts with big game hunters; and mortalities caused by black bear hunters mistaking a grizzly for a black bear. All of this promises to leave managers scrambling to deal with grizzly bear mortalities arising from foreseeable conflicts.

Disregard for the best available science together with inexplicable variation in security standards among ecosystems complicate any assessment of whether conditions on the Nez Perce-Clearwater National Forests provide adequate security for grizzly bears—which is further complicated by being nested within the larger issue of what's needed at a broader scale to insure population viability. But these sorts of complications do not debar an evaluation of landscape conditions and useful comparisons with other ecosystems.

There is an imperative to reduce road access on the Nez Perce-Clearwater National Forests, not only because median levels of habitat security for grizzly bears are subpar, but also because measures to prevent conflicts are inadequate and likelihood of poaching and other illegal killing is comparatively high. In other words, heightened odds of prospectively lethal confrontions between humans and grizzly bears increases the need to reduce levels of contact through restrictive management of road access.

Fragmentation

Natural colonization of north-central Idaho by grizzly bears will clearly depend on successful immigration of grizzly bears from the Selkirk, Cabinet-Yaak, and Northern Continental Divide Ecosystems. However, this on-going process will predictably proceed at a slow pace because of hazards created by I-90 to the north and human settlements in the Bitterroot Valley to the east. As much as natural colonization will depend on creation of *in situ* conditions that foster survival of newly-arrived grizzlies, it will also depend on making I-90 and the Bitterroot Valley more permeable to migrants. Fortunately, there is no shortage of knowledge and experience about how to do this, whether related to highway crossing structures or human-grizzly bear coexistence.

The Future

Dramatic increases in temperatures together with diminished snowpacks and substantial summer-time drying will predictably lead to deteriorating hydrologic regimes and increasingly frequent wildfires throughout most of Idaho. These and other environmental changes will almost certainly translate into foreseeable impacts on foods that are currently important to grizzly bears in Idaho's potential suitable habitat.

Emerging patterns in the Yellowstone and Northern Continental Divide Ecosystems foreshadow a future in which additional vegetal foods are lost and grizzly bears switch to alternate high-quality foods that catalyze local changes in distribution—a future in which meat from terrestrial sources plays a prominent dietary role, as it likely did at lower elevations in Idaho during the late Pleistocene and early to middle Holocene. If this future comes to pass, it will put human-bear relations increasingly to the test, especially when there are conflicts with livestock producers subject to depredation losses or hunters jealous of their preprogatives to kill harvestable elk.

Relations with humans will continue to dictate whether grizzly bears survive and thrive in the northern U.S. Rocky Mountains, including in the wildlands of Idaho. Yet relations with people have become increasingly typified by volatile dynamics at the juncture of human population increases, socio-economic change, political conflict, and unstable attitudes. The future of grizzlies will likely depend on whether human resentments and population increases are offset by the preservation of wild places and continued emergence of benevolent attitudes towards large carnivores.

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The Grizzly Bear Promised Land

Past, Present & Future of Grizzly Bears in the Bitterroot, Clearwater, Salmon & Selway Country

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2021

The Grizzly Bear Recovery Project

P.O. Box 2406, Livingston, Montana