A Review of population-based management of Southern Mountain caribou in BC

Stan Boutin and Evelyn Merrill

Department of Biological Sciences,

University of Alberta,

Edmonton, Alberta.

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The decline in Mountain caribou in BC over the past decades has resulted in research to guide caribou management by understanding the proximate and ultimate causes of the decline. Research has primarily focused on but was not restricted to the current and retrospective effects of habitat loss and fragmentation, caribou physiology, human disturbance, and increased predation on caribou. At the time of the Revelstoke Mountain Caribou Recovery Review in 2004, the leading paradigms for woodland caribou decline across Canada centered on (1) human-induced changes to landscapes and human disturbance, which triggered increases in other ungulates and their associated predators, and (2) historic climatic changes resulting in shorter winter seasons, warmer temperatures and fluctuating snowpack (Messier et al. 2004).

The outcome of the review indicated the ***highest concern*** at that time was for changes in forest-age structure that increased the amount of habitat for other ungulates, in particular moose and deer, located principally in valley bottoms. This, in turn, increased wolf populations which led to increased mortality of calves and adult females leading to population decline. Of ***moderate concern*** were snowmobiling and other human disturbances that resulted either in loss of functional use of habitat or increased access of predators to high elevation. ***Lowest concern*** was expressed for hunting, skiing, collisions, connectivity barriers (e.g. railways, reservoirs, highways).

Recommendations from the past review panel emphasized (1) increased (~3 yrs) and refined population monitoring, new studies of recruitment (e.g., pregnancy, calf survival, cow:calf ratios), (2) monitoring and telemetry studies of wolves, (3) monitoring of moose and deer abundance and productivity, and (4) research on silvicultural practices to discourage food sources of alternate ungulate and bears in areas of caribou overlap. The 2004 Review Panel stressed that mitigation measures at the habitat level were the most important for the long-term but such mitigation would not likely be sufficient for the next few decades due to the time lag of responses to a new forest age structure. Within this context, their mitigation guidance focused on: (1) management to maintain adequate forests to provide sufficient forage, (2) reductions in alternative prey and predator reductions, and (3) constraints on snowmobiling and heli-skiing (Messier et al. 2004).

MANDATE OF 2016 REVIEW PANEL

The mandate of the 2016 Review Panel was to critically evaluate the effectiveness, to date, of recent population-based management levers for southern mountain caribou groupings, which include some of the southernmost Northern subpopulations, and all Central and Southern subpopulations (Environment Canada 2014). We hereafter refer to these as the Southern Mountain (SM) caribou. Based on the information provided at Revelstoke meeting and the current literature, the panel was expected to make recommendations on future application of each lever as well as research and monitoring that would be important for future decisions. Recommendations were to be made in the context of north vs south of Highway 1, where caribou population sizes and the amount of habitat permanently converted to human settlement and agriculture differ considerably.

Since the last Panel Review in 2004, there has been considerable management and research in line with their overall recommendations. We provide a brief update on the status of the SM caribou and an overview of past and new information relevant to an evolving assessment since the 2004 Panel Review. This will provide a basis for the current recommendations that address the population and habitat levers.

STATUS AND UNDERSTANDING OF SM CARIBOU POPULATION DYNAMICS

The 2014 Federal Recovery Strategy for SM caribou reports on the status of herds in BC indicating there are approximately 6000 southern mountain caribou across British Columbia and Alberta (Environment Canada 2014). Most herds (subpopulations) are listed as declining, and this point also was emphasized in presentations during the review at the Revelstoke meeting. The Recovery Strategy indicates some subpopulations have sufficient suitable habitat within their ranges whereas for other subpopulations where sufficient habitat is currently unavailable, it could be made available through habitat management or restoration over the long term.

The Strategy also ranks the most important threats to SM caribou based on the current literature. At the top of the list is high predation rates brought about by human alteration of habitat and the subsequent alteration of predator-prey dynamics. The core argument is that the creation of early seral habitat through logging in valley bottoms has increased moose and deer abundance, which has in turn, increased predator densities (wolves, cougars, bears). The increased numbers of predators, along with their increased access to caribou habitat through the use of human-created linear features, has led to increased spatial overlap between caribou and their predators. The net result is a predation rate that leads to population decline. The link between human-caused habitat alteration, increased predators, and caribou population declines is well supported in the literature and thus forms the basis of population-based management of SM caribou.

Recreational activities, natural disturbance, and hunting are also listed as threats but the relative impact of these factors is considered far less than predation. Climate change, parasites, disease, avalanches, and noise and light disturbance were also listed but considered to be of lower concern.

Although reduction of alternative prey and predators is necessary to reduce the immediate risk of population extirpation of most caribou populations, habitat loss and fragmentation is accepted as the ultimate cause of caribou decline (Festa-Bianchet et al. 2011). Within this context, there are opportunities for enhancing habitat to achieve the best conservation success while employing predator reductions. The Recovery Strategy summarizes the current direction of habitat management for the Southern mountain caribou as "…large range areas of relatively undisturbed, interconnected habitat where they can separate themselves (horizontally and by elevation) from predators and other prey species, modify their geographic use in response to various natural and human-caused habitat disturbances and human activities, and access their preferred foods". However, it is clear that across the range, SM caribou show variation in movements and seasonal distribution reflecting habitat arrangements, snow conditions, and human and predator distributions.

In the interior wet snow belt of the SM caribou range caribou use high elevation mature/old subalpine forests (ESSF) in mid to late winter when deep snowpack provides access to arboreal lichens, and low elevation, mature cedar-hemlock (ICH) stands with litterfall, shrubs and forbs in early winter and again during spring green up until they return to high elevation during calving (Terry et al. 2000, Apps et al. 2001, Serrouya et al. 2007). In the central and northern portions of the SM caribou range where snow is relatively shallow, SM caribou herds show more varied distribution and seasonal movements including both short and long-distance shifts. In these areas caribou forage primarily on terrestrial lichens either in low elevation mature coniferous forests or on wind-swept alpine slopes during winter, and they summer and calve at high elevations. However, they also use forage on arboreal lichens in mature forests especially when snow conditions are not favourable to cratering for forage in snow (Environment Canada 2014).

Guidelines for habitat management to maintain caribou in areas of timber production have been evolving in BC. through the timber harvest planning process since the 1980s (Seip 1992, Seip and Cichowski 1996, Stevenson et al. 2001, Lewis et al. 2005, Serrouya et al. 2010). Delineation of large planning units and a variety of strategies exist in annual allowable cuts that are directed at: (1) retaining large, unfragmented patches of high elevation old-growth forests, low-elevation spring and early winter ranges, and linkages ("matrix") among high elevation ranges and/or high and low-

elevation habitats, (2) separating caribou habitat from areas of alternative prey for large carnivores, (3) implementing timber harvest via systems that may maintain either terrestrial or arboreal lichen abundance/diversity or maximize tree sapling growth, (4) managing to minimize or reduce forages for other ungulates, and (5) controlling human disturbance. Within this context there have been local efforts, such as those in the Columbia Forest District, to work with local timber companies and government to further refine protected habitats within management units, by optimizing the spatial arrangement of habitats, excluding poor habitats (e.g., very steep slopes), and prioritizing areas where multiple approaches (e.g. moose reductions or predators) are planned. However, on-the-ground efforts can prove challenging to allocate limited amounts of retention areas among caribou populations and within the constraints of an operable/inoperable timberland base (Serrouya et al. 2010).

Given concerted efforts to protect the remaining caribou habitat, the fact that caribou appear to be declining at rates faster than lichen-rich habitats are now being harvested, and the wide support for apparent competition, management in SM caribou ranges has focused on population-based levers. However, most habitat protection to date has emphasized early/late winter habitats. There is growing evidence that nutritional limitations on summer range is underappreciated and that nutritional contributions of seasonal ranges are not independent. High levels of body fat of ungulates in fall influence not only the probability of pregnancy, but regulate over-winter use of body reserves (Monteith et al. 2013, Cook et al. 2013) and allocation of protein and energy reserves to survival and reproduction (Parker et al. 2005, Barboza and Parker 2006, 2008, Couturier et al. 2008, Taillon et al. 2013, Gustine et al. 2014), which in turn have implications for timing of parturition, calf birth weight, growth rates and survival. Preliminary data on ingesta-free body fat (IFBF) recently collected for caribou herds in the Central region of BC (e.g., Graham, Parsnip, Dease Lake, Moberly, Quintette) indicate IFBF levels in herds were generally lower than those of boreal herds with the eastern boreal herd having almost 2x IFBF that of the montane herds (Cook and Cook 2015). Similar data are not available for caribou herds in the interior high snow-belt areas. Further investigation is warranted to determine if body fat data indicate that habitat conditions in the southern montane regions reflect potentially low population resilience of caribou herds to environmental stochasticity and predation relative to other caribou herds in boreal ecosystems.

A constraint in evaluating nutritional limitations in areas of high predation is that the influences can be confounded. For example, using indices of caribou IFBF or bone marrow that does not account for lactation status in areas with high predation is not likely to indicate nutritional limitation or habitat quality (Gerhart et al. 1997, Cook et al. 2013). In fact, only females that have lactated may be sufficiently sensitive to nutritional

regimes to be appropriate indicators of their nutritional environment (Cook and Cook 2015). Under the current management approaches directed at reducing predation, there may be opportunities to assess the potential nutritional limitations set by current habitat conditions and environmental stochasticity. Such efforts may be a step toward addressing the uncertainty in the adequacy of protected habitat for caribou recovery under the current management paradigm.

At the same time, addressing the uncertainty in the minds of the public that current levels of habitat protection are inadequate to support SM caribou recovery remains a challenging prospect at best. Retrospective analyses of the characteristics of areas where caribou still exist vs. have been extirpated within historical range or have shown rapid declines (e.g., Apps and McLellan 2006, Johnson et al. 2015) point to factors and perhaps thresholds of habitat components associated with caribou persistence, but they do not translate into animals number that can be supported. Approaches that use resource selection or use functions to estimate animal abundance (Boyce and McDonald 1999, Boyce et al. 2016) by identifying animal distributions and associated densities, as was used for estimating historical moose numbers in the SM caribou ranges (Serrouya et al. 2011), assume data used are from stable populations and that the composition of available habitat remains unchanged. Continued efforts to improve linkages between habitat conditions and animal performance/vital rates for inclusion into habitat-based population viability analyses along with other management scenarios (e.g., Decesare et al. 2011, Wittmer et al. 2007, 2010, 2014) may provide an avenue for updating and projecting our evolving understanding of the system dynamics. Unfortunately, the model complexities and uncertainties in model inputs, which are especially problematic in small populations, make these models of heuristic value but will not provide the assurances that current habitat condition will support long-term caribou recovery.

In the face of this uncertainty, continued management emphasis on refining timber cutting practices that minimize lichen loss, promoting lichen succession, fostering more rapid recovery of mature forest, and reducing functional habitat loss by limiting recreational activities is consistent with our assessment that no one management tool is likely sufficient to promote caribou persistence.

REVIEW OF RECENT POPULATION-BASED MANAGEMENT ACTIONS

Alternative prey management

The 2004 Panel Review recommendation was to reduce through liberalized hunting focused on females populations of moose and mule deer, which historically were at low levels, and white-tailed deer, which historically were absent, to levels anticipated to reduce the wolf populations (Messier et al. 2004).

There have been two moose reduction experiments conducted to date but no reported attempts to reduce deer densities through liberalized hunting. The Revelstoke moose reduction experiment began in 2003 when increased hunting permits were issued for moose over an area encompassing the Columbia North, Columbia South, and Frisby-Boulder caribou ranges. Moose declined from 1.5/km^2 to less than 0.3/km^2 in 2014, the last reported estimate. Wolf abundance dropped from 25 in 2007 to less than 10 by 2009 and has remained low through 2014. This lowered wolf density translates into winter densities of 9/1000km^2 and summer densities of 5-8/1000km^2. The Columbia North caribou population was declining prior to moose reduction but has now stabilized. The smaller Columbia South and Frisby-Boulder herds have continued to decline as have the surrounding control herds. Serrouya's overall conclusion was that the moose reduction acted to stabilize the larger Columbia North herd but failed to do so for the small herds because of potential Allee effects associated with small population size (see Serrouya 2013 and Serrouya et al. 2011, 2015 for details).

In 2006 annual moose hunting permits were doubled and maintained at this level thereafter in the Parsnip Caribou Range. Moose, wolves, and caribou were followed closely until 2012 and sporadically thereafter. Moose winter range densities dropped from 1.2 in 2006 to 0.4 moose/km^2 in 2012 and indices of moose numbers suggest that numbers remained low as of 2014. Wolf numbers measured from 2007-2011 remained stable despite some evidence that emigration from treated areas increased. Counts of caribou in the Parsnip range were erratic during the treatment but expert opinion was that the herd was stable whereas nearby control herds declined (as described in presentation by Doug Heard). A population estimate in 2015 indicated that the herd continues to be stable. More details about the experiment can be found in Steenweg (2011).

Overall, these experiments suggest that increased hunting permits can effectively reduce moose populations but there is mixed evidence that this translates to a reduction in wolf numbers. There is some evidence that caribou populations can be stabilized by reducing moose numbers but there are no cases to date of caribou populations increasing following this treatment.

Predator management

The 2004 Panel Recommendations were to reduce wolf and cougar populations through liberalized hunting and/or trapping, but not grizzly bears due to their low numbers. It was not recommended to increase long-term programs of wolf reduction without clear evidence that wolf predation is a primary cause of caribou population decline (Messier et al. 2004).

Wolf sterilization was conducted on the Quesnel Highlands between 2001 and 2012 and consisted of sterilization of breeding-age individuals and lethal removal of subordinate wolves. During the experiment wolf telemetry studies showed sterilized wolves maintained territories, maintained sexual pair bonds, and displayed typical survival rates. Moose harvest rates were also liberalized at the same time. A review of the program by Hayes (2013) indicated that wolf sterilization could reduce wolf densities by 39-48% but this did not translate into a statistically significant increase in the treated caribou herds relative to controls. Hayes outlined a number of shortcomings in experimental design and monitoring but concluded that sterilization and lethal removal of subordinates could reduce wolf densities. However, the BC government terminated the program. Reviews of wolf control programs suggest that wolf populations need to be reduced between 60-80% for them to be effective in allowing ungulate populations to increase (Hayes et al. 2003; Hervieux et al. 2014) indicating that wolf sterilization may not reduce wolf densities enough to affect caribou populations.

Lethal wolf reduction was implemented in two areas of BC in 2015. In the areas on and around the Moberly, Scott/Kennedy, and Quintette ranges, the aim was to reduce wolves by 80%. The removal program resulted in 29 of an estimated 29-49 wolves being removed in Moberly, 28 of an estimated 36-64 being removed in Quintette and only 2 of an estimated 32-53 being removed in Scott/Kennedy. In another removal program all wolves from packs whose territories overlapped with the South Selkirk herd were targeted to be removed. Two packs were originally identified and 9 of 9 wolves were removed from one pack and 2 of 3 from the other. While the removal was being conducted, another 2 packs were identified and some individuals from each pack were collared. These packs are expected to be removed in 2016.

There is no information available for how these wolf removals have affected adult survival and caribou recruitment but the treated herds are being monitored.
Lethal wolf control to improve caribou population dynamics has been implemented a number of times (see Hayes et al. 2003, Hervieux et al. 2014 for the most relevant examples) with the overall result being an improvement in calf survival that in some cases led to increased population size. The most recent program targeting a small

boreal caribou herd (Little Smoky) reported that the herd was stabilized, but did not increase during aggressive lethal wolf control. This program is ongoing.

Maternity pens

Since 2014, there have been two community-led maternity pens in operation for two years. The Klinse-Za pen (4-7ha) has housed 10-11 females in each of 2014 and 2015 taken from the Klinse-Za and Scott ranges. Wolf removal in 2014 was modest (ground-based and not immediately adjacent to the pen). Ten cows and nine calves were released with 2 cows and 5 calves killed by wolves soon after release. In 2015, efforts to remove wolves were increased (air and ground removal) and efforts were focused adjacent to the pen. Eleven cows (3 repeats from 2014) and 5 calves were released and all have survived to March 2016 (McNay pers. comm.). In winter 2016, 73 wolves have been removed in the area surrounding the pen and 14 cows (11 repeats) have been placed in the pen as of March 2016.

The Revelstoke Caribou Rearing in the Wild (RCRW) is also a community-based, non-profit society that was formed to conduct maternal penning in the Revelstoke Area. The 6.4ha pen was erected in 2014 and 10 and 18 adult females were placed in the pen in 2014 and 2015, respectively. In 2014, only 2 of 9 calves survived to 10 months of age after they were released from the pen, and one calf was confirmed to have been killed by wolves. All 10 adults released survived to the following March. In 2015, 4 calves died in the pen, but 8 of 11 calves released into the wild survived to March 2016. In 2014 no special predator control was implemented around the fence but in 2015 one cougar (after killing 2 adults and 2 calves) and one wolf were removed.

In both cases, the projects had very strong community support and participation. As well, in both instances, some animals have died inside the pens and calves and adults have been killed by predators outside of the pens. There was considerable information exchange between those involved in each project as to approaches and protocols that could be improved in the future. The important take-home messages provided by presenters were: 1) maternity pens demand substantial commitment and extreme care must be taken to avoid mortalities of individuals while they are in the pen, 2) the Klinse-Za team emphasized the importance of predator control outside of the fence, 3) the potential for maternity pens to positively affect caribou populations is highest when herd sizes are relatively small (a relatively large percentage of the female population must be penned to gain an overall effect).

Overall, results are too preliminary to determine the effectiveness of maternal penning as a means of stabilizing or increasing caribou herds but there is clearly strong support by local communities for penning to be one of the tools used for caribou recovery.

Results from the Klinse-Za pen suggest that predator control in the area surrounding the maternity pen could improve calf and adult survival post-release.

Translocations

Translocations were not recommended by the 2004 Panel but a number have been attempted. In 1998, caribou from the Itcha-Ilgatchuz herd were "hard" released to the South Selkirks. The release took place inside the range near resident caribou and there was 100% survival in the first year. In 2012, 19 northern mountain ecotype caribou were hard-released into the South Purcell herd, which numbered less than 15 at the time. The result was a complete failure with animals not joining up with any Purcell residents, and most animals were dead within one year of release. The South Purcell herd now numbers 20 animals.

The overall conclusion of personnel involved was that transplants have the potential to support small populations but stricter criteria for the source of transplant animals (same ecotype), methods of release (soft vs. hard release), and in situ conditions (low predation pressure) must be met. Given these greater restrictions it may be difficult to find source animals. Bergerud and Mercer (1989) suggested that caribou translocations will fail in areas where wolf density is greater than 10 wolves/1000 km^2. In a recent review of the potential for translocations as a recovery tool, Hayek et al. (2016) state that "given knowledge of the substantial threat predation poses to existing boreal caribou herds and outcomes of previous translocations, predation likely poses a significant risk to released caribou." A thorough review of caribou translocations can be found in Hayek et al. (2016).

Supplemental feeding

The panel received a presentation from Douglas Heard outlining a new population lever of supplemental feeding trial involving the Kennedy Siding caribou herd. The rationale for the feeding was that indirect predation effects could further reduce population growth if predation risk influences habitat use resulting in reduced food intake and nutritional condition. The Kennedy Siding herd received 6800 kg of food over a 105 day period from October to mid-January 2015-16 which followed a pilot year in 2014. Through the use of trail cameras 50 individual caribou were identified (similar to 2014) and pellet consumption averaged 1.5 kg pellets/caribou/day, An automatic weigh scale was established but malfunctioned such that weight changes for only 3 caribou were obtained. These caribou gained 5-13% body weight over the duration of feeding. There was some limited information to suggest that body condition was improved and overwinter survival of calves was improved following feeding in fall 2014, but that it did not increase calf production in 2015. The experiment established that caribou return to

the feeding areas and utilize the pellets in successive years. Heard recommended that food supplementation could be more effective if conducted in the spring and a pilot trial will take place in spring 2016. Nevertheless, challenges also may occur if predators learn to hunt in areas where caribou are fed or if disease concerns arise.

MITIGATION MEASURES AND CONTEXT

Government and private organizations should be commended for acting on the recommendations put forward by the 2004 Review Panel. This has resulted in a well-developed monitoring program and decisive action on habitat management, recreation and disturbance related activities, and in some cases, reduction of alternate prey. Unfortunately, SM caribou continue to decline, which has put increasing emphasis on population-based management tools. Apart from moose reduction, other population-based management strategies have not been in place long enough to get more than a preliminary assessment of feasibility; in particular, it is too premature to assess the effects on caribou recovery. Despite difficulties, use of experimental approaches to apply management treatments and monitoring core parameters, such as adult and calf survival and population counts, is key to program success. If predator removal or prey reduction is conducted, predator and prey populations need to be monitored as well. Preliminary results of recent experiments indicate that single management levers are unlikely to lead to stabilization and/or increase in caribou trends; instead a combination of tools will be needed to address the immediate population declines in caribou while promoting efforts to protect and restore habitat.

Population management levers can provide a means of maintaining caribou herds while habitats recover but their application is not short-term. It could be decades before any SM herds actually become self-sustaining. For herds north of Highway 1, the combination of current herd sizes, forest harvesting and regeneration targets, and management of other human activities make the potential for self-sustaining herds in the future most realistic. This may not be the case for the herds south of Highway 1 because extremely small population sizes (<20), limited capabilities to restore habitat in the long term, and the high potential for deer-supported predator populations greatly reduces the chances of short- and long-term success. These herds will require major intervention involving predator control, maternity pens, and possibly transplants but small starting populations mean that stochastic events could wipe out any gains made by population management. In all likelihood these small populations may never be self-sustaining so it is relevant to consider whether or not such major interventions are justified.

RECOMMENDATIONS

Overall

- Apply combinations of population management tools to recover herds.

Monitoring

- Continue monitoring of adult female survival, calf recruitment and population size across populations. Initiate monitoring of condition indices, in particular IFBF using available techniques (e.g., ultrasound) when animals are handled.
- Because population-based management remains experimental in nature, sufficient resources need to be devoted to monitoring management treatments and controls to maximize learning.

Alternative prey

- Because there is good evidence that liberalized hunter harvest can reduce moose populations, where feasible maintain high hunter harvest levels on or near caribou range to aid in keeping wolf densities low.
- Evaluate whether liberalized hunter harvest on deer can reduce numbers where deer have the potential to support high predator densities on or near caribou range.

Lethal predator control

- Ongoing experimental lethal control of predators should continue with re-evaluation after 5 years.
- Lethal control of wolves and cougars should be done to protect caribou released from maternal pens or translocations in areas that do not have naturally low predator densities.

Maternal penning

- Use maternal penning where it has the potential to supplement small populations but establish clear criteria for periodic re-evaluation of the cost-effectiveness of the program.
- Penning should occur in combination with lethal predator control surrounding the pen and in the release sites.
- Develop *best practices* for transport and rearing of penned caribou to proactively address health risks to individual caribou and the penned herd.

- Consider the value of using penned animals to address research questions related to winter feeding, animal condition, and post-release behaviors influencing cow and calf survival.

Translocation

- Transplants should not be conducted unless there is strong evidence that habitat conditions and predator abundance are conducive to success. This may require lethal control of wolves and cougars.
- Translocations should match the caribou ecotype of the source and receiving herds and not put the source herd at risk.
- Because translocation is a high-risk recovery strategy that has been largely unsuccessful to date, further evaluate the factors influencing caribou retention in the release area and post-release survival to develop *best practices* for release.

Supplemental feeding

- Although supplemental feeding may not be practical on a large scale, there is merit in evaluating it in selected situations such as the Kennedy Siding feeding experiment. It may represent an opportunity to determine if improved condition of caribou could override the direct effects of predation.

Habitat protection and restoration

- Further investigate the nutritional quality of seasonal habitats, how their use varies under stochastic environmental variation and predator/human disturbance, and the influence on animal performance measures. Initial investigations are best done in areas undergoing lethal predator control.
- As new information becomes available, explore opportunities at the local population level to increase the protection of key spatial arrangements of seasonal habitats and crucial habitats for caribou conservation within the on-going, long-term forest planning efforts.

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