

# **A review of wolf management programs in Alaska, Yukon, British Columbia, Alberta and Northwest Territories**

*for*

**Yukon Wolf Conservation and Management Plan Review Committee**

[www.yukonwolfplan.ca](http://www.yukonwolfplan.ca)

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# INTRODUCTION

To support the review of the Wolf Conservation and Management Plan (WCMP, 1992), the Review Committee contracted a review of the documented wolf management programs in Yukon and surrounding jurisdictions. The following report is organized in two sections: 1) a summary of the key elements of the wolf management programs and 2) a 1-2 page review of the completed and existing programs that involved wolf control in Alaska, British Columbia, Alberta, Northwest Territories and Yukon.

## PART 1: Summary of key topics

### Some concepts about predator – prey systems

When biologists discuss predator-prey systems there are a number of concepts that are frequently referenced. I have listed a few below:

- Wolf control: Wolf control is the deliberate reduction of wolf populations with the intent of increasing one of its prey species. Wolf control may include any method that reduces wolf numbers, such as direct killing through shooting, toxicants or trapping programs, surgical or chemical sterilization, or removal and relocation.
- Carrying capacity: This term refers to the ability of the habitat to support animals: the better the habitat the more animals the habitat will support.
- Multi (or simple) predator – Multi (or simple) prey systems: A multi-predator system has multiple species that prey on the same prey species. A multi-prey system has multi prey species eaten by one species of predator. A multi-predator multi-prey system has multiple species of predators that all consume the same multiple prey species. For Yukon, a typical predator prey system includes the predators, grizzly and/or black bears and wolves preying on moose and/or caribou. This is not to say that other predators (lynx, wolverine, coyotes, golden eagles) or other prey (elk, sheep) do not play a role. One exception is the major role of wolverine predation on newborn calves in northern B. C. (Gustine et al. 2006).
- Single or multiple equilibrium (alternative stable states): This term refers to whether predator and prey populations can exist in a stable state at one (single) or more (multiple) densities. For instance, two alternative stable states can exist in a predator-prey system: a lower equilibrium corresponding to very low prey and predator populations, and a higher equilibrium corresponding to high predator and prey populations (with prey close to their carrying capacity; NRC 1997). However, there is little evidence of stable high density equilibrium in nature (Messier 1994; Seip 1992). Theoretical models indicate that if a system has multiple equilibriums, 2- predator/single prey systems are more likely to be stable at low densities than are 1-predator/one prey systems. Thus, although wolf predation alone could limit the size or growth of a prey population, the

- presence of a second predator, such as brown bears, can favor a low-density equilibrium (Van Ballenberghe 1987; Messier and Crête 1985).
- Alternate prey: Prey taken by predators in addition to the primary prey that the predator normally relies upon. For example, in interior Alaska moose may be the primary prey and caribou, especially when abundant, may be the alternate prey. In Alberta, moose may be the primary prey species and white-tailed deer, as they expand after habitat disturbance, may be the alternate prey. Other examples include bison as main prey and moose as alternate prey (Larter et al. 1994) and moose as main prey and caribou as alternate prey (Schaefer et al. 1999).
  - Prey switching: This term generally refers to a predator that has a primary species of prey but will switch to another species of prey when the numbers of the primary prey drop and/or when alternate prey populations increase.
  - Limiting and regulating factors: Sinclair (1989) proposed that limiting factors included all mortality factors which affect the productivity of populations and that regulating factors are those that act with the density of prey to maintain a prey population at equilibrium or within a usual range.
  - Functional versus numerical response: Holling (1959) noticed that as the density of prey increased, more were being eaten and he determined this could happen if 1) each predator ate more prey when prey density increased (a functional response) or 2) the number of predators increased with increased prey density (a numerical response).
  - Proximate versus ultimate: Separating *proximate* from *ultimate* causes frequently leads to better understandings of the events and systems concerned. For example, the proximate cause of caribou declines in central B.C. may be high wolf predation and high harvest and/or poaching, but the likely ultimate cause was that logging created more access for hunters and more favourable habitat for moose, leading to higher wolf densities. In this case, hunters and wolves were the *proximate* cause (how caribou declined) but logging was the *ultimate* cause (why caribou declined).
  - Trophic cascades: As top predators are removed or dramatically reduced from the ecosystem, impacts are measurable at the lower trophic levels including herbivore and plant communities (Carpenter et al. 1985).
  - Mesopredator release: this hypothesis states that when top predators are removed from the ecosystem, the mesopredators (small to medium-sized predators such as coyotes and foxes) will increase.

## Four hypotheses about predator-prey interactions

The effects of wolf predation on their prey have received much debate over the years and a number of models have been proposed to explain how wolves interact with their prey. Where wolf predation can be considered to affect prey numbers, Boutin (1992) reviews four hypotheses:

- The predation limitation hypothesis proposes that while changes in prey densities are the result of a variety of factors (predation, winter severity, hunting), predation is the primary factor that limits prey density. In this system the prey does not exist in a state of equilibrium but fluctuates through time; if a prey declines following a disturbance, it does not necessarily return to its original density. Van Ballenberghe (1987) suggests that this system could exist in a simple wolf-moose system where alternate prey or additional predators do not play a significant role.
- The predation regulation hypothesis proposes that predation regulates prey densities around a low-density equilibrium. That is, following a change in prey density, prey populations return to their pre-existing equilibrium levels. Predation rates should follow ungulate densities when ungulates are at low or medium densities – as prey declines, the number of prey taken by wolves should also decline. These types of systems are most likely to exist when there are wolves and bears in a system.
- The predator pit hypothesis predicts that predation regulates prey densities at low densities, in a “predator pit” (similar to the predator regulation hypothesis), below carrying capacity, but if predators decrease (through disease or human action) or prey increase (due to favorable weather over a number of years), the prey population can “escape” the limitation of predation and stabilize at a higher density, presumably regulated by nutrition and carrying capacity of the range (Messier 1994). As with the predation regulation hypothesis, predation rates should follow ungulate densities when ungulates are at low or medium densities.
- The stable limit cycle hypothesis proposes that prey born under poor environmental conditions (following bad winters or during high densities) are more vulnerable to predation as adults than prey born under more favourable environmental conditions. This situation results in a complex system and may result in population cycles or high annual variability in predation rates as “weak” cohorts advance through the population. Thus predation becomes the “proximate” cause of death, while the “ultimate cause” is poor nutrition. Under this hypothesis, predation rates do not relate to the abundance of prey. Hegel et al. (2010b) found that for mountain caribou herds in Yukon, the effect of wolf control was nearly lost in years of good climatic conditions. This is important as it notes that the effect of wolves on recruitment was variable and could be quite reduced in certain years. Thompson and Peterson (1988) reported that summer moose calf mortality was high whether predators were present or not, and that snow conditions during the winter affected the vulnerability of calves to predation.

All of the four proposed hypotheses could describe the relationship between wolves and their prey. However, many studies that have sought to identify predator-prey dynamics between wolves and ungulates have failed to demonstrate any of the above (NRC 1997); environments are complex and

multiple-predator and multiple-prey systems are the norm in the natural environment. A comprehensive review of predator-prey studies (NRC 1997) demonstrated that no single pattern has dominated predator-prey interactions. Further, Boutin (1992) maintains that there is little doubt that wolves have some limiting effect on moose, where magnitude has been measured, but the effect of predation is no larger than other factors such as hunting. Additionally, variations in weather, habitat conditions, and behavior of predators and prey ensure that the relationships will be varied and difficult to predict and interpret.

## Jurisdictional Summary

Each jurisdiction has a different approach to wolf control programs, although they all appear to be influenced by the same historical approach, namely the poisoning and shooting of wolves in the 1940s and 1950s, a halt in this practice in the 1960s and early 1970s due to a subsequent increase in ungulate populations and then a re-initiation of wolf control in targeted area in the late 1970s and 1980s as wolf populations increased and ungulate populations declined. Given this history of exploitation and control, it is often difficult to determine what the normal level of predators and prey are in an ecosystem. Despite this uncertainty, when managers set "management goals" they often try to attain the unnaturally high prey populations that existed in the mid 20th century (Van Ballenberghe 2004)

### *Alaska*

- The State of Alaska has the longest history of predator control and currently has the most predator control programs.
- Alaska manages under the assumption that their predator-prey populations operate under a *Low Density Dynamic Equilibrium*. In other words, in an area where predators and their prey are lightly harvested, predator populations will suppress prey populations below the nutritional carrying capacity. Prey populations may escape low densities if predator populations decrease (for example, through disease or human control).
- In the 1940s and 1950s, shooting and poisoning resulted in widespread wolf and bear declines. Moose and caribou populations increased to record highs. Following statehood in 1959, one of the first actions of the legislature was to prohibit poisoning of predators. Shortly thereafter, bounties were stopped. In 1963, the Board of Fish and Game classified the wolf as a big game animal and a fur animal, the first official recognition of the wolf as a valuable species (Regelin 2002). Prey populations again declined to very low densities. In the 1970s a number of areas close to high human populations were targeted for predator control to provide more hunting opportunities, especially for moose.
- In 1994 the State passed an Intensive Management Law which requires the Board of Game to designate intensive management areas where human harvest is the highest priority. The Board established management

- and harvest objectives for moose and/or caribou in those areas. If the objectives are not met, and if more moderate measures fail (reducing harvest, liberalized predator harvesting) then predator control has to be considered (Van Ballenberghe 2004). This is still the legal framework used today.
- The then Governor stated that predator control would be based on sound science, it would be economically justifiable, and it would have broad public support (NRC 1997).
  - In the early 1990s, the National Research Council (NRC) was commissioned to review the effectiveness of predator control programs in Alaska. The NRC's report came to a number of conclusions and made a number of recommendations, including:
    - Most studies examining predator-prey dynamics in wolf-ungulate systems were insufficient to draw conclusions about the efficacy of wolf control. Many studies were correlative and had limited ability to establish causal relationships between predator and prey numbers.
    - The interaction between prey species and their plant resources had not been adequately understood.
    - 17 key conclusions and recommendations were presented with respect to wolf control programs.
  - The first attempt to implement the NRC's recommendations under the Intensive Management Law was in 2000 in the McGrath area. Although most recommendations were followed, in 2002 a new Governor was elected and appointed new members to the Board of Game. The new Board overturned many of the rules that were ongoing, expanded the control area, increased the moose population and harvest goals, liberalized the methods allowed to control wolves and disbanded the Adaptive Wildlife Management Team that had been set up (Van Ballenberghe 2004).
  - Presently, 39% of the state is designated as highest priority for human harvest under the Intensive Management law with predator control occurring in 9% of the state in 6 predator control programs.
  - Most of the control programs began in 2003-2004 and needed to be renewed after 5 years of predator control. (See Section 2 for a review of these programs). All 5 areas under predator control that were up for an additional 5 year renewal (Upper peninsula control program only began in 2008) have been renewed:
    - Unit 13 – Nelchina – re-authorizing the Predator control program is scheduled for the Board of Game (BOG) meeting in October 2010. <http://www.boards.adfg.state.ak.us/gameinfo/meetinfo/2010-2011/octobernelchina/legnote.pdf>. As the BOG is poised to continue with predator control, the Board passed recommendations to issue 1000 more permits to harvest the Nelchina caribou herd because it has exceeded its management goal and needs to be reduced through hunting.

- Unit 16 Cook Inlet is still under a predator control program for a second 5 year term  
[http://www.wildlife.alaska.gov/management/control/pdfs/2010\\_2011\\_wolf\\_control\\_supplement.pdf](http://www.wildlife.alaska.gov/management/control/pdfs/2010_2011_wolf_control_supplement.pdf)
- Unit 12,20,25 Upper Yukon/Tanana authorized a second 5 year control program on March 9, 2009  
<http://www.boards.adfg.state.ak.us/gameinfo/regs/09182bog.pdf>
- Unit 19A Mid Kuskokwim - authorized a second 5 year control program on March 9, 2009  
<http://www.boards.adfg.state.ak.us/gameinfo/regs/09180bog.pdf>
- Unit 19 B McGrath area - authorized a second 5 year control program on March 9, 2009  
<http://www.boards.adfg.state.ak.us/gameinfo/regs/09181bog.pdf>

### *British Columbia*

- The only early, well-documented program of wolf control in northern B.C. was reported by Bergerud and Elliot (1986) in north-eastern B.C.
- The National Research Council (1997) review of this study concluded that the northern B.C. program was more of a management activity than a scientific experiment. The sampling design was faulty, different areas were treated, and poor or inconsistent monitoring occurred. However, according to NRC (1997), it seemed obvious that removal of close to 1000 wolves did result in improved calf survival for the years of the treatment, but that wolves quickly recovered and calf mortality quickly returned to pre-control levels after the end of the program.
- The Bergerud and Elliot study took place in northern B.C. where a predator/prey system similar to Yukon and parts of Alaska is probably in force (i.e. low density dynamic equilibrium system)
- Presently in B.C., managers are primarily concerned with maintaining “threatened” mountain caribou populations. In contrast to Alaska, moose (deer in southeast B.C.) are considered part of the problem as they are expanding their range and densities in B.C. primarily because of enhanced habitat through logging.
- Because mountain caribou populations are considered uncommon they cannot support an average-to-high density predator population and thus a high moose (deer in southeast B.C.) density results in more accidental encounters between wolves (cougar in southeast B.C.) and caribou. This incidental predation (also called “apparent competition”) is also cited as the reason for the decline of Red Wine caribou in Labrador (Schaeffer et al. 1999) and wood bison in the Mackenzie Bison sanctuary, NWT (Larter et al. 1994).

- Thus the strategy to reduce predation on caribou is a 3-pronged approach: 1) reduce or eliminate hunting of caribou, 2) reduce moose populations, and 3) reduce predator populations.
- Currently there is only one program in B.C. which is a pilot program to determine if 1) reducing moose through liberalizing harvest seasons and 2) reducing wolves through trapping can benefit caribou survival (McNay et al. 2009; Gillingham et al. 2010). So far the results of this program are not dramatic but the experiment is ongoing.
- The B.C. government commissioned a technical review and recommendations on the role of predator-prey management to recover mountain caribou populations (Wilson 2009)
- Among the recommendations of Wilson (2009) are:
  - Intensity, duration and extent of predator-prey management actions should be scaled to the relative short-term risk facing different mountain caribou herds.
  - Wolf densities within mountain caribou range should not average more than 6.5 wolves/1000 km<sup>2</sup> in the long term and should be scaled to the relative risk facing caribou herds, based on population size and trend.
  - Wolf densities should average <1.5 wolves/1000 km<sup>2</sup> in all ranges of mountain caribou herds most at risk. to illicit significant population response.
  - Where caribou herds are most at risk, removal of all wolf packs is a justifiable short term goal.
  - Wolf numbers need to be reduced before, or concurrently with, reductions in moose numbers.
  - Moose densities in mountain caribou zones should average 50-300 moose/1000 km<sup>2</sup>, depending on the risk to mountain caribou herds.
- Wilson (2009) also referred to studies in the Quesnel Highlands to determine the feasibility of wolf sterilization (no reference was given). Also, some sterilization studies are being done in northern B.C. (Wilderness Committee 2002) although no results are available.
- In their latest interim strategy (B.C. MOE 2008) to recover small caribou herds, B.C. stated:
  - *Hunting regulations for predators have changed for 2007-8 in many parts of mountain caribou range. The objective of recovering caribou was not necessarily the only motivation for these changes. Adjustment of bag limits and season lengths will likely result in some localized benefits to caribou, particularly in summer. In early 2008, wolf removals will continue as part of an ongoing (since 2002) pilot project in the Quesnel Highland Planning Unit (5-B, Wells Gray North), and will be initiated in Arrow Lakes, South Purcells, and potentially Columbia South (in early fiscal 2008-9) according to existing MOE policy for protecting species at risk.*

## *Alberta*

- The history of Alberta's wolf population and management attitudes towards the species ran a similar path as the rest of western North America, with bounties, poisoning, and widespread killing triggered by concern for livestock, ungulate populations and rabies epidemics (Gunson 1992).
- Attitudes changed in the 1960s and 1970s primarily because wolves were fewer, ungulates were abundant and depredation on livestock was low. At the same time, the public and government gained a better understanding of the role of large predators, primarily wolves, in the environment and were reluctant to interfere with the predator/prey system.
- By the 1970s, attitudes again changed as wolf numbers and livestock depredations increased, and ungulate populations decreased. However, unlike the actions in B.C. (Bergerud and Elliot, 1986) and Alaska (numerous wolf control programs), the emphasis in Alberta was on more research and comprehensive management plans.
- The following is an example of the difficulty involved in implementing wolf control during this period. In the early 1980s the government identified two areas where wolf predation was determined to be playing a large part in the decline of caribou herds – the Willmore Wilderness-Grande Cache area and the Nordegg area. For both areas, wolf reductions were one component of comprehensive recovery actions which also included coordinated logging to ensure sufficient old-growth caribou habitat was retained on winter ranges, reduction of kills by Natives, education of hunters, and control of traffic to reduce mortalities. Although the other recovery actions were slowly implemented, public outcry resulted in no wolf control taking place in either area (Gunson 1992).
- In 1991, an Alberta Wolf Management Plan was released which outlined under what conditions wolf control would be considered. It was decided that before wolves would be controlled to enhance wildlife, government must 1) provide an incontestable scientific database on wolf-prey relationships, 2) conduct a cost-benefit analysis, and 3) undergo public review (Alberta Forest Lands and Wildlife 1991).
- At the same time, the caribou in Alberta were put on the provincial "red" list (species that are at risk) and later (1996) down-listed to the "blue" list (species that may be at risk) after a re-analysis of the data (Gunson 1992).
- The Alberta wolf management plan states that Alberta will try to maintain a minimum of 4000 wolves in the province. This will require 200,000 hooved animals to supply 30,000 prey animals for wolves annually, and allow a total harvest (trapping and hunting) of 1200 wolves per year, less than 25% of the provincial wolf population (Alberta Forest Lands and Wildlife 1991).

- Wolf control was identified as one tool to recover threatened caribou herds in the 2004-2014 Alberta Woodland Caribou Recovery Plan (Alberta Woodland Caribou Recovery Team 2005).
- The current thinking in Alberta is that, similar to B.C., caribou population numbers are controlled by hunting and by wolf predation, which increases as wolf population increases are supported by the emerging abundance of alternate prey (“apparent competition”). Moose are the primary prey of wolves, however, the habitat alterations from forestry and mineral and hydrocarbon exploration enhance habitat quality for the wolf’s alternative prey species (primarily white-tailed deer), and reduce habitat quality for caribou. In addition, access routes constructed for forestry and seismic operations are reported to increase hunting access by humans and the predation efficiency of wolves (Latham 2008). Thus, in this case, wolves are the “proximate” cause (how prey populations declined) of mortality while habitat alteration is the ultimate cause (why prey populations declined).
- In the past, caribou could effectively space-away from moose, but with the expansion of deer, wolf density has increased from 6 animals per 1000 km<sup>2</sup> to 11 animals per 1000 km<sup>2</sup> and so the overlap of wolf and caribou habitat has also increased dramatically (Latham 2008).
- The herd with probably the most intensive industrial development within its range is the Little Smokey herd. To facilitate recovery, Alberta government has 1) conducted intensive wolf control through aerial gunning and poisoning, 2) enhanced harvest on moose, elk and deer and 3) adopted the “Chisana” model of predator exclosures (Robichaud 2009).

### *Northwest Territories*

- In the mid 1900s a wolf control program was implemented in an attempt to increase prey populations for human consumption. No data or write-up of this initiative could be located for this report.
- The last wolf control program in the Northwest Territories was in 1977-1978.
- The current policy of NWT’s Environment and Natural Resources Department is that there will be no wolf control unless it is scientifically demonstrated that a bison, muskox, moose, or caribou population is threatened because of wolf predation. Such programs, however, will only be successful when carried out in conjunction with controls on hunting, if hunting has been identified as a contributing factor to decline (NWT ENR 2010).
- There is an estimated 10,000 wolves in NWT and Nunavut and reported harvest and trapping averages less than 200 per year (~2% harvest). These figures do not include unreported harvests (Defenders of Wildlife 2000).
- Currently there is no management plan for wolves in NWT

## *Yukon*

- In the last 30 years there have been six comprehensive predator control programs whose primary aim was to recover caribou (5) and moose (1) populations in the Yukon: the Finlayson, Southwest Yukon, Aishihik, Southern Lakes, Fortymile and Chisana projects (see appendices).
- All projects involved government wolf control (except Chisana and Southern Lakes) but none involved government bear removals (except for liberalized bear hunting in the Southwest Yukon project).
- Since 1992 the territory has been operating under a Wolf Conservation and Management Plan developed by a citizens group initiated by the Yukon government.
- The Plan provided ethical and scientific guidelines for managing wolves, including conditions for conducting wolf reductions.
- The Plan played a major role in the design of the Aishihik Recovery program.
- Yukon has been a leader in alternative means to recover caribou populations, both in the comprehensive design of its programs as well as in attempting innovative methods (Farnell 2010).
  - The Aishihik project (1993-1998) was the first to experiment with non-lethal sterilization of wolves as a means to reduce the number of wolves that needed to be removed.
  - The Southern Lakes recovery program (1994 – present), focused on hunter education and land use strategies and did not involve wolf removal.
  - The Chisana Project (2003 – 2006) did not involve wolf removal (except by encouraging trapping and by active trapper education). Predation was temporarily reduced by the construction of a fence which excluded predators during the caribou calf neonatal period.

## Factors influencing moose and caribou densities in interior Yukon and Alaska

### *Moose*

- Gasaway et al. (1992) suggest that the combined predation by wolves and bears was the primary factor limiting moose at densities well below the carrying capacity of their range, where moose are the primary prey and both predators and moose are lightly harvested. Notably, Gasaway et al. (1983) found no measurable effect of wolf control alone on moose calf survival and conclusions from this study are based on interpolations from several studies.
- Gasaway et al. (1992) found:

- Where predators were lightly harvested, average moose density was 148 animals per 1000 km<sup>2</sup>; where predators were controlled, the mean moose density was 648 animals per 1000 km<sup>2</sup>
- Interestingly, the highest moose density in an area without any wolf control was in the Teslin burn where the large burn of 1958 supported 417 moose per 1000 km<sup>2</sup>.
- Where data existed, bear predation accounted for 40% to 63% of moose calf mortality; wolves accounted for 1% to 25%
- Normally, wolves account for the majority of adult moose mortalities
- Gassaway et al. (1992) cite 3 conditions where moose populations can exist at high densities without the requirement for predator control:
  - In cases where there is only a single predator present, either black bears, grizzly bears or wolves
  - In cases where both grizzly and black bears are the major predators but wolves are absent, and
  - In cases where moose are a minor prey in a wolf-bear multi-prey system. This means that other ungulates are more important prey than moose.
- Of 24 sites reviewed by McNay (2006) the only instances where there were elevated moose densities occurred where humans had reduced predators. Thus, even in good habitats, moose were thought to be held below the ability of the habitat to support them by the combined effects of human harvest and wolf and bear predation. Unfortunately, in most studies the carrying capacity of the landscape was not identified through vegetation studies.
- Bertram and Vivion (2002) found that moose densities in the eastern interior of Alaska were affected by the interaction of predation and illegal cow moose harvest.
- Boutin (1992) and NRC (1997) noted that no study has been conducted to conclusively establish the key factors keeping moose at low densities, and that Gasaway et al. (1983) did not use appropriate methods or metrics for establishing their findings.

### *Caribou*

- Valkenburg et al. (2002) concluded that fluctuations in caribou are caused by an interaction of predation, density, climate and weather.
- Hegel et al. (2010a) investigated recruitment in populations of Yukon mountain caribou, characterized by generally high, but variable, neonatal mortality. They concluded that these herds were predator limited with respect to recruitment and that recruitment variability was best explained by winter weather prior to birth and

weather at calving. In turn, these weather variables were partially explained by the Pacific Decadal Oscillation. Hegel (2010b) found that the effect of wolf control was nearly lost in years of good climatic conditions. This is an important finding because it noted that the effect of wolves on recruitment was variable and could be quite reduced in certain years.

- In B.C. there is no clear consensus on the mechanisms that control caribou populations. Some argue that the populations are controlled by predators (Wittmer et al. 2005) (top-down control) while others state that the data is not available to rule out some control by nutrition (Brown et al. 2007) (bottom-up control). As researchers in other jurisdictions indicate, both forms of population control may play a role.
- Adams (2010) in reviewing Alaskan small caribou herds observed:
  - Predation by grizzly bears and wolves is a major limiting factor.
  - Primary impact of predation is via calf mortality.
  - Strength of predation effects vary among herds and over time.
  - Caribou can “escape” from predation, but mechanisms are unclear.
- For large caribou herds, such as the Porcupine Caribou Herd, the large fluctuations in population numbers are not believed to be controlled by predation, but computer simulations indicate that when populations decline to very low numbers the role of predation may become more important.

## Is wolf control effective?

- Predator control is effective if:
  - Wolf predation is a limiting factor: Numerous studies across North America have shown that wolf control does not always result in an increase in ungulate densities. It must be established that predation is indeed limiting the ungulate population. It seems easier to establish this relationship for moose than it does for caribou based on the above discussion. For example, as indicated in Hegel et al. (2010), wolf control has little effect on ungulate densities if conducted in bad weather years.
  - Able to control sufficient numbers of predators: wolf numbers have to be reduced by 65% to 80% of pre-control levels (NRC 1997). Wolf control is not effective if bears are the primary predator and bears are not controlled. Reviewing 24 North American studies Adams et al. (2008) showed that wolf population growth rate was not impacted with removal rates at 30% or lower. In other words, managers have no impact on

- annual wolf population structure unless they take more than 30%.
- Control occurs over a sufficient time period – need to implement predator control for at least four years or until population goal reached (NRC 1997). However, five of the six current predator control programs in Alaska have been ongoing for at least six years (one of these for ten years), and have authorization to continue for the next five years. Some have argued that moose population and harvest goals are unrealistically high (van Ballenburghe 2004).
  - Control occurs over sufficient area: over at least 10,000 km<sup>2</sup> (ADF&G 2007)
  - Habitat can support higher moose or caribou numbers: There is little point in controlling predators if the habitat is poor and is not likely to support more moose or caribou. If such situations occur, it would suggest that ungulate populations are regulated by density dependent factors. Habitat loss (direct or indirect) is often a confounding factor in ungulate population decline.
  - Hunting is curtailed. The success of a predator control program is improved by reducing mortality in the ungulate species. The elimination of hunting during the control program thus both improves the chance of success and improves the chances of gaining public support for the control program.
- Adams (2010) reviewed a number of control programs where there was sufficient monitoring to assess success or failure.
    - He identified three “successful” wolf programs, that is programs that achieved their short term goals in relation to ungulate response: Aishihik, Finlayson and the Tanana Flats. In those studies, between 69% and 77% of the wolves were removed for six to seven years and moose and caribou increased from 10% to 15% annually.
  - Adams (2010) identified four failed programs where there was no moose response to predator control. Wolves were reduced by 59% to 70% for two to five years. In three of the programs grizzly predation prevented a successful outcome (including the Southwest Yukon program). Although Adams (2010) identified grizzly predation in Southwest Yukon as the factor which prevented the program’s success, some have argued others factors played a role in the failure of this program. Moraj (pers. comm.) maintains that in the Southwest Yukon, the grizzly bear harvest was increased or liberalized. It was decided that the program did not run long enough, not that grizzly bear predation was too high. However, effects of subsistence harvest and weather were not factored in to the study.

## Wolf response to control

- Wolves are limited just like prey populations. Wolves are limited by the number of prey around and by the territorial behaviour of wolves; packs tend to avoid each other.
- McNay and DeLong (1998), comparing 12 North American studies, developed a relationship between wolf growth rate and prey density which showed a very steep growth rate as prey density increased. Thus, if wolves are artificially held at low densities during wolf control, they will exhibit very rapid growth rate when control ends.
- Although growth rates of wolf populations are primarily increased by immigration and higher reproduction, Adams et al. (2008), summarizing North America studies, concluded that wolf population trends were not affected by harvests of less than 30% and that compensating for harvest was primarily by dispersal into the treatment area rather than increased reproduction or reduced mortality. This finding was supported by wolf recovery after the Finlayson control program ended.
- The NRC (1997) concluded that “no available data suggests that the killing of wolves by humans has adversely affected the long-term social organization, reproductive rates or population dynamics of the species”.
- The NRC (1997) found, and many other reviews confirm, that wolf populations rebounded to from 88% to 112% of pre-control levels within three to five years after control measures ceased.

## Wolves in the ecosystem

Few studies adequately monitor the full effect of predator control on predators and prey; none monitor the effects of predator control on the ecosystem (NRC 1997). It is important to look beyond population responses of predators and prey when assessing the impacts of predator control programs.

Some studies are attempting to determine how reducing predators in a system affects the herbivores, and in turn, the plant communities of the system (a concept termed “trophic cascades”). For example, Hebblewhite et al. (2005) studied trophic cascades in a wolf-elk system in Banff National Park. Comparing an area with high wolf numbers to an area with low wolf numbers, they found that:

- wolf exclusion decreased aspen recruitment and willow production, and increased willow and aspen browsing intensity.
- elk were more abundant in the area with low wolf numbers
- beaver lodge density was negatively correlated to elk density, and
- elk herbivory had an indirect, negative effect on riparian songbird diversity and abundance.

Relationships in the environment are complex and ecosystems will respond differently to wolf control programs. Schmitz et al. (2000) reviewed a number of studies and concluded that the strength of trophic cascades varies across ecosystems due to variation in food web complexity, diversity, productivity, and indirect feedbacks, such as plant toxins that inhibit herbivory.

Wolves, similar to most top predators, can limit the distribution and abundance of smaller predators; wolves limiting coyotes and grizzly bears limiting black bears have been cited as examples. Thus removing or dramatically reducing top predators can result in a smaller predator “release”. This theory is termed the “meso-predator release”. Prugh et al. (2009) provide an overview of the concept and observe that over the last 200 years in North America, 60% of meso-predators have expanded their range and all top predators have declined. They conclude that meso-predator release is a common result of top predator removal around the world and that maintaining a high community diversity in the ecosystem should act as a buffer to high meso-predator outbreaks.

## Effectiveness of trapping

Most predator control programs involve the help of local trappers with removal of predators in the study areas. In only one of the programs reviewed for this report was it found that trapping was tested as the sole means of reducing predators. The primary problem with relying on trapping to reduce wolf numbers to a level that will impact ungulate survival is that a wolf harvest of less than 30% of the entire population has no effect on the wolf population growth rate. This means that, if trapping was the sole means of reducing wolf numbers, trappers would have to take more than 30% of the population to have any effect.

- In Alberta, Robichaud and Boyce (2010) concluded that trapping could not remove enough wolves over a large enough area to have any response in prey populations. Annually trappers harvest ~9.8% of the provincial wolf population.
- In B.C., McNay (2010) conducted a study where one of the main objectives was to determine if “*sufficient reduction in predation risk (and predation) [can] be achieved through licensed trapping to avoid the use of a more indiscriminant reduction of wolves for the purpose of caribou recovery?*” To increase the opportunity to trap wolves, managers provided trappers with logistic assistance (bait for bait stations), information on kill sites, and locations of highest risk habitats for wolf predation. Although the study is not finalized, the B.C. study found mixed results when the supported trapping area was compared with the control (normal or no trapping) area.
- In regards to the use of trapping to help recover small woodland caribou herds, B.C. concluded:
  - removal of entire wolf packs may be possible in some areas with trapping/snaring, but if unsuccessful, could lead to disrupted pack

social structures and, ultimately, higher birth rates and perhaps subsequent kill rates on caribou;

- lethal snares/traps cannot be used to selectively remove individual pack members;
- snares and traps are seen as less humane than some other options;
- non-target species, including moose and caribou, might be killed with snaring/trapping;
- traps and snares are impractical to set and monitor in remote or inaccessible areas; and,
- traps and snares are impractical in deep snow areas because snow fouls the operation of both devices (although snaring in spring might be practical at den sites).

## Alternative methods of enhancing ungulate populations

The discussion below outlines a number of alternative methods that agencies have used to control predator populations. None of these methods have ever been employed for any length of time and few are practical means of controlling predator populations over the long term due to high cost and staff time requirements.

### *Diversionsary feeding*

Alaska has tried to reduce the mortality on calves by providing alternative food sources for bears on a couple of occasions.

- In GMU20E, from May to June 1985, 12 tonnes of meat were aerielly-dropped to attract grizzlies and reduce moose calf mortality. In fall 1985 there were 53 calves:100 cows which was a significantly higher ratio than in the previous three years (11-15 calves:100 cows) and the following two years when feeding was not done (26-36 calves:100 cows) and in three, nearby untreated areas (10-19 calves:100cows) (Boertje et al. 2010)
- In GMU20D, ADF&G attempted in 1990 to retest diversionsary feeding. They dropped 26 tonnes over 15.8/1000 km<sup>2</sup>. Calf:cow ratios were higher in early winter 1990 (42 calves:100 cows) compared to eight prior years (12 – 38 calves:100 cows) and in nearby untreated sites (11-27 calves :100 cows). When the method was repeated in 1991, diversionsary feeding failed to yield significant results, although less meat was dropped (16 metric tons compared to 9.7 tons per km<sup>2</sup>)
- Boertje et al. (1995) ranked diversionsary feeding as “low” for cost-effectiveness.

## *Relocation*

On a few occasions Alaska has relocated predators, primarily bears, from areas with the objective of increasing moose calf survival.

- ADF&G relocated 60% of the grizzlies out of GMA13A and 13E,. In these same areas, wolves were rare due to aerial hunting and government removal program. After relocation, the ratio of moose calves to 100 cows increased from 34 to 58. There was no change in calf survival in two areas south of the relocation areas. The study concluded that relocation of grizzlies resulted in 78% reduction in calf mortality for the first five months and that this improved survival rate carried over to the spring.

## *Predator exclosure*

- Yukon pioneered a method to increase caribou calf survival by capturing pregnant cows from the Chisana caribou herd in late spring and placing them in a predator exclosure until calves were close to a month old, at which point the animals were released. The method turned out to be logistically feasible and penned calf survival was better than unpenned wild calf survival for most years of the study (Chisana caribou Recovery Team 2010). However, the method was very expensive and the contribution of calves to the Chisana population may not have been significant enough to justify repeating the experiment on herds of more than 100 adults.
- Alberta adopted a similar method for the Little Smokey Herd and even hired Chisana project personnel to assist with the operation. After release, penned calves had a higher survival than in previous years, however calves that had not been penned also had a high survival, not significantly different than penned calves. The comparison was confounded by ongoing wolf control outside of the exclosure (Smith and Pittaway in press)

## *Sterilization*

The goal of fertility control is to reduce or limit a wolf pack to a single dominant pair (the alpha male and female). This results in lower predation rates on ungulates, particularly during summer when wolves travel individually or in small groups (two or three pack members). Previous research found that a sterilized alpha male and female pair will mate in March, dig a den in May, and defend their territory throughout the year (Spence et al. 1999). This maintains the structure and distribution of wolf packs while reducing the overall density of wolves on the landscape.

The most effective sterilization method is to remove the entire wolf pack from the study area, and then capture the alpha pair that moves in to the vacant territory.

The captured alpha pair are then sterilized (surgically or chemically), fitted with radio-collars and monitored monthly to determine their survival rates and territory use. This method is preferred to capturing and sterilizing the alpha pairs in the original packs because the pair that immigrate into an area will not have pups and are substantially easier to isolate (Spence 1998).

Recent work in B.C. found that packs don't accept non-mating pairs long enough for the program to be worthwhile (Moraj pers. comm.).

### *Prescribed burning*

- Even without predator control, higher moose densities can exist if habitat conditions improve over a large enough area. This was the situation in the Teslin burn in the 1980s and 1990s when moose densities were 417 animals per 1000 km<sup>2</sup>, much higher than moose populations in areas of Yukon and Alaska without wolf control but lower than areas where successful predator control programs were conducted.
- Although prescribed burning is often cited as another means of increasing moose densities, no jurisdiction has used this method to improve moose range. To be effective, a large area would have to be burned which would likely not receive public support and would negatively impact many other species.

### *Alternative prey reduction*

In central B.C. and Alberta, small caribou herds often decline due to the range expansion and higher densities of alternative prey which support increased wolf numbers and predation on all prey species. In central B.C. the alternate prey is moose and in southeastern B.C. and Alberta, white-tailed deer. The strategy therefore is to relax regulations to increase harvest on wolves' alternate prey.

### **Cost**

The above discussion outlines a number of conditions that are necessary for predator control to temporarily increase ungulate populations, especially moose populations. In summary, predators must be limiting ungulate populations, the habitat must be able to support more ungulates, control must be effective in targeting the right predators, and control must occur for long enough and remove enough of the target predator. Another important consideration is the cost-effectiveness of the program, considering both the cost of the control and monitoring programs and the length of time elevated ungulate populations can be maintained. For example, although Adams (2010) considered the Finlayson program to be a success, Farnell (2010) noted that shortly after the end of the control program, the lack of a caribou management plan threatened to undo the

gains made in the control program, highlighting the need to consider “success” over the long-term. The cost of predator control programs is extremely variable and is dependent upon, among other things: the degree and duration of preliminary inventory and survey information required, the control method, cost of aircraft, the remoteness of the control area, the aerial extent of the study area, the role of the public (trappers, hunters, public aircraft and personnel), the duration and intensity of the control, the degree of monitoring and follow-up, and the establishment and monitoring of control areas. Listed below are the references found that address the cost of control programs. *Italicized in brackets after each cost is the value adjusted to 2010 dollars – see [http://www.economica.ca/cpi\\_ca.htm](http://www.economica.ca/cpi_ca.htm) for Canada and <http://www.westegg.com/inflation/infl.cgi> for the U. S.).*

- Van Ballenberg (2004) quotes that the cost of removing 1300 wolves between 1976-1983 was \$824,000 (*\$2.4 million in 2010*) or about \$63,000 (*\$183,000 in 2010*) per wolf.
- A pilot wolf control in the Little Smokey range in Alberta cost \$35 per km<sup>2</sup> per year (Schneider et al. 2010)
- Schneider (2010) calculated that the average cost of wolf control per herd in Alberta was \$3,720,000 (*\$380,000 to \$8.23 million*) for 10 herds in Alberta.
- The cost of current Alaskan control programs is over \$3.7 million per year. *Juneau Empire: Mary Wilson*  
[http://www.juneauempire.com/stories/040410/opi\\_601760060.shtml](http://www.juneauempire.com/stories/040410/opi_601760060.shtml)
- NOTE: depending on the area, most of the wolf removals in Alaska are done by unpaid citizens who obtain a permit for aerial shooting or land-and-shoot hunting. Thus the \$3.7 million figure quoted above is a minimum estimate and not really transferable to Yukon, as Yukon does not have the “private air force” that exists in Alaska.
- The Southwest Yukon predator/prey study between 1982 and 1987 cost \$1.375 million (*\$2.8 million in 2010*) (Larsen et al. 1989).
- Although official figures for the Finlayson project are not available, Farnell (pers. comm.) maintains that the annual budget during the control program from 1983 and 1990 was between \$50,000-\$70,000 (*\$96,000 - \$135,000 in 2010*) per year for the wolf removal activities and caribou monitoring. This value does not include the cost of monitoring and research studies and moose surveys conducted post-control program..

## Public Opinion

Surveys conducted to gauge public opinion of predator control programs have generated varied responses, depending on the wording of the questions and the group surveyed. In 2002 and 2003 ADF&G and Cornell University (Decker et al. 2006) surveyed 1300 Alaska residents to determine public attitudes about predator control. The following are the highlights of that survey:

- Interviewees were asked their support for 1) “lethal”, 2) “non-lethal” controls or 3) “no action” on wolves and grizzlies if the following groups could not find enough moose or caribou to hunt 1) locals who relied on moose or caribou, 2) non-locals who relied on moose and caribou, 3) locals who did not rely on moose or caribou, and 4) non-locals who did not rely on moose or caribou.
- A majority of respondents preferred “lethal” over “nonlethal” methods for both grizzly bears (60%) and wolves (64%) but support for “lethal” methods diminished and “no action” increased as the scenarios became less a matter of reliance and less of a local issue
- More people chose “no action” over “lethal” when people were not reliant on moose or caribou for food.
- “Non-lethal” methods were least preferred in all situations except when locals reliant on ungulates could not find enough to hunt (in that case “no action” was the least preferred).

Regardless of surveys such as these, predator control in Alaska has been extremely controversial and a number of organizations such as Defenders of Wildlife have championed the cause of wolf conservation.

- Since Statehood, the controversy surrounding predator control in Alaska has been a roller coaster ride driven by the sentiments of elected Governors who have the authority to appoint members to the powerful Board of Game (BOG). The BOG has been accused of being hijacked by hunters’ and trappers’ interests, often in opposition to the majority of Alaskans.
- Alaska Law allows citizens to place “ballot initiatives” (or referendums) on State elections. It is not easy to get a ballot initiative on the ballot. However two such ballot initiatives have passed, exemplifying overall state feelings towards predator control:
  - In November 1996, voters approved a statewide ballot initiative by a 60% majority that repealed the earlier regulation that allowed people with hunting or trapping licences to fly over wolf habitat, land their plane, and shoot wolves 100 yards from the plane. In addition, the state was prohibited from using planes for wolf control unless a biological emergency based on scientific data was declared by the ADF&G Commissioner. Wolf control must be carried out solely by ADF&G personnel.
  - In 2000, the Alaska legislature passed a bill that allowed the public to shoot wolves on the same day as airborne spotting, but only in areas where predator control was necessary and without the need to declare a biological emergency. The bill reversed the 1996 ballot initiative. This spurred the second ballot initiative which prohibited the same-day airborne hunting of wolves in areas authorized by the BOG. The initiative passed in November 2000 by a 54% majority.

- Fitzgerald (2009) provides an exhaustive 44 page review of the legislative and legal initiatives and challenges that have surrounded this issue. As well, the chronology of interventions, court challenges and public advocacy is summarized on the Alaskan Defenders of Wildlife webpage.
- In 2007, 172 wildlife professionals sent a letter to the Alaskan Governor to re-evaluate Alaska's predator control program and the implementation of the intensive management law and to ensure that programs are scientifically rigorous and consistent with the recommendations of the National Research Council report (Defenders of Wildlife 2010).
- In 2010, 39 ex-State wildlife employees wrote a letter to the commissioner of game asking for the ousting of the newly appointed Director citing a lack of experience and credentials and the new Director's strong support for predator control. The former biologists expressed worry that "*professional management will be replaced by a simplistic abundance management model where maximum production of wild game meat is the state of Alaska's single, overriding objective*". (Fairbanks News Miner 2010: [http://www.newsminer.com/view/full\\_story/6804714/article-Former-Alaska-biologists-want-state-s-new-wildlife-director-Rossi-ousted?instance=home\\_news\\_window\\_left\\_top\\_2](http://www.newsminer.com/view/full_story/6804714/article-Former-Alaska-biologists-want-state-s-new-wildlife-director-Rossi-ousted?instance=home_news_window_left_top_2))

## Rationale for wolf control

In the survey of programs and studies conducted for this report, a limited number of rationales were provided for entering into a predator control program:

- Recover "listed" populations – this pertains primarily to "threatened" boreal and Southern Mountain caribou in B.C. and Alberta and to "of special concern" Northern Mountain caribou in B.C. and Yukon. This rationale is being used to explore current control programs in B.C. and Alberta.
- Recover, well documented, rapidly declining, Northern Mountain caribou populations – this rationale was used to initiate the Finlayson, Aishihik and Chisana projects.
- Recover historically high migratory caribou populations – this was the case with the Fortymile caribou recovery project.
- Generally increase declining ungulate populations. This was the prevalent rationale for most of the control programs in all jurisdictions in the 1970s and 1980s following a general decline in ungulates and increase in wolves after the cessation of widespread poisoning programs during the 1940s and 1950s.
- Increase hunting opportunities adjacent to populated areas. This is the current rationale in all Alaskan predator control programs and is legislated under the Intensive Management Law of 1994. To apply control programs, the ungulate populations, primarily moose, do not necessarily need to be declining.

## **PART 2: Review of predator control programs**

### *Alaska*

#### **GMZ 20A (Upper Tanana)**

1. RATIONALE: Before wolf control began in 1976, the average age of the moose population was very low. Brown and black bear populations were also judged to be low. Between 1965 and 1975, moose and the Delta caribou herd in this area were overharvested by humans. A record snowfall in the winter of 1970–71 had caused substantial mortality of moose. Local trappers were taking approximately 20% of the wolves annually, but this harvest was not enough to permanently reduce the population of wolves in the area. The caribou hunting season was closed beginning in 1973 (NRC 1997 pg 92).
2. REDUCTION METHOD AND OTHER MANAGEMENT ACTIONS:
  - Aerial shooting of wolves
  - Regular trapping by private trapping
  - Reduction in human harvest
3. DURATION:
  - 7 years (1976-83)
4. REDUCTION:
  - 55% – 80% of pre-control levels each year (NRC 1997 pg 92, Boertji et al. 2010 pg 920)
  - At beginning, 14 wolves per 1000 km<sup>2</sup>; at end, 8 wolves per 1000 km<sup>2</sup> (NRC 1997 pg 92)
5. TARGET UNGULATE: moose, primarily, and caribou
6. UNGULATE RESPONSE:
  - moose population increased from 183 to 481 per 1000 km<sup>2</sup>, a mean annual rate of increase of 15% (NRC 1997 pg 92).
  - moose population continued to increase for 12 more years, reaching 1020 moose per 1000 km<sup>2</sup> by 1994, a mean annual increase of 5% (NRC 1997 pg 92).
  - caribou calf survival increased and adult mortality declined
  - the Delta caribou herd increased at 16% per year for the 7 years of wolf control (NRC 1997 pg 93).
  - caribou continued to increase at 6% per year 7 years after the control period (NRC 1997 pg 93).
7. PREDATOR RESPONSE:

- 3 years after the control programs were ended, wolf numbers had recovered to near pre-control levels in most of the area (Boertji et al. 2010 pg 920, NRC 1997 pg 93).

#### 8. CURRENT STATUS – WOLVES

- As of 2008, wolf numbers have remained high (Boertji et al. 2010 pg 920)

#### 9. CURRENT STATUS – UNGULATES:

- Ratio of moose per wolf rose from 13:1 in 1976 to 40:1 in 2004 (Boertji et al. 2010 pg 920)
- Moose population peaked at 1299 per km<sup>2</sup> in 2004 (2004 (Boertji et al. 2007 pg 318)
- ADF&G liberalized moose harvest in 2004 because of concern over low reproduction and low twinning in moose (caused by food limitation) – harvested at 97 moose/1000km<sup>2</sup> (Boertji et al..2007 pg 318).

#### 10. COMMENT:

The success of this program was attributed to high wolf predation and relatively low bear predation on moose prior to reduction. Replicating elevated yields in other regions of remote Alaska is problematic, (Boertji et al. 2007 pg 318)

because:

- bears killed only 24% of radio-collared calves compared to 39% to 67% in other areas
- bears killed only 9% of post-calving moose population compared to 18% to 27% elsewhere.
- attempts to find practical means to reduced bear populations have failed to date

### **GMU 20E (Fortymile range)**

#### 1. RATIONALE:

#### 2. REDUCTION METHOD:

- aerial shooting, public harvest and trapping

#### 3. DURATION:

- 3 years (fall 1981 – spring 1984)

#### 4. REDUCTION:

1. 58%, 47%, 28% (NRC 1997 pg 109)
2. For 4 years after control ended, public took average of 24% of wolves (NRC 1997 pg 109)

#### 5. TARGET UNGULATE: moose

6. UNGULATE RESPONSE:
  - Wolf control had no measurable effect on moose calf survival (NRC 1997 pg 109)
7. PREDATOR RESPONSE:
8. CURRENT STATUS – WOLVES:
9. CURRENT STATUS – UNGULATES:
10. COMMENT:
  - Although black bears were scarce they still accounted for 52% of moose calf mortality whereas wolves only took 12% to 15% (NRC 1997 pg 109)
  - Even though moose population was limited by predation, 3 years of wolf control had no measurable effect (NRC 1997 pg 109)

### **GMU 13 (Nelchina)**

1. RATIONALE: In the 1940s and 1950s, poisoning drastically reduced wolf and, probably, bear numbers. Moose populations increased during this control period, but environmental conditions (mild winters) also coincided with this period. When poisoning stopped, wolves again increased, moose were heavily harvested and moose numbers declined. Wolf control was then initiated on an experimental basis in 1978. (NRC 1997 pg 109)
2. REDUCTION METHOD: aerial shooting
3. DURATION: 3 years
4. REDUCTION: 42% - 58% annually
5. TARGET UNGULATE: moose
6. UNGULATE RESPONSE: no significant increase in moose populations
7. PREDATOR RESPONSE:
8. CURRENT STATUS – WOLVES:
9. CURRENT STATUS – UNGULATES:
10. COMMENT: An experiment to determine the impact of bear predation was conducted in 1979 when 60% of grizzlies were relocated in May and June. This resulted in a significant increase in moose calves surviving until autumn. However bears returned and calf mortality high in 1980. (NRC 1997 pg 111)

## GMU 19D (McGrath)

1. RATIONALE:
2. REDUCTION METHOD: aerial shooting of wolves, relocation and removal of black bears and grizzly bears
3. DURATION: 3 years (2004 – 2006)
4. REDUCTION:
  - 75% reduction in wolves over the 3 years in 19D east
  - Wolves remaining: 103 wolves in 2001(pre-control); 82 in 2005; 53-65 in 2006; no surveys in 2007 and 2008 (ADF&G 2009a pg 9)
  - In the intensive management area, pre-control black bears numbered 130; in 2003, 81 were removed and in 2004, 34 were removed (ADF&G 2009a pg 9)
5. TARGET UNGULATE: moose

### 6. UNGULATE RESPONSE:

The table below summarizes the 6 years of monitoring and 3 years of wolf and bear control (shaded) for the McGrath area (ADF&G 2007 pg 22; ADF&G 2009a pg 10)

year	wolf reduction (%)	bear predation (%)	calf survival (%) (May - June)	annual calf survival (%)	moose population size	moose density (per 1000 km <sup>2</sup> )
2001	30	45	43	33	3959	180
2002	30	43	40	27		
2003	30	24	63	51		
2004	75	6	81	40	4374	195
2005	75	30	56	42		
2006	75	18	75	63	5481	238

Moose increased from a density of 180 per 1000 km<sup>2</sup> to 238 per 1000 km<sup>2</sup> (ADF&G 2009a pg 10)

### 7. PREDATOR RESPONSE:

- Wolf control program is still ongoing so no estimate of recovery after wolf control
- There were 130 black bears in intensive management area before control and over the next 2 years 115 were removed. A count after these 2 removal years found that 72 still remained in the area indicating a high recovery rate. (ADF&G 2009a pg 10)

8. CURRENT STATUS – WOLVES: 103 in pre-control in 2001; 82 in 2005 and 53-65 in 2007. No surveys done in 2007 and 2008 (ADF&G 2009a pg 11)
9. CURRENT STATUS – UNGULATES: program still ongoing
10. COMMENT: State legislation allocated 39% of Alaska as priority for yield of moose and in 2004-2006 the Board of Game (BOG) passed implementation plans to reduce wolves in 9% of State. The McGrath area is one of these areas. ADF&G recommended the original control plan (ended 2009) be extended for another 5 years.

### **GMU 19A and 19B (Kuskokwim)**

1. RATIONALE: prior to 2004, local advisory board expressed concern that the local moose population was too low to meet consumptive demand for the area (ADF&G 2009 b).
2. REDUCTION METHOD: aerial shoot permit and land-and-shoot permits
3. DURATION: 4 years from 2004 - 2008
4. REDUCTION: objective is to reduce wolves from 110 to ~30 for a 75% reduction.
5. TARGET UNGULATE: moose
6. UNGULATE RESPONSE: moose numbers increased from 2700-4250 in 2006 to 3200-5275 moose in 2008.
7. PREDATOR RESPONSE: wolves numbered 107-115 in pre-control in 2006 and 78 in February 2008.
8. CURRENT STATUS – WOLVES: the project is ongoing so no recovery data is available
9. CURRENT STATUS – UNGULATES: the project is ongoing so no post-control data is available. The increase from 2006 to 2008 is not significant.
10. COMMENT: State legislation allocated 39% of Alaska as priority for yield of moose and in 2004-2006 the Board of Game passed implementation plans to reduce wolves in 9% of State. The Kuskokwim area is one of these areas. ADF&G recommended the original control plan (ended 2009) be extended for another 5 years.

## **GMU 13 (Nelchina)**

1. RATIONALE:
2. REDUCTION METHOD: same day airborne hunting, ground shooting, trapping, snaring
3. DURATION: 10 years
4. REDUCTION: average annual 47% reduction (2000-01 to 2008-09) (ADF&G 2010b pg 4)
5. TARGET UNGULATE: moose
6. UNGULATE RESPONSE:
  - Calves:100 cows rose from 10.8 to 19.4 between 2000 and 2008 (ADF&G 2010b pg 6)
  - Bulls:100 cows rose from 20.2 to 34.8 between 2000 and 2008 (ADF&G 2010b pg 6)
  - Total moose only rose 26% during that 8 year period (3549 to 4481 moose) (ADF&G 2010b pg 4)
  - Moose harvest was not curtailed and rose from 537 to 675 during the period (ADF&G 2010b pg 8)
7. PREDATOR RESPONSE:
  - Spring wolf population is around 150 animals (for last 3 years reported),,a drop of about 70% (ADF&G 2010b pg 4)
8. CURRENT STATUS – WOLVES: Program is still ongoing so recovery response of wolves is unknown
9. CURRENT STATUS – UNGULATES: the project is ongoing so no post-control data is available.
10. COMMENT: State legislation allocated 39% of Alaska as priority for yield of moose and in 2004-2006 the Board of Game passed implementation plans to reduce wolves in 9% of State. The Nelchina area is one of these areas. ADF&G recommended the original control plan (ends 2010) not be extended for another 5 years.

## **GMU-16 (Upper Cook Inlet)**

1. RATIONALE: As moose populations declined in the 1990s there was concern for the older adult female age structure because few calves were surviving (Titus 2007 pg 375)
2. REDUCTION METHOD:
  - For wolves: Same day airborne, ground shooting, trapping, snares
  - For black bears – relaxed harvest regulations, bait stations
3. DURATION: 5 years (2004 – 2009)
4. REDUCTION:
  - From the initial fall 2004 population of 180-200 wolves, ongoing reductions result in a current average of a 70-80 spring wolf population (ADF&G 2009c pg 3)
  - Black bear – over 500 taken between fall 2007 and spring 2008 (estimated 16% of total population) (ADF&G 2009c pg 8)
  - Of the 500 black bears taken 144 were from control program and 357 from general harvest. (ADF&G 2009c pg 8)
5. TARGET UNGULATE: moose
6. UNGULATE RESPONSE:
7. PREDATOR RESPONSE:
8. CURRENT STATUS – WOLVES:
9. CURRENT STATUS – UNGULATES:
10. COMMENT: State legislation allocated 39% of Alaska as priority for yield of moose and in 2004-2006 the Board of Game passed implementation plans to reduce wolves in 9% of State. The Cook Inlet area is one of these areas.

## **GMUs 12, 20B, 20D, 20E, and 25C (Upper Yukon Tanana)**

1. RATIONALE: Since the early 1980s residents in the area expressed concern for the chronically low Fortymile Caribou herd, thought to be held down by wolf predations, and low moose populations (in GMU12 and 20E), thought to be limited by a combination of wolf and grizzly predation. (ADF&G 2009d)
2. REDUCTION METHOD:
  - Wolves: same day airborne, trapping, ground shooting, snaring
  - Grizzly: Liberalized regulations
3. DURATION: 4 years
4. REDUCTION:
  - During pre-control period (2001-04) harvest and trapping averaged 47 wolves per year
  - During control period (2004-08) all forms of reduction averaged 107 per year
  - Pre-control population estimate for wolves was 350-410 (46-51 per 1000 km<sup>2</sup>)
  - Fall estimate for 2008 was modeled at 393-431 (i.e. population increased)
5. TARGET UNGULATE: moose, caribou
6. UNGULATE RESPONSE:
  - Moose calves per 100 cows averaged 26 during wolf control (2005-08) and 18 pre-wolf control (2000-04)
  - Moose population increased from 2600-4300 in 2004 to 3900-5500 in 2008
  - Caribou calves per 100 cows averaged 35 for 2 control years an increase from the average of 27 per 100 cows for the 5 previous years
  - 40 Mile caribou population estimate 41,000 (modeled) in 2008; 38,364 (counted) in 2007 and 43,375 (counted) in 2003.
  - Caribou population stable.
7. PREDATOR RESPONSE:
8. CURRENT STATUS – WOLVES: Program is still ongoing so no data on recovery rate
9. CURRENT STATUS – UNGULATES: Program is ongoing so no data on post-control response for moose

10. COMMENT: State legislation allocated 39% of Alaska as priority for yield of moose and in 2004-2006 the Board of Game passed implementation plans to reduce wolves in 9% of State. The Upper Tanana area is one of these areas. Because management goals have not been achieved ADF&G is recommending an additional 5 years of current control activities.

### **GMU 20A (Upper Tanana)**

1. RATIONALE: The delta caribou herd declined from 10,700 to 4,000 between 1989 to 1993. Main causes were high adult female mortality from wolves and other unknown causes, high summer calf mortality from unknown causes and high winter calf mortality from wolves (Valkenburg et al. 2004 pg746)
2. REDUCTION METHOD: Government and private trappers used snares, ground shooting and traps – helicopter assisted
3. DURATION: 2 years (1993-94)
4. REDUCTION: 60% reduction of pre-control levels in 1993 and 40% reduction in 1994. (Valkenburg et al. 2004 pg 749)
5. TARGET UNGULATE: caribou (Delta) herd
6. UNGULATE RESPONSE:
  - Although 60%-62% of the pre-control wolves were removed, fall calf:cow ratios, although increasing slightly, did not differ from adjacent non-control herds (Valkenburg et al. 2004 pg 753)
7. PREDATOR RESPONSE:
8. CURRENT STATUS – WOLVES: wolves returning to pre-control numbers within 4 years of the end of the control (Valkenburg et al. 2004 pg 750)
9. CURRENT STATUS – UNGULATES: the Delta herd remained stable from before wolf control (1993) until 2000 at around 3500 animals (Valkenburg et al. 2004 pg 751)
10. COMMENT: The failure of this program was attributed to the fact that not enough wolves were removed and wolves were not removed for a long enough period of time (Valkenburg et al. 2004 pg 746)

## ***British Columbia***

### **Northern B. C. (Ketchika, upper Kechika and Muskwa)**

RATIONALE: Moose, elk, stone sheep and, in particular, caribou, were thought to be declining in northeastern British Columbia in the 1970s and 1980s. In an attempt to stop the decline and to evaluate the role that wolf predation played in the dynamics of these ungulates, wolves were removed in three areas: the Horseranch, south Ketchika and the Muskwa

1. REDUCTION METHOD: poisoning, helicopter shooting
2. DURATION: Horseranch (1978- 80, 1985); south Ketchika (1981-83, 1985): Muskwa (1984, 1986-87)
3. REDUCTION:
  - Horseranch 38%, 11% and 11% of pre-removal levels (total 70 wolves killed) (NRC 1997 pg 104, 106)
  - Ketchika – 264 wolves removed from changing areas - % reduction hard to determine (NRC 1997 pg 106)
  - Muskwa – 505 wolves removed from changing areas - % reduction hard to determine (NRC 1997 pg 106)
4. TARGET UNGULATE: caribou, moose, sheep, elk
5. UNGULATE RESPONSE:
  - Caribou Pre-control Horseranch 246 caribou (1977) after 311 (1984) and 337 (1986) (NRC 1997 pg 106)
  - Caribou pre-control 6.3% calves (1977); after 15.2% calves 1984, 1986) (NRC 1997 pg 106)
  - Caribou in untreated areas 7.4 pre-control, 10.8 after control (Spatzizi); and 5.2% calves pre-control (1977) and 13.1% after control (Level/Kawdy) (NRC 1997 pg 106)
  - Moose in 3 untreated areas all populations were dropping during the control period; 1700 to 1100 in 3 years; 1000-800 in 3 years; and 600-90 in 6 years (NRC 1997 pg 107)
  - Moose in the treated Horseranch area moose populations increased from 690-900 in 4 years (NRC 1997 pg 107)
  - Moose 12 calves per 100 cows during the control period in untreated areas; compared to 52 calves per 100 cows in the removal Horseranch area (NRC 1997 pg 107)
  - Sheep had 23 lambs per 100 ewes in untreated area and 40 lambs per 100 ewes in the treated area (NRC 1997 pg 107)
  - Elk had 16 calves per 100 cows in the untreated area and 48 calves per 100 ewes in the treated area (NRC 1997 pg 107)

6. PREDATOR RESPONSE: Wolves quickly returned to pre-control levels within a year after the removal (NRC 1997 pg 107)
7. CURRENT STATUS – WOLVES:
8. CURRENT STATUS – UNGULATES: calf mortality returned to pre-control levels soon after control ended
9. COMMENT: The National Research Council (1997) review concluded that the northern B.C. program was more of a management activity than a scientific experiment. The sampling design was faulty, different areas were treated and poor or inconsistent monitoring occurred. However, it seems obvious that removal of close to 1000 wolves did result in improved calf survival for the years of the treatment, but that wolves quickly recovered and calf mortality quickly returned to pre-control levels (NRC 1997 pg 107)

### **North Central B.C.**

1. RATIONALE: Declining caribou populations of the “threatened” southern mountain ecotype. These declines continued despite eliminating harvests. The study had 2 treatment and 2 untreated areas. In one area (Chase), trapping was employed to try to reduce wolf numbers and in another treated area (Parsnip), enhanced moose harvest was employed to reduce predation pressure by wolves. The untreated area (Wolverine) was the control for the Chase experiment and the Hart area was the treatment for the Parsnip control area.
2. REDUCTION METHOD: targeted trapping in high risk areas: adjacent good moose habitat and along migration routes.
3. DURATION: 3 years
4. REDUCTION:
  - Wolves were reduced in the Chase area - average of 18 per year compared to 10 per year before the control period (McNay et al. 2009 pg 22)
  - Moose declined in the Parsnip area from 3000 in 2005 to 1200 in 2009 (Gillingham et al. 2010 pg 10)
  - Moose decline in the Parsnip area largely linked to increased bull harvest. In 1998 112 bulls:100 cows compared to 44 bulls:100 cows in 2009 (Gillingham et al. 2010 pg 9)
5. TARGET UNGULATE: caribou

6. UNGULATE RESPONSE:
  - Caribou Chase (wolf trapping area) estimated at 302, 556, 475 in the 3 years of wolf removal
  - Caribou Wolverine (untreated control to the wolf trapping area) was stable during the 3 years (313, 313, 377)
  - Caribou Parsnip (moose harvest area) stable from 2006 – 2010 (220, 200, 170, 190, 180)
  - Caribou Hart area (untreated control to the moose reduction area)– declined from 2006 – 2010 (495, 359)
7. PREDATOR RESPONSE: wolf status is not reported as this is an ongoing study.
8. CURRENT STATUS – WOLVES: not reported
9. CURRENT STATUS – UNGULATES: ongoing study so post-reduction response is not reported for either treatment
10. COMMENT: This study is ongoing. B.C. officials embarked on this approach to avoid controversial methods of enhancing caribou populations. The logic is that caribou were probably limited by wolf predation caused by the susceptibility of caribou elevated wolf numbers. In this region wolf numbers are considered elevated because extensive logging has enhanced the moose population which supports higher predator densities. Until early serial stages advance to more mature forest conditions and to ensure these threatened populations are not extirpated it was felt necessary to treat the overabundance of moose and wolves in the caribou environment.

## ***Yukon programs***

### **Finlayson project**

1. RATIONALE: poor calf survival and a declining caribou population could not support the 250+ adults harvested annually from this herd. Herd was estimated to be declining at 11% per year (Farnell et al. 2008 pg 3)
2. REDUCTION METHOD: Aerial control of wolves and enhanced trapping; Harvest reduced from 250+ pre-control to 102 during control and increased to about 159 after removal (1991-1998) (Farnell et al. 2008 pg 24). After 1998 harvest reduced to ~ 64 animals (Farnell et al. 2008 pg 25)
3. DURATION: 7 years of wolf control (1983-1989) followed by 8 years of monitoring

4. REDUCTION: In 1983, 42% of wolves removed and in following 6 years 83%-86% of remaining wolves removed each year – total of 451 wolves 77% shot from helicopter (Farnell et al. 2008 pg 20)
5. TARGET UNGULATE: caribou, moose also monitored in Francis Lake and North Canol areas
6. UNGULATE RESPONSE:
  - In 1982 there were between 2000 – 2500 caribou; in 1986 – 3073; in 1990 - 5950 caribou (average 18% per year) (Farnell et al. 2008 pg 23)
  - Adult mortality declined from 28% pre-control (1982), to 19% after first year control (1983) to an average of 11% from (1984-1987) (Farnell et al. 2008 pg 25)
  - Calf:cow ratios increased from 17:100 pre-control (1982) to an average for 50.6:100 during the reduction (Farnell et al. 2008 pg 23)
  - Moose only surveyed in 2 areas during the reduction; Francis Lake moose increased 18% per year between 1987 to 1991, while the North Canol moose increased 16% during the same time period
7. PREDATOR RESPONSE:
  - Wolves increased from 29 after control (March 1989) to 240 (March 1994) to 260 in 1996 (17% higher than pre-control) (Farnell et al. 2008 pg 21-22)
  - number of packs increased from 7 in 1989 to 23 by 1991 and 27-28 by 1992 (Farnell et al. 2008 pg 22)
8. CURRENT STATUS – WOLVES:
  - There are no recent surveys of wolves in the treatment area.
9. CURRENT STATUS – UNGULATES:
  - Caribou calves:100 cows declined from an average of 50.6 during wolf control to 44, 32 , 20. 30 in next 4 years similar to adjacent areas with no wolf control (NRC 1997 pg 98)
  - The Finlayson population dropped from 5950 after wolf control to 4537 over that 4 year period (declined 5% per year) (Farnell et al. 2008 pg 22)
  - Latest survey estimated 3077 Finlayson caribou in 2007 (Farnell et al. 2008 pg 22)
  - Moose in the North Canol declined from 1001 in 1991 to 810 in 1996 (4% decline per year) (NRC 1997 pg 98)
  - Moose in the Francis Lake area declined from 1475 in 1991 to 1320 in 1996 (2% annual decline) (NRC 1997 pg 98)
10. COMMENT: Farnell (2009), in retrospect, concluded that although the project resulted in the expected favourable response in the ungulate populations, the project failed as a long-term management solution because of a lack of long

term management guidelines. Unsustainable harvest and unprecedented mineral exploration activity required emergency conservation measures to be implemented in 1998.

## **Aishihik Project**

1. **RATIONALE:** Local hunters were reporting declining ungulate populations in the Aishihik area throughout the 1980s. Yukon government surveys confirmed that caribou declined by 50% during the 1980s and moose had dropped 62% from 1980 to 1992 (Hayes et al. 2003 pg 3)
2. **REDUCTION METHOD:** aerial shooting (1993-1998) and sterilization of dominant wolves in packs (1994-1997); some illegal poisoning occurred.
3. **DURATION:** 5 years February 1993 to March 1998
4. **REDUCTION:**
  - wolves were reduced to 69%-83% of pre-treatment levels from 1993-1997 (Hayes et al. 2003 pg 14)
  - wolf density, pack density and pack size were all lower during treatment compared to untreated areas (Hayes et al. 2003 pg 14)
5. **TARGET UNGULATE:** caribou and moose; less to a lesser degree, sheep
6. **UNGULATE RESPONSE:**
  - Even though hunting stopped between 1990 – 1992, Aishihik herd continued to decline (before wolf control) (Hayes et al. 2003 pg 14)
  - Aishihik herd increased during wolf reduction by 14% annually (Hayes et al. 2003 pg 15)
  - During removal period the Wolf Lake herd remained stable, Ibex Herd declined, Chisana Herd declined.
  - Calf: cow ratio in Aishihik increased from 15 before treatment to 42 during treatment (Hayes et al. 2003 pg 15)
  - Calf: cow ratio did not increase during treatment years for the control herds (Hayes et al. 2003 pg 15)
  - Moose numbers were rapidly declining pre-treatment and rapidly increased during treatment (-.71 to 1.19, respectively) (Hayes et al. 2003 pg 17)
  - Moose recruitment rate increased from 10.1% pre-treatment to 18.8% during treatment (Hayes et al. 2003 pg 17)
  - Little differences in treated versus untreated areas for sheep (Hayes et al. 2003 pg 19)
7. **PREDATOR RESPONSE:**

8. CURRENT STATUS – WOLVES:
9. CURRENT STATUS – UNGULATES:
10. COMMENT: A draft report on recent surveys in the Aishihik area is soon to be published by Environment Yukon

## **Southwest Yukon**

1. RATIONALE: The demand for moose exceeded supply in the southwest Yukon and moose populations either declined or remained stable at very low densities. Management action was designed to assess the factors limiting moose population growth, specifically grizzly bears and wolves.
2. REDUCTION METHOD: Aerial shooting for wolves; liberalized hunting regulations for grizzly bears
3. DURATION: 5 years (1982/83 to 1986/87)
4. REDUCTION:
  - wolves reduced on average 62% (44%-88%) of pre-treatment levels (Larsen et al. 1989 pg 1)
  - grizzlies were reduced on average 4% (0%-11%) (Larsen et al. 1989 pg 1)
5. TARGET UNGULATE: moose
6. UNGULATE RESPONSE:
  - Moose were not monitored in 2 of the reductions areas (Haines Junction and Lorne Mountain). Impact of control only assessed in Rose Lake (where the highest wolf reductions took place (NRC 1997 pg 100)
  - The moose population in Rose Lake did not increase significantly after 5 years of reducing the wolf population by more than 66% and 4 years of liberalized bear hunting regulations (607 in 1981 and 582 in 1982 compared to 717 in 1986) (NRC 1997 pg 100)
  - Moose calves:100 cows was 23.8 prior to wolf reductions and 22 during wolf reductions (NRC 1997 pg 100)
  - No difference in adult survival rate in treated area and untreated area (NRC 1997 pg 100)
  - Bears killed 58% of all moose killed and wolves 27% (NRC 1997 pg 100)
7. PREDATOR RESPONSE:

8. CURRENT STATUS – WOLVES:  
Wolves were surveyed in 2004 and again in 2009. The 2004 surveys indicated that wolf density had declined by 35% from the 1988 estimate. The 2009 surveys concluded that average pack size, wolf density, pack density and population size had declined from 2004 (Baer 2010)
9. CURRENT STATUS – UNGULATES:
10. COMMENT: Reducing wolf numbers by more than 60% for 5 years and liberalizing brown bear harvest in southwest Yukon failed to produce a substantial increase in moose numbers.

### ***Northwest Territories***

No control programs

## References

Adams, L. 2010. Predator-Ungulate management in Alaska: What's the scientific foundation? Presentation to the Western Association of Fish and Wildlife Agencies. 23 slides.

Adams, L. G., R. O. Stephenson, B. W. Dale, R. T Ahgook, and D. J. Demma.. 2008. Population Dynamics and Harvest Characteristics of Wolves in the Central Brooks Range, Alaska. Wildlife Monographs 170. 25 pp.

Alaska Board of Game. 2010. Notice of regulations changes in the Alaska Board of Game. Dated September 7, 2010. 4 pp. *Last accessed September 27, 2010.*

<http://www.boards.adfg.state.ak.us/gameinfo/meetinfo/2010-2011/octobernelchina/legnote.pdf>.

Alaska Board of Game. 2009b. Findings for the Alaska Board of Game 2009-182-BOG. Units 12B, 20B, 20D, 20E, and 25C Intensive Management Supplemental Findings, March 9, 2009. 2 pp. *Last accessed September 27, 2010. Last accessed September 10, 2010.*

<http://www.boards.adfg.state.ak.us/gameinfo/regs/09182bog.pdf>

Alaska Board of Game. 2009c. Findings for the Alaska Board of Game 2009-182-BOG. Unit 19 A. Intensive Management Supplemental Findings, March 9, 2009. 2 pp. *Last accessed September 15, 2010. Last accessed September 27, 2010.*

<http://www.boards.adfg.state.ak.us/gameinfo/regs/09180bog.pdf>

Alaska Board of Game. 2009d. Findings for the Alaska Board of Game 2009-182-BOG. Unit 19 D - East. Intensive Management Supplemental Findings, March 9, 2009. 2 pp. *Last accessed September 15, 2010. Last accessed September 27, 2010.*

<http://www.boards.adfg.state.ak.us/gameinfo/regs/09181bog.pdf>

Alaska Department of Fish and Game. 2007. Predator management in Alaska. 30 pp. *Last accessed September 27, 2010.*

[http://www.wildlife.alaska.gov/management/control/pdfs/predator\\_management.pdf](http://www.wildlife.alaska.gov/management/control/pdfs/predator_management.pdf)

Alaska Department of Fish and Game. 2009a. Unit 19D-East. Predation control implementation plan and activities. Division of Wildlife Conservation report to the Board of Game, March 2009. *Last accessed September 27, 2010.*

[http://www.wildlife.alaska.gov/management/control/pdfs/gmu19d\\_plan\\_mar\\_09.pdf](http://www.wildlife.alaska.gov/management/control/pdfs/gmu19d_plan_mar_09.pdf)

Alaska Department of Fish and Game. 2009b. Unit 19A. Predation control implementation plan and activities. Division of Wildlife Conservation report to the Board of Game, March 2009. *Last accessed September 27, 2010.*  
[http://www.wildlife.alaska.gov/management/control/pdfs/gmu19\\_uytpc\\_mar\\_2009.pdf](http://www.wildlife.alaska.gov/management/control/pdfs/gmu19_uytpc_mar_2009.pdf)

Alaska Department of Fish and Game. 2009c. GMU 13. Wolf control area: Winter 2008/2009. Division of Wildlife Conservation report to the Board of Game, March 2009. *Last accessed September 27, 2010.*  
[http://www.wildlife.alaska.gov/management/control/pdfs/gmu13\\_bog\\_presentation\\_mar\\_09.pdf](http://www.wildlife.alaska.gov/management/control/pdfs/gmu13_bog_presentation_mar_09.pdf)

Alaska Department of Fish and Game. 2009d. Predator control in Unit 16. Division of Wildlife Conservation report to the Board of Game, March 2009. *Last accessed September 27, 2010. Last accessed Sept. 27, 2010.*  
[http://www.wildlife.alaska.gov/management/control/pdfs/gmu16\\_bog\\_presentation\\_mar\\_09.pdf](http://www.wildlife.alaska.gov/management/control/pdfs/gmu16_bog_presentation_mar_09.pdf)

Alaska Department of Fish and Game. 2009e. Upper Yukon/Tanana. Predation control implementation plan and activities. Division of Wildlife Conservation report to the Board of Game, March 2009. *Last accessed September 27, 2010.*  
[http://www.wildlife.alaska.gov/management/control/pdfs/uytpc\\_mar\\_09.pdf](http://www.wildlife.alaska.gov/management/control/pdfs/uytpc_mar_09.pdf)

Alaska Department of Fish and Game. 2010. 2010-2011 Wolf predator control programs. Wolf Control Supplement. 4 pages. *Last accessed September 27, 2010.*  
[http://www.wildlife.alaska.gov/management/control/pdfs/2010\\_2011\\_wolf\\_control\\_supplement.pdf](http://www.wildlife.alaska.gov/management/control/pdfs/2010_2011_wolf_control_supplement.pdf)

Alberta Forestry, Lands and Wildlife. 1991. Management Plan for Wolves in Alberta. Wildlife Management Planning Series Number 4. 89 pp. *Last accessed September 27, 2010*  
<http://www.srd.alberta.ca/ManagingPrograms/FishWildlifeManagement/documents/MgmtPlanWolves.pdf>

Alberta Woodland Caribou Recovery team. 2005. Alberta woodland caribou recovery plan 2004-2014. Alberta Species at Risk Recovery Plan Number 4. 47 pp. *Last accessed Sept. 27, 2010.*  
<http://cpawsnab.org/resources/files/caribou-files/AB%20Woodland%20Caribou%20Recovery%20Plan%202004-5%20to%202013-14.pdf>

B. C. Ministry of Environment. 2008. Interim Strategy for Predator/Prey Management Actions in Support of Mountain Caribou Recovery: Fiscal 07/08 and early fiscal 08/09. 9 pp. *Last accessed Sept. 27, 2010.*

[http://www.env.gov.bc.ca/sarco/mc/files/interim\\_predator\\_pre\\_strategy\\_20080512.pdf](http://www.env.gov.bc.ca/sarco/mc/files/interim_predator_pre_strategy_20080512.pdf)

Baer, A. (2010). Wolf Survey in the Coast Mountains, 2009. Yukon Fish and Wildlife Branch Report TR-10-01, Whitehorse, Yukon, Canada. *Last accessed Sept. 30, 2010.*

[http://environmentyukon.gov.yk.ca/mapspublications/documents/coast\\_mtn\\_survey\\_2009.pdf](http://environmentyukon.gov.yk.ca/mapspublications/documents/coast_mtn_survey_2009.pdf)

Becker, M.S. 2008. Applying predator-prey theory to evaluate large mammal dynamics: Wolf predation in a newly-established multiple-prey system. PhD Thesis, university of Montana, Bozeman, Montana. 148 pp. *Last accessed Sept. 28, 2010.*

[http://www.carnivoreconservation.org/files/thesis/becker\\_2008\\_phd.pdf](http://www.carnivoreconservation.org/files/thesis/becker_2008_phd.pdf)

Bergerud AT and JP Elliott. 1986. Dynamics of caribou and wolves in northern British Columbia. *Can J Zool* 64:1515–1529.

Bertram, M. R., and M. T. Vivion. 2002. Moose mortality in eastern interior Alaska. *Journal of Wildlife Management* 66:747-756.

Boertje, R.D., Keetch, M.A., Young, D.D., Kellie, K.A., and Seaton, C.T. 2007. Managing for elevated yield of moose in interior Alaska. *J. Wildl. Management*. 73(3) 314-327.

Boertje, R.D., Keetch, M.A. and Paragi T. F. 2010. Science and Values Influencing Predator Control for Alaska Moose Management. *J. Wildl. Management*, 74(5):917-928. *Last accessed Sept. 27, 2010.*

<http://www.bioone.org/doi/pdf/10.2193/2009-261>

Boertje, R.D., D.G. Kellyhouse, and R.D. Hayes. 1995. Methods for reducing natural predation on moose in Alaska and Yukon: an evaluation. pp 505-513. *In Ecology and Conservation of wolves in a changing world.* Ludwig N. Carbyn, Steven H. Fritts, Dale R. Seip, editors. Proceedings of the Second North American Symposium on Wolves held in Edmonton, Alberta, Canada, 25-27 August 1992. *Last accessed Sept. 28, 2010.*

[http://www.wc.adfg.state.ak.us/pubs/techpubs/propubs/boertje\\_wolf\\_ecology\\_1995.pdf](http://www.wc.adfg.state.ak.us/pubs/techpubs/propubs/boertje_wolf_ecology_1995.pdf)

Boutin, S.. 1992. Predation and moose population dynamics: a critique. *Journal of Wildlife Management*. 56(1): 116-127.

Brown, G.S., Landriault, L., Sleep, D.J.H. & Mallory, F.F. 200. Comment arising from a paper by Wittmer *et al.*: hypothesis testing for top-down and bottom-up effects in woodland caribou population dynamics. *Oecologia*, 154, 485–492.

Carpenter SR, Kitchell JF, Hodgson JR. 1985. Cascading trophic interactions and lake productivity. *Bioscience* 35:634-639

Chisana Caribou Recovery Team. 2010. Recovery of the Chisana caribou herd in the Alaska/Yukon Borderlands: captive-rearing trials. Yukon Fish and Wildlife report. TR-10-02. 29 p.

Dale, B. M., L. G. Adams, and R. T. Bowyer. 1994. Functional response of wolves preying on barren-ground caribou in a multiple-prey ecosystem. *Journal of Animal Ecology* 63:644- 652.

Decker, D.J., C. A. Jacobson and T. L. Brown. 2006. Situation-Specific "Impact Dependency" as a Determinant of Management Acceptability: Insights from Wolf and Grizzly Bear Management in Alaska. *Wildlife Society Bulletin*. Vol. 34, No. 2 (Jun., 2006), pp. 426-432

Defenders of Wildlife. 2000. Wolves around the world: Global status of the Grey Wolf. 51 pp. *Last accessed September 27, 2010.*  
<http://www.kidsplanet.org/wolvesarworld.pdf>

Defenders of Wildlife. 2010. History of Wolf Control in Alaska. *Last accessed September 10, 2010. Last accessed Sept. 27, 2010.*  
[http://www.defenders.org/programs\\_and\\_policy/wildlife\\_conservation/imperiled\\_species/wolves/wolf\\_recovery\\_efforts/alaska\\_wolves/background/history\\_of\\_wolf\\_control\\_in\\_alaska/index.php](http://www.defenders.org/programs_and_policy/wildlife_conservation/imperiled_species/wolves/wolf_recovery_efforts/alaska_wolves/background/history_of_wolf_control_in_alaska/index.php)

Farnell, R. 2009. Three Decades of Caribou Recovery Programs in Yukon: A Paradigm Shift in Wildlife Management. Yukon Fish and Wildlife report. MRC-09-01. 18 pp.

Farnell, R., Hayes, R.D., Baer, A.M., Florkiewicz, R., Adamczewski, J. and Barichello, N. 2008. Effects of reducing the number of wolves and human hunting on a population of caribou in the east-central Yukon, from 1983-2007. YTG Internal draft report. 53 pp.

Fitzgerald, E. A. 2009. The Alaska wolf wars: The public trust doctrine missing in action. *Animal Law*, Vol. 15:193-235. *Last accessed Sept. 27, 2010.*  
[http://www.animallaw.info/journals/jo\\_pdf/lralvol15\\_2\\_p193.pdf](http://www.animallaw.info/journals/jo_pdf/lralvol15_2_p193.pdf)

Gasaway W.C., R.D. Boertje, D.V. Grangaard, D.G. Kellyhouse, R.O. Stephenson, and D.G. Larsen. 1992. The role of predation in limiting moose at

low densities in Alaska and Yukon and implications for conservation. *Wildl Monogr* 120:1–59.

Gillingham, M.P., Steenweg, R.W., and Heard, D.C. 2010. Parsnip caribou recovery trial – report on activities during 2009-2010. PFWWCP Report No. 339. 21 pp.

Gunson, J. 1992. Historical and present management of wolves in Alberta. *Wildl. Soc. Bulletin*. 20: 330-339.

Gustine, D.D., K.L. Parker, R.J. Lay, M.P. Gillingham, and D.C. Heard. 2006. Calf survival of woodland caribou in a multi-predator ecosystem. *Wildlife Monographs* No. 165. 32pp.

Hayes, R.D., Farnell, R., Ward, R.M.P., Carey, J., Dehn, M., Kuzyk, G.W., Baer, A.M., Gardner C.L. and O'Donoghue, M. 2003. Experimental Reduction of Wolves in the Yukon: Ungulate Responses and Management Implications. *Wildlife Monograph* No. 152: p 1-35.

Hebblewhite, M., White, C., Nietvelt, C., McKenzie, J., Hurd, T., Fryxell, J. and P. Paquet. 2005. Human Activity mediates a Trophic Cascade caused by Wolves," *Ecology* 86:2135-2144.

Hegel, T. M., Myrnerud, A., Ergon, T., Loe, L. E., Huettmann, F. and Stenseth, N. C. (2010a), Seasonal effects of Pacific-based climate on recruitment in a predator-limited large herbivore. *Journal of Animal Ecology*, 79: 471–482.

Hegel, T. M., Myrnerud, A., Huettmann, F. and Stenseth, N. C. (2010b), Interacting effect of wolves and climate on recruitment in a northern mountain caribou population. *Oikos*, 119: 1453–1461.

Holling, C.S. 1959. The components of predation as revealed by a study of small mammal predation of the European pine sawfly. *Canad. Entomol.* 91: 293-320.

Keech M. A. 2008. Response of moose and their predators to wolf reduction and short-term bear removal in a portion of Unit 19D East. Alaska Department of Fish and Game, Federal Aid in Wildlife Restoration, Research Performance Report, Grant W-33-6, Project 1.62, Juneau, USA. *Last accessed Sept. 27 2010.* [http://www.wildlife.alaska.gov/pubs/techpubs/research\\_pdfs/1.62\\_08.pdf](http://www.wildlife.alaska.gov/pubs/techpubs/research_pdfs/1.62_08.pdf)>.

Larson DG, DA Gauthier, and RL Markel. 1989a. Causes and rate of moose mortality in the southwest Yukon. *J Wildl Manage* 53:548–557.

Larson DG, DA Gauthier, RL Markel, and RD Hayes. 1989b. Limiting factors on moose population growth in the southwest Yukon. *Yukon Fish and Wildl. Br. Rep. Whitehorse*. 105 Pp.

Larter, N. C., Sinclair, A. R. E. & Gates, C. C. (1994). The response of predators to an erupting bison, *Bison bison athabasca* population. *Can. Field-Nat.* **108**: 318–327.

Latham, A. D. 2008. Wolf ecology and caribou—primary prey—wolf spatial relationships in low productivity peatland complexes in northeastern Alberta. Dissertation, University of Alberta, Edmonton, Canada.

McNay, M. 2006. Predator-prey management in Alaska. Presentation to the Alaska Board of game, May 2006. 48 slides. *Last accessed Sept. 28, 2010.* [http://www.wildlife.alaska.gov/management/control/pdfs/mcnay\\_presentation\\_may\\_06.pdf](http://www.wildlife.alaska.gov/management/control/pdfs/mcnay_presentation_may_06.pdf)

McNay M, and DeLong, R. 1998. Development and testing of a general predator-prey computer model for use in making management decisions. Alaska Department of Fish and Game. Federal aid in wildlife restoration. Research final report. W-24-1 and W-24-5. Study 1.46. Juneau, AK.

McNay R.S., F. MacDonald, L. Giguere. 2009. Mitigating risk of predation for woodland caribou in north-central British Columbia. Wildlife Infometrics Inc. Report No. 314. Wildlife Infometrics Inc., Mackenzie, British Columbia, Canada.

Messier, F. 1994. Ungulate Population Models with Predation: A Case Study with the North American Moose. *Ecology* 75:478–488.

Messier F and M Crête. 1985. Moose-wolf dynamics and the natural regulation of moose populations. *Oecologia* 65:503–512.

National Research Council. 1997. Wolves, Bears, and Their Prey in Alaska: Biological and Social Challenges in Wildlife Management. 224 pp.

NWT Environment and Natural Resources. 2010. Wolves in the NWT. *Last accessed September 27, 2010.* <http://www.enr.gov.nt.ca/live/pages/wpPages/Wolves.aspx>

Regelin, W. 2002. Wolf Management in Alaska with an historic perspective. Presentation to the Alaska Board of Game, May 2002. *Last accessed Sept.29, 2010.* [http://www.wc.adfg.state.ak.us/index.cfm?adfg=wolf.wolf\\_mgt](http://www.wc.adfg.state.ak.us/index.cfm?adfg=wolf.wolf_mgt)

Robichaud, C.B. 2009. Woodland caribou conservation in the Little Smoky: wolf management and the role of bears. MSc Thesis. University of Alberta. 120 pp.

Robichaud, C.B. and M.S. Boyce. 2009. Spatial and Temporal Patterns of Wolf Harvest on Registered Traplines in Alberta, Canada. *J. Wildlife management* 74(4): 635-643.

Schaefer JA, Veich AM, Harrington FH, Brown WK, Theberge JB, Luttich SN (1999) Demography of decline of the Red Wine Mountains caribou herd. *J. Wildl. Manage.*, **63**, 580–587.

Schneider, R.R. G. Hauer, W.L. Adamowicz , S. Boutin. 2010. Triage for conserving populations of threatened species: The case of woodland caribou in Alberta. *Biological Conservation* 143 (2010) 1603–1611.

Seip, D. 1992. Factors limiting woodland caribou populations and their interrelationships with wolves and moose in southeastern British Columbia. *Can. J. Zool.* 70:1494–1503.

Sinclair, A. R. E. (1989). Population regulation in animals. In *Ecological concepts* (ed. J. M. Cherrett), pp. 197–241. Blackwell, Oxford.

Smith, K.G. and L. Pittaway. In press. Little Smoky Woodland Caribou Calf Survival Enhancement Project. Presented at the 12<sup>th</sup> North American caribou Workshop. Goose bay, Labrador, November 2008.

Schmitz, O. J., P. A. Haïmbach, and A. P. Beckerman. 2000. Trophic cascades in terrestrial systems: a review of the effects of carnivore removals on plants. *American Naturalist* 155:141–153.

Spence, C.E. 1998. Fertility control and the ecological consequences of managing northern wolf populations. Thesis, University of Toronto, Toronto, Ontario, Canada.

Spence, C. E., Kenyon, J. E., Smith, D. R., Hayes, R. D., and Baer, A. M. 1999. Surgical sterilization of free-ranging wolves. *Canadian Veterinarian Journal* 40:118–121.

Thompson, I. D., and R. O. Peterson. 1988. Does wolf predation alone limit the moose population in Pukaskwa Park?: a comment. *Journal of Wildlife Management*. 52(3): 556-559.

Titus, K. 2007. Intensive management of wolves in Alaska. *Transactions of the 72<sup>nd</sup> North American Natural resources Conference*. P 366-377. *Last accessed Sept. 27, 2010.*

<http://www.wildlifemanagementinstitute.org/PDF/15-Intensive%20Management%20of....pdf>

Valkenburg P, MA Keech, RA Sellers, RW Tobey, and BW Dale. 2002. Investigation of Regulating and limiting factors in the Delta Caribou Herd.

ADF&G, Final Research Report, Study 3.42. Juneau. 105pp. *Last accessed Sept. 28, 2010.*

[http://www.wildlife.alaska.gov/pubs/techpubs/research\\_pdfs/3\\_42ca02faw.pdf](http://www.wildlife.alaska.gov/pubs/techpubs/research_pdfs/3_42ca02faw.pdf)

Valkenburg, P. McNay, M.E., and Dale, B.W. 2004. Calf mortality and population growth in the Delta caribou herd after wolf control. *Wildlife Soc. Bulletin*, 32(3):746-756.

Van Ballenerghe, V. 1987. Effects of predation on moose numbers: A review of recent North American studies. In: *Proceedings of the Second International Moose Symposium*. Swedish Wildlife Research, *Viltrevy Supplement* 1(2):430–460.

Van Ballenberghe, V.. 2004. Biological standards and guidelines for predator control in Alaska: application of the National Research Council's recommendations. Paper presented at 2004 carnivore Conference, New Mexico. *Last accessed Sept. 27, 2010.*

[http://www.defenders.org/resources/publications/programs\\_and\\_policy/wildlife\\_conservation/imperiled\\_species/wolf/alaska\\_wolf/guidelines\\_and\\_standards\\_for\\_predator\\_control\\_in\\_alaska.pdf](http://www.defenders.org/resources/publications/programs_and_policy/wildlife_conservation/imperiled_species/wolf/alaska_wolf/guidelines_and_standards_for_predator_control_in_alaska.pdf)

Wilderness Committee. 2002. Hunters fund wolf sterilization. *Last accessed November 6, 2010.*

[http://wildernesscommittee.org/news/hunters\\_fund\\_wolf\\_sterilization](http://wildernesscommittee.org/news/hunters_fund_wolf_sterilization)

Wilson, M.F. 2010. My turn: Predator 'control' is out of control. *Juneau Empire*. Published Aug 4, 2010. *Last accessed Sept. 27, 2010.*

[http://www.juneauempire.com/stories/040410/opi\\_601760060.shtml](http://www.juneauempire.com/stories/040410/opi_601760060.shtml)

Wilson, S.F. 2009. Recommendations for predator-prey management to benefit the recovery of Mountain Caribou in British Columbia. Rep. prep. for B.C. Minist. Environ., Victoria, BC. *Last accessed Sept. 28, 2010.*

[http://www.env.gov.bc.ca/sarco/mc/files/Recommendations\\_Predator-Prey\\_Management\\_Final.pdf](http://www.env.gov.bc.ca/sarco/mc/files/Recommendations_Predator-Prey_Management_Final.pdf)

Wittmer H.U., Sinclair A.R.E., McLellan B.N. 2005. The role of predation in the decline and extirpation of woodland caribou. *Oecologia*, 144:257–267

Wolf Song of Alaska. 2010. Wolves in Alberta – article included in the website authored by John Gunson. *Last accessed September 27, 2010*

[http://www.wolfsongalaska.org/wolves\\_canada\\_alberta.htm](http://www.wolfsongalaska.org/wolves_canada_alberta.htm)