October 8, 2018

The Honorable John Barrasso
Chairman, Committee on Environment and Public Works
United States Senate
410 Dirksen Senate Office Building
Washington, DC 20510

The Honorable Thomas Carper
Ranking Member, Committee on Environment and Public Works
United States Senate
456 Dirksen Senate Office Building
Washington, DC 20510

Dear Chairman Barrasso and Ranking Member Carper:

Thank you for the opportunity to provide a written statement for the Committee's October 10, 2018 hearing entitled, "From Yellowstone's Grizzly Bear to the Chesapeake's Delmarva Fox Squirrel—Successful State Conservation, Recovery, and Management of Wildlife". Please accept these comments for the hearing's official record.

My Background and Expertise

For the record, my name is David J. Mattson, a scientist and recently retired wildlife management professional with extensive experience in grizzly bear research and conservation spanning four decades. My educational attainments include a B.S. in Forest Resource Management, an M.S. in Plant Ecology, and a Ph.D. in Wildlife Resource Management. My professional positions prior to retirement from the U.S. Geological Survey (USGS) in 2013 included: Research Wildlife Biologist, Leader of the Colorado Plateau Research Station, and Acting Center Director for the Southwest Biological Science Center, all with the USGS; Western Field Director of the Massachusetts Institute of Technology-USGS Science Impact Collaborative; Visiting Scholar at the Massachusetts Institute of Technology; and Lecturer and Visiting Senior Scientist at the Yale School of Forestry & Environmental Studies.

My dissertation focused on the ecology of grizzly bears in the Greater Yellowstone Ecosystem (GYE) during 1977-1996 (Mattson 2000). I intensively studied grizzly bears in the GYE during 1979-1993 as part of the Interagency

Grizzly Bear Study Team (IGBST) and was charged with designing and supervising field investigations during 1985-1993. My field research focused on human-grizzly bear relations; grizzly bear foraging, habitat selection, diet, and energetics; and availability and ecology of grizzly bear foods. I have continued to closely observe grizzly bears and their habitats in the GYE since the end of my intensive field investigations in 1993.

Although my field studies in the GYE ended in 1993, my involvement in grizzly bear-related research, management, and education, both regionally and internationally, has continued through the present. Throughout my career I have been consulted by brown/grizzly bear managers and researchers worldwide, including from Russia, Japan, France, Spain, Greece, Italy, and, most notably, Canada. I have also given numerous public presentations on grizzly bear ecology and conservation, including talks, nationally, at the Smithsonian (Washington, D.C.) and American Museum of Natural History (New York, NY), and, regionally, at the Denver Museum of Natural History (Denver, CO), the Museum of Wildlife Art (Jackson, WY), and the Museum of the Rockies (Bozeman, MT).

My Expert Opinion in Brief

The grizzly bear sport hunt and other lethal management planned by Wyoming, Montana, and Idaho upon divestiture of federal management will likely cause irreparable harm to Greater Yellowstone's grizzly bears. This irreparable harm will occur not only immediately upon implementation of this management regime, but also longer-term by entrained effects that will magnify long-standing and newly emergent threats. These threats include deleterious environmental changes and resulting dietary shifts manifest in burgeoning lethal conflicts with humans; a population that is isolated and too small to insure viability; uncertain and misleading monitoring methods that debar timely remediation by managers; and a punitive management regime that entails purposeful population reduction, inadequate conflict prevention, and vague dilatory aspirations to facilitate population connectivity.

Each point that follows more fully explicates this thesis, with each point building on the ones before to clarify how implementation of foreseeable changes under auspices of state management will be the figurative straw that broke the camel's back, in this case embodied by elements of a natural and manmade system that have synergistically brought Greater Yellowstone's grizzly bear population to crisis.

Yellowstone's Grizzly Bear Are Unlike Any Others

The grizzly bears killed during purposeful population reductions and related lethal management will be of disproportionate importance to conservation and recovery, not only within the contiguous United States, but also continentally and globally. The reason is simple. Greater Yellowstone grizzly bears are ecologically, evolutionarily, and historically unique among bears worldwide.

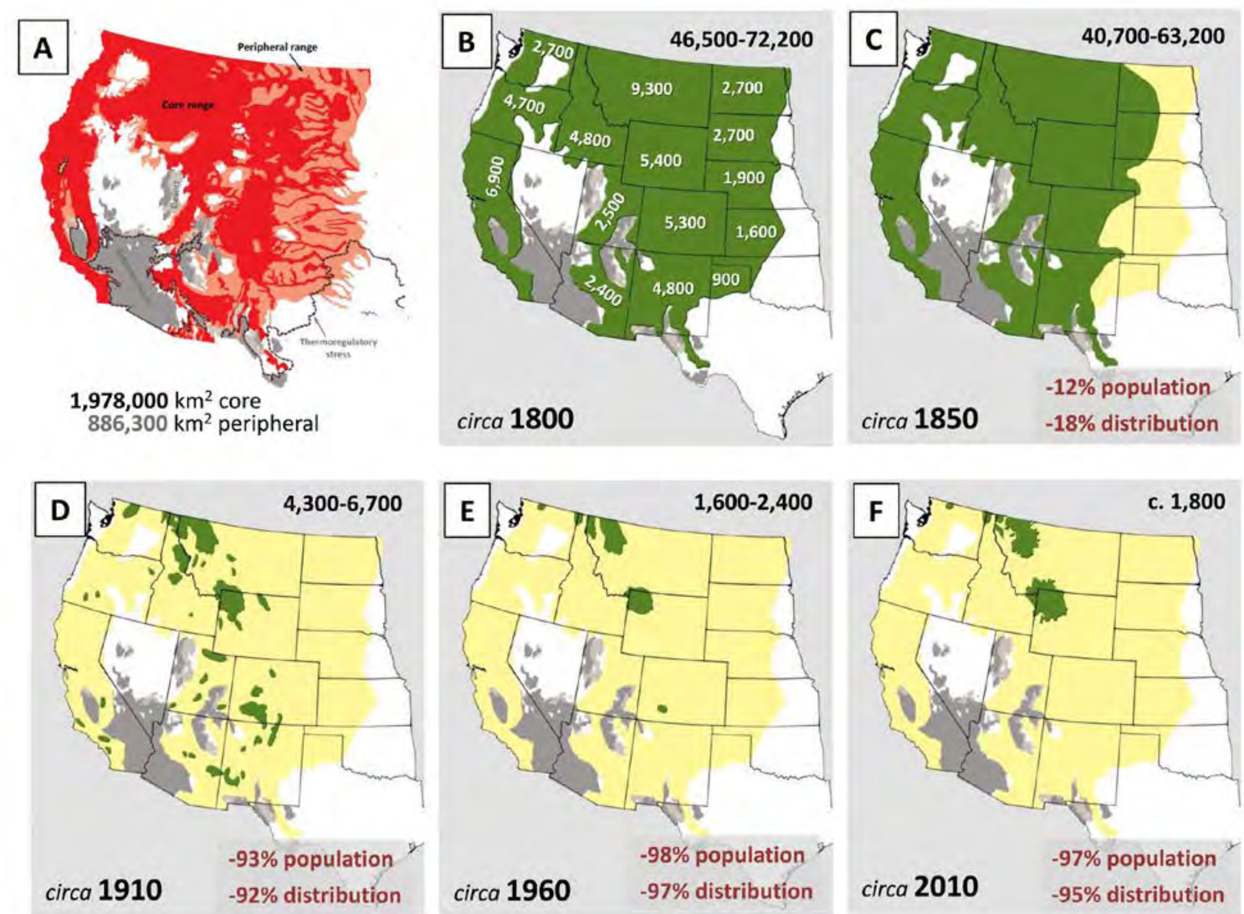

Figure 1. Losses of grizzly bear numbers and distributions in the western contiguous United States between 1800 and 1960 (Panels B, C, D, and E) along with the extent of gains since roughly 1970 (Panel F), largely under ESA protection. The extent of grizzly bear distributions at each time step are shown in green and the extent of losses in yellow. Estimated total populations are shown in the upper right corner of each figure and estimated cumulative losses of populations and distributions in red in the lower right-hand corner. Panel (A) shows estimated core and peripheral historical range relative to the extent of extreme desert and hot climates that would have imposed thermoregulatory limits on the distributions of grizzly bears.

Grizzly bears in the Greater Yellowstone region are the southernmost remnant of the 3% relic left after extirpations perpetrated by Europeans between

1800 and 1960 (see Fig. 1), and for that reason alone are important. As context, losses would almost certainly have been much greater without Endangered Species Act (ESA) protections (Mattson and Merrill 2002), although gains since listing have been sufficient to recoup only 1-2% of the totality lost during the 1800s and early 1900s.

Greater Yellowstone's grizzly bear population is also important from an evolutionary standpoint as part of a currently rare genetic lineage (Clade 4[1]) of brown bears that was one of three clades and subclades first emigrating from Eurasia to North America during the Pleistocene. These bears spread from Beringia south to middle latitudes of North America sometime before 30,000 years ago, prior to when continental ice sheets of the Last Glacial Maximum isolated grizzly bears to the south from conspecifics to the north. Since then, most bears of the Clade 4 lineage have been extirpated, and now consist only of a small relic in Hokkaido, Japan, and grizzly bears residing south of central Alberta and southeast British Columbia (Waits et al. 1998, Miller et al. 2006, Davison et al. 2011). These Clade 4 bears once occupied all of the western contiguous United States, south into Mexico, and bore the brunt of European-caused extirpations that resulted in the loss of roughly 95% of all bears belonging to this genetic lineage in North America, if not the world (Mattson, 2017, *What's in a grizzly name*, https://www.grizzlytimes.org/single-post/2016/11/11/Whats-in-a-Grizzly-Name). Conservation and recovery of Greater Yellowstone's grizzly bears are all the more important given that they are part of this rare and much diminished genetic lineage.

Finally, of ecological relevance, Greater Yellowstone's bears continue to exhibit behaviors and diets that were once widespread in mid-latitudes of North America, but now largely vanished due to historical extirpations. The Greater Yellowstone ecosystem is thus a museum, and the grizzly bears within a truly rare relic of much that has been lost behaviorally. Overall, Greater Yellowstone's grizzly bears exhibit foraging behaviors, diets, and habitat relations that are unique in North America, and possibly the world.

More specifically, nowhere else in the world do grizzly bears depend, as they do in Greater Yellowstone, largely on energy and nutrients from army cutworm moths (*Euxoa auxliaris*), whitebark pine seeds (*Pinus albicaulis*), elk (*Cervus elaphus*), bison (*Bison bison*), and, prior to 2000, spawning cutthroat trout (*Oncorhynchus clarki*; Mattson et al. 2004). Although some have claimed that grizzly bears along the Rocky Mountain East Front in Montana have similar diets, bears in this more northern region obtain most of their meat from livestock and deer rather than elk and bison (Aune and Kasworm 1989), very few seeds anymore

[1] Clades and subclades are roughly equivalent to subspecies and the nomenclature currently preferred by taxonomists and phylogenetisists for referencing noteworthy genetic lineages within species.

from whitebark pine (Smith et al. 2008, Retzlaff et al. 2016), and unknown but probably only regionally minor amounts of army cutworm moths (White et al. 1998).

Of lesser energetic importance—but emblematic of behaviors lost to historical extirpations in the western U.S. —grizzly bears in the GYE are also the only, worldwide, to currently eat substantial amounts of mushrooms, biscuitroots (*Lomatium cous*), yampah (*Perideridia gairdneri*), and pocket gopher (*Thomomys talpoides*) root caches, plus non-trivial amounts of wasps, bees, earthworms, and roots of sweet-cicely (*Osmorhiza* sp.) and pondweed (*Potamogeton* sp.) (Mattson 1997, 2000, 2002, 2004; Mattson et al. 2002a, 2002b, 2004, 2005).

Greater Yellowstone grizzly bears are truly unique whether reckoned ecologically, evolutionarily, or historically.

Grizzly Bears Are Vulnerable Because Of Their Life History

Greater Yellowstone grizzly bears are acutely vulnerable to any human-caused mortality simply because their birth rates are so low. In fact, grizzly bears are among the least fecund terrestrial mammals in the world, and certainly in North America. Figure 2 contextualizes this seminal point by locating grizzly bears relative to other terrestrial placental mammals in terms of three signifiers of fecundity: (1) annual reproductive rate; (2) age at which females reach sexual maturity; and (3) age at which a reproductive female replaces herself in the population. Grizzly bears, along with polar bears, have the lowest reproductive rate and longest generation length of any terrestrial mammal in North America. Globally, only elephants and some primates are less fecund. By contrast, black bears in North America produce ten to twenty- times as many cubs per unit area and exist at ten-times the densities of sympatric grizzly bears (Mattson et al. 2005).

As a consequence, grizzly bear populations are unable to accommodate appreciable human-caused mortality without declining, and even small rates of decline, if sustained, can result in catastrophic losses. Of relevance, even though annual rates of decline in grizzly bear populations in the western contiguous U.S. averaged only -3 to -4% between 1850 and 1910, cumulative losses totaled 90% (Mattson and Merrill 2002; Fig 2). This sensitivity of grizzly bear populations to even small, added increments of mortality leaves managers with little margin of error.

Consistent with this thesis, Weaver et al. (1996: 964, 972) succinctly note in their overview of carnivore conservation in the northern U.S. Rocky Mountains: "Grizzly bears…possess much less resiliency [than other carnivores] because of their need for quality forage in spring and fall, their low triennial productivity, and the strong philopatry[2] of female offspring to maternal home ranges."

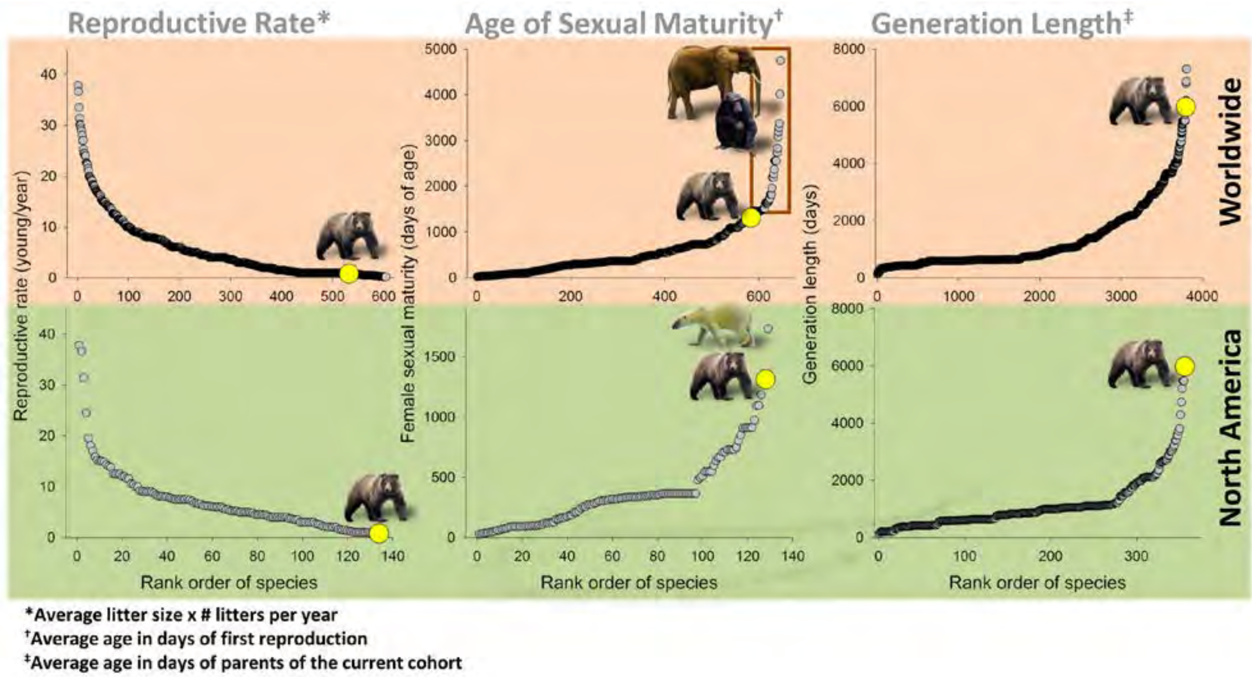

Figure 2. Signifiers of population productivity for grizzly bears (large yellow dots) relative to all other terrestrial mammals, worldwide (top) and in North America (bottom). Sources: Ernest, S. K. (2003). Life history characteristics of placental nonvolant mammals. Ecology, 84(12), 3402-3402. https://doi.org/10.6084/m9.figshare.c.3297992.v1; Pacifici, M., Santini, L., Di Marco, M., Baisero, D., Francucci, L., Marasini, G. G., ... & Rondinini, C. (2013). Generation length for mammals. Nature Conservation, 5, 87-94. http://datadryad.org/resource/doi:10.5061/dryad.gd0m3; Tacutu, R., Craig, T., Budovsky, A., Wuttke, D., Lehmann, G., Taranukha, D., Costa, J., Fraifeld, V. E., de Magalhaes, J. P. (2013). Human Ageing Genomic Resources: Integrated databases and tools for the biology and genetics of ageing. Nucleic Acids Research, 41(D1), D1027-D1033. http://genomics.senescence.info/species/query.php

The need for high-quality spring and fall forage leads to a conclusion seemingly at odds with the fact that grizzly bears are omnivores. Grizzlies do, in fact, require high-quality forage, optimally with high concentrations of fat (Erlenbach et al. 2014), typically provided by only a few foods in environments that are otherwise paradoxically over-run with alternate but low-quality foods. Such is the case with Greater Yellowstone grizzly bears that have depended on just four main foods for most energy and nutrients. In contrast to the many other foods available to Greater Yellowstone bears, the euphemistic "Big Four" provide much higher concentrations of net digested energy (Fig. 3; Mattson et al. 2004). As a consequence, grizzly bears such as those in Greater Yellowstone —as well as elsewhere in the world (Hilderbrand et al. 1999; McLellan 2011, 2015; Nielsen et

[2] Philopatry refers to the extent to which offspring share space and other resources with their mothers subsequent to attaining independence.

al. 2017; Hertel et al. 2018) — can be affected in potentially major ways by losses of a high-quality mainstay food, despite compensatory subsistence for periods of time on low-quality alternate foods.

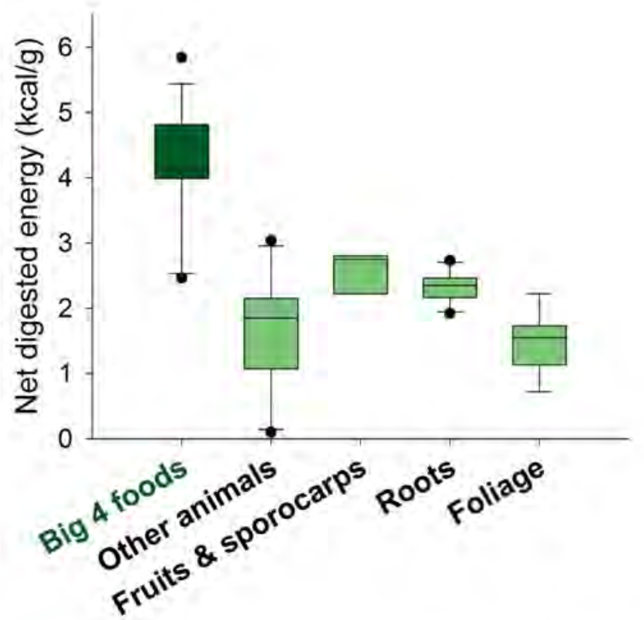

Figure 3. Median net digested energy available from the "Big 4" bears foods (whitebark pine seeds, army cutworm moths, meat from bison and elk, and cutthroat trout) versus all other known, alternate, foods in the GYE.

Yellowstone's Grizzly Bears Are Vulnerable Because Of Isolation

The effects of human-caused mortality are aggravated, not only by low fecundity, but also by the isolation and small size of Greater Yellowstone's grizzly bear population. The Greater Yellowstone population is, in fact, isolated and has probably been so for roughly a century (Miller and Waits 2003; Haroldson et al. 2010). This isolation is intrinsically problematic: first, because the genetic diversity of Greater Yellowstone grizzly bears is lower than that of any other mainland North American grizzly bear population (Miller and Waits 2003); and second, because the current population of roughly 700 bears is far fewer than the thousands currently deemed necessary to ensure long-term viability (e.g., 99% probability of persistence for 40 generations; Lande 1995; Brook et al. 2006; Traill et al. 2007, 2010; Frankham et al. 2014). More to the point, Reed et al. (2003) estimated that, for species such as grizzly bears, minimum viable populations need to be near 9,000 when managed for little or no increase, as is the case for the GYE population.

These viability considerations create a mandate for connectivity (e.g., Craighead and Vyse 1996; Servheen et al. 2001; Carroll et al. 2001, 2003, 2004; Proctor et al. 2005) that poses yet more problems, given the limited ability of grizzly bears to colonize even nominally nearby areas. Averaged across relevant studies (Blanchard and Knight 1991, McLellan and Hovey 2001, Proctor et al. 2004, Støen et al. 2006, Zedrosser et al. 2007, Norman and Spong 2015), female brown/grizzly bears disperse only around seven-miles from their natal ranges, in contrast to twenty-six miles for male bears. Assuming that annual survival rates in current protected areas apply to bears colonizing connective habitat, it would take female grizzlies roughly 80 years, and male grizzly bears roughly 50 years, to colonize areas 100 miles distant (note that the pace of colonization is slower than might be expected for males, given that their advance is pegged to the advance of reproductive females, barring the next to last generational step). Meaningful recovery and long-term viability is thus rendered nearly impossible if grizzly bears are subject to higher levels of mortality on the population periphery, as would likely be introduced by sport hunting and purposeful population reductions.

Yellowstone's Grizzly Bears Are Threatened by Environmental Change

All of these foundational considerations of relevance to human-caused mortality are being manifest in an environment typified by major losses of important grizzly bear foods. Since the mid-1990s climate warming and non-native invasive species have caused substantial deleterious and long lasting changes in the demography and diets of Greater Yellowstone grizzly bears. As I describe above, grizzly bears in the Greater Yellowstone Ecosystem once obtained most of their energy and nutrients from just four foods, or food-groups: (1) army cutworm moths; (2) elk and bison; (3) cutthroat trout; and (4) whitebark pine seeds. But predation by non-native lake trout, coupled with unfavorable climate-driven changes in the hydrology of spawning streams, had functionally extirpated cutthroat trout as a grizzly bear food by around 15 years ago (Kaeding 2010, Gunther et al. 2011; Fig. 4e). Soon after, between 2000 and 2010, 40 to 70% of all mature whitebark pine in the Greater Yellowstone Ecosystem were killed by an outbreak of mountain pine beetles (*Dendroctonus ponderosae*) driven by climate warming (Macfarlane et al. 2010, Van Manen et al. 2016). On top of these losses, almost all Greater Yellowstone Ecosystem elk populations declined between 1995 and 2010 (Fig. 4a) as a result of predation, deteriorating summer forage conditions, and sport hunting (Vucetich et al. 2005, Evans et al. 2006, Griffin et al. 2011, Brodie et al. 2013, Proffitt et al. 2014). As I elaborate below, the losses of cutthroat trout and whitebark pine likely catalyzed dietary changes that resulted in increasing grizzly bear mortality and stalling population growth.

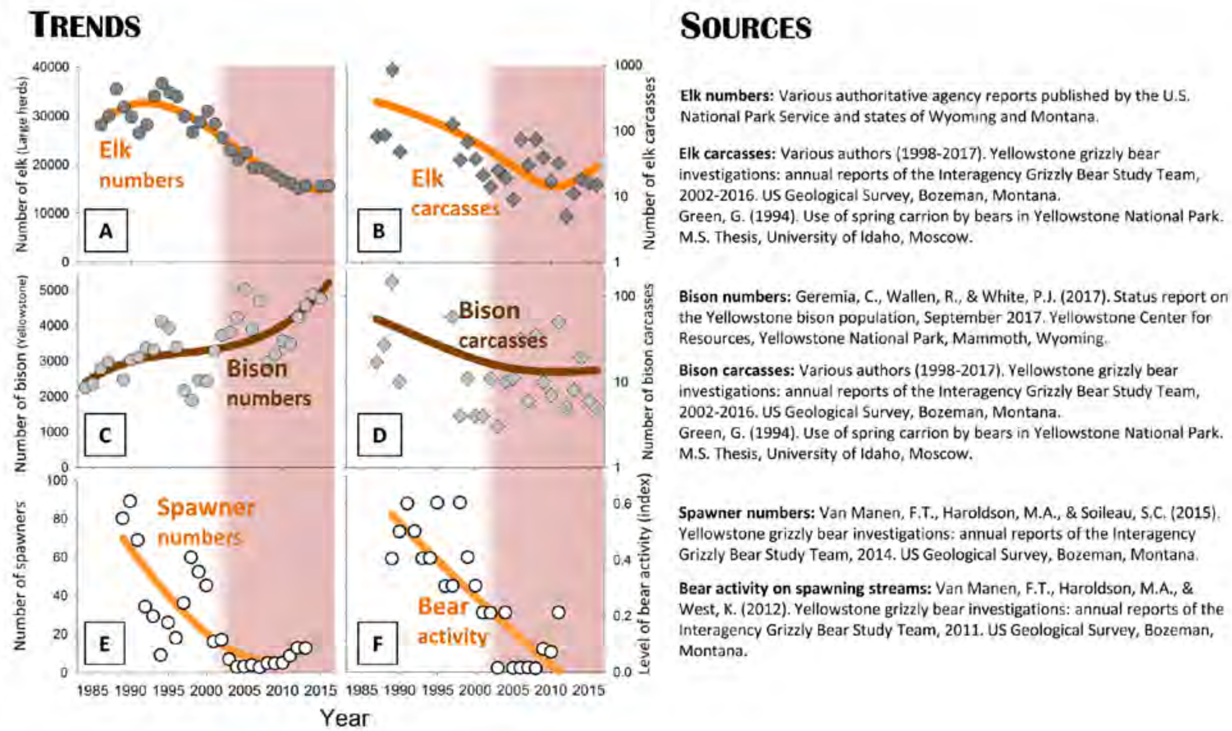

Figure 4. Summary of trends in availability of three important Greater Yellowstone Ecosystem grizzly bear foods, including: (A) size of the Northern Yellowstone and Jackson elk herds; (B) numbers of elk carcasses counted along fixed transects in Yellowstone National Park; (C) size of the Northern and Central bison herds; (D) numbers of bison carcasses counted along transects in Yellowstone Park; (E) numbers of spawning cutthroat trout counted in front-country streams around Yellowstone Lake; and (F) levels of indexed bear activity (scats and tracks) along these same streams. Sources for time series data are given to the right of each pair of graphs.

I have summarized key transitions in environments, diets, and demography of Yellowstone grizzly bears in Figures 4 and 5. Consumption of meat from large herbivores began to steadily climb around 2002 (Fig. 5d), soon after major declines in numbers of spawning cutthroat trout (Figs. 4e, 4f), and coincident with the onset of major losses of whitebark pine trees to bark beetles (Macfarlane et al. 2013). Meat consumption continued to increase after the mid-2000s when, of relevance to grizzly bears subsisting on pine seeds, losses of mature whitebark pine trees to beetles were no longer offset by what had been a fortuitous series of large cone crops (Fig 5d).

Several researchers, including Middleton et al. (2013), Schwartz et al. (2013), and Ebinger et al. (2016), hypothesized that increased consumption of meat from large herbivores by Greater Yellowstone grizzlies was in compensation for losses of cutthroat trout and whitebark pine seeds. The weight of available evidence certainly makes this the most plausible of any candidate explanation. If so, this begs the question of where grizzly bears obtained additional meat given that elk populations had declined substantially (Fig. 4a), and that spring availability of ungulate carcasses on ungulate winter ranges either declined or remained static (Figs. 4b, 4d) despite increases in bison populations (Fig. 4c). Given these trends, grizzly bears plausibly obtained more meat from early-summer predation on elk calves, evident in a tripling of grizzly bear-specific calf mortality rates between the mid-1980s and mid-2000s (Middleton et al. 2013). Otherwise, grizzly bears likely obtained more meat during summer from livestock and, during fall, from remains of elk killed by big game hunters.

These latter two sources of meat are implicated in the exponential increases of grizzly bears dying because of conflicts over livestock depredation and encounters with big game hunters (Fig. 5c), coincident with the terminal decline in ecosystem-wide availability of whitebark pine seeds beginning in 2007 (Fig. 5d). These dramatic increases in hunter- and livestock-related grizzly bear deaths — signifying greater reliance by bears on meat — substantially contributed to sustained increases in total grizzly bear mortality in the Greater Yellowstone Ecosystem beginning, again, around 2007 (Fig. 5b). Death rates of cubs and yearlings also increased substantially during this same period (Van Manen et al. 2016), consistent with greater reliance on meat by reproductive females. Not surprisingly, the steady increase in grizzly bear deaths during the last eleven to twelve years correlates with a static number of reproductive females in the ecosystem (Fig. 5a). Van Manen et al. (2016) claim that this drop in population growth rate was caused by increasing grizzly bear densities and related increases in bears killing bears. These authors point to increasing rates of cub and yearling deaths as evidence of their thesis.

However, their thesis fails for several reasons. First, at the same time that numbers of reproductive females remained static, the distribution of the population increased by over 40% (Fig. 5a). Axiomatically, population-wide densities dropped rather than increased, given that essentially the same number of bears was spread over a much larger area. Second, the expansion of a static population over a larger area is consistent with a decline in carrying capacity, which is consistent, in turn, with losses of key foods that occurred during the last fifteen to twenty years. Third, the modeling reported by Van Manen et al. (2016) is at odds with straight forward data showing a 3.6% per annum increase in grizzly bear deaths in the Greater Yellowstone Ecosystem at the same time that population size remained more-or-less constant — hence, basic math dictates that death rates (numbers of bears dying divided by numbers of live bears) likely increased (Fig. 5b). Finally, increased rates of cub and yearling deaths are plausibly attributed to a shift by reproductive females towards eating more meat, which, even with constant bear densities, predictably exposes dependent young more often, not only to predatory grizzly bears (Mattson et al. 1992b, Mattson 2000), but also to predatory wolves (Gunther & Smith 2004).

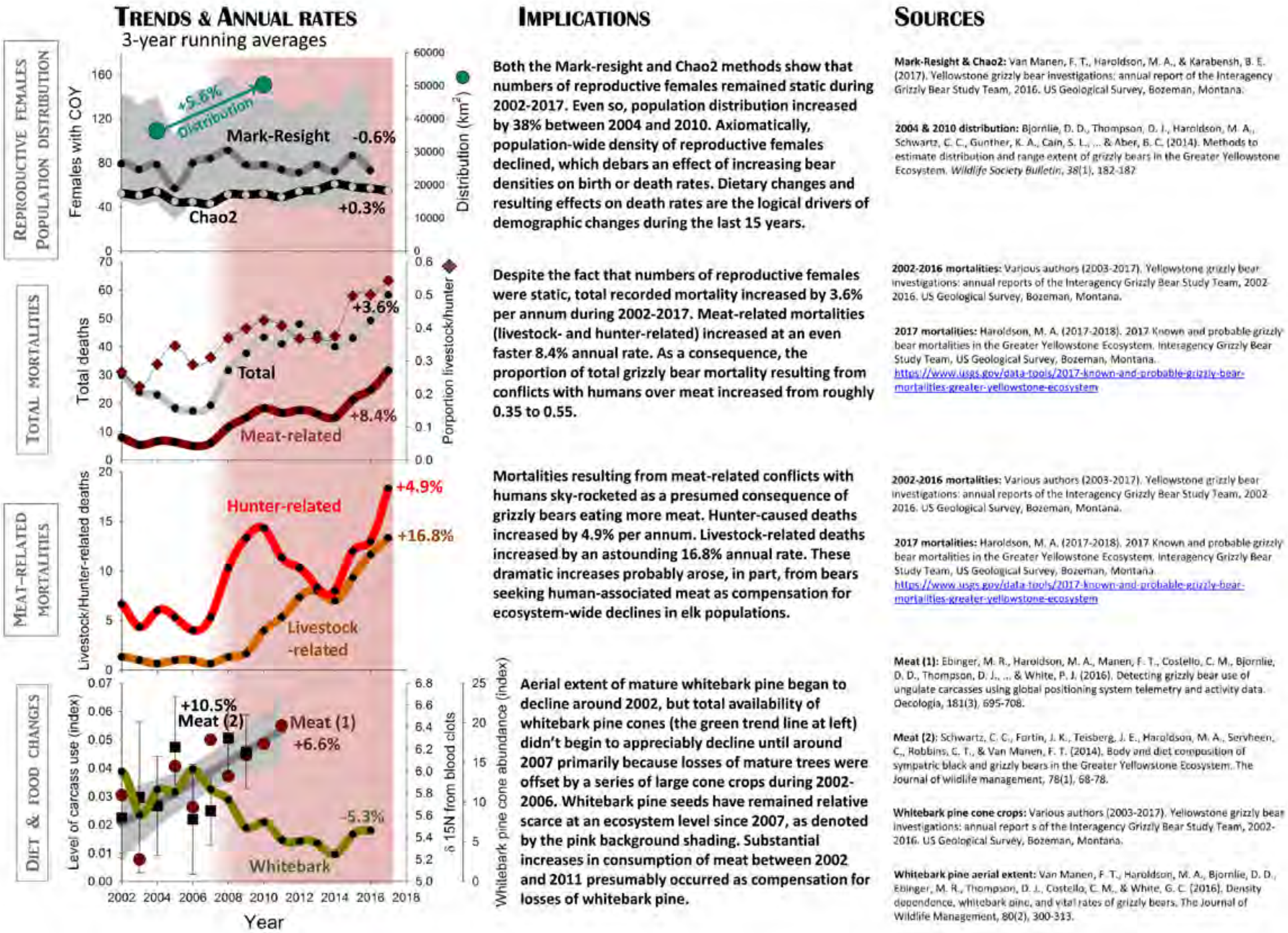

Figure 5. Synopsis of population, mortality, and dietary trends of Greater Yellowstone Ecosystem grizzly bears relevant to dynamics unfolding from 2002 to 2017. Sources for each data time series are provided farthest right, with a brief discussion of implications provided in the middle column. The pink-shaded background spanning all time series denotes the onset and subsequent persistence of whitebark pine losses caused by mountain pine beetles.

This collective evidence renders implausible central claims made by the FWS about Greater Yellowstone Ecosystem grizzly bears and their habitat, largely based on complicated, flawed models (see my comments submitted to the FWS dated 5 May (FWS_Pub_CMT_004008) and 7 October, 2016 (FWS_Pub_CMT_001630)). FWS argues that the population has grown, reached a static, invariate carrying capacity, and has thus spread-out commensurate to increases in population size, fully compensating for losses of key foods by eating other largely unspecified foods—without any explicit demographic consequences.

By contrast, the weight of evidence more defensibly suggests that losses of cutthroat trout and whitebark pine precipitated shifts to more hazardous diets comprised increasingly of human-associated meat, resulting in more dead grizzly bears, stalled growth in numbers of reproductive females, and burgeoning conflicts between people and grizzly bears on an ever-expanding population periphery (e.g., Van Manen et al. 2012, 2013). Moreover, theoretical (Doak 1995) and empirical (McLellan 2015) evidence of lagged responses by grizzly bear populations to deteriorating environmental conditions suggests that negative demographic trends will continue, especially given declines in future recruitment caused by the recent increases in mortality rates of young bears (Van Manen et al. 2016).

The picture painted by a clear-eyed comprehensive look at all of the available evidence is of a population in trouble, largely as a consequence of low reproductive rates, isolation and small population size, deleterious habitat changes – including the loss of important food sources – caused directly or indirectly by humans, compounded by lethal human responses to emerging arenas of conflict. The plight of such a population will be unambiguously worsened by the additional burden of deaths caused by sport hunting.

Connectivity is Necessary and Possible

Given the magnitude of historical losses (98 percent), comparatively small subsequent gains (approximately 1-2 percent), and current environmental deterioration, management of Greater Yellowstone Ecosystem grizzly bears would logically seek to accelerate rather than curtail expansion of this population into adjacent as-yet-unoccupied suitable habitat. Yet state management plans promise to do the opposite and, given the problematic context that I describe above, this is likely to result in irreversible negative consequences.

With connectivity and colonization of suitable adjacent habitat, Greater Yellowstone bears would have access to more foods in more areas to compensate for unfolding losses; long-term genetic health would be assured; the population would be more resilient to future environmental changes simply because of larger size; colonization of currently unoccupied potential habitat in the Selway-

Bitterroot Recovery Area of central Idaho would be facilitated; and colonization of other suitable areas farther south, in expanses depopulated during the heyday of human lethality, would be more likely.

Achieving such goals is obviously contingent on whether suitable habitat and connective corridors are located contiguous to or nearby occupied grizzly bear habitat. Figure 6 summarizes the results of research conducted by numerous researchers designed to identify potential corridors and other habitat suitable for long-term occupancy by grizzly bears in the U.S. Rocky Mountains, including areas farther south. There is clearly ample contiguous habitat with potential to sustain resident grizzly bears to the west of the Greater Yellowstone Ecosystem into central Idaho, thence north through the Selway-Bitterroot Recovery Area, and, further north yet, connecting with the Cabinet-Yaak Recovery Area. Substantial potential habitat also extends south in Wyoming into the Wind River, Wyoming, and Salt River Ranges.

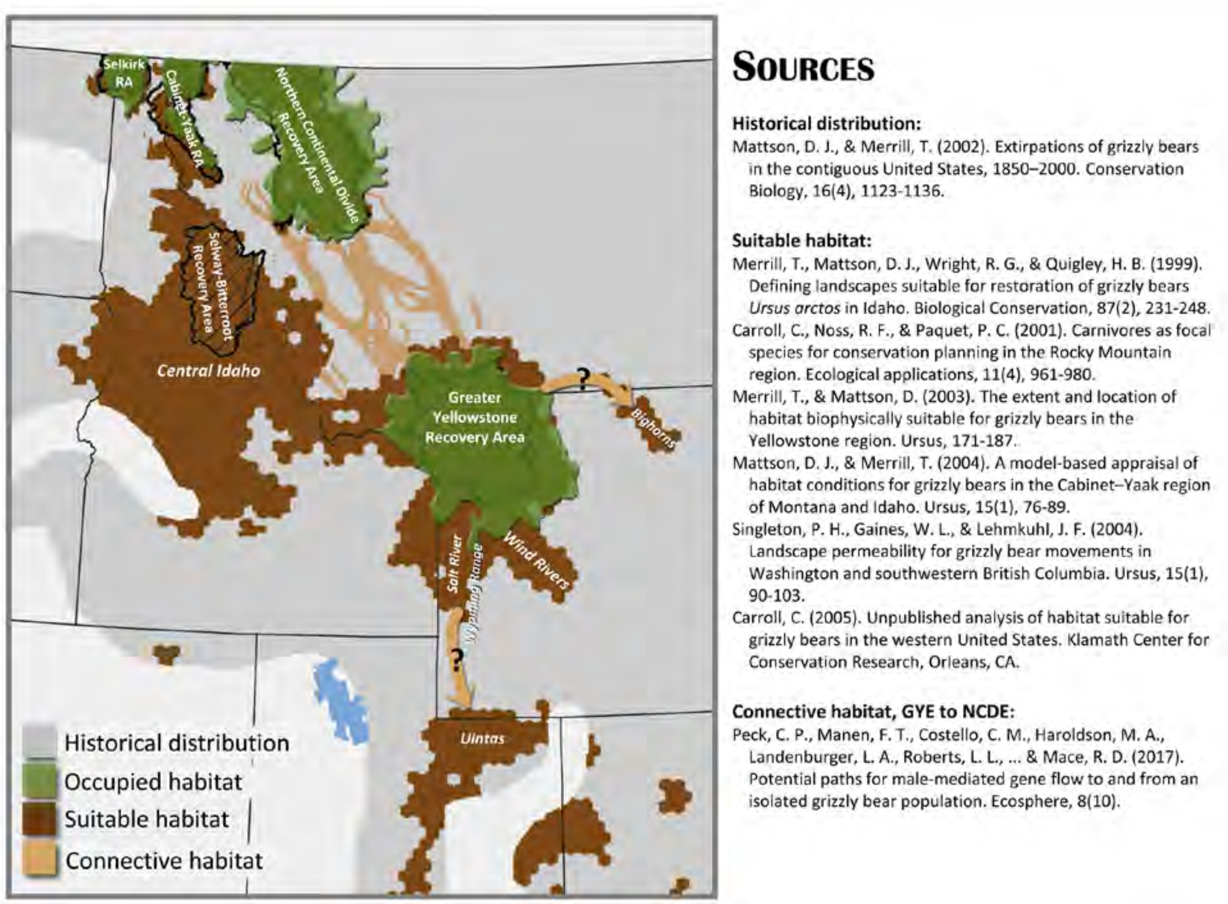

Figure 6. Currently occupied grizzly bear habitat in the northern U.S. Rocky Mountains (green) in relation to suitable, but unoccupied, habitat (dark brown) and potential dispersal routes between the Greater Yellowstone and Northern Continental Divide ecosystems (tan). Probable dispersal routes to the Bighorn Mountains and Uinta Mountains are also identified.

Additional but disjunct potential habitat occurs in the Uinta and Bighorn Mountains to the south and east of habitat contiguous with current grizzly bear distribution in the Greater Yellowstone Ecosystem. As research by Peck et al. (2017) and others have shown, corridors sufficient to host transient grizzly bears—independent of capacity to sustain permanent residents—also exist between the Greater Yellowstone Ecosystem and Northern Continental Divide Ecosystem, suggestive of additional corridors south and east of the Greater Yellowstone Ecosystem able to support colonizing dispersers.

However, all of this research makes a critical assumption: that human lethality is constant, and that the only features varying from one location to another are habitat productivity and remoteness from humans. Lethality can be understood as the probability that, given an encounter with a human, the involved bear will end up dead (Mattson et al. 1996a, 1996b). In other words, lethality can vary independent of habitat productivity and remoteness from humans, with landscapes becoming more or less deadly for grizzly bears depending on how lethality is managed — most notably, whether killing of grizzly bears is licensed or otherwise encouraged by those with authority over grizzly bear management. If management regimes become more lethal, as would be the case with sport hunting, even the most remote and productive wilderness can become inhospitable for grizzly bears, debarring colonization.

State Management Will be Highly Lethal and Not Subject to Remedy

The Memorandum of Agreement (MOA) that governs management of Greater Yellowstone's grizzlies after removal of Endangered Species Act (ESA) protections virtually guarantees that conditions will become more lethal for bears, and that sport hunting, as was planned to start September 1, 2018, will be an ingredient. Even though each state's Commission has expressly reserved the right to deviate from the MOA, this agreement nonetheless will govern — if not dictate — grizzly bear management now and until at least the end of FWS's five-year post-delisting oversight of state management.

Of particular relevance here, the MOA's protocols are expressly designed to prevent growth of the grizzly bear population within the DMA (as estimated by the Chao2 population estimation method; Fig. 5a) above levels observed from 2002 to 2014. If, as during 2017, estimated population size exceeds the 2002-2014 average, prescribed mortality rates will be increased to reduce bear numbers, with prospectively much of the differential between so-called "discretionary" and "non-discretionary" mortality allocated to sport hunting.

The FWS Final Rule describes provisions putatively designed to guard against post-delisting population declines within the Greater Yellowstone DMA, including statements averring that state managers will adaptively decrease mortality rates as population estimates drop below triggering thresholds, and disallowing sport hunting if estimated bear numbers drop below 600. However, neither provision is binding on the states — both are discretionary. The only substantive population-related trigger for authoritative FWS intervention occurs when estimated bear numbers drop below 500 ("The Service will initiate a formal status review and could emergency re-list the GYE grizzly bear population … If the population falls below 500 in any year ....").

However, all these provisions, discretionary or otherwise, are compromised by uncertainties, lags, and deficient assumptions built into the MOA's methods. These methods assume that males can be killed at roughly twice the rate as females (e.g., 15% versus 7.6% annually at a population of 674), even though males and females are born in roughly equal numbers (Schwartz et al. 2006; Van Manen et al. 2016). This alone guarantees decline in numbers and average ages of males, especially in non-Park areas that will exclusively bear the burden of sport hunting. Yet numbers of males are not directly monitored. Adolescent and adult males are numerically added to total population estimates proportional to retrospective estimates of their fractions in the population, based, in turn, on assumption-ridden model-contingent estimates of comparative mortality rates using data collected during the previous five to ten years. In other words, even if estimates of comparative mortality rates are unbiased, male population dynamics will be viewed through a rearview mirror, with relevant estimates lagging well behind unfolding real-time conditions.

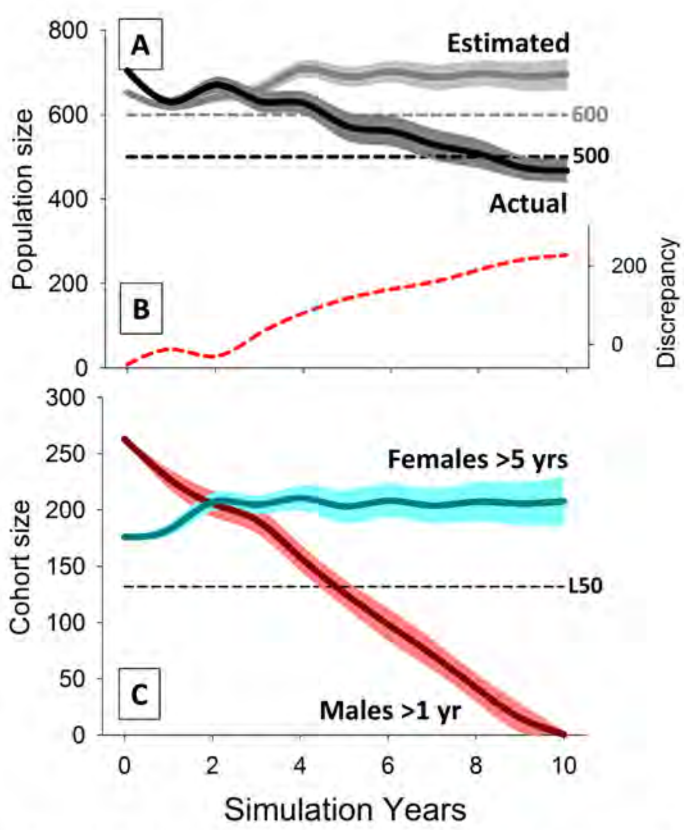

Figure 7. 10-year population projections simulating implementation of MOA protocols for management of grizzly bears inside the Yellowstone DMA. Estimated population size increasingly exceeds real population size over time (A), with over-estimates reaching near 200 bears by 10 years out (B), largely because the male segment >1-year-old crashes outside of National Park jurisdictions. Roughly 50% of adult males are killed within 5 years, corresponding to L50.

Figure 7 visually summarizes projections simulating the implementation of protocols specified by the Tristate MOA. These projections take the protocols at face value and, in the absence of any enforceable specifics, do not credit assertions by wildlife managers that untoward trends will somehow be detected and corrected. Succinctly, if fully implemented, the MOA protocols—including the sport hunting—will likely lead to an undetected crash in the DMA's male population segment outside National Park jurisdictions (Fig. 7c), at the same time that estimated population size increasingly exceeds true population size (Fig. 7a). By ten-years out, the population could be over-estimated by >200 animals (Fig. 7b). As a consequence, managers would not detect a population decline below 600, and then 500 (Fig. 7a), the putative trigger for a formal status review by FWS. Instead, state managers would be erroneously applying mortality rates designed to further depress a population assumed to be near 700, but actually nearer 500.

As an upshot, the near- and long-term effects of male-biased mortality, as planned by the states of Wyoming, Montana, and Idaho, will likely remain undetected and thereby debar timely correctives on the part of GYE grizzly bear managers—at the same time that these managers are purposefully instituting a hunt designed to reduce the bear population.

The Spatial Configuration of Planned Sport Hunting Will be Harmful

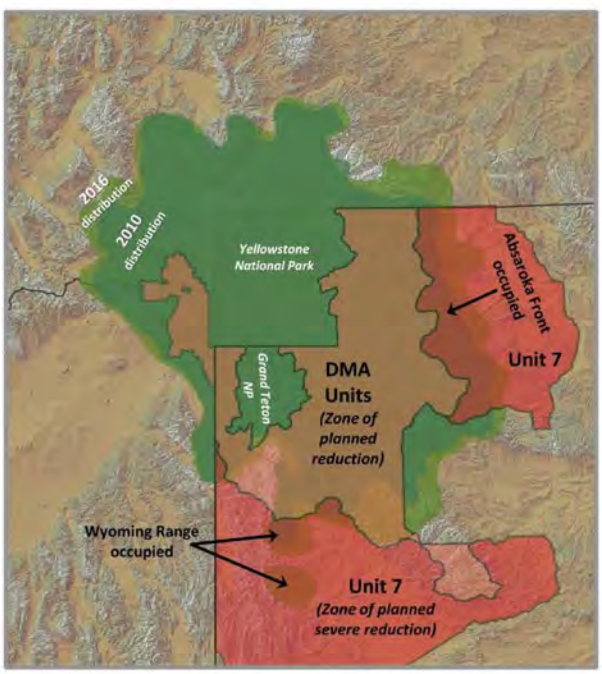

Figure 8. Map showing the estimated 2010 and 2016 distributions of the Greater Yellowstone grizzly bear population overlain by Wyoming and Idaho hunting units within which grizzlies will be sport hunted beginning September 1, 2018. Hunting units within the Demographic Monitoring Area (DMA) are differentiated by Wyoming's Hunting Unit 7 outside. Stated objectives are to reduce the size of the grizzly bear population within the DMA and sharply reduce bear numbers outside, in Unit 7, largely through sport hunting.

The spatial configuration and extent of planned sport hunting in Wyoming and Idaho warrants emphasis, and is particularly relevant to understanding the extent to which hunting-caused mortality will harm the Greater Yellowstone grizzly bear population both near- and long-term.

The map in Figure 8 shows the location and extent of zones within which planned sport hunting of grizzly bears will occur in the GYE relative to the current distribution of the population. Several key patterns and related implications are evident. For one, sport hunting will affect Greater Yellowstone grizzlies in the majority of their current distribution. In other words, hunting will directly and indirectly affect most bears in this population. For another, the portion of the DMA within which the states of Wyoming and Idaho intend to reduce grizzly bears numbers, in part through hunting, likewise entails the majority of current distribution. As problematic, areas outside the DMA where Wyoming plans to sharply reduce bear numbers, notably the Wyoming Range and the eastern front of the Absaroka Mountains, are non-trivial in extent and coincident with habitat that is sufficiently productive and remote from humans to support resident grizzly bears (Fig. 6).

It is clear from this that the spatial configuration of sport hunting planned by Wyoming and Idaho will harm the majority of the Greater Yellowstone grizzly bear population, with harm disproportionately concentrated in areas outside National Parks. Moreover, this harm will be especially severe in peripheral areas supporting the bears most likely to colonize adjacent and nearby suitable habitat.

State Plans Will Essentially Eliminate Grizzly Bears Outside the DMA

State plans for managing grizzly bears outside the DMA compound the deficiencies in protocols for managing grizzly bear mortalities within the DMA boundaries. These plans matter because FWS explicitly states in the Final Rule that: "Mortalities outside the DMA are the responsibility of each State and do not count against total mortality limits," 82 Fed. Reg. 30,502, 30,531 (table 3) (June 30, 2017), which functionally gives state managers *carte blanche*. Of relevance here, the three involved states either intend to limit or even prevent occupancy of areas outside the DMA by grizzly bears — as in the case of Wyoming — or, at best, allow for expansion in highly ambiguous and qualified terms — as in the case of Montana.

To quote the Wyoming Grizzly Bear Management Plan: "Habitats that are biologically and socially suitable for grizzly bear occupancy are the portions of northwestern Wyoming within the DMA that contain large tracts of undisturbed habitat, minimal road densities, and minimal human presence;" and: "Although grizzly bears will not be actively discouraged from occupying all areas outside the DMA, management decisions will focus on minimizing conflicts and may proactively limit occupancy where potential for conflicts or public safety issues are very high." (emphasis added).

As direct evidence of its intent, the State of Wyoming planned to sport hunt as many as twelve grizzly bears in areas outside the DMA during its fall 2018 hunting season. Two of these bears would have prospectively been adult females. Given that there are almost certainly no more than 90-100 bears outside the DMA, the sport hunt alone would have killed 12-13% of all extralimital grizzly bears in Wyoming, and this on top of other mortality that will likely be of equal magnitude (see Point 20.1 in my May 5, 2016, comments on Proposed Rule

(FWS_Pub_CMT_004076). No research has ever shown that an annual mortality rate near 25% can be sustained by any interior North American grizzly bear population. More commonly, as posited by the MOA, sustainable mortality rates are less than half such a rate, nearer 7-10% at maximum.

With reference to key linkages in Montana, the Final Rule merely states: "To increase the likelihood of occasional genetic interchange between the [Greater Yellowstone Ecosystem] grizzly bear population and the [Northern Continental Divide Ecosystem] grizzly bear population, the State of Montana has indicated they will manage discretionary mortality in this area in order to retain the opportunity for natural movements of bears between ecosystems." (emphasis added). The Grizzly Bear Management Plan for Southwestern Montana (Montana Fish, Wildlife & Parks, 2013) states throughout that "non-conflict" grizzlies will be accommodated in potential linkage zones, but then specifies measures for dealing with "conflict" grizzly bears, all of which history has shown lead to a high likelihood of death for the involved bear. As a consequence, and as the Plan itself acknowledges, connectivity between the Greater Yellowstone Ecosystem and other grizzly bear populations will depend on widespread effective efforts to prevent conflict and curb detrimental private land development—sufficient in part to mitigate, if possible, the effects of a hunt—all of which require ample funding.

State Management of Conflicts is Deficient, More So in the Future

Despite laudable language in various planning documents, FWS and the States of Wyoming, Montana, and Idaho are demonstrably ill-equipped to prevent or non-lethally mitigate escalating human-grizzly bear conflicts concentrated on the periphery of the Greater Yellowstone Ecosystem in ways that might mitigate harm from a sport hunt or other lethal management. As I note above, grizzly bear deaths have been increasingly linked since the mid-2000s to human-associated meat — notably livestock and the remains of hunter-killed big game, which together account for near 55% of known and probable grizzly bear fatalities. The fact that meat-associated grizzly bear deaths have been increasing at rates of 5% (hunter-related) and 17% (livestock-related) per annum (Fig. 5a) during a period of stalled population growth is a self-evident verdict on the deficiency of measures taken by managers to non-lethally address these burgeoning causes of human-grizzly bear conflict—a circumstance that will only be aggravated by sport hunting.

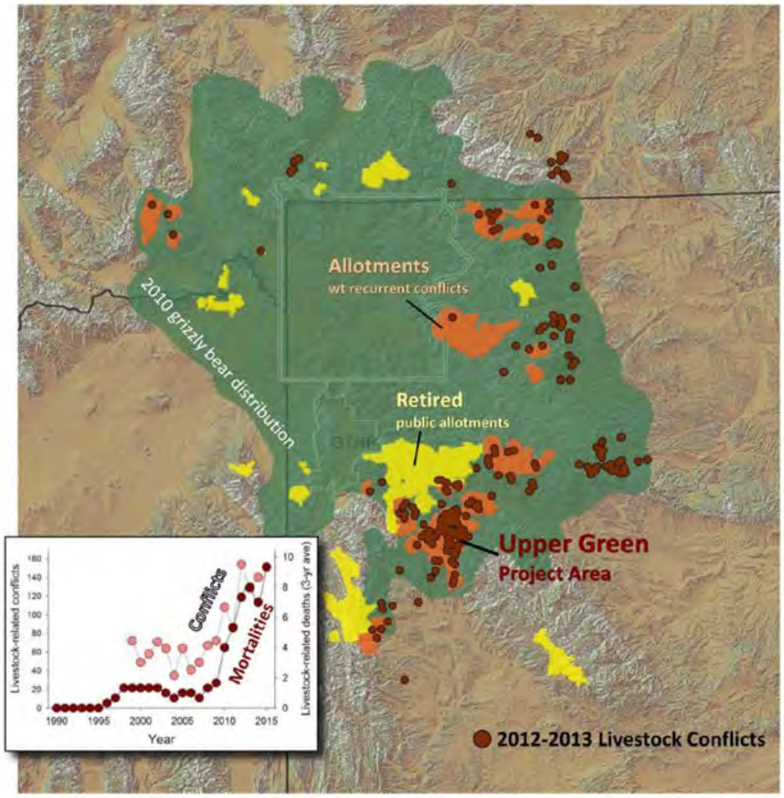

Figure 9. Distribution of grizzly bear depredation on livestock and related conflicts in the GYE during 2012-2013 (dark red dots) along with *circa* 2010 grizzly bear distribution (green), recently retired public land grazing allotments (yellow) and active allotments identified as having chronic conflicts. The inset graph shows trends in grizzly bear-livestock conflicts (pink) and related grizzly bear mortalities (dark red).

The 2016 Conservation Strategy (FWS_LIT_016978) along with state grizzly bear management plans, furthermore explicitly call for maintenance of the status quo, which will likely institutionalize an inadequate conflict prevention regime. A pointed example can be found in the Upper Green River Area Rangeland Project Final Environmental Impact Statement completed by the Bridger-Teton National Forest in October 2017. This project area contains the highest concentrations of grizzly bear depredations on livestock — mostly cattle — in the entire Greater Yellowstone Ecosystem.

Figure 9 shows the Upper Green River grazing allotments along with the ecosystem-wide locations of grizzly bear depredations during two emblematic years (2012 and 2013; mapped locations for more recent years are not publicly available). Despite the fact that these allotments continue to account for much of the livestock-related conflict in the Greater Yellowstone Ecosystem, the Final Environmental Impact Statement essentially enshrines the status quo. There is no provision for substantive changes in husbandry practices, stocking rates, or allotment delineations and infrastructure. Unmitigated conflict and resulting bear deaths will likely continue here and elsewhere, with localized sport hunting adding to the toll.

This prognosis is rendered even more plausible by the fact that state grizzly bear conflict specialists will likely be further under-resourced this year as well as in the near future. Appendix F of the 2016 Conservation Strategy summarizes the prospective annual costs of implementing mandated human/grizzly bear conflict management, estimated to be $650,000 for the U.S. Forest Service; $735,000 for the State of Wyoming; and $246,000 for the State of Montana. On top of this, the

Montana state plan also asserts the importance of "[s]ecuring important linkage habitats through purchase or easement…." Few of the requisite operating funds are currently available, much less funds for purchasing easements or fee simple titles. Out-year budgets for the Forest Service and state wildlife management bureaus suggest a worsening rather than improving fiscal situation.

Funding deficiencies are fully acknowledged in state grizzly bear management plans. For example, the 2013 Montana plan states "a funding mechanism to support Montana's responsibilities for Yellowstone grizzly bear management is necessary." Since then, the agency's wildlife-related budget has been essentially static after accounting for inflation, with no increased allocations to support grizzly bear conflict prevention. Likewise, the 2016 Wyoming Grizzly Bear Management Plan states that "costs associated with data collection and conflict management will vastly exceed any revenue generated by the grizzly bear program." The Wyoming Game and Fish Department's budget has concurrently declined by a net $6 million since 2016 (Wyoming Game & Fish Department 2017). There is little prospect that shortfalls will be covered by grants from the federal government, given that proposed 2018-2019 budgets for the FWS and Forest Service call for major cuts in programs supporting recovery of endangered and threatened species.

Mortality During 2018 is Already Excessive

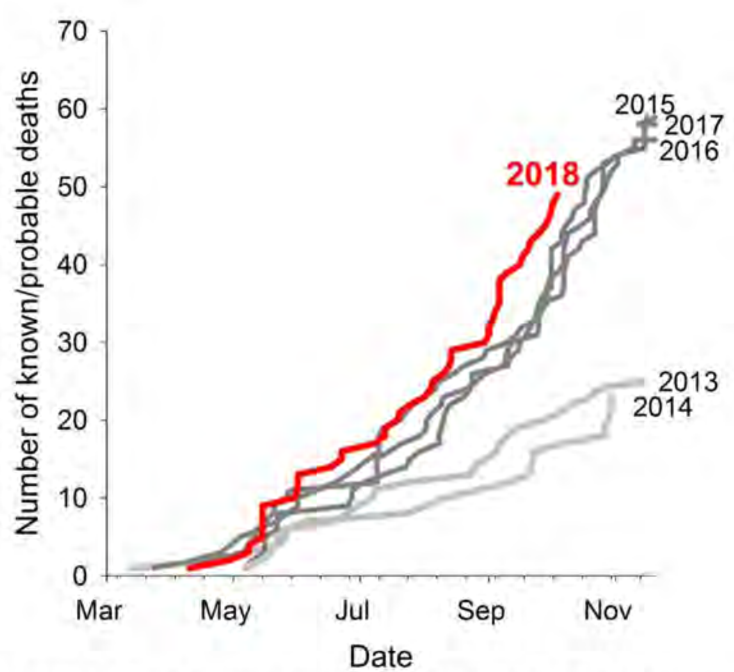

Figure 10. Annual accumulation curves for known and probable grizzly bear deaths in the GYE during 2013-2018. Deaths are attributable to all causes both inside and out of the DMA. The tally for 2018 is current through October 6th.

This picture of a population in trouble becomes even clearer upon examination of grizzly bear mortality trends in the Greater Yellowstone Ecosystem during the last three years, which have only accelerated during 2018. Figure 10 illustrates the pace at which known and probable grizzly bear mortalities accrued each year in the GYE from 2013 to 2017, and so far during 2018. Year-end totals broke records in 2015, 2016, and 2017, representing a dramatic jump from totals for the period between 2013 and 2014. As suggested by population trends in Figure 5a, this increase cannot be explained by either the non-existent increase in population size or modest increase in population distribution since 2014. And, of import here, the pace at which grizzly bears are dying in the Greater Yellowstone Ecosystem during 2018 already exceeds that of 2015-2017, and this represents a period during which state wildlife managers have been *de facto* in charge of conflict management. At a minimum, data from 2018 (see https://www.usgs.gov/data-tools/2018-known-and-probable-grizzly-bear-mortalities-greater-yellowstone-ecosystem) demonstrate that exceedingly high levels of mortality this year are, in part, a continuation of trends in livestock-related deaths that drove high levels of mortality from 2015 to 2017. These trends are a tacit verdict on the inadequacy of conflict prevention measures in the ecosystem and the current lethality of state-administered management of grizzly bears. Moreover, the trend unfolding during 2018 is alarming, with the promise of irrevocable harm, even prior to the sport hunts that were planned in Wyoming and Idaho during September-October 2018.

Hunting Will Add Mortalities, Not Compensate for Conflict Mortalities

Hunting will irrefutably harm Greater Yellowstone grizzly bears by, at a minimum, adding to, magnifying, and compounding dynamics heretofore described that already sorely compromise future prospects of this isolated population. But, even more problematic, this harm is likely to be irreparable, not only for the directly affected bears, but also for surviving bears, through a cascade of subsequent indirect effects.

Most obviously the grizzly bears killed by sport hunters will be irreparably harmed. These bears' lives will be irreversibly ended in ways definitively linked to hunting. They will, moreover, be unambiguously removed from the pool of potential reproductive individuals.

Beyond the obvious, there is the question of whether bears that will be killed by hunters would have likely died for other reasons during the subsequent year. If yes, then these hunting-related mortalities would have "compensated" for other causes of death. If no, then hunting-related mortalities would be in addition to any that would have otherwise occurred. This is the distinction in technical ecological literature between "compensatory" and "additive" mortality. If hunting-related mortality is fully compensatory, then at a population level there are no direct numeric effects incurred during a seasonal cycle. However, if mortality is additive, then population numbers will axiomatically be reduced below levels that would have otherwise been sustained. This is a key consideration because it sets the stage for determining whether, aside from irrefutable harm to individual bears, hunting this fall is likely to cause irreparable harm to the population and its long-term prospects—compounded by any hunting that might occur during subsequent years.

In fact, there is little doubt that most hunting-caused mortality will be additive, not compensatory. Deductively, sport hunters who deliberately seek out bears to kill them will be far more lethal than humans under virtually any other circumstances. Absent hunting, a certain number of independent-aged grizzly bears in the Yellowstone ecosystem would survive even the existing relatively lethal environments. At present, their exposure to such environments occurs largely because of choices *they* make, for example, by seeking out gut piles that bring them into close contact with elk hunters or by seeking out and either killing or scavenging livestock on public lands grazing allotments.

But, even more, these endemic scenarios do not translate into the near-certain death of the involved bears upon encountering the involved humans — which would be the case with a grizzly bear sport hunt. The point here is that sport hunting by its very nature is, deductively, *per capita* much more lethal to grizzly bears. By first principles, many deaths from sport hunting will be additive — that is, would not have otherwise occurred.

The weight of empirical evidence supports this conclusion. Without being exhaustive, research by Bishof et al. (2009) and Frank et al. (2017) has definitively shown additive effects of hunting in *Ursus arctos* populations, and is consistent with the additive effects shown for wolves by Creel & Rottella (2010), for American black bears by Obbard & Howe (2008), and for cougars by Weilgus et al. (2013), Robbinson et al. (2014), and Wolfe et al. (2015). By contrast, no credible investigation of any species of large carnivore has shown that hunting-related mortality wholly, or even largely, merely compensates for other causes of mortality; i.e., there is no credible evidence that hunting-related mortality is *not* additive.

Harm Caused By Hunting Will Be Compounded By Indirect Effects

The toll of sport hunting will not be limited to direct numeric effects on the Greater Yellowstone grizzly bear population. Other indirect effects — manifested in decreased production, survival, and recruitment of cubs — will likely transpire during subsequent months.

Some mammalian populations have been shown to increase reproduction and recruitment in the aftermath of elevated human-caused mortality. These responses have the potential to indirectly compensate for mortality caused by sport hunting. However, in other instances, human-caused mortality depresses reproduction during subsequent months, which amplifies and exacerbates direct numeric effects—a phenomenon termed ‘depensatory’. These sorts of depensatory effects have been most consistently shown for carnivore species in which males kill offspring of reproductive females to enhance their own reproductive opportunities — a phenomenon known as sexually-selected infanticide, or SSI (Ebensperger, 1998, Milner et al. 2007).

A priori, SSI is likely to be common in brown and grizzly bear populations, given the large average difference in size of male and female bears (i.e., sexual dimorphism) and the fact that females, as in the Greater Yellowstone ecosystem, have three-year reproductive cycles (Schwartz et al. 2006). Synthetic analyses by researchers such as Harano & Kutsukake (2018) have shown the SSI correlates with the same intense competition among males that leads to selection for increasingly large comparative size. Moreover, rough parity between numbers of adult males and females slaved to a three-year reproductive cycle, as in Greater Yellowstone (Schwartz et al. 2006), means that there are approximately three reproductive males for every breeding female. Such a skew by itself predictably leads to intense competition among males; a substantial portion of cubs unrelated to the males battling to reproduce; and significant incentive for males to kill cubs as a means of inducing premature estrus in the targeted female (Bunnell & Tait 1981). Even a lesser ratio of reproductive males to breeding females predictably generates such a dynamic.

Amplification of SSI by sport hunting that disproportionately targets adult males would entrain several deleterious consequences. Cub and yearling death rates would likely increase with an influx of non-sire males triggered by the disruption of a social structure otherwise maintained by mature resident males. Longer-term, reproductive females would likely abandon productive habitats to seek refuge in more spartan environs (for example; Mattson et al. (1987, 1992); Ben-David et al. (2004); Gardner et al. (2014)), with resulting depression of fecundity. All of this could exacerbate, longer-term, the direct and additive numeric effects arising from hunter-caused deaths.

In addition to a strong deductive case, there is overwhelming empirical support for the existence of SSI and related dynamics among grizzly bears, and for the amplification of these phenomena by human persecution. Without being exhaustive, there are more than twenty publications reporting evidence from investigations of brown and grizzly bears that: SSI is amplified by sport hunting (Bellemain et al. 2006; Gosselin et al. 2015, 2017; Bischof et al. 2018), including depensatory effects on birth and death rates (Stringham 1980, Swenson et al. 1997, Wielgus et al. 2013, Gosselin et al. 2015, Frank et al. 2017, Bishof et al. 2018); that deleterious social restructuring occurs, including an influx of potentially infanticidal males (Swenson et al. 1997; Wielgus et al. 2001; Ordiz et al. 2011, 2012; Gosselin et al. 2017; Leclerc et al. 2017; Bishof et al. 2018; Frank et al. 2018); and that foraging efficiencies of adult females decrease (Wielgus & Bunnell 2000; Ordiz et al. 2011, 2012; Hertel et al. 2016; Bishof et al. 2018) in tandem with increased physiological stress (Bourbonnais et al. 2013, Støen et al. 2015).

These results specific to *Ursus arctos* are in context of compendious research showing the same spectrum of results for large carnivores more broadly (e.g.; Milner et al. 2007, Packer et al. 2009, Harano & Kutsukake 2018), as well as more specifically for American black bears (Czetwertynski et al. 2007, Stillfried et al. 2015, Treves et al. 2010), mountain lions (Robinson et al. 2008, Peebles et al. 2013, Wielgus et al. 2013, Maletzke et al. 2014, Keehner et al. 2015, Teichman et al. 2016), and wolves (e.g.; Murray et al. 2010, Wielgus et al. 2014).

By contrast, research specific to *Ursus arctos* that calls into question the potential amplification of SSI and other depensatory effects by hunting amounts to essentially two publications (Miller et al. 2003, McLellan 2005). Even so, Miller et al. do not cover conditions of particular relevance to Greater Yellowstone's grizzly bear population, where, unlike what they considered, hunting would perturb social dynamics of a population hard up against a declining carrying capacity; and McLellan premises a regime where "some" adult males might be killed, which does not concur with the regime being proposed by Wyoming and Idaho entailing the hunting of twenty-one males in addition to others of the same sex that will have died from other human causes. Moreover, this paucity of findings casting doubt on the aggravating effects of sport hunting is consistent with a continent-wide deficit pertaining to other large carnivores. Only a handful of authors, notably Czetwertynski et al. (2007) and Murray et al. (2010), call into question depensatory effects of sport hunting on black bears and wolves, respectively, and, even so, with significant qualifications.

Deductive logic and the available evidence leaves little doubt that male-biased sport hunting will entrain longer-term depensatory effects that amplify the more immediate negative effects of elevated mortality among grizzly bears occupying hunting units managed by the States of Wyoming, Montana, and Idaho.

As Currently Planned, State Management Will Cause Irreparable Harm

The post-delisting regime for managing Yellowstone's grizzly bear population is designed to prevent numeric increases within the heart of the ecosystem (i.e., the DMA); discourage, if not prevent, dispersal to and colonization of most of the adjacent or farther distant suitable habitat; and promulgate inadequate conflict prevention programs. Moreover, this insufficient if not punitive management is being implemented using methods that not only engender considerable uncertainty, but also stand a good chance of leading to unintended undetected population declines.

This inauspicious regime is being imposed at a time when long-term conservation goals and on-the-ground conditions create an imperative to encourage

— not discourage — occupancy of all adjacent suitable habitat; connectivity with central Idaho and the Northern Continental Divide Ecosystem; and colonization of novel, yet suitable, habitats to the south and east by grizzly bears in the Greater Yellowstone ecosystem.

Compounding these manifold stressors and problems, the States of Idaho and Wyoming have moved aggressively forward with planning a sport hunt designed to kill the maximum number of bears allotted for this purpose. And these hunting-caused deaths will almost certainly be additive to the toll taken by humans for other reasons, and likely compounded by longer-term indirect, but depensatory, effects on female reproduction and recruitment.

Taken altogether, these problematic environmental dynamics coupled with uncertain monitoring methods and purposefully lethal post-delisting management promise irreparable harm to grizzly bears in the Greater Yellowstone population, and possibly other extant or potential grizzly bear populations in the Northern U.S. Rocky Mountains. As a consequence, prospects for meaningful recovery and restoration will be potentially fatally compromised, which is of all the greater consequence given that grizzly bears in this region represent a globally unique genetic and behavioral lineage, as well as an imperiled remnant of bears that once occupied most of the western contiguous United States.

I am not alone in this conclusion. Seventy-two other scientists raised similar concerns in a 2017 letter to Governor Matt Mead of Wyoming (see Attachment 1).

David J. Mattson, Ph.D.

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Attachment 2. Research Scientist Record for David Mattson, Ph.D., as of 2011, the most recent year of record

Attachment 1. Letter to Matt Mead, Governor of Wyoming, dated April 25, 2018, signed by 73 scientists.