Environmental Law Centre
UNIVERSITY OF VICTORIA

Murray & Anne Fraser Building
PO Box 1700 STN CSC
Victoria, BC V8W 2Y2
Phone: 250.721.8188
Email: elc@uvic.ca
Web: www.elc.uvic.ca

# Protecting Granby Valley Grizzly Bears

## A Report for the Friends and Residents of the North Fork

**By Hiram Ng and Satinder Dhaliwal, Law Students**

**Supervised by Calvin Sandborn and Anthony Ho**

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## PART I. INTRODUCTION

One of Canada's leading symbols of wilderness is the grizzly bear. Grizzly populations worldwide are a mere shadow of what they were. The bears have lost approximately 98% of their historical range in the United States and Mexico.[1] In the US, grizzly bears now only occupy Alaska and a few small islands of habitat in the lower 48 US states.[2] Grizzlies once occupied nearly all of western Canada and much of the north and east, but now grizzlies remain in only 26% of Canada's land mass—in BC, Alberta, the Yukon, the Northwest Territories, and Nunavut.[3] British Columbia alone has half of Canada's grizzly population,[4] and we are fortunate to still have those grizzlies. However, even in BC, the Provincial Government has predicted that by 2065 BC grizzly bears will be extinct or threatened in 38% of their former ranges in the province.[5]

Grizzly bears are an iconic species of fundamental importance to the ecological, cultural and economic health of this province. However, Grizzly bears face a number of threats, for example:

- habitat loss due to expanding industrial, agricultural and residential development;
- habitat degradation due to global warming; and

[1] Don Morgan, "Grizzly Bear: Summary of objectives and knowledge for decision support", *Bulkley Valley Centre for Natural Resources Research and Management* (27 March 2013) at 4, online: <http://bvcentre.ca/files/integrated/Iskut_GrizzlyBear_Values_and_Knowledge.pdf>.
[2] Jeff Gailus, *Securing a National Treasure: Protecting Canada's Grizzly Bear* (Vancouver: David Suzuki Foundation, 2013) at 5.
[3] Jeff Gailus, *Securing a National Treasure: Protecting Canada's Grizzly Bear* (Vancouver: David Suzuki Foundation, 2013) at 5.
[4] Don Morgan, "Grizzly Bear: Summary of objectives and knowledge for decision support", *Bulkley Valley Centre for Natural Resources Research and Management* (27 March 2013) at 2, online: <http://bvcentre.ca/files/integrated/Iskut_GrizzlyBear_Values_and_Knowledge.pdf>.
[5] Horejsi, B. et al. British Columbia's Conservations Strategy: An Independent review of science and policy (Calgary: Western Wildlife Consulting, 1998) at 64.

- persistent organic pollutants (POPs) that accumulate in the bodies of apex predators like the grizzly.[6]

Hunting is a key threat to grizzly bears. Recently, as a result of the request that the ELC had made on behalf of David Suzuki Foundation, the Auditor General of British Columbia launched an investigation into the Province's management of the grizzly bear, including the grizzly bear hunt[7] (see Appendix A for the ELC's request).

One of the biggest threats facing grizzly bear populations in this province is logging and the construction of logging roads. Such roads fragment habitat, prevent genetic interchange, and facilitate intense hunting.[8] In the Granby Valley in southeastern BC, road construction and the lack of adequate and enforceable legal protection from increasing road density are directly threatening grizzly bear populations.

Therefore, this report compares the ways that BC and the United States laws protect grizzlies from road development -- and makes recommendations for reform in BC.

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[6] Christensen et al. "Hibernation-Associated Changes in Persistent Organic Pollutant (POP) Levels and Patterns in British Columbia Grizzly Bears (*Ursus arctos horribilis*)" (2007) online: <http://www.raincoast.org/files/publications/papers/ES-T-Hibernation-paper.pdf>.

[7] See: <http://davidsuzuki.org/media/news/2016/06/auditor-general-opens-investigation-of-bcs-controversial-grizzly-bear-trophy-hun/> and Liam Britten, "B.C. auditor general to look into grizzly hunt", *CBC News* (2 June 2016), online: <http://www.cbc.ca/news/canada/british-columbia/grizzly-hunt-auditor-general-1.3613961>.

[8] Canada, Committee on the Status of Endangered Wildlife in Canada, *COSEWIC Status Report on the Grizzly Bear Ursus arctos* (Ottawa: Environment Canada, 2002).

## PART II. THE VALUE OF THE ICONIC GRIZZLY BEAR

The BC government has called grizzly bears a symbol of the British Columbian wilderness.[9] This is undoubtedly true, but grizzlies are much more than a charismatic ambassador for the natural beauty of British Columbia—they are vital to the ecological, cultural and economic health of this province.

### A. Ecological Values

Grizzly bears are an important symbol of ecological integrity. They are an "umbrella species," meaning that the ecosystem health required to sustain populations of grizzly bears is the same as that which is required for a host of other species with similar requirements for large wilderness landscapes. Thus, a healthy grizzly bear population indicates a healthy ecosystem for other species such as lynx, wolf, wolverine, marten, and mountain caribou.[10] In addition to this key indicator role, grizzly bears also make significant contributions to sustaining the health of the ecosystems in which they live.

#### *1) Perpetuation of natural systems*

Grizzlies contribute to the perpetuation of natural systems in a number of important ways. They aid in plant reproduction and dispersal by transporting the seeds of plants and berries through

[9] British Columbia, Ministry of Water, Land and Air Protection, Grizzly Bears in British Columbia: Ecology, Conservation, Management (Victoria: Province of British Columbia, 2002) online: <http://a100.gov.bc.ca/pub/eirs/finishDownloadDocument.do?subdocumentId=863>.
[10] James Peek et al., "Management of Grizzly Bears in British Columbia: A Review by an Independent Scientific Panel" (2003) submitted to: Ministry of Land, Air and Water Protection, Government of British Columbia. Online: <http://www.env.gov.bc.ca/wld/documents/gbear_finalspr.pdf>.

their feces.[11] Grizzly bears also aid plant life by excavating the ground looking for tubers to consume, thereby creating fertile sites for pioneering plant species.[12] They help to maintain plant and forest health by "dispersing plant seeds and aerating the soil as they dig for roots, pine nuts and ground squirrels."[13]

Grizzlies are a "keystone species" – a species that has a disproportionately large effect on its environment because they play a critical role in maintaining the structure of the ecological community, affecting many other organisms in an ecosystem and helping to determine the types and numbers of various other species in the community. Grizzlies are "ecosystem engineers" that help to regulate populations of their prey (such as elk and deer) and plant species such as blueberry and buffalo berry.[14] Keeping the grizzly bear population healthy directly helps to "maintain abundant populations" of other species of animals. One estimate "indicates that by protecting grizzly bears in the Central Canadian Rockies, approximately 400 terrestrial vertebrate species will also be protected". Healthy grizzly populations also maintain healthy ecosystems and clean supplies of water for downstream users. [15]

Along salmon streams, grizzlies act as a key link in the transfer of nutrients from marine to terrestrial ecosystems -- by transporting the salmon they consume far inland from the streams

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[11] James Peek et al., "Management of Grizzly Bears in British Columbia: A Review by an Independent Scientific Panel" (2003) submitted to: Ministry of Land, Air and Water Protection, Government of British Columbia. Online: <http://www.env.gov.bc.ca/wld/documents/gbear_finalspr.pdf>.

[12] James Peek et al., "Management of Grizzly Bears in British Columbia: A Review by an Independent Scientific Panel" (2003) submitted to: Ministry of Land, Air and Water Protection, Government of British Columbia. Online: <http://www.env.gov.bc.ca/wld/documents/gbear_finalspr.pdf>.

[13] Jeff Gailus, *A Grizzly Challenge: Ensuring a Future for Alberta's Threatened Grizzlies* (Alberta Wilderness Association, 2010) at 7.

[14] Jeff Gailus, *A Grizzly Challenge: Ensuring a Future for Alberta's Threatened Grizzlies* (Alberta Wilderness Association, 2010) at 7.

[15] Jeff Gailus, *A Grizzly Challenge: Ensuring a Future for Alberta's Threatened Grizzlies* (Alberta Wilderness Association, 2010) at 7.

where they were caught, fertilizing the forest.[16] Incomplete consumption of salmon carcasses also provides food for scavenging species.[17]

### 2) *Interspecies interactions*

Grizzly diet varies with region and season, but includes a wide range of items. In the Central Coast of British Columbia, 65 food items were identified including plants, insects, mammals, salmon, and intertidal invertebrates.[18] The result of this diverse diet is a complex interrelationship among species that interact with the grizzly bear. As an apex predator, grizzly bears have inter-dependent relationships with prey species such as moose, caribou, elk, small mammals, muskoxen, mule deer and mountain goats, to name only a few, and human interference with these complex relationships can have unexpected results.[19]

An independent scientific panel commissioned by the BC government succinctly characterized the ecological importance of grizzly bears in their report:

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[16] G.V Hilderbrand et al. "Role of brown bears (*Ursus arctos*) in the flow of marine nitrogen into a terrestrial ecosystem." (1999) 121 *Oecologia* 546.

[17] Don Morgan, "Grizzly Bear: Summary of objectives and knowledge for decision support", *Bulkley Valley Centre for Natural Resources Research and Management* (27 March 2013), online: <http://bvcentre.ca/files/integrated/Iskut_GrizzlyBear_Values_and_Knowledge.pdf>.

[18] A.G. MacHutchon, S. Himmer, & C.A. Bryden. "Khutzeymateen Valley grizzly bear study: final report" (1993) Wildlife Report No. R-25, Wildlife Habitat Research Report No. 31. Ministry of Forests, Victoria, BC, online: <http://www.env.gov.bc.ca/wld/documents/gbear_finalspr.pdf>.

[19] S.D. Miller and W.B. Ballard. "Analysis of an effort to increase moose calf survivorship by increased hunting of brown bears in southcentral Alaska." (1992) 20 *Wildlife Society Bulletin* 445.

*If we fail to nurture grizzly bears and the conditions necessary for them to thrive, there can be little hope that functionally intact ecosystems will continue to support the diversity of life forms that enhance our lives and the human spirit.*[20]

## B. Cultural Values

Bears are important figures in story and ceremony in cultures around the world where they still exist,[21] and British Columbia is no different. The importance of bears to indigenous communities across North America, including British Columbia, has been documented by anthropologist David Rockwell,[22] and recently, many Aboriginal communities across British Columbia have publicly expressed serious concerns over the future of the grizzly bear and stressed its importance to their spiritual wellbeing in the past, present and future.

### *1) Social organization*

Many indigenous communities have grizzly bear houses or clans. For example, in the creation story of the Nuxalk people of Bella Coola, the Creator put their ancestors on earth in various animal cloaks, including the grizzly. To this day people are grouped into houses based on this ancestral connection, including the House of the Grizzly. Elder Elise Jacobs describes the effect of losing the species from which their ancestors originated:

[20] Canada, Committee on the Status of Endangered Wildlife in Canada, *COSEWIC Status Report on the Grizzly Bear* Ursus arctos (Ottawa: Environment Canada, 2002) at 5.
[21] Lydia T. Black, "Bear in Human Imagination and Ritual" (1998) 10 *Ursus* 343.
[22] D. Rockwell, Giving Voice to Bear: North American Indian Rituals, Myths, and Images of the Bear, ( Niwot, CO: Roberts Reinhart Publications, 1991).

*You can put on your dancing blanket and say that you're proud to be from the house of the grizzly bear, or you can put on your dancing blanket and say that your grandfather was a raven, or you can say that you are proud to be a killer whale... but what is happening to the grizzly bear? To the raven? To the killerwhale? They're getting kicked out of their house... what are you doing about it? And you put on your blanket and say you're proud? I don't think so. It doesn't work that way.*[23]

*2) Spiritual connection*

The Katzie people of the Pitt watershed claim a close relationship with the grizzly bears in their territory in the Upper Pitt watershed. The Katzie did not kill grizzlies for their meat, and would only occasionally take one for its hide, because the grizzlies are helpers of Khaals, an important figure in the creation story of the Katzie people. The Katzie could also distinguish between two distinct groups of grizzlies in their territory:

- One, to whom if they said its name, the grizzly would leave peacefully.
- Another, known as the "Sta'mx" or "warrior" grizzlies, who would kill strangers, but not Katzie people.[24]

The proposed Jumbo Ski Resort project in South Eastern BC has caused a strong reaction from the Ktunaxa people as the land on which the resort is proposed is a sacred place for the Grizzly Bear Spirit which provides them with guidance, strength, protection, and spirituality. The area is

[23] Nuxalk Nation, "Nuxalk Environment" (2012) online: Nuxalk Nation <http://www.nuxalknation.org/content/blogcategory/56/150/>.
[24] Katzie First Nation, "Katzie History" (2002) online: Katzie First Nation <http://www.katzie.ca/katzie_history_part_3.htm>.

also important for the grizzly bears living there now, and the Ktunaxa feel a strong stewardship obligation to the grizzlies within it.[25]

These are only a few examples of First Nations that share an important cultural connection with the grizzly bear—a connection that will be irrevocably damaged or even lost altogether if this species disappears.

*3) Symbolic value*

The grizzly is a vital cultural icon for non-Aboriginals as well. Consider that the symbol on the California state flag is still a grizzly, over a century after the last California grizzly died. Similarly, grizzlies are clearly part of the broader Canadian consciousness. It is this connection to grizzlies that gives grizzlies a high profile in popular culture. For example, the grizzly is a recurring symbol of strength and ferocity for sports teams in BC such as the former Vancouver Grizzlies NBA basketball team,[26] the Victoria Grizzlies Junior "A" hockey team,[27] and the Revelstoke Grizzlies Junior "B" hockey team.[28]

Along with orcas, grizzlies are the most vivid symbol of "SuperNatural" BC – one of the province's major tourism draws. Grizzlies are prominently featured in tourism advertising for BC[29] and can be found in public artwork,[30] company names[31], and the names of geographical

[25] Ktunaxa Nation, Qat'muk Declaration (2010) online: Ktunaxa Firat Nation <http://www.ktunaxa.org/news/documents/QatmukDeclaration.pdf>.
[26] "Grizzlies History" (2012) online: Memphis Grizzlies <http://www.nba.com/grizzlies/about/history.html>.
[27] Victoria Grizzlies (2012) online: <http://www.victoriagrizzlies.com/>.
[28] Revelstoke Grizzlies (2012) online: <http://www.revelstokegrizzlies.com/leagues/front_pageGrizzlies.cfm?clientID=4563&leagueID=15207>.
[29] British Columbia, "Bear Watching" online: Super, Natural British Columbia Canada <http://www.hellobc.com/british-columbia/things-to-do/parks-wildlife/bear-watching.aspx>.

features.[32] *National Geographic* has called the Great Bear Rain Forest the "wildest place in America," specifically citing the great forest's Kermode and grizzly bears.[33]

## C. Economic Values

The grizzly bear also represents an important resource for the health of the BC economy. All British Columbians gain from the economic benefits, but they are particularly important for more remote communities and First Nations economic development.

The two most obvious sources of economic benefit from grizzly bears are hunting and eco-tourism. A 2003 study by the Centre for Integral Economics and Raincoast Conservation Society calculated revenue generated by grizzly hunting guide outfitters at $3.3 million a year and revenue from grizzly viewing ecotourism was almost twice as much at $6.1 million a year.[34] A new study by the Center for Responsible Travel (CREST), looking specifically at the Great Bear Rainforest, found an even wider disparity—guided resident and non-resident hunters generated a combined $1.2 million in 2012, while bear-viewing expenditures for the same year were more than twelve times higher at $15.1 million.[35] The study also found that bear-viewing generated

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[30] See e.g. in Kelowna, online: <http://kelowna.ca/CM/Page2852.aspx>; in Vancouver's Stanley Park, online: <http://app.vancouver.ca/PublicArt_net/ArtworkDetails.aspx?ArtworkID=93&Neighbourhood=&Ownership=&Program>; in Revelstoke: <http://transcanadahighway.com/bc/Revelstoke.htm>.
[31] See e.g. Grizzly Transport Ltd, Surrey, online: <http://www.manta.com/ic/mt6b9mr/ca/grizzly-transport-limited>; Grizzly Springs Water Co Ltd, Penticton, online: <http://www.manta.com/ic/mtqspqd/ca/grizzly-springs-water-co-ltd>; Grizzly-Man Resource Management Ltd, Kamloops, online: <http://www.bcachievement.com/aboriginalbusiness/recipient.php?id=32>; Grizzly Security Ltd, Vancouver, online <http://www.profilecanada.com/companydetail.cfm?company=2211824_Grizzly_Security_Ltd_Vancouver_BC>.
[32] E.g. Grizzly Mountain, BC.
[33] Bruce Barcott, "Spirit Bear" *The National Geographic* (August 2011), online: National Geographic <http://ngm.nationalgeographic.com/2011/08/kermode-bear/barcott-text>.
[34] Z. Parker and R. Gorter, *Crossroads: Economics, Policy, and the Future of Grizzly Bears in British Columbia* (Victoria: Centre for Integral Economics and Raincoast Conservation Society, 2003).
[35] Center for Responsible Travel (CREST), *Economic Impact of Bear Viewing and Bear Hunting in The Great Bear Rainforest of British Columbia* (Washington, DC: Center for Responsible Travel (CREST), Janurary 2014), online:

more than eleven times more direct revenue for the BC government, and more than twelve times as many full-time equivalent jobs.[36] These figures suggest a significant expansion in bear-related ecotourism in recent years. A BC government report also notes the importance of non-consumptive activities associated with grizzly bears such as reading books, watching films, and purchasing toys, art, and crafts. That report estimated that 90% of provincial residents engage in these kinds of activities.[37]

Both hunting and ecotourism rely on sustainable management of grizzly bears to be economically viable in the long term; however, they are in competition for the same resource. As a result, ecotourism operators, particularly First Nations trying to build sustainable economies in remote parts of BC, are concerned that hunting will decrease or eliminate the viability of their operations. The Coastal First Nations, an alliance of First Nations on BC's North and Central Coast and Haida Gwaii, have expressed their opposition to the grizzly hunt, fearing it will jeopardize the sustainable industries they are developing to support their community, including guided bear viewing.[38] The debate over what role grizzlies will play in BC's economic future continues; but wherever that debate lands, the grizzly bear population has to be sustainable in order to be an economic driver, and British Columbians have a deep interest in making sure that their government's policy reflects this necessity.

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<http://www.responsibletravel.org/projects/documents/Economic_Impact_of_Bear_Viewing_and_Bear_Hunting_in_GBR_of_BC.pdf>.

[36] Center for Responsible Travel (CREST), *Economic Impact of Bear Viewing and Bear Hunting in The Great Bear Rainforest of British Columbia* (Washington, DC: Center for Responsible Travel (CREST), Janurary 2014), online: <http://www.responsibletravel.org/projects/documents/Economic_Impact_of_Bear_Viewing_and_Bear_Hunting_in_GBR_of_BC.pdf>.

[37] British Columbia, Ministry of Environment, Lands and Parks, *Conservation of Grizzly Bears in British Columbia: Background Report* (Victoria: Ministry of Environment, Lands and Parks, 1995).

[38] Pacific Wild, Media Release, "Imagine the Great Bear Rainforest without Bears" (18 March 2009) online: Pacific Wild <http://www.pacificwild.org/site/press/1237386238.html>.

Proper management of this resource may require a reduction in grizzly bear uses, such as hunting, to protect the species. However, this economic cost is made up in the long term by economic, cultural, and ecological benefits of ensuring that these bears are with us for years to come. As the BC Government Background Report stated in 1995:

> *Economic studies show that preservation (non-use) values are as large as use values, and typically larger. The preservation values that British Columbia residents place on grizzly bears likely exceed use values because hunting and viewing are limited activities. Most importantly, a large proportion of British Columbians place a value on knowing that grizzly bears occur and are a symbol of the relatively pristine wilderness thought to be a trademark of our province.*[39]

Whether or not British Columbians or tourists actually ever see a grizzly bear in the wild, many place a high value in the simple fact that we share our province with such rare and majestic creatures.

## PART III. GRANBY VALLEY GRIZZLIES

The Granby River valley is home to the Kettle-Granby population of grizzly bears that lives in a zone between the dry Okanagan and the wet Kootenays. The Granby River, located in southeastern BC, is a tributary that joins up with the Kettle River at the border town of Grand Forks. The river is roughly half-way in between the cities of Kelowna and Nelson.

[39] British Columbia, Ministry of Environment, Lands and Parks, *Conservation of Grizzly Bears in British Columbia: Background Report* (Victoria: Ministry of Environment, Lands and Parks, 1995).

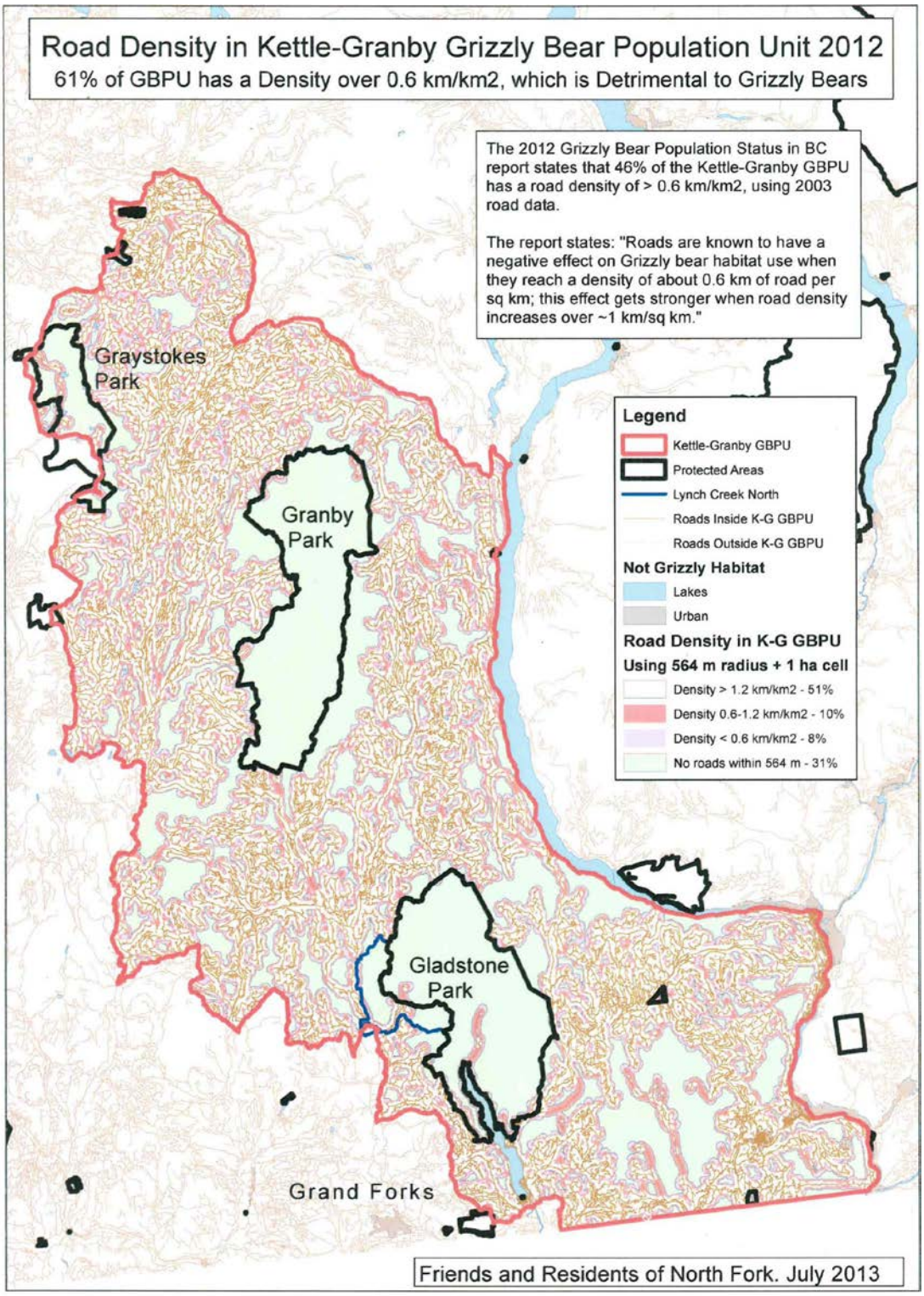


*Figure 1*: Road density in the Kettle-Granby Grizzly Bear Population Unit 2012. Based on 2003 road data, 46% of the habitat of the Kettle-Granby GBPU exceeded road density maximum of 0.6 km/km$^2$. By 2012, that figure has risen to 61%. Source: Friends and Residents of North Fork, July 2013 (Calculated by David Leversee based on 2012 roads data from the Ministry of Forests, Lands and Natural Resource Operations. Leversee is a GIS consultant and wildlife biologist with over 25 years' experience working with GIS data and maps, including mapping in Great Bear Rainforest, Haida Gwaii, Vancouver Island and other locations in B.C.).

Of the 56 designated "Grizzly Bear Population Units" (GBPUs) across the province, 47 are considered "Viable", while 9 are considered "Threatened" (the population is less than 50% of what the area could support).[40] Significantly, the Kettle-Granby grizzly has been highlighted as one of the nine threatened populations of grizzly bears.

In 1994, two parks were established northeast of Grand Forks. Granby Provincial Park and Gladstone Provincial Park were created in large part to "protect core grizzly habitat."[41] Research has shown that large carnivores such as grizzly, wolf, and wolverine require extensive ranges for survival. Parks like the Granby and Gladstone offer "some protection, but are too small to provide secure and suitable habitat for such far-ranging species."[42]

In 1997, a scientific study by the BC government suggested that habitat around the two parks was at the time adequate to sustain a small population of grizzly bears. However, according to the Granby Wilderness Society, the landscape has since then seen radical changes. Many of the "roadless and intact forests outside the parks no longer exist" and as a result the Kettle-Granby grizzly is "suffering from the loss of critical habitat."[43]

Figure 1 above below shows a map of the Granby and Glastone Provincial Parks, situated within the habitat of the Kettle-Granby Grizzly Bear Population Unit. Aside from the Graystokes, Granby, and Gladstone Provincial Parks, and pockets of roadless areas, most of this population's

[40] Don Morgan, "Grizzly Bear: Summary of objectives and knowledge for decision support", Bulkley Valley Centre for Natural Resources Research and Management (27 March 2013), online: <http://bvcentre.ca/files/integrated/Iskut_GrizzlyBear_Values_and_Knowledge.pdf>.
[41] "Grizzly Bears: A majestic creature faces extinction in some BC and Alberta populations (2008)", online: <https://www.wildernesscommittee.org/sites/all/files/publications/grizzly_ntl_park_web.pdf>.
[42] "Grizzly Bears: A majestic creature faces extinction in some BC and Alberta populations (2008)", online: <https://www.wildernesscommittee.org/sites/all/files/publications/grizzly_ntl_park_web.pdf>.
[43] "Grizzly Bears: A majestic creature faces extinction in some BC and Alberta populations (2008)", online: <https://www.wildernesscommittee.org/sites/all/files/publications/grizzly_ntl_park_web.pdf>.

habitat has been subject to intense fragmentation by roads. Based on road data from 2012, approximately 61% of the range of Kettle-Granby population has road densities of over 0.6 km/km$^2$.[44] As will be discussed further in the next Part, current science indicates that this is the threshold beyond which road densities would have a significant adverse effect on the population viability of grizzly bears.

The blue outline in Figure 1 next to Gladstone Park shows an area known as Lynch Creek North, which, at the time the map was created, was subject to a plan by BC Timber Sales to open up for logging operations.[45] Since then, logging has begun in parts of that area.[46] Environmentalists are concerned that additional road construction beside the protected park would further exacerbate the already dire habitat fragmentation that threatens the Kettle-Granby grizzlies.[47]

Dr. Brian Horejsi, a wildlife scientist and forester, says that "unless government changes course and restricts logging in a wildlife corridor that links the two parks, grizzlies will slowly fade away in the mountainous landscape north of Grand Forks".[48] According to a 2013 *Globe and Mail* article, at that time there were currently about 85 grizzlies in what is known as the Granby

[44] Calculated by David Leversee based on 2012 roads data from the Ministry of Forests, Lands and Natural Resource Operations. Leversee is a GIS consultant and wildlife biologist with over 25 years' experience working with GIS data and maps, including mapping in Great Bear Rainforest, Haida Gwaii, Vancouver Island and other locations in B.C.

[45] Mark Hume, "Activists ask BC Timber to postpone logging plans", *Globe and Mail* (4 June 2013), online: <http://www.theglobeandmail.com/news/british-columbia/activists-ask-bc-timber-to-postpone-logging-plans/article12329512/>.

[46] David Leversee, personal communication, June 15, 2016.

[47] Mark Hume, "Activists ask BC Timber to postpone logging plans", *Globe and Mail* (4 June 2013), online: <http://www.theglobeandmail.com/news/british-columbia/activists-ask-bc-timber-to-postpone-logging-plans/article12329512/>.

[48] Mark Hume, "Land-use decisions will determine fate of Granby and Gladstone grizzly populations", *The Globe and Mail* (25 August 2013), online: <http://www.theglobeandmail.com/news/british-columbia/land-use-decisions-will-determine-fate-of-granby-and-gladstone-grizzly-populations/article13946505/>.

population.[49] They roam the forests in and around the two provincial parks. The parkland is protected, but outside the boundaries, the forest is being cut up into smaller and smaller pieces. In a report written for Friends and Residents of the North Fork, Dr. Horejsi says the bear population is already marginal because a breeding population of 100 to 400 bears is needed to assure long-term survival.[50] Furthermore, Dr. Horejsi believes that "the Granby-Gladstone grizzly-bear population and the landscape it depends on are in crisis," and that protecting the habitat for the grizzlies would require a "total withdrawal of road building and forest-management activities in landscape units."[51]

## PART IV. IMPACTS OF ROAD DENSITY

### A. Road Density Effects on Wildlife in General

Habitat conversion, degradation and fragmentation, hunting and the introduction of exotic species are among the primary factors causing loss of biodiversity. Road density is a "valuable indicator of these anthropogenic factors".[52] There are many reports suggesting that, in general, roads negatively affect many wildlife species. As road density increases, so does the likelihood of native species extirpation. The "probability of extirpation is correlated to body size, with

[49] Mark Hume, "Land-use decisions will determine fate of Granby and Gladstone grizzly populations", *The Globe and Mail* (25 August 2013), online: <http://www.theglobeandmail.com/news/british-columbia/land-use-decisions-will-determine-fate-of-granby-and-gladstone-grizzly-populations/article13946505/>.
[50] Mark Hume, "Land-use decisions will determine fate of Granby and Gladstone grizzly populations", *The Globe and Mail* (25 August 2013), online: <http://www.theglobeandmail.com/news/british-columbia/land-use-decisions-will-determine-fate-of-granby-and-gladstone-grizzly-populations/article13946505/>.
[51] Mark Hume, "Land-use decisions will determine fate of Granby and Gladstone grizzly populations", *The Globe and Mail* (25 August 2013), online: <http://www.theglobeandmail.com/news/british-columbia/land-use-decisions-will-determine-fate-of-granby-and-gladstone-grizzly-populations/article13946505/>.
[52] Beazley K et al. *Road Density and Potential Impacts on Wildlife Species such as American Moose in Mainland Nova Scotia* (Halifax: School for Resource and Environmental Studies Dalhousie, 2004).

larger animals such as grizzly bears becoming extirpated at lower road densities."[53] Field studies suggest that medium and large-sized vertebrates—including moose, grizzly bears, and also white-tailed deer—are adversely affected by increasing road density.[54] Roads can harm wildlife by "fragmenting [their] habitat and isolating [the] animals from needed resources.[55]

Moreover, roads cause habitat avoidance behaviour in animals, disrupting natural ranging patterns and leading to the fragmentation of populations and habitat, which altogether result in changes in species distributions and population viability.[56] Populations are fragmented into smaller subpopulations, which are vulnerable to environmental and demographic fluctuations, inbreeding depression and associated losses of genetic variability, and ultimately local extirpation.[57]

Beazley suggests that there is a maximum or threshold road density for a "naturally functioning landscape containing sustained populations" of large mammals.[58] Above this threshold, some large mammal populations decline due to disturbance effects and increased mortality.[59] Average

[53] Beazley K et al. *Road Density and Potential Impacts on Wildlife Species such as American Moose in Mainland Nova Scotia* (Halifax: School for Resource and Environmental Studies Dalhousie, 2004).
[54] Beazley K et al. *Road Density and Potential Impacts on Wildlife Species such as American Moose in Mainland Nova Scotia* (Halifax: School for Resource and Environmental Studies Dalhousie, 2004).
[55] "Decommissioning old roads", Conservation Northwest (2013), online: <http://www.conservationnw.org/what-we-do/northcascades/decommissioning-removing-old-roads>.
[56] Don Morgan, "Grizzly Bear: Summary of objectives and knowledge for decision support", Bulkley Valley Centre for Natural Resources Research and Management (27 March 2013), online: <http://bvcentre.ca/files/integrated/Iskut_GrizzlyBear_Values_and_Knowledge.pdf>.
[57] Don Morgan, "Grizzly Bear: Summary of objectives and knowledge for decision support", Bulkley Valley Centre for Natural Resources Research and Management (27 March 2013), online: <http://bvcentre.ca/files/integrated/Iskut_GrizzlyBear_Values_and_Knowledge.pdf>.
[58] Beazley K et al. *Road Density and Potential Impacts on Wildlife Species such as American Moose in Mainland Nova Scotia* (Halifax: School for Resource and Environmental Studies Dalhousie, 2004).
[59] Beazley K et al. *Road Density and Potential Impacts on Wildlife Species such as American Moose in Mainland Nova Scotia* (Halifax: School for Resource and Environmental Studies Dalhousie, 2004).

road density of 0.6 km/km$^2$ across a landscape has been identified as an apparent threshold value above which natural populations of certain large vertebrates would decline.[60]

## B. Road Density Impacts on Grizzly Bears

Research shows that roads and human activity associated with roads "have a range of direct and indirect impacts on grizzly bears and their habitat".[61] These effects include increased risk of mortality (e.g., from hunting, traffic), exposure to anthropogenic foods, change in bear behavior, habitat loss, habitat alteration, habitat displacement, habitat fragmentation, and population fragmentation.[62] Scientific evidence indicates that "the most crucial element in grizzly bear recovery is providing adequate amounts of secure habitat".[63] In this regard, road densities play a crucial role in maintaining secure and un-fragmented habitat -- with "0.6 km of road per square kilometer of area being the [maximum] threshold for secure habitat."[64]

In particular, it is significant to note that "the majority of human-caused mortality of grizzly bears occurs near roads or human occupied areas."[65] One study found that "85% of mortalities in the Central Rockies ecosystem of Alberta and British Columbia occurred within 500 m of roads

[60] Beazley K et al. *Road Density and Potential Impacts on Wildlife Species such as American Moose in Mainland Nova Scotia* (Halifax: School for Resource and Environmental Studies Dalhousie, 2004).
[61] Grant MacHutchon & Michael Proctor, *The Effect of Roads and Human Action on Roads on Grizzly Bears and their Habitat* (Trans-Border Grizzly Bear Project, 2015) at 1.
[62] Grant MacHutchon & Michael Proctor, *The Effect of Roads and Human Action on Roads on Grizzly Bears and their Habitat* (Trans-Border Grizzly Bear Project, 2015) at 1.
[63] Jeff Gailus, *Securing a National Treasure: Protecting Canada's Grizzly Bear* (Vancouver: David Suzuki Foundation, 2013) at 19.
[64] Jeff Gailus, *Securing a National Treasure: Protecting Canada's Grizzly Bear* (Vancouver: David Suzuki Foundation, 2013) at 19.
[65] Grant MacHutchon & Michael Proctor, *The Effect of Roads and Human Action on Roads on Grizzly Bears and their Habitat* (Trans-Border Grizzly Bear Project, 2015) at 3.

and front country developments and 200 m around trails and backcountry developments."[66] High levels of road density also fragment grizzly bear habitat—vehicle traffic and human activity on roads or trails "may influence bears strongly enough to make some habitat fragments unavailable or no longer effective habitat for bears."[67] Meanwhile, roads and rights-of-ways "can act as a barrier of movement because of (a) removal of vegetative security cover, (b) human behavior on roads, or (c) traffic volume, timing, and pattern."[68] These effects are severe. A recent study found that grizzly bear survival "improved as secure habitat and elevation increased but declined as road density, number of homes, and site developments increased."[69] Furthermore, the study's result "strongly supported previous research that identified roads and developed sites as hazards to grizzly bear survival."[70]

Having more roads results in increased wildlife road kills and injuries. First, roads have a high ability of heating up, which is attractive to animals such as grizzly bears for "basking [and] can increase incidence of road kill."[71] Second, there are increased death rates for grizzly bears and injuries because roads create a platform for easy access to hunting, trapping, and poaching areas. Third is loss of "species, habitat and vegetation and a further diminished habitat suitability adjacent" to roads, which is triggered by "edge effects".[72] Finally there is increased human

[66] Grant MacHutchon & Michael Proctor, *The Effect of Roads and Human Action on Roads on Grizzly Bears and their Habitat* (Trans-Border Grizzly Bear Project, 2015) at 3.
[67] Grant MacHutchon & Michael Proctor, *The Effect of Roads and Human Action on Roads on Grizzly Bears and their Habitat* (Trans-Border Grizzly Bear Project, 2015) at 5.
[68] Grant MacHutchon & Michael Proctor, *The Effect of Roads and Human Action on Roads on Grizzly Bears and their Habitat* (Trans-Border Grizzly Bear Project, 2015) at 5.
[69] Schwartz, C.C., M.A. Haroldson, and G.C. White, "Hazards affecting grizzly bear survival in the greater Yellowstone ecosystem" (2010) 74:654-667 Journal of Wildlife Management at 654.
[70] Schwartz, C.C., M.A. Haroldson, and G.C. White, "Hazards affecting grizzly bear survival in the greater Yellowstone ecosystem" (2010) 74:654-667 Journal of Wildlife Management at 654.
[71] "Access Management and Resource Roads: 2015 Update", Forests Practices Board (April 2015), online: <https://www.bcfpb.ca/sites/default/files/reports/SR49-Access-Management.pdf>.
[72] United States, United States Department of Agriculture Forest Service, *Assessment of the Flathead National Forest Part 1* (Montana: USDA Forest Service, 2014) at 162.

disturbance of sensitive wildlife caused by factors such as "noise, traffic movement and lights" which results in habitat effectiveness being degraded.[73] In addition to this there are "contaminant emissions (e.g., road salt, oil, gasoline, metals, or other chemicals), noise and other disturbances [which] may extend into roadside vegetation for varying distances."[74]

## PART V. CROSS-JURISDICTIONAL COMPARISON

In this Part, we compare the legal protection and management practices for grizzly bear populations in British Columbia and the United States. First, we compare and contrast the legal regimes applicable to grizzly bear protection in the two jurisdictions generally. Then, we focus on the particular topics of managing road densities, decommissioning/deactivating roads within grizzly bear habitats, and managing roads within the context of the mountain pine beetle epidemic. The lessons we derive through the cross-jurisdictional comparison below lead to the recommendations that we set out in Part VI.

### A. Legal Protection of Grizzly Bear

There is no single piece of legislation that applies to the protection of wildlife such as grizzly bears in BC. Instead, there are a number of federal and provincial legislation and policy frameworks that are relevant to the protection of grizzly bears in this province.

The *Species at Risk Act* (*SARA*) provides the federal legislative framework for the protection of endangered and threatened species in Canada. The *SARA* establishes a two-step procedure for the

[73] United States, United States Department of Agriculture Forest Service, *Assessment of the Flathead National Forest Part 1* (Montana: USDA Forest Service, 2014) at 162.
[74] United States, United States Department of Agriculture Forest Service, *Assessment of the Flathead National Forest Part 1* (Montana: USDA Forest Service, 2014) at 162.

listing of wildlife. First, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) uses scientific knowledge to classify wildlife species as extinct, extirpated, endangered, threatened or of special concern.[75] Second, taking into account COSEWIC's recommendation, the government may amend Schedule 1 to the *SARA* and place a wildlife species within the legal protection of the statute.[76] Legal protection of a species is only triggered if the second step is taken—*i.e.*, the government adds a species onto Schedule 1. At present, COSEWIC has designated the Western population of grizzly bear (of which the Kettle-Granby population is a part) as a species of special concern.[77] However, since the government has not added grizzly bear onto Schedule 1, the *SARA* does not offer any legal protection to grizzly bear.

The BC Conservation Data Centre (BCCDC), which is part of the BC Ministry of Environment, collects and disseminates information on wildlife in BC.[78] The BCCDC also categories species into Red, Blue, and Yellow lists based upon their Conservation Status Rank.[79] The grizzly bear is a Blue Listed species,[80] meaning that it is a species of special concern in BC.[81] However, the BCCDC's designation of species into Red, Blue, and Yellow lists carries no force of law, and such listing, by itself, does not give the listed species any legal protection.

Provincial legislation for the protection of wildlife consists of a number of different statutes. One of the most important statutes in this regard is the *Wildlife Act*, which offers legal protection to

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[75] *Species at Risk Act*, S.C. 2002, c. 29, s. 15.
[76] *Species at Risk Act*, S.C. 2002, c. 29, s. 27.
[77] Government of Canada, Species at Risk Registry, Species Profile – Grizzly Bear Western population, online: <https://www.registrelep-sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=1195>.
[78] *Government of BC*, B.C. Conservation Data Centre Home, *online:* <http://www.env.gov.bc.ca/cdc/>.
[79] *Government of BC*, FAQs: Red, Blue and Yellow Lists, *online:* <http://www.env.gov.bc.ca/atrisk/faq3.html>.
[80] BC Conservation Data Centre, Ursus arctos, online: <http://a100.gov.bc.ca/pub/eswp/speciesSummary.do?id=16065>.
[81] Government of BC, *Glossary*, online: <http://www.env.gov.bc.ca/atrisk/glossary.html>.

wildlife in BC such as the grizzly bear from direct harm except as allowed by regulation.[82] Also, under the *Wildlife Act*, species that have been legally designated as an endangered or threatened species are offered additional protection.[83] However, grizzly bears are not legally designated as an endangered or threatened species under the *Wildlife Act*.

Aside from the *Wildlife Act*, another piece of relevant provincial legislation is the *Forest and Range Practices Act* (*FRPA*). Pursuant to the *Government Actions Regulation* under the *FRPA*, the government may identify a wildlife species as a "species at risk" if satisfied that the species are endangered, threatened or vulnerable.[84] Under the auspices of this provision, BC has designated grizzly bear as a "species at risk" for the purpose of the *FRPA*.[85] In addition, the *FRPA*, the *Government Actions Regulation*, and the *Forest Planning and Practices Regulation* together allow the government to create Wildlife Habitat Areas (WHAs) that meet the habitat requirements of a category of species at risk, and to set out wildlife objectives that are necessary to protect or conserve the species.[86]

*The US Approach*

In contrast to the relatively weak protection offered to grizzly bears in BC, section 7 of the US *Endangered Species Act* (*ESA*) plays a powerful role protecting US grizzly populations. This is because the grizzly bear is listed as a threatened species under the *ESA*.[87] On a general level, the

[82] *Wildlife Act*, R.S.B.C. 1996, c. 488.
[83] E.g., *Wildlife Act*, R.S.B.C. 1996, c. 488, ss. 5, 6, 26, 78.
[84] *Government Actions Regulation*, BC Reg 582/2004, s. 13(1).
[85] Order – Category of Species at Risk, online: <http://www.env.gov.bc.ca/wld/documents/identified/approved_sar_order_list.pdf>.
[86] *Forest and Range Practices Act*, S.B.C. 2002, c. 69, s. 149.1(1)(a)(ii); *Government Actions Regulation*, BC Reg 582/2004, ss. 9-10; *Forest Planning and Practices Regulation*, BC Reg 14/2004, s. 7(1).
[87] National Park Service, *Grizzly Bears and the Endangered Species Act*, <https://www.nps.gov/yell/learn/nature/bearesa.htm>.

*ESA* "directs all Federal agencies to work to conserve endangered and threatened species and to use their authorities to further the purposes of the Act".[88] And section 7 of the Act specifically requires that:

> *Each Federal agency shall… insure that any action…by the agency is not likely to jeopardize the continued existence of any endangered species or threatened species.*

Section 7 of the *ESA* is "the mechanism by which Federal agencies ensure the actions they take, including those they fund or authorize, do not jeopardize the existence of any listed species."[89] Under section 7, all Federal agencies "must consult with the U.S. Fish and Wildlife Service (Service) when *any action* the agency carries out, funds, or authorizes (such as through a permit) may affect a listed endangered or threatened species."[90]

This process usually begins as an informal process where a Federal agency in the early stages of project planning approaches the Service and requests informal consultation – discussions between the two agencies may include what types of listed species may occur in the proposed action area, and what effect the proposed action may have on those species.[91] If it appears that the agency's action "may affect a listed species, that agency may then prepare a biological assessment to assist in its determination of the project's effect on a species."[92] When a Federal agency determines, through a biological assessment or other review, that its action is "likely to

[88] United States, United States Fish & Wildlife Service, *Section 7 Consultation* (Endangered Species, 2016) <http://www.fws.gov/Midwest/endangered/section7/section7.html>.
[89] United States, United States Fish & Wildlife Service, *Section 7 Consultation* (Endangered Species, 2016) <http://www.fws.gov/Midwest/endangered/section7/section7.html>.
[90] United States, United States Fish & Wildlife Service, *Section 7 Consultation* (Endangered Species, 2016) <http://www.fws.gov/Midwest/endangered/section7/section7.html>.
[91] United States, United States Fish & Wildlife Service, *Section 7 Consultation* (Endangered Species, 2016) <http://www.fws.gov/Midwest/endangered/section7/section7.html>.
[92] United States, United States Fish & Wildlife Service, *Section 7 Consultation* (Endangered Species, 2016) <http://www.fws.gov/Midwest/endangered/section7/section7.html>.

adversely affect a listed species, the agency submits to the Service a request for formal consultation."[93] During formal consultation, the Service and the agency "share information about the proposed project and the species likely to be affected."[94]

In making a determination on whether an action will result in jeopardy, the Service "begins by looking at the current status of the species", as well as "various effects – direct, indirect, interrelated, and interdependent – of the proposed Federal action."[95] The Service also "examines the cumulative effects of other non-Federal actions that may occur in the action area, including state, tribal, local, or private activities that are reasonably certain to occur in the project area."[96] The Service's analysis is then "measured against the definition of jeopardy"—which under the *ESA* occurs when "an action is reasonably expected, directly or indirectly, to diminish a species' numbers, reproduction, or distribution so that the likelihood of survival and recovery in the wild is appreciably reduced."[97]

Thus, U.S. companies seeking federal approval to conduct logging in grizzly habitat must go through the s. 7 regulatory process—and must avoid activities that would reasonably be expected to "jeopardize" the species. In other words, they must not carry out activities that would directly

[93] United States, United States Fish & Wildlife Service, *Section 7 Consultation* (Endangered Species, 2016) <http://www.fws.gov/Midwest/endangered/section7/section7.html>.
[94] United States, United States Fish & Wildlife Service, *Section 7 Consultation* (Endangered Species, 2016) <http://www.fws.gov/Midwest/endangered/section7/section7.html>.
[95] United States, United States Fish & Wildlife Service, *Section 7 Consultation* (Endangered Species, 2016) <http://www.fws.gov/Midwest/endangered/section7/section7.html>.
[96] United States, United States Fish & Wildlife Service, *Section 7 Consultation* (Endangered Species, 2016) <http://www.fws.gov/Midwest/endangered/section7/section7.html>.
[97] United States, United States Fish & Wildlife Service, *Section 7 Consultation* (Endangered Species, 2016) <http://www.fws.gov/Midwest/endangered/section7/section7.html>.

or indirectly "diminish a species' numbers, reproduction, or distribution so that the likelihood of survival and recovery in the wild is appreciably reduced."[98]

## B. Road Density Thresholds

As discussed above, neither the federal *SARA* nor the provincial *Wildlife Act* recognizes grizzly bear as an endangered or threatened species. Therefore, any avenues under those statutes to incorporate legally enforceable road density thresholds to protect grizzly bear habitat are foreclosed. However, the Province of BC can implement enforceable road density thresholds as part of the wildlife objectives of a WHA, particularly since, as mentioned earlier, grizzly bear is recognized as a species-at-risk for the purpose of the provincial *FRPA*.[99] In the Granby Valley, the Province has established Wildlife Habitat Area 8-373 for the protection of the Kettle-Granby grizzly bear population, with an accompanying *Government Actions Regulation* Order 8-373 that sets out general wildlife measures for the WHA (see Figure 2 below).[100] The problem is that the Order does not contain any legal *requirements* to limit road density. It limits itself to a non-enforceable Appendix 2 that lays out "Recommended Management Guidelines" of 0.6 km/km$^2$ that is utterly unenforceable—as shown in Figure 1 above, approximately 61% of the habitat of the Kettle-Granby population already exceed this 0.6 km/km$^2$ threshold.

[98] Interview with Joe Scott on February 9, 2016. Joe Scott is the International Programs Director at Conservation Northwest.
[99] *Forest and Range Practices Act*, S.B.C. 2002, c. 69, s. 149.1(1)(a)(ii); *Government Actions Regulation*, BC Reg 582/2004, ss. 9-10; *Forest Planning and Practices Regulation*, BC Reg 14/2004, s. 7(1).
[100] Order – General Wildlife Measures #8-373, online: http://www.env.gov.bc.ca/wld/documents/wha/URAR_8-373_Ord.pdf.

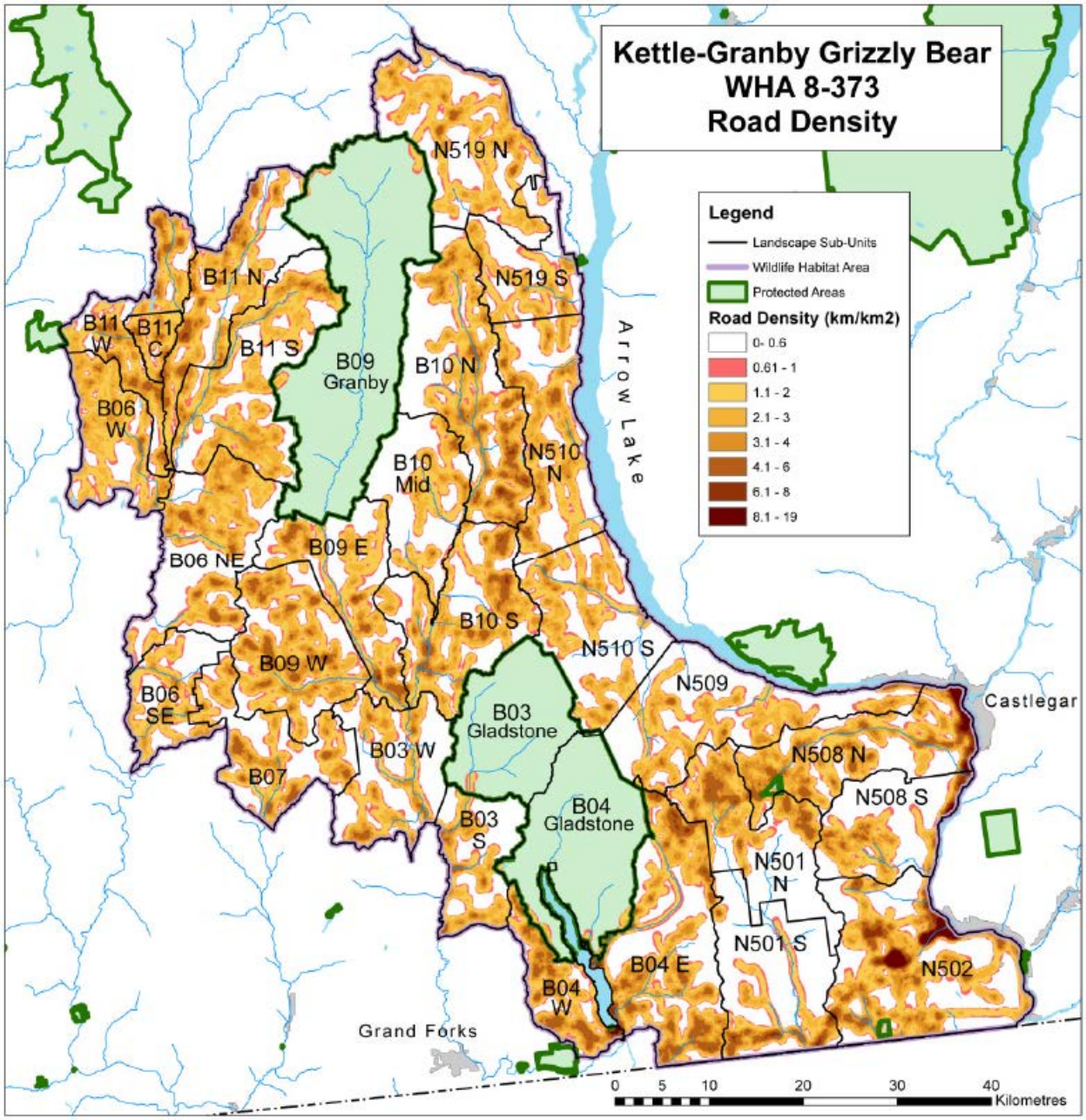


*Figure 2*: This map shows the boundaries of WHA 8-373, which are almost identical to the range of the Kettle-Granby Grizzly Bear Population Unit (see Figure 1). As with Figure 1, this map shows the extent to which this grizzly population's habitat has been fragmented by roads.
Source: Margaret Steele, *Save the Threatened Kettle-Granby Grizzly Bear*, prepared for the Friends and Residents of the North Fork (31 March 2014) at 7.

In contrast, the legal regime in the United States provides for strong, legally enforceable road density thresholds.[101] Due to the listing of grizzly bear under the *ESA*, there is a robust process that federal agencies must go through in making decisions about road density standards.[102] Once the road density thresholds are set, they largely stand as enforceable rules, with the potential option to change—and often improve—them as science changes.[103] While the numerical thresholds for road density maximums in the United States are sometimes slightly higher than what we see in BC guidelines, these BC density thresholds are not meaningful because they are not codified into any legally enforceable standards.

In contrast, due to s. 7 ESA requirements, United States Forest Plans provide legally enforceable road density thresholds for the protection of grizzly bears.[104] Road density thresholds in US Forest Plans were originally based on the recommendations of a taskforce that was created by the Interagency Grizzly Bear Committee (IGBC)[105] in the mid-1990's.[106] This task force had two goals: (1) to summarize the science around the issue of road density and grizzly bear populations, and (2) to give biologists a standardized set of metrics to come up with the standards in question.[107]

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[101] Interview with Bill Gaines on February 29, 2016. Bill Gaines was a US Forest Service biologist and a member of the IGBC North Cascades Tech team. He also had a large part in the Okanogan Wenatchee Forest Plan Revision.
[102] Interview with Bill Gaines on February 29, 2016. Bill Gaines was a US Forest Service biologist and a member of the IGBC North Cascades Tech team. He also had a large part in the Okanogan Wenatchee Forest Plan Revision.
[103] Interview with Bill Gaines on February 29, 2016. Bill Gaines was a US Forest Service biologist and a member of the IGBC North Cascades Tech team. He also had a large part in the Okanogan Wenatchee Forest Plan Revision.
[104] Interview with Bill Gaines on February 29, 2016. Bill Gaines was a US Forest Service biologist and a member of the IGBC North Cascades Tech team. He also had a large part in the Okanogan Wenatchee Forest Plan Revision.
[105] Today, aside from various federal and state agencies, the members of the IGBC also include the BC Wildlife Branch, Alberta Wildlife Branch, and Parks Canada: Interagency Grizzly Bear Committee, "IGBC FAQs", online: <http://igbconline.org/about-us/igbc-faqs/>.
[106] Interview with Bill Gaines on February 29, 2016. Bill Gaines was a US Forest Service biologist and a member of the IGBC North Cascades Tech team. He also had a large part in the Okanogan Wenatchee Forest Plan Revision.
[107] Interview with Bill Gaines on February 29, 2016. Bill Gaines was a US Forest Service biologist and a member of the IGBC North Cascades Tech team. He also had a large part in the Okanogan Wenatchee Forest Plan Revision. The

Aside from US Forest Plans that set out enforceable maximum allowable road densities, there are also four Grizzly Bear Recovery Zones established for large regions of the United States, such as the North Cascades Recovery Zone in Washington State. The maximum densities in all Grizzly Bear Recovery Zones are less than 1.1 mile of road per square mile of forest (1.1 mi/mi$^2$ = 0.68 km/km$^2$, which, as indicated above, is slightly higher than the 0.6 km/km$^2$ non-legally enforceable threshold often used in BC guidelines, such as those attached to the WHA Order for the Granby Valley discussed above).[108] Each Recovery Zone is subsequently divided into Bear Management Units (BMUs). Each BMU must have "core security habitats", which are based on scientific requirements for bear habitat.[109] Seventy percent of a BMU has to be "core security habitat", which means that the area is roadless and free of human uses.[110] The definition of human uses include heavily used trails.[111]

There is a Recovery Plan for each of the four Recovery Zones. These Recovery Plans set out the maximum road densities permitted within the Zone. While all of the density thresholds in these Recovery Plans are below 1.1 mi/mi$^2$, the actual threshold allowed in each Zone can vary, often depending on the prevailing scientific knowledge at the time the Recovery Plans were written.[112] Current science now illustrates that the maximum road density should be no more than 0.7

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taskforce recommended a four-step procedure for "evaluating motorized access effects on grizzly bear habitat": (1) delineate the analysis area(s); (2) develop access route density maps; (3) Identify existing/potential core areas; and (4) define acceptable level(s) of motorized access. -- Interagency Grizzly Bear Committee, *Interagency Grizzly Bear Committee Taskforce Report – Grizzly bear/Motorized Access Management* (Revised 1998) at 4-5.

[108] Interview with Joe Scott on February 9, 2016. Joe Scott is the International Programs Director at Conservation Northwest.

[109] Interview with Joe Scott on February 9, 2016. Joe Scott is the International Programs Director at Conservation Northwest.

[110] Interview with Joe Scott on February 9, 2016. Joe Scott is the International Programs Director at Conservation Northwest.

[111] Interview with Joe Scott on February 9, 2016. Joe Scott is the International Programs Director at Conservation Northwest.

[112] Interview with Joe Scott on February 9, 2016. Joe Scott is the International Programs Director at Conservation Northwest.

mi/mi$^2$.[113] For example, the new North Cascades Recovery Plan that is currently being developed will have to adopt a maximum road density of 0.7 mi/mi$^2$ -- or face a likely successful court challenge by environmental groups.[114] Note that this new US standard of 0.7 mi/mi$^2$ works out to actually be a lower road density than even the *putative and non-enforceable* 0.6 km/km$^2$ guideline BC has used.

Most significant, the US maximums—unlike BC's—are actually legally enforceable. The *ESA* requires that the road density contained in any new Forest Plan or Recovery Plan reflect the scientific knowledge at the time such Plans are written. As the Act prohibits actions that would "jeopardize" the species, the Forest Service by law must not set out a road density threshold that would adversely impact the survival or recovery of grizzly bear populations.[115]

Older US Recovery Plans and Forest Plans have higher road density thresholds only because, at the time the plan was created, the prevailing science had indicated that these road densities would not jeopardize a listed species. However, when revisions to old Plans are done, the revised Plans too will have to incorporate the newer, more stringent road density threshold.[116]

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[113] Interview with Joe Scott on February 9, 2016. Joe Scott is the International Programs Director at Conservation Northwest.
[114] United States, United States Fish & Wildlife Service, *Section 7 Consultation* (Endangered Species, 2016) <http://www.fws.gov/Midwest/endangered/section7/section7.html>. If this stringent maximum is not adopted, environmental groups would be able to sue for a violation of the *ESA*'s section 7 prohibition of jeopardizing a listed species.
[115] United States, United States Fish & Wildlife Service, *Section 7 Consultation* (Endangered Species, 2016) <http://www.fws.gov/Midwest/endangered/section7/section7.html>.
[116] Beazley K et al. *Road Density and Potential Impacts on Wildlife Species such as American Moose in Mainland Nova Scotia* (Halifax: School for Resource and Environmental Studies Dalhousie, 2004).

## C. Road Decommissioning/Deactivation

Provincial legislation in BC offers very little protection for grizzly bear populations in the context of making decisions about deactivating or decommissioning roads in the forestry sector that may affect grizzly bear habitats. The *Forest Planning and Practices Regulation* (*FPPR*) under the *FRPA* provides the following mandatory requirements during road deactivation:

> 82 (1) A person who deactivates a road must do the following:
> (a) barricade the road surface width in a clearly visible manner to prevent access by motor vehicles, other than all-terrain vehicles;
> (b) remove bridge and log culvert superstructures and stream pipe culverts;
> (c) remove bridge and log culvert substructures, if the failure of these substructures would have a material adverse effect on downstream property, improvements or forest resources;
> (d) stabilize the road prism or the clearing width of the road if the stabilization is necessary to reduce the likelihood of a material adverse effect in relation to one or more of the subjects listed in section 149 (1) of the Act.[117]

Clearly, these requirements under s. 82(1) would not prevent people from accessing the road. In fact, it specifically contemplates allowing all-terrain vehicles continued access. The Forest Practices Board recommends that "it may be prudent to undertake deactivation works that anticipate some level of continued motorized use until the road fully brushes in or consider re-designating the road as a recreation trail if appropriate."[118] Neither would these provisions ensure that grizzly bear populations would not be impacted by deactivated roads that continue to contribute to road density in grizzly habitat.

A forestry company that maintains a road can decide to keep it as a wilderness road rather than to deactivate a road altogether. In fact, according to an audit by the BC Forest Practices Board

[117] *Forest Planning and Practices Regulation*, B.C. Reg. 14/2004, s. 82(1).
[118] Forest Practices Board, *Access Management and Resource Roads: 2015 Update Special Report* (April 2015) at 23, online: <https://www.bcfpb.ca/sites/default/files/reports/SR49-Access-Management.pdf>.

released in 2015, three-quarters of roads authorized under forestry road permits are currently being maintained as wilderness roads.[119] In these circumstances, while the company is no longer required to maintain the road to the normal standards set out in the *FPPR*, it must still "ensure there is no material adverse effect on a forest resource."[120] However, neither the *FRRP* nor the *FRPA* contains a definition of "forest resource", so it is not certain whether wildlife such as grizzly bear falls under the definition of a "forest resource." Under the former *Forest Practices Code of British Columbia Act*, which has now been largely repealed except for a handful of sections, the definition of "forest resource" was broad enough to encompass grizzly bears:

> ***"forest resources"*** *means resources and values associated with forests and range including, without limitation, timber, water, wildlife, fisheries, recreation, botanical forest products, forage and biological diversity.*[121]

Currently, one of the ways in which the Province can ensure that decisions about road deactivation or decommission are made in a way that is protective of grizzly bear habitats would be to include stringent requirements as "wildlife measures" for a WHA. In the Granby Valley, where the government has established WHA 8-373 for the protection of grizzly bears, there is no requirements regarding road decommissioning found within the government order setting out legally enforceable wildlife measures.[122]

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[119] Forest Practices Board, *Access Management and Resource Roads: 2015 Update Special Report* (April 2015) at 23, online: <https://www.bcfpb.ca/sites/default/files/reports/SR49-Access-Management.pdf>.
[120] *Forest Planning and Practices Regulation*, B.C. Reg. 14/2004, s. 81(a).
[121] *Forest Practices Code of British Columbia Act*, R.S.B.C. 1996, c. 159, s. 1, as repealed by *Administrative Tribunals Statutes Amendment Act, 2015*, S.B.C. 2015, c. 10, s. 90.
[122] Order – General Wildlife Measures #8-373, online: <http://www.env.gov.bc.ca/wld/documents/wha/URAR_8-373_Ord.pdf>.

In the United States, road decommissioning practices are much more stringent where Forest Plans containing grizzly bear management objectives apply. One good example is the way in which the US Forest Service has been decommissioning roads within the Flathead National Forest, which is located in Montana just south of the BC-Montana and Alberta-Montana borders. In 1995, the Forest Service approved *Forest Plan Amendment #19*. In it, the Forest Supervisor established objectives for reducing road densities within areas of the forest covered by Bear Management Units (BMU), such as limiting road densities that are greater than 1 mi/mi$^2$ to no more than 19% of a BMU subunit within 5 years.[123] Between 1995 and 2015, 787 miles of roads have been decommissioned within the Flathead National Forest.[124] Unlike a "deactivated" road within the BC legislative context, which may involve nothing more than barricading the road, a "decommissioned" road within the definition of the Forest Plan for the Flathead National Forest requires the "stabilization and restoration of an unneeded road to a more natural state."[125] In this way, decommissioning a road would ameliorate the adverse impacts of the road on grizzly bears much more effectively than deactivating a road in the BC context.

## D. Mountain Pine Beetle

One of the impacts facing grizzly bear populations in BC involves the effects of the government's logging policies to combat the mountain pine beetle epidemic. As evidenced in a 2012 *Vancouver Sun* article, the mountain pine beetle epidemic is hailed as "unprecedented in North American history" and described as "biblical plagues of mountain pine beetles sweeping

[123] United States Forest Service, *Flathead National Forest – Forest Plan Amendment #19* (March 1995) at 4, online: <http://merid.org/~/media/Files/Projects/FNF/General%20Resources/Amendment19Grizzly%20Bear%20Habitat%20Mgt.pdf>.
[124] United States Forest Service, *DEIS for the revised forest plan for the Flathead National Forest – Volume 2* (May 2016) at 38, online: <http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd502199.pdf>.
[125] United States Forest Service, *Proposed Action—Revised Forest Plan – Flathead National Forest* (March 2015) at 157, online: <http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3831332.pdf>.

across the Interior landscape in dark clouds, leaving a dead zone."[126] In response, the government fought back with an "equally aggressive salvage-logging strategy, initially to try to stop the beetle's spread, and then to harvest as much dead wood as possible before it decayed or burned."[127] Massive clear-cuts occurred in those zones deemed to be at risk and permits that would normally take a long time were fast-tracked for approval.[128] Critics have argued that the beetle has become an excuse to obtain logging approvals for areas of timber that companies would not normally be able to harvest.

The provincial government has wide discretion in allowing companies to log infested areas. Under the *Forest Act*, the provincial Cabinet may designate Crown land infested by mountain pine beetles as a mountain pine beetle salvage area for a prescribed period and allow logging to take place.[129] Moreover, there is no legal requirement to limit the density of logging roads built to access these infested areas, and no requirement to conduct environmental assessment to determine the predicted impact of such salvage logging on grizzly bears.

In contrast to BC, the United States has protective processes to prevent companies from using the mountain pine beetle threat as an excuse to log valuable timber stands. First, any proposal by the US Forest Service to allow salvage logging in an area that may affect a listed species under the *ESA* must be assessed and approved by the US Fish and Wildlife Service (USFWS).[130] Therefore, the USFWS can restrict road density in salvage logging areas in order to protect

[126] Larry Pynn, "The environmental costs of BC's logging war on pine beetles", The Vancouver Sun (September 2012), online: <http://www.vancouversun.com/technology/Part+wake+plague/5800904/story.html>.
[127] Larry Pynn, "The environmental costs of BC's logging war on pine beetles", The Vancouver Sun (September 2012), online: <http://www.vancouversun.com/technology/Part+wake+plague/5800904/story.html>.
[128] Larry Pynn, "The environmental costs of BC's logging war on pine beetles", The Vancouver Sun (September 2012), online: <http://www.vancouversun.com/technology/Part+wake+plague/5800904/story.html>.
[129] *Forest Act*, R.S.B.C. 1996, c. 157, s. 14.1(1).
[130] David J. Willms, "The Mountain Pine Beetle: How Forest Mismanagement and a Flawed Regulatory Structure Contributed to an Uncontrollable Epidemic" (2010) 10(2) *Wyoming Law Review* 487 at 496-498.

grizzly bear populations. Second, proposals to allow salvage logging can also trigger the *National Environmental Policy Act* (which is the environmental assessment statute in the USA).[131] In BC no equivalent processes exist that forestry companies must follow before they log in an infested area. There is no scientific process to distinguish between necessary salvage logging and logging that may be motivated more by potential financial gain than by good ecosystem management.

## PART VI. RECOMMENDATIONS

Ever-increasing road densities are threatening the grizzly bear population in the Granby Valley. The current legal and policy regimes in BC to protect the Kettle-Granby grizzly bear population has not been effective at limiting road density. The road density maximum of 0.6 km/km$^2$ that the Province has set out for the Kettle-Granby wildlife habitat area is simply not legally enforceable. As a result, approximately 61% of the habitat of the Kettle-Granby grizzlies already exceed this 0.6 km/km$^2$ threshold. Moreover, provincial practices with regards to road decommissioning and logging in mountain pine beetle infested areas do not take adequate account of road density effects on grizzly populations.

In contrast, legal protection of the grizzly bear is more stringent in the United States. A grizzly bear that wonders across the border from BC to the United States benefits from much greater legal protection, including:

- legally enforceable road density maximums based on current scientific knowledge;

[131] David J. Willms, "The Mountain Pine Beetle: How Forest Mismanagement and a Flawed Regulatory Structure Contributed to an Uncontrollable Epidemic" (2010) 10(2) *Wyoming Law Review* 487 at 499-502.

- road decommissioning practices that restores habitat to a natural state; and
- greater procedural safeguards before a government agency can allow salvage logging in mountain pine beetle infested areas.

Based on the cross-jurisdiction comparison of grizzly bear protection in BC and the United States, we propose the following three recommendations in order to better maintain a viable population of grizzly bears in the Granby Valley:

1. The Province of British Columbia should implement legally enforceable road density thresholds for all Wildlife Habitat Areas that are established for the protection of grizzly bears.[132] In particular, the Province should establish a legally enforceable road density threshold of no greater than 0.6 km/km$^2$ for WHA 8-373 in order to protect the viability of the Kettle-Granby Grizzly Bear population.

2. The Province of BC should require road deactivation within grizzly bear habitat to involve stabilization and restoration of the road to a natural state.

3. The Province of BC should establish a regulatory process through which salvage logging operations in mountain pine beetle infested areas should be carefully assessed, with due consideration taken in regards to the potential adverse impacts of road density increases that may be associated with such logging operations on grizzly bear populations.

[132] Using its authority to establish wildlife objectives for Wildlife Habitat Areas under s. 10(2) of the *Government Actions Regulation* and s. 7 of the *Forest Planning and Practices Regulation* and other statutory powers.

## APPENDIX A: REQUEST TO THE AUDITOR GENERAL FOR A GRIZZLY AUDIT

Environmental Law Clinic
UNIVERSITY OF VICTORIA

Murray & Anne Fraser Building
PO Box 1700 STN CSC
Victoria, BC V8W 2Y2
Phone: 250.721.8188
Email: elc@uvic.ca
Web: www.elc.uvic.ca

Our file: 2011-03-19

October 27, 2014

Carol Bellringer
Auditor General of British Columbia
8 Bastion Square
Victoria, BC V8V 1X4

Dear Ms. Bellringer:

**RE: REQUEST FOR AN AUDIT AND EXAMINATION OF THE FAILURE OF THE MINISTRY OF ENVIRONMENT TO CARRY OUT ITS DUTY TO SUSTAINABLY MANAGE HUMAN-CAUSED MORTALITY OF GRIZZLY BEARS.**

## Introduction

On behalf of the David Suzuki Foundation[1], we hereby request that you undertake an examination of the failure of the government of British Columbia's grizzly bear management policy to adequately protect the species from human-caused overmortality.

Attached are letters supporting this request from Valhalla Wilderness Society, Yellowstone to Yukon Conservation Initiative, BC Nature/Federation of BC Naturalists, Taku River Tlingit First Nation, Kitasoo/Xai'xais Nation, Bears Forever and the Coastal First Nations Working Group on Bears. (See Appendix A.)

This request is specifically requested because recent peer-reviewed evidence published in an international science journal has revealed widespread, frequent and significant failures of the province to keep mortality below the upper limits that their own policy and procedures deem as sustainable.

We urge you to undertake this examination pursuant to:

- Section 11 (8) of the *Auditor General Act* (the "*Act*"), and specifically under your authority to report on whether government is operating economically, efficiently and effectively; and
- Section 13 of the *Act*, under your authority to conduct an examination respecting government, if it is in the public interest to do so.

The requested examination should consider whether government policies and actions regarding grizzly bear stewardship are consistent with:

- the following statutory purposes of the Ministry of Environment as set out in the *Ministry of Environment Act*:

- "to encourage and maintain an optimum quality environment through specific objectives for the management and protection of land, water, air and living resources of British Columbia;
- to undertake inventories and to plan for and assist in planning, as required, for the effective management, protection and conservation of all water, land, air, plant life and animal life;
- to manage, protect and conserve all water, land, air, plant life and animal life, having regard to the economic and social benefits they may confer on British Columbia;
- to set standards for, collect, store, retrieve, analyze and make available environmental data".[2]

- the objectives of the Ministry of Environment set out in its 2013/14 - 2015/16 Service Plan:
  - "encouraging and maintaining the effective protection, management, and conservation of B.C.'s water, land, air, and living resources ...
  - tak[ing] a leadership role in engaging with stakeholders, First Nations and industry in sharing the stewardship of our environment ...
  - monitoring, assessing, and reporting on environmental conditions."[3]

Grizzly bears are an iconic species of fundamental importance to the ecological, cultural and economic health of this province. They are a unique and invaluable public resource that government has a duty to conserve. Adequately managing human-caused mortality is critical to conserving this species for the benefit of future generations and the survival of the ecosystems on which they depend.

Attached in Appendix B is a recent peer-reviewed study that demonstrates that the BC government's current policy does not provide sufficient protection for grizzly bears from mortality by human causes. Even when the policy is followed, human-caused mortality exceeds the limits set by the government itself. The pertinent findings of this study are outlined in this report.

Grizzly bears face a number of threats, for example, habitat loss due to expanding industrial, agricultural and residential development, habitat degradation due to global warming and genetic isolation due to road development.[4] However, direct human-caused mortality is the most obvious and easily controlled threat to the species' survival and in most areas it is the greatest cause of grizzly mortality.[5] As such, proper management of this direct mortality is crucial to protecting the species as a whole. The BC government's failure to do so is a failure to properly steward a public resource of great importance to British Columbians and a failure to operate "economically, efficiently and effectively" as per s.11(8) of the *Auditor General Act*.

Grizzly bears live and die as a public resource on Crown land. It is in the public interest that this resource with great ecological, cultural and economic significance not be lost or diminished. It is clearly in the public interest that grizzly bears be managed properly - and that their management be transparent to the public eye. It follows that it is also in the public interest for the Auditor General to investigate whether public resources are being wasted on policies that try, but ultimately fail, to protect this valuable species.

The argument for why the Auditor General should investigate this matter is presented below as follows:

1. The significance of grizzly bears to British Columbians;

2. The current state of the species;
3. Evidence of a failing grizzly policy in BC;
4. The Auditor General's legal authority to investigate;
5. Conclusion.

## 1. The Significance of Grizzly Bears to British Columbians

The BC government has called grizzly bears a symbol of the British Columbian wilderness.[6] This is undoubtedly true, but grizzlies are much more than a charismatic ambassador for the natural beauty of British Columbia - they are a vital species to the ecological, cultural and economic health of this province.

### *Ecological*

Grizzly bears are an important symbol of ecological integrity. They are an "umbrella species," meaning that the ecosystem health required to sustain populations of grizzly bears is the same that is required for a host of other species with similar requirements for large landscapes. Thus, a healthy grizzly bear population indicates a healthy ecosystem for other species such as the lynx, wolf, wolverines, marten, and mountain caribou.[7] In addition to this symbolic role, grizzly bears also make significant contributions to sustaining the health of the ecosystems in which they live.

#### Perpetuation of natural systems

Grizzlies contribute to the perpetuation of natural systems in a number of important ways. They aid in plant reproduction and dispersal by transporting the seeds of plants and berries through their feces.[8] Grizzly bears also aid plant life by excavating the ground looking for tubers to consume, thereby creating fertile sites for pioneering plant species.[9]

Research has shown that grizzlies act as a key link in the transfer of nutrients from marine to terrestrial ecosystems by transporting the salmon they consume far inland from the streams where they were caught, fertilizing the forest.[10] Incomplete consumption of salmon carcasses also provides food for scavenging species.[11]

#### Interspecies interactions

Grizzly diet varies with region and season, but includes a wide range of items. In the Central Coast of British Columbia, 65 food items were identified including plants, insects, mammals, salmon, and intertidal invertebrates.[12] The result of this diverse diet is a complex interrelationship among species that interact with the grizzly bear. As an apex predator, grizzly bears have inter-dependent relationships with prey species such as moose, caribou, elk, small mammals, muskoxen, mule deer and mountain goats, to name only a few, and human interference with these complex relationships can have unexpected results.[13]

An independent scientific panel commissioned by the BC government succinctly characterised the ecological importance of grizzly bears in their report:

> *If we fail to nurture grizzly bears and the conditions necessary for them to thrive, there can be little hope that functionally intact ecosystems will continue to support the diversity of life forms that enhance our lives and the human spirit.*[14]

### *Cultural*

Bears are important figures in story and ceremony in cultures around the world where they still exist,[15] and British Columbia is no different. The importance of bears to indigenous communities across North America, including British Columbia, has been documented by anthropologist David Rockwell,[16] and recently, many Aboriginal communities across British Columbia have publicly expressed serious concerns over the future of the grizzly bear and stressed its importance to their spiritual wellbeing in the past, present and future.

#### Social organization

Many indigenous communities have grizzly bear houses or clans. For example, in the creation story of the Nuxalk people of Bella Coola, the Creator put their ancestors on earth in various animal cloaks, including the grizzly. To this day people are grouped into houses based on this ancestral connection, including the House of the Grizzly. Elder Elise Jacobs describes the effect of losing the species from which their ancestors originated:

> *You can put on your dancing blanket and say that you're proud to be from the house of the grizzly bear, or you can put on your dancing blanket and say that your grandfather was a raven, or you can say that you are proud to be a killer whale... but what is happening to the grizzly bear? To the raven? To the killerwhale? They're getting kicked out of their house... what are you doing about it? And you put on your blanket and say you're proud? I don't think so. It doesn't work that way.*[17]

#### Spiritual connection

The Katzie people of the Pitt watershed claim a close relationship with the grizzly bears in their territory in the Upper Pitt watershed. The Katzie did not kill grizzlies for their meat, and would only occasionally take one for its hide, because the grizzlies are helpers of Khaals, an important figure in the creation story of the Katzie people. The Katzie could also distinguish between two distinct groups of grizzlies in their territory:

- One, to whom if they said its name, the grizzly would leave peacefully.
- Another, known as the "Sta'mx" or "warrior" grizzlies, who would kill strangers, but not Katzie people.[18]

The proposed Jumbo Ski Resort project in South Eastern BC has caused a strong reaction from the Ktunaxa people as the land on which the resort is proposed is a sacred place for the Grizzly Bear Spirit which provides them with guidance, strength, protection and spirituality. The area is also important for the grizzly bears living there now, and the Ktunaxa feel a strong stewardship obligation to the grizzlies within it.[19]

These are only a few examples of First Nations that share an important cultural connection with the grizzly bear – a connection that will be irrevocably damaged or even lost altogether if this species disappears.

### Symbolic value

The grizzly is a vital cultural icon for non-Aboriginals as well. Consider that the symbol on the California state flag is still a grizzly, over a century after the last California grizzly died. Similarly, grizzlies are clearly part of the broader Canadian consciousness. It is this connection to grizzlies that gives grizzlies a high profile in popular culture. The grizzly is a recurring symbol of strength and ferocity for sports teams in BC such as the former Vancouver Grizzlies NBA basketball team,[20] the Victoria Grizzlies Junior "A" hockey team,[21] and the Revelstoke Grizzlies Junior "B" hockey team.[22]

Along with orcas, grizzlies are the most vivid symbol of "SuperNatural" BC – one of the province's major tourism draws. Grizzlies are prominently featured in tourism advertising for BC[23] and can be found in public artwork,[24] company names[25] and the names of geographical features.[26] *National Geographic* has called the Great Bear Rain Forest the "wildest place in America," citing the great forest's kermode and grizzly bears.[27]

### *Economic*

The grizzly bear also represents an important resource for the health of the BC economy. All British Columbians gain from the economic benefits, but they are particularly important for more remote communities and First Nations economic development.

The two most obvious sources of economic benefit from grizzly bears are hunting and eco-tourism. A 2003 study by the Centre for Integral Economics and Raincoast Conservation Society calculated revenue generated by grizzly hunting guide outfitters at $3.3 million a year and revenue from grizzly viewing ecotourism was almost twice as much at $6.1 million a year.[28] A new study by the Center for Responsible Travel (CREST), looking specifically at the Great Bear Rainforest, found an even wider disparity – guided resident and non-resident hunters generated a combined $1.2 million in 2012, while bear-viewing expenditures for the same year were more than twelve times higher at $15.1 million.[29] The study also found that bear-viewing generated more than eleven times more direct revenue for the BC government, and more than twelve times as many full-time equivalent jobs.[30] These figures suggest a significant expansion in bear-related ecotourism in recent years. A BC government report also notes the importance of non-consumptive activities associated with grizzly bears such as reading books, watching films and purchasing toys, art and crafts. That report estimated that 90% of provincial residents engage in these kinds of activities each year.[31]

Both hunting and ecotourism rely on sustainable management of grizzly bears to be economically viable in the long term; however, they are in competition for the same resource. As a result, ecotourism operators, particularly First Nations trying to build sustainable economies in remote parts of BC, are concerned that hunting will decrease or eliminate the viability of their operations. The Coastal First Nations, an alliance of First Nations on BC's North and Central Coast and Haida Gwaii, have expressed their opposition to the grizzly hunt, fearing it will jeopardize the sustainable industries they are developing to support their community, including guided bear viewing.[32] The debate over what role grizzlies will play in BC's economic future continues; but wherever that debate lands, the grizzly bear population has to be sustainable in order to be an economic driver, and British Columbians have a deep interest in making sure that their government's policy reflects this necessity.

Proper management of this resource may require a reduction in grizzly bear uses, such as hunting, to protect the species. However, this economic cost is made up in the long term economic, cultural and

ecological benefits of ensuring these bears are with us for years to come. As the BC Government Background Report stated in 1995, "[e]conomic studies show that preservation (non-use) values are as large as use values, and typically larger. The preservation values that British Columbia residents place on grizzly bears likely exceed use values because hunting and viewing are limited activities. Most importantly, a large proportion of British Columbians place a value on knowing that grizzly bears occur and are a symbol of the relatively pristine wilderness thought to be a trademark of our province."[33]

Whether or not British Columbians or tourists actually ever see a grizzly bear in the wild, many place a high value in the simple fact that we share our province with such rare and majestic creatures.

## 2. Current State of the Species

The grizzly bear population worldwide is a mere shadow of its former self, having lost an estimated 50% of its former range and abundance since the mid-1800s, and it has been eliminated from 98% of its historical range in the United States and Mexico.[34] In Canada, the grizzly bear historically occupied nearly all of western Canada and much of the east, but now the grizzly remains in only 26% of Canada's land mass, in BC, Alberta, the Yukon, the Northwest Territories and Nunavut.[35]


*Former and current grizzly bear range. From "Grizzly Bear Current and Historic Range Map" by Sightline Institute, Copyright 2006 Sightline Institute; used with permission.*

In 2002, the Committee on the Status of Endangered Wildlife in Canada estimated the Canadian grizzly population at 26,000 bears,[36] the majority of which were found in BC. The most recent published BC government estimate in 2012 pegs the grizzly population at 15,075 bears.[37] However, as will be discussed later in this report, it is hard to know if this is even accurate, as population estimates are very uncertain. Moreover, when new and better information becomes available, population estimates are regularly reduced.

Grizzlies occupy an area of approximately 750,000 km$^2$ - yet "protected" areas (Provincial and National parks) where resource extraction is prohibited covers only 9.5% of that. Provincial parks cover 8.9% of

grizzly range, but hunting is allowed in nearly all of them. Rare no-hunting zones for grizzlies include the Khutzeymateen Provincial Park of 443 km$^2$, created explicitly as a grizzly sanctuary,[38] and 470,000 hectares in the Great Bear Rainforest that are closed to grizzly hunting (although 53% of the Great Bear remains open to hunters).[39]

The BC government has designated 56 Grizzly Bear Population Units ("GBPUs") across the province as an organizing tool for grizzly management. Only 47 are currently considered "Viable" by the province, while 9 are considered "Threatened" (the population is less than 50% of what the area could support).[40] This does not include the 10% of their former range in BC from which grizzlies have been extirpated.[41]

The long-term decline of grizzlies paints an unsettling picture. There are a number of different threats to the grizzly bear population that have led to these extirpations in BC and beyond, and continue to threaten grizzlies with the prospect of further population declines.

### *Threats to Grizzly Bears in BC*

Human-caused mortality is the greatest threat facing populations of grizzly bears. Natural mortality does contribute to overall mortality, but most (i.e., > 85%) grizzlies die from human-caused mortality in nearly all regions, including within protected areas.[42]

Grizzly bears face a number of different human-caused threats to their continued survival in the province. These include:

1. habitat loss and fragmentation due to agricultural, residential and industrial development, climate change and roads;[43]
2. reduction in habitat effectiveness due to proximity to humans;[44]
3. persistent organic pollutants (POPs) that accumulate in the bodies of apex predators like the grizzly;[45] and
4. direct human-caused morality including hunting, animal control kills and vehicle collisions.[46]

Grizzlies are especially vulnerable to these threats because of their particular biology and behaviour. Their low reproductive and dispersal rates make populations of grizzly bears very sensitive to population declines and incredibly difficult to manage. Their heightened sensitivity to human activity means that unhabituated bears will avoid zones of human activity, even if the quality of the habitat itself is not otherwise reduced.[47]

Of all human causes of mortality, licensed hunting accounted for around 84% Canada wide in 2002.[48] Hunting pressure is also the easiest source of mortality to predict and control, and therein lies its central importance to grizzly bear management. The fate of populations of grizzly bears around the province rests on whether the BC government adequately manages human-caused mortality.

## 3. Evidence of a Failing Policy Regarding Grizzly Bear Mortality in BC

### *Uncertainty in Population Estimates - A Foundation of Sand*

The BC government sets "annual allowable mortality" ("AAM") for each Grizzly Bear Population Unit in the province. This represents the allowable mortality due to human causes for each year. AAM is generally set at 6% of the population within each of the 49 viable Grizzly Bear Population Units ("GBPU"), unless a conservation rationale supports the use of a higher or lower limit.[49] In 2010, 50% of the province's viable GBPUs were set at 6% maximum allowable human-caused mortality, 24% were set at 5%, and 26% were set at 4%. The policy also states that no greater than 30% of the AAM can consist of female bears. A series of calculations called "step-downs" are then used to remove other sources of mortality, such as First Nations harvest and unreported mortality, to reach the Annual Allowable Harvest (AAH) rate, or the number of bears that are allocated for hunting.[50] The BC government has claimed this system of management results in "conservative" mortality levels - however numerous studies have questioned this conclusion.[51]

In 1995, the BC government's own policy document "A Future for the Grizzly: British Columbia Grizzly Bear Conservation Strategy" expressed "concerns that in some areas population estimates have been inaccurate and have led to the over-hunting of grizzly bears" and promised an accelerated program of population research to improve population estimates and confidence in indirect methods of estimating population density.[52] It is clear that in 1995 the government itself had concerns over its methods of estimating population and admitted that uncertainty in these estimates had led to over-hunting.

This concern was again expressed in 1998, this time in an Independent Review of Science and Policy by independent scientists Horejsi, Gilbert and Craighead. The study outlined a history of population estimation errors from 1972 to 1998. Despite changing methods of population estimation over this time, significant errors still occurred -- including some errors that had the potential to be devastating for bear populations. The study called for a commitment of significant, long-term resources to develop and maintain the most accurate population estimates possible. The study argued such resources were not available in 1998, with potentially dire consequences for grizzly bears.

A panel was commissioned by the BC government in 2001 to review grizzly bear management to ensure that hunting, as it was currently managed, would not threaten the long-term conservation of grizzly bears, and make recommendations for reform. In 2003 this panel released a report that again expressed concerns over the uncertainty of population estimates, and how they might lead to overmortality.[53] The panel's report stated that animals like grizzly bears, with slow reproductive processes and large ranges, support a low rate of harvesting - because any harvest rate is bound to be close to the maximum sustainable harvest and therefore methods that over-estimated population sizes are inherently dangerous for sustainable management. The panel found problems with the Fuhr-Demarchi method of estimating population based on estimates of habitat quality, and problems with the "step-down" process.

The panel ultimately recommended that harvest rates should be adjusted to account for the uncertainty in population estimates, and that the upper end of the scale of allowable mortality should be reduced from 6% to 5%, to provide greater leeway for error. This recommendation has clearly not been followed as the 6% figure continues to be the upper limit in current management strategies and is applied in 50% of GBPUs.

It should be noted that the government did take some of the panel's recommendations. For example, the BC government no longer uses the Fuhr-Demarchi method that has been criticized in the aforementioned reports as their main method of population estimation. The revised management procedure from 2007 states that it now relies on mark-recapture methods that use DNA analysis of hair snags to inventory bears within a survey area in a GBPU. It should be stressed that this approach still contains considerable uncertainty.[54] In areas where a survey is not possible or has not yet been completed, a Multiple Regression Model uses estimates from inventories in other areas to predict populations by relating environmental, geographic and human influences.[55]

However, there are still uncertainties inherent in these methods. The scientific review in 2003 briefly highlighted the concern that mark-recapture DNA sampling methods could still lead to over-estimation of bear densities.[56] In addition, the revised management procedure states that where these methods are not practicable, habitat-based population methods like the Fuhr-Demarchi method may still be used.[57] As of 2010, only 14% of areas were assessed using DNA analysis, while 30% were assessed via expert opinion and 56% were assessed using regression.[58]

Although the BC government has worked to improve their population estimation methods after repeated criticism, uncertainty cannot be eliminated. Yet, the government continues to use the 6% allowable mortality rate as the default, unless a written rationale supports a higher or lower rate for a particular area. In support of this 6% value, they rely on a 1986 report,[59] despite concerns expressed in a study commissioned in 2003 by the Independent Scientific Review panel suggesting that rates of 2.8% to 4.9% were more appropriate to account for uncertainties inherent in population estimation.[60] This suggests that, despite efforts at improvement, grizzly management in BC is still built on a questionable foundation.

One important reason for an audit is to determine how the BC government can maintain that its allowable mortality limits based on a 6% figure adequately account for the uncertainty in population estimates, when there have been repeated suggestions in the scientific community that this is not the case. The BC government has not taken the advice of independent scientists, even the ones they commissioned themselves, on this crucial issue. An audit is needed to determine what should be done to make provincial grizzly bear management sufficiently conservative.

### *Evidence of Overmortality*

In addition to the dubious scientific foundation for the allowable 6% harvest rate, there is the problem that actual mortality exceeds the rates set. A recent peer-reviewed study in the international journal PLOS ONE, by a team of biologists (four professors, two PhD students) from Simon Fraser University, the University of Victoria and the Raincoast Conservation Foundation, entitled "Confronting Uncertainty in Wildlife Management: Performance of Grizzly Bear Management",[61] reveals that the BC government is failing to keep reported Mortality at even this questionable limit. (See Appendix B.)

During the course of their study population estimates were updated as new data was added to population models and in the majority of cases, population estimates went down[62] - demonstrating that despite new methods, the uncertainty in population estimates that concerned previous studies remains. However, the study also found that in addition to this uncertainty, the government policy was not adequately accounting for uncertainty in non-hunting mortality (such as road and rail accidents, self-defence kills, poaching), leading to incidents of exceeding government's own mortality limits in GBPU's

across the province. Their findings suggest that the current management approach is not sufficiently conservative as the Ministry of Environment has claimed.

The new study reveals that this Annual Allowable Mortality is being exceeded at an alarming frequency across the province. The researchers examined three study periods: 2001 – 2003, 2004 – 2006, and 2007 – 2011.[63] The study found that total mortality limits were exceeded in about 14% of the cases of comparison. In cases where overmortality was found, percent excess mortality ranged from 2% to 171%.[64] In a separate analysis, the female mortality limit, set at 30% of the total limit, was exceeded in 26% of cases. Percent excess mortality in these cases ranged from less than 1% to 178%.[65]

The results of this study clearly show that BC government policy is failing to meet its own objectives on a regular basis. Some might argue that 74% compliance with Allowable Mortality (for females) and 86% (overall) is sufficient. However, the scientists point out a number of reasons why exceeding mortality by any frequency and in any amount is a serious conservation risk. First, when mortality levels are set near or at the maximum considered sustainable, this should be a hard limit. A cautious management approach would never let mortality levels come near this critical limit. Second, overmortality should be a concern given two inherent uncertainties in this grizzly bear management policy: population estimates (as discussed above in this submission) and unreported mortality estimates.

Third, grizzly bears currently face a number of serious threats as discussed earlier in this submission, and as animals with a slow life cycle, can be slow to adapt as a species. It is difficult to predict how the various threats facing the species will interact, and what effects this might produce. Finally, overmortality of female bears is particularly troubling because of their importance to population viability. The seriousness of this study's findings should not be downplayed. A *maximum* limit should be a hard limit if grizzly management is to be truly sufficiently cautious to keep the species healthy in the face of numerous threats.

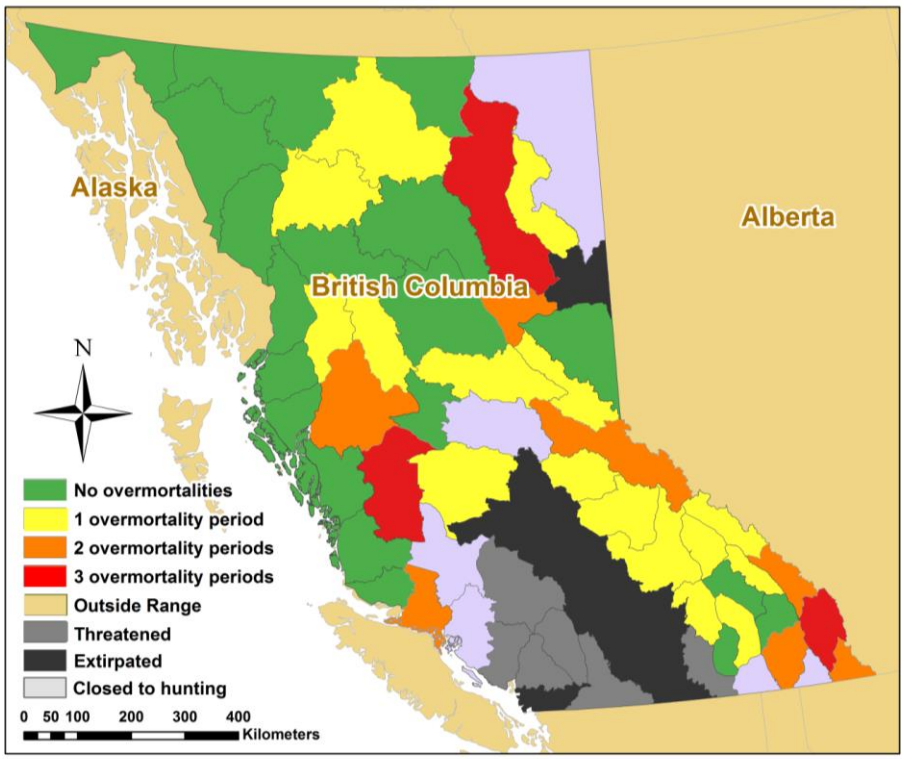



Figure 1: Number of allocation periods (2001–2003, 2004–2006, or 2007–2011) in which female or total overmortality occurred in Grizzly Bear (U. arctos horribilis) Population Units ("population units") of British Columbia, Canada. Shown are 2009 population unit boundaries. Hunting is not allowed in areas denoted as "threatened", "extirpated", or "closed to hunting". Three additional population units have been reclassified as threatened as of 2012.
Please note that this a corrected version of the figure that was originally published in the PLOS ONE paper, used with permission of the authors. PLOS ONE is expected to receive the corrected version shortly.

### *Licensed Hunting Mortality – Predictable, Controllable Source of Grizzly Bear Mortality*

The findings of the recent PLOS ONE study indicate that current policy does not adequately account for uncertainty in predicting the levels of mortality from the non-hunting sources that contribute to over-mortality. It was other sources of mortality, outside of what the government can control with licences, which pushed mortality over the limit. However, this suggests that the Annual Allowable Harvest is not being set at a level that allows enough space for other more unpredictable sources of mortality. Again, uncertainty is not being adequately accounted for in the policy.

It is difficult, for example, to predict how many bears will need to be killed for control purposes. Hunting licences, on the other hand, can be easily controlled - as an example, the PLOS ONE study notes that reducing hunting by half would have reduced the chance of overmortalities by 85% overall (75% for females), even after allowing for uncertainty. What this study suggests then, is that hunting pressure should be reduced, if not eliminated, in order to allow for the uncertainty in mortality caused by factors other than hunting. An audit is required to understand why reductions in hunting pressure have not been undertaken, despite consistent instances of overmortality - and the best way to design grizzly management in the future to address concerns of uncertainty. Such an audit is particularly necessary,

since the government's response to the publication of the PLOS ONE paper was to reassert its confidence in managing the hunt based on its existing numbers.[66]

## 4. The Auditor General's Legal Authority to Investigate

As this report has outlined, grizzly bears are a public resource of vital ecological, cultural and economic value to the people of British Columbia. The Ministry of the Environment has a duty to sustainably manage and steward this resource in the public interest. A failure to implement a policy that operates to successfully manage grizzly bear mortality within set, sustainable limits is a failure to act economically, efficiently and effectively as per s. 11(8) of the *Auditor General Act*. It is in the public interest for the Auditor General to examine this issue of whether the invaluable grizzly bear resource is being adequately managed, pursuant to s. 13 of the *Act*.

There is precedent for such a report in the Auditor General's previous audits of the province's management of public resources such as groundwater, drinking water, wild salmon and forest resources.[67] The Auditor General has thus previously recognized the economic and other values associated with public resources, and the critical importance in ensuring their proper management.

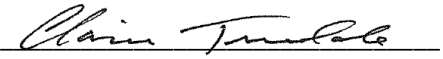
## 5. Conclusion

Grizzly bears are a critical public resource that contributes significantly to the ecological, cultural and economic vitality of the province. The Ministry of the Environment has a statutory duty to manage, protect and conserve animal life in recognition of its social and economic value to British Columbians.[68] Furthermore they have a stated objective of fostering sustainable natural resources management through collaborative approaches with the public, non-profit groups, communities, First Nations governments, academia and industry.[69] The BC government has made a public commitment "to maintain in perpetuity the diversity and abundance of Grizzly Bears and the ecosystems on which they depend throughout British Columbia",[70] yet there are serious questions about whether current policy direction can ensure this promise is fulfilled.

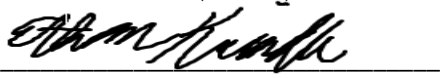
We urge the Auditor General to undertake an investigation into the sustainability and effectiveness of current British Columbia Ministry of Environment grizzly bear management policy. We ask that the Auditor General undertake this investigation pursuant to sections 11 and 13 of the *Auditor General Act*.

We would be pleased to discuss this important matter at any time.

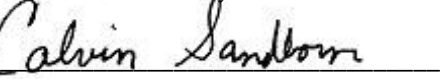
Yours sincerely,



Claire Truesdale, (former) ELC law student



Ethan Krindle, Lawyer



Calvin Sandborn, Legal Director

[1] **The David Suzuki Foundation** collaborates with Canadians from all walks of life, including government and business, to conserve our environment and find solutions that will create a sustainable Canada through science-based research, education and policy work. Its mission is to protect the diversity of nature and our quality of life, now and for the future. Its vision is that within a generation, Canadians act on the understanding that we are all interconnected and interdependent with nature.
[2] *Ministry of Environment Act*, RSBC 1996, c 299, s 4.
[3] British Columbia, Ministry of Environment, *Revised 2013/14 – 2015/16 Service Plan* (Victoria: Ministry of Environment, 2013) at 6, online: http://www.bcbudget.gov.bc.ca/2013_June_Update/sp/pdf/ministry/env.pdf.
[4] Canada, Committee on the Status of Endangered Wildlife in Canada, *COSEWIC Status Report on the Grizzly Bear* Ursus arctos (Ottawa: Environment Canada, 2002).
[5] *Supra*.
[6]British Columbia, Ministry of Water, Land and Air Protection, *Grizzly Bears in British Columbia: Ecology, Conservation, Management* (Victoria: Province of British Columbia, 2002) online: http://a100.gov.bc.ca/pub/eirs/finishDownloadDocument.do?subdocumentId=863.
[7] James Peek et al., "Management of Grizzly Bears in British Columbia: A Review by an Independent Scientific Panel" (2003) submitted to: Ministry of Lamd, Air and Water Protection, Government of British Columbia. Online: http://www.env.gov.bc.ca/wld/documents/gbear_finalspr.pdf.
[8] *Supra*.
[9] *Supra*.
[10]G.V Hilderbrand et al. "Role of brown bears (Ursus arctos) in the flow of marine nitrogen into a terrestrial ecosystem." (1999a) 121 Oecologia 546.
[11] *Supra* note 4.
[12]A.G. MacHutchon, S. Himmer, & C.A. Bryden. " Khutzeymateen Valley grizzly bear study: final report" (1993) Wildlife Report No. R-25, Wildlife Habitat Research Report No. 31. Ministry of Forests, Victoria, BC, online: http://www.env.gov.bc.ca/wildlife/wsi/reports/4692_WSI_4692_RPT_FINAL_1993.PDF.
[13]S.D. Miller and W.B. Ballard. "Analysis of an effort to increase moose calf survivorship by increased hunting of brown bears in southcentral Alaska." (1992) 20 Wildlife Society Bulletin 445.
[14]*Supra* note 7 at 5.
[15] Lydia T. Black, "Bear in Human Imagination and Ritual" (1998) 10 Ursus 343.
[16] D. Rockwell, *Giving Voice to Bear: North American Indian Rituals, Myths, and Images of the Bear*. Niwot, CO: Roberts Reinhart Publications, 1991).
[17]Nuxalk Nation, "Nuxalk Environment" (2012) online: Nuxalk Nation http://www.nuxalknation.org/content/blogcategory/56/150/.
[18]Katzie First Nation, "Katzie History" (2002) online: Katzie First Nation http://www.katzie.ca/katzie_history_part_3.htm.
[19] Ktunaxa Nation, *Qat'muk Declaration* (2010) online: Ktunaxa Firat Nation http://www.ktunaxa.org/news/documents/QatmukDeclaration.pdf.
[20]"Grizzlies History" (2012) online: Memphis Grizzlies http://www.nba.com/grizzlies/about/history.html.
[21] Victoria Grizzlies (2012) online: http://www.victoriagrizzlies.com/.
[22] Revelstoke Grizzlies (2012) online: http://www.revelstokegrizzlies.com/leagues/front_pageGrizzlies.cfm?clientID=4563&leagueID=15207
[23] British Columbia, "Bear Watching" online: Super, Natural British Columbia Canada http://www.hellobc.com/british-columbia/things-to-do/parks-wildlife/bear-watching.aspx.
[24] See e.g. in Kelowna, online: http://kelowna.ca/CM/Page2852.aspx; in Vancouver's Stanley Park, online: http://app.vancouver.ca/PublicArt_net/ArtworkDetails.aspx?ArtworkID=93&Neighbourhood=&Ownership=&Program=; in Revelstoke http://transcanadahighway.com/bc/Revelstoke.htm.
[25]See e.g. Grizzly Transport Ltd, Surrey, online: http://www.manta.com/ic/mt6b9mr/ca/grizzly-transport-limited; Grizzly Springs Water Co Ltd, Penticton, online: http://www.manta.com/ic/mtqspqd/ca/grizzly-springs-water-co-ltd; Grizzly-Man Resource Management Ltd, Kamloops, online: http://www.bcachievement.com/aboriginalbusiness/recipient.php?id=32; Grizzly Security Ltd, Vancouver, online http://www.profilecanada.com/companydetail.cfm?company=2211824_Grizzly_Security_Ltd_Vancouver_BC.
[26] E.g. Grizzly Mountain, BC
[27]Bruce Barcott, "Spirit Bear" *The National Geographic* (August 2011), online: National Geographic http://ngm.nationalgeographic.com/2011/08/kermode-bear/barcott-text.
[28]Z. Parker and R. Gorter, *Crossroads: Economics, Policy, and the Future of Grizzly Bears in British Columbia.*

(Victoria: Centre for Integral Economics and Raincoast Conservation Society, 2003).
[29] Center for Responsible Travel (CREST), *Economic Impact of Bear Viewing and Bear Hunting in The Great Bear Rainforest of British Columbia* (Washington, DC: Center for Responsible Travel (CREST), Janurary 2014), online: http://www.responsibletravel.org/projects/documents/Economic_Impact_of_Bear_Viewing_and_Bear_Hunting_in_GBR_of_BC.pdf
[30] *Supra.*
[31]British Columbia, Ministry of Environment, Lands and Parks, *Conservation of Grizzly Bears in British Columbia: Background Report* (Victoria: Ministry of Environment, Lands and Parks, 1995).
[32]Pacific Wild, Media Release, "Imagine the Great Bear Rainforest without Bears" (18 March 2009) online: Pacific Wild http://www.pacificwild.org/site/press/1237386238.html.
[33] *Supra* note 31.
[34] *Supra* note 4.
[35] *Supra.*
[36] *Supra*.
[37]Ministry of Forests, Lands and Natural Resource Operations, "British Columbia Grizzly Bear Population Estimate for 2012" (April 2012) online: http://www.env.gov.bc.ca/fw/wildlife/docs/Grizzly_Bear_Pop_Est_Report_Final_2012.pdf
[38] *Supra* note 4.
[39] British Columbia, Ministry of Environment, "Grizzly Bear Hunting: Frequently Asked Questions" (7 October 2010) online: http://www.env.gov.bc.ca/fw/wildlife/management-issues/docs/grizzly_bear_faq.pdf .
[40] *Supra*.
[41] British Columbia, North Cascades Grizzly Bear Recovery Team, *Recovery Plan for Grizzly Bears in the North Cascades of British Columbia* (1 June 2004) online: http://www.env.gov.bc.ca/wld/documents/recovery/ncgbrt_final.pdf.
[42] Schwartz et al. *In press.* Grizzly/brown bear. In Wild Mammals of North America. John Hopkins University Press. Baltimore, MA, as cited in COSEWIC Report *supra* note 4.
[43] *Supra* note 4.
[44] *Supra*.
[45]Christensen *et al.* "Hibernation-Associated Changes in Persistent Organic Pollutant (POP) Levels and Patterns in British Columbia Grizzly Bears (*Ursus arctos horribilis*) (2007) online: http://www.raincoast.org/files/publications/papers/ES-T-Hibernation-paper.pdf.
[46] *Supra* note 4.
[47] *Supra.*
[48] *Supra*.
[49] *Supra* note 39.
[50] *Supra*.
[51] See e.g. Peek et al. *supra* note 7; COSEWIC Report *supra* note 4; and Brian L. Horejsi, Barrie K. Gilbert and F. Lance Craighead, *British Columbia's Grizzly Bear Conservation Strategy: An Independent Review of Science and Policy* (Calgary: Western Wildlife Environments Consulting Ltd., 1998).
[52] A Future for the Grizzly: BC GB Conservation Strategy 1995, pg. 8 of print-out
[53] *Supra* note 7.
[54] Artelle KA, Anderson SC, Cooper AB, Paquet PC, Reynolds JD, et al. (2013) Confronting Uncertainty in Wildlife Management: Performance of Grizzly Bear Management. PLoS ONE 8(11): e78041. doi:10.1371/journal.pone.0078041.
[55]*Supra* note 39.
[56] *Supra* note 7 at 23.
[57] British Columbia, Ministry of Environment, "Procedure Manual: Grizzly Bear Harvest Management" (Ministry Procedure Manual) Vol. 4 Section 7. (Victoria: Ministry of Environment, 2007).
[58] *Supra* note 54, Appendix S1.
[59] *Supra* note 39.
[60] Philip D. McLoughlin, *Managing Risks of Decline for Hunted Populations of Grizzly Bears Given Uncertainty in Population Parameters*, Final Report to British Columbia Independent Scientific Panel on Grizzly Bears(5 March 2003) online: www.env.gov.bc.ca/wld/documents/gbear_mcl.pdf.
[61] *Supra* note 54.
[62] *Supra* note 54, Appendix S3.
[63] Note: these study periods mirror the "allocation periods" used by the government that changed from three year periods to five year periods in 2007.
[64] *Supra* note 54, Appendix S2.
[65] *Supra*.

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[66] See: CBC News, *Grizzly bears overhunted in B.C., say researchers,* 06 November 2013, online: http://www.cbc.ca/news/canada/british-columbia/grizzly-bears-overhunted-in-b-c-say-researchers-1.2417306
[67] See: http://www.bcauditor.com/pubs/subject/environment-%2526-natural-resources.
[68] *Supra* note 2.
[69] *Supra* note 3, at 21.
[70] British Columbia, Ministry of Environment, *A Future for the Grizzly: British Columbia Grizzly Bear Conservation Strategy* (Victoria: Ministry of Environment, 1995), online: http://www.env.gov.bc.ca/wld/grzz/grst.html.

# Appendix A

# Letters of Support

**Valhalla Wilderness Society**
Box 329, New Denver, B.C.
V0G 1S0
www.savespiritbear.org

January 14, 2014

Russ Jones, Auditor General
8 Bastion Square
Victoria, B.C. V8V 1X4

Dear Auditor General:

Please be advised that the Valhalla Wilderness Society supports the David Suzuki Foundation's request for an investigation into whether the British Columbia Ministry of Environment's current grizzly bear management policy related to the grizzly bear hunt is effective and sustainable. Having been involved in grizzly bear preservation and management issues in the BC for the past 30 years, including the establishment of several grizzly bear no-hunting reserves on the BC coast (GBMAs), we have serious concerns about this policy as it relates to the management of the grizzly bear hunt.

As a registered professional biologist with a specialty in bear research and management, and who has published over 80 technical reports on bears and other wildlife issues (including some published papers on grizzly bears), I am deeply concerned that the province continues to falsely claim they are managing the grizzly bear hunt on a sustainable basis when a recent peer-reviewed scientific paper found that that government frequently fails to keep grizzly mortality within their own sustainability limits. In addition, I have documented instances in the past where the province allowed grizzly bear hunts in management units where only small numbers of grizzly bears were left.

Years ago I spent four years on the government's Grizzly Bear Scientific Advisory Committee (GBSAC) to help facilitate implementation of the province's Grizzly Bear Management Plan. This met with limited success including the failure of the province to implement stronger guidelines for logging in prime grizzly bear habitat as well as a network of grizzly bear no-hunting reserves called GBMAs. For over a decade or so this matter has continued to deteriorate while the grizzly hunt has continued almost unabated in many areas where habitat degradation and conflicts with people and industrial development have been escalating. In fact some of these areas include subpopulations where grizzly bears have been determined to be threatened by the

province's own guidelines and yet the hunt is allowed or re-introduced based on very questionable population data. At the same time the provincial government has failed to implement grizzly bear recovery plans where needed.

Very recently I had the opportunity to document that the unreported killing of grizzly bears was considerably in excess of what the province estimated in a grizzly bear management unit in the BC Chilcotin in which the province was proposing to resume the grizzly hunt of a "threatened" subpopulation.

Since the Auditor General is assigned the power to investigate mismanagement of Crown resources, our request asks for you to investigate the failure of government to properly steward the invaluable grizzly population. We ask the Auditor General to investigate whether the current grizzly management policy is effective and sustainable, and why annual hunt kill rates have not been reduced in light of this scientific evidence.

We therefore support this request for a transparent, public review of the grizzly bear management policy by the Auditor General.

Sincerely (Signed),

Wayne P. McCrory, RPBio.
Bear/Wildlife Research Programs Coordinator,
Valhalla Wilderness Society

YELLOWSTONE TO YUKON
CONSERVATION INITIATIVE

January 30, 2014

Russ Jones, B.C. Auditor General
8 Bastion Square
Victoria, B.C. V8V 1X4

Dear Auditor General:

The Yellowstone to Yukon Conservation Initiative supports the David Suzuki Foundation's request for an investigation into whether the British Columbia Ministry of Environment's current grizzly bear management policy is effective and sustainable.

The Yellowstone to Yukon Conservation Initiative (Y2Y) is an international non-profit organization based in Canmore, Alberta, with operations in both Canada and the United States. We seek to preserve and maintain the wildlife, native plants, wilderness and natural processes of the mountainous region from Yellowstone National Park to the Yukon Territory. More than one-third of the Yellowstone to Yukon region is in B.C., and the region includes the headwaters of major B.C. rivers such as the Fraser, Columbia and Peace. Y2Y takes a scientific approach to conservation and is recognized as one of the planet's leading mountain conservation initiatives. We work with more than 100 partner organizations, aboriginal communities, businesses and government agencies in pursuit of this goal. (For more information, please visit www.y2y.net)

Y2Y's Grizzly Bear Conservation Strategy is one of the most extensive, large-landscape grizzly bear conservation efforts in the world. The presence of healthy populations of a large, wide-ranging mammal like the grizzly bear signifies an intact, diverse environment, and this is why securing and recovering grizzly-bear populations is central to our efforts to maintain and restore the unique natural heritage of the Yellowstone to Yukon region. The goal of the Grizzly Bear Conservation Strategy is to make sure that grizzly bears have adequate core habitats to sustain viable populations, and that bears – and other wide-ranging wildlife – can move safely between core habitats. This will ensure population stability and a robust genetic pool.

B.C.'s grizzly bear management policy determines how many grizzly bears will be allocated for hunting each year. There is clearly a lack of consensus as to whether B.C.'s management policy can sustain the long-term health of the province's grizzlies.

Therefore, Y2Y supports this request for a transparent, public review of the grizzly bear management policy by the Auditor General.

Regards,

K Heuer

Karsten Heuer
President

BCnature
FEDERATION OF BC NATURALISTS

May 23, 2014

Russ Jones,
Auditor General
8 Bastion Square
Victoria, B.C. V8V 1X4

Dear Sir:

BC Nature is a federation of natural history clubs in BC. We speak for approximately 5,300 naturalists and citizen scientists in the province on matters related to wild species and ecosystems in B.C. Our motto is "To know nature and keep it worth knowing," meaning that we promote both the pursuit of knowledge on nature, and nature conservation.

I am writing to you now to support the David Suzuki Foundation's request for an investigation into whether the British Columbia Ministry of Environment's current grizzly bear management policy and practices are effective and sustainable. BC Nature has serious concerns about the BC Government's management of grizzly bears, and enclosed with this letter is a copy of a resolution on grizzly bear management in BC, passed at our Annual General Meeting in Victoria earlier this month, on 3 May 2014.

We support the request of the David Suzuki Foundation for a transparent, public review by the Auditor General of the Province's grizzly bear management policy.

Sincerely,

Cornelis (Kees) Visser,
President, BC Nature (Federation of BC Naturalists)

Attachment

BC Nature – 1620 Mt. Seymour Road, North Vancouver, BC V7G 2R9
Tel (604) 985-3057 ~ Fax (604) 985-3059 email: manager@bcnature.ca - Web site – www.bcnature.ca

**Resolution 2014-01 Conservation of BC's Grizzly Bear Populations**
**Submitted by Arrowsmith Naturalists**

**WHEREAS** grizzly bears are designated a species of "special concern" by both the Committee on the Status of Endangered Wildlife and BC's Conservation Data Centre; and

**WHEREAS** grizzly bear numbers in many of BC's 56 sub-populations are too low to maintain optimal healthy, genetically-diverse populations; and

**WHEREAS** grizzly bears reproduce at one of the slowest rates of any North American land animals; and

**WHEREAS** grizzly bear populations are particularly sensitive to loss of habitat and human activity; and

**WHEREAS** government estimates of grizzly bear populations do not consistently reflect the use of rigorous, peer-reviewed scientific methodology and yet provide the basis for the limits of allowable human-caused mortality, of which trophy hunting accounts for 88% of the mortalities; and

**WHEREAS** a recent study suggests that in as many as 70% of BC's Grizzly Bear Population Units, allowable mortality limits may have been exceeded; and

**WHEREAS** the provincial government's 1995 BC Grizzly Bear Conservation Strategy has been promised but never implemented;

**BE IT RESOLVED** that BC Nature urge the BC Ministry of Environment and the Ministry of Forests, Lands and Natural Resource Operations to halt the sport hunting of grizzly bears in British Columbia; and

**BE IT FURTHER RESOLVED** that BC Nature urge the provincial government departments responsible to recommit to implementing an updated BC Grizzly Bear Conservation Strategy, and;

**BE IT FURTHER RESOLVED** that BC Nature urges the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) to consider recommending Canada's grizzly bears a Species At Risk under the federal Species At Risk Act (SARA).

**TAKU RIVER TLINGIT FIRST NATION**
***Land and Resources Department***
**BOX 132**
**ATLIN BC V0W 1A0**
**PHONE (250)651-7900 FAX (250)651-7909**

August 20, 2014

Russ Jones, Auditor General
8 Bastion Square
Victoria, B.C. V8V 1X4

Dear Auditor General:

The Taku River Tlingit First Nation supports the David Suzuki Foundation's request for an investigation into whether the British Columbia Ministry of Environment's current grizzly bear management policy is effective and sustainable.

Grizzly bears are significant to the Taku River Tlingit First Nation for cultural, ecological and economic reasons. Interacting with grizzly bears is an important part of connecting with the land and Tlingit culture; spiritually, for example, they provide protection and guidance to Tlingit people. Grizzly bears are integral to the health of ecosystems; as omnivores, they are inter-dependent on various ecotypes and trophic levels throughout the Traditional Territory, but especially in the Taku River watershed salmon ecosystem. The Taku River Tlingit First Nation encourages a shift towards wildlife viewing rather than consumptive uses of grizzly bears, and anticipates that this industry will continue to grow as a sustainable and ethical source of revenue in the Traditional Territory.

The Taku River Tlingit First Nation has serious concerns about the current grizzly bear management policy because it infringes upon certain ethical cultural values, it is based upon questionable scientific management that does not incorporate traditional ecological knowledge and it is not a sustainable model for future use of grizzly bears in Taku River Tlingit Traditional Territory.

Therefore, the Taku River Tlingit First Nation supports the David Suzuki Foundation's request for a transparent, public review of the grizzly bear management policy by the Auditor General.

Sincerely,

Nicole Gordon

Nicole Gordon
Land & Resources Manager
Taku River Tlingit First Nation

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# Appendix B

Artelle *et al.*, "Confronting Uncertainty in Wildlife Management: Performance of Grizzly Bear Management

OPEN ACCESS Freely available online

PLOS ONE

# Confronting Uncertainty in Wildlife Management: Performance of Grizzly Bear Management

**Kyle A. Artelle[1,2]*, Sean C. Anderson[1], Andrew B. Cooper[3], Paul C. Paquet[2,4], John D. Reynolds[1], Chris T. Darimont[2,4]**

**1** Earth to Ocean Research Group, Department of Biological Sciences, Simon Fraser University, Burnaby, British Columbia, Canada, **2** Raincoast Conservation Foundation, Sidney, British Columbia, Canada, **3** School of Resource and Environmental Management, Simon Fraser University, Burnaby, British Columbia, Canada, **4** Department of Geography, University of Victoria, Victoria, British Columbia, Canada

## Abstract

Scientific management of wildlife requires confronting the complexities of natural and social systems. Uncertainty poses a central problem. Whereas the importance of considering uncertainty has been widely discussed, studies of the effects of unaddressed uncertainty on real management systems have been rare. We examined the effects of outcome uncertainty and components of biological uncertainty on hunt management performance, illustrated with grizzly bears (*Ursus arctos horribilis*) in British Columbia, Canada. We found that both forms of uncertainty can have serious impacts on management performance. Outcome uncertainty alone – discrepancy between expected and realized mortality levels – led to excess mortality in 19% of cases (population-years) examined. Accounting for uncertainty around estimated biological parameters (*i.e.*, biological uncertainty) revealed that excess mortality might have occurred in up to 70% of cases. We offer a general method for identifying targets for exploited species that incorporates uncertainty and maintains the probability of exceeding mortality limits below specified thresholds. Setting targets in our focal system using this method at thresholds of 25% and 5% probability of overmortality would require average target mortality reductions of 47% and 81%, respectively. Application of our transparent and generalizable framework to this or other systems could improve management performance in the presence of uncertainty.

**Citation:** Artelle KA, Anderson SC, Cooper AB, Paquet PC, Reynolds JD, et al. (2013) Confronting Uncertainty in Wildlife Management: Performance of Grizzly Bear Management. PLoS ONE 8(11): e78041. doi:10.1371/journal.pone.0078041

**Editor:** Maura Geraldine Chapman, University of Sydney, Australia

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**Competing Interests:** The authors have declared that no competing interests exist.

* E-mail: kartelle@sfu.ca

## Introduction

Confronting uncertainty poses a central problem in the management of wildlife. Decisions made without proper consideration of uncertainty can have undesirable consequences, and have been implicated, for example, in widespread overfishing [1]. Although often poorly accounted for or ignored, uncertainty exists about the "true" value of estimated biological parameters [2], [3], [4], [5]. Parameter uncertainty propagates to uncertainty in important management estimates, including the magnitude of mortality a population can withstand without experiencing long-term declines or other deleterious effects (hereafter "mortality limit uncertainty") [6], [7]. Management performance can also be compromised by outcome uncertainty, defined as the difference between targeted and realized (*i.e.*, known after the period of exploitation) mortality levels [8]. Remarkably, however, scholarly and independent retrospective examination of wildlife or fisheries management performance – in the presence of uncertainty, or, in general – is rarely conducted (but see [8], [9], [10]).

Several methods can account for and incorporate uncertainty into decision-making, estimating *a priori* the probability that specific scenarios will lead to over-exploitation [1], [2]. Key to implementing these approaches is distinguishing between targets (mortality levels management aims to achieve) and limits (mortality levels management should never exceed). Given that there is always some chance of exceeding a target, management should avoid setting targets as high as limits, or conflating the two [6], [7].

Grizzly bears (*Ursus arctos horribilis*) provide an ideal model species for assessing uncertainty in the management of wildlife. Management of most populations occurs with limited demographic information [11], [12], [13]. Moreover, grizzly bears have life-history characteristics – including long lifespans, low reproductive rates, delayed reproductive maturity, and slow population growth rates [11]– that cause high vulnerability to population declines in many other taxa [14]. Finally, as with many vertebrate taxa [15], mortality is primarily human-caused [11], [16], [17]. As such, management decisions can have considerable influence on population viability [13], [18].

Management of grizzly bear mortality in British Columbia (BC) provides a particularly useful case study for examining effects of uncertainty on management performance. Most populations are managed for sustained yield whereby, in theory, a maximum

number of bears ("mortality limit") can be killed each year by humans, mostly by hunting (Legends Figure 1), without causing population declines [19], [20], [21]. However, uncertainty in mortality limits is only partially addressed by managers in BC; biological parameters and calculated mortality limits are treated as point estimates, with uncertainty adjustments dictated by professional judgement [22], not probabilistic assessments. As such, "true" mortality limits might be lower than suggested [12], [13]. Furthermore, outcome uncertainty is not incorporated; mortality limits are used as mortality targets [20], [23] thereby conflating targets with limits.

Debate about large carnivore management is often contentious and the situation with BC grizzly bears is no exception. Independent scientists have recommended more conservative management [13], [24]. Grizzly bears have been extirpated from a large portion of the province, and, citing sustainability concerns, the European Union has banned the import of BC grizzly bear parts since 2002 [24], [25]. Despite concerns, and concurrent with an increasing number of populations gaining threatened status, hunting mortality increased across the province from 2001–2011 (Legends Figure 1; [26], unpublished data).

We use grizzly bear management in BC from 2001–2011 to explore the potential effects of unaddressed uncertainty on management performance (in our case, the ability to maintain mortality below acceptable limits) and to illustrate general methods for confronting uncertainty in management. Others have highlighted the need to quantitatively address various aspects of uncertainty in management [13], [18], [24]; we add empirical insight by retrospectively assessing historical management. Specifically, we assessed outcome uncertainty by comparing known human-caused mortality with targeted levels. We then used simulation modeling to estimate the biological uncertainty around mortality limit point estimates based on parameter uncertainty and assessed how mortality limit uncertainty might affect overmortality probabilities. Finally, we incorporated outcome and mortality limit uncertainty into a generalizable and transparent method for identifying mortality targets that maintain the probability of overmortality below pre-determined thresholds. We discuss how this general approach might help inform population management of other exploited species.

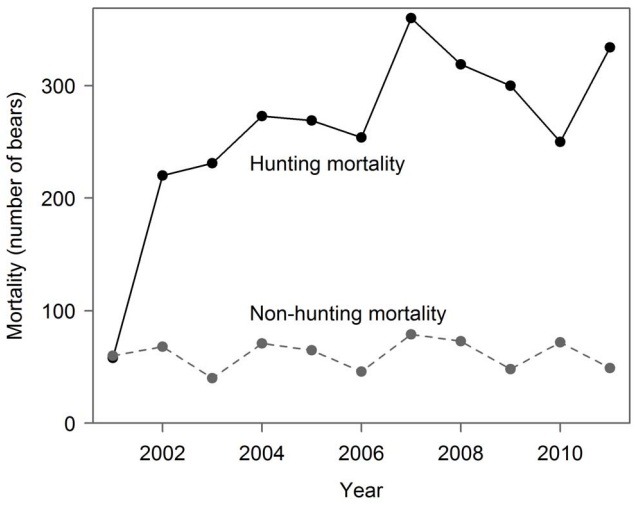


**Figure 1. Total grizzly bear (*U. arctos horribilis*) mortality from hunting (solid-black line) and non-hunting sources (dashed line) in British Columbia, Canada, from 2001–2011.** A province-wide moratorium on the trophy hunt during one of two hunting seasons caused lower hunting mortality in 2001.
doi:10.1371/journal.pone.0078041.g001

## Methods

We conducted our analyses at the Grizzly Bear Population Unit (hereafter "population unit") spatial scale, thought to reflect ecologically and demographically relevant sub-populations [21]. We divided our study period into the same multi-year allocation periods (2001–2003, 2004–2006, and 2007–2011) used by the British Columbia Ministry of Environment (hereafter "government"; [21]). We calculated known mortality for each population unit and each allocation period using a government database ("Compulsory Inspection Database") of all known human-caused mortality including licensed hunting, animal control kills, road and rail accidents, and known poaching [21]. Additionally, we followed government procedures for calculating mortality limits (in units of bears per allocation period) based on estimates of population size, annual allowable mortality (AAM; proportion of a population that can theoretically be removed without causing population declines), and unreported mortality (from rates observed in one population unit and extrapolated to other population units based on four variables thought to correlate with unreported mortality; See Appendix S1). In our outcome uncertainty analyses we applied the government's "uncertainty correction factors" to population estimates, whereas in subsequent analyses we used an empirical and probabilistic approach to address uncertainty. In most population units, the correction factors used by BC managers are deterministic values, based on expert judgement, that are inversely proportional to estimated population sizes (Appendix S1, [23]). Our analyses followed the government practice of calculating mortality limits for the entire population (Eq 1) and for females separately (Eq 2) to account for the sensitivity of populations to female mortality [19], [21], [27]. We also calculated female mortality as a percentage of total mortality. The government subtracts predicted non-hunt mortality (*e.g.* road kill, animal control kills, and illegal hunting) estimates from mortality limits and allocates the remaining mortality to hunting. We note, however, that by allocating mortality right up to mortality limits, BC managers treat limits as targets, conflating the two; we hereafter refer to true targeted mortality levels (whether or not they are conflated with mortality limits by managers) as "targets" and true, biologically-determined mortality limits as "limits". Details on mortality limit calculations, and on how they differed among periods, are provided in Appendices S1 and S2, respectively.

Eq 1: total mortality limit = population estimate × uncertainty correction factor × (annual allowable mortality – estimated unreported mortality) × period length – previous period total overmortalities.

Eq 2: female mortality limit = 0.3 × population estimate × uncertainty correction factor × (annual allowable mortality – estimated unreported mortality) × period length – previous period female overmortalities.

### Outcome Uncertainty and Mortality Patterns

We assessed outcome uncertainty across population units and across study periods by calculating the difference between known mortality (from the Compulsory Inspection Database) and targeted mortality:

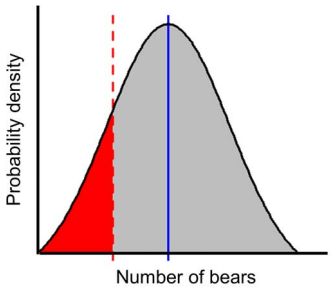


**Figure 2. Illustration of method for estimating the probability of overmortality in an individual Grizzly Bear (*U. arctos horribilis*) Population Unit (''population unit'') and period.** Blue vertical line represents the mortality limit point estimate used by government. Entire distribution (in this example a hypothetical normal distribution used for simplicity) represents the distribution of mortality limit uncertainty, or the distribution of simulated mortality limits. Red dashed line represents the known mortality for the same population unit-period. Red portion of the distribution represents the proportion of simulated mortality limits that fell below known mortality levels in the population unit-period. The percent area of the overall distribution occupied by the red portion provides a proxy for the probability that overmortality occurred. See also Video S1.
doi:10.1371/journal.pone.0078041.g002

$$\text{percent difference} = 100 \times \frac{\text{known mortality} - \text{targeted mortality}}{\text{targeted mortality}} \quad (3)$$

We further explored patterns of mortality types associated with overmortality events.

We characterized outcome uncertainty as a function of targeted mortality. Using maximum likelihood estimation, we fit Michaelis-Menton curves to model known mortality as a function of targeted mortality, for each period, and for total and female mortality:

$$\text{known mortality}_i = a + \frac{b(\text{targeted mortality}_i)}{(c + \text{targeted mortality}_i)} + \varepsilon_i, \quad \varepsilon_i \sim \text{Negbin}(0, k) \quad (4)$$

where i represents a population unit-period; **a**, **b**, **c**, are estimated parameters of the curve; $\varepsilon_i$ represents residual error; and **k** is the estimated size parameter of a negative binomial error distribution with a mean of 0. We used this error distribution because targets must be positive integer values. We fit the models using *optim* in R 2.14.1 (R Core Team 2012, R Foundation for Statistical Computing) with the Nelder-Mead method and with estimated parameters in log space.

## Mortality Limit Uncertainty and Probability of Overmortality

Whereas current management procedure (above) treats mortality limits as point estimate, we propagated biological parameter uncertainty to estimate cumulative uncertainty around mortality limits using simulation modeling [28], [29] and assessed how this uncertainty might affect the probability of overmortality. We focused on three key parameters currently treated as point estimates by managers. Because empirically derived uncertainty estimates are lacking for most BC populations, we derived parameter uncertainty estimates from a literature review (Appendix S3). For each parameter, we took random draws from a continuous uniform distribution centered on existing point estimates. The distributions were bounded by: population estimates: +/−40% of point estimate; AAM: +/−2% of population estimate (because AAM is a percentage of population estimate); and unreported mortality: from 50% (*i.e.* half) to 200% (*i.e.*, double) of the point estimate (Appendix S3). We calculated simulated female and total mortality limits by substituting randomly drawn parameter values into Eq 1 and Eq 2. We did

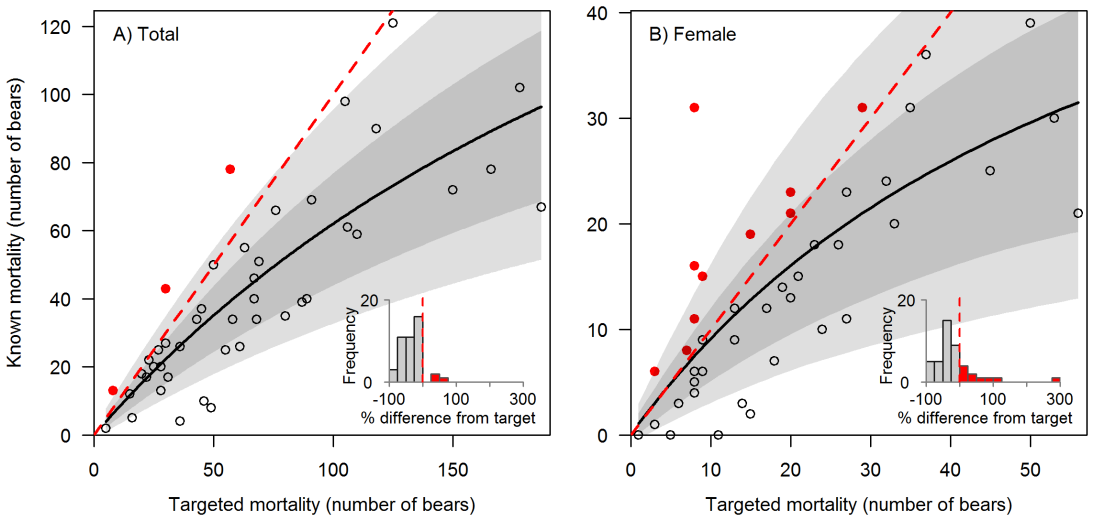


**Figure 3. Outcome uncertainty for A) total and B) female mortality in Grizzly Bear (*U. arctos horribilis*) Population Units (''population units'') in British Columbia, Canada, 2007–2011 (see SI for additional periods).** Black curve is a Michaelis-Menten curve fitted by maximum likelihood, assuming a negative binomial error distribution. Red dashed line indicates a 1:1 relationship; solid red dots above this line signal population unit-level overmortality events. Dark and light grey-shaded regions encompass the 50% and 80% prediction intervals, respectively (smoothed for visual purposes). Inset histograms show the distribution of GBPU-level percent difference between known mortalities and mortality targets (conflated with limits under mortality management policy); red bars to the right of red dashed lines indicate overmortality events.
doi:10.1371/journal.pone.0078041.g003

not incorporate the government's estimated uncertainty correction factors in these calculations. We repeated these simulations 1000 times in each population unit and period to construct a distribution of realistic mortality limits (the simulated breadth of mortality limit uncertainty). We used the percentage of simulations in which simulated mortality limits fell below known mortalities as a proxy for overmortality probability (Figure 2, Video S1).

### Identifying Targets that Incorporate Outcome and Mortality Limit Uncertainty

We used derived distributions of outcome and mortality limit uncertainty to calculate targets for each population unit that maintained the probability of overmortality below 5% (low risk-tolerant, conservation-prioritizing scenario) or 25% (higher risk-tolerant, exploitation-prioritizing scenario), using data from 2007–2011. For a given target, we used a "plug-in" approach [30] to estimate outcome uncertainty. This approach estimates outcome uncertainty from the stochastic component (the negative binomial error) of Eq 4, assuming that the deterministic component (the Michaelis-Menten curve) was fixed at the maximum likelihood estimate. For each population unit, we calculated the intersection of the resultant outcome uncertainty and mortality limit distributions for all possible target values, keeping mortality limit distributions fixed, to find the highest target for which the resultant outcome uncertainty distribution intersected with less than the maximum area (the given thresholds, 5% or 25%) of the mortality limit distribution (Video S2). We performed all analyses with R 2.14.1 (R Core Team 2012, R Foundation for Statistical Computing).

## Results

### Outcome Uncertainty and Mortality Patterns

Outcome uncertainty varied across population units and periods, with discrepancies between targeted and known mortality being more pronounced for female mortalities than total mortalities (Figure 3, S1, and S2). Because government procedures conflated targets with

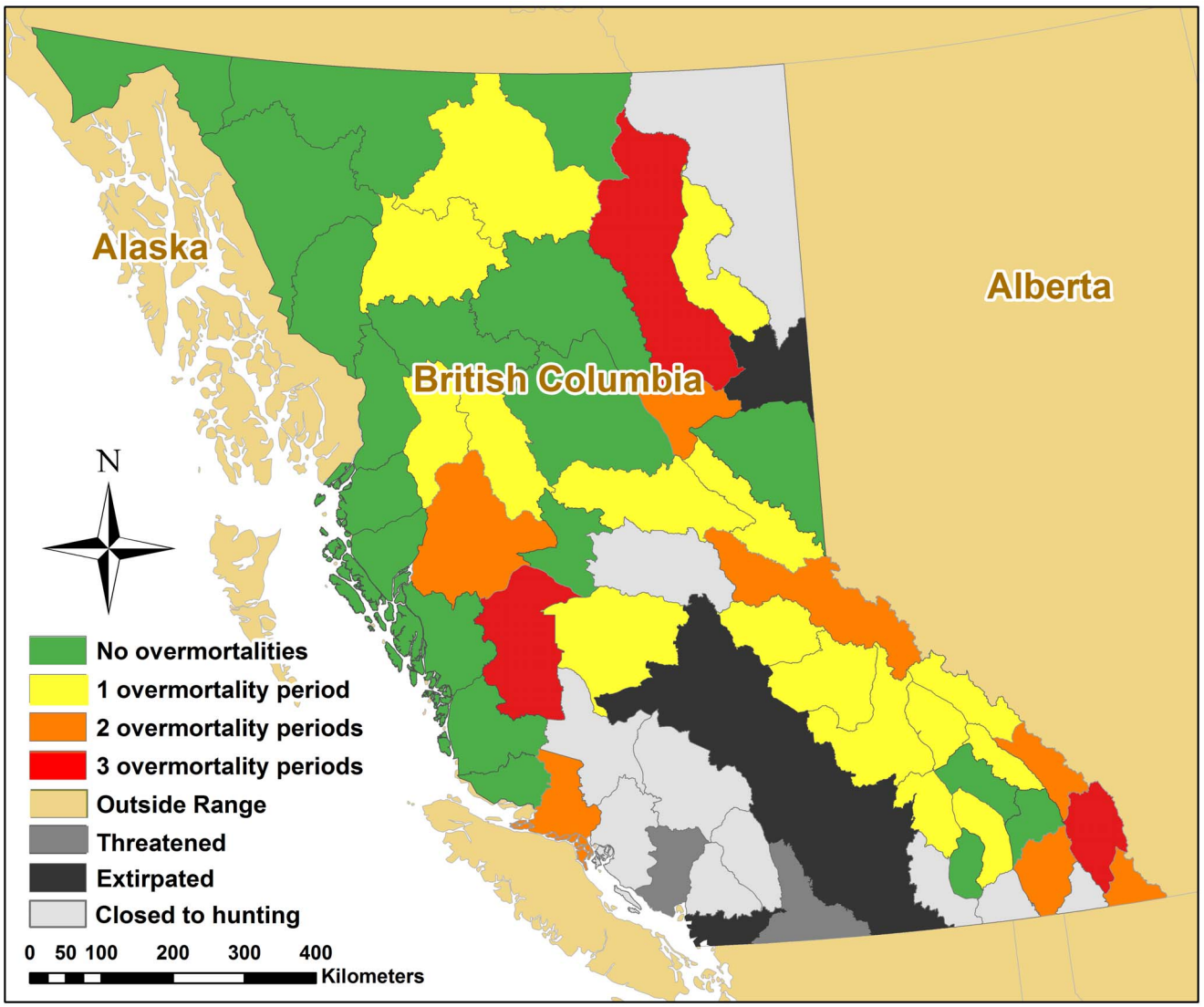


**Figure 4. Number of allocation periods (2001–2003, 2004–2006, or 2007–2011) in which female or total overmortality occurred in Grizzly Bear (*U. arctos horribilis*) Population Units ("population units") of British Columbia, Canada.** Shown are 2009 population unit boundaries. Hunting is not allowed in areas denoted as "threatened", "extirpated", or "closed to hunting". One additional population unit (Blackwater-West Chilcotin) has been reclassified as threatened as of 2012.
doi:10.1371/journal.pone.0078041.g004

limits, cases in which targets were exceeded also constituted overmortalities. While mortality fell mostly below targets, overmortalities occurred in at least one period in 26 of the approximately 50 population units open for hunting, and most frequently in southern and eastern BC (Figure 4). Overmortalities (18 total cases and 33 female cases from 2001–2011) occurred more frequently in population units with smaller targets (Figure 3, S1, S2, and S3). In seven population units, overmortality events occurred in two periods, whereas in three population units they occurred in all three periods (Figure 4). Overmortality events ranged from one to 24 bears. Finally, targets were also frequently approached but not exceeded (Figure S3).

The most common factor associated with total overmortalities was unpredicted non-hunting mortality. However, most of the total overmortalities from 2001–2011 (17 of 18, or 94%) could have been avoided with reduced hunting mortality (Figure S3). The most common factor associated with female overmortalities was hunting mortality. Most female overmortalities (25 of 33, or 76%) could have been avoided with reduced hunting mortality (Figure S3).

The female component exceeded 30% of *total* mortality (from hunting and non-hunting sources combined) in 55% of all cases and in 94% of all female overmortality events (Figure 5 A and B, respectively). The female component exceeded 30% of *total hunting* mortality in 50% of all cases and in 82% of all female overmortality cases (Figure 5 C and D, respectively).

## Mortality Limit Uncertainty and Probability of Overmortality

Accounting for components of biological uncertainty revealed that overmortalities might have occurred in 90 of 127 (71%) examined female cases and 89 of 127 (70%) examined total cases. This comprised an additional 45% of female cases and 56% of total cases relative to overmortality assessments that did not consider uncertainty (Figures 6 A and B, S4 A and B, and S5 A and B). Even in the face of uncertainty, reducing hunting by half would have reduced the probability of overmortality by an average of 85% for total and 75% for female overmortality cases (Figures 6C, S4C, and S5C), whereas completely eliminating hunting would have reduced the probability of overmortality by an average of 96% for total and 89% for female overmortality cases (Figures 6D, S4D, and S5D).

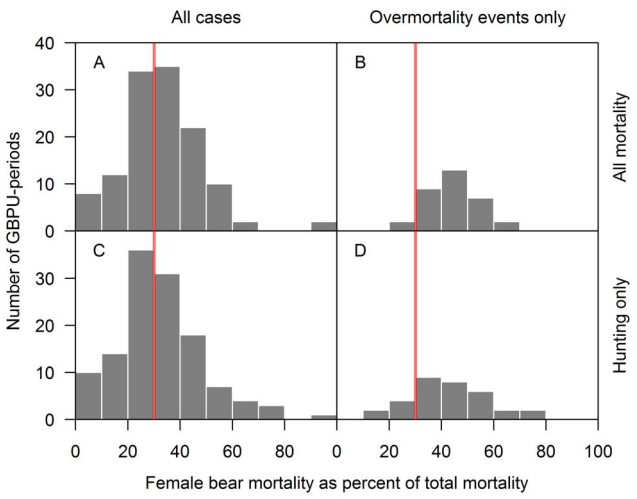


**Figure 5. Female mortality as percent of total mortality across Grizzly Bear (*U. arctos horribilis)* Population Units (''population units'') in British Columbia, Canada, and allocation periods (2001–2003, 2004–2006, and 2007–2011).** (A) female mortality as percent of all mortality, (B) female mortality as percent of all mortality in female overmortality events, (C) female hunting mortality as percent of all hunting mortality, and (D) female hunting mortality as a percent of all hunting mortality in female overmortality events. Vertical red lines indicate 30%, the threshold below which female mortality must remain for total mortality limits to be theoretically sustainable according to the BC government's mortality management procedure.
doi:10.1371/journal.pone.0078041.g005

## Identifying Targets that Incorporate Outcome Uncertainty and Mortality Limit Uncertainty

To maintain the probability of overmortality below a 5% threshold, mortality targets would need to be reduced by an average of 81% across all population units relative to 2007–2011 targets, and by 100% in 15 (Figure 7 A, B and E). For the exploitation-prioritizing 25% threshold, mortality targets would still need to be reduced by an average of 47% across all population units, and by 100% in four population units (Figure 7 C, D, and F).

# Discussion

Our analysis illustrates the importance of assessing management performance and uncertainty. Specifically, we found that unaddressed uncertainty could compromise management performance by leading to excessive mortalities in hunted species. We found that grizzly bear overmortalities in British Columbia, Canada, were spatially widespread, occurred repeatedly, and were more frequent in females. Considering biological uncertainty around mortality limits revealed that many additional populations might have experienced overmortalities. A target-setting framework that incorporates outcome and mortality limit uncertainty shows that considerable reductions in targeted mortality would be required to improve management performance.

## Considerations

We used grizzly bears to illustrate general issues applicable to many other taxa, rather than prescribing specific management actions for this particular species. Moreover, mortality limit simulations used uniform distributions with ranges considerably narrower than the full extent suggested in the literature (see Appendix S3 for full ranges). We had insufficient data to determine clearly which particular distribution best approximated such parameters; however, the use of such limited ranges of uncertainty suggests our estimates of overmortality risks and target reductions were underestimated even if the true error structure followed a different distribution (*e.g.* normal or log-normal). Importantly, estimated probabilities of overmortality and reductions in targeted mortalities would change if empirically derived and area-specific ranges and distributions of uncertainty were known for each population unit. Similarly, given that the outcome uncertainty was estimated from management performance over a short time, our derived distributions likely underestimated the true range of uncertainty. Additionally, the relationship between targeted and known mortality changes through time (as might be expected given the fluidity of political, social, and ecological contexts, for example), which potentially affects the ability to predict the future using historical data. However, by frequently and iteratively re-evaluating management performance, managers adopting this approach could detect such changes and respond by updating outcome uncertainty distributions. Finally, our analyses did not address assumptions used by management in setting specific parameter point estimates for each area, or in adjusting estimates among periods, which could have affected our ability to detect overmortalities (Appendix S2). Given these considerations, our results could provide minimal requirements for improving

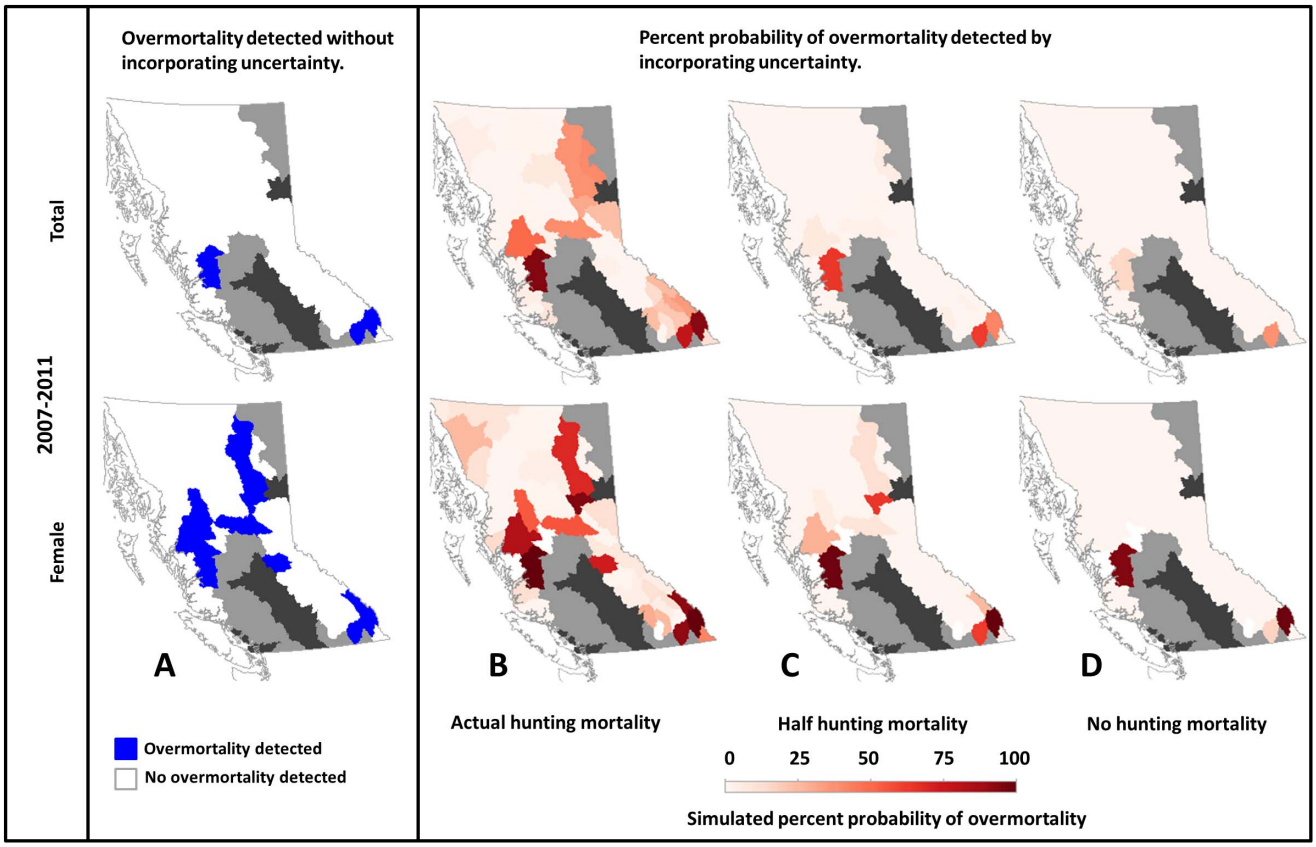


**Figure 6. Total and female overmortalities of Grizzly Bear (*U. arctos horribilis*) Population Units (''population units'') of British Columbia, Canada, from 2007–2011 (see SI for additional periods).** A) Overmortalities detected given known hunting mortality levels and without consideration of mortality limit uncertainty. Blue indicates population units with detected overmortality whereas white indicates population units without. B–D) Simulated probability of total or female overmortality, incorporating uncertainty around mortality limits. Panel B shows simulated probability of overmortality given known mortality rates; panels C and D show what the probability of overmortality would be had hunting mortality been reduced by 50% or 100%, respectively, assuming other sources of mortality remained unchanged. Increasingly dark red indicates an increasing probability of overmortality in a given period. Grizzly bears have been extirpated from dark-grey areas. Light-grey areas indicate population units in which populations are either threatened or were closed to hunting during the study period.
doi:10.1371/journal.pone.0078041.g006

performance in this particular system; we recommend that management systems adapting this approach obtain geographically-explicit data, and characterize and incorporate uncertainty. We also recommend that management be re-evaluated, updated, and refined iteratively to account for possible changes in dynamics in targeted species and hunter behaviour.

## Additional Sources of Uncertainty

Our analyses addressed only a subset of uncertainty in the management of wildlife. For example, there is additional uncertainty about the appropriateness of models used in setting limits (''model selection error''; [1]); genetic, phenotypic, or social effects of exploitation on hunted populations (e.g. [31], [32], [33]); time required for population recovery [14]; effects of declining food availability [34]; and the cumulative effect of other anthropogenic disturbances such as logging, mineral extraction, roads, and development [12], [24], [35]. Despite examining only a subset of uncertainty, our work empirically illustrates potential effects on management performance, and suggests methods management agencies could consider.

## Management Performance and Outcome Uncertainty

Multiple processes may contribute to outcome uncertainty. For instance, in the case of grizzly management, hunting mortality, especially in females, was often higher than targeted. Guidelines that encourage hunters to avoid females seem inadequate given that female mortality consistently exceeded the 30% threshold dictated by government procedures [21], [23], [27]. Similar barriers to limiting female mortality might also apply to other wildlife species in which sexes are not particularly dimorphic, with similar concerns about population dynamics (e.g. caribou *Rangifer tarandus*, [36]). Additionally, although most total and female overmortality events could have been prevented through hunting reductions, mortality sources beyond management control might also contribute to outcome uncertainty. In our analysis road kill, animal control kills, and illegal hunting were important, highlighting that measures beyond hunt reductions are likely required to safeguard populations. Importantly, not explicitly incorporating outcome uncertainty into procedures for management of wildlife could result not only in sporadic and isolated, but also chronic and repeated, overmortality events, as highlighted in our study period in which overmortalities occurred repeatedly in many areas.

## Mortality Limit Uncertainty

In addition to outcome uncertainty, uncertainty not explicitly accounted for in estimating biological parameters, such as mortality limits, can also lead to excessive mortality. For example, by accounting for mortality limit uncertainty, our simulations revealed

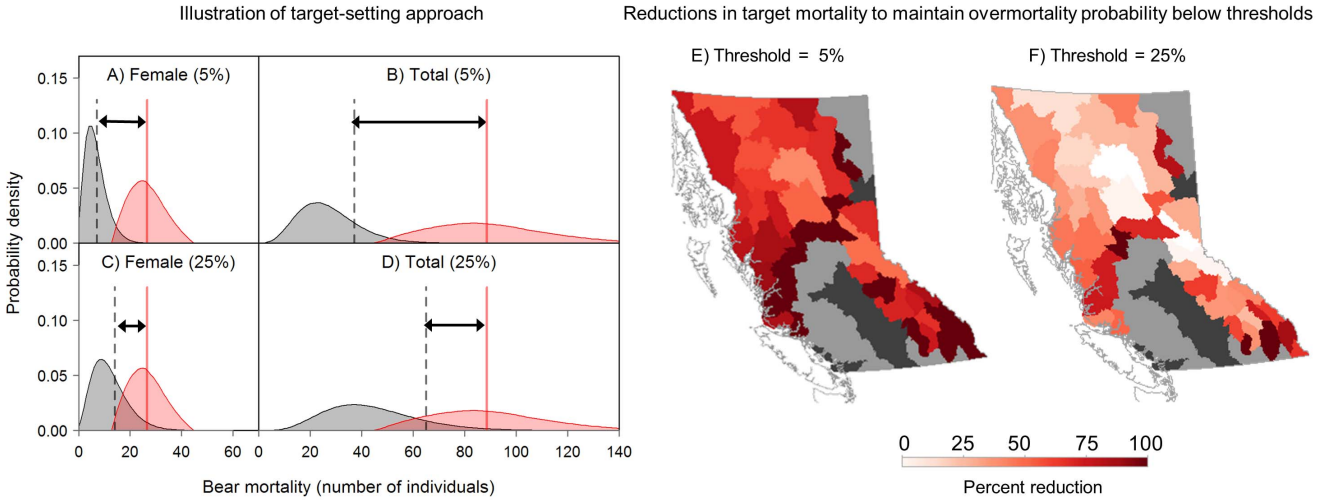


**Figure 7. Illustration of our method for setting female (A and C) and total (B and D) mortality targets, with maximum probability of overmortality of 5% (A and B) or 25% (C and D) by integrating outcome uncertainty (grey distribution) and mortality limit uncertainty (red distribution), using the Stewart Grizzly Bear (*U. arctos horribilis*) Population Unit as an example.** Targets (dashed black lines) from this approach are set so that the resulting outcome uncertainty distribution (grey distribution) overlaps with a maximum of 5% or 25% of the mortality limit uncertainty distribution (red distribution). Red vertical lines represent mortality limits (conflated with targets in previous periods under mortality management policy) set by the government in 2007–2011. Magnitudes of recommended target reductions are shown by black double-headed arrows. E-F) Reduction in mortality targets, relative to 2007–2011 targets (conflated with limits under mortality management policy), required to maintain the probability of both female and total overmortality below E) 5% or F) 25%. Increasingly dark red indicates increasing target reductions identified.
doi:10.1371/journal.pone.0078041.g007

that overmortality events might have occurred in many cases in which mortality did not exceed government-determined mortality limits. We found that the probability of overmortality would have decreased considerably had hunting been reduced or eliminated, as expected for any system in which hunting constitutes most mortality. This result provides management a direct and easily controlled route to reducing the probability of over-exploitation.

## Identifying Targets that Incorporate Uncertainty

Our framework for transparently incorporating uncertainty identified targets that reduce the probability of over-exploitation. This approach is a considerable improvement from the deterministic and ad hoc "uncertainty correction factors" used in previous management. In our approach, uncertainty is incorporated in a repeatable, quantitative and transparent fashion, and can readily include new data as they become available. Of particular relevance to managers, the public, and decision-makers is how mortality management might change if this approach were implemented. Our simulations revealed that careful management would require considerable target reductions, consistent with the conservative 'bet-hedging' recommended for cautious management [2], [12]. Importantly, given that female mortality seems difficult to control independently of total mortality, a given population unit's total target mortality would need to be reduced sufficiently to maintain total and female overmortality probabilities below thresholds. Recommended targets changed considerably depending on the threshold used, highlighting the importance of careful consideration and engagement of stakeholders when setting targets. Although the acceptable probabilities of overmortality used in our approach (5% or 25%) were arbitrary, they might represent thresholds for a low risk-tolerant, conservation prioritizing scenario and a higher risk-tolerant, exploitation-prioritizing scenario, respectively. Notably, hunting reductions would be required even in the exploitation-prioritizing scenario.

## Identifying Targets in Other Scenarios

Our case study illustrated an approach for reducing the risk of *over*mortality of species managed for long-term population viability. This approach could also be used for reducing the risk of *under*mortality of species managed for population reduction or elimination, such as in the control or eradication of invasive species (*e.g.* control of invasive lionfish through exploitation [37]). In such cases targets would be set sufficiently *high* to ensure they do not fall below levels needed to obtain population reductions required. This approach provides the first steps to a full decision analysis framework, a quantitative approach for weighing various management options that might be appropriate in future management deliberations [2], [29].

## Importance of Incorporating Best-practices from Other Disciplines

This study illustrates the merit of incorporating approaches from other disciplines and taxa into wildlife management. Whereas BC grizzly bear management incorporates data and management techniques from grizzly bear management in other jurisdictions [19], [21], it does not incorporate some promising methods from other disciplines. For example, our approach, which relies on the principle that targets should be set sufficiently low to account for uncertainty (and lower than most of the estimated range of mortality limits; [2], [6], [7]) is used in fisheries but far less commonly in wildlife management, highlighting the need for better integration of best practices across taxa and disciplines.

# Conclusion

Science can provide valuable insight into management issues often mired in heated debate. Management often occurs within contentious social environments, with interest groups advocating strongly for different scenarios, informed by varying ethical perspectives and philosophies [10], [38], [39], [40], [41]. Science

can inform such debate by assessing the ability of management to achieve objectives and by transparently communicating risks associated with various scenarios. We suggest that many management systems might benefit from retrospective and empirical examinations that can inform present and future management. These could be conducted as a part of the management process or, as in this study, by third parties. Results and predictions from such examinations in any system could help to communicate likely outcomes while simultaneously improving future management performance.

## Supporting Information

**Figure S1 Outcome uncertainty for A) total and B) female mortality in Grizzly Bear (*U. arctos horribilis*) Population Units (''population units'') in British Columbia, Canada, 2001–2003 (see SI for additional periods).** Black curve is a Michaelis-Menten curve fitted by maximum likelihood, assuming a negative binomial error distribution. Red dashed line indicates a 1:1 relationship; solid red dots above this line signal population unit-level overmortality events. Dark and light grey-shaded regions encompass the 50% and 80% prediction intervals, respectively (smoothed for visual purposes). Inset histograms show the distribution of GBPU-level percent difference between known mortalities and mortality limits (conflated with limits under mortality management policy); red bars to the right of red dashed lines indicate overmortality events.
(TIF)

**Figure S2 Outcome uncertainty for A) total and B) female mortality in Grizzly Bear (*U. arctos horribilis*) Population Units (''population units'') in British Columbia, Canada, 2004–2006.** Black curve is a Michaelis-Menten curve fitted by maximum likelihood, assuming a negative binomial error distribution. Red dashed line indicates a 1:1 relationship; solid red dots above this line signal population unit-level overmortality events. Dark and light grey-shaded regions encompass the 50% and 80% prediction intervals, respectively (smoothed for visual purposes). Inset histograms show the distribution of GBPU-level percent difference between known mortalities and mortality targets (conflated with limits under mortality management policy); red bars to the right of red dashed lines indicate overmortality events.
(TIF)

**Figure S3 Mortality targets (conflated with limits under mortality management policy) and known mortalities for each Grizzly Bear (*U. arctos horribilis*) Population Unit (population unit) in British Columbia, Canada, during A) 2001–2003, B) 2004–2004, and C) 2007–2011 allocation periods.** Green and orange bars represent number of bears killed by non-hunting and hunting sources, respectively. Vertical grey lines denote mortality targets and vertical black lines denote predicted non-hunt mortality for each period. Population unit rows in which known mortality exceeded mortality targets ('overmortality') are shown with grey highlighting. Open blue circles denote population units in which hunting mortality alone exceeded the mortality targets for all sources combined; filled blue circles denote areas in which the unpredicted non-hunting mortality (difference between known and predicted non-hunting mortality) exceeded the excess mortality.
(TIF)

**Figure S4 Total and female overmortalities of Grizzly Bear (*U. arctos horribilis*) Population Units (''population units'') of British Columbia, Canada, from 2001–2003.** A) Overmortalities detected given known hunting mortality levels and without consideration of mortality limit uncertainty. Blue indicates population units with detected overmortality whereas white indicates population units without. B–D) Simulated probability of total or female overmortality, incorporating uncertainty around mortality limits. Panel B shows simulated probability of overmortality given known mortality rates; panels C and D show what the probability of overmortality would be had hunting mortality been reduced by 50% or 100%, respectively, assuming other sources of mortality remained unchanged. Increasingly dark red indicates an increasing probability of overmortality in a given period. Grizzly bears have been extirpated from dark-grey areas. Light-grey areas indicate population units in which populations are either threatened or were closed to hunting during the study period.
(TIF)

**Figure S5 Total and female overmortalities of Grizzly Bear (*U. arctos horribilis*) Population Units (''population units'') of British Columbia, Canada, from 2004–2006.** A) Overmortalities detected given known hunting mortality levels and without consideration of mortality limit uncertainty. Blue indicates population units with detected overmortality whereas white indicates population units without. B–D) Simulated probability of total or female overmortality, incorporating uncertainty around mortality limits. Panel B shows simulated probability of overmortality given known mortality rates; panels C and D show what the probability of overmortality would be had hunting mortality been reduced by 50% or 100%, respectively, assuming other sources of mortality remained unchanged. Increasingly dark red indicates an increasing probability of overmortality in a given period. Grizzly bears have been extirpated from dark-grey areas. Light-grey areas indicate population units in which populations are either threatened or were closed to hunting during the study period.
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**Appendix S1**
(DOCX)

**Appendix S2**
(DOCX)

**Appendix S3**
(DOCX)

**Video S1**
(WMV)

**Video S2**
(WMV)

## Acknowledgments

We thank the British Columbia Ministry of Environment for providing data, error-checking draft outcome uncertainty analyses, and helpful feedback. Two additional anonymous reviewers improved this manuscript considerably.

## Author Contributions

Conceived and designed the experiments: KAA CTD PCP ABC SCA JDR. Performed the experiments: KAA CTD. Analyzed the data: KAA SCA. Wrote the paper: KAA SCA ABC PCP JDR CTD.

## References


1. Harwood J, Stokes K (2003) Coping with uncertainty in ecological advice: lessons from fisheries. Trends Ecol Evol 18: 617–622. doi:10.1016/j.tree.2003.08.001.
2. Reckhow K (1994) Importance of scientific uncertainty in decision making. Environ Manage 18: 161–166. doi:10.1007/BF02393758.
3. Hilborn R, Mangel M (1997) The ecological detective: confronting models with data. Princeton University Press. Available: http://books.google.ca/books?hl=en&lr=&id=katmvQDi8PMC&oi=fnd&pg=PR11&dq=ecological+detective&ots=2TyPRpsHp8&sig=QfadANtzEEnylfp3eMvWDBDgjKo. Accessed 9 November 2012.
4. Regan HM, Ben-Haim Y, Langford B, Wilson WG, Lundberg P, et al. (2005) Robust decision-making under severe uncertainty for conservation management. Ecol Appl 15: 1471–1477.
5. Armitage DR, Plummer R, Berkes F, Arthur RI, Charles AT, et al. (2009) Adaptive co-management for social-ecological complexity. Front Ecol Environ 7: 95–102.
6. Caddy JF, McGarvey R (1996) Targets or limits for management of fisheries? N Am J Fish Manage 16: 479–487.
7. Prager MH, Porch CE, Shertzer KW, Caddy JF (2003) Targets and limits for management of fisheries: a simple probability-based approach. N Am J Fish Manage 23: 349–361.
8. Holt CA, Peterman RM (2006) Missing the target: uncertainties in achieving management goals in fisheries on Fraser River, British Columbia, sockeye salmon (Oncorhynchus nerka). Can J Fish Aquat Sci 63: 2722–2733.
9. Ross PI, Jalkotzy MG, Gunson JR (1996) The quota system of cougar harvest management in Alberta. Wildlife Soc B 24: 490–494. doi:10.2307/3783332.
10. Linnell JDC, Broseth H, Odden J, Nilsen EB (2010) Sustainably harvesting a large carnivore? Development of Eurasian Lynx populations in Norway during 160 years of shifting policy. Environ Manage 45: 1142–1154. doi:10.1007/s00267-010-9455-9.
11. Miller S (1990) Population management of bears in North America. Int C Bear 8.
12. Mattson DJ, Herrero S, Wright RG, Pease CM (1996) Science and management of Rocky Mountain grizzly bears. Conserv Biol 10: 1013–1025.
13. McLoughlin PD (2003) Managing risks of decline for hunted populations of grizzly bears given uncertainty in population parameters University of Alberta. Available: http://www.env.gov.bc.ca/wld/documents/gbear_mcl.pdf. Accessed 27 September 2012.
14. Reynolds JD (2003) Life histories and extinction risk. In: Blackburn TM, Gaston KJ, editors. Macroecology. Oxford, UK: Blackwell Publishing. 195–217. Available: http://books.google.ca/books?hl=en&lr=&id=3vUUii37DEQC&oi=fnd&pg=PA195&dq=Life+histories+and+extinction+risk&ots=HGy_Xw4aM1&sig=ObiP5HlSd_m6nydjLsEkSxEScT4. Accessed 15 November 2012.
15. Collins C, Kays R (2011) Causes of mortality in North American populations of large and medium-sized mammals. Animal Conservation 14: 474–483. doi:10.1111/j.1469-1795.2011.00458.x.
16. Peek JM, Pelton MR, Picton HD, Schoen JW, Zager P (1987) Grizzly bear conservation and management: a review. Wildlife Soc B 15: 160–169.
17. Treves A (2009) Hunting for large carnivore conservation. J Appl Ecol 46: 1350–1356. doi:10.1111/j.1365-2664.2009.01729.x.
18. McLoughlin PD, Messier F (2004) Relative contributions of sampling error in initial population size and vital rates to outcomes of population viability analysis. Conserv Biol 18: 1665–1669.
19. Hamilton AN, Austin MA (2002) Grizzly bear harvest management in British Columbia: background report. British Columbia Ministry of Water, Land, and Air Protection, Biodiversity Branch, Victoria, British Columbia, Canada. Available: http://www.env.gov.bc.ca/wld/documents/gbearbckgrdr.pdf. Accessed 26 September 2012.
20. Lunn K, Ethier T (2007) Grizzly bear harvest management. British Columbia Ministry of Environment, Fish and Wildlife Branch.
21. British Columbia Ministry of Environment, Fish, Wildlife and Habitat Branch (2010) Grizzly bear hunting: frequently asked questions.
22. Hamilton AN, Austin M (2004) Estimating grizzly bear (Ursus arctos) population size in British Columbia using an expert-based approach. British Columbia Ministry of Water, Land and Air Protection. Available: http://www.env.gov.bc.ca/wld/documents/gb_est_pop_size.pdf. Accessed 25 September 2012.
23. Austin MA, Heard DC, Hamilton AN (2004) Grizzly bear (Ursus arctos) harvest management in British Columbia. British Columbia Ministry of Water, Land and Air Protection Victoria, Canada. Available: http://www.env.gov.bc.ca/wld/documents/gb_harvest_mgmt.pdf. Accessed 25 September 2012.
24. Peek J, Beecham J, Garshelis D, Messier F, Miller S, et al. (2003) Management of grizzly bears in British Columbia - a review by an independent scientific panel. Submitted to: Minister of Water, Land and Air Protection Government of British Columbia Victoria, B.C.
25. Knapp A (2007) A review of the European Union's import policies for hunting trophies. Brussels, Belgium.
26. Ministry of Forests, Lands and Natural Resource Operations (2012) British Columbia grizzly bear population estimate for 2012.
27. Harris RB (1986) Modeling sustainable harvest rates for grizzly bears. Unpublished manuscript.
28. Milner-Gulland EJ, Shea K, Possingham H, Coulson T, Wilcox C (2001) Competing harvesting strategies in a simulated population under uncertainty. Anim Conserv 4: 157–167. doi:10.1017/S1367943001001184.
29. Peterman RM (2004) Possible solutions to some challenges facing fisheries scientists and managers. ICES J Mar Sci 61: 1331–1343.
30. Bolker BM (2011) Ecological models and data in R. Princeton University Press. 410 p.
31. Swenson JE, Sandegren F, Söderberg A, Bjärvall A, Franzén R, et al. (1997) Infanticide caused by hunting of male bears. Nature 386: 450–451. doi:10.1038/386450a0.
32. Wielgus RB, Sarrazin F, Ferriere R, Clobert J (2001) Estimating effects of adult male mortality on grizzly bear population growth and persistence using matrix models. Biol Conserv 98: 293–303. doi:10.1016/S0006-3207(00)00168-3.
33. Darimont CT, Carlson SM, Kinnison MT, Paquet PC, Reimchen TE, et al. (2009) Human predators outpace other agents of trait change in the wild. Proc Natl Acad Sci U S A 106: 952–954. doi:10.1073/pnas.0809235106.
34. Levi T, Darimont CT, MacDuffee M, Mangel M, Paquet P, et al. (2012) Using Grizzly Bears to Assess Harvest-Ecosystem Tradeoffs in Salmon Fisheries. PLoS Biol 10: e1001303. doi:10.1371/journal.pbio.1001303.
35. Weaver JL, Paquet PC, Ruggiero LF (1996) Resilience and Conservation of Large Carnivores in the Rocky Mountains. Conserv Biol 10: 964–976.
36. Festa-Bianchet M, Ray JC, Boutin S, Côté SD, Gunn A (2011) Conservation of caribou (Rangifer tarandus) in Canada: an uncertain future. Can J Zool 89: 419–434. doi:10.1139/z11-025.
37. Akins JL (2012) Control strategies: Tools and techniques for local control. In: Morris JA Jr., editor. Invasive lionfish: A guide to control and management. Gulf and Caribbean Fisheries Institute Special Publication Series. Marathon, USA, Vol. 1. 24–47.
38. Lackey RT (1998) Seven pillars of ecosystem management. Landscape Urban Plan 40: 21–30. doi:10.1016/S0169-2046(97)00095-9.
39. Paquet PC, Darimont CT (2010) Wildlife conservation and animal welfare: two sides of the same coin. Anim Welfare 19: 177–190.
40. Darimont CT, Paquet PC (2012) Lessons from the Lorax. a scientists' lament and a plea for ethics. In: Wright, A., editor. Faltering Light. Cold Coast Press.
41. Phillis CC, O'Regan SM, Green SJ, Bruce JEB, Anderson SC, et al. (2012) Multiple pathways to conservation success. Conserv Lett: 1–9. doi:10.1111/j.1755-263X.2012.00294.x.