Grizzly Bear Biological Assessment and Potential Options for Managing Grizzly Bear Predation on the Range of the Bathurst and Bluenose-East Barren-ground Caribou Herds

Grizzly Bear and Wolverine Biological and Management Feasibility Working Group
Technical Working Group
Yellowknife, Northwest Territories
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Executive Summary

The current decline in the Bathurst and Bluenose-East barren-ground caribou herds has led to strong public concern about the future of the herd. The decline of both herds has led to management actions on caribou harvest and wolves. Based on the high rate of decline and small population size of the Bathurst herd, the Wek'èezhìı Renewable Resources Board (WRRB) determined a total allowable harvest (TAH) of zero for all users of the herd in Wek'èezhìı starting in 2016/17 through to the 2020/21 harvest season (WRRB 2019a). Harvest of Bathurst caribou in Nunavut was limited to ten caribou/year by the Government of Nunavut in 2020 following a hearing by Nunavut Wildlife Management Board in consideration of one family living on the land. For the Bluenose-East herd, the WRRB initially determined a TAH of 750 bulls only in 2016/17, with a further reduction to 193 bulls only for the 2019/20 and 2020/21 harvest seasons (WRRB 2019b). With limited harvest there are strong concerns over food security and lost chances to transfer traditional knowledge and experience between generations.

While wolves are recognized as the main and year-round predators of barren-ground caribou, grizzly bears may have a greater impact on early caribou calf survival in some herds. The Grizzly Bear and Wolverine Biological and Management Feasibility Working Group (WG) was formed to compile information about grizzly bear predation on Bluenose-east and Bathurst Caribou, as well as management options and their risks.

As an illustrative exercise, extrapolating using the best available information, including that from other jurisdictions, and acknowledging key assumptions regarding bear density and kill rates, grizzly bear predation rates for Bathurst and Bluenose-East calves on the calving ground may be on the order of 41% and 13% respectively. This extrapolation does not account for compensatory deaths or possible calf mortality from other predators including wolves, wolverine, and eagles. Predation rates for adult Bathurst and Bluenose-East caribou are conjectural as kill rates are uncertain. Using available information and key assumptions, the grizzly bear predation rates on adult caribou may be on the order of 2-6% based on 2018 herd sizes.

Grizzly bear management options are to be provided to management authorities, who in turn, and depending on their decisions, will submit specific management proposals

for review in a public forum to allow for further discussion. The WG examined options for reducing grizzly predation through lethal and non-lethal removal of bears. The WG acknowledges that more details will be required for specific proposals. Although management options are listed, the working groups did not assess feasibility, costs, and potential effectiveness of different management techniques for those options. If a grizzly bear management program is considered in Northwest Territories and Nunavut, then this document may be used for developing specific options and criteria for evaluation.

Technical Working Group Membership

- Tłı̨chǫ Government (TG), Department of Culture & Lands Protection;
- Government of the Northwest Territories, Environment & Natural Resources (ENR);
- Wek'èezhìı Renewable Resources Board (WRRB);
- North Slave Métis Alliance (NSMA);
- Yellowknives Dene First Nation (YDFN); and
- Łutsel K'e Dene First Nation (LKDFN).

Observers of the Working Group included representatives from each of the following organizations:

- Government of Nunavut (GN);
- Nunavut Tunngavik Inc (NTI);
- Nunavut Wildlife Management Board (NWMB);
- Kitikmeot Inuit Association;
- Kitikmeot Regional Wildlife Board; and
- Kugluktuk Angoniatit Association.

Disclaimer: The Working Group completed this report because of commitments made by parties at the WRRB public hearings for the Bluenose-East herd and the Bathurst herd in 2016. It is being provided for review by decision-makers in the Government of the Northwest Territories, Government of Nunavut, and Tłı̨chǫ Government. The Assessment does not reflect specific support for grizzly bear management by participants in the Working Group. The options presented do not imply any preferred direction or commitment by any of the management authorities in the Northwest Territories or Nunavut.

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Purpose of this Assessment

The Bathurst herd has declined by 98% between 1986 and 2018 (Adamczewski et al. 2019a) and has reached numbers lower than Indigenous Elders have known during previous population cycles (WRRB 2019a). Collar-based cow survival rates for the Bathurst herd were consistently low between 2009 and 2013 with annual estimates between 52% and 63% (Boulanger, unpublished data). Since then, between 2014 and 2019 collar-based survival rates have increased with annual estimates between 67% and 95%, and the 2018 and 2019 estimates were 92% and 95% (Boulanger, unpublished data.).

The Bluenose-East herd has also been declining rapidly since 2010 and was further reduced by half between 2015 and 2018 (Boulanger et al. 2019, WRRB 2019b). Collar-based cow survival rates for the Bluenose-East herd declined between 2015 and 2017 and then were higher for 2018 and 2019 at 85%. The average survival rate for 2015-2019 was 84.8%, which is an encouraging trend though it should be recognized that there may be limited collared cow numbers in any one year.

Calf:cow ratios in late winter, which are an index of calf survival until nine to ten months old, have been low which has likely contributed to the herd declines. In general, calf:cow ratios have been higher in the Bluenose-East herd than in the Bathurst (Adamczewski et al. 2019a, Boulanger et al. 2019).

The decline of both herds has led to management actions limiting caribou harvest and encouraging wolf harvest. Based on evidence for a high rate of decline and small population size of the Bathurst herd, the WRRB determined a total allowable harvest (TAH) of zero for all users of the herd in Wek'èezhìı starting in 2016/17 through to the 2020/21 harvest season (WRRB 2019a). Harvest of Bathurst caribou in Nunavut was limited to ten caribou/year by the Government of Nunavut in 2020 after a hearing by the Nunavut Wildlife Management Board, to accommodate a family living on the land and relying on caribou hunting for sustenance. For the Bluenose-East herd, the WRRB initially determined a TAH of 750 bulls only in 2016/17, with a further reduction to 193 bulls only for the 2019/20 and 2020/21 harvest seasons (WRRB 2019b).

The *Wolf Technical Feasibility Assessment – Options for managing wolves on the range of the Bathurst barren-ground caribou herd* describes options in the Bathurst herd's range to

reduce wolves. Wolf reduction could increase survival rates of both calf and adult Bathurst caribou, halt population decline, and start the recovery of the herd (Wolf Feasibility Assessment Technical Working Group 2017). The GNWT initially implemented a wolf harvest incentive program in the North Slave Region in 2010. In 2019/20, GNWT increased financial incentives to its *Enhanced North Slave Wolf Harvest Incentive Program*. Tłı̨chǫ Government initiated its *Community-based Dìga (Wolf) Harvest Training Program* in the 2019/20 harvest season (WRRB 2019a and b; Conference of Management Authorities 2020). In late winter 2020, wolves were also removed from the Bathurst and Bluenose-East winter ranges as part of an ongoing wolf removal program (Nishi et al. 2020, WRRB 2020). A review of this program will be conducted at the end of 5 years.

While wolves are recognized as the main and year-round predators of barren-ground caribou, grizzly bears are also known to impact early caribou calf survival in some herds (Conference of Management Authorities 2020, Kugluktuk Angoniatit Association 2016, WRRB's 2016 Bathurst and Bluenose-East Public Hearings). To examine the possible impact of grizzly bear predation on the Bathurst and Bluenose-East herds, the Wek'èezhìı Renewable Resources Board's, Recommendation #4B-2016 (Bathurst), Recommendation #4B-2016 (Bluenose-East) and Recommendation #6-2019 (Predator) established a grizzly bear working group to undertake a grizzly bear biological assessment (WRRB 2016a and b, WRRB 2019c). Those recommendations called for a grizzly bear biological assessment to be completed to summarize current information on grizzly bear abundance, movement, and diet for the Bluenose-East and Bathurst caribou herds' seasonal ranges.

Thus, the Working Groups' report, follows the format and approach taken by the 2017 Wolf Feasibility Assessment Technical Working Group in reporting on technical background information on grizzly bear status and predation on caribou. Although management options are listed, the grizzly bear working group did not assess feasibility, costs, and potential effectiveness of different management techniques for those options. If a grizzly bear management program is considered in the Northwest Territories and Nunavut, then this document may be used for developing specific options and criteria for evaluation.

The Working Group did not repeat existing compilations of published literature on grizzly bear biology such as the Species at Risk Assessment (SARC) in 2017, instead the

Working Group focused on the literature on grizzly bear predation and unpublished industry reports on grizzly bear surveys listed in the public registries of the Mackenzie Land and Water Board and the Nunavut Impact Review board.

Biological Assessment

Grizzly Bear Biology and Behaviour

Grizzly bear range in the NWT includes the entire mainland except the Taiga Plains south of Great Bear Lake and east of the Mackenzie Mountains, and the Taiga Shield to the southeast of Great Slave Lake (SARC, 2017). The following summary paragraph is drawn from SARC (2017) which includes the original citations.

The wide ranges of the species reflect their generalist approach to habitat selection and omnivorous diet, see the section titled, Grizzly Bear Diet for further details. Prior to denning in autumn, grizzly bears typically consume carbohydrate-rich berry crops in large quantities (SARC, 2017). Grizzly bears are dormant (hibernation) in winter, entering a den that is usually excavated on a slope with a southern aspect in late October and occupying it for as long as seven months (timing varies by sex and age). Harvesters and communities who coexist with grizzly bears are aware of the locations and characteristics of these dens. Cubs are born in dens in litters of usually between 1 and 3 offspring. Females and males will reach physiological maturity at approximately five years of age, but age at first reproduction can be delayed, especially in areas of poor productivity (e.g., on the barrens) where females may not produce a litter until eight years of age. Generation length (average age of parents of newborns) is between 10-15 years, and longevity between 20-30 years in the wild. The sex and age structure of grizzly bear populations are strongly influenced by reproductive rates and by the management regime to which a population is subjected. In the NWT, approximately half the population can be expected to be of breeding age (SARC, 2017).

In general, grizzly bear home ranges, directions, movement rates are tied to age and sex of the individual, and habitat or feeding requirements. Habitat and feeding areas may affect seasonal migrations in elevation (as described for the Mackenzie Mountains in SARC 2017) or depend on available food sources like caribou. Home ranges of grizzly bears in the NWT include the largest ranges reported for the species, particularly for bears inhabiting the

central barrens of mainland NWT whose home ranges average approximately 1,150-7,250 km^2 and females 250-2,100 km^2 (SARC, 2017).

The interspecific interactions of grizzly bears classify them as omnivores and predators. Disease and parasitism have not been noted as an important limiting factor for any grizzly bear population (SARC, 2017).

Overview of Grizzly Bear Management

Grizzly bears have been designated as 'Special Concern' based on their naturally low densities and reproductive rates in Canada (COSEWIC 2012). They were determined to be not at risk in the NWT (CMA, 2019). COSEWIC (2012) and SARC (2017) summarized information on the status and biology of grizzly bears. The NWT regulates grizzly bear harvest, allows for killing of bears in defense of life and property, and permits a once-in-a-lifetime harvest within the Mackenzie Mountains by Resident Hunters. Currently, the Inuvialuit and Gwich'in regions have co-management harvest management plans for grizzly bears (Nagy and Branigan 1998, Gwich'in Renewable Resources Board 2000). In Nunavut, grizzly bears are harvested by Inuit hunters for subsistence and also in defense of life and property, while harvesting for sport hunting is limited by total allowable harvests established by the Nunavut Wildlife Management Board; a co-management was accepted by GN in 2017 (GN 2017, Awan and Szor 2012).

Current understanding of grizzly bears on the Bathurst and Bluenose-East caribou range

The current understanding of grizzly bear impacts on the Bathurst and Bluenose-East seasonal ranges is based on traditional and local community knowledge, as well as genetic mark-recapture studies. The genetic mark and recapture studies have provided regional estimates of abundance, trends, and sex and age composition in the western Kitikmeot and in the vicinity of mines or proposed mines in the NWT and Nunavut. Earlier studies in the NWT during the 1990s described reproductive rates, diet, and movements (summarized in SARC 2017).

Grizzly bear abundance

Grizzly bear abundance in 2017 was estimated at 4,000 to 5,000 grizzly bears in the NWT and 1,500 to 2,000 grizzly bears in Nunavut (SARC 2017, COSEWIC 2012). Grizzly bears are increasing in Nunavut's Kitikmeot Region (GN 2017), which covers the northern calving and summer ranges of the Bathurst and Bluenose-East herds. The NU annual rate of increase for grizzly bears was estimated at 2-3% during the 1990s, which, based on hunters' reports, has continued (GN 2017).

Estimates of abundance using mark and recapture methods for the western Kitikmeot (150,000 km^2) was estimated as 780 to 915 bears in the 1990s (GN 2017). In the Lac de Gras study area (Fig. A1) the number estimated was 136 grizzly bears (55 males and 81 females) in a 16,000 km^2 regional study area centered on Lac de Gras and the trend since the 1990s appears relatively stable (ERM 2018). In the DeBeers study area (Fig A1), Jessen (2017) estimated a density of 2.7 bears per 1,000 km^2. In 2013, the density of bears in the combined Lac de Gras and DeBeers study areas was estimated to be 4.6 bears per 1,000 km^2 (Jessen 2017). On the Bathurst calving ground, we estimated 6-8 grizzly bears per 1000 km^2 (Appendix A). On the Bluenose-East calving ground we estimated 5.9-6.2 grizzly bears per 1000km^2 (Appendix A).

For the Bluenose-East herd's late summer and fall ranges, during a muskox survey, the bear sighting rate in August 2017 was 5.1 bears/10 hours (Le Clerc 2018) but the area overlapped the calving ground (Figure 1). While sighting rates for grizzly bear during aerial surveys are unavailable for the Bathurst herd's summer and fall ranges, sighting rates per observer per day in the vicinity of Contwoyto Lake (2016-2019) are relatively consistent at 0.15-0.25 bears/day (Tłı̨chǫ Research and Training Institute 2016, 2017, 2018 and 2019).

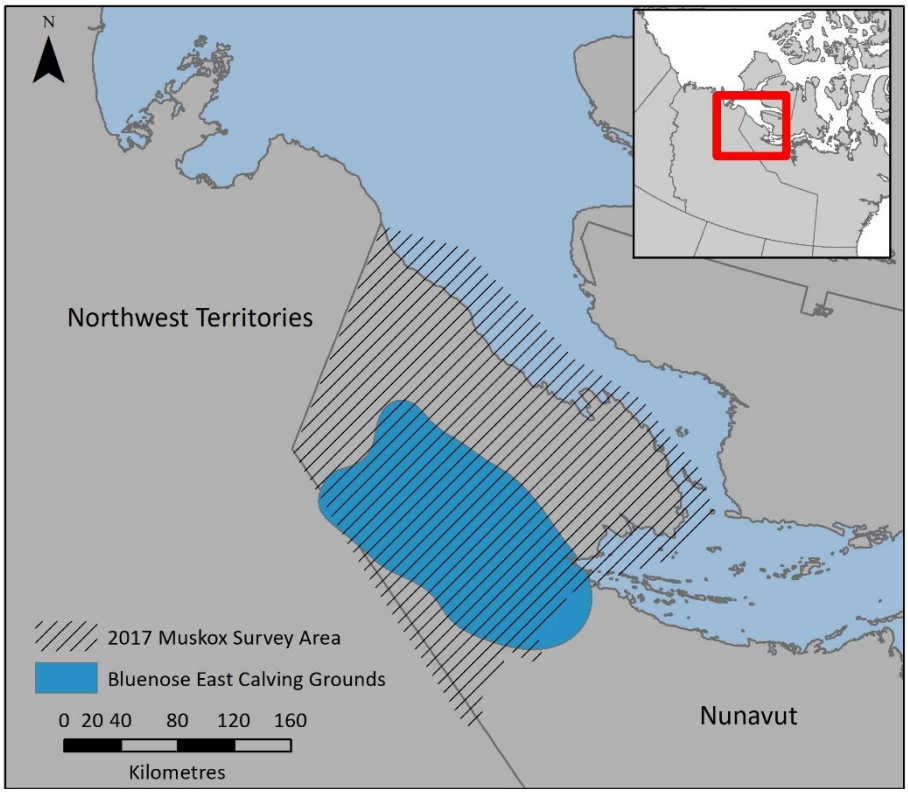

Figure 1. Bluenose-East calving grounds relative to the August 2017 muskox survey area which had bear sighting rate of 5.1 bears/10 hours.

The late winter and fall caribou sex and age composition surveys are in March-April and October which reduces the likelihood of incidental grizzly bear sightings as the timing overlaps with denning. However, another source of information is the incidental sightings compiled for the Ekati open pit and underground mine on the Bathurst herd's annual range (ERM 2020). Inferences are limited as sightings were reported in an opportunistic (versus standardized) manner, since 2001, the numbers of bears sighted on separate days and family groups has not declined and annually averages 52±4.6 SE bear sightings (ERM 2020).

Predation Risk

Risk of predation is the probability of being killed during a specified time. It is related to the encounter rate between predator and prey, the probability of death given an encounter, and the time spent vulnerable to encounter (Lima and Dill 1990). Predation risk

to caribou from grizzly bears depends on when and where caribou are exposed to bears as well as the kill and predation rates. Caribou distribution relative to grizzly bears is seasonally predictable at a regional scale as caribou migrate together and return to their traditional calving grounds. As well, caribou use water-crossings and land corridors between large lakes which increases densities in those areas temporarily (Tłı̨chǫ Research and Training Institute 2013). However, the low density of grizzly bears and their large home ranges reduces the predation risk on caribou. There is no evidence from individually marked bears that they aggregate on caribou calving grounds.

Additionally, bears are only active for about 5-6 months of the year which reduces the likelihood of encounters between grizzly bears and caribou. In the central barrens, grizzly bears den during the last two weeks of October and most emerge from dens in the 1st week of May (McLoughlin *et al.* 2002). Barren ground grizzly bears have exceptionally large home range sizes averaging 6,685 km^2 for adult males and 2,074 km^2 for adult females (McLoughlin *et al.* 1999).

Grizzly Bear Diet

Gau et al (2002) characterized grizzly bear diet on the range of the Bathurst herd in the mid 1990s as being predominantly carnivorous based on scat composition: of 60-76% caribou by volume in spring and autumn and 8%, 36%, and 39% in early, mid, and late summer, respectively. When caribou were scarce in the study area (during calving and summer), bears fed on shoots of horsetails (*Equisetum* spp.), arctic cotton grasses (*Eriophorum* spp.), and sedges (*Carex* spp.). Grasses comprised up to 88% of the total volume of bear fecal samples in the early summer, berries comprised up to 42% in the late summer, and caribou up to 76% in the autumn (Gau et al. 2002). Bears ate ground squirrels (*Spermophilus parryii*) from spring to fall (6-10%; Gau et al. 2002). Radio-collared bears have been observed with freshly killed caribou during daily observations, which suggests that bears are preying on caribou versus scavenging carcasses (Gau et al. 2002). Bears ate ground squirrels (*Spermophilus parryii*) from spring to fall (Gau et al. 2002).

Across Nunavut between 2009 and 2013, the diet of grizzly bears was more like that of wolves than that of wolverines based on isotope analysis, although the grizzly bear

samples were mostly for the fall (L'Hérault et al. 2016). The fall diet was about 20-25% berries and arctic ground squirrels in southeast Nunavut as well as 20-25% caribou and muskoxen while waterfowl eggs, vegetation, seals and small birds were the remainder, suggesting a highly varied diet (L'Hérault et al. 2016). The number of bears sampled for Kugluktuk and Cambridge Bay was only 2 and 7, respectively which limited interpretation of diet.

In Alaska's Nelchina Basin, while individual variation in grizzly bear diet was high, a key finding was that about 30% of the bears were consistently carnivorous as their diets were more than 80% caribou and moose calves in spring, summer and fall (Brockman et al. 2015). Most bears had diets switching from moose or caribou calves in spring and fall to vegetation in summer (Brockman et al. 2015). Conclusions are consistent that kill rates by grizzly bears are individualistic and bears are opportunistic in their foraging behavior, which can include consumption of ground squirrels, sedges, or roots (Arthur and Del Vecchio 2017, Brockman et al. 2017). Brockman et al. (2017) specified:

> "The calf risk model estimated that 82.6% of summer calf mortality occurred by 30 June. Based on the kill rates of calves by bears from the calf risk model, during the interval from 15 May to 30 June, individual kill rates were extrapolated to be 34.4 calves/bear, including 16.2 moose calves killed/bear (range: 0–33.4), 14.1 caribou calves/bear (0–35.1), and 4.1 unidentified calves/bear (range: 0–12.7). Three of the 7 bears in the study were selected due to their known history of calf predation and this may have influenced the high kill rates. Kill rates in this study should not be applied to the population at large because of small sample sizes and the non-random selection of bears during 2011."

The diet of grizzly bear on the range of the Bluenose-East herd and more recently on the range of the Bathurst herd, since caribou abundance has declined, is unknown. The effects of declining wolf numbers either as possible competitors or a source for scavenging is another uncertainty (Klaczek et al. 2016). Muskoxen serve as alternate prey as grizzly bears (Case and Stevenson 1991, Clarkson and Liepins 1993); however, muskox numbers declined in the 1990s and have remained unchanged on the Bluenose-East herd's calving and summer ranges (Leclerc 2018). Along the coast, grizzly bears also hunt seals and scavenge

beached whales (Harwood 2018). Other larger-bodied prey may include moose, as sightings of moose on the tundra are increasing (Tłı̨chǫ Research and Training Institute 2020). However, while overall moose densities remain low on the tundra, they are unlikely to be a major component in grizzly bear diets. Although the presence of moose could affect kill rates on caribou, this remains a knowledge gap.

Kill Rate

Kill rate is the number of prey killed per predator per unit of time (Vucetich *et al.* 2011) and is difficult to accurately measure as the frequency and duration of observation depends on the time to find, kill, consume prey and digest it, and if needed, cache the remains of the kill. Prior to the introduction of GPS collars and video-collars, estimates of kill rates relied on direct observations of the bears from the air using VHF radio-collars to find the bears and kill-sites (Boertje et al. 1988, Young and McCabe 1997). On the Porcupine caribou herd's calving ground in 1993 and 1994, the estimated kill rate of caribou based on aerial observations averaged 3.1 calves/bear/day, with the highest for sows with young (young = bears ≤3 years) at 6.3 calves/bear/day (Young and McCabe 1997). When based on point locations from radio-tracking, the estimated kill rate averaged 4.8 calves/bear/day (Young and McCabe 1997). These methods are likely an underestimate and do not include kills that are made quickly. However, these methods likely miss kills when the bear's handling time of the kill is brief. We have used kill rates from the Porcupine herd's calving ground as it has a similar suite of predators and gregarious calving ecologically similar to the Bathurst and Bluenose East calving grounds.

In the Nelchina herd's calving and summer ranges, 2011-2013, moose are common and grizzly bear density was estimated at 21.3 bears/1000 km^2 (Brockman *et al* 2017). Bears were fitted with collar-mounted video cameras for the calving period (cameras failed or removed by 30 June). The video clips from seven bears showed median handling times were 60 min for moose calves and 40 min for caribou calves, and 45 minutes for adult caribou, compared to 13 hours for adult moose. The average kill rate of grizzly bears was 11.9 ± 4.5 SE caribou calves (range 0-30) during the same time period (15 May-17 June) when the bears also had a similar kill rate for moose calves (Brockman et al. 2017). For adult moose and

caribou during the same period, the mean adult kills/bear was 1.4 (0–5.3). Brockman et al (2017) commented that the high kill rates were not the result of higher bear densities. The mean number of caribou and moose calves killed per bear varied from none to 31 between 15 May and 17 June.

The relatively high daily rates (Brockman et al. 2017) are consistent with, for example, near Inuvik, observations of Abraham Carpenter who saw grizzly bears moving into the semi-domestic reindeer herd and killing as many as 15 to 20 calves at one time (pers. comm. to John Nagy in Nagy and Branigan 1998). Grizzly bear predation on caribou and reindeer is widespread where their distribution overlaps. In Sweden, brown (grizzly) bears averaged a kill rate of 11 semi-domestic reindeer calves/bear/season (10 May to 30 June) (Sivertsen 2017). The rate was estimated from finding and examining calf carcasses at GPS collar location clusters. It was determined that bears caused about half of the observed calf mortality (Sivertsen 2017). Wolves were absent, and lynx (*Lynx lynx*) and wolverine (*Gulo gulo*) were scarce. The bears were territorial while the reindeer were dispersed in smaller groups in the forest during calving, but at higher densities than forest-living wild reindeer and caribou.

Even less information is available to describe kill rates of adult (non-calf) caribou than for caribou calves. Table 1 depicts a summary of methods and sources for kill rates and predation rates on ungulate calves by grizzly bears. Studies have focused on calving (Boertje et al. 1988, Young and McCabe 1997, Brockman et al. 2015) although Boertje et al. (1988) reported on daily observations of radio-collared grizzly bears on the ranges of the Fortymile herd for summer, fall, and calving. Boertje et al. (1988) report a kill rate of 1 caribou/year/female bear 0-2.3 90%CI) on the Fortymile range where the bears were also killing moose at 0.6-0.8 adult moose/year but male bears killed moose at 3.3 to 3.9 adult moose/year (0.8 and 6.6 90% CI). These rates seem low compared to McLoughlin (2001), who reported that “when the Bathurst caribou herd was migrating through the ranges of grizzly bears studied by Gau et al. (2002), grizzly bears were observed to be capable of killing and consuming an adult caribou every second day or a caribou calf every day (personal observation).” Rob Gau (Pers. Comm. to Robert Mulders Feb 5th, 2021) who reiterated that his observations were based on the collared bears he was monitoring and feeding strategies

may vary between individual bears as described in Gau et al (2002). Although Gau et al. (2002) concluded that grizzly bears were effective predators of barren-ground caribou, they observed that the relative volume and occurrence of caribou in bear scats was highest in spring and autumn, which suggested that the comparatively high potential kill rates occurred only in seasons where encounter rates were highest. However, a key uncertainty in applying this potential kill rate to an overall assessment of predation risk, is the seasonal variability in rates of encounter between caribou and bears. Additionally, relatively little information is available on the hunting behavior of grizzly bears either by direct observation or from clustering of locations of GPS collared bears.

Table 1. Summary of methods and sources for kill rates and predation rates on other ungulate calves by grizzly bears.

Caribou herd	Method	Caribou calves	Source
Porcupine caribou calving ground	Aerial observations and point VHF collar relocations	Estimated kill rate was highest for sows with young (6.3 kills/bear/day; followed by barren sows (4.6 kills/bear/day; n = 5), boars (1.9 kills/bear/day; n = 5), and, finally, consorting pairs (1.0 kills/bear/day; n=8). Observed average was 3.1 compared to an estimated rate of 4.8 kills/bear/day	Young and McCabe 1997
Fortymile moose and caribou calving	Daily observations from radio-tracking flights of collared grizzly bears	5.4 $\pm$ 0.8 (SE) minimum kill rate of moose calves per bear annually	Boertje et al. 1988
Nelchina moose and caribou calves (15 May – 17 Jun; 2011-2013)	Collar-mounted video cameras on 7 grizzly bears	Calving period: 11.9 ± 4.5 SE mean caribou calves killed per bear (range 0-30), and 3.3 unknown calves (either moose or caribou; 0-8.0). Daily: 1.2 calf kills/day (range¼0.3–1.8).	Brockman et al. 2017

Predation rate

Predation rate is the proportion of prey animals (i.e. caribou) killed by predators (i.e. grizzly bears). As described below, predation rates have been measured for caribou calves either by monitoring radio-collared individuals or searching for and assigning causes of death to caribou calves that died.

Calf predation rate

The grizzly bear predation rate on radio-collared caribou calves that are less than or equal to 30 days of age in the Alaskan Denali herd averaged 19% compared to 11% for wolves but annually varied. Overall, calf mortality was highest (53%) in 1985 following a deep snow winter than rates of 29-38% in 1984 and1986-87 (Adams et al. 1995). On the Porcupine caribou herd's calving grounds, grizzly bear predation rates also varied annually: 10.0% of marked calf mortality in 1983, none in 1984, and 22.2% in 1985 (Reynolds and Gardner 1987). The overall calf mortality varied annually (average 26 ± 3.9% SE 1983-1990) (Fancy and Whitten 1991). Years of high calf mortality corresponded to years in which collared grizzly bears and caribou cows were associated more closely and related to the pattern of snowmelt on the coastal plains and foothills (Young et al. 1994). Young and McCabe (1997) also noted that the rate of grizzly bear predation on caribou calves was lower in high calving density areas.

In a recent study searching for and assigning cause of death for caribou calves on the Qamanirjuaq herd's calving ground revealed predators caused 9% (2/21 calf carcasses) of the deaths in 2010 and 32% (13/40 calf carcasses) of the deaths in 2012 (Szor et al. 2014). In 2010, two calves were killed by an unknown predator. In 2012, seven of the 13 predator-killed calves were by an unknown predator, four were by wolves, one by a grizzly bear, and one by an eagle.

Szor et al. (2014) distinguished between additive and compensatory mortality for calves with sufficient tissue in 2010 and 2012: 37.5% (3/8) of the predator-killed calves had an underlying health problem. The overall calf mortality, based on systematic surveys, was low, 1.2% and 2.97% in 2010 and 2012, respectively. The low predation rate was attributed to the high harvest rates of wolves (Szor et al. 2014) during pre-calving migration as only 1

and 7 wolves were seen during reconnaissance surveys in 2010 and 2012, respectively. The total number of bears observed was 2 and 9 bears in 2010 and 2012.

Following the same approach using systematic searching as for the Qamanirjuaq herd, Szor et al. (2014) reported that, on the coastal Beverly herd's calving grounds, calf deaths due to predation in 2011 and 2013 were 52% and 58%, respectively. Only one death was attributed to a grizzly bear and wolves caused 76.9% (20/26) and 91.0% (10/11) calf deaths in 2011 and 2013, respectively. For calves with sufficient tissue, 55.6% (10/18) of the wolf-killed calves had an underlying health problem. The overall calf mortality based on a systematic survey was low, being 6.9% in 2011 and 4.6% in 2013. The total numbers of wolves, 9 and 19 in 2011 and 2013, respectively, were high while only 3 and 5 bears were seen in these years. For both the Qamanirjuaq and the Beverly herds, the number of predators was recorded specifically during the transect flights to search for calves (Table 2). The number of grizzly bears was low (Table 2).

Table 2. Grizzly bear and wolf sightings during systematic caribou calf mortality surveys of calving grounds by helicopter (data from Szor, G. M. Awan and M. Campbell. 2014. The effect of predation on the Qamanirjuaq and Beverly subpopulations of Barren-Ground Caribou (Rangifer *tarandus groenlandicus*). Unpublished report, Government of Nunavut, Department of Environment)

	Qamanirjuaq caribou herd		**Beverly caribou herd**	
	2010	**2012**	**2011**	**2013**
Total number of transects (10km long) flown	116	106	119	148
Grizzly bear	1	2	3	
Wolf			4	5

In 1981-83, on the Beverly inland calving grounds, wolf predation was the highest cause of calf mortality (68.5%) and grizzly bear predation was low at only 0.4% (Miller et al. 1988). The number of bears seen opportunistically varied between nine in 1981, none in 1982 and two in 1983 which is consistent with the lower numbers of bears relative to higher numbers of wolves on calving grounds east of Bathurst Inlet. In total, wolves killed nine and grizzly bears five of 24 cows found dead and necropsied 1981-1983. Miller et al. (1988) suggested that the kill rate for calves was an under-estimate as bears may have almost

entirely consumed calves and thus the carcasses were not found. However, the basis for this suggestion was not detailed and so the extent of the under-estimation is unknown.

Grizzly bear predation and kill rates are unmeasured for the Bathurst and Bluenose-East herds; however, kill rates from other caribou calving grounds may be useful as an approximation of potential kill rates of calves by grizzly bears. However, results from other caribou herds (some much larger in size and from different time periods) may not be directly applicable to these two herds in their current demographic state.

As an illustrative exercise, the extrapolated number of grizzly bears on the calving grounds (Appendix A) can be applied to average kill rates measured for the Porcupine herd (three calves/day) over a ten-day period to approximate a predation rate. Taking this approach and applying the kill rates measured for the Porcupine herd, the approximate overall calving ground calf mortality for the Bathurst herd in 2018 would be 1470 calves killed by grizzly bears (49 bears x three calves x ten days). If it is assumed that all breeding caribou females had a calf, then grizzly bear predation rates may be 41% for the total calving ground. This extrapolation is for illustrative purposes only and does not account for compensatory deaths or possible calf mortality from other predators including wolves, wolverine, and eagles. Key assumptions are:

1. Extrapolated numbers of bears from regional studies, including a study in 2008-2009, are applicable to the Bathurst herd in 2019-2020; and
2. Predation rates of bears on caribou calves found for the Porcupine herd 1983-1985 are the same on the Bathurst and Bluenose-East herds in 2019-2020.

Similarly, for the Bluenose-East herd, if the same assumptions hold, then the approximation of predation rate on calves is 13% for the total calving ground in 2018.
Percentage of breeding cows is an indicator of annual birth rate (see for example, Adamczewski et al. 2019 for details), while calving ground calf:cow ratios indicate possible early calf mortality (depending on the survey timing relative to the peak of calving.) In June 2019, calf:breeding cow ratios were 64.3:100 for Bathurst and 79.8:100 for Bluenose-East, which may suggest approximately 26% and 20% initial calf mortality for Bathurst and Bluenose-East (Adamczewski et al. 2019). The Bathurst survey was 8-11 June and the

Bluenose–East was 12-14 June relative to the peak of calving, which was 2-4 June 2019 for both herds. The timing could affect results as there were about 3 more days on the Bluenose-East calving ground for calves to be born. The calf:cow ratios are an approximation as the monitoring is not designed to measure early calf mortality and its sequence during the peak of calving and into early post-calving.

Calf survival during the summer is indexed by calf:cow ratios determined during fall sex and age composition (for example, Adamczewski et al. 2019). Between 2006 and 2020, the mean calf cow ratio for the Bathurst herd was 34.8 ± 3.26 (SE) and for the Bluenose-East herd, the average ratio 2008 was 39.9 ± 2.8 (SE). The calf summer survival is annually variable and since 2006 it has not followed a consistent trend.

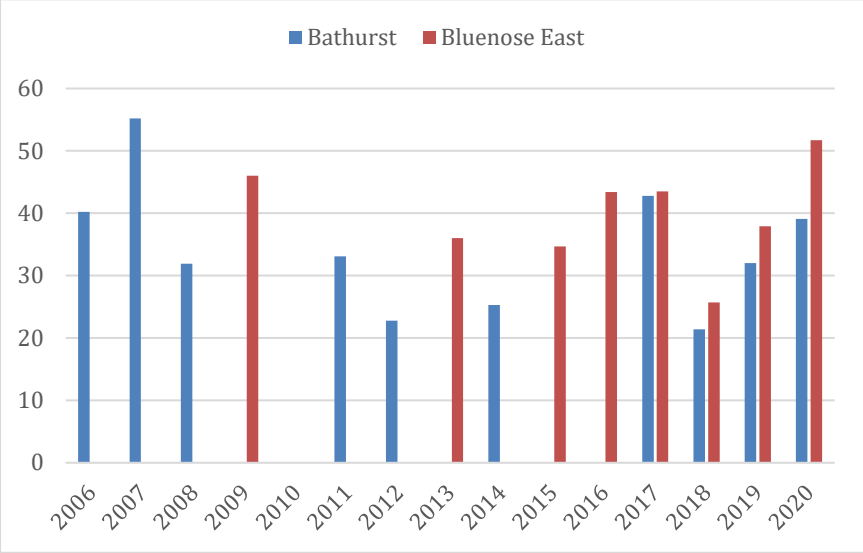

Figure 2. Fall calf:cow ratios for the Bathurst and Bluenose-East herds, 2006-2020 (data from GNWT. Zero values are years with no survey.

Cow Mortality Estimate

Predation rates for adult caribou are unknown for the Bathurst and Bluenose-East herds which is the case for most caribou herds. The predation rate on adult caribou can be projected from 2016-2020 information on summer and fall ranges for the Bathurst herd and Bluenose-East caribou (Table 3).

Table 3. Average area of fall, and summer ranges of Bathurst and Bluenose-East herds 2016-2020, and number of grizzly bears based on extrapolations from bear densities: 2-5 bears/ 1000km^2 in the Lac de Gras area (ERM 2018) for the southern Bathurst range; 6 bears/ 1000km^2 Dismal Lake area (Dumond et al. 2015) and 9 bears/ 1000km^2 Izok Lake area (Boulanger et al. 2013a).

	Bathurst		Bluenose-East	
	Both Sexes (km^2)	Extrapolated number of Bears	Both Sexes (km^2)	Extrapolated number of Bears
Summer	32,165	64-160	63,373	380-570
Fall	45,196	90-226	70,785	424-637

Figure A2 depicts the calving, fall, and summer ranges of Bathurst and Bluenose -East herds from 2016-2020 based on 95% kernels for both male and female collared caribou (Jan Adamczewski pers. comm. 2021). We applied estimated bear densities (Appendix A) to the caribou summer and fall ranges to derive a possible number of bears (Table 3). Minimal data adds uncertainty for the grizzly bear kill rate for caribou on the summer and fall range : Two possible estimates are one caribou/bear/year (Boertje et al. 1988) to as high as one caribou/bear/two days (Gau et al. 2002). If we applied a middle rate at one caribou/ten days/bear to August-September (60 days when the bears are maximizing food intake), and a third of the bears are strongly carnivorous, then 30-75 bears on the Bathurst fall range could annually remove 180-450 caribou. Likewise, 141-212 bears on the Bluenose-East fall range could annually remove 848-1274 caribou. The predation rates based on 2018 herd sizes and the maximum kill rate are 2-6% and 4-6%, Bathurst and Bluenose-East herds, respectively.

The assumptions are:

1. The extrapolated density of bears from the cited bear study areas are applicable to the summer and fall caribou range.
2. Based on experience in Alaska, the assumption that only a third of the bears are strictly carnivorous (Brockman et al. 2015).

3. The kill rate of 6 caribou/year/bear is a guess between 1 caribou/bear/year (Boertje et al. 1988) and 1 caribou/2 days/bear (Gau et al. 2002).

A maximum grizzly bear predation rate on Bathurst adult caribou is possible given the current adult caribou survival rates as monitored through collared caribou. The caribou collars show the seasonality of death but not the causes of death. Measuring the precision of the annual rates was limited by a low number of collars, but this low number has increased recently (Adamczewski et al. 2019). Annual adult cow survival in the Bathurst herd for June 2017 to June 2020 averaged 88% (76-95%) for adult cows (Boulanger unpubl. 2020). Summer survival has increased since 2011, but annual winter survival is variable. By comparison, summer calf survival from calving to fall has no consistent trend since 2005 and varies annually (Adamczewski et al. 2019).

For the Bluenose-East herd, annual adult cow survival was estimated at 82% (75-85%) for June 2017 to June 2020 based on collar data (Boulanger unpubl. 2020). Summer adult survival has increased since 2017, but winter survival is relatively stable (Boulanger unpubl. 2020). Summer calf survival varies annually with no consistent trend and is higher compared to the Bathurst summer calf survival (Adamczewski et al. 2019). The grizzly bear predation rates for adult caribou estimated from the kill rates are uncertain and conjectural. The extrapolations do make the point that while grizzly bear predation is unknown it is potentially a factor in either halting declines or starting recoveries.

However, although we have identified grizzly bear predation as having a potential role in either halting caribou declines or starting caribou recoveries, this assessment is but the first step and is to compile information about grizzly bear predation and management options. We do not, at this stage, have information to describe whether and under what conditions grizzly bears limit or regulate caribou abundance. Similarly, we are limited in describing the theoretical aspects of predation including functional and numerical responses of grizzly bears. We expect that if the management authorities develop specific management proposals, those proposals would include details on for example the limiting or regularity role.

Summary

This assessment provides a conceptual framework for compiling and evaluating available information on predation of caribou by grizzly bears, and seeks to address a key question:

- is there sufficient evidence for concluding that grizzly bear predation on caribou calves and/or adults is sufficiently high that management intervention on bears is needed to increase population growth rates of Bluenose-East and/or Bathurst caribou herds?

Since there are limited empirical data specific to predation of Bluenose-East and/or Bathurst caribou by grizzly bears, the answer to the question is uncertain but the weight of evidence through studies in Alaska and estimates of bear densities in portions of the caribou ranges suggest grizzly bear predation may influence early calf survival in these herds. Importantly, this framework establishes a logical basis for interpreting available information and assessing how bear predation may impact population growth and recovery of caribou. As part of this assessment, key assumptions (Table 1, Table 3) and uncertainties (Table 6) were highlighted, which in turn may be used to identify key data gaps prior to or associated with management action(s). Based on this assessment, the impact pathways (Figure 3) of predation by grizzly bears on caribou should be explored in more detail through scenario analyses of potential management actions based on simulation modeling approaches. This in turn would be an important step in developing a more formal adaptive management approach that would include 1) proposing specific and time-bound actions, i.e., numerical reduction of grizzly bears, to reduce mortality rates on caribou calves and/or adults, 2) developing and adjusting predictions based on magnitude of management action(s), 3) identifying, selecting, and tracking key response indicators, and 4) identifying and monitoring potential confounding and interacting factors.

In summary, this assessment provides several key insights:

- It provides a conceptual modelling framework that integrates available knowledge and empirical data from relevant studies with application to Bluenose-East and

Bathurst caribou. In turn, this provides a transparent basis for exploring impact pathways of grizzly bears on barren-ground caribou herds and whether the main effects of predation are mediated through increased mortality on caribou calves or adult females.

- It highlights key uncertainties and helps identify a need for empirical data in these specific areas.
- It provides a basis for further assessment and review of evidence, which may be undertaken with population modelling that formalizes impacts pathways and key uncertainties, which in turn may form the basis of management objectives.

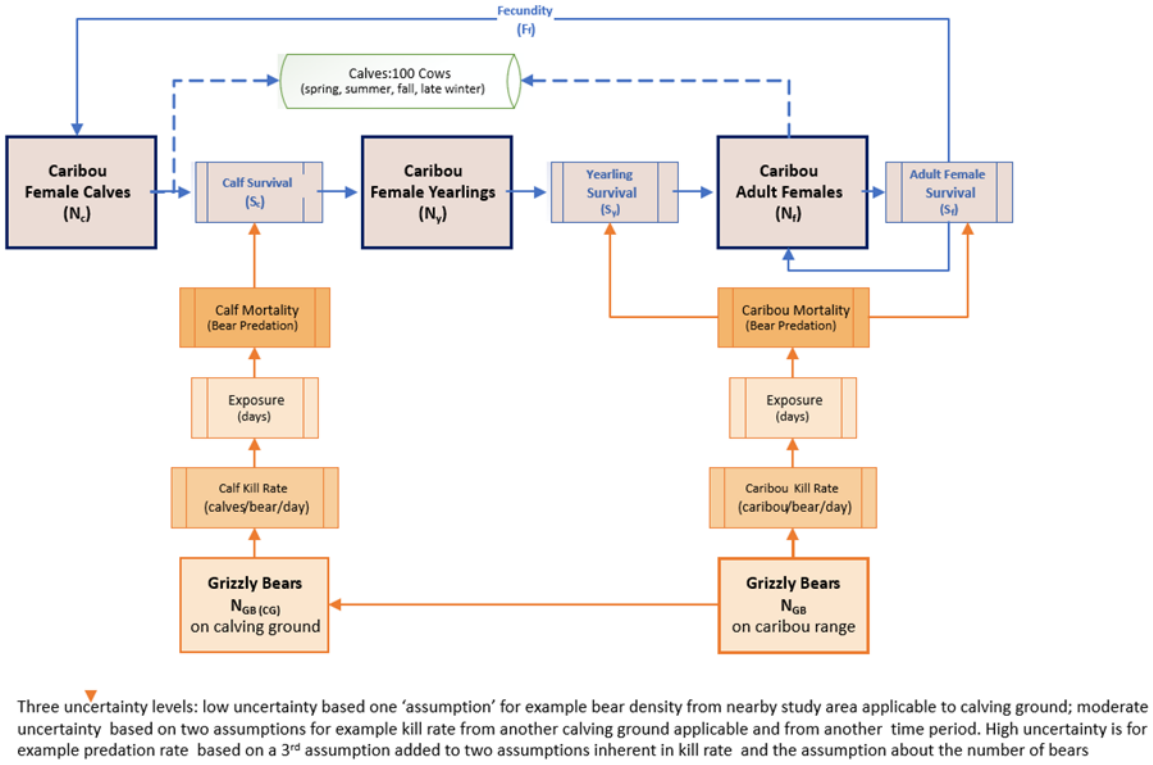

Figure 3. Model pathways for predation effects of grizzly bears on barren-ground caribou.

Management Options

Current approaches to grizzly bear harvest

In Nunavut, harvesters voluntarily report their grizzly bear harvest. Harvesting depends on accessibility of grizzly bears and individual hunter preferences (e.g., interest,

hunting for food, clothing, sport, and/or predator or nuisance threat). The grizzly bear subsistence harvest, sports hunt, and defense kills were considered sustainable in the Kitikmeot for 2000-2008 as the harvest was relatively consistent, averaging 15 bears/year (SD = 5.1) (Awan and Szor 2017). Between 2013 and 2019 (Table 4), the harvest was annually variable and increased from 2017 to 2019 (M. Awan Pers. Comm. 2020). Most of the harvest is males (86%), and half of those males harvested are adults. Awan and Szor (2017) point out that the males have larger home ranges and movements after den emergence to the end of June, compared to females. In NWT, bear management on the barren-ground caribou ranges does not include harvesting, instead bears are removed in defense of life or property are recorded, and these are low (Table 5).

Table 4. Reported total grizzly bear harvest in the Kitikmeot region of Nunavut between 2013 and 2020: total of regular (subsistence) and sport hunt (Data from Government of Nunavut; there was no sport hunt in 2020; Cambridge Bay harvest includes Umingmaktok and Kingaok).

	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Cambridge Bay	5	9	17	2	11	6	10	6
Kugluktuk	2	5	11	5	5	10	8	9
Taloyoak	-	-	-	-	-	1	-	
TOTAL KITIKMEOT	**7**	**14**	**28**	**7**	**16**	**17**	**18**	**15**

Table 5. Grizzly bear mortalities reported to GNWT as Defense of Life and Property kills (DLPs) within the North Slave Region (2005-2020).

Year	2005	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	'18	'19	2020
DLP's	7	6	3	1	1	1	0	0	0	0	1	1	0	0	2	2

How grizzly bears and caribou respond to grizzly bear removals

Theoretical predator-prey relationships are a basis to explore how reducing grizzly predation will affect caribou abundance. The functional response is the relationship between kill rate per bear and caribou density. Bears may be similar to wolves in being efficient at

killing prey at low prey densities (Type II functional response, Dale et al. 1995). The functional response for the summer-fall ranges vs calving grounds will be influenced by the pattern of clumped spatial density of caribou, including aggregations during insect harassment or at water crossings. This will increase annual variation in the functional response as insect harassment varies between years, and predation is swamped at high densities.

The theory of predator-prey relationships also predicts that predation rate depends on the ratio of predators to prey (Vucetich et al. 2011). However, in practice, the ratio is imprecise as a basis for management as other factors are influential, especially whether predation is compensatory or additive in a two-predator system (Vucetich et al. 2011). It follows that the predation rate will increase if prey abundance is low (Boertje et al. 1987). Any effect of increased bear abundance is uncertain. The importance of the predator-prey ratio does suggest that predation rates will differ between the calving ground and summer ranges. In addition, Young and McCabe 1997 wrote*:*

> *… assuming a density-independent relation exists, as Boertje et al. (1988) concluded for moose and grizzly bears in east central Alaska, we would expect that predation by grizzly bears would have a proportionately greater effect on the population as calving density decreased. Adams et al. (1995) concluded that mortality caused primarily by grizzly bears and secondarily by wolves in a low-density caribou herd was additive and therefore a major limiting factor*.

Grizzly Bear Response

Grizzly bears are a species of Special Concern as they are at low densities, are long-lived, and have a low reproductive rate (SARC 2017). The grizzly bear's numerical response is the changes in bear reproduction or survival due to any proposed removal of bears as a management approach. A response to removal would have to be considered relative to how, and if, the bears are already responding to the reduced availability of a main part of their diet, the caribou and if they are compensating for caribou decline by prey switching.

To date, Inuit harvesters have reported an increase in grizzly bear occurrence and encounters in the Kitikmeot despite the steep reduction in caribou numbers. This may be in

part because caribou likely have maintained relative densities by decreasing their seasonal range sizes. For example, Adamczewski et al. (2019a) reported how a reduced core calving ground area led to increased caribou calving density, but the increase was brief as subsequently caribou density declined from 2012-2018. However, given that grizzly bears have large territories, they will still likely encounter caribou despite the caribou range shift and contraction in size.

The apparent lack of a numerical response to the sharp decrease in caribou numbers may also be because the bears are responding through reduced litter size or delayed age of first reproduction. However, in the absence of detailed monitoring of bear vital rates, a change in productivity will not be detected. An additional factor is that a compensatory response to a male biased harvest (GN 2017) may modify a numerical response to the caribou decline as male bears can kill females with litters (compensatory response). Additionally, the role of immigration is unknown, but bears may move to occupy territories of bears removed during a management action. At this stage, there are uncertainties in projecting forward how the grizzly bears will respond to any proposed removal in addition to the current harvesting (GN 2017). The response of bears to specified removal relative to caribou management can be explored through enhanced monitoring and existing or new computer models to assess numerical response of grizzly bears under different assumptions and scenarios.

Caribou Response

The numerical response of caribou to bear removals is uncertain as it depends on the season of removal and the basic model of caribou population dynamics. Caribou populations are especially sensitive to even small changes in adult survival but less sensitive to variation in calf survival unless it is a consistent trend. There remains the question of whether grizzly bear predation is additive or compensatory to other causes of death.

The grizzly bear kill and predation rates for adult caribou are unknown, but the low densities of grizzlies on the post-calving, summer and fall ranges may point to low rates. Bear removal may not, then, measurably increase adult caribou survival. Initial and exploratory predation rate on the calving grounds, and the experience from Alaska, suggests that calf

survival could be increased by bear removal. An uncertainty is whether the rates of compensatory deaths during wolf predation on calving grounds east of Bathurst Inlet are applicable to grizzly bear predation (Szor et al. 2012). Current population modeling available for both Bathurst and Bluenose-East herds would help in examining the level and duration of increased calf survival necessary for a positive numerical response to bear removal.

Development of Grizzly Bear Removal Options

We considered the options which the Technical Feasibility Assessment Working Group (2017) had developed for wolf management. However, we considered the differences between wolf and grizzly bear ecology which meant we did not include the four winter options. We did not consider relocation to a zoo or captive facility to be practical and we did not include sterilization as an option given the bear's low reproductive rate.

Knowledge gaps and uncertainties

We have also considered uncertainties or gaps in information (Table 6). Uncertainties arise because most experience with grizzly bear removal is for moose management in Alaska where there were also wolves and alternate prey (including caribou and Dall sheep). Knowledge gaps include almost no current information on grizzly bear movements and feeding ecology on the seasonal ranges of the Bathurst and Bluenose-East herds. The current estimates of grizzly bear abundance have been mostly undertaken in the vicinity of mines and it is uncertain how representative those estimates are for the relative density of bears on caribou seasonal ranges.

Estimates of grizzly bear kill rates and predation rates are lacking and are mostly for caribou calves from the Alaskan caribou herds, including the Porcupine herd. What is known about grizzly bear kill rates adds considerable uncertainty as bears vary individually, and by sex and age class in their predatory behavior. Gaps and uncertainties in caribou information include causes of death, which are mostly unknown. Annual and seasonal survival rates are monitored through collared caribou, but statistical power is limited by sample sizes.

We do not know the combined effects of wolf and grizzly bear predation. For that, we would need to know how grizzly bears and wolves affect each other's kill and predation rates

or the nature, if any, of a competitive relationship such as whether it is interference (direct) or exploitive (indirect). The Kugluktuk Angoniatit Association has shared the following information (Amanda Dumond pers. comm. 2021):

> "I've seen when there are lots of wolves around, they go after young bears. They will kill them for food, and it eliminates competition. On the mainland, in the zones of Bluenose East and Bathurst caribou there are a lot of food sources: rabbits, mice, squirrels, ptarmigan. We don't really know how bears and wolves affect each other's kill and predation rates as we are not in the calving grounds; that's when there would be a lot of competition. "

The relative exposure of grizzly bears and wolves to calves on the calving grounds and brief handling time given a small calf body mass suggests that grizzly bears and wolves may not influence each other's kill rate. Given the high numbers of calves available on a calving ground, and an assumed lack of interference, the predation rates of grizzly bears and wolves are possibly additive. In summer, grizzly bears and wolves may compete through interference if the availability of predator-killed caribou carcasses affects wolf or grizzly bear kill rates. A possible parallel is that grizzly bear scavenging reduced the wolf kill rate on moose and other large ungulates in both Scandinavia and Yellowstone National Park (Tallian et al. 2017). However, in Alaska, grizzly bears killed more animal tissue than they scavenged and appropriated more wolf kills than the other way round (Boertje et al. 1998). A complication in assessing relationships between grizzly bear and wolf predation is the decline in wolves on the Bathurst herd's summer range (Klaczek et al. 2016) and the effect of climate on predation (Griffin et al. 2011, Wilmers et al. 2020).

Table 6. Specific knowledge gaps and uncertainties with *responses provided by the Kugluktuk Angoniatit Association (Amanda Dumond pers. comm. 2021)*.

Topic	***Uncertainty***
Grizzly bear abundance	How well do the six survey areas (DNA mark and recapture) sample the regional abundance of bears and specifically calving grounds?
Movements	Do some grizzly bears follow breeding female caribou during their pre-calving migration to the calving grounds, which could increase

	bear density and kill rates? *Yes; when we used to track with collars, some would follow. It's mostly they wait for the caribou; migrate to calving ground, migrate north south.*
Incidental sightings	How well do incidental sightings correlate with grizzly bear densities or trends in abundance?
Diet	What is current spring (calving grounds) and summer bear diet and extent of individual variation, especially the proportion of strongly carnivorous bears? *Spring after coming out, they don't eat right away, after 2 weeks they look for meat., protein. The summer bear diet is lots of vegetation, very healthy because it's all new growth. In the fall it's berries and vegetation and they look for meat for protein to get fat.*
	How have bears compensated in their diet for reduced caribou numbers based on comparing current diet and diet described in the late 1990s? *More muskox predation in the springtime; moose in the fall time when caribou not there* *Grizzly bears go after squirrels and rodents*
	How will bears respond to removals? *In the old days, bears were marked and moved but they would be back. If they know there's food, they will be back.* *Killing all the big males will create more problems, we need to harvest smaller bears.* *Hire people to be around the calving grounds, it will create a disturbance to the caribou, but it will help them survive.*
Caribou	What are the causes of calf and adult mortality and extent of compensatory mortality for calves?
Kill rates	What are grizzly bear kill rates for caribou adults and calves on Bluenose-East and Bathurst calving grounds and how do they vary annually? *In the old days we used to see lots of calves chased and kills by both grizzly bears and wolves. They would get one, then go after another, running, it's their instinct.* *People are not as present on the land as they used to be, to observe changes, to observe everything, to harvest these predators.*

	Vary by number of caribou; calving locations have changed, don't see them as easily
Predation rates for calf and adult caribou	What are current bear numbers by sex and age class, proportion of likely specialist carnivorous bears, kill rates by sex age classes and current caribou and calf numbers. *We know the population is high, there is a good mixture of male and female. Female population may be higher as there has been more harvest of males lately*
Topic	***Uncertainty***
Grizzly bear abundance	How well do the six survey areas (DNA mark and recapture) sample the regional abundance of bears and specifically calving grounds?
Movements	Do some grizzly bears follow breeding female caribou during their pre-calving migration to the calving grounds, which could increase bear density and kill rates?
Incidental sightings	How well do incidental sightings correlate with grizzly bear densities or trends in abundance?
Diet	What is current spring (calving grounds) and summer bear diet and extent of individual variation, especially the proportion of strongly carnivorous bears?
	How have bears compensated in their diet for reduced caribou numbers based on comparing current diet and diet described in the late 1990s?
	How will bears respond to removals?
Caribou	What are the causes of calf and adult mortality and extent of compensatory mortality for calves?
Kill rates	What are grizzly bear kill rates for caribou adults and calves on Bluenose-East and Bathurst calving grounds and how do they vary annually?
Predation rates for calf and adult caribou	What are current bear numbers by sex and age class, proportion of likely specialist carnivorous bears, kill rates by sex age classes and current caribou and calf numbers.

Grizzly bear Removal Options

We have listed four possible management options based on experience mostly in Alaska. Two options (diversionary feeding and relocation) are non-lethal and two options are lethal (targeted shooting on the calving ground and summer harvesting). The Working Group's assessment of options is collaboratively developed advice to be considered by management authorities considering grizzly bear management as a conservation tool for

Bluenose-East and Bathurst herds. The options as described can be modified to be implemented through governments, co-management agencies, and/or community-conservation plans and can be combined (such as both live and lethal removal on the calving grounds). Reducing overall bear numbers may not be as effective as removing bears from specific locations or a particular sex and age class.

Diversionary feeding

This option is providing carcasses (e.g. fish, seals, whale, muskoxen, bison) to divert grizzly bears from hunting caribou especially caribou calves on the calving grounds.

Background

Diversionary feeding has been tried elsewhere mostly to divert grizzly bears from human-bear conflict situations (reviewed by Garshelis *et al.* 2017). In Alaska, Boertje *et al.* (1991) noted on the Fortymile caribou calving ranges that diversionary feeding had high social acceptability, however the logistics were a limitation. They used 16 and 26 metric tons of bait (moose that had been accidentally killed) in late May 1990 and 1991, respectively to divert grizzly bears (16 bears/1,000 km^2). The baits were distributed on the Macomb Plateau in east-central Alaska where caribou and moose calved in a 1,650-km^2 area. The diversionary feeding increased moose survival but not early caribou calf survival in the declining Macomb herd (1988-1992). In Newfoundland, using a control and treatment caribou calving grounds, diversionary feeding of black bears and coyotes for two years during calving slightly increased calf survival although only the bears and not coyotes were attracted to bakery waste or beaver carcasses. Lethal removal of coyotes did more to increase calf survival (Lewis et al. 2018).

Relocation to remote areas

Bears on the calving ground that are either seen hunting caribou or in vicinity of caribou would be live captured and flown ~200 km by helicopter, collared to map their subsequent movements, and then released. By the time the bears return to their territory or the calving ground, the caribou calves would be larger and less vulnerable. Experience in the

NWT includes a sow and 2 yearlings live-captured near the Diavik mine on July 31, 2020 (R. Mulders, pers. comm.) and moved 100 km to the east.

Background

Relocation was proposed for the Fortymile herd's ranges in 2003 if grizzly bear predation on calves increased following wolf removal but as the increase was not recorded, the translocations were cancelled (Boertje and Gardner 1999). Relocation for black and grizzly bears was tested for increasing moose calf survival in Alaska in 2003 and 2004 (Keech *et al.* 2011). It was expensive and difficult to find areas to take the bears to that were not controversial and the relocation program was abandoned. Subsequently, a lethal option was implemented (shooting from a helicopter and harvesting; ADF&G 2014). Two potential disadvantages are if the bear's capture and handling did not deter the bear from returning the following year, or if calving caribou might be affected by the bear captures due to low-flying helicopter activity.

Aerial shooting on calving ground

The targeted aerial shooting of grizzly bears on the calving ground is based on recognizing predatory behavior and the potential for multiple kills in a short time period. It also has the advantage of being more likely to select individual bears with a higher kill rate. Supporting hunters (either subsistence or sport) could be highly effective in targeting specific bears based on their behavior during pre-calving migration, and on the calving grounds (with suitable care to avoid disturbing calving cows).

Background

This has not been applied to caribou but in Alaska the decline of the North Slope muskoxen led to a recovery plan whose actions included selective removal of bears seen threatening or attacking muskoxen. Seven bears (6 males) were killed 2012-2015 and although the rate of muskoxen deaths from bears decreased, the expected recovery in muskox numbers was reduced by an unpredictable accident when 20 muskoxen (about 10%

of the total numbers) broke through thin ice and drowned in a small lake in fall 2012 (Lenart 2015).

Harvest assistance

Support for harvesters will likely be essential to targeting bears relative to caribou locations (such as on pre-calving ranges and calving grounds and caribou water-crossings). The 2017 Government of Nunavut Grizzly Bear Management Plan does not discuss options for using grizzly bear harvesting to increase caribou survival, but the Bluenose-East community management plan acknowledges the need for a predator management program including grizzly bears (Kugluktuk Angoniatit Association 2016).

Background

Harvest assistance as a removal technique has been used for moose in Alaska to support moose recovery (Management Unit 19D), ADF&G issued harvester permits to shoot grizzly and black bears using bait in addition to wolf control in a specific predator control area (1368 km^2; ADF&G 2110)

Criteria for assessment

Criteria should be developed to rate the options outlines above. Criteria should be focused on humaneness and welfare, efficiency, effectiveness, and risks and uncertainties. As much as possible, the four criteria should be objective and quantitative. For example, disease risk assessment in wildlife uses a decision tree to compare options by showing the level of risk in the presence of uncertainty.

Humaneness and Welfare

Humaneness and welfare have social and ethical aspects. The experience of international agencies should be drawn on and viewed as "humaneness" for the individual grizzly bear. Lethal options should cause immediate unconsciousness and subsequent death without excitement, pain or distress, and non-lethal options should cause minimal excitement, pain, injury, and/or discomfort. Evaluation should also consider the welfare of

the individual grizzly bear, members of its family (if applicable), and other wildlife species, as well as rated welfare based on the five freedoms: freedom from hunger or thirst; discomfort; pain, injury or disease; to express (most) normal behavior and freedom from fear and distress. It may not be possible to address issues related to reduction of predator abundance on other predators or scavengers. Ecological effects of grizzly bear management or its absence and caribou may not be included in the feasibility assessment.

Efficiency

Assessment of efficiency should be based on estimated costs related to implementing the options. The costs could include transport (type/hourly rate), fuels costs, equipment/supplies (e.g. collars, bait for diversionary feeding), and personnel (fees, per diems) but may exclude staff time. Development of standardized rates (e.g. time/distance/fuel required to reach the seasonal range) would allow for comparison across options. Costs should be estimated both on a per capita basis (per individual grizzly bear), as well as the total for the first year of implementation. The expectation may be for a 5-year program followed by extensive re-appraisal. Subsequent annual costs change as for example, search effort and per capita costs (catch per unit effort) may increase as fewer grizzly bears are needed to maintain the rate of removal, but those fewer grizzly bears may be more difficult to find and remove.

Effectiveness

Assessment of effectiveness should be based on the combined likelihood of a) finding the target number of bears and b) the option's required treatment.

Risks and Uncertainties

Risk can be measured as the likelihood of an outcome, whereas uncertainty is a lack of knowledge and less amenable to estimating the likelihood. An assessment should list possible negative consequences associated with each option and assign a relative overall rank of low, medium, or high risk to the options. Risks specific to humaneness or effectiveness should be described. For example, the risk of not meeting the target number of

grizzly bears owing to the difficulty of locating should be considered as part of assessing effectiveness.

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Appendix A: Extrapolations of Grizzly Bear Densities on Bathurst and Bluenose-East Calving Grounds

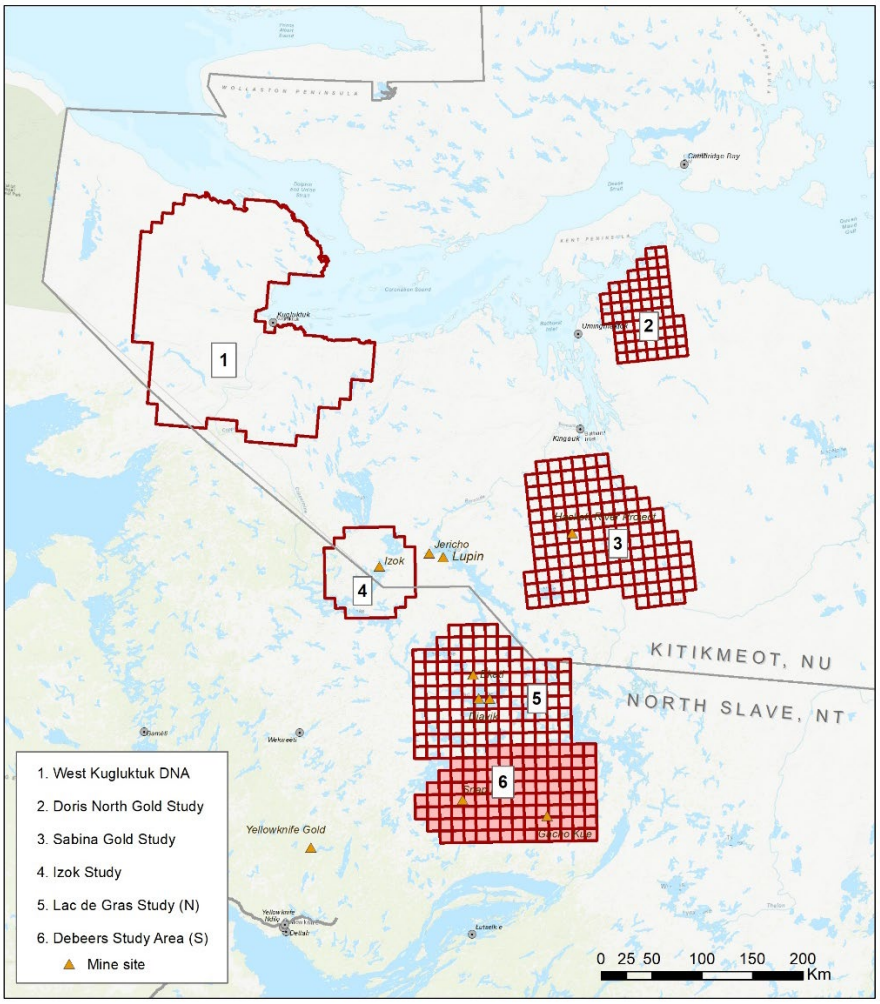

Figure A1. Grizzly bear study areas in Northwest Territories and Nunavut (R. Mulders pers. comm.)

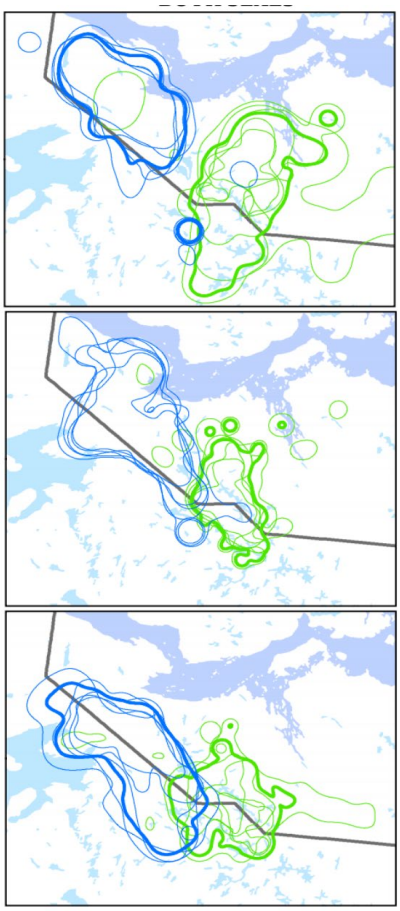

Figure A2. Calving, fall, and summer ranges of Bathurst (green line) and Bluenose-East herd (blue line) 2016-2020 (J. Adamczewski pers. comm.).

Grizzly bear abundance on the caribou calving, summer and fall ranges can be extrapolated from densities estimated during previous studies in the region while recognizing possible limitations from different methods (Figure 1, Table A1). The estimated number of grizzly bears on the Bathurst herd's calving ground in 2018 is 7 and 49 for the high caribou density (photo) stratum and the total calving ground, respectively. To be conservative, the estimated number of bears is extrapolated from lower confidence limit for bear densities estimated in 2014 for the southern part of the Bathurst Inlet area (Rescan 2014). The estimated densities were derived from a grizzly bear DNA mark and recapture study for the Sabina mine and the study area overlapped the moderate and low-density Bathurst caribou survey strata in 2018 (Boulanger et al. 2019). The estimated number of

grizzly bears on the Bluenose-East herd's calving ground in 2018 is 35 and 52 for the high density (photo) stratum and the total calving ground, respectively, extrapolated from a 2008-2009 estimate of bear densities (Dumond et al. 2015). We note these are approximations, not up-to-date estimates of grizzly bear numbers from the calving grounds.

Table A1. Extrapolations for numbers of grizzly bears on the Bathurst and Bluenose-East calving grounds in 2018 based on densities estimated during environmental assessment and monitoring for mines (see text for details).

	Bathurst		Bluenose-East	
	Calving ground survey (2018)	Extrapolated bear abundance[a]	Calving ground survey (2018)	Extrapolated bear abundance[a]
Total calving ground survey area[b]	8,195 km^2	57 (49 - 66)	8,672 Km^2	52 (51 - 54)
High density photo survey area[b]	1,227 km^2	8 (7 - 10)	5,839 Km^2	35 (34 - 36)
Sightings of grizzly bears during composition surveys[c]	8		21	
Estimate of breeding female caribou (95% confidence interval)[b]	3,636 (2,709 - 4,880)		11,675 (9,971 - 13,670)	
Estimated density (grizzly bears/1000 km^2)		6 - 8[d]		5.9 - 6.2[e]

[a] mid-point estimate rounded to whole number (range)
[b] Adamczewski et al. 2019a, Boulanger et al. 2019
[c] Adamczewski et al. 2019b
[d] Estimated bear density 6-8 bears/1000 km^2 from Rescan (2014)
[e] Estimated bear density 5.9–6.2 bears/1000 km^2 from Dumond et al. (2015)

Despite potential sources of sightability bias, observations of grizzly bears during caribou surveys may be a useful index of grizzly bear abundance on caribou seasonal ranges, with the utility of the index dependent on consistent reporting of all incidental predator observations along with clear reporting of hours flown, and whether ferry flights, reconnaissance flights, etc. are included (Poole et al. 2014). Observations of grizzly bears

during calving ground surveys may include repeat sightings although this bias may be reduced by only using sightings from one part of the survey such as the helicopter-based composition flights. The sighting rates are reported as the number of bears per hour flown during the surveys and allow for direct comparisons between areas when survey methods are similar. In 2007 and 2008, most calving grounds of barren-ground caribou in NWT and NU were surveyed by fixed-wing aircraft during calving which revealed that for the same years, more grizzly bears were observed than wolves on calving grounds as one moves west of Bathurst Inlet (Poole et al. 2014).

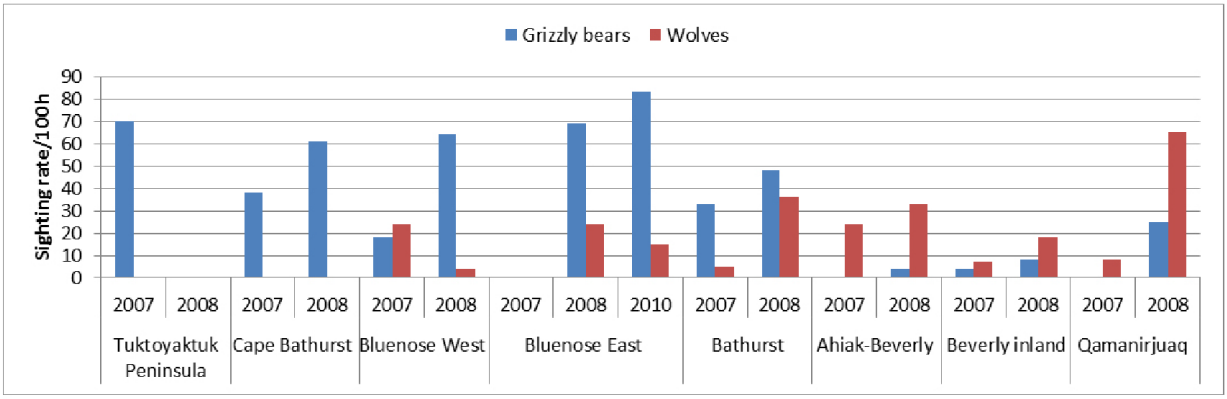

Figure A3. Grizzly Bear and Wolf sighting rates during fixed-wing reconnaissance surveys of calving grounds, NWT and NU, 2007-2008 (from Poole et al. 2014, ENR unpubl.)

Specifically, for the Bathurst and Bluenose-East calving grounds, sighting rates for grizzly bears were on average three times higher than wolves although sightability bias between the two species was likely different (Figures A2 and A3). For the Bathurst calving ground, the observed rates for 2006-2015 were 1.3 ± 0.03 (SE) wolves/10 hours compared to 4.9 ± 1.56 grizzly bears/10 hours (D. Cluff unpubl. data, Poole *et al.* 2014), which covers the period when wolves were declining (Klaczek et al. 2016). The average sighting rate of bears is similar (4.8 ± 0.98 SE and 5.7 ± 0.82 SE bears/10 hours for Bathurst and Bluenose-East herds, respectively) with relatively high annual variation and no trend for 2008 to 2019 (Figure A3).

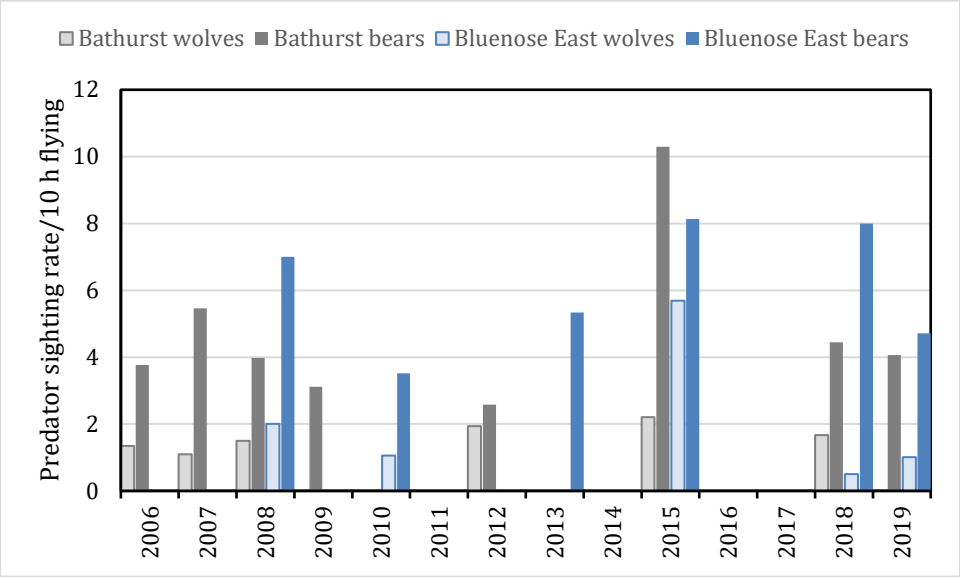

Figure A4. Sighting rates for grizzly bears and wolves (individuals/10 flying hours) recorded during calving ground surveys for the Bathurst and Bluenose-East herds 2006-2020 (data from GNWT).

The sighting rate of grizzly bears may be comparatively high on a caribou calving ground because some bears may move to the calving grounds, as documented for the Western Arctic Herd in Alaska (Reynolds and Gardner 1987). Although most bears on the Western Arctic range are territorial, a few bears followed the pre-calving migration of the Porcupine herd to their calving grounds (Reynolds and Gardner 1987). A similar pattern was found for sub-adult male grizzly bears following the pre-calving migration of the Bathurst herd (Gau *et al.* 2004). Future studies using marked bears would help resolve whether grizzly bears move to the caribou calving grounds during calving.

Appendix B: Grizzly bear Feasibility Working Group - Terms of Reference

Grizzly Bear and Wolverine Biological and Management Feasibility Working Group
Terms of Reference - FINAL

Preamble

The Grizzly Bear and Wolverine Biological and Management Feasibility Working Group is being organized to meet the recommendations of the Wek'èezhìı Renewable Resources Board (WRRB), Recommendation #4B-2016 (Bathurst), Recommendation #4B-2016 (Bluenose-East) and Recommendation #6-2019 (Predator). These recommendations called for a grizzly bear biological assessment to be completed in order to summarize current information on grizzly bear abundance, movement, and diet for the Bluenose-East and Bathurst caribou herds' seasonal ranges.

In its 2019 Bluenose-East Reasons for Decision Report, the WRRB acknowledged the role of the wolverine as a predator to barren-ground caribou. In addressing the biological assessments and management feasibility of the two predators under one terms of reference, the hope is that efficiencies will be made given the current status of the Bluenose-East and Bathurst caribou herds.

In 2017, a Wolf Feasibility Assessment Technical Working Group published the Wolf Technical Feasibility Assessment: Options for Managing Wolves on the Range of the Bathurst Barren-ground Caribou Herd. As such, this working group will not consider wolves in their assessment.

Disclaimer: The Grizzly Bear and Wolverine Biological and Management Feasibility Working Group is conducting the Grizzly Bear and Wolverine Biological and Management Feasibility Assessment because of commitments made by parties based on recommendations from the

WRRB in 2016 and 2019. The Assessment does not reflect specific support for predator management by participants in the Working Group.

Objectives

The Working Group shall:

a) Collaboratively conduct a biological assessment in order to identify and assess the biological state of grizzly bears and wolverines present on the range of the Bathurst and Bluenose-East caribou herds;

b) Collaboratively identify the different grizzly bear and wolverine management techniques that may be implemented on the range of the Bathurst and Bluenose-East caribou herds to increase calf and adult caribou survival rates sufficiently to stabilize the herd and initiate recovery to higher numbers;

c) Bring forward any currently available traditional and/or scientific knowledge relevant to the assessment;

d) Support the development and timely implementation of a communication strategy regarding the grizzly bear and wolverine biological assessment and management by communications experts;

e) Treat all reports and supporting material as confidential, unless otherwise specified; and

f) Set up meeting procedures necessary to its operations.

Terms of Reference

This Working Group has been established to conduct a biological assessment of wolverines and grizzly bears to identify a series of different grizzly bear and wolverine management techniques in the annual range of the Bathurst and Bluenose-East herds. The primary scope of the assessment is the herd's range in the Northwest Territories and Nunavut. The Working Group will communicate with appropriate agencies in the Northwest Territories and Nunavut, request their input at appropriate points and respect jurisdictional boundaries.

The Working Group is accountable for overseeing, reviewing, and providing advice on a biological and initial management feasibility assessment for grizzly bear and wolverine management on the annual range of the Bathurst and Bluenose-East caribou herds by:

a) Fostering collaboration and ensuring that both existing traditional and scientific knowledge are used to identify all possible options for grizzly bear and wolverine management on the annual range of the Bathurst and Bluenose-East caribou herds;

b) Summarizing experience with grizzly bear and wolverine management and monitoring in other North American jurisdictions and its relevance to grizzly bears and wolverines associated with migratory barren-ground caribou; and,

c) Ensuring that an effective communication strategy is developed to inform and educate the public and other parties with interest in the Bathurst and Bluenose-East caribou herds on the grizzly bear and wolverine biological assessment and management, including reviewing existing communication strategies to build on recent experiences of others.

- The members of the Working Group shall include representatives from each of the following organizations:
    - Tłı̨chǫ Government (TG), Department of Culture & Lands Protection;
    - Government of the Northwest Territories, Environment & Natural Resources (ENR);
    - Wek'èezhìı Renewable Resources Board (WRRB);
    - North Slave Métis Alliance (NSMA);
    - Yellowknives Dene First Nation (YKDFN); and
    - Łutsel K'e Dene First Nation (LKDFN).

- Observers of the Working Group shall include representatives from each of the following organizations:
    - Government of Nunavut (GN);
    - Nunavut Tunngavik Inc (NTI);

- Nunavut Wildlife Management Board (NWMB);
- Kitikmeot Regional Wildlife Board;
- Kitikmeot Inuit Association; and
- Kugluktuk Angoniatit Association.

- The Working Group shall engage with appropriate Nunavut agencies, organizations and experts to ensure cross-border collaboration and respect for jurisdictional boundaries.

- The Working Group may also seek input from additional Working Group members' staff as well as other agencies, organizations and experts, including Nunavut, as required by the Working Group members. Following Working Group consensus, non-members shall be invited to attend meetings either in person or via teleconference.

- The individual group members are responsible for reporting back on activities of the Working Group and seeking advice from their respective organizations.

- The membership of the Working Group will commit to attending all scheduled meetings, where possible; sharing all communications and information with Working Group members; and making timely decisions.

- The Chair of the Working Group will be chosen at the beginning of each meeting. Quorum will be representatives from at least three organizations of the Working Group (in person or via teleconference).

- The Working Group will seek consensus (everyone supports the decision and agrees to move forward) on all decisions. When differences arise, the following steps will be taken:
    - Every effort will be made to resolve issues, recognizing that compromise is required to accommodate differences.

- Should the Working Group fail to find ways to compromise with each other to accommodate all members, both the majority view and the dissenting view(s) will be recorded and included in the final recommendations report.

- WRRB shall ensure administrative support to the Working Group including:
  - Organizing meetings, including providing physical location and/or video or teleconference information;
  - Preparation of meeting correspondence;
  - Coordination of the preparation of background information; and
  - Minute/note taking.

- WRRB shall take the lead in providing definitions of any key technical terms while indigenous organizations will provide definitions based on traditional knowledge.

- All parties will be responsible for expenses of their representatives on the Working Group.

- This Terms of Reference is effective from 16 September 2019 and continues until the completion of the assessment.

Appendix C: Grizzly Bear abundance and seasonal distribution on the range of the Bathurst and Bluenose-East caribou herds

Table A2. Grizzly bear densities for study areas in NWT and NU. The cited sources describe methods which differ between studies).

Study area	Date	Density bears/1000 km2	Method	Source
Tuktoyaktuk Highway	2013-14	9.7 (CI=6.7-18.4)	DNA mark-recapture	Boulanger and Branigan 2017
Tuktoyaktuk Peninsula and Richards Island	1973-78	4	Collar mark and recapture	Nagy and Branigan 1998
Anderson-Horton rivers	1987-1989	8	Collar mark and recapture	Nagy and Branigan 1998
Brock-Hornaday rivers	1992-1993	6	Collar mark and recapture	Nagy and Branigan 1998
West Kugluktuk	2008-2009	5.9–6.2	DNA mark-recapture	Dumond et al. (2015)
Lac des Gras		3.5	Collar mark and recapture	McLoughlin and Messier 2001
Lac des Gras regional males	2012, 2013 and 2017	2 - 3	DNA mark-recapture	ERM 2018
Lac des Gras regional males		3.6 – 4.7	DNA mark-recapture	ERM 2018
Lac de Gras & DeBeers	2013	4.6	DNA mark-recapture SECR = Spatially-explicit mark recapture	Jessen 2017
DeBeers (South only)	2014	2.7	DNA mark recapture (SECR)	Jessen 2017
East of Bathurst Inlet Doris North Gold	2011	6	DNA mark-recapture	Rescan (2013)
South Bathurst Inlet Sabina-Back River	2014	6–8	DNA mark-recapture	Rescan (2014)
Southeast of Kugluktuk Izok Lake baseline study	2012	8.7	DNA mark-recapture	Boulanger 2013b

	Bluenose-East Calving Ground Surveys			**Bathurst Calving Ground Surveys**	**Area of survey strata - calving ground survey km²**
2018	44 total sightings		2018	29 total sightings Estimated	8200
2016	No sightings reported		2016	No sightings reported	

2013	No sightings reported		2012	No sightings reported	
2010			2009	No sightings reported	
2008	69/100 flying hours		2008	48/100 flying hours	
2007	Incomplete data		2007	33/100 flying hours	
			2006	No sightings reported	
			2003	No sightings reported	