BRITISH COLUMBIA
The Best Place on Earth

April 28, 2010

File Number: 2913682

To the reader:

On October 16, 2007, government announced the Mountain Caribou Recovery Implementation Plan (MCRIP) with a goal to restore the mountain caribou population to the pre-1995 level of 2,500 animals within 20 years. One of the management actions in the MCRIP is to augment mountain caribou populations such that they have a critical mass to permit self-sufficiency. The attached document, "Augmentation Plan for the Purcells-South Mountain Caribou Population" provides the technical and logistical recommendations on how to conduct a caribou transplant. The recommendations outline funding implications, timing and procedural requirements. This report was completed under contract and received extensive review. Government will need to consider recommendations in the report and decide whether they are appropriate for use. The recommendations will need to be balanced with other recovery objectives and incorporated into caribou recovery activities.

This report is a significant accomplishment and will guide government in moving forward with Mountain Caribou Recovery. For more information on Mountain Caribou Recovery in British Columbia, please visit the recovery website at:
http://www.env.gov.bc.ca/sarco/mc/index.html
If you have any questions on the attached augmentation document or Mountain Caribou recovery, please feel free to contact me (250) 614-9910.

Sincerely,

Chris Ritchie
Species at Risk Recovery Coordination Manager
Environmental Stewardship Division, Prince George

Ministry of Environment
Species at Risk Recovery Implementation
Environmental Stewardship Division
4051 – 18th Avenue
Prince George BC V2N 1B3

Telephone: (250) 614-9910
Facsimile: (250) 565-6940
www.gov.bc.ca/env/

Augmentation Plan for the Purcells-South Mountain Caribou Population

17 February 2010


Steve Forrest photo

For:
BC Ministry of Environment (Ecosystems Branch)
Victoria, BC

By:
Trevor A. Kinley, R.P.Bio
Sylvan Consulting Ltd.
Invermere, BC
(250) 342-3205
sylcon@telus.net

Summary

The southern part of the Purcell Mountains has been identified provincially as the Southeast Kootenay planning unit (PU 1B) for mountain caribou recovery. Within it, caribou are only known to remain within the Purcells-South (PS) herd, and the 14 caribou there are normally separated into two bands. Recovery without population augmentation is very unlikely. Augmenting the herd would dramatically increase genetic diversity, decrease the risk from random events, speed growth, and be consistent with provincial direction to augment herds having <50 caribou. Translocations of 15 to >100 caribou have been successful at many sites across North America, including locations where predators include wolves or cougars.

Over 1400 km^2 of caribou habitat has been protected from forest harvesting in PS under an ungulate winter range (UWR) designation enacted through a government actions regulation (GAR). This adjoins several small to very large parks, and an additional >700 km^2 of GAR UWR for the Purcells-Central (PC) herd (www.env.gov.bc.ca/wld/frpa/uwr/approved_uwr.html). Restrictions on access and other disturbances are also in place. Protected areas largely capture the best habitat, and this should improve with time as younger stands age within both the UWR and parks.

The main limiting factor in PS is expected to be predation. After a rapid decline due mainly to predation in the 1990s, the PS caribou population has been stable for the past decade. However, the wolf density has now grown to about 10/1000 km^2 and the cougar population appears to have rebounded recently to about the level it was when the last caribou decline was detected. Combined densities of wolves and cougars are now about double the level that would allow long-term caribou persistence, and an order of magnitude higher than needed for rapid caribou population growth. Translocation will likely be far more successful if female cougar quotas in wildlife management units immediately around caribou are increased or eliminated, sub-regional cougar quotas are increased slightly, and wolf density is reduced to about 1/1000 km^2 through aerial control. This is achievable within the winter in which caribou are translocated but wolf monitoring and possibly control should be maintained at least through the year after the final augmentation is completed, because ongoing wolf reproduction and immigration is expected. It should be evaluated at that point and periodically thereafter. Predator-management decisions could, alternatively, be made only after monitoring mortality of translocated caribou but this would present a much higher risk and is not recommended. Achieving long-term predator limitation by managing primary prey species near caribou range has merit, but must be approached carefully to avoid undesired effects. Augmentation should proceed while this is pursued. Early-seral habitat configurations can affect prey and therefore predator distribution, which must be considered in decisions regarding salvage logging, mineral exploration and fire suppression. Caribou disturbance and displacement can be limited by legalizing any unsuccessful voluntary access closures and making further decisions as recovery proceeds or new proposals come forward.

Consistent with government direction and in consideration both of logistical issues and past successes, it is recommended that 40 caribou be translocated to the PS herd, spread across 2

years, beginning in 2011. Translocates should be heavily biased toward females and moved during late winter. The source herd is to be determined by the Ministry of Environment (MOE). The preferred method is to netgun caribou, fly them to a staging area for collaring, inspection and sampling, then load them individually into crates for immediate truck transport to PS. Some circumstances would warrant them being held temporarily in corrals prior to crating, or transported uncrated in stock trailers then crated at PS. They would then be flown to a site in late-winter range and released in rapid succession near residents. Maternal penning to increase first-year calf recruitment is biologically and logistically viable but would have a cost:benefit ratio several times less favourable than that of translocation. It is not recommended except under unusual circumstances, such availability of only one group of 20 caribou or the availability of funding specific to maternal penning. Annual augmentation planning should begin with confirmation of a source herd by the autumn prior to the expected date of the late-winter translocation.

Fluctuation around a goal of about 100 caribou in PS is reasonable under a scenario of short- to medium-term predator management and longer-term habitat recovery and local prey management. This number corresponds to a density of 30 caribou/1000 km^2 over the gross area where caribou have occurred recently, or 60/1000 km^2 within remaining and designated habitat. Many scenarios for population trends are possible after release. Targets set here are based on a Moderate Growth scenario, which would result in the population reaching 100 about 14 years after the first release. Assumptions for this are relatively conservative, if predation remains at sustainable levels. The Moderate Growth scenario assumes that 8 caribou would either leave PS or die in the first year of each translocation. However, the growth rate in subsequent years under the modeled conditions would be similar to that recorded recently for the South Selkirks herd and lower than recorded following translocation to the Telkwa Mountains. Population goals should be re-evaluated about every 3-5 years to ensure that they are realistic in light of the number of caribou present at that time, the level of predation, and other ecological conditions.

Monitoring of translocated caribou is important for establishing mortality patterns and other demographic and distribution trends. Collars that collect data by GPS and transmit it to a website via satellite are recommended, to allow almost real-time detection of mortalities. Immediate ground inspection of mortality sites is critical in attributing deaths to a specific cause and, in the case of predation, species. Along with continued monitoring of wolves and data from cougar harvest, this will indicate whether predator management has been successful or, if not, whether it can be modified to become successful. Late-winter caribou population surveys should continue. Combined with mortality monitoring, they will provide data to measure success against provincially established standards, namely annual adult survival >88%, calves forming >15% of the late-winter population, and a positive growth rate. Those standards are near minimums for persistence; growth following translocation is expected to be faster. Winter wolf monitoring would indicate whether reduction targets have been met and whether control is needed.

The budget is preliminary because there are uncertainties regarding the caribou source, personnel (staff versus contracts), and methods. It does not include allocations for snowmobile-use surveys or population surveys as these are considered to be baseline activities that will continue to occur in the short term regardless of translocation, nor does it include the cost of getting approval for a source herd. However, the budget does include predator monitoring and control, caribou translocation, and monitoring of translocated caribou. Assuming labour for predator monitoring and control is provided by MOE but most labour for translocation and monitoring is on contract, estimated costs are about $301,000 in the first year for wolf monitoring and control, translocation of 20 caribou and about a month of caribou monitoring; $341,000 in the second year for wolf monitoring or control, translocation of 20 more caribou and a full year of caribou monitoring; and $156,000 in the third year for wolf monitoring or control and caribou monitoring. This totals $798,000 over 3 years. Monitoring for additional years, if desired, would be about $60,000 per year. Across the 3-year budget, direct costs would be reduced by about $106,000 for translocations and $42,000 for monitoring if done entirely by staff and volunteers from MOE or other agencies.

Key factors in making this augmentation plan a success are:

- Obtaining approval to translocate 40 caribou from elsewhere in BC.
- Locally reducing cougar density through hunting regulation changes, and monitoring its effect on cougars and caribou.
- Locally controlling wolf numbers initially then periodically as needed, and monitoring its effect on wolves and caribou.
- Persisting in such management efforts at least until the caribou population has reached its target. It is expected that mortality and dispersal of caribou will be high in the first year after each translocation, so progress toward population goals should be judged on that basis.

The portion of PU 1B formerly inhabited by the PC herd is probably now vacant but includes GAR UWR and parks. After the PS herd recovers, caribou may naturally emigrate to PC because the two ranges are adjoining. If not, it is recommended that the PC herd be re-established through translocation, to create a larger, more resilient population throughout 1B. This would be consistent with provincially established population targets and management guidelines.

Table of Contents

List of Tables

List of Figures

1. Study Area

1.1 Boundaries

The Purcell Mountains are the easternmost range of the Columbia Mountains, lying in southeast B.C. and northwest Montana. They are bounded to the west by the Selkirk Mountains and to the east by the Rocky Mountain Trench. Three populations (hereafter "herds") of mountain caribou[1] occur partly or entirely in the Purcells (Wittmer et al. 2005a). The Purcells-Central (PC)[2] and Purcells-South (PS) herds are both in the southern half, separated by the lower St. Mary River valley. Both fall within the Southeast Kootenay planning unit (PU 1B) designated through the Mountain Caribou Recovery Implementation Plan (http://www.env.gov.bc.ca/sarco/mc/files/Oct16_2007_Implementation_Plan_Map.pdf). Nearby, the Duncan herd covers a small part of the northern Purcell Mountains, and the South Selkirks herd (SS) lies to the west across Kootenay Lake. The latter two are outside of PU 1B. This report deals strictly with the PS herd, except where conditions within the ranges of other herds have some direct effect on PS or vice-versa.

The area in which translocation is considered in this document is a 3,375-km^2 polygon combining the following (Figure 1):

- The area designated for habitat protection under ungulate winter range order #U-4-013 (http://www.env.gov.bc.ca/wld/frpa/uwr/approved_uwr.html) issued by the Ministry of Environment (MOE) under the authority of a government actions regulation (the GAR UWR order), but excluding the portion in PC. That is, this includes 1401 km^2 in PS but excludes the 726 km^2 in PC, which is northeast of a line formed by Dewar Creek and the St. Mary River downstream of Dewar Creek.
- Any polygons of non-designated land completely enclosed within the GAR UWR area.
- A minimum convex polygon formed by locations occupied by caribou adjacent to the GAR UWR area (but excluding the range of PC and areas south or east of Highway 3 or north of the St. Mary River drainage), as indicated by:
  - public sightings records from the most recent 2 decades, 1990 to 2009;
  - VHF and GPS radiotelemetry records from 1990 to 2002 (year of last record); and
  - census records from 1993 (first census) to 2009.

It is expected that any future caribou activity in PS will occur almost entirely within areas designated under the GAR UWR order and adjacent parks, but conditions over the larger study area will undoubtedly play a role in recovery.

[1] In this document, "mountain caribou" refers to the ecotype of woodland caribou (*Rangifer tarandus caribou*) that depends on arboreal rather than terrestrial lichen for winter forage and occurs only in the Interior Wet-Belt of east-central and southeast B.C. and adjoining northern Idaho and Washington.

[2] The Purcells-Central subpopulation appears to now be functionally if not completely extirpated (DeGroot 2009).

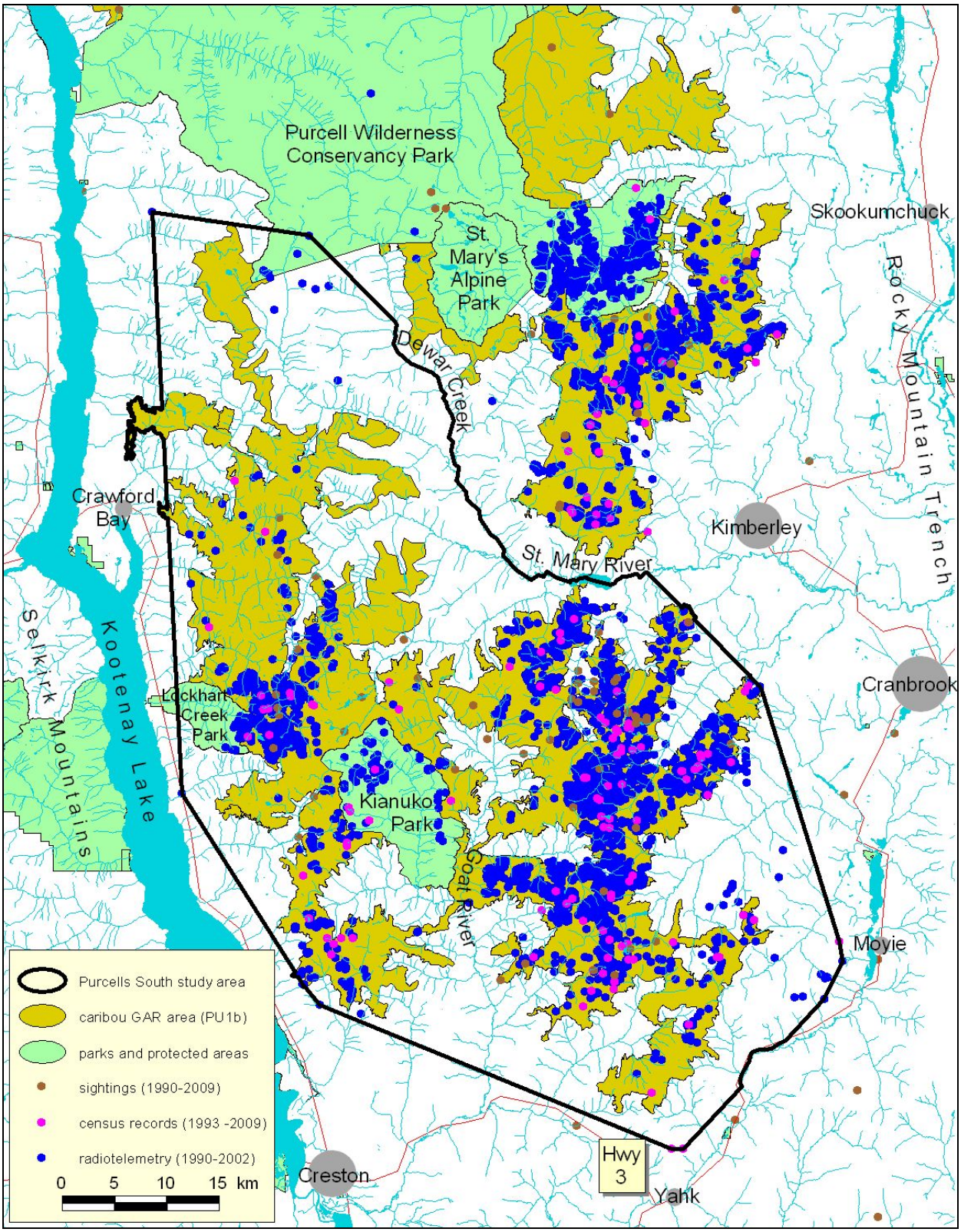

Figure 1. Purcells-South caribou translocation study area in relation to management areas and recent caribou records. Caribou records and GAR UWR caribou management areas northeast of the study area are within the range of the Purcells Central herd.

1.2 Ecosystems

The Purcell Mountains straddle three ecosections of the Northern Columbia Mountains ecoregion. With the exception of its northwest corner, the study area has relatively moderate terrain. Elevations in it range from about 550 m (west) or 1000 m (east) to 2700 m but most ridges typically do not exceed 2300 m. Terrain, climate and vegetation are highly variable, leading to complex biogeoclimatic patterns (Table 1, Figure 2). Both dry and wet subzones of the Engelmann Spruce – Subalpine Fir (ESSF) zone are present, and lower elevations include both the Montane Spruce (MS) and Interior Cedar – Hemlock (ICH) zones. Regardless of classification, most of the study area is transitional between wet and dry ecosystems. For example, even in drier areas the forest includes western redcedar, western hemlock and western white pine, while even in wetter areas there is an abundance of lodgepole pine. Notable characteristics throughout are the extensive distribution of the woodland and parkland subzones of the ESSF (where whitebark pine is common to dominant), and the general lack of the IMA (Interior Mountain-heather Alpine) zone. Interpolating based on elevation, average annual maximum snow depths from 1980 through 2004 were 133 cm at the ESSFdm/dmw transition and 220 cm at the ESSFwm/wmw transition (unpubl. data used in calculations for Kinley et al. 2007). These represent the approximate lower limits of caribou distribution during late winter, so slightly deeper snowpacks would typically be experienced by caribou.

Table 1. High habitat variability within and among ecosections of the Purcells-South study area.

Ecosection	Area	BEC Sequence	Terrain	Climate	Recent Caribou Use
Central Columbia Mountains	north-west	*Kootenay Lake Drainage:* ICHmw2 → ICHwk1 → ESSFwm → ESSFwmw → ESSFwmp → IMAun *Upper St. Mary Drainage:* ICHmk1 → ICHdm → ESSFwm → ESSFwmw → ESSFwmp → IMAun *Lower St. Mary Drainage:* ICHmk1 → ICHdm → ESSFdm → ESSFdmw → ESSFdmp	high ridges with narrow valleys	wet to moist	least concentrated
Southern Columbia Mountains	west-central and south	*Extreme Northwest:* ICHdw → ICHmw2 → ICHwk1 → ESSFwm → ESSFwmw → ESSFwmp → IMAun *Remainder:* ICHdw1 → ICHdm → ESSFdm → ESSFdmw → ESSFdmp	high ridges with broad valleys	moist to wet	intermediate
McGillivray Range	east-central	*Headwaters:* MSdk → ESSFdm → ESSFdmw → ESSFdmp *Front Ends of Drainages:* MSdk → ESSFdk1 → ESSFdkw → ESSFdkp	subdued ridges	dry to moist	most concentrated

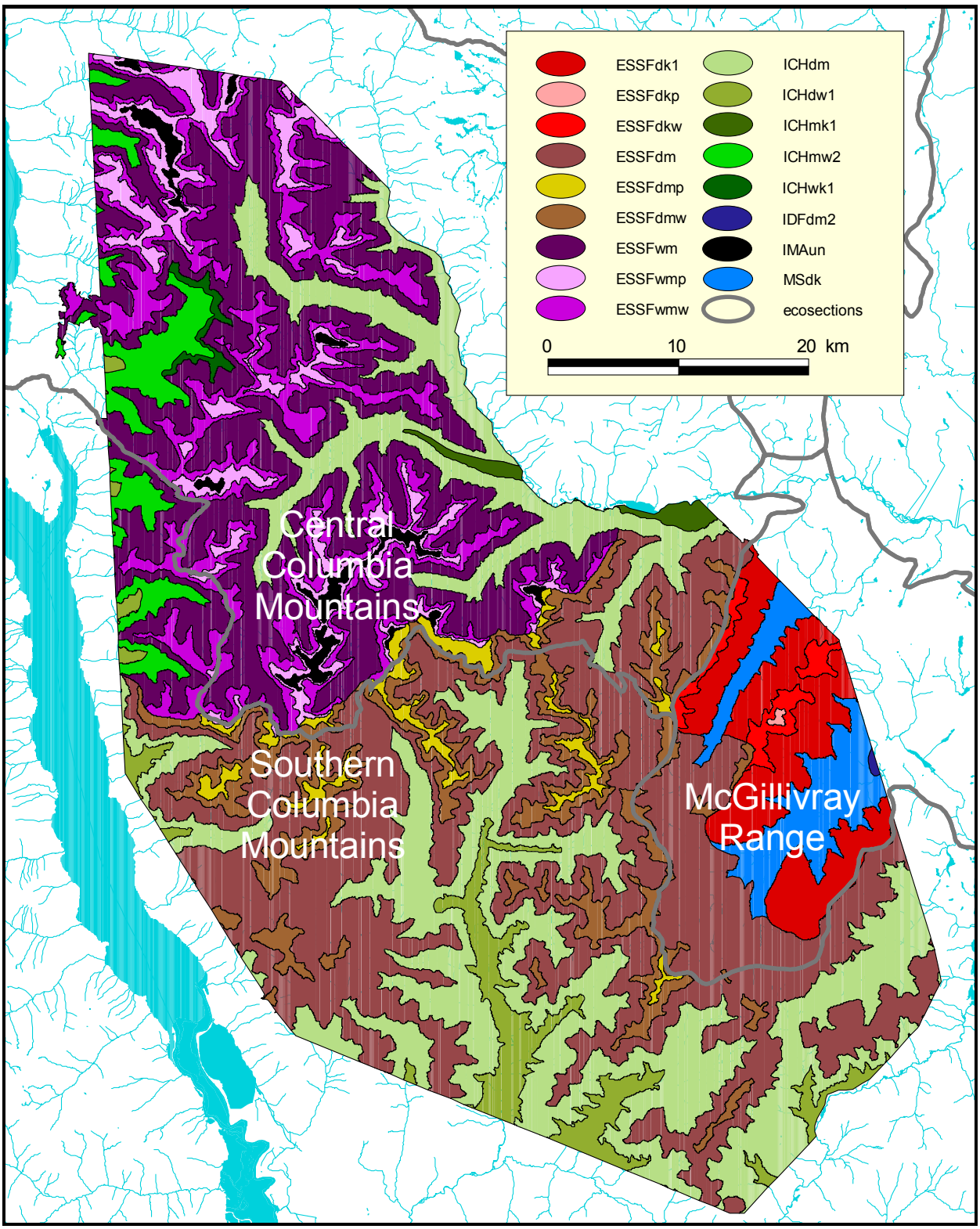

Figure 2. Ecosections and biogeoclimatic units within the Purcells-South Caribou translocation study area.

2. Need for Augmentation

Caribou were historically widespread in the Purcells, both within and beyond the study area. They are still reported outside of known ranges but primarily occur within defined herds (Figure 1; Figure 3; T. Kinley, unpubl. data). During radiotelemetry monitoring from 1987 to 2002 of both residents and PS immigrants earlier translocated to the SS, none moved between PS and PC (J. Almack, Wash. Dept. Nat. Res., unpubl. data; T. Kinley, unpubl. data).

Within the PS study area, activity by radiocollared caribou has in general been separated into two nodes separated by the Goat River (Figure 1, Figure 3), with only 5 movements across that drainage recorded for 4 individuals (2 M residents, 2 F immigrants). Late-winter census records have become particularly localized. In each of the last three surveys, 3 or 4 caribou were recorded in Redding or Kianuko Creeks on the west side, and 10 or 11 were in Hellroaring Creek at Grassy Mountain on the east side. Single individuals were also found in Perry Creek on the east side in 2 of those years (Kinley 2006, 2007, DeGroot 2009). While there may still be occasional caribou use of PC, none have been recorded there in recent surveys (ibid.).

It is not known how many caribou were present in PS historically. The distribution of recorded sightings (Figure 3) suggests PS may have been part of a larger, contiguous herd with animals farther north and south and possibly east and west, rather than being a distinct entity. For just the PS study area, an estimate done without the benefit of data put the population at 21-28 in 1975 (Russell et al. 1982). This seems unrealistically low, given that (a) it followed harvests averaging 11 caribou/year from 1964-1971 (ibid.); (b) the estimated population in the mid 1980s was 100-150 (R. Demarchi, pers. comm., as cited in Manley 1986); and (c) the first complete PS survey in 1995 recorded at least 63 caribou (Kinley 2007). An original population of several hundred therefore seems likely. Whatever the early population may have been, corrected survey estimates for PS declined rapidly from a high of 63 in 1995 to 13 in 2000, then remained roughly stable with a count of 14 in 2009 (Figure 4).

Even with recent protective management (Section 3), and stability in the population (Figure 4) the low population indicates that recovery is very unlikely without augmentation because:

- It is likely to be impaired by demographic “quirks”, either now or in the future (e.g., unfavourable sex ratios, older age structure).
- A negative random event (e.g., targeted predation, avalanche, a sterile bull) has a higher likelihood of catastrophic consequence for smaller populations. For example, an avalanche recently eliminated what may have been the entire North Banff herd (Kinley 2009).
- Samples taken in the mid 1990s with a much higher population already indicated greatly reduced genetic heterozygosity (Zittlau 2004), and breeding must now necessarily be between even more closely related individuals.
- The above problems are exacerbated by the low frequency of movement between the east and west sides of PS, and the lack of recent movement from other herds.
- Even with rapid growth and no genetic issues, it would take a very long time for such a small population to become more secure (e.g., >40 years to reach 100 animals at 5% average annual growth).

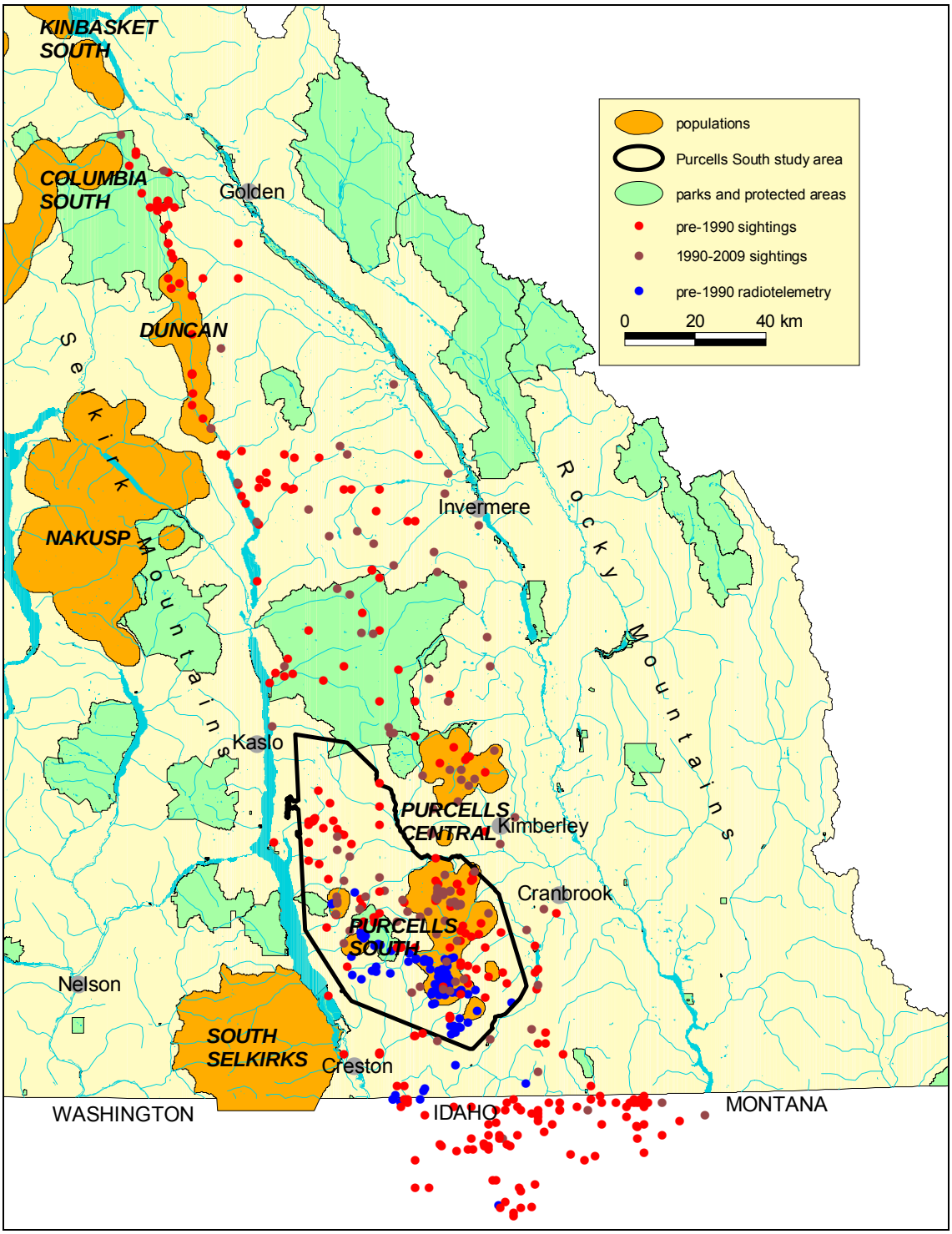

Figure 3. Historic and recent records of caribou in the Purcell Mountains of B.C., Idaho and Montana, excluding census and recent radiotelemetry data. Recent herd ranges (95% fixed-kernels except Canadian portion of South Selkirks) from Wittmer et al. (2005a). Sightings compiled by the author, T. Their (Mont. Dept. Fish, Wildl. Parks) and from published sources, mainly Flinn (1956), Evans (1960), Stevenson and Hatler (1985), and Manley (1986). Accuracy varies. Pre-1990 radiotelemetry courtesy J. Almack, Wash. Dept. Nat. Res. Point locations for Rockies and Selkirks not shown.

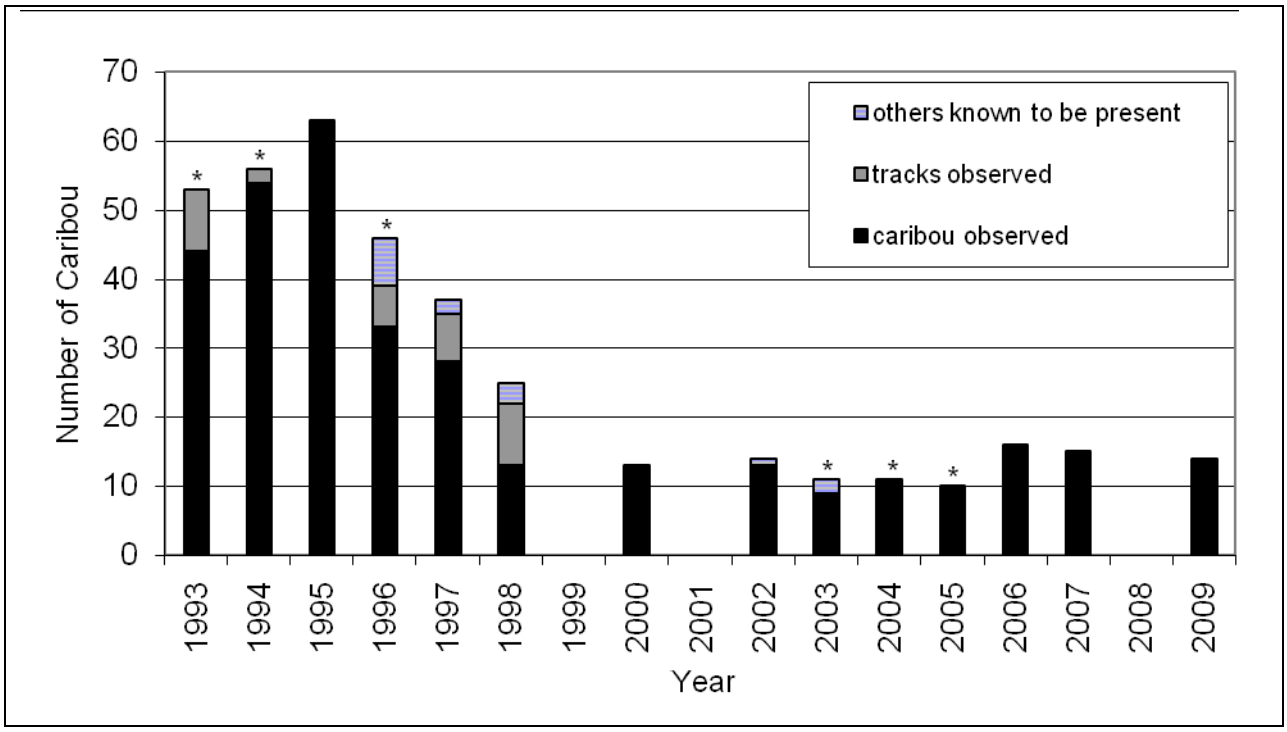

Figure 4. Minimum population sizes for the Purcells-South herd, 1993-2009 (from Kinley 2007 and DeGroot 2009). Asterisks indicate incomplete surveys.

Even under the best of circumstances, the above considerations indicate that recovery of the Purcells-South herd is highly unlikely unless augmented with other caribou. Doing so would dramatically increase heterozygosity, decrease the impact of random events, and greatly shorten the window required for a growing population to reach a more secure level. Augmentation has been identified as a desired activity for herds with <50 animals, and monitoring of its outcomes has been identified as an element of adaptive management for mountain caribou (Wilson and Nyberg 2009).

3. Suitability of Purcells-South and Means of Maximizing Suitability

Caribou historically inhabited large areas of the Purcell Mountains and continue to be present within the range of the PS herd. After a precipitous drop during the 1990's, the PS population has remained low but stable this decade. During the last few years, habitat has been protected (Section 3.1) and recreation management plans have been put in place specifically for this herd (3.3), while mineral exploration (3.2.3), salvage logging (3.2.3) and new recreational tenures (3.3) will be limited in the same manner as elsewhere in mountain caribou range. Movements through PS are facilitated by generally gentle, well-connected terrain. The role of predation (3.2) is now far better understood than in the past. While several steps are recommended to ensure that conditions are optimal, the above factors taken together suggest that the study area is capable of supporting a caribou herd if augmentation is used to initiate recovery, improve genetic characteristics, and reduce the impact of random negative events. Details of relevant factors are described below.

3.1 Habitat

This section deals with habitat generically, i.e., general forest and terrain characteristics associated with mountain caribou activity. Specific habitat characteristics that may be valuable in limiting predation are discussed in Section 3.2.3.

A model of landscape occupancy potential covering the Columbia Mountains from Bowron Lakes to the USA indicates that the PS study area has a moderate probability of caribou persistence (Apps and McLellan 2006). A multi-scale caribou habitat suitability model for the southern Purcell Mountains was developed by Apps and Kinley (2000). The areas protected for caribou under the GAR UWR order in the PS study area (1,400 km^2), the adjacent PC range (>700 km^2), and parts of adjoining parks match well with areas of greater habitat suitability (Figure 5). Habitat modeling developed by the Mountain Caribou Science Team for the range of mountain caribou showed 1590 km^2 of habitat in the "high" class in PU 1B, although not all was in the PS study area.

A key consideration for interpreting models is that older forests are rated by all of them as better habitat (Apps and Kinley 2000, Kinley and Apps 2000, Apps and McLellan 2006, McNay and McKinley 2007). Forested areas of PS now protected as UWR are largely younger than age class 8 (Figure 6), so caribou values predicted by each of the models will continue improving over the coming century.[3] Another important consideration is that two small parks and one very large park (Purcell Wilderness Conservancy) adjoin the GAR UWR area (Figure 1), providing more habitat. Also, the variability in climatic, vegetation and terrain types in PS (Section 1.2) provides potential resilience to changing or atypical climatic conditions.

[3] Fire appeared to accelerate with the influx of miners and settlers in the late 1800s (Drewry 1894, MacDonald 1996), and more recently there has been considerable logging. Little logging is expected within the GAR UWR area in the future, and means of minimizing impacts are outlined in Section 3.2.3.

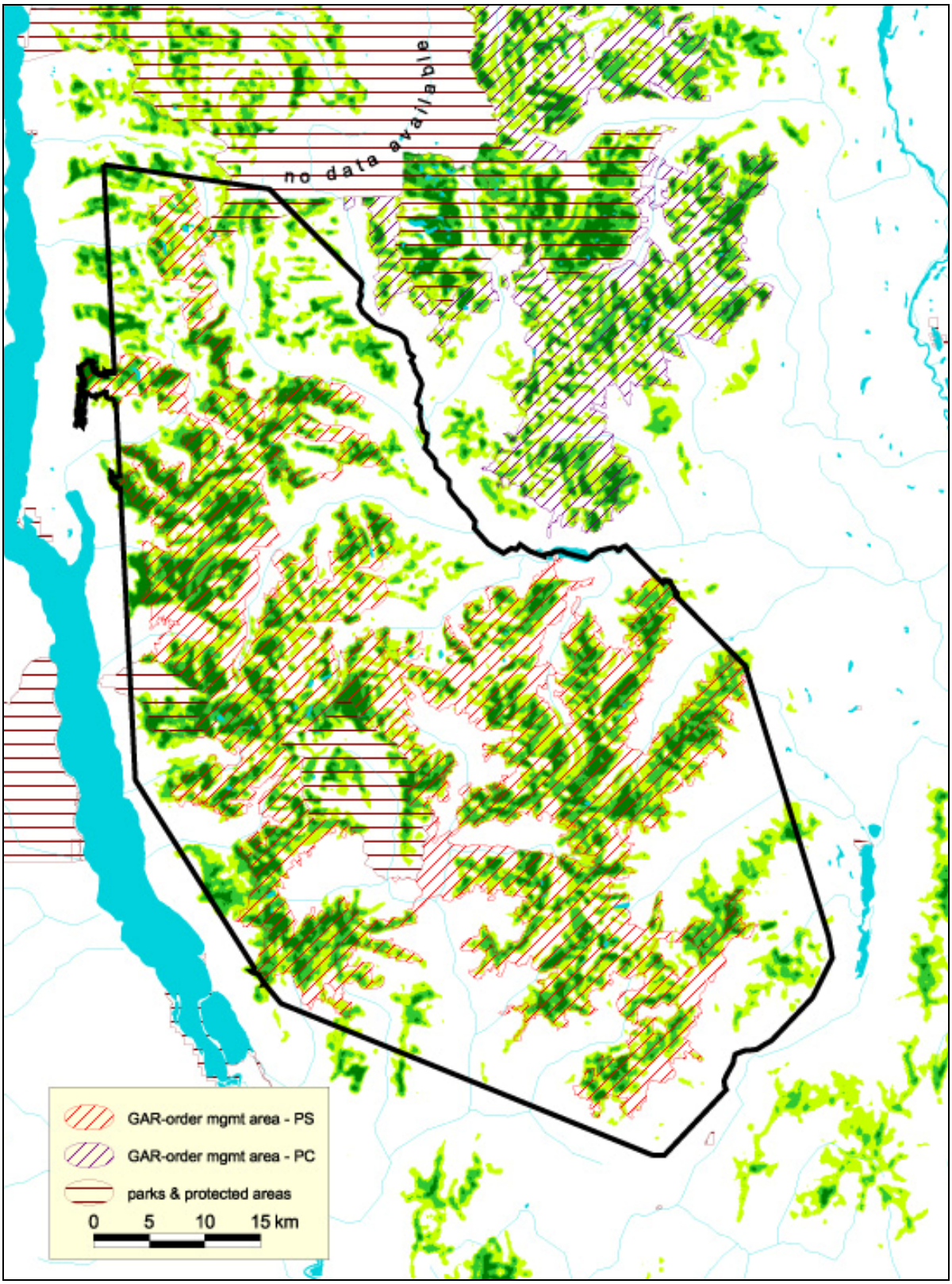

Figure 5. Caribou all-season habitat ratings (Apps and Kinley 2000) for southern Purcell Mountains, including areas designated for protection within ranges of PS and PC herds and adjacent parks. Darker green indicates higher-rated habitat.

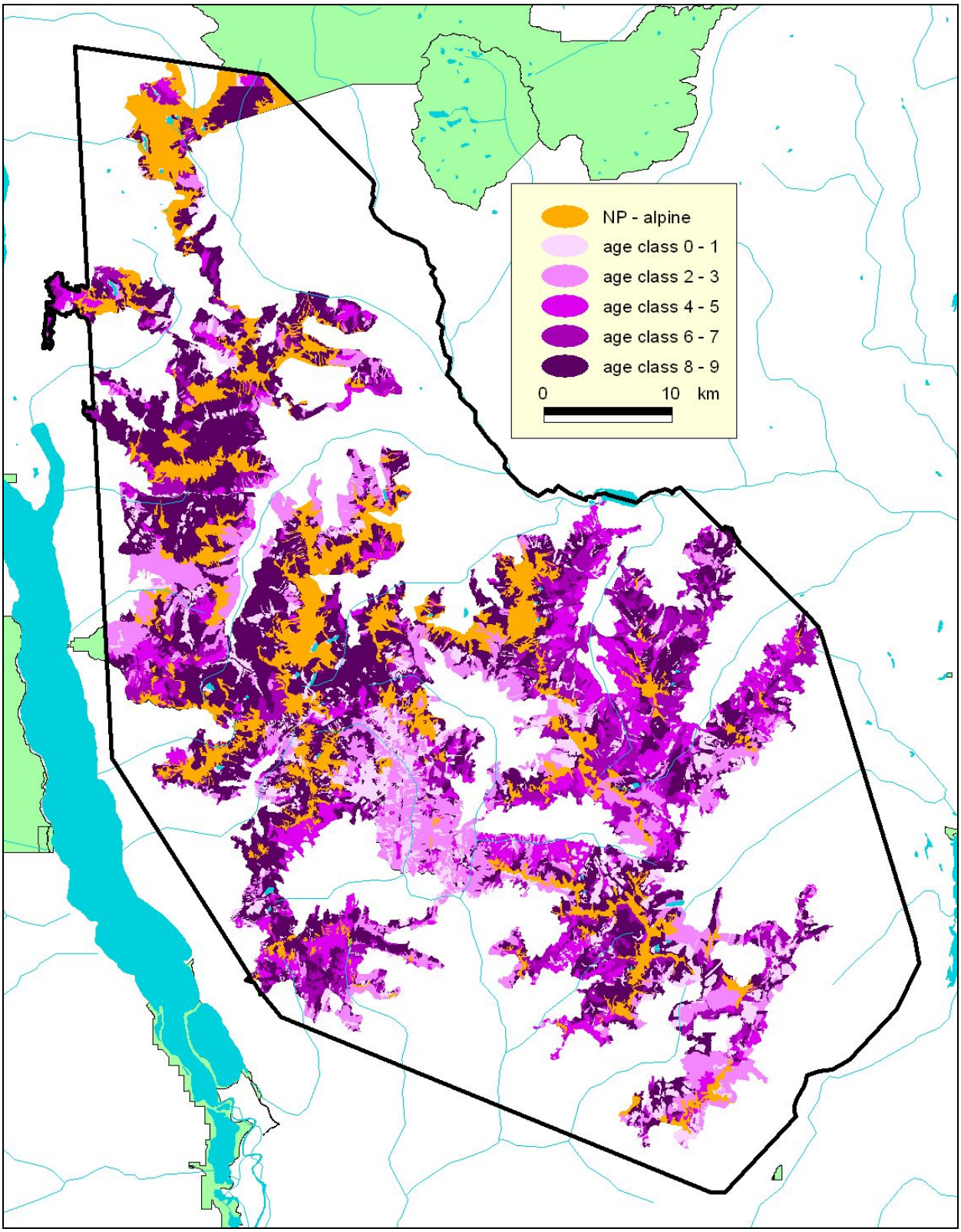

Figure 6. Forest age classes and extent of areas coded as non-forested alpine in parks and areas protected for caribou under the GAR UWR order, within the range of the Purcells-South herd.

3.2 Predation

The primary limiting factor reported for woodland caribou of boreal and cordilleran forests is predation (Bergerud 1988, Seip 1991, Kinley and Apps 2001, Wittmer et al. 2005b, Courtois and Ouellet 2007). This is influenced by both predator numbers and the location of those predators in relation to caribou. These relationships and means of making conditions more favourable to caribou are summarized below.

3.2.1 Influence of Predator Density on Predation

Documented mountain caribou predators include grizzly and black bears, wolves, cougars and wolverines (Compton et al. 1995, Almack 2000, Wittmer 2004, Stotyn 2008). As in the rest of mountain caribou range (Wilson 2009), managing predation by bears and wolverines will not be considered here as they are not the main predators in the Purcells, wolverines and grizzlies have not likely increased compared to past centuries, and none can be reduced sufficiently without intensive effort or long-term ecological and social impacts. In contrast, wolves and cougars appear to have increased across mountain caribou range, in response to human-induced expansion in the number or distribution of elk, deer and moose, are already managed as game species, and are resilient to localized human impacts.

Cougar or wolf densities above which caribou populations are expected to decline will depend on local conditions, including the species and densities of prey and predators present, and the degree of spatial separation between caribou and other prey. Hebblewhite et al. (2007) predicted a threshold of 2.1 to 4.3 wolves/1000 km^2 in Jasper National Park. Wilson (2009) recommends Bergerud's (1988) wolf density estimate of 6.5/1000 km^2 be viewed as an upper limit for caribou persistence, with a target of <1.5 wolves/1000 km^2 where caribou are at high risk, and possibly initial removal of all packs in the area of interest. Similarly, Wilson (2009) estimates that a cougar density of 10/1000 km^2 is the limit for caribou persistence but that this should be reduced to below 2.5/1000 km^2 and potentially to zero for at-risk caribou herds. For practical purposes, the difference between wolves and cougars in their effect on caribou is likely smaller than the uncertainty in population estimates, and their populations will be constantly in flux. For simplicity, the target for growth is about 2 wolves or cougars combined/1000 km^2, and the longer-term target for stability is about 8 wolves or cougars combined/1000 km^2.

The degree of risk now posed by predation in PS must be considered in light of three distinct periods in its history: the 1990s, 2000-2009, and the present. The population has remained stable, albeit at a low level, for a decade (Figure 4). This suggests a dramatically different situation than during the rapid decline (~25% annually) in the 1990s. This stability is particularly notable given that the low calf recruitment in the 7 years leading up to the 2000 survey would have created an aging population at that point. There can, therefore, have been little predation of adult caribou within PS for about the past 10 years. However, this observation must be considered in light of the apparent risk posed by current predator numbers and trends. Cougar predation was the leading cause of adult mortality during the 1990s (Kinley and Apps 2001). Cougar abundance initially declined after 1998 but appears to have rebounded in recent years

to about the level that occurred when caribou monitoring began in PS in 1993 (Figure 7), which was followed by 7 years in which adult caribou mortality averaged 24% and calves formed only 5% of the population by late winter (Kinley and Apps 2001). It is assumed that the regional cougar trend and that of PS, specifically, are roughly synchronous. Wolves may have caused some deaths of unknown cause or of non-collared caribou in PS during the 1990s, but were not recorded as a caribou predator (Kinley and Apps 2001). They were uncommon within caribou range at that time (pers. obs.). It is likely that current wolf abundance in and near PS reflects a slow rebound from previous decades of wolf control. Precise numbers are not known, but tracking during the winter of 2008-2009 indicated that the outside bounds of the PS range included at least 23 to 29 resident wolves (7 packs and a single), with another pack of 5 or 6 wolves there on occasion (C. Gaynor, MOE, Nelson, pers. comm.). Given uncertainty in pack boundaries and wolf numbers, and movements of wolves in relation to boundaries of the estimate area, this translates to a density of roughly 10 wolves/1000 km^2. Current summer cougar density in PS is unknown but a crude estimate is half of wolf density.

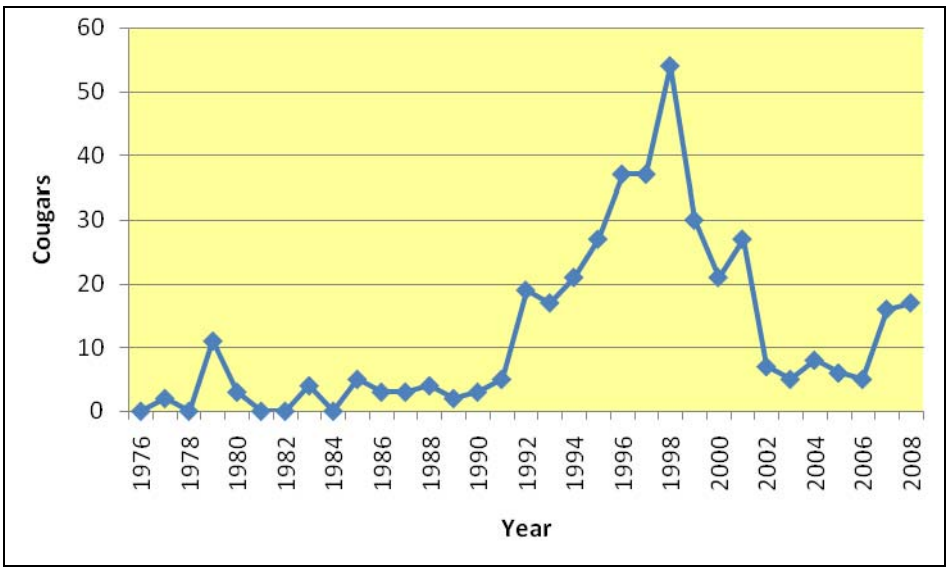

Figure 7. Cougars killed as problem animals in the Kootenays (Region 4), 1976 to 2008, as an index of the regional cougar population. Data courtesy G. Mowat, MOE, Nelson.

The above estimates indicate the total density of cougars and wolves combined in PS to be, very roughly, double the level considered by Wilson (2009) to be sustainable in the long term and nearly an order of magnitude greater than levels that would allow rapid caribou population growth. In light of this, the stability of the caribou population over the past decade probably relates to predator densities having increased only recently. *To improve the likelihood of translocation success, it is recommended that predator numbers be reduced by the following means:*

1. *Increase or eliminate the female cougar quota where caribou occur. Wildlife management units (WMUs) 4-05 to 4-08 and 4-20 overlap with the PS, PC and SS herds. They have had a collective annual quota of 5 female cougars since 2007-2008, separate from the remainder of the West and East Kootenays. Winter cougar numbers are believed to be low*

in most of those 5 WMUs, but 4-20 extends well into the Rocky Mountain Trench. In addition to setting a legal limit, the low quota may reduce hunting pressure in those WMUs because of social pressure within the hound-hunting fraternity to not cause a season closure. This likely extends to small toms that are difficult to distinguish from females. Doubling or eliminating the quota would have little effect on regional cougar numbers but could significantly decrease the exposure of caribou within PS to cougars. Additionally, if the portion of 4-20 within the Trench was included with the quota for the remainder of the East Kootenay, harvest in the 5 WMUs of interest could be focused more on areas closer to caribou. The risk to houndsmen of closing their local season by reaching the quota would also be minimized. Ideally, a cougar density target would be set but accurately determining the number overlapping with caribou during summer would be challenging, particularly after the population is reduced.

2. *Implement the proposed (G. Mowat, MOE, Nelson, pers. comm.) increase in the female cougar quota in the rest of the East Kootenay from 15 to 20, and consider increasing it further pending hunter returns for 2009/10. This would reduce immigration into PS and be closer to quotas in place in the mid to late 1990s.*
3. *Assuming that the above actions result in a local cougar population of about 1/1000 km^2, also reduce wolf density to about 1/1000 km^2 [4]. MOE has used and will likely continue to use contract trappers, but the effect of contract and regular trapping combined with hunting seems to be limited (Robichaud 2009, Wilson 2009; G. Mowat, MOE, Nelson, pers. comm.). Wolves appear to quickly learn to avoid humans and traps. The mixed sterilization-euthanization approach employed in the Quesnel Highlands (Roorda and Wright 2009) can have a significant effect when funding is in place, but is costly and has not have achieved densities as low as the above. The most effective, economical and humane method to control wolf numbers appears to be simple aerial control, i.e. shooting wolves from a helicopter. This has recently resulted in the halting of a decline and a possible increase in the Little Smoky caribou herd of west-central Alberta (Robichaud 2009). The efficiency of this approach can be maximized by first spotting wolf tracks with fixed-wing flights then baiting wolves into openings (cutblocks or lakes) in those locations.*

Initial reductions in cougars and wolves should be achievable within one winter. For example, if cougar hunting regulation changes and wolf control go into effect the winter of 2010/11, the reduction should occur in time for a caribou release in late winter of 2011. Immigrant cougars would undoubtedly partially counter the effect of liberalized harvest, but if the local quota was high or non-existent on a continued basis and the regional population was kept from increasing further, they would be continually removed and immigration would be slowed. The speed of wolf recolonization in PS is likely to be reduced somewhat by the presence of Kootenay Lake to the west and the Rocky Mountain Trench acting as a partial barrier to dispersal from the east; harvest regulations and human settlement there may make it a wolf population sink. Colonizing

[4] This equals about 4 wolves in an area bounded on the west by Kootenay Lake, on the north by the Gray Creek/Redding Creek/St. Mary River FSR and St. Mary Lake Road, on the east by Highways 95A and 3, and on the south by Highway 3. Except for the west, those are not natural boundaries, so operational decisions would need to consider the effects of culling or leaving wolves present outside of those bounds.

wolves would more likely arrive from the north or south. *It is recommended that wolf control targeting a residual density of 1 wolf/1000 km^2 occur in the winter prior to the first translocation, with monitoring and further control (likely needed) during the following 2 winters. Decisions on future control should be based on results from those years and later monitoring of wolf numbers and locations. Depending on the effect of cougars and other predators, the target wolf density could be several times greater as the goal becomes caribou population maintenance rather than growth after caribou targets are achieved (Wilson 2009, Wilson and Nyberg 2009).*

The alternative to the above proactive approach would be to make predator management decisions each fall based only on the previous summer's caribou monitoring, rather than reducing predators prior to translocation. However, given recent increases in wolves and cougars, this would almost certainly result in more caribou deaths initially and therefore a lower effective translocation number. It might also create confusion over the Ministry's intentions. *Overall, strictly reactive predator management would increase risk and be a less effective use of translocated caribou, so a proactive approach is recommended. After initial predator reductions have been achieved and the augmented herd begins to grow, a more reactive approach to monitoring predator numbers and management needs may become appropriate*.

3.2.2 Influence of Prey Density on Predation

In addition to directly reducing predator density through harvest or control, reductions could potentially be achieved by limiting prey populations, particularly when considering longer periods (Wilson and Nyberg 2009). The advantages of a prey-reduction approach are that it:

- Has lower operational costs (hunters are unpaid).
- Provides additional ungulate hunting opportunities in the short term.
- Is likely to have a more lasting effect than direct predator control, by dealing with the factor supporting high predator numbers.

For the above reasons, an ungulate-reduction strategy could speed caribou recovery. In fact, recent harvest regulation changes have already been made to limit white-tailed deer and moose numbers near caribou ranges in much of the West Kootenay, including the west side of PS. Similarly, previous requirements to manage for elk, moose and deer winter ranges at low elevations are no longer in effect adjacent to PS within the Kootenay Lake Forest District. *However, it is not recommended that translocation be delayed pending prey reduction* because:

- It is essential to reduce wolves and cougars before reducing their prey, or the predators will pose an even greater risk to the remaining prey (including caribou).
- There is no evidence that wolves and cougars are currently food-limited in PS. The degree of prey reduction required to achieve that state is unknown.
- Adequate reduction of white-tailed deer may not be feasible (Wilson 2009) given the scale of change in management needed to achieve it.
- Considerable time may be needed to find and implement solutions deemed workable by stakeholders and First Nations, particularly regarding elk and mule deer.

It is recommend that:

1. *Managers consider long-term limitations to predators through localized reductions in elk, moose and deer in and near PS, and by eliminating requirements to manage for winter ranges of those species adjacent to PS within the Rocky Mountain Forest District. These actions would affect about 1% of the Kootenay Region.*
2. *Decisions on the above be independent of translocation planning.*
3. *Cougars and wolves be reduced prior to reducing their prey (Section 3.2.1).*

3.2.3 Influence of Habitat on Predation

Habitat configurations can influence the numbers and distribution of primary prey (elk, moose, white-tailed deer, mule deer), and therefore their predators. Those species are present in caribou range mainly during the summer, and their total numbers are unlikely to be affected much by summer forage. However, their distribution may be. Early-seral patches contain high-quality habitat so influence the landscape distribution of moose, elk, mule deer and white-tailed deer (Wallmo 1969, Arthur 2003, Fisher and Wilkinson 2005, Wilson 2009). While recognizing that wolves, cougars and other predators cover large areas and a variety of habitat conditions, they do presumably tend to focus their activity, in general, on sites with greater foraging efficiency. The risk to caribou of predation should be greater near burns, avalanche paths, or manmade early-seral features such as cutblocks and roads that contain high-quality habitat and therefore attract other ungulates and their predators, and where the efficiency of travel is greatest (Stuart-Smith et al. 1997, Rettie and Messier 2000, Chowns and Gates 2004, James et al. 2004, McLoughlin et al. 2005, Neufeld 2006, Courtois et al. 2007). Forest harvesting and road building therefore increase the risk of future predation.

There is to be little further logging within areas protected under the GAR UWR order. Previously approved cutblocks “grandfathered” into the order and other areas identified for restricted (as opposed to no) harvest amount to <1% of the GAR UWR order area and are largely on the edges of it. Additional road building and harvesting may occur through forest-health logging and mineral exploration. Forest-health guidelines are still under development, requiring proponents to seek an exemption from MOE to conduct such activities (C. Pasztor, MOE, Victoria, pers. comm.). Mineral exploration guidelines are complete and are “intended to support mountain caribou recovery” (MEMPR and MOE 2009). Standard operating practices guidelines have been endorsed for clearing associated with commercial backcountry skiing (Hamilton and Pasztor 2009). *It is recommended that the influence of harvesting and road building on predation risk be primary considerations when interpreting guidelines for salvage logging, backcountry ski development and mineral exploration, to maximize the probability of a successful translocation.* Similarly, wildfire is of concern. Priorities for suppression within the GAR UWR area have been forwarded by ILMB to the Southeast Fire Centre, but *MOE biologists should communicate the need and priorities for suppression annually, at the initial stages of any wildfire in caribou habitat, and for its duration.*

3.3 Disturbance

Management of disturbances to caribou from industrial and recreational activities occurs in PS as in the rest of mountain caribou range. Concerns over disturbance will be greater following augmentation. This is because the recovering population will (a) consist largely of animals without a strong affinity for the area, so they will be more likely to be displaced; (b) expand into areas not occupied by the remnant herd now in PS, encountering disturbances not experienced by the current herd; and (c) possibly reach high enough levels that winter forage will be locally depleted, resulting in greater consequence of being displaced from preferred habitats.

Wind power generation has been proposed on several ridges in the southern Purcell Mountains. However, areas currently tenured within the GAR UWR area are unlikely to be developed because of concerns regarding the effects on mountain caribou of disturbance and habitat alteration (K. Bisset, MAL, Cranbrook, pers. comm.).

The only commercial backcountry skiing operation is in Powder Creek, at the extreme NW corner of the GAR UWR area. It is not occupied by caribou. There is a region-wide moratorium on granting new commercial recreation tenures in caribou habitat until 2013 (Lunan 2008).

Snowmobile closures are in place over most of the GAR UWR area, particularly off of roads and cutblocks (http://www.env.gov.bc.ca/fw/wildlife/snowmobile-closures/). The effects of non-commercial backcountry skiing are largely controlled by snowmobile closures as anything except dispersed activity requires snowmobile access. Compliance with closures is not complete (DeGroot 2009), and enforcement will be stepped up in 2010 (L. DeGroot, MOE, Nelson, pers. comm.). Most closures in the portion of PS within the Rocky Mountain Forest District remain voluntary, so legal enforcement is possible mainly in the Kootenay Lake District. The likelihood of winter access limiting the activities of resident caribou would be more of a concern with a numerically and geographically expanded population. A second concern is that road building will continue within the GAR UWR area, albeit at a reduced pace, because timber salvage, mineral exploration, fire suppression and possibly wind-energy development are expected to continue to some degree. Current guidelines allow snowmobiles on roads in most areas. *It is recommended that the following steps be taken in the near future to maximize the ability of translocated and resident caribou to make use of winter habitat:*

1. *Legalize the voluntary portion of the snowmobile closure if compliance does not improve significantly in 2010.*
2. *Enforce the legal closures.*
3. *Close any new roads rather than including them in the existing closure exemption.*
4. *Monitor the movements of translocated caribou to determine whether further closures of roads, cutblocks, ski areas or snowmobile play areas are justified.*
5. *Ensure that monitoring already underway (L. DeGroot, MOE, Nelson, pers. comm.) continues to include recording backcountry ski and snowboarding locations.*
6. *Ensure that any commercial recreation tenures proposed after the moratorium is lifted or any proposed wind-power generation facilities will have no negative effect on caribou.*

4. Translocation Plan

4.1 Provincial Translocation Policy

This proposal is consistent with each directive of the provincial policy statement (Table 2).

Table 2. Compliance of this plan with provincial translocation policy (4-7-13.02, 29 May 2001).

Policy	Compliance
Ensure that translocations are both justifiable and likely to succeed, and the scientific community can learn from each initiative ...	See sections 2 and 3 for justification and likelihood of success. Post-translocation monitoring (Section 5) will indicate reasons for success or failure.
Minimize the risk of adverse side effects that may occur as a result of translocations.	Side effects anticipated in PS limited to need for additional predation management (Section 3.2). Source herd rationale to be determined by MOE.
Consider the welfare of animals ...	See Section 4.3.1.
Prevent the translocation of non-native species ...	Caribou are native to PS.

4.2 Number and Characteristics of Caribou to be Translocated

Inverse density-dependent declines reported for caribou (Wittmer et al. 2005b, Hebblewhite et al. 2007) suggest the value of releasing large numbers. Across taxa, translocations are likely to succeed when more animals are released (Griffith et al. 1989, Wolf et al. 1998, Forsyth and Duncan 2001), although with large native species there is an asymptote at 20 to 40 animals. In general, a higher number of released animals will reduce the effects of high initial dispersal and mortality (Compton et al. 1995, Almack 2000, Young et al. 2001), and increase genetic diversity. This must be weighed against costs, logistics, and the difficulty of sourcing animals.

Planning for translocation to PS and PC has been underway since 2001 (Woods 2001, Kinley 2002, Ingham 2005, DeGroot 2008). The goal has consistently been to move 20 animals in the first year, with consideration for up to 2 additional years (Woods 2001; DeGroot 2008). Those numbers did not reflect formal analyses of optimal numbers based on survivorship or genetics; they were estimates of what was manageable from an animal handling perspective, had a reasonable cost, would have no measurable impact on the source herd, and had been successful in previous translocations. A goal of 20 caribou per translocation has also been proposed provincially (Wilson and Nyberg 2009). Kinley (2009) summarized 37 introductions, reintroductions or augmentations conducted in Canada and U.S.A., at least 67% of which were successful in establishing new or larger herds, with releases of 15 to 146 caribou. In most cases potential predators were present. Table 3 updates the summary from Kinley (2009) but is restricted to the 10 cases where wolves or cougars (and other predators) occurred. Of those, a reintroduction of 6 and an introduction of 8 caribou failed, apparently due to wolf predation on islands. A reintroduction of 24 apparently failed when the adults travelled back the 80-90 km to their point of origin. Two reintroductions of 28 and 35 caribou resulted in caribou remaining several decades after release but with unknown longer-term prospects. Six reintroductions or

augmentations of 15-103 caribou (median of 56) were successful. Two of those were single-year efforts and one used captive-reared calves.

Table 3. Caribou translocations into areas with wolves or cougars but no meningeal worm.

Location	Year	Type	Release	Status	Citation
Chickaloon River, Kenai NWR, AK	1965	reintro	15 wild caribou	400 in Kenai Mtn herd; wolves not present until about 1980	Burris and McKnight 1973, Ernst 2002; Morton 2007; R. Ernst, Kenai NWR, Soldotna, AK, pers. comm.
Watson Lake, Kenai NWR, AK	1966	reintro	29 wild caribou	130 in Lowland herd; wolves not present until about 1980	
Tustutmena Gla., Kenai NWR, AK	1985 and 1986	reintro	28 wild caribou	Eventually coalesced into 2 herds (not certain whether sourced from each of the 4 releases); Killey River herd peaked at 700 before avalanche killed >150; Fox River herd peaked at 98 then declined to 40 (overgrazing?)	Ernst 2002; Morton 2007; R. Ernst, Kenai NWR, Soldotna, AK, pers. comm.
Emma Lake, Kenai NWR, AK			18 wild caribou		
Caribou Lake, Kenai NWR, AK			16 wild caribou		
Green Lake, Kenai NWR, AK			18 wild caribou		
Charlotte Alplands, BC	1984-1986	reintro	24 wild caribou (21 adults, 1 yearling, 2 calves)	Some and likely all returned to source	Young et al. 2001; J. Youds and N. Freeman, MOE, Williams Lake, pers. comm.
	1986-1991		28 wild caribou (3 yearlings, 25 calves)	≥53 caribou by 1993; ≥23 in 2001 (wolf or grizzly predation?); still present in 2009 but unknown number	
Telkwa Mountains, BC	1997-1999	augment	32 wild caribou; 6-8 residents prior	All remained in target area; reached ~100 by 2006 (>11% annual growth); may have since declined but full survey not done	Houwers 2006; Stronen et al. 2007; G. Schultze, MOE, Smithers, pers. comm.
Southern Selkirk Mountains, ID, WA & BC	1987-1998	augment	103 (4 wild sources of 2 ecotypes in 6 releases); ~20 residents present prior	Continued decline to 33 by 2004, then 9% annual growth to 46 by 2008 then no change to 2009; initially much dispersal (incl. to adjacent herds) and mortality	Warren et al. 1996, Almack 2000, Upper Columbia Fish and Wildlife Office 2008, Wakkinen et al. 2009
Bowman Island, ON	1985	reintro	6 wild caribou	died or disappeared; partly or entirely due to wolf predation	Bergerud and Mercer 1989, OWCRT 2008
Montreal Island, ON	1984	intro	8 wild caribou	at least 14 in 1988; now gone (wolves reached island?)	
Lake Superior Prov. Pk., ON	1989	reintro	35 wild caribou	high initial mortality; still present in low numbers	
Laurentide Wildlife Reserve, QC	1969-1972	reintro	81 or 83 captive-reared calves	high initial mortality but herd reached 100 by 1990 and remains present	Karns 1978, Vandal 1984, McCollough and Connery 1990

Given the variability in numbers of caribou successfully translocated previously, the population remaining in PS, animal capture and handling logistics, and provincial guidance (Nyberg and Wilson 2009), the desired characteristics of animals to be captured are as follows:

1. Translocate 40 caribou, aiming for 20/year in 2 successive years, or if necessary with a 1-year gap between. Alternatively, all caribou may be moved in a single year. This could reduce the total cost of personnel travel, caribou transport and helicopter ferry, but would require additional crates (if caribou crated for trucking), and a longer period of suitable weather and staff availability. Also, all funding would have to be available in a single-year, and capture would presumably need to be spread over a larger area to prevent impacts to the source herd.
2. Begin as soon as possible, preferably in 2011.
3. Move animals during late winter (January to March), when the deeper snowpack allows safer capture, large bulls have lost their antlers, and cows are still several months away from calving so there is minimal risk of them losing their calves. Timing will depend in part on the ecology of the source herd; capture is easiest when caribou use open habitats. If the snowpack is unusually shallow within PS in the year of translocation, move animals near the end of that period so caribou can reach lichen on standing trees.
4. For each group of 20, include 3 bulls (>2.5 years old) to promote breeding.
5. For the remaining 17, include younger (but >1.5-year-old) females to the extent possible. Ages of animals older than young-of-the-year can be difficult to assess from the air but any that are obviously aged, weak or diseased (based on observations made after capture) should be released and replaced with healthier animals.
6. Calves (young-of-the-year) are less desirable because they may have a lower chance of survival and their sex may not be evident from the air. Some time and budget would be wasted capturing male calves that were then rejected. Calves are thus not preferred but may be acceptable if at the heel of captured cows, depending on the availability of source animals and capture conditions.

4.3 Capture, Handling, Transportation and Release

A process for selecting source herd(s) is being undertaken by MOE, independently of this document. Ingham (2005) outlined details for capture, handling, transportation and release based on the assumption that caribou would be sourced from the Itcha-Ilgachuz herd. The following sections are adapted from that plan, but are not specific to that herd. Some details and costs will vary depending on the source.

4.3.1 Procedures

Details of the following general outline are provided in Table 4. After selecting the source herd, the best location(s) in the general area for capture and handling will be chosen based on a fixed-wing survey flight and local knowledge. A staging site with good road access will be established where a setup crew will assemble a corral and related structures and stockpile feed, prior to the arrival of capture, support, handling and transport crews. A briefing will occur on or immediately before the day of capture. When all personnel and equipment are assembled, and roles and responsibilities are clear, the capture crew will leave and begin net-gunning caribou. A support crew will follow the capture crew in a separate helicopter and will assist in preparing the caribou for transport, and placing them blindfolded and hobbled in animal-transport bags. The support helicopter will then fly caribou individually to the staging site, unload them there, and return to the capture area while the capture crew nets the next caribou. At the staging site, the handling crew will carry each caribou into a separated enclosure adjoining the corral. Each animal will be aged, sexed and examined for health by the wildlife veterinarian. If in good health and suitable for the project, the animal will be sampled according to a standard protocol and fitted with a radiocollar.

There are several options for animal handling and transportation to the release site (Table 4). Ideally, animals will be transported in large, single-animal wooden crates to minimize handling at the release end. Handling can be further limited by placing caribou directly in crates after collaring and vet exams at the staging site. However, this is appropriate only if conditions at the onset of captures indicate that there will be enough caribou captured to complete a truckload that day, so that transport can begin promptly. The second option is to release caribou, after collaring and vet exams, into the main corral then later individually move them from the corral into a squeeze, and into crates for transport. The third option, appropriate if caribou are sourced from very distant locations or there is some other reason why they cannot be expeditiously transported and released, is to load them directly into large, partitioned, adapted horse trailers without using crates[5]. If so, caribou will be grouped to avoid antler injuries from aggressive behaviour. Regardless of method, appropriate feed and snow will be provided. Each truck will have two drivers having contact with the other members of the team. They will drive nonstop except for fuel stops to the release site according to the Transport of Animals regulations (http://www.inspection.gc.ca/english/anima/trans/transe.shtml). If delays occur, additional feed and snow will be provided. After arriving at the PS area, either the crates will be unloaded or caribou will be released into a corral then let through a squeeze into crates. Crates will then be flown to the release site and opened in very quick succession.

[5] Caribou were transported both crated and not when augmenting the SS herd.

Table 4. Steps in project preparation and the capture, handling, transport and release of caribou. Details may vary, depending on source herd, local logistical considerations, and decisions made by project coordinator or wildlife veterinarian. Capture and support team are to be experienced in netgunning and animal handling, respectively.

Stage	Steps or Considerations
Autumn prior to translocation	• Finalize selection of source herd and approvals. • Determine likely general sites for capture and staging based on normal location of caribou, road locations, winter road maintenance, helicopter ferry distances, and accommodation. • Set tentative date for translocation. • Reserve contractors and other personnel for capture, handling and release. • Ensure all crates are built and equipment & accommodation are available. • Based on crate sizes and transport option (below), finalize truck requirements and make tentative booking. • Confirm availability of appropriate pelleted feed and bedding. • Locate forest stand for harvesting lichen near staging site. • MOE wildlife vet finalizes sampling protocol; ensures supplies available.
Several weeks prior to capture	• Project coordinator ensures all crew leaders and contractors are aware of procedures, animal handling methods, schedule, time constraints, safety considerations and contact information. Crew leaders ensure that their crew members understand this information, have equipment ready, and are certain of how to use and repair it. This may entail a mock handling exercise, including setting up and testing a corral, squeeze and crates. • Finalize all reservations and bookings.
1 week prior to capture	• Project coordinator and local MOE staff or other experienced personnel locate bands of caribou (fixed-wing) and finalize staging location. Stress to caribou will be minimized and ease of capture improved if there are several smaller groups rather than one large group. Ensure road to staging site remains in adequate travel condition; plough, grade or sand if necessary. Handling site should be relatively level and large enough to allow corrals and related facilities to be set up some distance from helicopter landing site, provide sufficient parking, and allow adequate access for trucks or trailers transporting caribou. A landing within a cutblock would be ideal. • In PS, locate resident caribou and find suitable release site nearby (Section 4.3.3), and identify staging area from which helicopter will pick them up for transport to release site.
Several days prior to capture	• Set up corral with squeeze, with enough room for animals to move freely and avoid each other if necessary. It will be at least 3 m high and with plywood or tarps around lower portion to provide a visual barrier, limit the chance of caribou injury, minimize disturbance from outside, and prevent predator entry[a]. Include a separate smaller compartment linked to main corral by a gate, for handling caribou as they arrive. Set up a heated wall tent, trailer or camper for warming staff and supplies. Post perimeter of staging area with

	warning signs to limit public access. • Stockpile feed (terrestrial and hair lichen and pelleted feed) and bedding. Bring in fuel for heater in wall tent, trailer or camper. Establish jet fuel cache. • If transportation is to not involve crates (below) set up corral and squeeze in release staging area in PS. • Provide briefing regarding roles and responsibilities on the night before capture begins.
Capture and handling	• All personnel will receive final briefings on safety, handling and slinging methods, and capture locations and options will be confirmed. The capture helicopter (pilot and netgunner) and support helicopter (pilot and handler, preferably capable of netgunning if needed) will then fly to the capture area. Target animals will be as per Section 4.2. Any captured animals that are obviously aged or injured or are in excess of the target number for their sex will be released immediately. In all other cases, the support helicopter crew will be radioed to assist in hobbling and blindfolding the caribou, removing it from the capture net, and placing it in an animal-transport bag. The support helicopter will then fly the caribou to the staging site, either suspended by longline in a Kevlar animal transport bag with no crew on board, or in the back of the helicopter in the "crouch" position (also blindfolded, hobbled and bagged) with a single crew member with it. After unloading the caribou at the staging area, the support crew will return to the capture area with any hobbles, blindfolds and transport bags from previous animals. [If shuttle distance is short, support helicopter may not be needed; the capture helicopter with netgunner and handlers would be adequate.] • The capture crew will net another caribou after receiving notice that the support crew is returning. In the event that a caribou is netted when the support helicopter cannot fly, the capture crew will fly it to the staging area. Hobbled animals will not be left unattended on the ground. • At the staging area, the handling crew will carry the caribou by stretcher into an enclosure adjoining the corral and remove the transport bag. The veterinarian will examine it then take measurements and samples following a standard protocol to test for pregnancy, health and genetics, and provide additional treatments to ensure long-term health. These may include antibiotics and long-acting sedatives[b]. • An experienced biologist will fit it with a GPS-satellite radiocollar, and ensure the collar is functioning. Collars will be remote- or timed-releasable so will use regular webbing (no rot-off segment) but will be fit slightly loosely on calves and bulls. Antlers will not be removed (mature bulls will have shed theirs; crating will separate caribou during transport) and caribou will not be eartagged (all will be collared). The blindfold and hobbles will be removed and the caribou will either be released into the main corral with the others or into individual crates (see Transport entry, below). • Penned caribou will be periodically observed for signs of injury; if any are

	evident, they will be released, treated or euthanized on the advice of the wildlife vet. If any caribou act aggressively enough toward others to cause injuries, they will be held separately. • The handling crew will provide feed and adequate snow for hydration at the end of each day, and fasten locks to the corrals to prevent gates from being opened inadvertently. • Two crew members will remain at the site through the night to ensure that predators, dogs or the public do not interfere with the caribou. • Capture is anticipated to take <2 to 4 days.
Transport	• Ideally, caribou will be crated for transport. Doing so will eliminate additional direct animal handling near the release site, prevent animals from injuring others with their antlers during trucking, and require fewer trucks or trailers. However there are two options for loading caribou into crates and an option that does not involve crates: o *Preferred:* Place bedding (clean hay with no noxious weeds, or wood shavings), snow and feed into single-animal wooden crates.[c] Load caribou directly into crates after they have been examined and collared. Immediately load crates into a truck. Assuming no more than 10 caribou will be processed per day, this will require at least two trucks (e.g., 5-ton trucks with freight lifts and ventilation). When a truck is full or at day's end (whichever is first), drive crated caribou directly to release staging area (fuel stops only; will require two drivers) and unload crates there. o *2nd Option:* This option is appropriate if it is unclear at the onset of capture each day whether a full truckload of caribou is likely to be captured that day, or if it is determined in advance that all 20 caribou are to be transported in a single semi-trailer. It will result in a slightly longer holding time for some caribou. For this option, do not directly crate caribou after processing and collaring. Instead, release caribou into the corral. When enough have been captured to fill a truck, load caribou individually from the corral into a squeeze, then into transport crates and onto the truck(s). All other procedures will be as for the *Preferred* option above. o *3rd Option:* If it is anticipated that the time from loading in crates to release in PS will exceed 36 hours, total capture period is expected to exceed 4 days, or large trucks cannot access the staging areas, use this method. Rather than using large corrals (above), place feed and snow in large stock trailers then load caribou directly from a small handling corral into trailers, without crates. Provide partitions in trailers to minimize animal movement and allow segregation if some animals are aggressive. At the end of each day, or earlier if trailers are full, drive caribou directly to the release staging area (fuel stops only; will require two drivers) and unload into corral there. Return trailer to handling capture area if needed. Move crates to release staging area while caribou are being transported. When all caribou are at release staging area, move them individually from the corral into a squeeze, then into crates.

Release	• Have a veterinarian on standby in case treatment or euthanasia is required. • Fly release crew and any other personnel (such as photographers) to the release site. Leave another crew at the release staging site. • Transport crated caribou to release site by longline using helicopter capable of lifting 3 at a time (such as an A-Star B2), first fitting crates into a metal frame. At release site, settle crates into snow and tie together if possible to prevent tipping. • When all crates are assembled and helicopter is shut down, remove bracing from crate doors. • Simultaneously open one crate per crew member, ensure each caribou exits, then immediately repeat until all caribou are released. • Do not use helicopter for at least 30 minutes after release to allow caribou to find each other and settle, then fly crates and crew out in opposite direction of last known caribou location. • Do not use snowmobiles during release, to avoid creating a path that recreational snowmobilers or predators might follow into area used by caribou.

[a] MOE and the FWCP in Cranbrook have 2 corrals approximately 10 m in diameter. These should be set up adjoining each other so that it is possible to move caribou between them.

[b] Disease/parasite transmission should not limit translocation but all animals will be treated prophylactically to limit the transport and loads of potential pathogens and to maximize health (H. Schwantje, MOE, Victoria, pers. comm.). Sampling protocol for pregnancy, DNA, and diseases and parasites to be updated from Appendix 1 of Ingham (2005). At the veterinarian's discretion and when needed, sedatives may also be provided to caribou by the capture crew.

[c] Crates must be large enough for animals to stand up or lie down as they wish. It is not clear if crates used in SS translocations are still present in Cranbrook MOE warehouse; regardless, more may be needed so that 20 are available. Ensure crate doors are secure, such as by fitting them with 2"x4" wooden braces.

4.3.2 Contracts, Equipment and Personnel

Requirements for personnel, equipment and services outlined in Table 5 do not include obtaining approval for source herds.

Table 5. Staffing, contract and equipment requirements.

Task	Contract	Other Personnel[a]	Equipment & Supplies
All		• Project coordinator with authority to make operational and financial decisions.	
Early preparation		• Crew to construct crates	• Shop, tools and building materials
Determine sites for capture, capture staging, release staging and release	• Fixed-wing flight at capture location • Helicopter flight at release location • Possibly road maintenance	• Project coordinator • Regional MOE staff	
Setup for capture staging site		• 5-person crew to set up staging site, haul feed and supplies, and harvest lichen, then knock down after completion	• Corrals w/ squeezes • 20 crates • Tent/trailer/camper, heater • Generator and fuel • Tarps and storage bins • Shovels, chainsaws, tools
Capture and handling	• Capture helicopter, including experienced netgunner, pilot and equipment • Support helicopter, including experienced 1-person crew • Accommodation and meals	• 5-person handling crew • Wildlife vet • First aid attendant (may be one of above)	• First aid gear and emergency transport vehicle[b] • 4x4 trucks for crews & gear • ≥4 sets of restraint gear (each with blindfold and 2 pr of hobbles) and ≥ 2 transport bags • Stretcher for caribou • radiocollars, tools for fitting them, and receiver • Supplies for vet work and samples • Radios to communicate with helicopters
Transport	• 2 5-ton trucks or 1 semi-trailer for crated caribou (40 m^2) with ventilation; if using alternative method, 2 stock trailers[c] capable of carrying ≥7 caribou with suitable trucks for towing • 2 drivers/truck		• Cell or satellite phones for maintaining contact while driving
Release	• A-Star B2 or similar helicopter capable of carrying 3 crated caribou	• ≥4-person crew for release staging area • ≥4-person crew for release site • Vet on standby	• Metal frame for holding crates while flying[d] • 20 crates if not already crated for transport • Shovels & ropes to stabilize crates at release site

[a] Will overlap among some tasks.

[b] Requirements should be confirmed with Worksafe BC. May also be needed at release staging area.

[c] MOE may have trailers and be able to provide staff drivers, rather than obtaining these on contract.

[d] apparently is at MOE or FWCP warehouse or at Bighorn Helicopters (Ingham 2005)

4.3.3 Release Site

The exact release site will depend on the location of resident caribou at the time, and finding a suitably level and open location. However, based on locations of caribou virtually every year of the survey, this is likely to be in the Grassy Mountain area (west side of Perry, top of Angus or east side of Hellroaring drainages) in the first year. In particular, there are several small lakes and old cutblocks in suitable locations at the head of Angus Creek. Ploughed roads in any of those three drainages would allow helicopter shuttle distances of <5 km from the release staging area. If none were ploughed, the alternative is to use the nearest point on the St. Mary River FSR, which is 10 km from the release site and is maintained year-round.

A decision for the second release will depend in part on animal movements following the first release. Initial options are using Grassy Mountain again or shifting to Leadville Creek (which has excellent habitat and supported concentrated caribou use when numbers were higher; it is near the southern end of the eastern node of PS caribou activity), or to the upper Kianuko-Redding-Lockhart creeks area (similar characteristics to Leadville; typically supports 3-4 remaining caribou during surveys; in western node of PS activity).

4.3.4 Other Release Options (Not Recommended)

The release method described above can be considered a “synchronous hard release”. All caribou would be released nearly simultaneously and would not be held in caribou habitat prior to release.

Soft Release

A second option is a “soft release”, in which all caribou would be held at the release (not staging) site for several days to several weeks in an effort to develop social structure and bonds within the group and limit dispersal. However, this would require building a fence capable of keeping caribou in and predators out, in an environment with a several-metre snowpack and enclosing an area of at least a hectare. It would also require 24-7 staffing to maintain the fence, guard against predation and disturbance, and provide feed. Any potential benefits of this method have not been established with caribou, it would require a siting commitment that could not be changed if residents moved elsewhere, and there are risks associated with holding caribou in captivity, whereas hard releases have been successful. *Soft releases are therefore not recommended.*

Maternal Penning

A third option is maternal penning. This would involve retaining pregnant translocated caribou in a large pen within caribou habitat, possibly with the addition of several residents. The intent would be to significantly reduce the high mortality normally experienced immediately post-parturition, thereby increasing recruitment, increasing the effective size of the translocation, and speeding recovery (Kinley 2009). This approach was taken for the Chisana caribou herd in southwest Yukon from 2003 to 2006, during which time 146 pregnant wild caribou were held

until about a week after the last calf was born. Predators were excluded by fencing and patrols. Calves born in the pen had over 2.5 times greater survivorship to the release date than those born to free-ranging mothers (L. Adams, U.S. Geological Survey, Anchorage, pers. comm.). While limitations on the proportion of females that could be penned meant that it ultimately could not provide a large enough boost to the overall herd recruitment to justify costs for the large Chisana herd (T. Hegel, Yukon Environment, Whitehorse, pers. comm.), it might be more feasible for small populations (Adams et al. 2006). Until results from this project are published, logistical details are available through Environment Yukon or in Furk (2005) or Neale (2006). A smaller-scale and single-year project was conducted for the Little Smoky herd in west-central Alberta (K. Smith, Alberta Fish and Wildlife Division, Edson, pers. comm.). Ten pregnant cows were penned. Recent wolf control aided free-ranging caribou, and some penned animals returned to the pen site post-release where they were killed by bears, so no benefit was evident for the year tested.

DeGroot (2008) estimated that for a group of 18 pregnant cows translocated to the SS herd, maternity penning would result in 8 additional calves compared to a hard release. He further estimated that, given the anticipated cost of maternity penning, the cost per caribou gained in the recipient herd from doing so would be 63% higher than for a hard release. Penning costs are likely to be higher for PS than SS, given the lack of all-weather access to caribou habitat. Costs of maternal penning associated with a proposed translocation to Banff National Park were projected at $250,000 for the first year and $200,000 for subsequent years (Kinley 2009). Penning is more expensive than translocation and predator control combined (Section 6), so increasing the initial size of the PS herd will almost certainly be achieved far more economically by putting funding toward translocation and predator management rather than penning. Prioritizing funding toward translocation rather than maternal penning would also increase genetic diversity by reducing relatedness, and reduce the period of staff requirements each winter.

It is recommended that MOE not pursue maternity penning unless several of these factors are in play:

- *Predator control does not achieve the targets set in Section 3.2.1.*
- *There is great difficulty in locating enough source animals for translocation.*
- *Funds are available for maternity penning that are not available for translocation.*
- *Translocation costs after the first year indicate the economics of maternity penning to be more favourable.*

4.4 Projected Population Growth

The target population for PU 1B has been set provincially at 159 caribou (Wilson and Nyberg 2009). However, this includes GAR UWR areas in both PS and PC, provincial parks, and other Crown land. It also considers present, not future, habitat conditions. The maturation of younger stands in the GAR UWR and parks, and the recovery of caribou in PS, would likely allow a single population across 1B (i.e. interchange would occur between PS and PC) with a population exceeding 159 caribou and reduced risks to viability. Achieving this would require caribou to emigrate from PS to PC and potentially beyond, or the reintroduction of caribou into habitat protected in PC as GAR UWR and parks. Both the short- and long-term targets discussed below deal with PS in isolation. *The distinction between PS and planning unit 1B should be recognized. Unless the renewed PS herd spreads into the former range of PC on its own, the eventual goal should be to also reintroduce caribou into PC to make use of the >700 km^2 of GAR UWR there and the much larger area in adjacent parks.*

4.4.1 Long-term Population Target for Purcells-South

Within PS only, there is about 1700 km^2 of available habitat.[6] Considerations for a density target for PS are that:

- The 1700 km^2 noted above has mainly high habitat capability but does include some steep terrain and rock.
- In the Prince George Forest District density on core habitat is about 200/1000 km^2 (D. Seip, MOFR, Prince George, pers. comm.), which matches the winter density in preferred habitats in Wells Gray Park and the Quesnel Highland prior to declines (Seip 1992).
- Based on range-wide habitat modeling developed by the Mountain Caribou Science Team, the assumed density in PU 1B was 100 animals/1000 km^2 of high-suitability habitat (Wilson and Nyberg 2009).
- Recent mountain caribou densities range from almost nil to about 150/1000 km^2 of gross habitat area, with a mean of about 30-50/1000 km^2 (Seip and Cichowski 1996; MCTAC 2002; D. Seip, MOFR, Prince George, unpubl. data).
- Northern caribou herds in B.C. have a median density of 50 and a mean of 76/1000 km^2 of gross habitat (D. Seip, MOFR, Prince George, unpubl. data).
- Recovery should by definition result in a population at least in the mid range of densities for other mountain caribou herds, which are generally in decline.
- Even with the population in PS believed to have declined by 1995 there were at least 63 caribou present at that time (Section 2).
- Woodland caribou populations often rise and fall rapidly. The biggest driver is likely to be predation, so the density will largely be a function of current and recent predation history.

[6] The PS study area includes 1401 km^2 in the GAR UWR area and about 170 km^2 of Lockhart Creek, Kianuko and Purcell Wilderness Conservancy parks. Some adjacent non-designated areas will also provide habitat at any given time through old-growth management areas, other reserves and unharvested mature timber, stands that are not economical to harvest, and alpine. This totals about 1700 km^2.

Considering these points and the expectation that effective predator management would accompany translocation, a reasonable long-term target density for the 1700 km^2 (GAR UWR and immediate environs) is fluctuation around 60 caribou/1000 km^2, or 100 caribou total. This equates to 30 caribou/1000 km^2 for the PS study area as a whole. In comparison to the 1995 population, achieving this would involve expanding landscape occupancy by about 10% into the northernmost portion of the GAR UWR, and increasing the density by about 50%.

4.4.2 Short- to Medium-term Scenarios and Targets

Many scenarios for population growth following translocation are possible (Table 6, Figure 8). All cases assume that 20 caribou/year are released, in 2 sequential years. Age and sex ratios are as targeted in Section 4.2, with the exception that 3 calves are included/year to allow for slightly suboptimal captures. Survivorship and dispersal reported by Compton et al. (1995) and Almack (2000) for two series of South Selkirk augmentations included all animals, not just those in their first year after translocation. Interpreting those reports with respect to first-year animals only, survival appeared to range from 37% to ≥89%. To be conservative, all but the Rapid Growth scenario assume first-year survivorship to be less than the midpoint of that range (63%) and second-year survivorship to also be compromised. Calf survivorship per surviving cow is assumed to be 50% lower for first-year translocates than for residents (Table 6). Wilson and Nyberg (2009) target a recruitment level for translocates that is at least half that of residents. Combining cow and calf survivorship assumptions from Table 6, first-year recruitment varies among scenarios from 28-39% of that assumed for residents. This increases to 85-89% for their second year in PS.

Under this simplified modeling, growth rates are initially high (once past high adult mortality and reduced recruitment immediately post-translocation) due to the population being biased to females (Table 6, Figure 8). Growth rates per caribou decline as the sex ratio reaches parity. The Flat scenario results in a population that reaches a stable state at 41 animals in its second decade. The Base Case scenario assumes that MOE's population goals (Wilson and Nyberg 2009) of 88% adult survivorship and 15% calves (percent of total population) are met after initially high post-translocation mortality and low initial recruitment. This results in the population reaching 100 caribou 24 years after the first release. Under the Moderate Growth scenario, adult survivorship is assumed to be slightly higher, reducing the time needed to exceed 100 caribou to 14 years. This would be equivalent to the recent growth rate in the SS herd (Table 3). Additional changes for the Rapid Growth scenario are that the initial mortality or dispersal of translocated caribou is not as great, and calf recruitment is slightly higher. Under Rapid Growth, the growth rate approximates that extrapolated for the Telkwa caribou translocation (Table 3) and results in PS reaching 100 animals by Year 9 (Table 6, Figure 8).

Table 6. Assumptions and results of four scenarios for population growth after translocation.

Factor		Scenario Assumptions and Results			
		Base Case	Flat	Moderate Growth	Rapid Growth
Pre-translocation residents[a]		10 total – 3 bulls, 6 cows, 1 female calf			
Translocated caribou – Yr 0		20 total: 3 bulls, 14 cows, 2 female calves, 1 male calf[b]			
Translocated caribou – Yr 1		20 total: 3 bulls, 14 cows, 2 female calves, 1 male calf[b]			
Adults surviving and not dispersing	1st year in PS[c]	0.52	0.48	0.60	0.70
	2nd year in PS[d]	0.76	0.74	0.80	0.80
	All others	0.88[e]	0.87	0.90	0.90
Calf recruitment to late winter[f]	#/100 cows[g]	35.3	29.9	35.3	41.0
	Nominal pop. %	15[e]	13	15[e]	17
Years to population ≥100[h]		24	N/A	14	9
Lambda[h]	Year 3 to 4	1.08	1.04	1.11	1.14
	Final year	1.04	1.00	1.07	1.10

[a] Based on number of caribou recorded in Grassy Mountain area in 2009 (DeGroot 2009); to be conservative, assumes that translocated caribou do not initially mix with smaller group typically found farther west or that they do but both resident groups are reduced by the time of augmentation.

[b] The target is to have no calves; these numbers are assumed here to provide conservative scenarios.

[c] 4x resident mortality or dispersal rate for Base, Flat and Moderate scenarios; 3x for Rapid scenario.

[d] 2x resident mortality or dispersal rate for all scenarios.

[e] Target as per Wilson 2009, and Wilson and Nyberg 2009.

[f] For year following release, assumptions reduced 50% from values shown in table.

[g] This is a direct conversion of % of population to no. per 100 cows assuming even sex ratio of adults. In reality, more cows than bulls will be translocated so the calves as % of population will exceed stated values until adult population reaches parity .

[h] These are results, not assumption. Lambda (growth rate) values are lower for years 0 to 3.

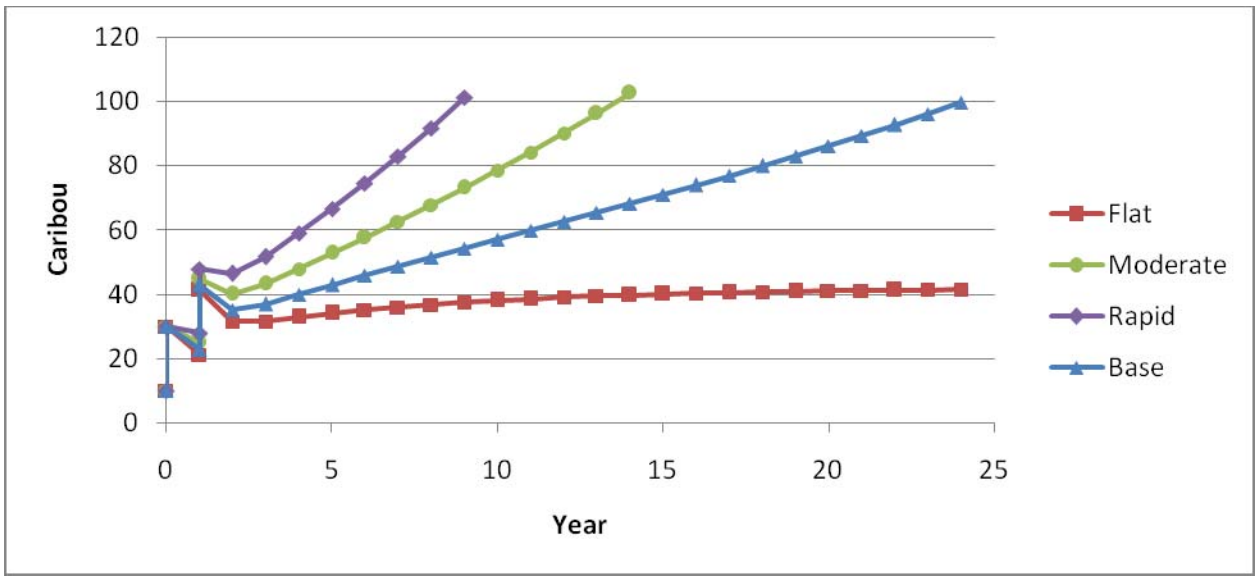

Figure 8. Projected population growth in years after first translocation under four scenarios (see Table 6).

Modeled population parameters implicitly assume that predation has been managed before and after translocation. The scenario that most closely approaches reality is likely to be related mainly to the effectiveness of predator management. Other scenarios, where survivorship and recruitment are insufficient to sustain a stable to growing herd, are possible if predator management is ineffective. In addition, the models do not consider the potential for negative random events to push trends from stability or growth into decline. This possibility is greater when populations are small. Therefore, this risk is very high if there is no population augmentation, but is also significant if the population remains low for prolonged periods following translocation. As a result, the risk of irreversible impacts from random events is greatly diminished under the Moderate Growth and Rapid Growth scenarios, which in turn rely on low predation rates and therefore effective predator management.

It is recommended that the Moderate Growth scenario be the basis of staged targets (Table 7). Measures of success (Wilson and Nyberg 2009) include total population size and trend, calf recruitment, and adult survivorship. All of these can be readily obtained or inferred from late-winter surveys. These indicate cumulative success to date (total population), recent changes in success (adult survivorship as measured by population size in comparison to previous years), and likely future trends (recruitment). Targets should be modified if the actual number, characteristics and timing of caribou translocated differ from assumptions in Table 6.

Table 7. Targets based on predictions from Moderate Growth scenario (first release in 2011).

Year	Years Since First Release	Total Late-Winter Population	No. Calves (incl. in total)
2012	1	25[a]	4
2013	2	40	7
2016	5	53	9
2021	10	79	13
2025	14	~100	15

[a] just prior to second release of 20 caribou

Population targets should be evaluated about every 3-5 years to ensure that they are realistic in light of the number of caribou present at that time, the level of predation, and other ecological conditions. The need for predator management is likely to be much diminished by the time the population target is met because logged areas currently providing ungulate forage within the GAR UWR will be largely past the herb or shrub stage (Section 3.1); localized prey reduction may be in place; and predation levels can be considerably higher for caribou maintenance compared to growth (Wilson 2009).

5. Monitoring and Adaptive Management

5.1 Caribou Monitoring

The success of translocation should be monitored over at least the projected 14-year window needed to achieve the target, but the intensity and type of telemetry should be re-evaluated 1 year after the second augmentation. The main goals of telemetry-based monitoring are to determine survivorship, mortality causes, and general movement patterns. Unless there are exceptionally low rates of mortality and dispersion, this information is needed to judge the adequacy of management actions and translocation methods, and to modify future management activity if required.

5.1.1 Telemetry Monitoring Type

Three main options are available for fitting caribou with collars for monitoring – VHF, GPS and GPS-satellite collars. Important considerations include:

- Projected lifespan should be at least 2 years and preferably more, with a low failure rate in that time.
- Data precision and richness is not critical; habitat reserves have already been established so fine-scaled habitat research will have less management value now than in the past.
- The shortest possible delay in detecting mortalities is critical to determining causes of death and therefore potential management actions.

VHF collars typically last much longer than the others and are more reliable during that period. However, even an intensive VHF monitoring regime would result in much longer delays in detecting mortalities compared to GPS-satellite collars, especially considering flight scheduling and weather problems. Monitoring of VHF collars would also result in greater danger for those flying, and greater disturbance of the caribou. Conventional GPS collars (without satellite-based communication) would need to be monitored aerially for mortalities, so would have the same drawbacks as VHF collars and also a high cost per collar. In contrast, GPS-satellite collars provide frequent transmission of data to a website, including detection of non-movement (mortality). Compared to VHF collars, they have a high initial cost but low data acquisition costs, and their reliability appears to now be approaching that of VHF collars. GPS-satellite collars have the additional benefit of providing a rich dataset which, though not necessary for the immediate goals of this project, would be more likely to attract the support of academic institutions. *Based on the above, the preferred option is to use GPS-satellite collars, with the GPS fix rate reduced to a level allowing a projected lifespan of 3 years while providing daily satellite transmission of movement data.*

The model chosen must provide an automated indication of whether the animal has stopped moving. At the time of writing, the two leading candidates are a GPS-Iridium system supplied by Lotek Wireless (Newmarket, ON) and a GPS-Globalstar system supplied by North Star Science and Technology (King George, VA). The Lotek system detects non-movement with an

accelerometer, while the North Star system has on-collar software that calculates distances between GPS fixes and sends a message when they are under a specified threshold. Lotek expects to also have a Globalstar system in place by late 2010. SirTrack Tracking Solutions (North Liberty, IA) currently has a GPS-Argos system without an automated mortality messaging system, but may have other systems shortly. There are also European suppliers of GPS-satellite systems.

5.1.2 Telemetry Monitoring Schedule

Details of the GPS-fix schedule will depend in part on prioritizing data transmission and collar lifespan. However, it is anticipated that several fixes can be attempted per day while still maintaining daily data transmission. A more significant monitoring need is to ensure that contractors or staff log onto the web to check for indications of mortality, i.e. a lack of collar movement. *Based on the timing of past mortalities in the southern Purcell Mountains, these mortality checks should ideally be done at least every other day from June through October and at least weekly from November through May.*

5.1.3 Mortality Site Inspections

For collars in mortality mode, sites must be examined on the ground as soon as possible to maximize the ability to determine the cause of death. Use of a helicopter is preferred for speed and safety (it will likely temporarily drive off bears if present) but travel by truck is also feasible and less costly. Regardless of method, kill sites should be visited the day the mortality signal is detected if possible, by two people equipped with bear spray or firearms. The need for a flexible schedule is a key consideration in establishing staffing or contractors for monitoring. A protocol for mortality-site inspections is needed, but at a minimum those visiting kill sites should take photographs, make extensive notes, look for predator tracks, scat, hair and tooth marks, determine whether the hide has been torn off, search for signs of struggle, and look for evidence of other mortality causes (avalanche, falls, vehicle collisions, etc.) or pre-disposing factors (broken bones, worn teeth, poor body condition, lack of marrow fat, etc.). For cows, the area should also be searched for calf remains. Tooth samples should be taken for aging, a long bone should be taken to document marrow fat content, and (if possible) scat samples should be examined to determine recent forage types. Based on the above, the certainty over the cause of death should be assigned to a 3- to 5-point nominal scale from completely unknown to certain.

5.1.4. Late-winter Population Surveys and Population Trends

Annual surveys should be conducted as in the past (e.g. DeGroot 2009). With a larger population after translocation, helicopter-only surveys may be more efficient than combining fixed-wing track spotting with helicopter classification. Mature bulls are usually obvious from their body proportions and lack of antlers (or large rack), but attempts to accurately differentiate

young bulls from cows or to sex calves typically require prolonged disturbance and are often unsuccessful in the forest. Doing total counts, correcting counts based on sightings of collars known to be present, and differentiating adults from calves (young of the year) is straightforward. From that data over successive years, the three indicators of success identified by Wilson and Nyberg (2009) can be tested: population trend, calves as a percentage of the total population, and adult survivorship, all averaged over 3 years. The latter can be inferred from survey results across years or measured more directly from telemetry monitoring, especially when many animals are collared.

5.2 Predator Monitoring

The need for, and ability to, monitor predators varies by species. *No management of bears or wolverines is expected, so there is no need to monitor them*. Cougars are very difficult to survey accurately, but their local population trends should be tracked because of their history as the main predator in PS, the recent increase in their numbers, and the recommendation for hunting guidelines aimed at localized reductions. *Cougar trends, or at least risk to caribou, should be estimated annually by (a) tracking the number of problem-animal and hunter kills based on compulsory inspection data, especially in the WMUs overlapping with PS, and (b) determining the number of collared caribou killed by cougars*.

Funds budgeted for a combined wolf monitoring and control program for the first 3 years (Section 6) should be used to determine whether the target set for wolf density (Section 3.2.1; Wilson and Nyberg 2009) is achieved, and to keep the wolf population at that target. Less control effort is likely to be required in the second and third years because wolf populations will probably not fully rebound each year, but monitoring effort is not as closely related to population size. The budget allows for aerial monitoring, but ground-based track monitoring similar to that undertaken in the past several years (C. Gaynor, MOE, Nelson, in prep.) may be part of that effort during the second or third years, depending on staff availability. *After the third year, the need for wolf monitoring should be determined in part by whether collared caribou are killed by wolves, and from anecdotal local information about wolf numbers, but monitoring should occur at least once every 3 years*.

6. Budget

This budget (Table 8) makes several assumptions:

- There will be no maternal penning (Section 4.3.4).
- Snowmobile-use surveys and late-winter population surveys will be conducted regardless of whether translocation occurs so are not included in the budget. Consultation and other costs of gaining approvals are not budgeted either.
- Costs for predator surveys underway in recent years will become part of the budget for wolf control. Costs, if any, of revisions to cougar management will be covered within existing staff and operations budgets.
- Wolf monitoring and control will be done by MOE staff so the budget for it includes only aircraft charter and other fixed costs.
- Most labour for caribou translocation and monitoring will be provided on contract, supplemented by some staff time from MOE and potentially other agencies or volunteers. Across the 3-year budget, direct costs would be reduced by about $106,000 for translocations and $42,000 for monitoring if done entirely by staff and volunteers from MOE or other agencies.
- All caribou transport crates need to be built; in reality, some or all from previous efforts may be in an MOE warehouse (L. Ingham, FWCP, Cranbrook, pers. comm.).
- For the purposes of this budget, caribou will be sourced from the Itcha-Ilgachuz herd. This is far from certain but provides a basis for budgeting. Sourcing from more distant herds will result in higher costs.
- No additional road maintenance will be required.
- The capture and staging locations are sufficiently distant that it will be more efficient to use a separate helicopter to sling captured animals to the staging area. In reality, if the capture area is close, it will be more economical to directly transfer them with the capture helicopter, and a second helicopter will not be needed.
- Caribou will be crated at the capture staging area for shipping, and remain in crates until released in PS.
- No government-owned stock trailers are available. If they are, they could be used for the alternative transport option or even for moving caribou in crates. This might be more economical or practical than the use of transport trucks.
- No first-aid attendant or vehicle will be required at the release staging area. This may depend on whether caribou are crated. Requirements should be checked with Worksafe BC.
- Mortality-site checks are done by helicopter; some locations and situations will make access equally or more feasible or economical by truck.
- No resident caribou are to be radiocollared.

Because of these assumptions and because many other details are not yet known, this budget should be considered very preliminary. It does not include any contingency fund.

Table 8. Estimated costs of Purcells-South caribou translocation and monitoring.

Item	Cost
WOLF MONITORING AND MANAGEMENT, PER YEAR[1]	
Pre-control baiting	$6,000
Fixed-wing time, for searches and to spot for helicopter crews (30 hr @ $400/hr)	$12,000
Helicopter for monitoring and control (60 hr @ $1200/hr)	$72,000
Firearms and ammunition	$2,000
Staff time	N/C
Wolf Monitoring and Management Yearly Total, Assuming MOE Staff Labour	**$92,000**
TRANSLOCATION	
Translocation Contracts and Expenses, Each of Year 1 & Year 2 (excluding collars)	
Materials for construction of 20 transport crates; assumes MOE workshop available	$3,000
Pre-capture flight to locate caribou and ID staging area; Cessna 337 (4 hr @ $550)	$2,200
Netgunning capture contract (20 caribou @ $1250)	$25,000
Support helicopter (Jet Ranger) to fly captured caribou to staging area (10 hr @ $1300)	$13,000
Pre-release flight (Jet Ranger) to confirm PS herd caribou locations (1 hr @ $1300)	$1,300
Release helicopter (A-Star B2 or similar) for transport of crew and caribou (5 hr $2100)	$10,500
Trucking of crated caribou (2 5-ton trucks or 1 semi-trailer)	$6,000
Veterinary and sampling supplies; travel expenses for veterinarian	$1,500
Feed, miscellaneous lumber and supplies	$1,000
Caribou restraint and handling gear, tent, generator, tools, corrals, slinging frame for release to be supplied by netgun contractor and from MOE/FWCP stock	N/C
Mileage, excluding trucking (8,000 km @ $0.50)	$4,000
Subtotal	**$67,500**
Translocation Labour, Each of Year 1 and Year 2 (excluding for helicopters and trucking)	
Project coordination: arrange contracts and crews, liaise with MOE staff, ensure all activities occur, manage project, report results, oversee field activities (30 days @ $600)	$18,000
Crew for crate construction, staging area setup, support helicopter, caribou handling, and knock-down (techs: 40 days @ $350; crew leader: 20 days @ $500)	$24,000
Contract wildlife vet - coordination with provincial vet, travel, on-site work (8 days @ $600)	$4,800
Crew for release staging area & release site (techs: 8 days @ $350; leader: 3 days @ $500)	$4,300
First aid attendant/vehicle at capture staging area	$2,000
Meals & accommodation for all capture and handling crew, including MOE staff, capture crew and other contractors (70 person-days @ $100/day (shared rooms at local lodge)	$7,000
Provincial and regional MOE staff time: contract coordination, caribou searches, provincial wildlife vet, local advice, presence at capture and release sites, media contact (50 days)	N/C
Subtotal	**$60,100**
Translocation Total Per Year, Assuming Contract Labour	**$127,600**

CONTINUED ON NEXT PAGE ...

... CONTINUED FROM PREVIOUS PAGE

MONITORING	
Monitoring Costs, Year 1	
20 GPS-satellite collars (Globalstar system from Northstar Sci & Tech) @ $3780[2]	$75,600
Data delivery to website, including not-moving alarm: 20 collars @ $37.80/mo x 1 mo	$756
Monitor for not-moving alarms on internet; compile GPS data (3 bio days @ $600)	$1,800
Database mgmt, correspondence, meetings and reporting (4 bio days @ $600)	$2,400
Travel and miscellaneous expenses	$500
MOE staff time: contract coordination, meetings, etc.	N/C
Year 1 Monitoring Total	**$81,056**
Monitoring Costs, Year 2[3]	
20 GPS-satellite collars (Globalstar system from Northstar Sci & Tech) @ $3780[2]	$75,600
Data delivery: 20 collars @ $37.80/mo x 12 months plus 20 collars @ $37.80/mo x 1 mo	$9,828
Monitor for not-moving alarms on internet; compile GPS data (20 bio days @ $600)	$12,000
Mortality site checks: biologist & assistant (4 bio days @ $600, 4 tech days @ $400)	$4,000
Helicopter (Jet Ranger) checks of mortality sites (8 hr @ $1300)	$10,400
Database mgmt, correspondence, meetings and reporting (12 bio days @ $600)	$7,200
Travel for fieldwork, meetings, etc.; miscellaneous expenses	$2,500
MOE staff time: contract coordination, meetings, etc.	N/C
Year 2 Monitoring Total	**$121,528**
Monitoring Costs, Year 3[3]	
Data delivery: 40 collars @ $37.80/mo x 12 months	$18,144
Monitor for not-moving alarms on internet; compile GPS data (20 bio days @ $600)	$12,000
Mortality site checks: biologist & assistant (6 bio days @ $600, 6 tech days @ $400)	$6,000
Helicopter (Jet Ranger) checks of mortality sites (12 hr @ $1300)	$15,600
Database mgmt, correspondence, meetings and reporting (15 bio days @ $600)	$9,000
Travel for fieldwork, meetings, etc.; miscellaneous expenses	$3,000
MOE staff time: contract coordination, meetings, etc.	N/C
Year 3 Monitoring Total	**$63,744**

YEAR 1 TOTAL (monitor/control wolves, translocate 1st 20 caribou & monitor 1 mo)	**$300,656**
YEAR 2 TOTAL (monitor /control wolves, monitor 1st 20 caribou 12 mo; translocate 2nd 20 caribou & monitor 1 mo)[3]	**$341,128**
YEAR 3 TOTAL (monitor/control wolves, monitor all 40 caribou 12 mo)[3,4]	**$155,744**
3-YEAR TOTAL	**$797,528**

[1] as per estimates by G. Kuzyk, MOE, Victoria and C. Ritchie, MOE, Prince George; labour for this task to be provided by MOE staff; cost may be lower in Yr 2 & 3 depending on wolf response between years

[2] includes activation; Lotek Iridium & SirTrack Argos also available at ~25-50% more (through Year 3); Globalstar system expected to be available from Lotek and possibly SirTrack by 2010, so prices for those companies expected to decline; costs converted to CDN$ @ $1.08

[3] monitoring costs for Years 2 and 3 should be slightly lower than budgeted, as fewer collared caribou will be alive over time

[4] assuming collars are programmed to allow 3 years of battery life, monitoring could be extended for almost 1 more year for the first group of 20 caribou and almost 2 more years for the second group of 20. At that point, collar recovery would be necessary. Considering the lower number of collars in final years but the need to begin recovering them, monitoring in future years would be slightly cheaper than Year 3.

7. Acknowledgements

I wish to acknowledge the information, reports, discussions, guidance and reviews provided by L. DeGroot, N. Freeman, C. Gaynor, G. Kuzyk, G. Mowat, C. Pasztor, C. Ritchie and H. Schwantje of the Ministry of Environment; G. Woods of Woods Wildland Consulting; L. Ingham of the Fish and Wildlife Compensation Program – Columbia Basin, S. Wilson of EcoLogic Research, W. Wakkinen of the Idaho Department of Fish and Game, K. Laudon of Montana Fish, Wildlife and Parks, and all those whose contributions to an earlier proposal for Banff National Park are reflected in this report.

8. Literature Cited

Adams, L., R. Farnell, M. Oakley, G. Roffler, and J. McLelland. 2006. The Chisana caribou recovery project: a modeling assessment of the utility of captive rearing as a management tool for at-risk caribou populations. unpublished *PowerPoint* presentation, U.S. Geological Survey – Alaska Science Center, Fairbanks, AK.

Almack, J. A. 2000. Mountain caribou recovery in the southern Selkirk Mountains of Washington, Idaho, and British Columbia. Progress report October 1998 – March 2000. Washington Department of Fish and Wildlife, Olympia, WA.

Apps, C., and T. Kinley. 2000. Multi-scale habitat associations of mountain caribou in the southern Purcell Mountains, British Columbia. Prepared for East Kootenay Environmental Society, Kimberley, BC, and Tembec Industries Inc., Cranbrook, BC. Aspen Wildlife Research, Calgary, AB.

Apps, C. D., and B. N. McLellan. 2006. Factors influencing the dispersion and fragmentation of endangered mountain caribou populations. Biological Conservation 130:84-97.

Arthur, W. R. 2003. Peace Arm elk ungulate winter range (UWR) (U-7-005) report. Ministry of Water, Land and Air Protection, Prince George, BC.

Bergerud, A. T. 1988. Caribou, wolves and man. Trends in Ecology & Evolution 3:68-72.

Bergerud, A. T., and W. E. Mercer. 1989. Caribou introductions in eastern North America. Wildlife Society Bulletin 17:111-120.

Burris, O. E., and D. E. McKnight. 1973. Game transplants in Alaska. Technical Bulletin No. 4, Alaska Department of Fish and Game, Juneau, Alaska.

Chowns, T., and C. C. Gates. 2004. Ecological interactions among caribou, moose, and wolves: literature review. Technical Bulletin No. 893, National Council for Air and Stream Improvement, Research Triangle Park, NC.

Compton, B. B., P. Zager, and G. Servheen. 1995. Survival and mortality of translocated woodland caribou. Wildlife Society Bulletin 23:490-496.

Courtois, R., and J.-P. Oullet. 2007. Modeling the impacts of moose and wolf management on persistence of woodland caribou. Alces 43:13-28.

Courtois, R., J.-P. Oullet, L. Breton, A. Gingras, and C. Dussault. 2007. Effects of forest disturbance on density, space use, and mortality of woodland caribou. Ecoscience 14:491-498.

DeGroot, L. 2008. Augmentation plan for the recovery of mountain caribou in British Columbia. Draft 1.0. Ministry of Environment, Nelson, BC.

DeGroot, L. 2009 mountain caribou census. South Purcell Mountains. Ministry of Environment, Nelson, BC.

Drewry, W. S. 1894. Photo-topographical survey of West Kootenay. Report to T. Kains, Surveyor General. complete citation not available.

Ernst, R. 2002. Caribou herd reduction accomplished naturally. Refuge Notebook, Kenai National Wildlife Refuge, U.S. Fish and Wildlife Service, Soldotna, AK. http://kenai.fws.gov/overview/notebook/2002/sep/27sep2002.htm; accessed 11 Dec 2009

Evans, H. F. 1960. A preliminary investigation of caribou in northwestern United States. Thesis, University of Montana, Missoula, MT.

Fisher, J. T., and L. Wilkinson. 2005. The response of mammals to forest fire and timber harvest in the North American boreal forest. Mammal Review 35:51-81.

Flinn, P. 1956. Caribou of Idaho. Idaho Department of Fish and Game, Boise, ID.

Forsyth, D. M., and R. P. Duncan. 2001. Propagule size and the relative success of exotic ungulate and bird introductions to New Zealand. American Naturalist 157:583-595.

Furk, K. 2005. An assessment of implementing a mountain caribou 'captive rearing in the wild' project in the Columbia Forest District. Discussion paper. Prepared for Species at Risk Coordination Office, Ministry of Agriculture and Lands, Victoria, BC, and Fish and Wildlife Compensation Program, Nelson, BC.

Griffith, B., J. M. Scott, J. W. Carpenter, and C. Reed. 1989. Translocation as a species conservation tool: status and strategy. Science 245:477-480.

Hamilton, D., and C. Pasztor. 2009. A guide to commercial backcountry skiing standard operating practices for ski run development, helicopter landing and pickup site development, and snow trail development in mountain caribou habitat. Ministry of Environment, Victoria, BC.

Hebblewhite, M., J. Whittington, M. Bradley, G. Skinner, A. Dibb, and C. A. White. 2007. Conditions for caribou persistence in the wolf-elk-caribou systems of the Canadian Rockies. Rangifer Special Issue 17:79-91.

Houwers, C. 2006. The woodland caribou of the Telkwa Mountains: a history in the making. Living Landscapes Northwest Natural History Series. Royal BC Museum, Victoria, British Columbia. http://www.livinglandscapes.bc.ca/northwest/telkwa/index.html (accessed 12 Dec 2009)

Ingham, L. 2005. Purcell caribou transplant logistics plan. Draft no. 5. Fish and Wildlife Compensation Program - Columbia Basin, Nelson, BC.

James, A. R. C., S. Boutin, D. M. Hebert, and A. B. Rippin. 2004. Spatial separation of caribou from moose and its relation to predation by wolves. Journal of Wildlife Management 68:799-809.

Jones, R. D. Jr. 1966. Raising caribou for an Aleutian introduction. Journal of Wildlife Management 30:453-460.

Karns, P. D. 1978. Environmental assessment report. Reintroduction of woodland caribou. Unpublished draft. Minnesota Department of Natural Resources, St. Paul, Minnesota, and Superior National Forest, Duluth, Minnesota.

Kinley, T. 2002. Background information for public consultation regarding the proposed translocation of caribou from the Itcha-Ilgachuz Mountains to the southern Purcell Mountains. Prepared for Columbia Basin Fish and Wildlife Compensation Program, Nelson, BC, and Ministry of Water, Land and Air Protection, Nelson, BC. Sylvan Consulting Ltd., Invermere, BC.

Kinley, T. A. 2006. 2006 population survey for the Purcells-Central and Purcells-South subpopulations of mountain caribou. Prepared for Columbia Basin Fish and Wildlife Compensation Program, Nelson, BC. Sylvan Consulting Ltd., Invermere, BC.

Kinley, T. A. 2007. 2007 population survey for the Purcells-Central and Purcells-South subpopulations of mountain caribou. Prepared for Tembec Industries Inc., Cranbrook, BC, and Ministry of Environment, Nelson, BC. Sylvan Consulting Ltd., Invermere, BC

Kinley, T. A. 2009. Feasibility of translocation-aided recovery in Banff National Park. Prepared for Parks Canada Agency, Radium Hot Springs, BC. Sylvan Consulting Ltd., Invermere, BC.

Kinley, T. A., and C. D. Apps. 2000. Stand-level selection for forest attributes by mountain caribou in the southern Purcell Mountains, British Columbia. Prepared for East Kootenay Environmental Society, Kimberley, BC, and Tembec Industries Inc., Cranbrook, BC. Sylvan Consulting Ltd., Invermere, BC.

Kinley, T. A., and C. D. Apps. 2001. Mortality patterns in a subpopulation of endangered mountain caribou. Wildlife Society Bulletin 29:158-164.

Kinley, T. A., T. Goward, B. N. McLellan, and R. Serrouya. 2007. The influence of variable snowpacks on habitat use by mountain caribou. Rangifer Special Issue 17:93-102.

Lunan, J. 2008. Notice of amendment of a Land Act section 16 map reserve (letter to Doug Krogel, ILMB, Kamloops, 4 February 2008). Ministry of Agriculture and Lands, Cranbrook, BC.

MacDonald, G. A. 1996. Caribou and human agency in the Columbia Mountains. Parks Canada, Calgary, AB.

Manley, T. L. 1986. Status review of woodland caribou in Montana. Montana Department of Fish, Wildlife and Parks, Helena, MT.

McCollough, M., and B. Connery. 1990. An evaluation of the Maine caribou reintroduction project 1986 to 1989. Maine Caribou Project, Inc., Portland, Maine.

McLoughlin, P. D., J. S. Dunford, and S. Boutin. 2005. Relating predation mortality to broad-scale habitat selection. Journal of Animal Ecology 74:701-707.

McNay, R. S., and R. M. McKinley. 2007. Reduction and recalibration of Bayesian models used to assess mountain caribou winter ranges in British Columbia. Prepared for Ministry of Agriculture and Lands, Victoria, British Columbia. Wildlife Infometrics Inc., Mackenzie, BC.

Ministry of Energy, Mines and Petroleum Resources, and Ministry of Environment. 2009. Notice of work permit conditions and operational guidance for mineral exploration activity in mountain caribou habitat. Province of British Columbia, Victoria, BC.

Morton, J. 2007. Give caribou a break. Refuge Notebook, Kenai National Wildlife Refuge, U.S. Fish and Wildlife Service, Soldotna, AK. http://kenai.fws.gov/overview/notebook/2007/april/13april2007.htm; accessed 11 Dec 2009

Mountain Caribou Technical Advisory Committee. 2002. A strategy for the recovery of mountain caribou in British Columbia, version 1.0. Ministry of Water, Land and Air Protection, Victoria, BC.

Neale, G. 2006. Ecological assessment of mountain caribou captive rearing near Revelstoke, British Columbia. Prepared for Mount Revelstoke and Glacier National Parks, Revelstoke, BC. Garcia and Associates, Bozeman, MT.

Neufeld, L. M. 2006. Spatial dynamics of wolves and woodland caribou in an industrial forest landscape in west-central Alberta. M.Sc. thesis, University of Alberta, Edmonton, AB.

Ontario Woodland Caribou Recovery Team. 2008. Woodland caribou (Rangifer tarandus caribou) (forest-dwelling, boreal population) in Ontario. Ontario Recovery Strategy Series. Ministry of Natural Resources, Peterborough, ON.

Rettie, W. J., and F. Messier. 2000. Hierarchical habitat selection by woodland caribou: its relationship to limiting factors. Ecography 23:466-478.

Robichaud, C. B. 2009. Woodland caribou conservation in the Little Smoky: wolf management and the role of bears. M.Sc. thesis, University of Alberta, Edmonton, Alberta.

Roorda, L., and R. Wright. 2009. Quesnel Highlands wolf project progress report April 1, 2008 – March 31, 2009. Ministry of Environment, Williams Lake, BC.

Russell, J., R. A. Demarchi, and H. R. Jamieson. 1982. Mountain caribou in the Kootenay region. Ministry of Environment, Cranbrook, BC.

Seip, D. R. 1991. Predation and caribou populations. Rangifer Special Issue 7:46-52.

Seip, D. R. 1992. Factors limiting woodland caribou populations and their interrelationships with wolves and moose in southeastern British Columbia. Canadian Journal of Zoology 70:1494-1503.

Seip, D. R., and D. B. Cichowski. 1996. Population ecology of caribou in British Columbia. Rangifer Special Issue 9:73-80.

Stevenson, S. K., and D. F. Hatler. 1985. Woodland caribou and their habitat in southern and central British Columbia. Volume 2. Land Management Report No. 23, Ministry of Forests, Victoria, BC.

Stotyn, S. A. 2008. Ecological interactions of mountain caribou, wolves and moose in the North Columbia Mountains, British Columbia. M.Sc. thesis, University of Alberta, Edmonton, AB.

Stronen, A. V., P. Paquet, S. Herrero, S. Sharpe, and N. Waters. 2007. Translocation and recovery efforts for the Telkwa caribou, *Rangifer tarandus caribou*, herd in westcentral British Columbia, 1997-2005. Canadian Field-Naturalist 121:155-163.

Stuart-Smith, A. K., C. J. A. Bradshaw, S. Boutin, D. M. Hebert, and A. B. Rippin. 1997. Woodland caribou relative to landscape patterns in northeastern Alberta. Journal of Wildlife Management 61:622–633.

Upper Columbia Fish and Wildlife Office. 2008. Southern Selkirk mountain caribou population (*Rangifer tarandus caribou*). 5-year review. Summary and evaluation. U.S. Fish and Wildlife Service, Spokane, WA.

Vandal, D. 1984. Ecologie comportementale du caribou du parc des Grand-Jardins. M.Sc. thesis, Université Laval, Laval, Quebec.

Wakkinen, W., L. DeGroot, R. Clarke, and T. Hill. 2009. 2009 woodland caribou census, South Selkirk Mountains. Department of Fish and Game, Bonners Ferry, ID, Ministry of Environment, Nelson, BC, and Fish and Wildlife Compensation Program – Columbia Basin, Nelson, BC.

Wallmo, O. C. 1969. Response of deer to alternate-strip clearcutting of lodgepole pine and spruce-fir timber in Colorado. Research Note No. RM-141, USDA Forest Service, Fort Collins, CO.

Warren, C. D., J. M. Peek, G. L. Servheen, and P. Zager. 1996. Habitat use and movements of two ecotypes of translocated caribou in Idaho and British Columbia. Conservation Biology 10:547-553.

Williams, J. D., and V. Tutiakoff, Jr. 2005. Aerial survey of barren-ground caribou at Adak Island, Alaska in 2005. Report AMNWR 05/14, U.S. Fish and Wildlife Service, Homer, AK.

Wilson, S. F. 2009. Recommendations for predator-prey management to benefit the recovery of mountain caribou in British Columbia. Prepared for Ministry of Environment, Victoria, BC. EcoLogic Research, Gabriola Island, BC.

Wilson, S. F., and J. B. Nyberg. 2009. A proposed monitoring and adaptive management strategy for mountain caribou recovery implementation. Draft 1. Prepared for Ministry of Environment, Victoria, BC. EcoLogic Research, Gabriola Island, BC, and Nyberg Wildland Consulting, Brentwood Bay, BC.

Wittmer, H. U. 2004. Mechanisms underlying the decline of mountain caribou (*Rangifer tarandus caribou*) in British Columbia. Dissertation, University of British Columbia, Vancouver, BC.

Wittmer, H. U., B. N. McLellan, D. R. Seip, J. A. Young, T. A. Kinley, G. S. Watts, and D. Hamilton. 2005a. Population dynamics of the endangered mountain ecotype of woodland caribou (*Rangifer tarandus caribou*) in British Columbia, Canada. Canadian Journal of Zoology 83:407-418.

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

Wolf, C. M., T. Garland, Jr., and B. Griffith. 1998. Predictors of avian and mammalian translocation success: reanalysis with phylogenetically independent contrasts.

Woods, G. 2001. Purcell mountain caribou transplant proposal. Draft. Ministry of Water, Land and Air Protection, Nelson, BC.

Young, J. A, J. A. Youds, and N. L. Freeman. 2001. Status of the Charlotte Alplands caribou herd: a successful short distance caribou transplant. Ministry of Water, Land and Air Protection, Williams Lake, BC.

Zittlau, K. A. 2004. Population genetic analyses of North American caribou (*Rangifer tarandus*). Ph.D. dissertation, University of Alberta, Edmonton, AB.