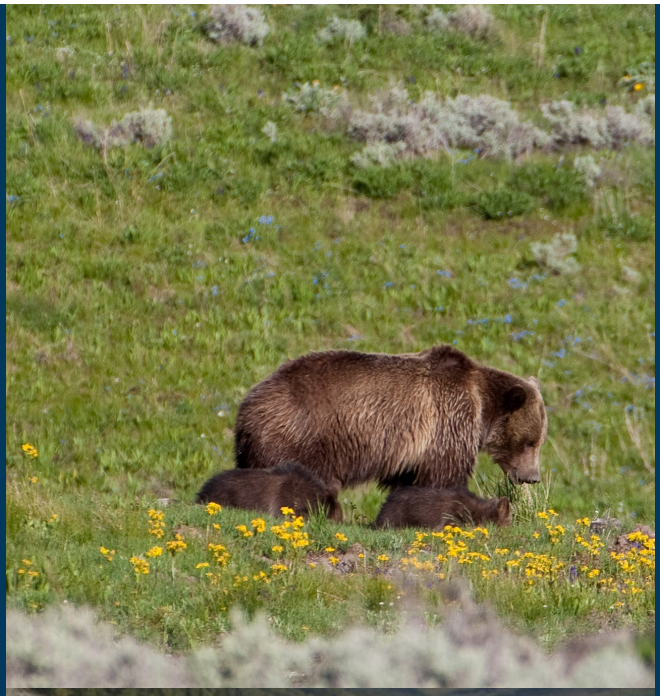
The Status of the Grizzly Bear and Conservation of Biological Diversity in the Northern Rocky Mountains

A Compendium of Expert Statements



Dr. Fred W. Allendorf

Dr. Lee H. Metzgar

Dr. Brian L. Horejsi

Dr. David J. Mattson

Dr. Frank Lance Craighead

October 2019

Flathead-Lolo-Bitterroot Citizen Task Force
P.O. Box 9254
Missoula, MT 59807

montanaforestplan.org

Photo credits: cover: alh1 via Flickr; courtesy Fred Allendorf, Lee H. Metzgar, Brian L. Horejsi, David J. Mattson, F. Lance Craighead, Mike Bader; grizzly bears: National Digital Library; landscape: Keith J. Hammer.

Design and layout: Dawn Serra

Foreword

This compilation of statements from leading grizzly bear and conservation scientists represent a cumulative body of knowledge and experience covering more than 200 years. They convey information that is essential for the survival and biological recovery of the grizzly bear in the Rocky Mountains. This includes the conservation genetics, population viability, habitat dynamics and security, food habits, bear-human interactions and total spatial requirements in a meta-population context.

Grizzly bear management in the Rocky Mountains has long been an exercise in political appeasement of economic interests. The best available scientific information is ignored or cited out of context to suit management prerogatives. Agency scientists and decision-makers are now shackled by an unprecedented exploitative agenda.

In his 1996 award acceptance speech before The Wildlife Society, legendary grizzly bear scientist Dr. John J. Craighead said:

> *"To preserve the grizzly bear in its natural state, we must keep intact the entire spectrum of biodiversity present within its public-land habitat in the Northern Rockies. Concomitantly by preserving the grizzly, we automatically preserve the great biodiversity that is its environment. If the wildlife profession is to play a determining role in the conservation of our public wildlife resources, then biologists should be encouraged to practice scientific advocacy. The public must be awakened to their vested interests and encouraged to protect them. I believe we can retain our objectivity as scientists and yet advocate what our science tells us. We will need the vigorous support of an informed public, one that has the facts direct from the professionals. To ensure long-term persistence of grizzly bears or any other component of our public land trust, we must do more than science; we must educate and persuade. To accept this challenge in the face of entrenched political forces will test the heart and soul of our profession."*

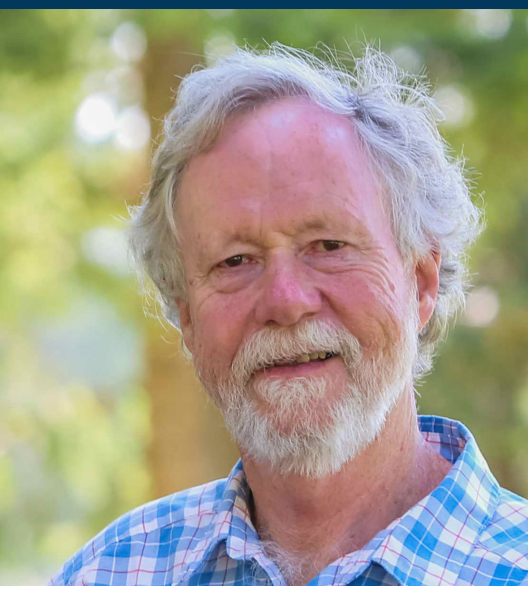
This is a unique opportunity for the public, the media and decision-makers to hear "*the facts direct from the professionals*," unencumbered by special interests. What these professionals have to say is important to the future of the grizzly bear and the unique character of the northern Rockies landscape.

There is enough space on the landscape to sustain the grizzly bear in the Rocky Mountains. Is there enough space within ourselves to make it happen? All readers are encouraged to share this information with others.

Michael G. Bader, editor

Michael Bader is an independent consultant in Missoula, Montana. A University of Montana alumni, he has been involved in grizzly bear conservation since the 1980s, authoring and co-authoring numerous professional papers and reports on grizzly bear habitat, spatial needs and ecosystem protection.

DR. FRED W. ALLENDORF



My name is Fred Allendorf. I have a Ph.D. in Fisheries and Genetics from the University of Washington. I am currently Regents Professor of Biology Emeritus at the University of Montana. I have been a Fulbright Scholar and was awarded the 2015 Molecular Ecology Prize for lifetime achievements in the fields of molecular ecology and conservation genetics. I have published numerous papers on conservation genetics and population viability related to many species including grizzly bears.

The U.S. Fish and Wildlife Service Conservation Strategy for Grizzly Bears in the Northern Continental Divide Ecosystem (NCDE Subcommittee 2018) has a population management goal of maintaining a 90% chance of not falling below 800 grizzly bears. This goal is not adequate for maintaining a genetically-diverse and demographically secure grizzly bear population. Allendorf and Ryman (2002) found as many as 5,000 grizzly bears may be needed in a single population for viability.

The traditional method of assessing the probability of population persistence (Population Viability Analysis) is confidence of a 95% chance of persisting over a discrete timeframe (Shaffer and Samson 1985, Allendorf, et al. 2001, Harris and Allendorf 1989). The appropriate timeline for such analyses applied to grizzly bears is several hundred years. This is due to the long generational time of grizzly bears.

Moreover, repeated simulations of grizzly bear populations have shown a low probability of going extinct within 100 years, but also show extinction probability rising sharply after 100 years, with many populations going extinct within 200-300 years (Shaffer and Samson 1985).

The Conservation Strategy is partially reliant upon connectivity with grizzly bears in Canada to maintain genetic diversity and avoid inbreeding depression. While increased connectivity with grizzly bear populations in southeast British Columbia and southwest Alberta is a general conservation goal, reliance on this strategy may be problematic for two reasons:

1. the Endangered Species Act does not apply within Canada, a sovereign nation, and thus there can be no assurance of adequate regulatory mechanisms that will ensure future connectivity;
2. there is growing evidence of genetic and demographic fragmentation in grizzly bear populations in southern British Columbia and southwestern Alberta.

The southern-most grizzly bear sub-populations in British Columbia and Alberta are increasingly isolated from the larger population to the north (Proctor et al. 2002, 2005). Since that time, nine southern Grizzly Bear Population Units in British Columbia have been re-classified as Threatened (Auditor General of British Columbia Report 2017). The current province wide population estimate for Alberta is N $\approx$ 900 (Alberta Environment and Parks 2016). Proctor et al. (2018) report that remaining grizzly bear populations in Alberta are very low density (4.3/1000km^2) and "Bear Management Areas are separated by genetic discontinuities through Alberta, mediated by major east-west highways."

The Conservation Strategy claims the NCDE is sufficiently connected to other bear populations based on heterozygosity and genetic diversity similar to bear populations to the north. There is a well-documented lag effect in detecting significant environmental changes (Doak 1995). For example, if the NCDE were to become genetically isolated, estimation of heterozygosity would not detect this effect until well after isolation was underway or complete. There is very low power to detect the loss of heterozygosity in a population the size of the NCDE where N ≈ 1,000 (Costello et al. 2016). The expected rate of loss is $1/2N_e$. If a population has 500 bears, the N_e would be greater than 100. Thus, we would expect a loss of 0.005 every 10 years. Even if it were possible to sample all of the offspring each year and estimate the effective number of breeders (N_b), there would still be a lag time of many generations before a trend could be detectable.

The Conservation Strategy (1:29) states 50% of all marked bears in Southwest Alberta also had locations in the U.S. and this "further supports substantial connection across the boundary." However, this is an inappropriate measure of connectivity between sub-populations. For example, immediately north of the Montana-Alberta border is Waterton National Park contiguous with Glacier National Park. It makes sense that grizzly bears in the area would have locations within different parts of this contiguous protected area.

"Without a reliable plan for genetic and demographic continuity between the sub-populations, the long-term prospects for recovery and survival of grizzly bears in the lower 48 states appear dim."

A better measure is how much connectivity there is between the NCDE and the Canadian National Parks further north. Proctor et al. (2002, 2005) show evidence that major highways are effective barriers to female grizzly bear movement and dispersal. Males are still able to pass but at lower frequencies than in the past.

NCDE and Other Sub-Populations in the U.S. Northern Rockies Remain Isolated

Genetic interchange between the five sub-populations has not been observed (Montana Fish, Wildlife and Parks Public Presentation 2018, Peck et al. 2017). Continued genetic and demographic isolation is a significant threat to the long-term existence of the listed population of grizzly bears in the lower 48 states. This effect has been detected in the Yellowstone sub-population long after isolation, where heterozygosity is significantly less than in the other sub-populations (0.55 and 0.60, respectively) and no recent immigrants have been detected through genetic analysis (Miller and Waits 2002, Haroldson et al. 2010). The Cabinet-Yaak and Selkirk, which have had more recent connectivity with sub-populations in Canada, also have low values for H_e and H_o. Without a reliable plan for genetic and demographic continuity between the sub-populations, the long-term prospects for recovery and survival of grizzly bears in the lower 48 states appear dim.

Conclusion

The U.S. has legal responsibilities through the Endangered Species Act, National Environmental Policy Act and National Forest Management Act and other laws to protect and recover listed species which can be enforced through an appeals process and the Judicial Branch. There are no comparable laws or processes in Canada. Increased connectivity and restoration of grizzly bear populations in southeast British Columbia and southwest Alberta are desirable conservation goals but do not lessen U.S. responsibilities to recover listed species on its own lands.

Since none of the five Northern Rockies recovery areas are of sufficient geographic area to support a viable grizzly bear population by themselves, the most desirable method to recover and maintain a genetically diverse and demographically secure grizzly population is to unify the five areas through protected habitat linkages with enough security to permit residency and gene flow by male and female grizzly bears (Metzgar and Bader 1992, Bader 2000.). A minimum meta-population goal for this approach should be no less than ≈ 2,500-3,000 grizzly bears.

Literature Cited

Alberta Environment and Parks 2016. Alberta Grizzly Bear (*Ursus arctos*) DRAFT Recovery Plan. Alberta Environment and Parks. Alberta Species at Risk Recovery Plan 38. Edmonton, AB.

Allendorf, F.W. and N. Ryman. 2002. The role of genetics in population viability analysis. In: Population Viability Analysis, S.R. Beissinger and D.R. McCullough (eds.) University of Chicago Press.

Allendorf, F.W., R.B. Harris, and L.H. Metzgar. 1991. Estimation of effective population size of grizzly bears by computer simulation. Pages 650-654 in E.C. Dudley (ed.), Proceedings 4th International Congress of Systematics and Evolutionary Biology. Dioscorides Press, Portland, OR.

Auditor General of British Columbia. 2017. An Independent Audit of Grizzly Bear Management. Victoria, BC. 73p.

Bader, M. 2000. Distribution of grizzly bears in the U.S. northern Rockies. Northwest Science 74(4): 325-334.

Costello, C.M., R.D. Mace, and L. Roberts. 2016. Grizzly bear demographics in the Northern Continental Divide Ecosystem, Montana: research results (2004–2014) and suggested techniques for management of mortality. Montana Department of Fish, Wildlife and Parks. Helena. 121p.

Doak, D.F. 1995. Source-sink models and the problem of habitat degradation: general models and application to the Yellowstone grizzly. Conservation Biology 9(6): 1370-1379.

Harris, R. B. and F. W. Allendorf. 1989. Genetically effective population size of large mammals: an assessment of estimators. Conservation Biology 3: 181-191.

Haroldson, M.A., C. C. Schwartz, K. C. Kendall, K. A. Gunther, D. S. Moody, K. Frey, and D. Paetkau. 2010. Genetic analysis of individual origins supports isolation of grizzly bears in the Greater Yellowstone Ecosystem. Ursus 21(1):1–13

Kendall, K. C., J. B. Stetz, J. Boulanger, A. C. MacLeod, D. Paetkau, and G. C. White. 2009. Demography and genetic structure of a recovering grizzly bear population. Journal of Wildlife Management 73:3-17.

Metzgar, L.H. and M. Bader. 1992. Large mammal predators in the northern Rockies: grizzly bears and their habitat. Northwest Environmental Journal 8(1):231-233.

Miller, C.R., and L.P. Waits. 2003. The history of effective population size and genetic diversity in the Yellowstone grizzly (*Ursus arctos*): Implications for conservation. Proceedings of the National Academy of Sciences, USA 100:4334–4339.

NCDE Subcommittee, Interagency Grizzly Bear Committee. 2018. Conservation strategy for the grizzly bear in the Northern Continental Divide Ecosystem. (170 pages + appendices)

Peck, C.P., F.T. van Manen, C.M. Costello, M.A. Haroldson, L.A. Landenburger, L.L. Roberts, D.D. Bjornlie and R.D. Mace. 2017. Potential paths for male-mediated gene flow to and from an isolated grizzly bear population. Ecosphere 8(10):1-17.

Proctor, M. F., B.N. McClellan and C. Strobeck. 2002. Population fragmentation of grizzly bears in southeastern British Columbia, Canada. Ursus 13: 153-160.

Proctor, M.F., B. N. McLellan, C. Strobeck and R. M. R. Barclay. 2005. Genetic analysis reveals demographic fragmentation of grizzly bears yielding vulnerably small populations. Proceedings of the Royal Society B. doi:10.1098/rspb.2005.3246 Published online.

Proctor, M. F., B. N. McLellan, G. B. Stenhouse, G. Mowat, C. T. Lamb, and M. Boyce. 2018. Resource Roads and Grizzly Bears in British Columbia, and Alberta. Canadian Grizzly Bear Management Series, Resource Road Management. Trans-border Grizzly Bear Project. Kaslo, BC. Canada http://transborder-grizzlybearproject.ca/research/publications.html.

Shaffer, M.L., and F.B. Samson. 1985. Population size and extinction: a note on determining critical population sizes. American Naturalist 125:144-152.

DR. LEE H. METZGAR, PH.D.

I am Dr. Lee H. Metzgar, Ph.D. (ret.). I am a population ecologist and hold a Ph.D. in Zoology from the University of Michigan. I have expertise in grizzly bear population dynamics and minimum viable population size. My publications relevant here include: Harris and Metzgar (1987a,b, 1990); Allendorf, Harris and Metzgar (1991); Metzgar and Bader (1992); and Knight et al. (1993). Additionally, I have authored several reports on grizzly bears, given numerous professional presentations on grizzly bears and reviewed numerous pre-publication manuscripts relevant to grizzly bears. On behalf of the U.S. Fish and Wildlife Service, I served as an invited participant on the Yellowstone Grizzly Bear Population Task Force. While employed as a Professor of Zoology, Biology, Wildlife Biology and Environmental Studies at the University of Montana (1968–1997), I served terms as Chairman of the Zoology Department and as Director of Wildlife Biology.

Grizzly Bears Are Not Recovered

I wish to address the nature of a "recovered" grizzly bear population in the contiguous U.S. 48 states. It is long overdue for the U.S. Fish and Wildlife Service, Montana Fish Wildlife and Parks and other state and federal agencies to recognize the well-documented, scientific reality that any truly recovered grizzly bear population will include thousands of individuals. In the Northern Rockies, none of the grizzly bear recovery areas are geographically large enough to support such a population on their own. Attaining such numbers is possible only within a protected network of subpopulations and connecting zones through which significant genetic exchange occurs (Allendorf and Ryman 2002, 2017; Bader 2000a; Metzgar and Bader 1992).

At present, there is no recovered population of grizzlies in the lower 48 states. No existing "population" includes sufficient numbers to be considered recovered, no recovery zone is large enough to accommodate a recovered population and there is no evidence for natural genetic exchange among grizzly bears in all five U.S. subpopulations (Peck et al. 2017; Costello 2018). Existing research implies that linkage corridors between sub-populations will require sufficient size and security for at least periodic occupancy by breeding males and females (Bader 2000b; Mattson 1993; Mattson et al. 1996; Proctor 2018; Proctor, et al. 2005).

Our federal and state agencies must recognize that Montana has special responsibilities for grizzly bear recovery in the contiguous 48 states. Montana contains most of the possible linkage corridors among the several grizzly bear subpopulations, including most of the essential linkages among the Yellowstone, Bitterroot and Northern Continental Divide Ecosystems.

"At present, there is no recovered population of grizzlies in the lower 48 states. No existing 'population' includes sufficient numbers to be considered recovered, no recovery zone is large enough to accommodate a recovered population and there is no evidence for natural genetic exchange among grizzly bears in all five U.S. subpopulations."

In view of Montana's responsibilities and given the best available science, it is clear that the U.S. Fish and Wildlife Service and the Montana Department of Fish, Wildlife and Parks must:

1. Abandon the pretense that 800 or 1000 grizzly bears can ever be considered "recovered" or even healthy;
2. Recognize that grizzly bears in potential corridors between the Yellowstone and other ecosystems are essential to a recovered population and therefore do everything possible to give those corridors the highest level of security for bears;
3. Commit to not hunting grizzlies until their subpopulations and corridors are occupied, secure and producing surpluses.

Literature Cited

Allendorf, F.W., R.B. Harris and L.H. Metzgar. 1991. Estimation of effective population size of grizzly bears by computer simulation. In: E.C. Dudley (ed.) Proceedings 4th International Congress of Systematics and Evolutionary Biology: 650-654. Dioscorides Press. Portland, OR.

Allendorf, F.W. and N. Ryman. 2002; 2017. The role of genetics in population viability analysis. In: Population Viability Analysis, S.R. Beissinger and D.R. McCullough (eds.) University of Chicago Press. 1st and 2nd editions.

Bader, M. 2000a. Distribution of grizzly bears in the U.S. northern Rockies. Northwest Science 74(4): 325-334.

Bader, M. 2000b. Spatial needs of grizzly bears in the U.S. northern Rockies. Abstract. International Society for Conservation Biology Conference 2000:129. Special Report No. 10. Alliance for the Wild Rockies. Missoula, MT. 28p.

Costello, C. 2018. Montana Department of Fish, Wildlife and Parks. Presentation, Interagency Grizzly Bear Committee Meeting, June 19, Polson, MT.

Harris, R.B. and L.H. Metzgar. 1987a. Estimating harvest rates of bears from sex ratio changes. Journal of Wildlife Management. 51:802-811.

Harris, R.B. and L.H. Metzgar. 1987b. Harvest age-structures as indicators of decline in small populations of grizzly bears. International Conference on Bear Research and Management 7:109-116.

Harris, R.B. and L.H. Metzgar. 1990. Reproductive values of bears: using both theory and simulation to gain insight: an example using reproductive values. 10th Eastern Black Bear Workshop.

Knight, R., J. Beecham, B. Blanchard, L. Eberhardt, L. Metzgar, C. Servheen, and J. Talbot. 1993. Report of the Yellowstone grizzly bear population task force. In: Appendix C : Grizzly bear recovery plan, U.S. Fish and Wildlife Service, Missoula, MT 181p.

Mattson, D.J. 1993. Background and proposed standards for managing grizzly bear habitat security in the Yellowstone ecosystem. College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow. 17p.

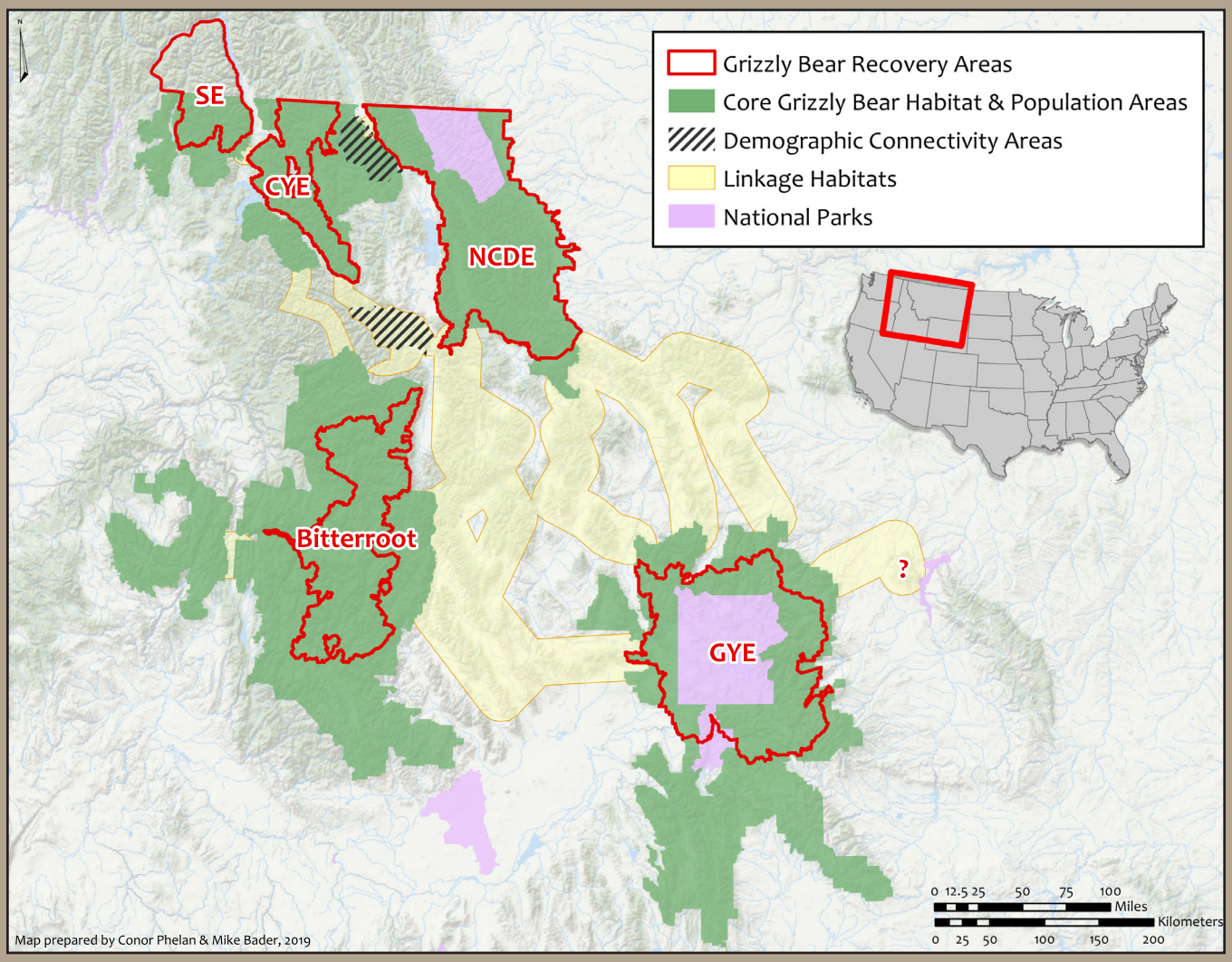
Mattson, D.J., S. Herrero, R.G. Wright and C.M. Pease. 1996. Designing and managing protected areas for grizzly bears: how much is enough? Pages 133-164 In: National Parks and Protected Areas: Their Role in Environmental Protection, R.G. Wright (ed.) Blackwell Science, Cambridge, MA.

Metzgar, L. H. and M. Bader. 1992. Large mammal predators in the Northern Rockies: grizzly bears and their habitat. The Northwest Environmental Journal 8:231-233.

Peck, C.P., F.T. van Manen, C.M. Costello, M.A. Haroldson, L.A. Landenburger, L.L. Roberts, D.D. Bjornlie and R.D. Mace. 2017. Potential paths for male-mediated gene flow to and from an isolated grizzly bear population. Ecosphere 8(10):1-17.

The spatial needs of a grizzly bear metapopulation exceed 70,000 square miles (185,000 km^2) of connected, secure habitat. By contrast, the isolated Grizzly Bear Recovery Areas provide just 38% of spatial needs including the Bitterroot, which does not yet have a population. In numbers of grizzly bears, the two largest populations are just 28-36% of numbers required for minimum viability.

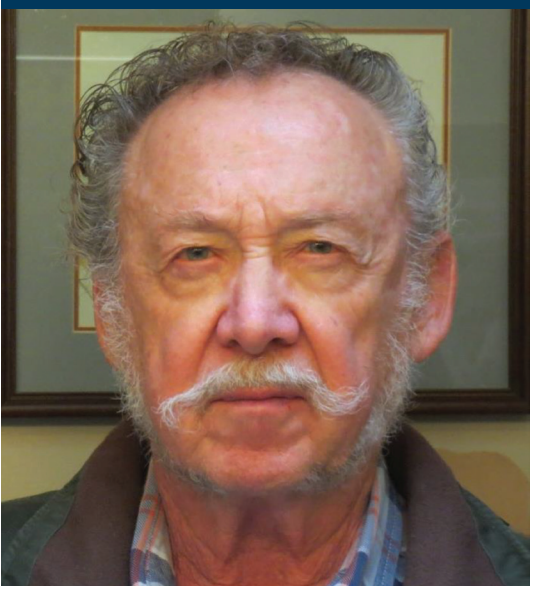
Grizzly Bear Habitat Needed for Biological Recovery in the U.S. Northern Rockies



Sources: Habitat- Bader (2000c); Recovery Areas and Demographic Connectivity Areas- U.S. Fish and Wildlife Service (2018).

Note: One or more potential linkages for grizzly bears have been identified by Picton 1986; Bader 1991; Shaffer 1992; Bader and Bechtold 1996; Walker and Craighead 1997; Bader 2000c; Servheen, Waller and Sandstrom 2001; Peck and others 2017; U.S. Fish and Wildlife Service 2018.

Dr. BRIAN L. HOREJSI



My name is Brian L. Horejsi. I have a Bachelor of Science in Forestry from the University of Montana and a Ph.D. in the Behavioral Ecology of Large Mammals from the University of Calgary. I have been employed as a research biologist and forester in Alberta, the Yukon and the Northwest Territories, and I have worked extensively (1976-present) with grizzly bears and conservation efforts in Alberta and British Columbia as an independent scientist and active citizen.

My grizzly bear field research has included measurement of mortality risk and grizzly bear response to roads, expressed as Habitat Effectiveness. A sample of my professional publications and presentations include Horejsi (1986, 1993, 2003, 2004, 2005); Horejsi, Gilbert and Craighead (1998); Horejsi and Gilbert (2006).

The U.S. Fish and Wildlife Service conservation plan for grizzly bears in the Northern Continental Divide Ecosystem is critically flawed at a number of levels. In this statement I address two levels:

1. most directly the presumption that grizzly bear populations and habitat in British Columbia and Alberta are viable;
2. the presumption that regulatory standards and practices in those provinces are capable of providing and continuing to support bear populations that would buttress demographic and genetic continuity for the U.S. bear population.

Inadequate Regulatory Environment

It may be most revealing to ask U.S. citizens and authorities what it would be like to manage for recovery of grizzly bear populations:

- without the Endangered Species Act;
- without the National Environmental Policy Act;
- without road density and core security area habitat protection standards;
- without any legal system that provides avenues through which citizens and independent scientists can challenge decisions by the equivalent of state agencies, in this case the Alberta Fish and Wildlife (Ministry of Environment) and the British Columbia Ministry of Forest Land and Natural Resource Operations;
- without any Forest Plans for public forests;
- finally, but by no means minimally, understanding that virtually all public land is owned and managed by the Provinces (equivalent of State jurisdiction). This contrasts sharply with the 79% federal ownership within the Northern Continental Divide Grizzly Bear Recovery Area.

Summary of Advantages on U.S. National Forests vs Alberta and British Columbia "Provincial" Lands

	U.S. National Forests	Canadian Provincial Lands
Comprehensive Forest Management Plan	Yes	No
National Forest Management Act	Yes	No
National Environmental Policy Act	Yes	No
Environmental Impact Statements	Yes	No
Appeals and Citizen Suit Provisions	Yes	No
Administrative Procedure Act	Yes	No
National Roadless Rule	Yes	No
Travel Management Plans	Yes	No
Full Endangered Species Act Protections	Yes	No*

*In Canada the Federal Species At Risk Act applies only to Federal Land

Questionable Intent

The strategy of Alberta public servants in the DRAFT Grizzly Bear Recovery Plan (2016) exposes:

1. the politics and career survival mentality of these public servants and the provincial wildlife, land and agriculture management organizations (Alberta Forest Service, Department of Agriculture, Fish and Wildlife). This is not uncharacteristic of state and provincial agencies, but it should be recognized as a source of bias;
2. collusion between academic researchers (primarily from the University of Alberta) and the Foothills Research Institute (FRI), an organization that evolved from a "Model Forest" initiative started by the timber industry and their major funders – the government of Alberta and the timber industry.

FRI claims independence, but often thanks Weyerhaeuser and West Fraser Timber Company for supporting the project. FRI's Annual Report states the Research Institute spends about $6.5 million annually, of which about $4.3 million comes from corporations and "non-profit entities" which are not defined. The DRAFT Alberta plan, page 8 (as of January 2019 not finalized) states: *"within west central Alberta, research indicates that grizzly bears select for forestry cutblocks… and roads;" and "grizzly bears did not avoid disturbed areas in the foothills of Alberta, including clear-cuts, roads, pipelines, well-sites, power-lines, and railways."*

To point out one measure of the pro industry slant that Alberta Fish and Wildlife employs, they decided (likely at closed meetings with off road vehicle clubs) to use "open roads" for their measure of human impacts, distinguishing these roads from "open routes." They then define "open roads" as only those accessible by highway vehicles - versus "open routes" which would be accessible by all motorized means including industry use.

The convenience for existing land users is evident: off road vehicle users get a free ride, as do all the industries using access via cut-block roads, seismic roads, power line and pipeline rights of way.

Present Status of the Alberta – Montana Link

The Alberta Bear Management Area BMA 6 includes southern Alberta and borders on the Continental Divide in the west and on the international boundary with Montana. It is 3600 km^2 (about 1460 mi^2) and almost all of it is less than 30 km wide (18 mi); 14% is federal land (Waterton National Park) and 42% is private land.

BMA 6 is divided into two designations: "recovery" zone, about 50% of the BMA, and "support" zone. On page 23 the Draft Plan notes that within the recovery zone, *"oil and gas activities, timber harvest, and recreation occur in the portion of the recovery zone north of Waterton Lakes National Park with widespread cattle grazing."* It is important to note that the Draft Recovery Plan proposes no restrictions on these intensive land use activities.

On page 14 the Draft cites a 2007 population estimate of 51 bears. In my report (Horejsi 2004) I estimated that ≈ 55–65 bears occupied BMA 6. The Draft discloses that BMA 6 has the highest total mortality rate of grizzly bear in Alberta (almost 40% higher than the BMA to the north), and has the highest female mortality rate in Alberta (almost 75% higher than the BMA to the north).

More recently, Morehouse and Boyce (2017) estimated that 61 bears have home ranges largely within southern Alberta south of Highway 3 in the BMA that links Alberta and Montana (see Global Forest Watch figure). They also identified a number of additional bears that were identified through DNA analysis in Montana and British Columbia; they indicated that greater than half of the bears contributing to an expanded population estimate were bears whose home ranges include Montana and British Columbia.

Contrary to Morehouse and Boyce (2017) who claim the population increased from 2004-2016, my interpretation of this evidence, given similarity in estimated numbers between Horejsi (2004) and Morehouse and Boyce (2017), a 14-year time difference, and acceptable margins of error, BMA 6 has been and continues to periodically be a high mortality landscape. It is a matter of relevance that the Draft Recovery Plan and Morehouse and Boyce (2017) did not reference to Horejsi (2004). This omission suggests by-design bias. This is not constructive when planning or executing a grizzly bear recovery plan.

Impact of Roads

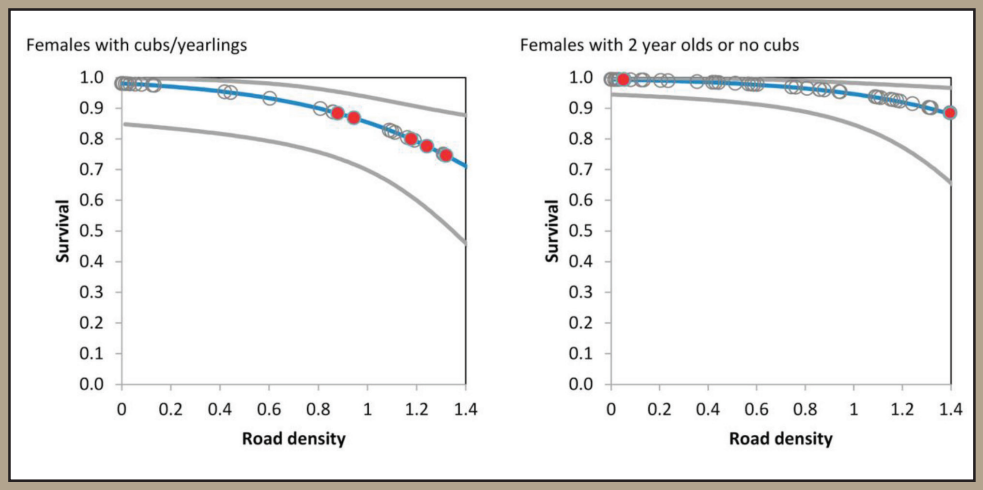
The following 2 paragraphs come from The Impact of Roads on the Demography of Grizzly Bears in Alberta. (Boulanger and Stenhouse 2014).

"This analysis demonstrates that road density affects both the direct demography and trend of bear populations but introduces additional risk into reproduction and recruitment. Previous analyses of bears in Yellowstone National Park and the surrounding area also concluded that human development was the principal factor influencing survival rates of grizzly bears. Based on previous demographic analyses it was suggested that sink habitats would be created if adult female survival rate declined below 0.91. Our analyses suggested that the actual survival rate required for areas to not risk declining populations depends on reproductive state. If lower survival rates of females

with dependent offspring is considered then the threshold of road density that bears can tolerate is reduced further. The sensitivity of results to adult female survival rates and reproductive state follows from other demographic studies that demonstrate the highest sensitivity of population trend to adult female survival rates.

Our results illustrate that larger watershed areas outside of the mountainous zones have potential to have lower chance of population increase or stability if mortality risk near roads is not managed. This distribution of watersheds suggests that the majority of core areas are in areas of lower road density and therefore have the potential to be source habitats. Alternatively, 57% of secondary habitat are either in moderate (0.75–1.25) or high road density (1.25) suggesting that these areas will require more intensive management to aid in population recovery and conservation actions. Currently the Alberta government is attempting to manage identified core and secondary conservation zones within each BMA at road densities of.6 km/km² and 1.2 km/km² respectively."

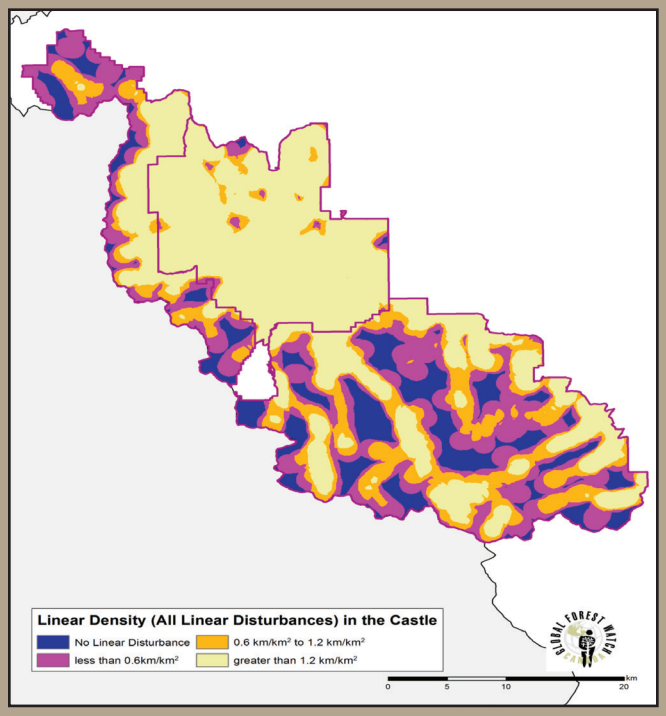
"…it would be willfully negligent to state that Southwestern Alberta and Southeastern British Columbia contribute positively to the conservation of grizzly bears in the Northern Continental Divide Ecosystem in Montana."



From: Boulanger and Stenhouse (2014).

Keep in mind that as of this date there are no written or legal obligations for the provincial Forest Service to manage for any road density standards. The statement quoted above is perhaps wishful thinking, but in practice even that standard (1.2 km/km² or nearly 2 mi/mi²) would be destructive. Boulanger and Stenhouse estimate that mortality of females with cubs/yearlings falls below the .91 survival threshold when road density is greater than 0.8 km/km².

Global Forest Watch Canada (2016) did a road density analysis of the public land section of BMA 6, and concluded most of it was roaded well beyond 0.8 km/km². At the bottom right of their map, in white, is Waterton National Park. For my study (Horejsi 2004) I calculated average road density on public land to be about 1.75 km/km² (nearly 3 mi/mi²); on



the north half of the BMA it is >2.75 km/km^2 (> 4.4mi/mi^2). Even Waterton Lakes National Park has a road density of about 0.6 km/km^2.

British Columbia struggles with near crippling regulatory inadequacy in land and wildlife management affairs. The Office of the Auditor General of British Columbia undertook an audit of grizzly bear management in the Province in 2017. I was interviewed and made a written submission to that investigation. The subsequent report exposes the province's incapacity to reign in or recover from a massive legacy of industrial road access that severely hampers grizzly bear conservation efforts.

From an analytical perspective, and incorporating a cumulative context, the sum of this information on mortality, landscape integrity and size, and the virtually non-existent regulatory environment, along with the near total absence of public democratic and legal procedures which prohibits access to government agencies and decision making, it would be willfully negligent to state that Southwestern Alberta and Southeastern British Columbia contribute positively to the conservation of grizzly bears in the Northern Continental Divide Ecosystem in Montana.

Literature Cited

Alberta Environment and Parks. 2016. DRAFT Alberta Grizzly Bear (*Ursus arctos*) Recovery Plan. Alberta Environment and Parks, Alberta Species at Risk Recovery Plan No. 38. Edmonton, AB. 85p.

Auditor General of British Columbia. 2017. An Independent Audit of Grizzly Bear Management. Office of the Auditor General of British Columbia. Victoria, British Columbia. 73p.

Boulanger, J., and G.B. Stenhouse. 2014. The impact of roads on the demography of grizzly bears in Alberta. 2014 PLos ONE 9(12).

Global Forest Watch Canada. 2016. Disturbance, Intactness, and Linear Density in the Castle Wilderness Area of Alberta. Draft Report.

Horejsi, B.L. 1986. Industrial and agricultural incursion into grizzly bear habitat: the Alberta story. Pages 116-123 In: Proceedings— Grizzly Bear Habitat Symposium. Compilers, G.P. Contreras and K.E. Evans. USDA Forest Service General Technical Report INT-207. Intermountain Research Station, Ogden, UT.

Horejsi, B.L. 1993. Grizzly Bear Habitat Effectiveness: A Workshop. Alliance for the Wild Rockies Annual Meeting. October 2nd, Corvallis, MT.

Horejsi, B.L., Gilbert, B.K. and F.L. Craighead. 1998. British Columbia's Grizzly Bear Conservation Strategy: An independent review of science and policy. Western Wildlife Environments Consulting Ltd., Calgary, Alberta. 64p.

Horejsi, B.L. 2003. Science based habitat and population protection thresholds: access induced displacement and access management standards for grizzly bears (*Ursus arctos*). In: Access Management: Policy to Practice. Proceedings of the Alberta Society of Professional Biologists Conference, Calgary, Alberta.

Horejsi, B. 2004. Grizzly bears in southwest Alberta; a vision and plan for population and habitat recovery. Western Wildlife Environments Consulting Ltd., Calgary, Alberta.

Horejsi, B.L. 2005. Uncontrolled land use threatens an international grizzly bear population. Conservation Biology 3(3):220-226.

Horejsi, B.L. and B.K. Gilbert. 2006. Conservation of grizzly bear populations and habitat in the northern Great Bear Rainforest. Biodiversity 7(2):3-10.

Morehouse, A.T., and M.S. Boyce, 2017. Grizzly bears without borders: spatially explicit capture – recapture in southwestern Alberta. Journal of Wildlife Management 80(7): 1152-1166.

DR. DAVID J. MATTSON

I am David J. Mattson, a scientist and recently retired wildlife management professional with extensive experience in grizzly bear research and conservation spanning four decades. I have 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, as well as 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 and Environmental Studies.

Of more explicit relevance to this statement, my dissertation focused on the ecology of grizzly bears in the Greater Yellowstone Ecosystem (GYE) during 1977-1996 using data collected during intensive studies of grizzly bears in the GYE. During much of this period I was charged with designing and supervising field investigations for the Interagency Grizzly Bear Study Team. 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.

My statement here focuses on the current status of grizzly bears in the contiguous United States, with explicit reference to meaningful standards for recovery and inadequacies of the current U.S. Fish and Wildlife Service (USFWS) Grizzly Bear Recovery Plan. My thesis, in brief, is that we are far short of meaningful recovery no matter how reckoned, and that the current Recovery Plan offers an impoverished and profoundly deficient blueprint. What follows is necessarily succinct, but references and additional supporting details can be found in Mattson (2016, 2018a, 2018b, 2019a, 2019b, 2019c, 2019d, 2019e) and Mattson et al. (2018).

What We Once Had

At the time of European settlement, approximately 46,500-72,200 grizzly bears occupied an area of roughly 2,865,000 km^2 (≈ 1.1 million mi^2) in what was to become the contiguous United States. Throughout much of the eastern portion of this distribution grizzly bears subsisted primarily on carrion from bison, whereas in western portions spawning salmon were a dietary staple. In the Southwest and California acorns were a mainstay, augmented by resources from the marine environment in coastal areas. Farther inland, fruit, whitebark pine seeds, and meat from bison and elk comprised a major part of the diet—as they do now.

These grizzly bears were part of a unique genetic lineage with a unique evolutionary and biogeographic history. This lineage, known as Clade 4, was among the very first grizzly bears to arrive during the Pleistocene in North America from Eurasia, and the only genetic lineage known to have survived at mid-latitudes after closure of continental ice sheets during the Last Glacial Maximum around 30,000 years ago. Clade 4 grizzly bears from mid-latitudes subsequently migrated north as the ice sheets melted, but got no

farther than what is now southeastern British Columbia and central Alberta. Here they met grizzly bears descended from another more recent wave of migrants, comprised of a different genetic lineage (Clade 3), that were spreading south. Meanwhile, Clade 4 grizzly bears had gone extinct everywhere else on Earth, with the exception of a small remnant on the Japanese island of Hokkaido.

What We Lost

European-perpetrated extirpations of grizzly bears began in the early 1800s, accelerated after 1850, and culminated around 1950. During this brief period, we lost roughly 98% of pre-European bear numbers in 97% of the places they once lived. In addition, we lost priceless ecological relationships, including the dietary economies centered on spawning salmon, acorns, Great Plains bison, and more. The Greater Yellowstone Ecosystem (GYE) stands out as a relic and repository of otherwise lost biodiversity in that it is the only place in North America where grizzly bears still consume significant amounts of whitebark pine seeds and, even more notably, the only place globally where bears still eat meat from bison—constituting <0.1% of the former extent of this behavior.

Notably, Clade 4 grizzly bears bore the brunt of European-perpetrated extirpations, whereas Clade 3 grizzly bears farther north were largely spared. When reckoned for the entirety of the United States, Canada, and Mexico, roughly 95% of all Clade 4 grizzly bears were extirpated, including all in Mexico, and nearly all in the United States.

What We've Regained

Since affordance of protections to grizzly bears under the U.S. Endangered Species Act (ESA), only 1% of former numbers has been restored in only an additional 2% of former distributions—even taking overly optimistic statements about gains at face value. None of the biodiversity represented by broad-scale ecological relations on the Great Plains, in the Southwest, or along the coasts has been regained. At most, grizzly bears currently occupy only 5% of their former distribution at only 3% of their former numbers in five demographically isolated populations. Claims by the U.S. Fish and Wildlife Service that these small gains constitute restoration to a "significant portion of former range" are at variance with any definition of "significant" to be found in law, statistics, or common-language dictionaries. Nor can these gains plausibly be viewed as restoration of lost biodiversity or ecological function. Nor can these gains be viewed as meaningful recovery of the globally rare, nearly extirpated, Clade 4 grizzly bears.

What We Need

The ESA mandates recovery of listed species and populations to the point where they are no longer vulnerable to current and foreseeable threats. This mandate has been interpreted as including assurance of viability, entailing genetic and demographic vigor sufficient to insure survival for the indefinite future. As emphasized by Dr. Allendorf and Dr. Metzgar, this kind of assurance is only provided by genetically conversant and demographically contiguous populations of grizzly bears numbering in the thousands—not mere hundreds.

What We Have

Notably, even taking current inflated estimates at face value, our two largest grizzly bear populations—

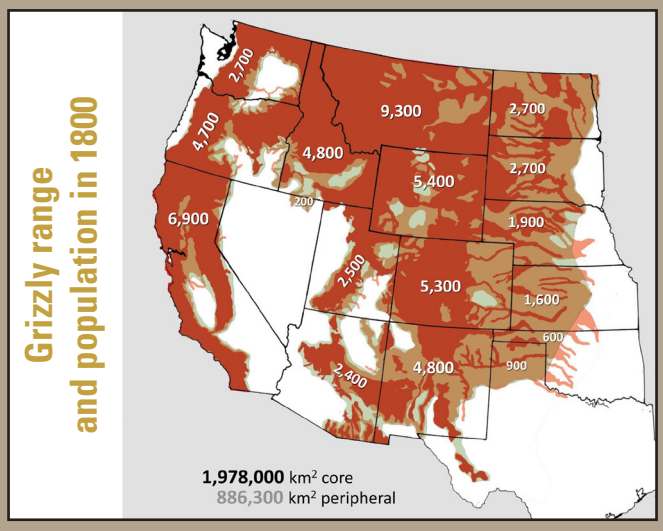
in the GYE and Northern Continental Divide (NCDE)—number no more than 1000. More likely these populations number nearer 800-900. The other three populations occupying the Yaak region and Selkirk and Cabinet Mountains number no more than 25-40 each, and thus remain acutely vulnerable. The two designated Grizzly Bear Recovery Areas in the North Cascades and Selway-Bitterroot have no populations of grizzly bears, despite having ample potential. All of these populations are demographically and genetically isolated from each other, despite the appearance of occasional dispersers from elsewhere. None of this handful, barring one, has been known to successfully breed.

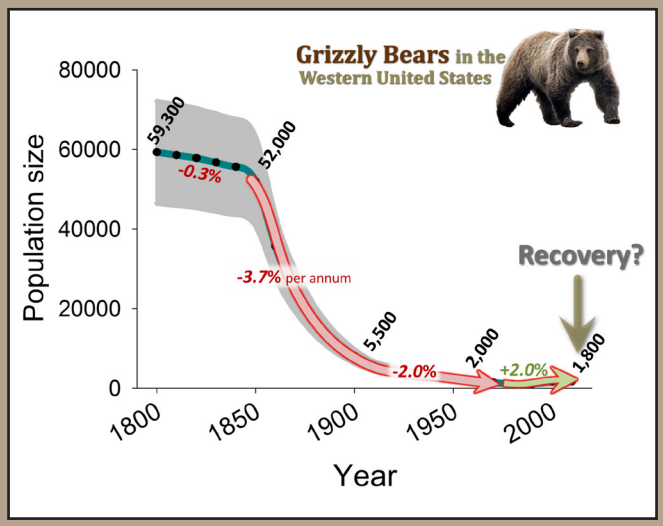
Parenthetically, all the estimates of population size and trend that have been produced by federal and state researchers for grizzly bears in the contiguous U.S. are deficient in major ways and, moreover, prey to inflationary bias. Despite rapidly increasing distributions in the NCDE and GYE, growth of grizzly bear populations has likely stalled coincident with record-breaking levels of mortality, almost all of which continues to be caused by humans. In fact, 80-90% of all adolescent or adult bears that have died since 1975 have been killed by humans, resulting in altogether novel—even perverse—selective pressures. Whatever else we are doing, we are not conserving the genetic legacy embodied by grizzly bears in the contiguous U.S.

Enduring and Emergent Threats

Our comparatively small and isolated grizzly bear populations in the contiguous U.S. remain subject to a number of on-going and foreseeable threats. For one, key food resources have been lost or destabilized by rapidly changing environments and climates. Whitebark pine was functionally extirpated as a bear food throughout the NCDE and in most of the GYE, with much of the losses in the GYE happening during 2000-2010 due to an unprecedented outbreak of mountain pine beetles unleashed by a warming climate. Cutthroat trout that had been consumed while spawning in streams tributary to Yellowstone Lake were functionally extirpated as a bear food between 1995 and 2005 by a non-native piscivorous predator

"…there is currently ample potential for more grizzly bears in more places—in fact, enough grizzly bears in geospatial configurations sufficient to achieve meaningful recovery."





Graphics courtesy D.J. Mattson

and by deteriorating hydrologic conditions. Elk populations in the GYE declined during this same period, along with two of the three bison populations—as did the mule deer population along the Rocky Mountain Front in the NCDE. Meanwhile, a dramatic increase in wildfires since 1985 produced rapid increases in transient unproductive habitats in wildlands of the NCDE.

All of these dynamics have driven changes in grizzly bear diets and distributions that have, in turn, led to problematic increases in conflicts with humans. In the GYE grizzly bears have taken a compensatory turn towards eating more meat, with most of that meat coming from scavenging or predating on livestock or exploiting the remains of elk shot by big game hunters. Under both circumstances bears come into conflict with people who are often armed and intolerant—resulting in escalating conflicts and bear deaths. In the NCDE, grizzly bears have rapidly spread into agricultural landscapes, likely in compensation for diminished food resources in wildland areas. Here, as in the GYE, conflicts with livestock producers and farmers have dramatically increased—along with resulting bear deaths.

Grizzly bears spreading out into human-impacted areas on the west side of the NCDE have come up against increasing urban and suburban sprawl, as well as other more remote residential developments, all of which are populated with human-associated attractants that likewise bring bears into conflict with people—and result in yet more dead bears. Compounding all of this, steadily increasing traffic in transportation corridors of the NCDE has resulted in an accelerating toll of grizzly bears killed by vehicle and train strikes.

Finally, without exhausting all of the identifiable threats, grizzly bears remain threatened by malicious killing, often by people driving backcountry road networks. These roads are nowhere more problematic than on Forest Service jurisdictions where management prioritizes industrial-scale extraction of timber over all other values—and nowhere more so than in the Selkirk and Cabinet-Yaak Ecosystems as well as in western portions of the NCDE on the Flathead and Lolo National Forests.

Foreseeable Threats

Looking to the future, few of the threats rooted in environmental change and human population growth are likely to abate. Regional human populations will almost certainly continue to grow, as will residential developments built to accommodate unrelenting demand. Increasing human populations will predictably fuel more traffic on high-speed highways as well as ever-more hikers, runners, and mountain bikers on backcountry trails. Bear foods in wildlands will also, in the net, almost certainly continue to be lost. Climate warming promises to eliminate the last crucial native food for grizzly bears in the GYE—army cutworm moths concentrated in alpine areas to feed on wildflowers in alpine tundra that we will lose within the next 100 years. Fruit, the main staple of grizzly bears west of the Continental Divide, will also be less abundant as climate change eliminates much of the habitat currently suitable for serviceberry, chokecherry, and buffaloberry—with huckleberry also at risk. And nearer term yet, pressure from conservative politicians in regional and national offices are driving a backward-looking agenda that promises more timber harvest, more roads, and more tacit encouragement for poaching on public lands.

What We Could Have

Despite these threats, there is currently ample potential for more grizzly bears in more places—in fact,

enough grizzly bears in geospatial configurations sufficient to achieve meaningful recovery. Numerous modelers have identified existing potential suitable habitat for grizzly bears that is contiguous from the GYE to Canada via the Selway-Bitterroot, Cabinet-Yaak, and NCDE. When put together, this potential habitat combined with existing populations could provide for in excess of 3000 grizzly bears as part of one demographically contiguous population connected to additional grizzly bears in Canada.

Importantly, this modeling is based almost solely on existing habitat productivity and remoteness from humans, holding human lethality and related drivers of conflict constant. This proviso is important because demonstrably more grizzly bears can be supported within a given configuration of remoteness and productivity if there are improvements in habitat security, development of coexistence institutions, widespread deployment of coexistence practices, and related transformations of human attitudes.

How We Get There

The steps to achieving meaningful recovery of grizzly bears in the contiguous United States have been and will continue to be challenging. They are, nonetheless, self-evident. Without being comprehensive:

- First, the Interagency Grizzly Bear Committee (IGBC) and the U.S. Fish and Wildlife Service (USFWS) need to stop pushing relentlessly for removal of ESA protections for grizzly bears, regardless of the severity of threats and the status of populations. The fact that the State of Wyoming was agitating for delisting of Yellowstone's grizzly bear population in the mid-1980s, when this population was at its undisputed nadir, is emblematic of the on-going ideological rather than evidence-based agenda among wildlife managers.
- Second, the USFWS needs to revise its 1993 Grizzly Bear Recovery Plan to reflect the enormous amount of relevant science that has been produced during the past 26 years—including much that informs standards for judging viability of populations and species.
- Third, the USFWS needs to authoritatively embrace the need for functional connectivity among currently isolated populations of bears in both its planning and practice. Connectivity should no longer be represented as a hypothetical good, but rather as a necessary precondition for recovery.
- Fourth, grizzly bears need to be managed in perpetuity under federal auspices that preclude trophy hunting and other regressive management practices, encompassing provisions similar to those of the Bald Eagle Protection Act and the recently introduced Tribal Heritage and Grizzly Bear Protection Act (H.R. 2532).

Of relevance to more concrete on-the-ground measures in prioritized linkage areas and connectors:

- Fifth, highway and railway crossing infrastructure needs to be installed along heavily-trafficked transportation corridors.
- Sixth, enhancement of habitat security needs to be prioritized over resource extraction on public lands.
- Seventh, prudent measures designed to

prevent conflicts between grizzly bears and big game hunters need to be mandated on public lands.

- Eighth, public-land grazing allotments allocated to sheep need to be retired, and allotments designated for cattle need to be more closely regulated, including mandates for precautionary non-lethal measures designed to prevent conflicts between grizzly bears and livestock producers.
- Ninth, efforts on privately-owned agricultural lands to implement coexistence practices need to be more comprehensive as well as adequately and sustainably resourced.
- Tenth, efforts on private lands need to be substantially increased to reduce availability of attractants and to otherwise install a coexistence infrastructure. Where needed, these measures need to be mandated by state, county, and municipal governments.

Taken together, these measures would not only promote meaningful recovery of grizzly bears, but also yield numerous benefits for wildlands and other wildlife, while fostering much-needed reform in institutions and agencies governing natural resources management.

References

Mattson, D. J. 2016. Comments on the US Fish and Wildlife Service proposal to remove grizzly bears in the Yellowstone ecosystem from the list of endangered and threatened wildlife protected under the US Endangered Species Act (ESA); Federal Register 81(48): 13174-13227, and Related Materials. Grizzly Bear Recovery Project, Livingston, Montana. 73 pages plus attachments.

Mattson, D. J. 2018a. Declaration of David J. Mattson in Wildearth Guardians, a non-profit organization, plaintiff, vs. Ryan Zinke, as Secretary of the Department of the Interior; the United States Department of the Interior, a federal department; Greg Sheehan, as acting director of the U.S. Fish and Wildlife Service; and the United States Fish and Wildlife Service, a federal agency, Federal-Defendants. No. 17-cv-00118-DLC. 49p.

Mattson, D. J. 2018b. Testimony to the Senate Committee on Environment and Public Works, 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." 34p.

Mattson, D. J., et al. [72 other signatories]. 2018. Letter to the Honorable Matt Mead, Governor for the State of Wyoming, Re: Stay Wyoming's unscientific, drastic grizzly bear hunt for an outside peer-review process. 12p.

Mattson, D. J. 2019a. Effects of trains and railways on grizzly bears: an evaluation of the effects of increased train traffic on the Burlington Northern Santa Fe and Montana Rail-Link Railways, Montana-Idaho. Grizzly Bear Recovery Project Report GBRP-2019-1.

Mattson, D. J. 2019b. Heart of the Grizzly Bear Nation: an evaluation of the status of Northern Continental Divide grizzly bears. Grizzly Bear Recovery Project Report GBRP-2019-2.

Mattson, D. J. 2019c. Effects of pedestrians on grizzly bears: an evaluation of the effects of hikers, hunters, photographers, campers, and watchers. Grizzly Bear Recovery Project Report GBRP-2019-3.

Mattson, D. J. 2019d. Testimony to the Senate Committee on Environment and Public Works on the proposed "Promoting Resourceful and Effective Deterrents Against Threats Or Risks involving Species (PREDATORS) Act" (S. 2194), and larger challenges of non-lethal coexistence between grizzly bears and people. 9p.

Mattson, D. J. 2019e. Assessment of Kasworm et al. (2018) as applied in the Draft Supplemental Environmental Impact Statement Montanore Evaluation Project. Grizzly Bear Recovery Project, Livingston, Montana. 14p.

DR. FRANK LANCE CRAIGHEAD

My name is Frank Lance Craighead. I received a Ph.D. in Biological Sciences from Montana State University in 1994, an M.Sc. in Wildlife Ecology from the University of Wisconsin-Madison in 1976, and a B.A. in Biology from Carleton College, Minnesota, in 1969. My research has included authoring and co-authoring numerous professional papers and reports on grizzly bear ecology, including book chapters on grizzly bear metapopulations and genetic considerations for carnivore conservation in the Greater Yellowstone Ecosystem. I believe that my education in ecology, however, has been greatly augmented by travel; working in different cultures around the world on different animal species with different colleagues. The greatest lesson I have learned is that natural ecosystems have evolved over millennia to work efficiently to support and maintain biodiversity: the plants and animals and other species that comprise the ecosystem. We need healthy ecosystems in order to exist. Human population growth and habitat alteration has fragmented and damaged those ecosystems to the point where we have altered the world climate and produced a new wave of extinctions.

The Importance of Intact Ecosystems

Intact ecosystems which are not fragmented by human developments or degraded by human activities are important for many reasons. These include the provision of ecosystems services such as clean air and clean water, climate regulation, soil formation, nutrient cycling, and harvesting of food, fuel, fibers, and pharmaceuticals. Ecosystems also provide spiritual and psychological benefits. These benefits, like many others derived from wild places, cannot be exactly measured in traditional economic terms. We need to think about more than just dollars. We need to think about ecosystems.

To ensure that wildlife have sufficient habitat for population persistence into the future, and to confer resilience in the face of climate change and land use change, there must be an adequate amount of protected habitat available among the spectrum of lands that are accessible to those wildlife. The more permanent that protected habitat is, and the larger the area is, the more certainty there is that wildlife populations can persist. Fragmenting of natural areas into smaller pieces of protected habitat has greatly diminished its value for wildlife habitat and the provision of ecosystems services, and severely reduced its ability to function as a refuge from climate change.

How Much Habitat and How Many Bears?

The inevitable question about habitat protection is always; "How much is enough?" Before humans appeared on the scene in large enough numbers to disrupt ecosystems, we could say that 100% in 'natural' conditions appeared to be enough. Now that we've messed things up, E.O. Wilson estimates that we need at least 50% to maintain biodiversity and functioning ecosystems (Wilson 2016). Another way to figure out how much is enough is to see how much we need to maintain a wide-ranging, vulnerable species like the grizzly bear. If we have healthy grizzly populations (and perhaps a few other 'umbrella' species), then we have a healthy ecosystem. This begs the question; what is a healthy grizzly population?

Another way to phrase this, is what is a viable grizzly population? Mark Shaffer developed the overall systems concept of population viability in 1978 and explained that for a population to persist it needed to be large enough and diverse enough to survive random changes in genetics (genetic stochasticity), demographics (demographic stochasticity), environmental variables (environmental stochasticity), and wide-ranging catastrophic events. It also needed security from deterministic changes such as a continued loss of habitat (Shaffer 1981).

Shaffer originally suggested that a minimum viable population for Yellowstone grizzlies was 35-70 and revised that estimate to 70-100 grizzlies needed to have a 95% probability of surviving for 100 years (Shaffer 1978, 1980). These were early estimates using simple models and no serious biologist today would agree that 70-100 grizzlies are sufficient to maintain a population in isolation, or that 100 years is a reasonable time-frame for a keystone species like the grizzly to be allowed to exist. I include these early estimates to help illustrate how far the science has progressed since then. Gilpin and Soule (1981) refined Shaffer's approach and introduced the concept of extinction vertices resulting from feedback loops among the fields such that any decrease in one area such as population size also reduces genetic variability and so on (Gilpin and Soule 1986), and our understanding of extinction has increased steadily since then.

In this series of statements, Dr. Fred Allendorf explains our current understanding of the genetic diversity, and the demographic security, needed for grizzlies to persist for several hundred years, and has estimated that up to 5,000 grizzly bears may be necessary (Allendorf and Ryman, 2002). Dr. Lee Metzgar also emphasizes the large numbers and large areas needed to consider the grizzly population recovered. Dr. Brian Horejsi further addresses the inadequacy of government agency practices and regulations in Canada, to ensure that these large numbers of grizzlies, and large areas of habitat will persist. Dr. David Mattson provides a comprehensive review of the history of grizzly bear declines and the threats to their continued existence. He provides a blueprint for meaningful recovery under the existing legal framework. We all agree that the current situation does not provide enough habitat or large enough populations.

Connectivity

Two items of consensus among most conservation biologists are that: 1. existing protected areas within the Greater Yellowstone, Northern Continental Divide, Central Idaho (Selway-Bitterroot), and other U.S. Grizzly Bear Recovery Areas are too small individually to support a viable population over a long time frame (say 500-1000 years); 2. the only feasible way to provide enough habitat is to connect these recovery areas with protected habitat corridors so the animals can move between them and thus provide demographic and genetic connectivity.

Connectivity is therefore the main focus of habitat and population conservation efforts. Providing policy and regulatory frameworks to ensure this is also necessary. And none of this can happen without the understanding and support of local citizens in our United States and Canadian democracies.

Conclusion

Ensuring the survival of grizzly bears requires habitat; but habitat is disappearing as human populations expand, as humans alter the habitat, and as humans alter the climate which changes the habitat. In fact, humans are changing the environment so greatly, on a global scale, that many scientists are now referring

to this era in time as the Anthropocene, as summarized by Biello (2016). Whether you subscribe to the label of Anthropocene or not, human activities are now a part of the geologic record and sediments contain radiation that began with atomic bomb testing and intensified when Chernobyl melted down. That signal will last for perhaps 100,000 years. More recently, humans have blanketed the waters of the earth with microplastics that are also part of the sediment layer and may last indefinitely. The point I am trying to make is that humans are the cause of most of our environmental problems, including the current mass extinction event. Humans can also provide solutions, but in many places it is already too late. Here in the Rocky Mountain West we can still slow down our destruction of the environment and keep these critical ecosystems intact. We can start by continuing to protect the grizzly bear.

Literature Cited

Allendorf, F.W. and N. Ryman. 2002. The role of genetics in population viability analysis. In: Population Viability Analysis, S.R. Beissinger and D.R. McCullough (eds.) University of Chicago Press.

Biello, D. 2016. Humans Leave a Telltale Residue on Earth. Scientific American, January 7.

Craighead, F. Lance, M. Gilpin, and E.R. Vyse. 1999. Chapter 11: Genetic considerations for carnivore conservation in the Greater Yellowstone Ecosystem. In: Carnivores in Ecosystems. Clark, T., S. Minta, and P. Karieva (Eds.). Yale University Press.

Craighead, F. Lance, E.R. Vyse. 1996. Chapter 14: Brown and grizzly bear metapopulations. In: Metapopulations and Wildlife Conservation. D. McCullough (Ed.). Island Press. p. 325-351.

Gilpin, M. E., and M. E. Soule. 1981. Minimum Viable Populations: Processes of Species Extinctions. In: Conservation Biology – The Science of Scarcity and Diversity. Sinauer and Associates, Sunderland Mass. :19-34.

Shaffer, M. L. 1978. Determining minimum viable population sizes: A case study of the grizzly bear (Ursus arctos L.). Ph.D. Thesis. Duke Univ., Durham, N.C. 190p.

Shaffer, M. L. 1980. Determining minimum viable population sizes for the grizzly bear. In: Bears: Their Biology and Management. Vol. 5, A Selection of Papers from the Fifth International Conference on Bear Research and Management, Madison, Wisconsin, USA, February 1980 (1983), Int. Conf. Bear Res. and Manage. 5:133-139.

Shaffer, M.L. 1981. Minimum population sizes for species conservation. Bio-Science 31: 131-134.

Wilson, E.O. 2016. Half-Earth: Our Planet's Fight for Life. W.W. Norton and Company Ltd. London. 259p.