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Attorneys for Plaintiffs

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF COLUMBIA

WESTERN WATERSHEDS PROJECT, ALLIANCE FOR THE WILD ROCKIES, and YELLOWSTONE TO UINTAS CONNECTION Plaintiffs, v. DAVID BERNHARDT, in his official capacity as Secretary, U.S. Department of the Interior, UNITED STATES FISH AND WILDLIFE SERVICE, and UNITED STATES FOREST SERVICE, Defendants.	**Civil Action No. 1:20-cv-860-APM**

DECLARATION OF DR. DAVID J. MATTSON

I, DAVID J. MATTSON, hereby declare:

1. I am a scientist and 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, DC) 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).

2. What follows is my assessment of the analysis of impacts on grizzly bears reported in the Environmental Impact Statement (EIS) and Biological Opinion (BiOP) for grazing operations on US Forest Service allotments in the Upper Green River (UG) area of the Bridger-Teton National Forest. I start with some necessary ecological context, then address relevant temporal and geospatial dynamics in the Greater Yellowstone Ecosystem (GYE), and end with my evaluation of the analyses and related conclusions reported in the EIS and BiOP.

Attachment 1 contains the scientific literature and sources that I cite in this declaration. Attachment 2 contains figures and figure captions that I reference throughout.

ECOLOGICAL CONTEXT

3. Meat from livestock and other large herbivores is a high-quality grizzly bear food (Mattson et al. 2004; Erlenbach et al. 2014).

4. Male bears tend to eat more meat. However, if meat is one of the few high-quality foods available to bears, levels of meat consumption by male and female bears will converge (Jacoby et al. 1999; Mattson 1997, 2000; Hobson et al. 2000; McLellan 2011; Mace & Roberts 2012; Fortin et al. 2013; Schwartz et al.

2013).

5. Some level of depredation by bears will predictably occur if livestock are available and vulnerable (Murie 1948, Johnson & Griffell 1982, Bjorge 1983, Knight & Judd 1983, Jorgensen 1983).

6. Availability of vulnerable livestock or human-associated carrion can attract bears to an area and lead to local increases in bear densities (Bailey 1931, Brown 1996, Storer & Tevis 1996, Mattson & Merrill 2002, Haroldson et al. 2004).

7. Grizzly bears eat more meat from large herbivores when other high-quality foods are not as abundant; bears can also be a significant source of predation on large herbivores (Mattson 1990, 1997; Mowat & Heard 2006; Zager & Beecham 2006; Barber-Meyer et al. 2008; Vulla et al. 2009; Middleton et al. 2013; Schwartz et al. 2013; Ebinger et al. 2016; Niedziałkowska et al. 2018).

8. Dependence of grizzly bears on meat from livestock leads to higher mortality rates, reduced densities and local extirpations under regimes where lethal control is the primary human response (Storer & Tevis 1996, Brown 1996, Mattson & Merrill 2002, Merrill & Mattson 2003, Mowat et al. 2013).

CONCLUSIONS: Ecological Context

9. These basic observations lead to some unambiguous prefatory conclusions, including: (i) consumption of meat from livestock by grizzly bears is normal and to be expected given the high quality of this food resource; (ii) some level of predation on livestock is also normal, expected, and even inevitable any time livestock and grizzly bears share space; (iii) consumption of meat from large herbivores will increase as abundance of other high-quality foods lessens, either

inter-annually, as a trend over time, or as a function of intrinsic ecological conditions; and (iv) livestock can be an attractant, a local driver of increased bear densities, as well as more often a catalyst for lethal relations with humans that lead to sometimes dramatic reductions in bear numbers, followed by local extirpations.

THE GREATER YELLOWSTONE ECOSYSTEM (GYE) AS CONTEXT FOR THE UPPER GREEN (UG)

10. Seeds from whitebark pine cones were once a critically important food for GYE grizzly bears, more so for female bears than for male bears (Mattson et al. 1991a, 2004; Mattson 2000).

11. When whitebark pine was still an abundant part of GYE grizzly bear habitat, conflicts with as well as exposure to humans increased during years when whitebark pine seeds were scarce (Mattson et al. 1992, Haroldson & Gunther 2013), resulting in higher levels of bear mortality during years with poor whitebark pine seed crops (Mattson et al. 1992, Mattson 1998, Pease & Mattson 1999, Schwartz et al. 2006).

12. Roughly 70% of mature cone-producing whitebark pine trees were lost in the GYE between 2000 and 2010 to a climate-driven outbreak of mountain pine beetles (Macfarlane et al. 2013; Van Manen et al. 2016, 2019; Figure 1c).

13. Losses of trees were most pronounced in the central and southern Absaroka Mountains and in the UG area (Macfarlane et al. 2013; Figure 1b).

14. Losses of whitebark pine *seeds* accelerated after 2007. Ecosystem-wide, after accounting for both tree losses and production of cones per tree, seed availability has remained at low levels since then (Van Manen et al. 2016; data from: Schwartz & Haroldson 1999-2004; Schwartz et al. 2005-2011; Van Manen

et al. 2012-2019; Figure 1c-e)

15. Consumption of meat from large herbivores by grizzly bears in the GYE has steadily increased since the early 2000s, likely in compensation for losses of whitebark pine and cutthroat trout (Orozco & Miles 2012; Middleton et al. 2013; Schwartz et al. 2013; Ebinger et al. 2015; Figure 2a-b), at the same time that numbers of elk declined along with numbers of ungulate carcasses available for spring foraging by bears on winter ranges (Figure 2c-e).

16. Army cutworm moths are another high-quality bear food intensively used by grizzly bears, primarily in the central Absaroka Mountains. Moth sites are notably absent in and near the UG area (Mattson et al. 1991b, French et al. 1994, Robison 2009; Figure 3b,f).

17. Although numbers of moth sites have not increased, levels of bear activity on these sites have increased substantially since 2010, likely in compensation for losses of whitebark pine (data from: Van Manen et al. 2019; Figure 3c,d).

18. Trend of the reproductive segment of the grizzly bear population within the GYE Demographic Monitoring Area (DMA) has been stable to only slightly increasing since the early 2000s (data from: Van Manen et al. 2019; Figures 5,6).

19. Total known and probable deaths of adolescent and adult grizzly bears within the GYE have been increasing at annual rates greater that any possible increase in total size of the bear population (data from: Schwartz & Haroldson 1999-2004; Schwartz et al. 2005-2011; Van Manen et al. 2012-2019, Figure 6).

20. Most of this increase in bear mortality has been driven by deaths

related to conflicts with humans over meat resources, including livestock and carcasses associated with elk hunters (data from: database for 1959-2014 obtained under terms of Federal FOIA; Schwartz & Haroldson 1999-2004; Schwartz et al. 2005-2011; Van Manen et al. 2012-2019; Figure 2g,h & Figure 4c).

21. In common with other grizzly bear populations, growth of the Yellowstone grizzly bear population is more sensitive to annual survival of adult females than to any other single vital rate (e.g., Knight & Eberhardt 1985, Hovey & McLellan 1996, Schwartz et al. 2006). In other words, increase or decline of the population will be strongly affected by the rates at which reproductive-aged females are recruited and survive. In recognition of this basic fact, current protocols governing management of mortality for the Yellowstone grizzly bear population prescribe an allowable rate of mortality for adolescent and adult female bears that is only half that allowed for adolescent and adult males (Wyoming Game & Fish Department 2016).

22. Distribution of the GYE grizzly bear population encompassed the UG area as early as 1998 and, overall, has increased at an annual rate 4- to 26-times greater than increases in population size (data from: Van Manen et al. 2019; Figure 1a,b). Increases in distribution cannot be explained solely by increases in bear numbers.

23. Depredation-related conflicts in the UG area escalated dramatically after 2010 along with lethal removal of depredating grizzly bears (data from: Schwartz & Haroldson 1999-2004; Schwartz et al. 2005-2011; Van Manen et al. 2012-2019; Figures 4d, 5, 7).

24. Female grizzly bears have accounted for a significant portion of

depredation-related removals after but not before 2010 (data from: Schwartz & Haroldson 1999-2004; Schwartz et al. 2005-2011; Van Manen et al. 2012-2019; Figure 7).

25. Concentrations of depredations and depredation-related conflicts are 9- to 24-times greater in the UG grazing allotments (depending on time period) compared to any other single allotment or complex of allotments in the GYE (data from: Schwartz & Haroldson 1999-2004; Schwartz et al. 2005-2011; Van Manen et al. 2012-2019)—in defiance of any straight-forward relationship with local landscape features (Figure 8).

26. Escalation of depredations in the UG after 2010 is not temporally or spatially correlated with increases in size and distribution of the GYE grizzly bear population (data from: Schwartz & Haroldson 1999-2004; Schwartz et al. 2005-2011; Van Manen et al. 2012-2019; Figure 9).

27. At a broad scale, escalation of depredations in the UG is strongly positively correlated, temporally and spatially, with losses of whitebark pine and absence of army cutworm moth sites (Mattson et al. 1991b, Macfarlane et al. 2013, Robison 2009; Figures 4b,d and Figure 9).

28. At a finer scale, level of depredation is correlated with the existence of remnant stands of whitebark pine that presumably continue to attract grizzly bears into areas near the UG (Costello et al. 2014, Wells et al. 2019).

29. Dynamics associated with depredation of livestock in the UG strongly resemble those of an "ecological trap" such as has been described for grizzly and brown bears elsewhere (Knight et al. 1988, Falcucci et al. 2009, Northrup et al. 2012, Lamb et al. 2017).

CONCLUSIONS: The GYE as context for the UG

30. Weight of evidence overwhelming supports concluding that: (i) livestock on grazing allotments in the UG serve as an attractive high-quality food for most grizzly bears in the area; (ii) grizzly bears in this area have turned increasingly to exploiting livestock to compensate for losses of whitebark pine, with this diet switch amplified by scarcity of high-quality alternative foods such as cutworm moths and the nearness of remnant stands of whitebark pine to extant grazing allotments; (iii) livestock in the UG fuel an "ecological trap," attracting bears of both sexes into situations that end up being lethal to the involved bears; and (iv) there is not a surfeit of grizzly bears in the DMA able to sustain the locally elevated rate of mortality associated with lethal response to depredation in the UG.

GEOSPATIAL CONTEXT

31. Five different scientific analyses have shown there to be ample potential suitable habitat for grizzly bears south and southeast of the UG in the Wind River and Wyoming Ranges (Carroll et al. 2003, Merrill & Mattson 2003, Craighead et al. 2005, Merrill 2005, Schwartz et al. 2010; Figure 10).

32. Expansion of the GYE grizzly bear population since 1990 has confirmed the validity of these prior analyses (Van Manen et al. 2019).

33. The UG is located in a critical area separating core and peripheral grizzly bear habitat in the GYE (Merrill & Mattson 2003, Craighead et al. 2005, Merrill 2005, Schwartz et al. 2010; Figure 10).

34. Roads and livestock-related mortalities associated with UG grazing allotments are associated with a zone of elevated mortality rates separating core and peripheral grizzly bear habitat (Merrill & Mattson 2003, Schwartz et al. 2010;

Figure 10a,b).

CONCLUSIONS: Geospatial Context

35. The overwhelming weight of evidence supports concluding that: (i) the UG area is important to continuity between core and peripheral habitat grizzly bear habitat in the GYE; (ii) peripheral habitat in the Wind River Range beyond the UG supports a substantial portion of the bears required to meet demographic objectives within the DMA; and (iii) high levels of road access and livestock-related grizzly bear mortality within the UG have created one of the most pronounced fracture zones within the GYE.

MITIGATION MEASURES

36. There is some evidence suggesting that selective removal of a few depredating grizzly bears (e.g., 1-3 over a period of 1-2 years) can resolve conflicts for short periods of time (e.g., 1-3 years), but contingent on specific favorable circumstances (Anderson et al. 2002, Miller et al. 2016, Morehouse et al. 2016, Swan et al. 2017, Lennox et al. 2018, Proulx 2018).

37. There is little or no evidence that supports the effectiveness or conservation-efficacy of removing numerous bears every year to resolve depredation-related conflicts, especially under circumstances where livestock are a primary high-quality food fueling an "ecological trap" (e.g., Sagør et al. 1997, Graham et al. 2005, Treves & Naughton-Treves 2005, Northrup et al. 2012, Miller et al. 2016, Morehouse et al. 2016, Treves et al. 2016, Eklund et al. 2017, Lamb et al. 2017, Swan et al. 2017, Lennox et al. 2018, Lute et al. 2018, Moreira-Arce et al. 2018, Proulx 2018, Haswell et al. 2019). Rather, as in the UG, most evidence suggests that conflicts continue unabated until bears are locally extirpated.

38. There is both correlative and causational evidence suggesting that non-lethal measures can reduce levels of depredation for sustained periods of time, including: guardian dogs; selective deployment of electric fence and other deterrents; change in species, sex, and age of grazed livestock; closer guarding; relocation of pastures during key periods of livestock vulnerability; and removal of livestock carcasses (e.g., Bjorge 1983; Wilson et al. 2005, 2006; Karlsson & Johansson 2010; Miller et al. 2016; Treves et al. 2016; Eklund et al. 2017; Moreira-Arce et al. 2018; Khorozyan & Waltert 2019a, 2019b; Wells et al. 2019).

39. There is definitive evidence from the GYE showing that retirement of livestock grazing allotments eliminates or precludes depredation-related conflicts with bears (e.g., lack of depredations in retired allotments [Wells 2017, Wells et al. 2019]; also, lack of depredations after retirement on the Blackrock-Spread Creek allotment immediately to the west of the UG where conflicts had been chronic since before the 1930s [Murie 1948, Knight & Judd 1983, Anderson et al. 2002]; and lack of depredations after retirement of sheep grazing allotments with a long history of chronic conflict [Johnson & Griffel 1982, Knight & Judd 1983, Jorgensen 1983, Van Manen et al. 2019]; see Figure 4a).

CONCLUSIONS: Mitigation Measures

40. Weight of evidence supports concluding that: (i) short of causing near-term local extirpation of grizzly bears, continued lethal removal of depredating bears will not appreciably resolve conflicts in the UG; (ii) sustained deployment of non-lethal measures stands a good chance of reducing levels of depredation; and (iii), given the evident drivers, the most effective means for resolving depredation-related conflicts in the UG is retirement of allotments

suffering chronic conflict.

EVALUATION OF THE UPPER GREEN EIS AND BIOP

41. The US Forest Service EIS and related US Fish & Wildlife Service BiOP justify future grazing operations in the UG are based on the following series of explicit or tacit claims: (i) Conflicts/depredations in the UG have increased solely because of an increasing and expanding grizzly bear population; (ii) Prospective non-lethal mitigation measures are unproven, infeasible, or precluded by negative side-effects; (iii) Killing bears is the only feasible way of preventing and resolving conflicts in the UG; (iv) Because the bear population is increasing and expanding and will continue to do so in the future, managers can kill as many bears in the UG during the next 10 years as they have in the past; (v) There is no need to factor future or recent changes in population-wide bear mortality into mortality that is allowed in the UG during the next 10 years; (vi) High levels of mortality in the UG are not problematic at a landscape level because there is little or no potential suitable habitat for grizzlies to the south and southeast; (vii) Depredation-related grizzly bear mortality and conflicts in the UG are not exceptional; and (viii) Female bears are as expendable as male bears.

41. Claims (i), (ii), (iii), (v), (vi), and (vii) contradict or are inconsistent with the best available science, as summarized above. Increased conflicts are not correlated with changes in grizzly bear population size and distribution. Instead, this increase is positively correlated with loss of whitebark pine and a dearth of nearby moth sites that would otherwise accommodate a switch to eating cutworm moths. There is no evidence supporting the efficacy of killing bears to resolve depredation conflicts when conflicts are likely organized around an "ecological

trap." Instead, there is good evidence supporting the efficacy of various non-lethal strategies, foremost of which is retiring allotments with chronic conflict. And, finally, the bear population within the DMA has been nearly static since conflicts, conflict-related bear deaths, and ecosystem-wide bear deaths have escalated during the last 6 years, which does not support the contention that the population has absorbed and can continue to absorb bear deaths in the UG without some degree of harm.

42. Claim (v) is problematic because of a logical disconnect. The Memorandum-of-Agreement (MOA) guiding current management of the GYE grizzly bear population adjusts allowable or target mortality rates based on estimates of total grizzly bear population size (Wyoming Game & Fish Department 2016). If the estimated population declines, progressively lower rates are applied. As a consequence, fewer bears can be killed population-wide each year if the population is to be sustained. Current arrangements require that consultation with the USFWS be reinitiated only if numbers of bears killed within or near the UG surpass a certain threshold, not if mortality thresholds for the entire population have been lowered or surpassed. This oversight could allow bears to be killed in the UG as a percent of total estimated population size at a rate that is higher in the future than in the past if the DMA population has declined, which contradicts the assumption that future mortality in the UG will take no more of a toll on the population than has past mortality. This risk is not addressed in either the EIS or BiOP.

43. Of relevance to claim (v) as well, the situation in the UG is clearly dynamic. This fact is evident in the extent to which conflicts escalated and average

bear mortality increased after 2010 along with the presence of female bears in this toll. Absent any real-time monitoring of conditions driving these increases, a moving average of bear deaths will be tantamount to managing through a rearview mirror and will, moreover, offer no insight into reasons why changes may have occurred. Without such insight, managers will be handicapped when trying to identify options for rectifying a worsening situation.

44. The short-comings of relying primarily on a running-average of past mortality for management of grizzly bears in the UG are exacerbated by the fact that the Upper Green EIS and BiOP fail to consider foreseeable effects of climate change. The relevant body of science is too large to allow for even a cursory summary here. At the very least, we can expect more extensive and frequent wildfires (e.g., Westerling et al. 2011, Liu & Wimberly 2016, Clark et al. 2017, Gergel et al. 2017), distorted hydrologic regimes (e.g., Littell et al. 2011, Luce 2018), loss of wetlands (Ray et al. 2019), changes in amounts and seasonal availability of forage (e.g., Reeves et al. 2014, Hufkens et al. 2016, Thoma et al. 2019), little or no recovery of whitebark pine and cutthroat trout (e.g., Williams et al. 2009; Isaak et al. 2012; Al-Chokhachy et al. 2013, 2017; Chang et al. 2014; Case & Lawler 2016; Buotte et al. 2016, 2017), reductions in amounts of berries (Prevéy et al. 2020), and collapse of alpine environments (e.g., Rehfeldt et al. 2012, Hansen & Phillips 2015) along with alpine-associated army cutworm moth sites (Mattson et al. 1991b, White et al. 1998). The EIS and BiOP offer no assessment of these foreseeable impacts on grizzly bears and, for unexplained or poorly justified reasons, assume that post hoc monitoring of mortality will be sufficient for addressing this momentous issue.

45. Of relevance to the Government's claim (viii), the UG EIS does not acknowledge the toll that mortality has taken on females grizzly bears since 2010 and also fails to make any provision for the preferential protection of females. As I note under point 21 above, growth of the Yellowstone grizzly bear population is far more sensitive to the rates at which reproductive females are recruited and survive than to the same rates for male bears. Lack of stringent protections for female grizzly bears in the UG EIS is thus both alarming and a fatal short-coming.

CONCLUSIONS: Failings of the UG EIS and BiOP

46. The Upper Green EIS and BiOP are fatally flawed and offer an approach to managing grizzly bears in this region that exacerbates rather than alleviates threats. For one, key issues are not addressed. For another, the reported analyses use only a selection of relevant scientific information, with this selectivity appearing to serve preordained ends. Perhaps more disturbing, grizzly bears of both sexes are assumed to be expendable. As an apparent consequence, the efficacy of lethal management is grossly over-stated and the potential benefits of non-lethal methods given short-shrift. Most important of all, the alternative of terminating grazing on allotments suffering chronic conflict is not given appropriate consideration. This omission is especially troubling given that this option that has been widely implemented elsewhere in the GYE.

As Richard Knight and Steven Judd observed several decades ago, "We believe that cattle allotments can be permitted in grizzly bear habitat if it is understood that the cattle owners are willing to absorb grizzly bear predation losses" (Knight & Judd 1983). This sort of perspective—voiced by respected wildlife researchers—apparently did not guide either the US Forest Service or US

Fish & Wildlife Service. The EIS is neither precautionary nor prudent, but rather profligate with grizzly bears protected by the Endangered Species Act.

47. For all of the reasons articulated above, it is my expert opinion that: (i) analyses pertaining to impacts on grizzly bears presented in the Upper Green EIS and supporting BiOP are patently inadequate and at odds with the best available science; and (ii) grazing operations and grizzly bear management planned under terms of the Upper Green EIS will needlessly harm not only individual grizzly bears and the GYE Yellowstone grizzly bear population, but also long term conservation of this population.

Pursuant to 28 U.S.C. § 1746, I declare under penalty of perjury that the foregoing is true and correct.

Executed on this 24th day of March, 2020.

David J. Mattson

David J. Mattson, Ph.D.

Attachment 1. Literature Cited in Main Text.

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Attachment 2. Figures Referenced in Main Text.

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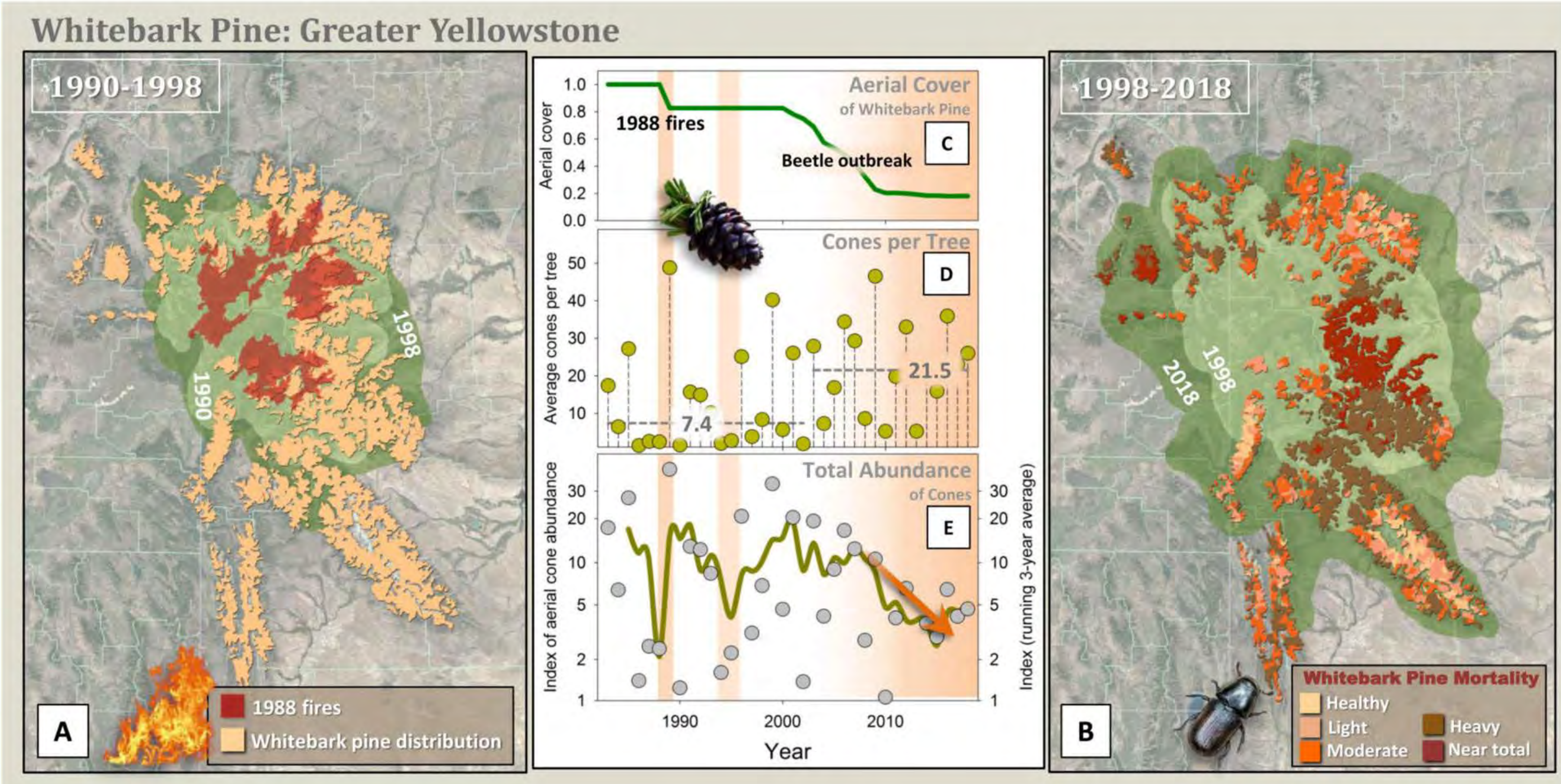

Figure 1. Status and trend of whitebark pine (*Pinus albicaulis*) in the Greater Yellowstone Ecosystem (GYE): (a) extent of healthy whitebark pine forests (in beige) circa 2000 relative to extent of wildfires during 1988 (red) and distribution of the Yellowstone grizzly bear population 1990 and 1998 (Macfarlane et al. 2013, Van Manen et al. 2019); (b) extent and magnitude of mature whitebark pine mortality caused by bark beetles (*Dendroctonus ponderosae*) during 2000-2009 relative to the approximate distribution of grizzly bears around 1998 and 2018 (Macfarlane et al. 2013; Van Manen et al. 2019) ; (c) trend in extent of mature whitebark pine forests 1980-2018 (green line) (Mattson 2000; Macfarlane et al. 2013; Van Manen et al. 2016a, 2019); (d) annual average number of whitebark pine cones counted on individual trees at fixed transects in the GYE (yellow-green dots) (Schwartz & Haroldson 1999-2004; Schwartz et al. 2005-2011; Van Manen et al. 2012-2019); and (e) index of total whitebark pine cone abundance derived from multiplying cones per tree by relative extent of whitebark pine forests. Orange vertical bands in (c)-(e) denote periods during which whitebark pine seeds were scarce. Note that distribution of grizzly bears had encompassed the Upper Green River area by before 1998 and that grizzly bears occupied this area for over a decade before livestock-related conflicts began to rapidly escalate.

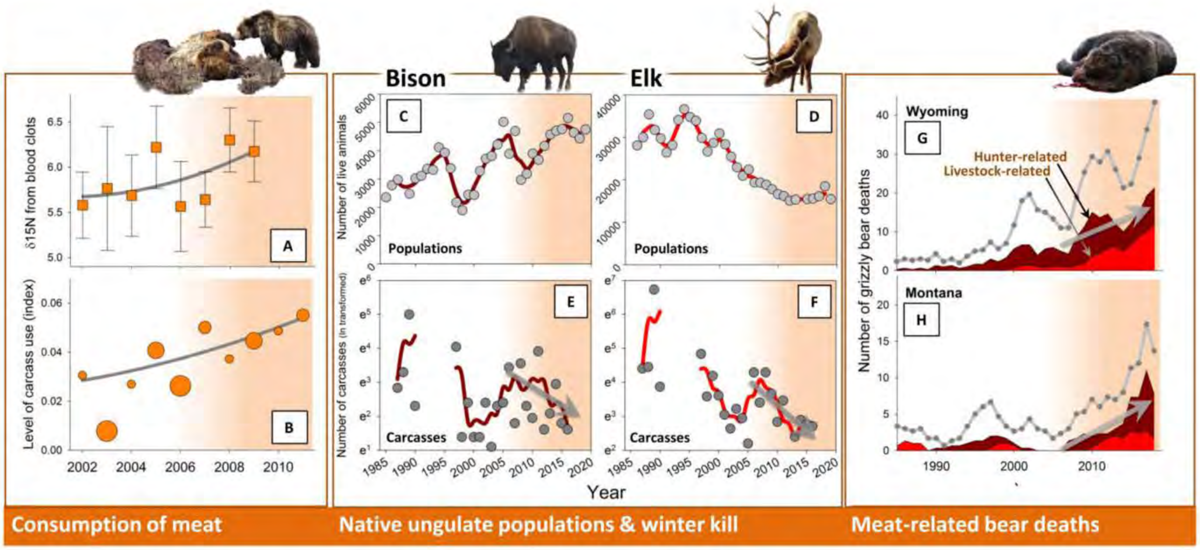

Figure 2. Trends related to consumption of meat by grizzly bears in the Greater Yellowstone Ecosystem (GYE): (a) increase in dietary contribution of meat to metabolized energy of Yellowstone grizzly bears (Schwartz et al. 2013); (b) increase in frequency of exploitation of native ungulates detected at radio-telemetry locations of Yellowstone grizzly bears (Ebinger et al. 2016); (c) trend in total numbers of bison (*Bison bison*) in the GYE (White et al. 2015, Geremia et al. 2019); (d) total number of elk (*Cervus canadensis*) observed in the Northern Range and Jackson elk herds (Lubow & Smith 2004, MacNulty et al. 2016, Northern Yellowstone Cooperative Wildlife Working Group 2016-2019, Wyoming Game & Fish Department 2005-2019); (e-f) total numbers of bison and elk carcasses detected during March-May along fixed transects on ungulate winter ranges (Green 1994; Schwartz & Haroldson 1999-2004; Schwartz et al. 2005-2011; Van Manen et al. 2012-2019; (g-h) total numbers of known and probable grizzly bear deaths in Wyoming and Montana, respectively, along with portions of those deaths attributable to livestock-related conflicts and encounters with big game hunters (hunter-related) (data for 1959-2014 from a database obtained under terms of a FOIA request; Schwartz & Haroldson 1999-2004; Schwartz et al. 2005-2011; Van Manen et al. 2012-2019). The orange vertical band in each figure denotes the period during which abundance of whitebark pine cones was in terminal decline (from Fig. 1). Note the substantial increase in consumption of meat by grizzly bears beginning as early as 2002 coincident with declines of elk and numbers of elk and bison carcasses on ungulate winter ranges, and immediately preceding the rapid increase of grizzly bear deaths in Wyoming and Montana related to conflicts and encounters over anthropogenic meat, all of which was correlated with terminal declines in abundance of whitebark pine.

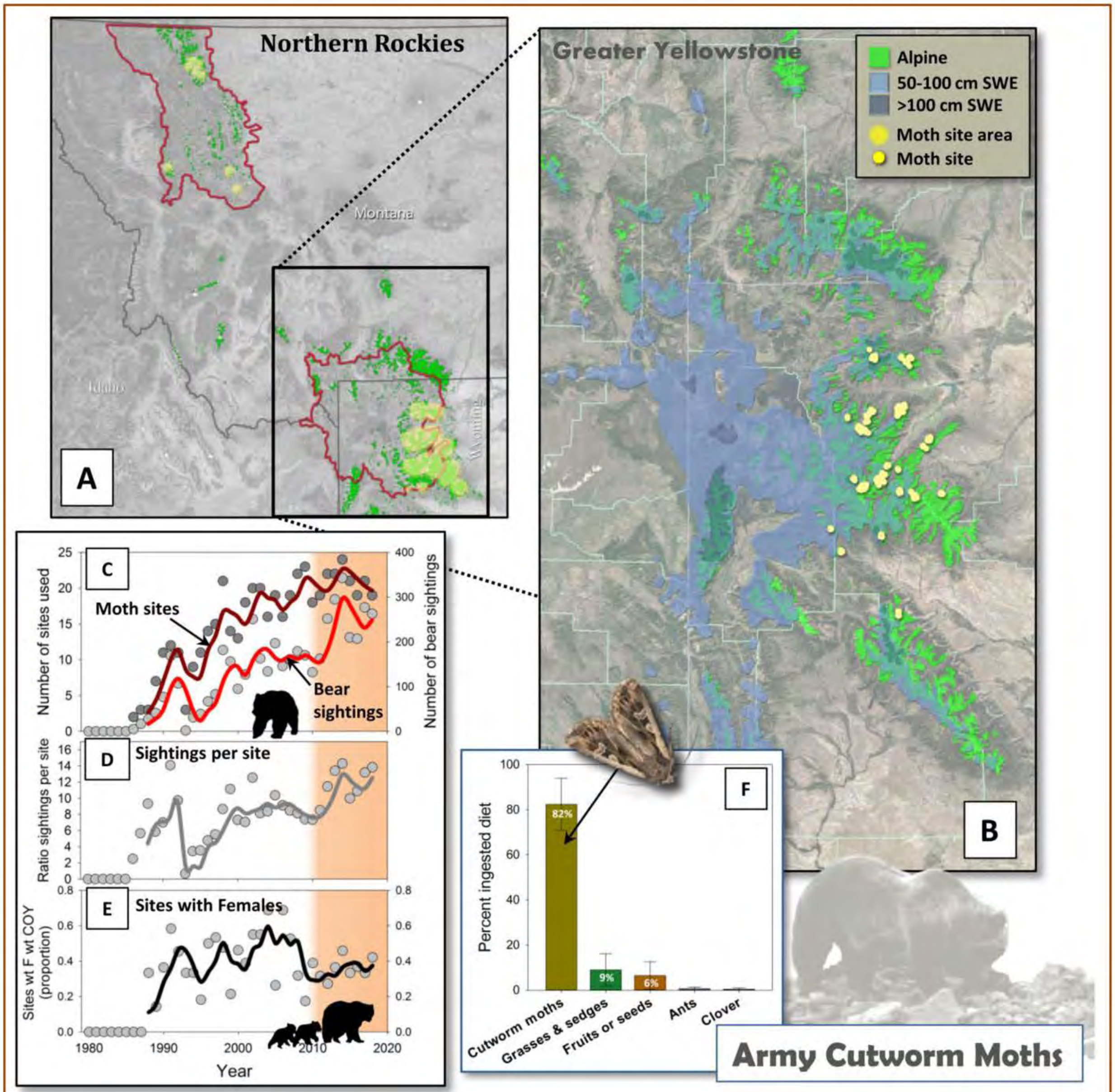

Figure 3. Status and trends related to availability and consumption of army cutworm moths (*Euxoa auxilliaris*) by grizzly bears: (a) location of sites where grizzly bears are known to consume moths in the Northern Continental Divide and Greater Yellowstone (GYE) Ecosystems (yellow-green shading) (Chapman et al. 1955, Craighead et al. 1982, Aune & Kasworm 1989, Robison 2009) relative to the extent of alpine environments (green; GAP/LANDFIRE 2011); (b) location of moth sites (yellow) in the GYE relative to alpine environments (green) and areas of heavy snow pack (blue) (Robison 2009, Chapman et al. 2004, GAP/LANDFIRE 2011, Marcus et al. 2012); (c) trend in numbers of known moth sites and sightings of grizzly bears on moth sites (Van Manen et al. 2019); (d) numbers of sightings per site; (e) proportion of moth sites where a female with cubs-of-the-year (COY) was first observed (Van Manen et al. 2019); and (f) composition of bear diets while on or near GYE moth sites (Mattson et al. 1991b, French et al. 1994). The orange vertical bands in (c)-(e) denote the period of terminal decline in abundance of whitebark pine cones and seeds (from Fig. 1). Note the concentration of moth sites in the central Absaroka Mountains, the comparative absence of moth sites in the Upper Green River area, and the increased concentration of grizzly bears on moth sites beginning with terminal declines in abundance of whitebark pine, as well as corresponding proportional declines in observations of female bears with COY.

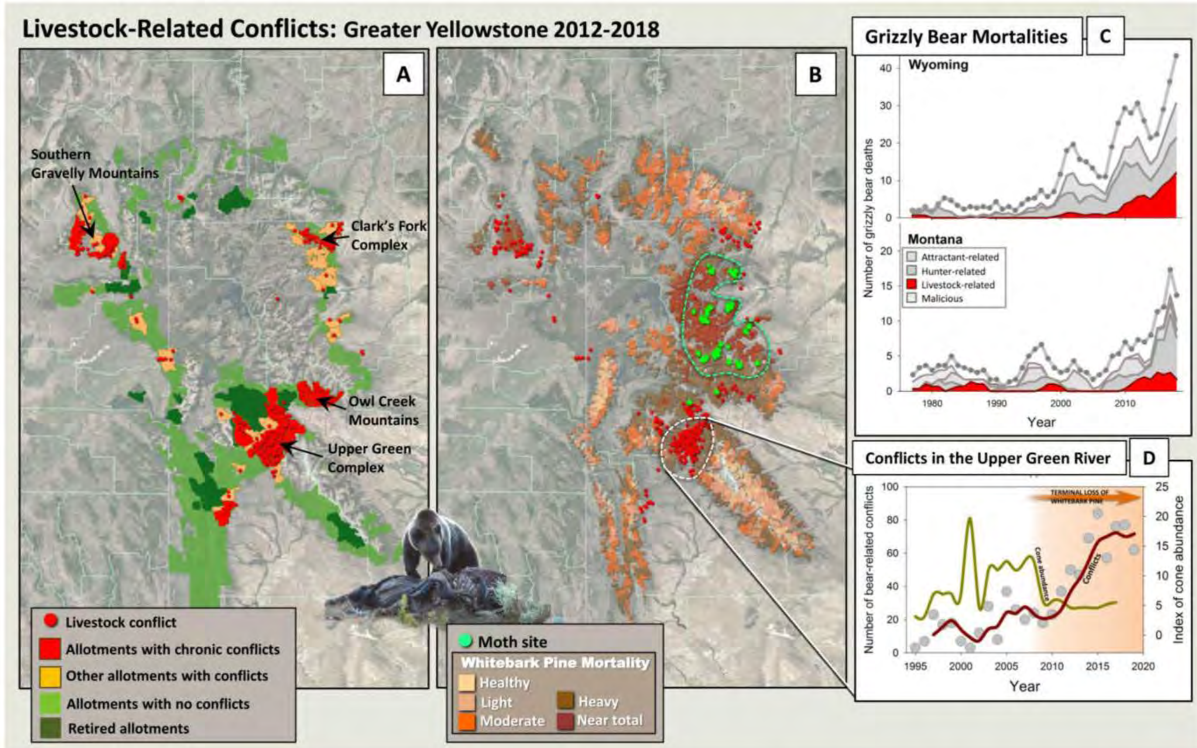

Figure 4. Trends and geospatial patterns related to grizzly bear depredations of livestock in the Greater Yellowstone Ecosystem (GYE): (a) US Forest Service grazing allotments differentiated by whether they have been retired (dark green), experienced chronic depredation-related conflicts (red), conflicts at less than chronic levels (orange), or none at all (light green) relative to specific locations of conflicts during 2012-2018 (red dots) (National Wildlife Federation 2015; Wells 2017; Van Manen et al. 2012-2019); (b) locations of livestock-related conflicts (red dots) relative to losses of whitebark pine to mountain pine beetles 2000-2009 (Macfarlane et al. 2013) and locations of sites where grizzly bears were known to consume army cutworm moths (green dots; Robison 2009); (c) trends in total known and probable grizzly bear deaths in Wyoming and Montana (gray dots and line) along with the portion of deaths attributable to livestock-related conflicts (red shading) (data for 1959-2014 from a database obtained under terms of a FOIA request; Schwartz & Haroldson 1999-2004; Schwartz et al. 2005-2011; Van Manen et al. 2012-2019; (d) trend in numbers of livestock-related conflicts in the Upper Green River area (burgundy line as 3-year moving average; gray dots for annual numbers) relative to abundance of whitebark pine cones in the GYE (yellow-green line) (see Fig. 1; Schwartz & Haroldson 1999-2004; Schwartz et al. 2005-2011; Van Manen et al. 2012-2019). The orange vertical shading in (d) corresponds with the terminal decline in whitebark pine abundance. Note the magnitude of whitebark pine losses in the Upper Green River area, the absence of nearby moths sites, the increase in numbers of conflicts in the Upper Green coincident with declines in whitebark pine, and the absence of conflicts on retired allotments in the GYE that had previously experienced chronic conflict.

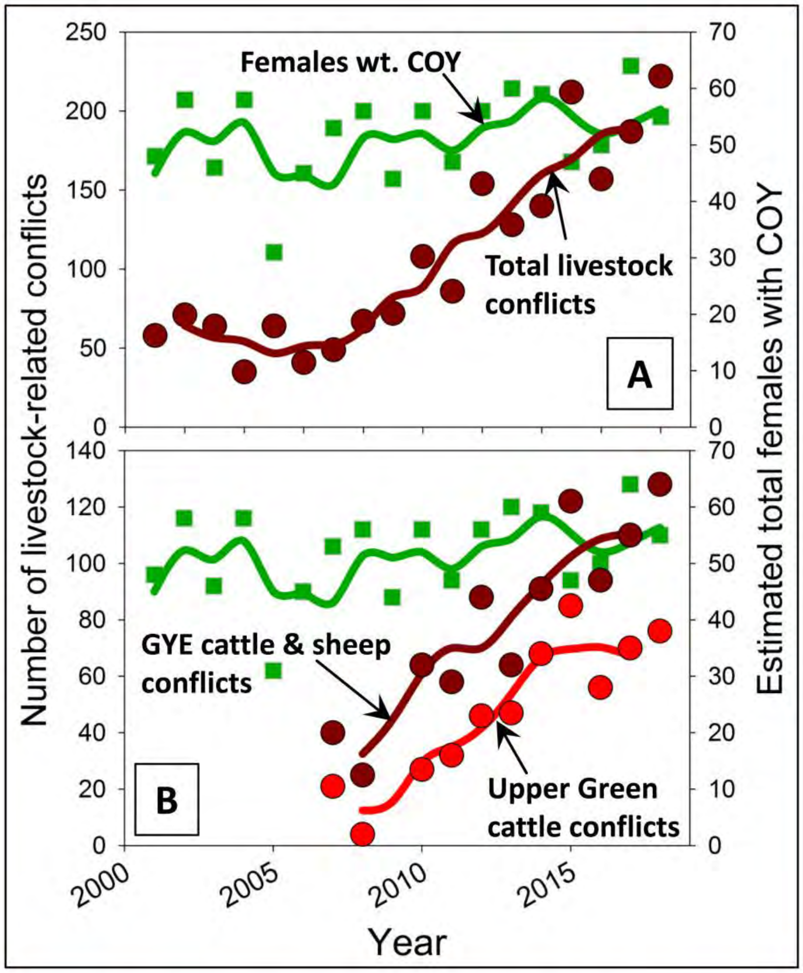

Figure 5. Trends in numbers of reproductive grizzly bear females and livestock-related conflicts in the Greater Yellowstone Ecosystem (GYE): (a) estimated numbers of females with cubs-of-the-year (COY) ecosystem-wide based on the Chao2 method as a 3-year moving average (green line) and as individual annual estimates (green squares) together with total number of livestock-related human-grizzly bear conflicts, including conflicts involving cattle, sheep, horses swine, and other smaller domestic animals (Schwartz & Haroldson 1999-2004; Schwartz et al. 2005-2011; Van Manen et al. 2012-2019); and (b) estimated numbers of females with COY relative to total numbers of cattle- and sheep-related conflicts in the GYE (burgundy line and dots) as well as conflicts only within the Upper Green River area (red line and dots) (Schwartz et al. 2008-2011; Van Manen et al. 2012-2019). Note the rapid escalation of livestock-related conflicts beginning around 2009 and the lack of corresponding increase in grizzly bear population trend.

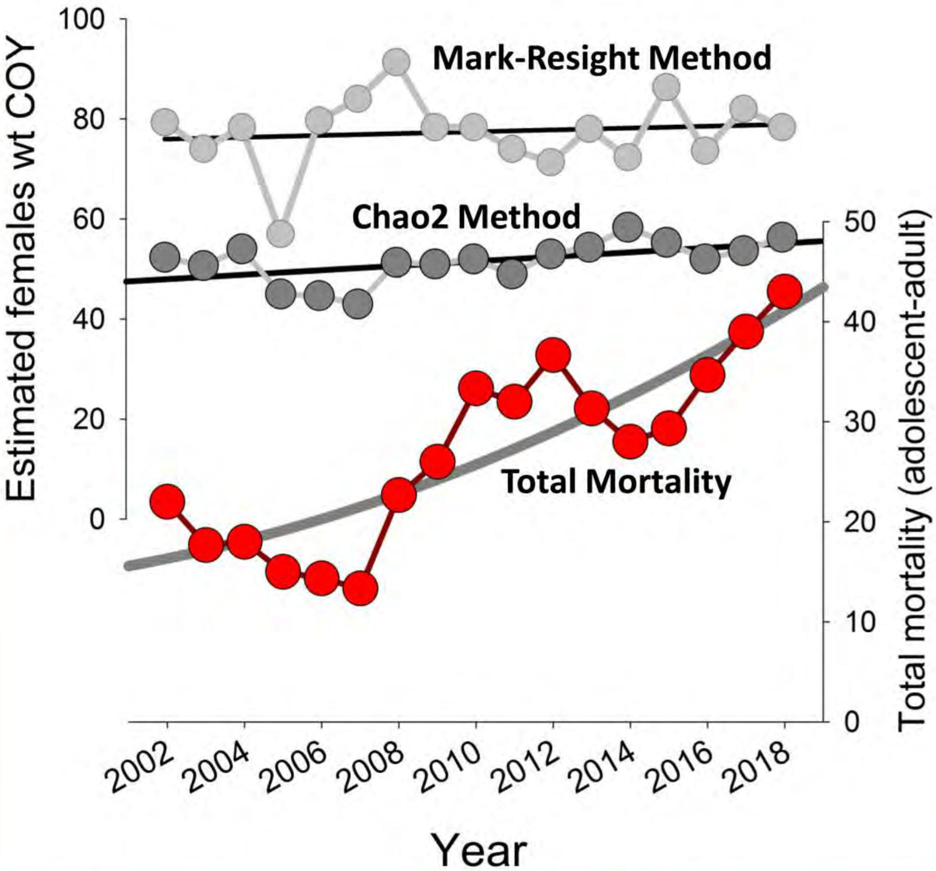

Figure 6. Trends in estimated numbers of reproductive grizzly bear females, ecosystem-wide, by two different methods (Mark-resight and Chao2) relative to trend in total known and probable deaths of adolescent and adult grizzly bear in the Greater Yellowstone Ecosystem expressed as a three-year running average (Schwartz & Haroldson 2003-2004; Schwartz et al. 2005-2011; Van Manen et al. 2012-2019). Estimated numbers of females with cubs-of-the-year, as a three-year running average or three-year sum, are used to monitor trend of the Yellowstone grizzly bear population (Van Manen et al.. 2019). Note the only slight increase in numbers of reproductive females at the same time that numbers of known and probable grizzly bear deaths increased substantially. By deduction, if population size increased only slightly at the same time that deaths escalted, grizzly bear death rates must have increased, especially after 2009, suggesting that mortality was becoming increasingly unsustainable.

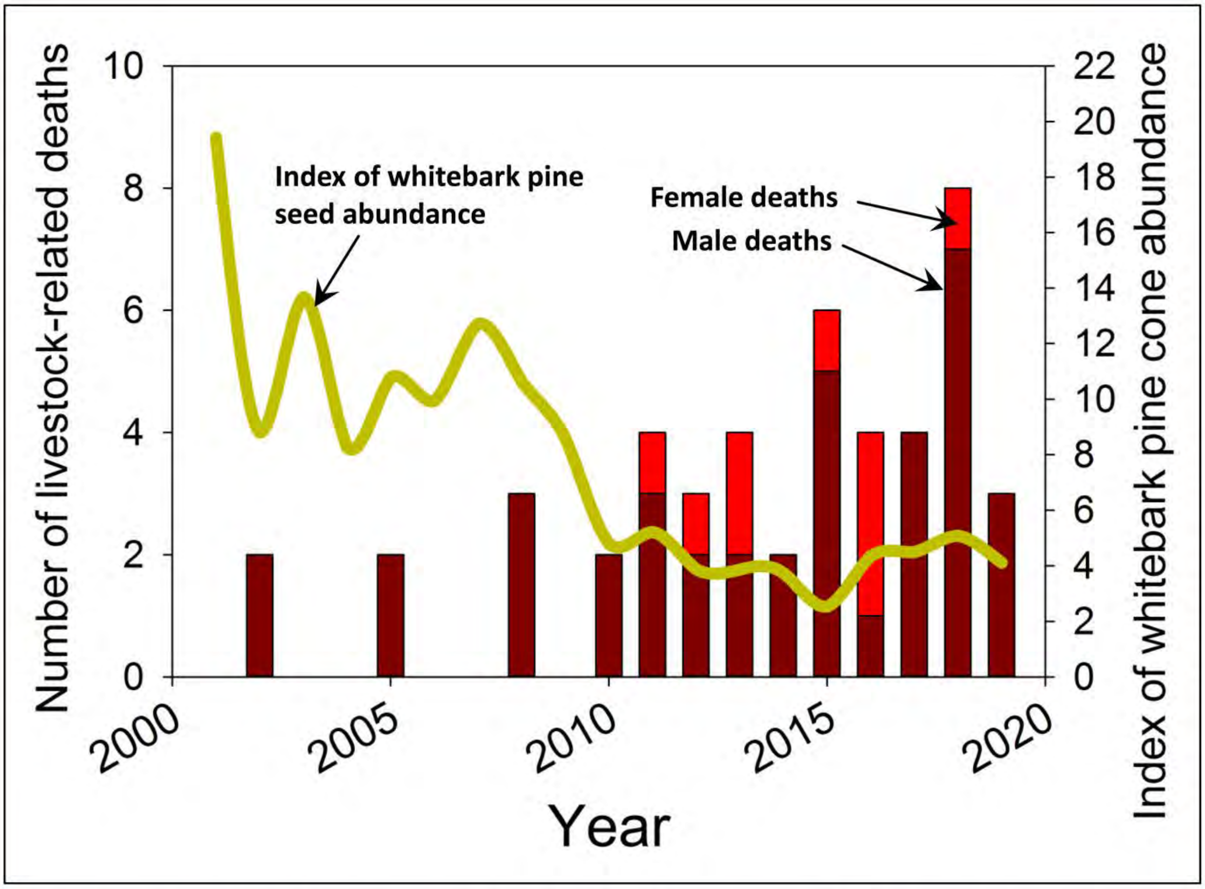

Figure 7. Numbers of grizzly bears known to have been killed annually in the Upper Green River area because of livestock-related conflicts (red and burgundy bars) relative to the index of whitebark pine cone abundance (yellow-green line, from Fig. 1) (Schwartz & Haroldson 1999-2004; Schwartz et al. 2005-2011; Van Manen et al. 2012-2019). Numbers of female and male bears killed each year are shown in red and burgundy, respectively. Note the surge in bear mortality as well as consistent toll year-to-year that began in 2010, coincident with the terminal decline in abundance of whitebark pine. Note also the absence of female bears deaths—in this case almost all of reproductive aged animals—prior to 2010. Grizzly bear were known to be in the Upper Green area as early as 1998, more than 10 years before the surge in deaths (Van Manen et al. 2019).

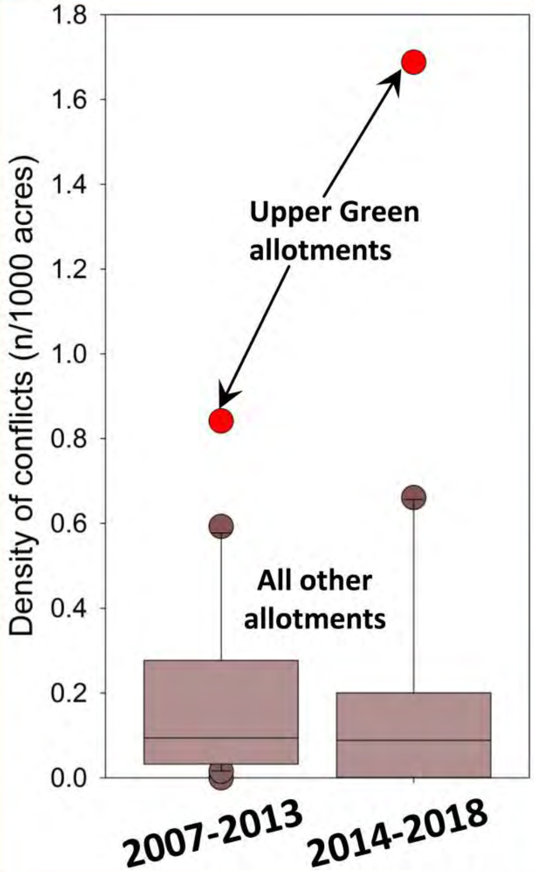

Figure 8. Density of livestock-related human-grizzly bear conflicts on public land grazing allotments for two different time periods in the GYE: 2007-2013 (7 years) and 2014-2018 (5 years), expressed as box-and-whisker plots (Schwartz et al. 2008-2011; Van Manen et al. 2012-2019). Density was calculated only for individual allotments >10,000 acres in size as well as for the complex of adjoining allotments in the Upper Green River area ("Upper Green allotments", denoted by red dots). Note that during both time periods density of conflicts on Upper Green allotments was orders-of-magnitude higher than the median for other large allotments in the GYE, and an order of magnitude greater than the allotment with the next highest density of conflicts during 2014-2018. Note that no other allotment or complex of allotments, other than those in the Upper Green area, was in an area that experienced as much absolute losses of whitebark pine in an area that also lacked an alternative high-quality food in the form of army cutworm moths (see Figs. 1 and 2).

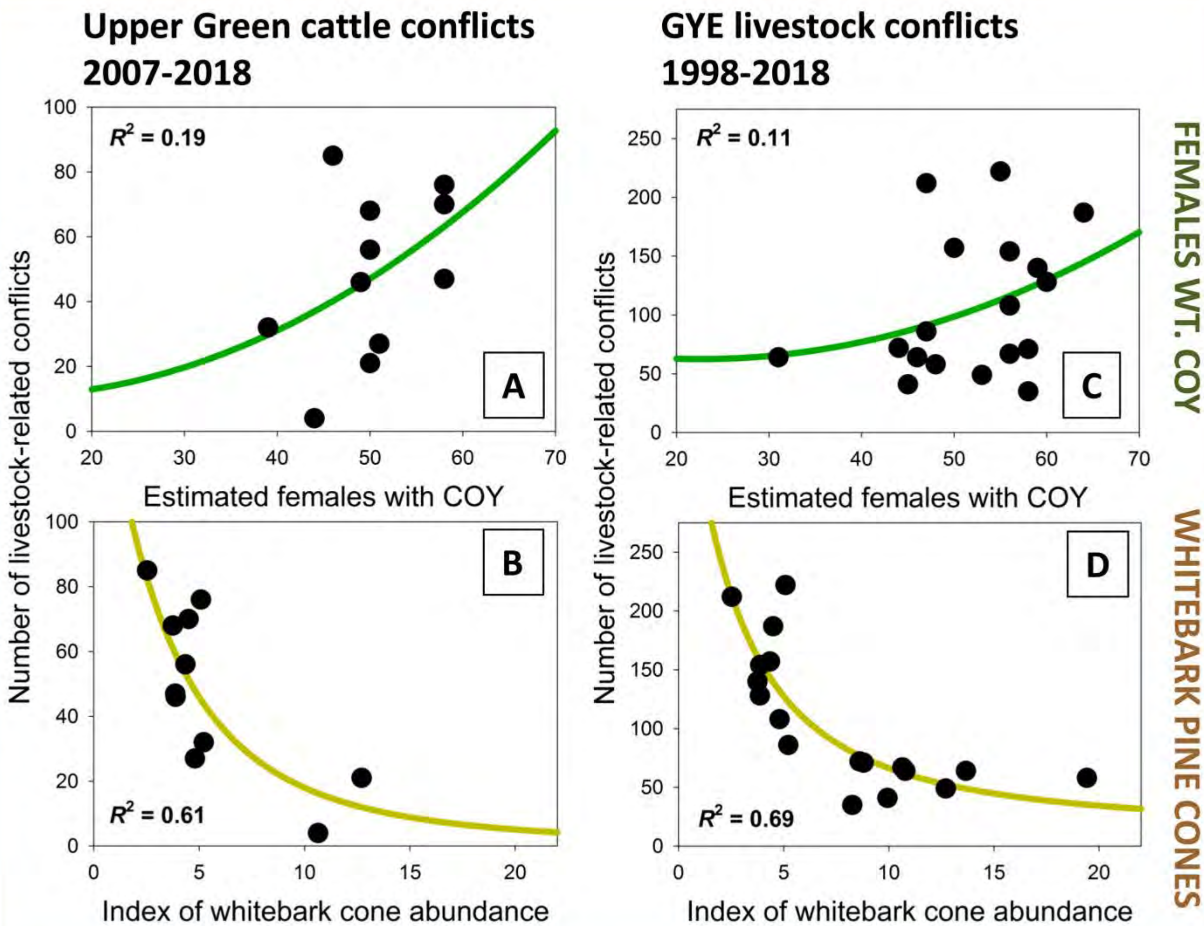

Figure 9. Relations between annual numbers of livestock-related human-grizzly bear conflicts and either estimated numbers of reproductive females (based on Chao2 estimates of females with cubs-of-the-year [COY]) or annual indices of whitebark pine cone availability (see Fig. 1) (Schwartz & Haroldson 1999-2004; Schwartz et al. 2005-2011; Van Manen et al. 2012-2019). Panels (a) and (c) show relations with females with COY, and (b) and (d) relations with whitebark pine cone availability. Panels (a) and (b) are only for cattle conflicts in the Upper Green, 2007-2018, whereas panels (c) and (d) are for all livestock-related conflicts in the GYE—including cattle, sheep, swine, and smaller domestic animals—for a longer period, 1998-2018. Note the lack of relationship between females with COY and conflicts, in contrast to the strong relationship between whitebark pine cone availability and conflicts. These latter relationships explain 60-70% of inter-annual variability in conflicts. Note also the logical curvilinear relationship of conflicts to cone availability, which is consistent with a rapid and potentially self-reinforcing escalation of conflicts after cone availability dropped below a certain threshold.

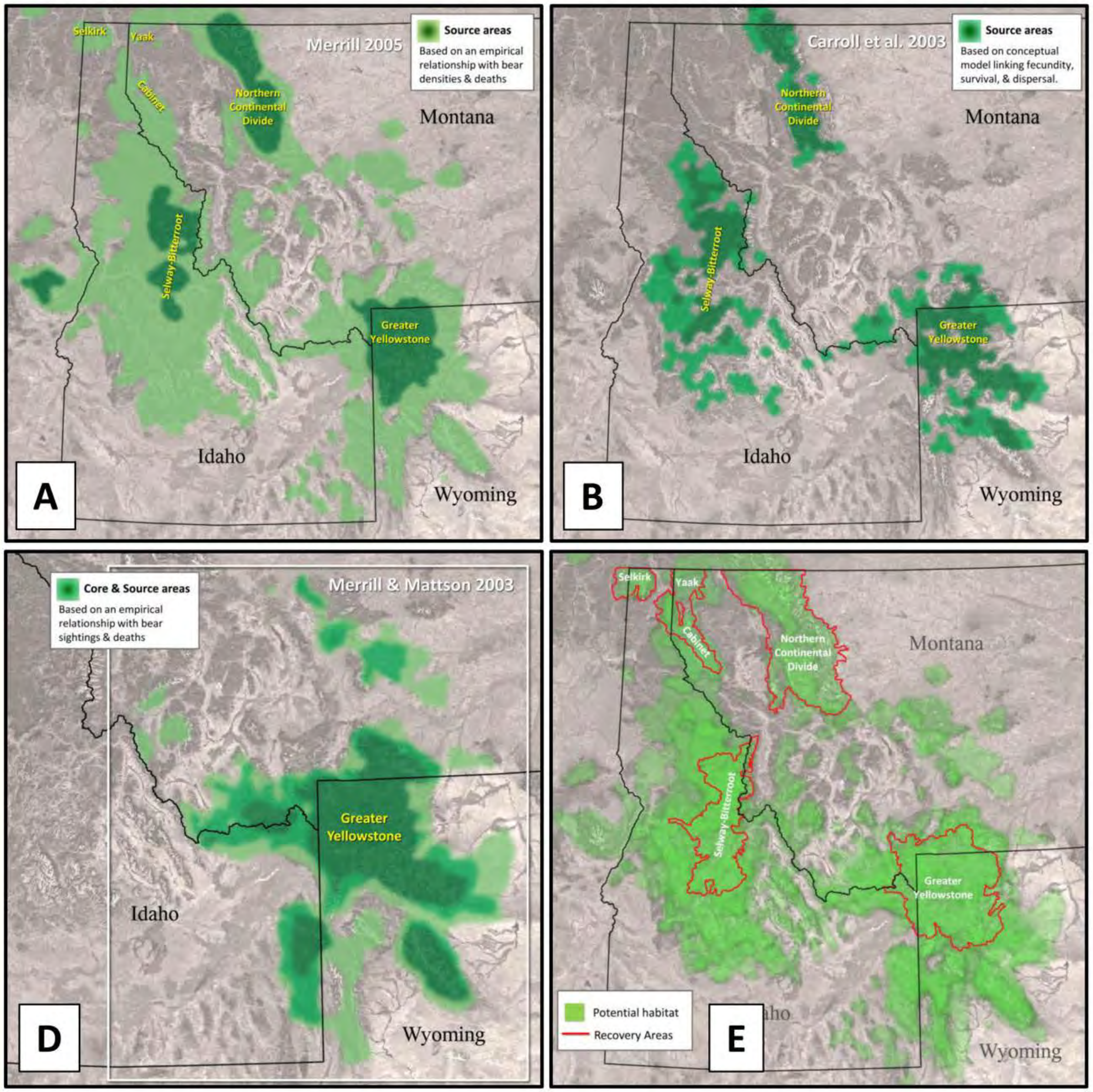

Figure 10. Maps of potential suitable habitat for grizzly bears in the Northern Rocky Mountains and Greater Yellowstone Ecosystem (GYE). Panels (a)-(d) show the results of different individual analyses , with citations for each source given in each panel. Panel (e) consolidates all of the analyses into a single map of potential suitable habitat for grizzly bears in the Northern Rocky Mountains, shown relative to current Recovery Area boundaries. All analyses included assessments of both habitat productivity and security. Note the consistent representation of extensive potential suitable habitat in the Wind River and Wyoming Ranges, south and southeast of the Upper Green area, and also the presence of potential fracture zones in (a) and (d), consistent with results of Schwartz et al. (2010).