Maternal penning in the Northern Columbia Mountains: Revelstoke Caribou Rearing in the Wild's first-year pilot and results of the 2015 calf census

The 2014 ground capture team. Credit: Rob Buchanan

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Executive summary

Revelstoke Caribou Rearing in the Wild (RCRW) is a community led, non-profit society that was formed to conduct maternal penning in the Revelstoke Area, specifically for the Columbia North caribou subpopulation. Maternal penning was initiated by RCRW independently from additional Recovery efforts led by the Province of British Columbia that include habitat protection of old growth forest, snowmobile closures, avoidance protocols for the heli-ski industry, and reducing moose to historic levels to indirectly reduce predator numbers. The Columbia North subpopulation was selected for maternal penning because population trends had stabilized following recovery efforts, but recovery targets were not yet achieved. The goal of RCRW was to use maternal penning to help increase the abundance of the Columbia North subpopulation. Specific objectives were to determine if pregnant females birthed live young, if penned calves had higher survival compared to wild calves, and if penned caribou resumed typical habitat-use patterns post-release.

After substantial community involvement and fundraising, a 6.4-ha pen was built in the fall of 2013. On March 24, 2014, 12 caribou were captured and transported to the maternity pen. Two of these caribou were calves, 1 was a non-pregnant adult female, and the remaining 9 were pregnant adults. Adult and neonate caribou were fitted with radio-collars to monitor survival and to track movements.

All 9 pregnant females birthed live calves, and the 21 animals (9 newborn calves plus the 12 captured caribou) remained alive until released from the pen on 23 July, 2014. However, 4 of the calf collars fell off prematurely and 2 malfunctioned, making it difficult to track survival and causes of mortality. Only 1 mortality cause was confirmed, when wolves killed a collared calf in early November 2014. As of October 7th, 6 of 9 calves were confirmed alive and 1 was possibly dead, and the fate of 2 others unknown, but by February 2015 only 2 of 9 caribou survived. All 10 adult caribou were alive as of March 2015, 1 year after they had been captured. The fate of the two 10-month-old calves captured in March 2014 was difficult to track because they were not fitted with radio collars, but 1 of them was observed during a monitoring flight in February 2015.

Two survey flights were conducted on March 4th and 10th, 2015 to estimate recruitment in the Columbia North subpopulation. The survey indicated a recruitment rate (percentage of calves in the population) of 11.5% that is within the range reported since the late 1990s (8.9-14.3%) but well below the rate reported in the early 1990s (≈ 19%) when caribou populations were stable or increasing. A warm winter, with a below average snowpack prevented a full population survey, however, the last full survey in 2014 indicated the overall subpopulation has been roughly stable since 2003 after a substantial decline in the late 1990s. This years survey was conducted in conjunction with efforts to determine calf survival of animals released from a maternal pen in July 2014. Survival of penned caribou calves (22%) was similar to the estimated survival of wild calves (roughly estimated at 20%).

With 2 of 9 calves surviving (22%), our objective of increasing calf survival was not realised. However, two other objectives were achieved: we determined that pregnant caribou birthed live young, and that penned caribou resumed normal habitat-use patterns and settled within their natal

subpopulation bounds. An additional objective that was developed post-hoc was tracking the survival rate of penned adult females (AFS), which was 100%. This rate was higher than wild caribou monitored post 2000 (~85%). If the increased AFS was caused by penning, then penning could have an unanticipated benefit of increasing 2 vital rates: calf and adult survival.

Acknowledgements

The Revelstoke Caribou Rearing in the Wild Society would like to acknowledge all the participants, funders, stakeholders and supporters of this project. If it weren't for the contributions of this diverse group, the project could not have accomplished what it has.

Thank you to the many volunteers that put in hundreds of hours. From falling and brushing in the pen, to building the fence, collecting lichen, capturing caribou, monitoring caribou in the pen and in the wild. Special thanks to the board of directors (Virginia Thompson, Jody Lownds, Angela Threatful, Gary van Os, Marnie Graf) that have put in tireless hours of writing funding proposals, protocols, media releases, doing presentations and organizing and overseeing the project. Thanks to Cindy Pearce for laying the groundwork for this project and the team of the Chisana Project in the Yukon/Alaska for valuable advice. Also to the shepherds that have put in many hours watching and observing the animals, ensuring their well-being and safety. These include John Flaa, Adam Christie, Bert Marchand, Len Edwards, Doug Heard, Dale Seip and Leo DeGroot. Thanks to Brian Glaicar of Monashee Outfitting who has been a major supporter of the project from the beginning, suggested the site and worked with all the different people and groups coming through his camp and disturbing his peace and quiet.

The Splatsin First Nation and the Okanagan Indian Band are key partners to this project. We thank Stuart Lee and Randy Williams for helping to facilitate this project. Other key partners include the Revelstoke Snowmobile Club, Mica Heliskiing, and the North Columbia Environmental Society.

RCRW would like to acknowledge the Columbia Mountains Caribou Research Project for access to data and experience that helped set the stage for this project. RCRW also thanks individuals who assisted with capture, including Clay Wilson of Bighorn Helicopters, Dave Lewis, Geoff Skinner with Parks Canada, Bruce McLellan with FLNRO, Bobby and Kim Doebert. Rick Farnell, Helen Schwantje, Robert McCorkell, and Nigel Caulkett assisted with advice and animal processing. Alex Taylor helped with monitoring and Rob Buchanan provided excellent photographs. Mary Clayton provided a steady hand of support during media releases, and several individuals helped with developing our website (Christine Friedrichsmeier, Karilyn Kempton, and Chris Payne). Our sincere thanks to Helen Schwantje, Provincial Wildlife Veterinarian for countless hours of protocol reviews, advice and support.

RCRW acknowledges all the organizations that have funded and given money or in-kind contributions. Every time we had an issue or problem someone stepped up to help get the job done. From Score Fencing who we bounced many different fence designs by, to Revelstoke Mountain Resort who donated day ski passes for lichen pickers, to David Moore from K3 Catskiing who donated and operated his snow cat to remove snow from around the fence when there was just too much. Selkirk

Tangiers Heli Skiing/Mustang Helicopters; Selkirk Mountain Helicopters; Sure Haul Transport; Cooper Beauchesne and Associates; Parks Canada; Beaumont Timber; the Revelstoke Community Forest Corporation; and the Ministry of Forests, Lands and Natural Resource Operations, the Revelstoke Wildfire Branch crews who all donated time, expertise or something else needed for the project. Finally, we would like to recognize all the financial contributors to the project: the Government of Canada's Habitat Stewardship Program, Columbia Basin Trust, BC Government, Parks Canada, the Fish and Wildlife Compensation Program, Shell Canada - Fueling Change, Downie Timber, Golder Associates, Mustang Powder Catskiing, Crescent Spur Heliskiing, Canadian Mountain Holidays, RK Heliskiing, Eagle Pass Heliskiing.

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Introduction

The Southern Mountain population of woodland caribou is listed as endangered by COSEWIC, and Threatened under the Species at Risk Act. The primary mechanism of population decline is habitat modification that converts forests to shrubs, which favours the abundance of moose and deer, leading to higher predator numbers (Wittmer et al. 2005b, Wittmer et al. 2007). Factors other than forestry have also been important agents of decline, including climate change that increases the distribution of white-tailed deer (*Odocoileus virginianus*)(Dawe 2011), and the historic overhunting of mountain caribou (McLellan 2010).

The most often-cited approaches to recover mountain caribou include protecting habitat, reducing predators, or reducing primary prey (Seip 2008, Serrouya et al. 2011) that can indirectly reduce predator numbers (Serrouya et al. 2015). The latter 2 options are based on the notion of reducing predation rates on caribou until the habitat recovers. Several of these recovery measures have been initiated in the Revelstoke area. These include the legal protection of harvestable and non-harvestable forest (termed "Government Action Regulations"), snowmobile closures, and modified practices for the heli-ski industry. As well, an adaptive management experiment was implemented to reduce moose numbers to test the hypothesis that this action would reduce wolf numbers and improve caribou demography. This hypothesis was supported because following the moose reduction, wolf numbers declined and the largest caribou subpopulation – Columbia North – stabilized, whereas other adjacent populations that were very small or without moose reductions continued to decline (Serrouya 2013, Serrouya et al. 2015).

An additional option to reduce predation rates involves protecting caribou calves in an enclosure during their first month of life, which is when they are most vulnerable to predators (Adams et al. 1995, Gustine et al. 2006). This approach is often referred to as maternal penning, and is identified as one option (of many required) to recover caribou in the Southern Mountain Caribou Recovery Strategy. Maternal penning consists of transporting adult female caribou to an enclosure where they can birth and rear their calves for about 1 month, at which time all caribou are released into the wild. Capture and transport of pregnant caribou usually occurs in late March, and release from the enclosure occurs in July.

Revelstoke Caribou Rearing in the Wild Society (RCRW) was formed as a non-profit organization in 2013, whose goal and sole focus is to fundraise, plan and conduct maternal penning of mountain caribou to increase calf survival in the Columbia Mountains over a 5-year pilot period. RCRW represents a group of local stakeholders that have come together to help recover caribou in the Revelstoke area. Maternal penning was initiated in 2014 by RCRW with funding and support from several agencies. This report focuses on results 1 year after penning began in March 2014, and makes recommendations for

future penning activities. Our group recognizes that maternal penning is one of several management tools that will be required to recover caribou.

The Columbia North subpopulation was selected for RCRW's penning pilot for the following reasons: 1) the reduction of predator numbers via the moose reduction would reduce the risk of compensatory calf mortality; 2) The population was relatively large and stable and would benefit from actions that would help promote population growth; 3) concurrent habitat protection was implemented; and 4) caribou calf survival was low, allowing for the potential of substantial improvement in calf survival.

Objectives

The objectives of the RCRW pilot are split into three categories: individual-level, population-level and logistical objectives, each with associated response metrics to track achievement. For the first year of implementation, our goal was to capture approximately 10 adult caribou and place them into the pen. However, if an adult that was targeted for capture included a calf at heel, that calf would also be transported to the pen.

Individual-level objectives

1. Determine if parturition rates are as high as pregnancy rates in the Columbia Mountains Ecosystem (CME). Mountain caribou pregnancy rates in BC are 92% (Wittmer et al. 2005b), but it remains unknown whether pregnant cows give birth to viable calves. A corollary to this objective was to achieve a target of 90% survival of calves born in the pen to the time of their release.

2. At least double the survival rate of penned calves relative to recent survival rates of wild calves for this area. Recent calf survival rates in the CME range from 19 to 26% at 10 months of age. It is possible that increased neonate penned calf survival will be offset by predation later in the year when calves are released (compensatory mortality). This component will be evaluated based on our pilot study, though the risk of compensatory mortality is expected to be low because of the reduced wolf numbers as a result of the moose reduction experiment.

3. Determine if cows and calves released from the pen mix with the rest of the population. It will be important to determine if animals transported to the pen resume normal habitat use and elevational migrations that occur in the CME (Apps et al. 2001).

Population-level objectives

1. To increase population-level recruitment rates (% calves in the population in March), relative to previous recruitment that has varied between 10 and 16%[1] since the mid 1990s.

2. To increase the size of the Columbia North subpopulation.

[1] Note that we define recruitment as the % of the population that consists of calves during a March census. This is a different metric than calf survival. We can estimate wild calf survival by knowing recruitment, pregnancy rate and estimating the bull:cow ratio. For example, recruitment of 10 to 16% is approximately equal to survival of 21% to 35%, assuming a 92% pregnancy rate and 70:100 bull:cow ratio.

Logistical objectives

We had 1 primary logistical objective: to determine if penning was logistically feasible in the deep-snow region of the Columbia Mountains, and if caribou could be effectively protected from predators in the pen.

Methods

Power analysis to determine the number of females to be penned

Prior to initiating any broad-scale conservation effort, it is important to forecast outcomes to help minimize risk and to avoid costly mistakes. Such an approach will also help gauge the level of effort needed to achieve success. Without such tools, the chance of disappointing results is increased and the return on investment will be difficult to anticipate. The primary forecasting tool we used was a life-table analysis, where we varied the proportion of adult females to be penned, with the goal of determining how this variation would affect the population growth rate (lambda [λ]; the finite rate of change). Lambda is the change in population size from 1 time step to the next: $\lambda = (N_{t+n}/N_t)^{(1/n)}$, where N is population size, *t* is time (year in this case), and *n* is the number of time increments. When $\lambda > 1$, the population is increasing, and declining when $\lambda < 1$.

Most parameters for our life table analyses were empirically derived from the CME, with adult female survival = 0.90, pregnancy rate = 0.92, age at first parturition = 3, litter size = 1, and wild calf survival = 0.25. Assumed parameters were calf survival in the pen = 0.90, calf survival the next 11 months after release = 0.6 (so 0.9 X 0.6 = 0.54 annual survival for penned calves). Also, given that some cows will be in the pen for 3 – 4 months, this should also increase adult female survival by a modest amount because they would not be subject to predation during spring, when the highest daily predation rates occur (Wittmer et al. 2005b). Therefore, we added 5% to the survival of penned adults.

Predictions from the life table analysis are presented as population size over time, as a function of the proportion of the population that is penned. It is important to note that this analysis is meant to act as a rough guide. Outputs from this forecasting tool will clearly be sensitive to the input parameters, but this sensitivity will likely affect each scenario equally, so readers should focus on the relative difference in population size among the scenarios (i.e. scenarios are based varying the % of the adult female population that is penned).

Protocol Development

Detailed project objectives and protocols for animal capture, handling, care and maintenance, quarantine/hygiene, necropsy/sampling, calving, release and monitoring were developed in 2014 by biologists and the Provincial Wildlife Veterinarian (H. Schwantje). This document; “Protocols and Guidelines for the Rearing Caribou in the Wild Maternity Penning Project, February 2014, Version 1.2” (Kellner and Serrouya 2014) includes a decision tree for veterinary assistance, and another to guide staff response in the case of predators on-site during operations. This is a living document that forms the basis for wildlife capture and handling permits, and will be reviewed in Fall 2015 to incorporate lessons learned from operations in 2014 and 2015.

Capture and handling

In the fall of 2013 a 6.4-ha pen was built by Score Fencing Inc., at a remote site on the N side of Ruddock Creek (Figs. 1-2). The site was chosen for four reasons: 1) It was away from human traffic and settlement; 2) it was within the boundary of the Columbia North subpopulation, in early winter habitat; 3) it was operationally feasible because it was adjacent to Monashee Outfitting's camp, where sleeping cabins, electricity, and communication was already available; and 4) the site had flat topography with good lines of sight.

The fence perimeter was cleared and the ground was leveled using an excavator and crawler tractor. The fence posts were 18 feet long, 2 7/8" wide oil field tubes driven in place at 12 foot centers with a vibratory driver, six feet into the ground. A 3/8" galvanized cable was threaded through links welded to the top of the posts. Non-woven 11 oz geotextile fabric was laid over the cable and held in place by large zap straps. The electric fence was constructed using 1 7/8" square galvanized pipe, extended 6" from the posts with 14 strands of high-tensile wire with alternating live ground connections. The pen was cleared of small trees and debris, though a substantial number of slash piles were present during the first year of the project. A blind was also installed at the SE corner of the pen, where most of the observations occurred. Three tree stands were set up around the pen to offer additional opportunities to observe the animals.

Figure 1. Photo of the pen's fence, electric wires and caribou feeding at a trough. Taken from the NW corner of the pen.

Figure 2. Aerial photo of the pen. Credit: Cory Legebokow

Capture of the cows was timed to be during the early part of the third trimester of pregnancy, during late March. Ungulate capture in BC is typically not conducted after early April due to concerns with the weight of the fetus in pregnant animals and the more sensitive physiology of pregnant animals. In addition, consideration was given to the depth of snow and ambient temperature as deep snow will cushion animals and reduce the potential trauma of physical capture and reduce the speed of running animals. Cool temperatures (approximately – 10 to +10 C) are also preferred to reduce the stress and physiological changes associated with hyperthermia (increased body temperatures).

The capture method chosen was a net gun fired from a Hughes 500 helicopter (Bighorn Helicopters Inc.). Groups of caribou were located and the decision to select a group was made by the capture team and an experienced biologist. The helicopter separated the target animal and carefully moved her into a safe location, restricting the intense and close time to as short as possible (<2 minutes). The net was fired from the back seat of the helicopter just in front/over the animal. Once the net was fired on an animal, the helicopter landed briefly and a handler restrained the caribou. The legs are hobbled by freeing one front and hind leg from the net and strapping them firmly, then moving to the second set of legs. A blindfold was placed over the eyes. Medetomidine hydrochloride (an alpha-2 sedative) was given by handlers to most cows in a standard dose by intranasal administration. The captured 10-month old caribou were not sedated. All caribou were placed in individual custom nylon transport bags and lifted into the back compartment of one of two A-Star helicopters. Two animals were usually placed side by side and one handler accompanying them held up their heads. They were transported as soon as possible to the pen and all capture sites were less than 20 minutes from the pen.

The A-Star transport helicopter landed approximated 150 m from the Pen, where caribou were lifted from the helicopter, transferred to a snow skimmer, with their heads held on the lap of an accompanying handler. The skimmers were towed to the pen by a snowmobile. Animals were brought into the pen and unloaded to one of two processing sites.

The provincial wildlife veterinarian (Helen Schwantje) supervised handling at the pen. Animals were assessed for depth of sedation, age estimate, physical condition, injury, presence of external

parasites, including assessing Besnoitia lesions in the eyes and palpating the lower limbs. A sampling protocol was followed for each cow with 20ml of blood, an ear biopsy, hair and feces collected. Each cow was evaluated for pregnancy using an ultrasound operated by a veterinary reproductive specialist. Blood was allowed to clot and centrifuged for serum collection. Progesterone levels were determined by Prairie Diagnostic Services lab using standard progesterone assays. Hair and biopsy sample were air dried in paper envelopes for DNA archiving and feces were frozen and submitted to the University of Calgary's parasitology lab for analysis. A standard protocol of prophylactic treatments was followed with each cow receiving a vitamin E/selenium supplement, a larvicidal anthelmintic, and an anti-inflammatory medication. A long acting antibiotic was available for treatment if required but was not needed. All caribou were fitted with ear tags, and adults were fitted with a Vectronic Aerospace Ltd. GPS Plus-2 Satellite collars with mortality (12 hour delay, threshold of 15) and proximity detection, programmed to obtain a fix every 2 hours. Collars transmitted locations and mortality status via satellite every 8 hours, and transmitted a VHF signal between 6:30 AM and 10:00 PM (UTC-7). After initial processing and sampling was completed the animals were carried a short distance from each processing site, the hobbles and blindfolds were removed and they were positioned to safely walk away. Once in position, sedated caribou were given a reversal of atipamezole, an alpha-2 antagonist to reverse the effects of the medetomidine.

Once capture was completed, caribou were fed with natural lichens in custom and commercial feeders and then transitioned from lichen to pellets over a 10-day period. Animals were given 23 kg of arboreal lichen on the first day and lichen was reduced 10% while a special formulated pellet (Unifeed 19-3702) was increased 10% per day to 23 kg. Feeding occurred twice a day, in the morning and evening.

Observation protocols required that all animals were visually confirmed within the pen at least twice a day and observed for feeding and drinking behaviour. A decision tree for veterinary consultation was developed and followed (Kellner and Serrouya 2014). Physical appearance and behaviour was noted and once calving approached, any increase in size of the udder or physical signs or behaviour associated with birthing was recorded. Once a calf was suspected or confirmed, the cow/calf pair were left alone for a minimum of 10 hours and up to 24 hours to bond. Shepherds then entered the pen and gently cornered and restrained the calf to collar, ear tag, sex, weigh and take a hair sample. Calves were collared using lightweight expandable collars with VHF transmitter, mortality sensor (3 hour period) and UHF proximity tag from Vectronic Aerospace Ltd (Fig. 3). Contact time was minimized and typically took less than 8 minutes to complete. The pair was left alone to reunite and was observed at a distance until cow and calf united.

Figure 3. Neonate caribou calf being fitted with a radio collar. Credit: Cory Legebokow

Shepherds completed external fence patrols twice daily in the morning and evening, testing fence voltage and observing for predator tracks. Two sand track traps were set up to aid in this process. Predators were also monitored using Reconyx Game Cameras. Cameras were set up in four locations, 2 along the fence perimeter (release gate and SW corner) and 2 further away from the pen to the north and west (North along the lake road and west on an old roadbed 200 meters away). Camera cards were checked every second to third day, or daily if new tracks were observed in the area. Protocols and guidelines were developed, including a decision tree for responding to predators near the pen (Kellner and Serrouya 2014).

In mid-July, a week before release, the feeding troughs were moved to the west side of the pen near the release gate. The immediate area was patrolled by shepherds and the surrounding area by hunting hounds 2 days prior to release. Additional game cameras were installed and checked daily. Food was reduced the day prior to release to encourage animals to leave the pen. On release day troughs with lichen were placed outside of the pen and the release gate was opened. Shepherds were stationed to observe the animals leave. Once all the caribou had left the pen, the gate was closed.

Monitoring consisted of volunteers signing up for a 1-week period. Animals were checked daily for the location, calf proximity collars and separation events. All information was recorded on a post release spreadsheet. If a separation event occurred, 24 hours was given to reconnect. If a mortality signal or separation event >24 hours occurred a 2 person team was dispatched to investigate the location.

Recruitment Census

To obtain an estimate of recruitment, a portion of the Columbia North subpopulation with the highest density of caribou was surveyed. This census followed similar protocols that have been used repeatedly since 1992 (Wittmer et al. 2005a, McLellan et al. 2006). Briefly, mountains are contoured at treeline using a Bell 206 Jet Ranger helicopter at speeds of approximately 130 - 160 km/hr. This

elevation is where caribou are most often found during late winter (Apps et al. 2001). When tracks are encountered they are followed to locate caribou and count their numbers. Since 2013, we have been taking high-resolution photographs of each group so that numbers and composition (% calves in the population) can be verified in the office, and to minimize animal harassment. Caribou are classified as either adult (includes juveniles) or calves. To calculate the percent of caribou calves in the population (recruitment), we divided the number of calves seen by the total number of caribou seen.

In addition to these standard survey methods, collared caribou that were released from the maternal pen in July 2014, were located using telemetry and observed on the ground at a distance of 200-400 m using a spotting scope to determine if each female had a calf at heel.

Excellent sightability is not strictly required for a recruitment census since it does not require a count of the entire population. However, poor sightability may be a concern if a subset of the population (e.g.. bull groups) are less likely to be visualized during a poor snow year. Therefore snowdepths are also reported here. To conduct a full population census requires a minimum of 300 cm of settled snow at Mt. Fidelity, where snow is manually recorded by Parks Canada staff. This threshold is based on an empirical relationship demonstrating that caribou sightability is greater than 90% when the snowpack reaches 300 cm (Flaa and McLellan 1999).

Survival

Calf survival was calculated based on the Kaplan-Meir estimator (Pollock et al. 1989), using biweekly (2/mo) survival intervals. Calf survival was monitored using the proximity and separation sensors from the mothers' collars. If the calf collar fell off prematurely, survival was inferred by observing the mother during monitoring flights and based on the mothers' movements tracked from the GPS collars.

Results

Power analysis

Given that the current trend (2003 to 2013) of the Columbia North subpopulation is approximately stable (Serrouya et al. 2015), the power analysis suggests that roughly 30 % of the population would have to be penned to achieve 2 % growth per year (i.e. $\lambda = 1.02$; Fig. 4). Assuming a starting population of 60 adult females, this growth rate would result in 66 animals after 5 years, 73 after 10 years, and 81 after 15 years (Fig. 4), and would mean that the population level recruitment rate would have to be approximately 23.5% (equivalent to a survival rate of 0.335). This projection assumes that all parameters are held constant, including the pregnancy rate (see Discussion section for challenges to this assumption).

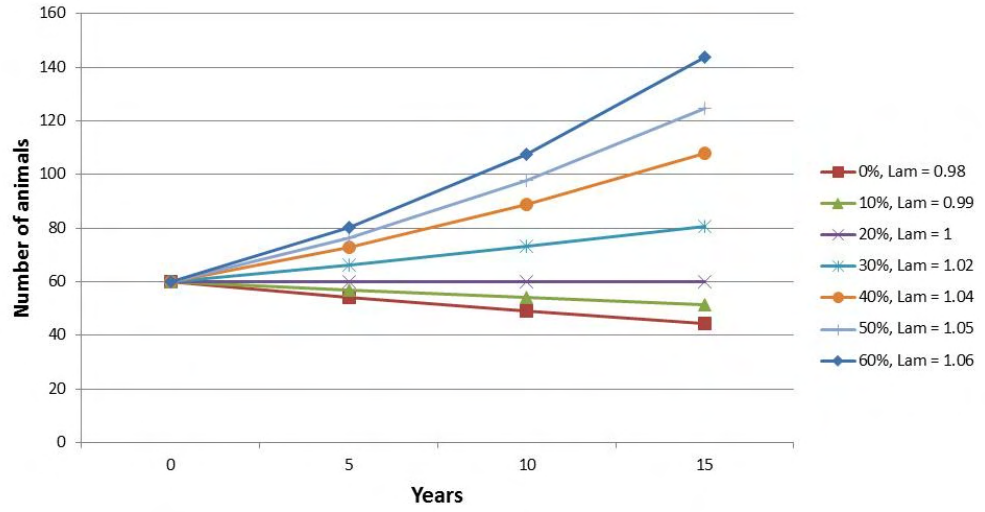

Figure 4. Population projections for 6 scenarios that vary the proportion of the adult females penned. Also shown in the legend is the modeled λ (Lam) value for each scenario. See text for parameters that were used in the life table analysis.

Capture

On March 24 2014, 12 caribou were captured and transported to the pen. Ten of these caribou were adult females and 2 were 10-month old calves. Nine of the 10 adult females were pregnant (Table 1). Four of the animals were captured in French Creek, three at Mica Creek, and 5 at Louis Lee Creek (including the 2 calves). All of these capture locations are on the east side of Lake Revelstoke. After approximately 10 days in the pen, caribou were fully transitioned from arboreal lichen, their natural food source, to the commercial pellet-based food.

Table 1. Details of the caribou captured on March 24, 2014. Caribou 11 and 12 were ear tagged, but not collared.

RCRW Caribou ID	WHID ID	Collar ID	Capture location	Age class	Sex	Pregnant	Calving date
1	14-4944	13139	French Crk	Adult	F	Y	June 2
2	14-4945	13138	French Crk	Adult	F	Y	May 28
3	14-4946	13141	French Crk	Adult	F	Y	June 14
4	14-4947	13144	French Crk	Adult	F	Y	May 27
5	14-4948	13140	Mica Crk	Adult	F	Y	June 1
6	14-4949	13137	Mica Crk	Adult	F	Y	May 27
7	14-4950	13142	Mica Crk	Adult	F	Y	June 3
8	14-4951	13136	Louis Lee Crk	Adult	F	Y	May 24
9	14-4952	13145	Louis Lee Crk	Adult	F	N	na
10	14-4953	13143	Louis Lee Crk	Adult	F	Y	July 8
11		NA	Louis Lee Crk	Calf	F	N	Na
12		Not NA	Louis Lee Crk	Calf	F	N	na

Release

On release day, most of the animals left the pen within a few hours. However, 1 calf became separated from its mother shortly after they left the pen, after which the calf returned to the pen. By the next day, the mother had returned to the pen, collected her calf, and proceeded up slope, as did all the other caribou. Within 36 hours all caribou were in high elevation summer habitat (see Figs. 5 & 6), but the ridge that they localized on (directly above the pen) is very rarely used by wild caribou in summer (based on telemetry data).

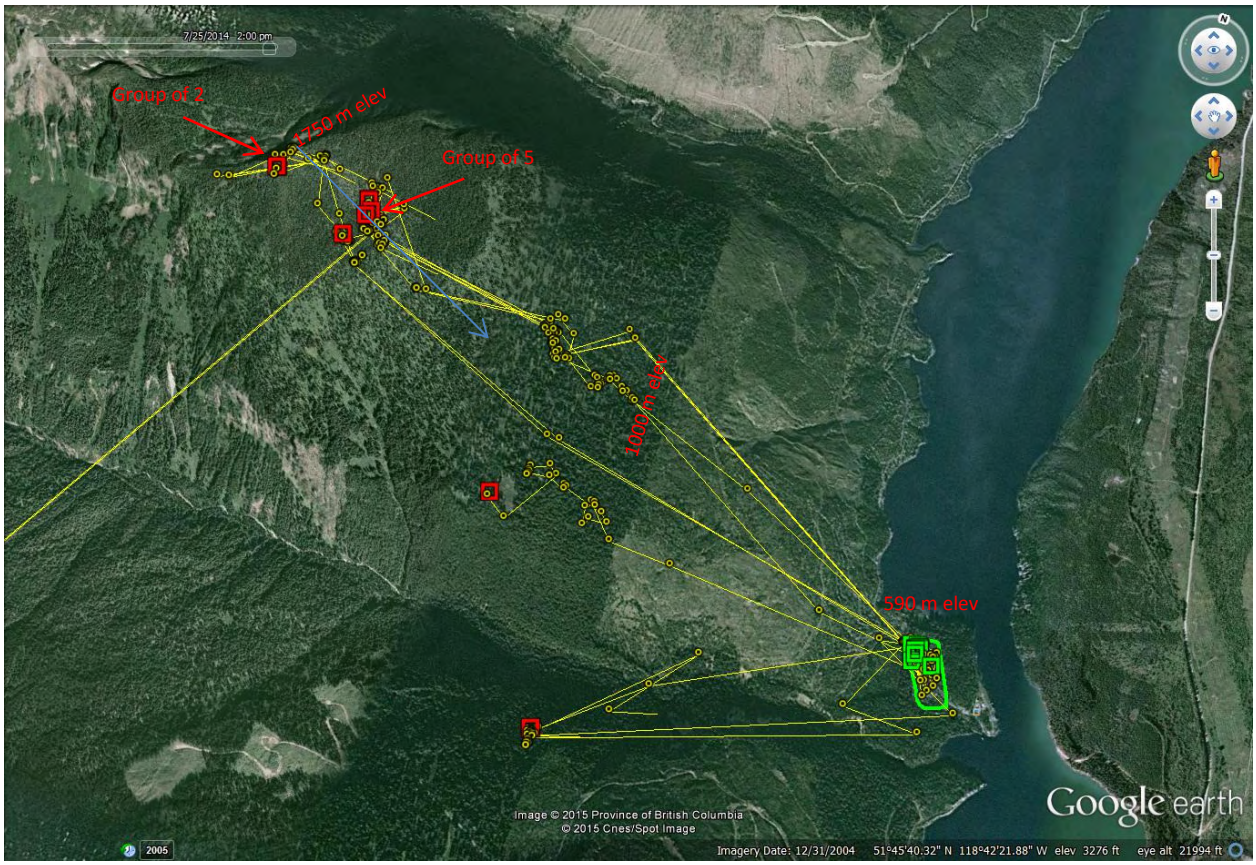

Figure 5. Caribou locations (red squares), movement paths, 36 hours after release from the pen (green square). Each point represents 2 hours of time elapsed.

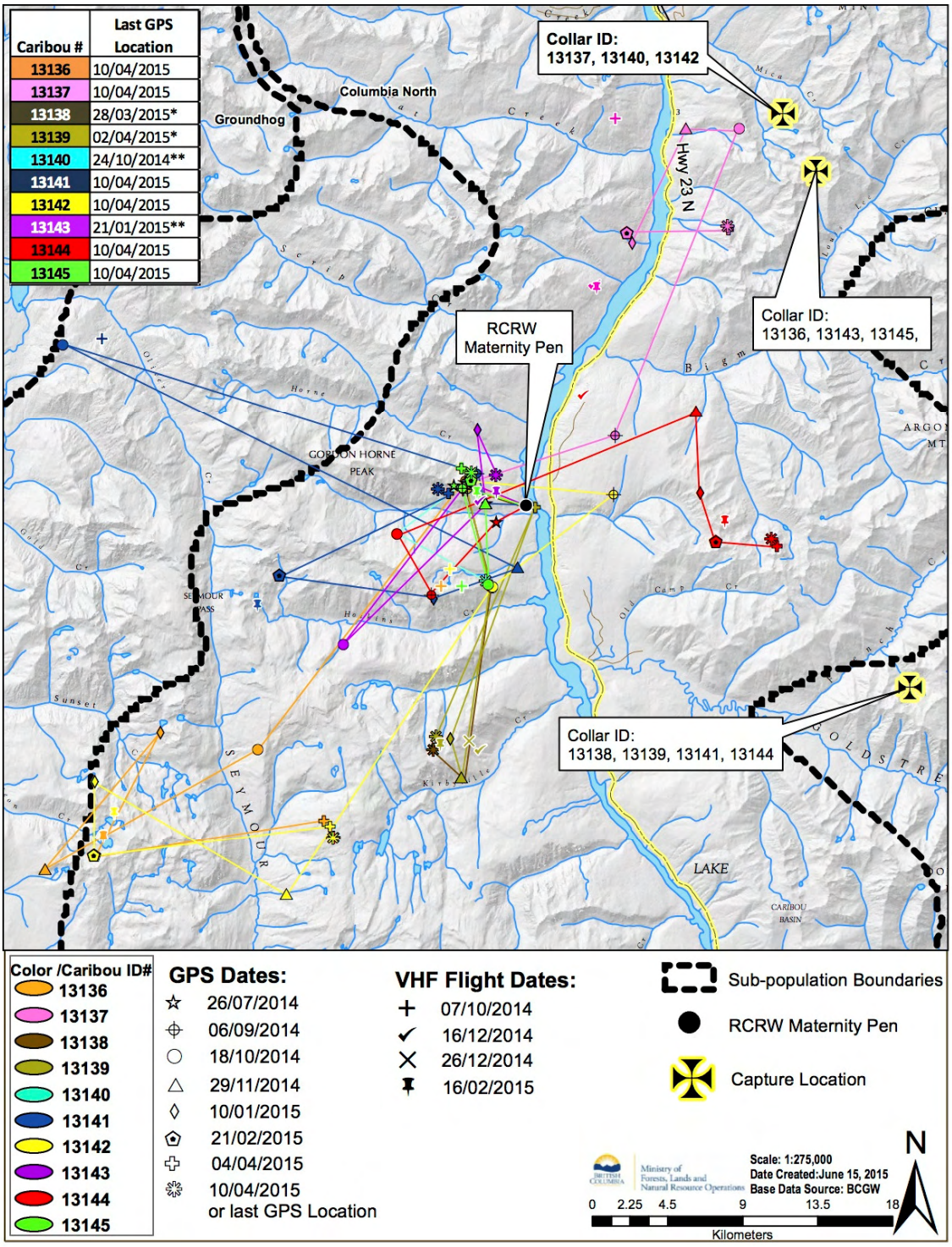

Figure 6. Caribou locations at capture, and every 6 weeks post release. * 2 adult caribou (and one calf) from the 2014 pen were recaptured in late March/early April and transported to the pen ** 2 of the adult collars went into premature GPS battery failure – these collars were only locatable by VHF signal after this date.

Monitoring and Survival

The 9 pregnant females birthed 9 live calves. Pregnant cows had an average serum progesterone level of 5.6 (SD 2.6) and the single the non-pregnant female had a serum progesterone level of 1.6 ng/ml. Calving dates ranged from 24 May to 8 July (Fig. 7), birth weights averaged 8.4kg (SD 1.1kg), and there were four male calves and five female calves. All 21 caribou (9 calves plus 12 transported to the pen) remained alive until release from the pen. The 10 adult caribou survived at least 1 year from the date they were captured (i.e. to March 2015). Collars were programmed to blow off on April 15, so the fate of these cows became unknown after this date. However, 2 of these cows were recaptured, re-collared, and placed in the pen in March 2015. Two of the 9 calves born in the pen survived until the end of March, 2015, when the second year of capture began. One of those 2 calves was captured with its mother and transported to the pen in March 2015.

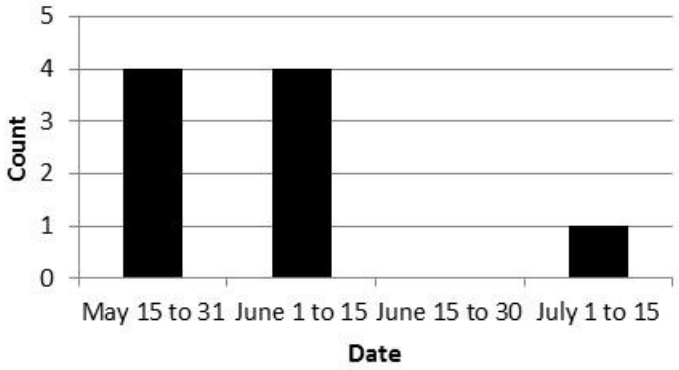

Figure 7. Timing of the 2014 calf births.

The timing of calf mortality indicated that 7 of 9 calves were alive up to October 7, 2014 (Fig. 8), the beginning of the early winter season in the Columbia Mountains. However, 4 of the collars fell off prematurely (2 in the pen prior to release and 2 post release), reducing our ability to asses causes of mortality. In these cases, mortality was presumed when the calf was not observed with its mother during overflights. Wolves killed 1 collared calf on November 3rd, 2014, one collared calf transmitted a mortality signal (October 2014) – but the VHF beacon in the collar failed, preventing investigation and another collared calf was picked up by adult collars only intermittently, and the VHF beacon could not be located in the field.

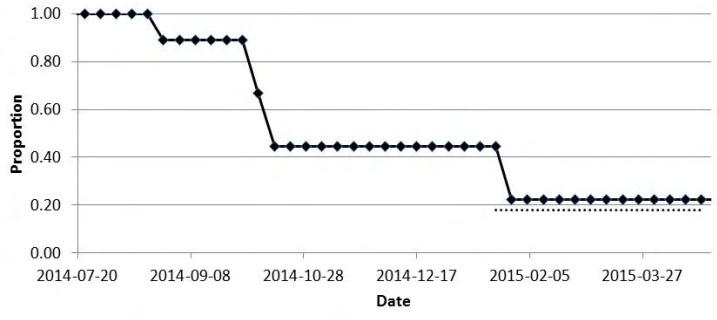

Figure 8. Survival rate of 9 calves penned during the first year of the project. Calves were released from the pen on July 23rd 2014. The dashed line represents the estimated wild calf survival rate.

Recruitment Survey

A portion of the Columbia North subpopulation was surveyed on March 4th and March 10th, 2015. Weather conditions were excellent with sunny and cool conditions overnight (daytime freezing levels around 1500 m on the 4th and 2000 m on the 10th), however there had not been a significant snowfall immediately prior to either flight, so caribou tracks were extensive. Snow depths at Mt. Fidelity were approximately 250 cm during the surveys, which was 50 cm below average (Figure 9). This survey was a mix of typical census techniques and targeted surveys of groups with collared females (n=10) using satellite transmission data and VHF telemetry. Caribou habitat in the Monashee Mountains between Ratchford and Ruddock Creeks, including the Bischoff Creek area, was surveyed along with caribou habitat in the Cummins, Wood River and Molson Creek area (Fig. 10).

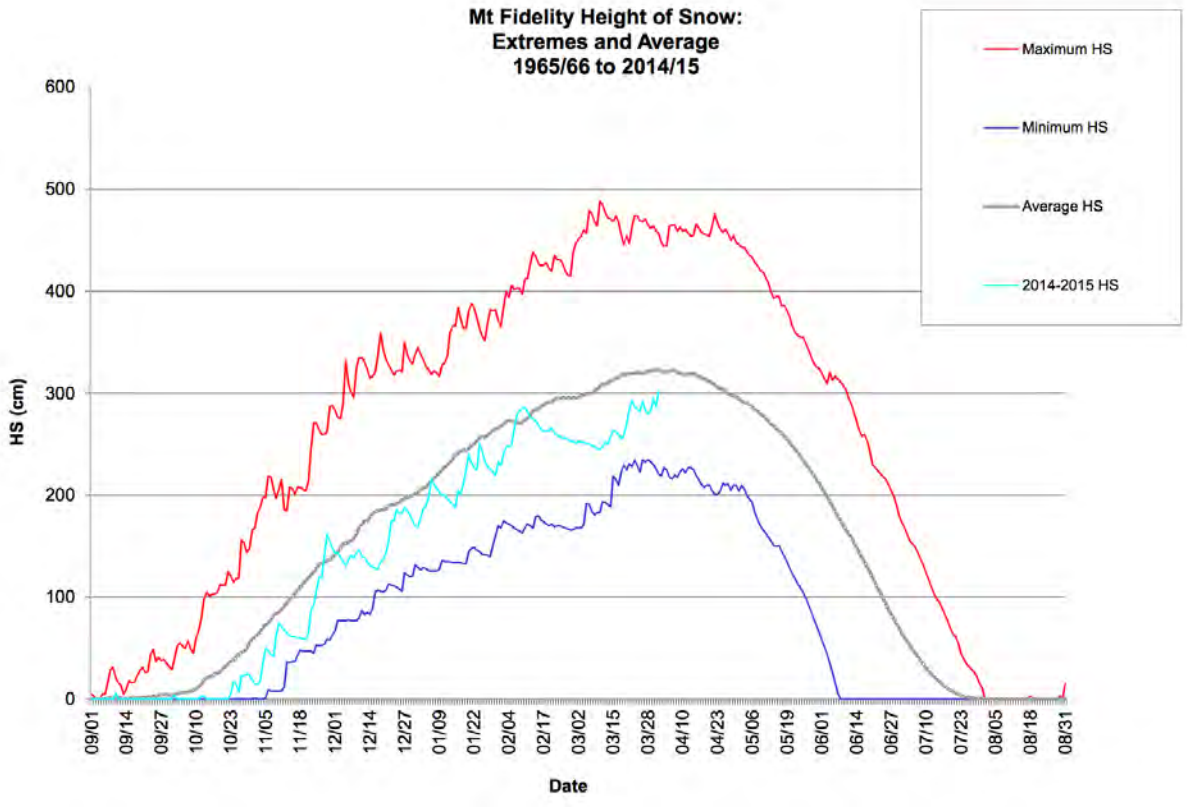

Figure 9. Snowpack depths at the Mt. Fidelity snow station east of Revelstoke at 1036 m.

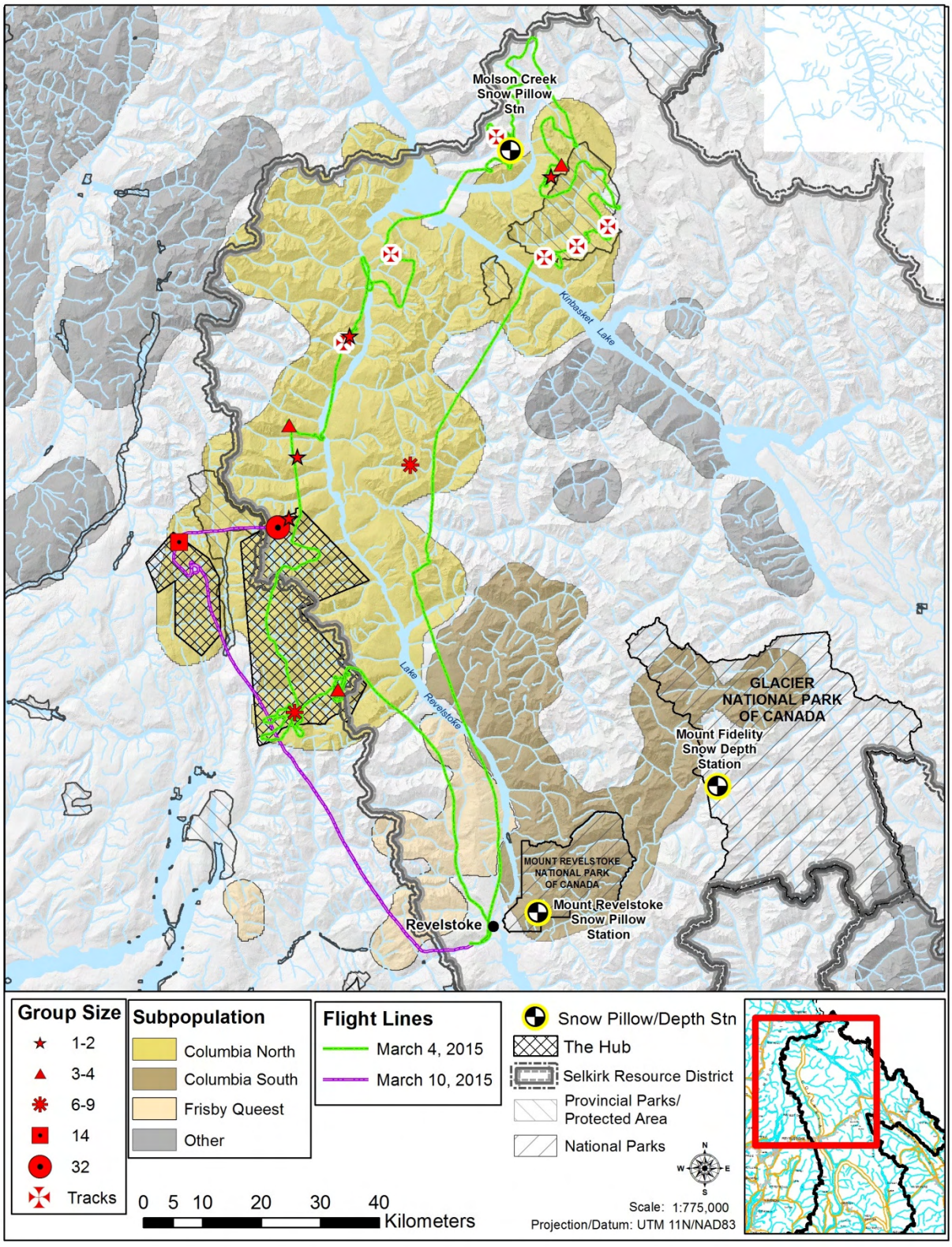

Figure 10. Map of North Columbia caribou subpopulation 2015 recruitment survey flight-lines.

It was easy to locate tracks, however the lack of snow and extensive tracking made it very difficult to locate caribou, and we were not able to locate several groups that had descended into the timber. These conditions supported our decision not to conduct a complete population estimate survey. The total number of calves seen was 9, and total number of all caribou seen was 78 for a calf recruitment rate of 11.5 %. Eleven groups were located and group size varied from 1 to 32. The Columbia north population survey results are updated in Table 2.

There were 10 female (9 were pregnant) collared caribou released from the maternal pen along with 9 calves, and two un-collared juveniles in July 2014. All 10 females, and only 2 calves (both collared) were still alive in March 2015. In addition, one of the two pen-released juveniles (ear tagged) was observed during the survey. Three of 10 adult female caribou returned to near or within their seasonal home ranges by March 2015 and the remaining 7 penned adult caribou remained in the Monashee Mountains. Most penned animals were found within groups of resident animals in March 2015.

Observing caribou with a scope from the ground worked reasonably well to determine if collared/ear tagged animals had a calf at heel. With >300 m distance and a visual and sound barrier in the form of a hill we were able to land the helicopter behind the hill and hike up to a knoll with no flight response from caribou. However, landing the helicopter within 200 m, with no visual barrier caused a flight response (after observing caribou for ½ an hour) on start-up of the helicopter.

A rough estimate of survival for wild-born calves can be estimated by excluding pen born animals and their mothers from the values above, and converting recruitment to survival with an assumed 50:50 bull:cow ratio (Bruce McLellan, Clay Wilson, Rob Serrouya; personal observation) and a 92% pregnancy rate (Wittmer et al. 2005a). Wild calf survival was similar to survival for calves born in the pen (2/9; 22.2%) at approximately 19.7% (7 calves were associated with 65 animals that we saw, that did not originate from the pen).

Table 2. Population census results and recruitment values (% calves) for the Columbia North caribou subpopulation. Adapted from McLellan et al. (2006).

Columbia North	Observed (+ Tracks)	Calves (%)	Number Collared	Collars Observed	Calculated Estimate *	90% CL
1994	206 (209)	19.4	12	12	206	206-229
1996	167 (193)	19.2	11	11	167	167-188
1997	203 (204)	11.8	17	15	280	210-280
2002	145 (152)	11.7	7	7	145	145-175
2004	129 (136)	14.0	12	12	129	129-143

Columbia North	Observed (+ Tracks)	Calves (%)	Number Collared	Collars Observed	Calculated Estimate *	90% CL
2006	125 (131)	14.3	10	9	138	127-181
2008	139 (142)	12.9	6	5	166	142-200
2010	NA*	10.4		NA	NA	NA
2011	101 (123)[a]	8.9	0	0	NA	NA
2012	NA*	12.9	0	NA	NA	NA
2013	148 (152)	14.2	0	NA	NA	NA
2014	115** (123)	13.3	0	NA	NA	NA
2015	NA*	11.5	NA***	NA	NA	NA

*No population estimate was conducted these years.

**The 2014 estimate is also considered to be unreliable due to a very low snow pack. This number (115 or 123 is considered very conservative).

***10 adult females were collared, and 2 juveniles had ear tags. All 10 adults, 2 surviving calves, and one juvenile were located using a mix of standard census methods and telemetry.

Discussion

Two out of the three individual-level objectives were achieved. Pregnant caribou gave birth to live young, and caribou resumed normal elevation patterns after release from the pen. There were no in-utero or neonatal deaths in this first year of the project. This preliminary result suggests that inbreeding depression is not affecting parturition rates. In addition, our results are in contrast to the view of several authors in the literature that argue high pregnancy rates do not necessarily mean viable young are birthed. This argument is used in support of a hypothesis that food limitation, rather than predation, is causing caribou to decline. We anticipated 90% calf survival in the pen prior to release, but achieved 100% survival.

Penned caribou appeared to resume normal habitat-use patterns. They moved to high elevations immediately after release, and their elevation use became more variable throughout fall. Several of the caribou were integrated into groups of wild caribou on the W side of Lake Revelstoke, which they had not previously encountered. Only 1 caribou moved back to her original capture location. The remaining caribou remained on the west side of Lake Revelstoke for the majority of the summer and fall with 1 group of 2 cow/calf pairs and 1 yearling moving to the east side of the lake on October

25th, and spent the winter on the east side. Cow #3 was observed with some erratic behaviour beginning on October 1st. It is suspected that this behaviour was initiated by the death of her calf as she moved up Horne Creek and circled Tum Tum Lake twice. She was observed without a calf during the February 2015 monitoring flight. As of March 24, 2015, she was located back above the pen and her movements were much less erratic.

However, the third and most important objective was not achieved. At 22 % (2/9 calves), calf survival was not substantially higher than wild calf survival. This result will not contribute to the ultimate population-level objective of increasing the size of the Columbia North subpopulation. We can only offer conjecture as to why this pattern occurred, with the following potential explanations:

1) Snowfall was low during the 2014/15 winter, and rain-on-snow events were more frequent, causing a hard snowpack. Parks Canada stated that "A climate summary for the month of February, 2015 at Rogers Pass found some remarkable results. Compared with the 47 year average, temperature conditions were 4°C warmer , the total snowfall was almost half (82 cm vs. 145.1cm) and total rainfall was 1364% higher (53.2mm vs 3.9mm)." This weather pattern would affect caribou in 2 ways: first, the low snowfall prolonged the early winter season (Apps et al. 2001), when caribou, moose and wolves are in relatively close proximity with each other (Stotyn 2008). Second, the rainfall resulted in a hard, crusty snowpack that may have allowed wolves to travel more extensively, particularly to higher elevations where caribou are usually separated from wolves during the late winter season.
2) Calf mortality may be distributed evenly throughout the year, rather than clustered during the first month of life. This pattern would be in contrast to all caribou studies and most ungulate literature in North America. If this is the case, then penning will have little effect on λ (lambda or population growth rate). This pattern may occur because Revelstoke contains a full complement of predators, including limited wolf and cougar abundance (Serrouya et al. 2015), but high grizzly and black bear density, and wolverines that are relatively abundant. All 5 of these predators were photographed within 1 km of the pen within a 2-week period during the 2014 spring.
3) Pen born calves are subject to higher mortality rates after release than wild born calves due to an unknown reason.

With a sample size of 18 pregnant cows currently in the pen, and if 2015/16 proves to be a "typical" winter, we should be able to discriminate among these 3 reasons. Furthermore, we have ordered calf collars that are more resilient to vegetation in North American forests, so collars are less likely to fall off. This monitoring may allow us to determine cause and timing of mortalities with greater certainty.

Recruitment Survey

The 2015 survey is not a population census; rather an estimate of calf recruitment (the percentage of the population consisting of calves in March). The survey sample size (78) was slightly higher than the last recruitment-only survey in 2012 (n=70). However, as with 2013, conditions for surveying were extremely poor this year, with a low snowpack resulting in poor sightability due to caribou spending more time below tree-line. Bull-only groups tend to be small and are often located in more rugged terrain; they may have been missed at a higher rate than mixed groups due to conditions. In addition, we targeted groups with collared females using telemetry. This may skew the calf recruitment rate upwards by excluding some males from the total. However, the recruitment rate is relatively robust to changes in the total number of caribou surveyed (e.g. if we missed 10 bulls this would decrease the percent of calves to 10.2%).

The calf recruitment rate in 2015 (11.5%) is within the range (8.9-14.3%) reported since the late 1990s and far below the calf recruitment rate reported in the mid 1990s (approx. 19%) when the population was stable or increasing.

As part of efforts to recover caribou populations, the moose population has been reduced by 83% from the 2003 population of 1650 with hunting to near the historic ecological carrying capacity (Serrouya et al. 2011, Serrouya et al. 2015) and wolf populations have declined by 50 % since 2007 (Serrouya et al. 2015). However, bear and wolverine predation is also thought to be a limiting factor in neonate survival (Gustine et al. 2006) and is unlikely to be reduced by reducing moose populations. In spite of recent population surveys suggesting that the Columbia North caribou subpopulation is stable or perhaps increasing (Serrouya et al. 2015) possibly due to a reduction in wolf mortality, the calf recruitment rate remains stubbornly low.

A population census should be conducted every three years and only when conditions will result in a reliable estimates. Calf recruitment surveys should be conducted annually to determine the impact of the maternal pen.

Effect of adult female survival

For most long-lived mammals, it is generally accepted that adult female survival has a greater influence on population growth than calf survival (Hovey and McLellan 1996, Gaillard et al. 1998). In our case however, the increased adult survival (100%) did not compensate for the low calf survival we observed. The 100 % adult survival rate was 5 – 10 % higher than expected, and consequently increased λ by ~ 1 unit, but had the calf survival been at the 60% level, λ would have been 2 units higher than the status quo. Assuming that we did not disrupt any animals during the first year of capture, it appears as

though the penning did not worsen the population trend, and may have caused a slight improvement due to the effect of increasing the survival of 10 adult females (roughly 1/6th of the adult female population) to 100 %. We are careful not to claim that the pen had the effect of increasing adult survival because we had no wild adults simultaneously collared for comparison, and 10 adults is a small sample size. However, from 1992 to 2004, wild adult survival never exceeded 90 % in any year in the Columbia North subpopulation (Wittmer et al. 2005a).

Challenges and future considerations

There remain significant challenges with this project. Penned adults may be less likely to become pregnant, either because their movements have been disrupted due to transport and containment within the pen, or because they are more likely to have a calf at heel during breeding. The latter factor can be characterized as a density dependent effect, something we did not include in our life-table analysis, but should be considered in the future. Another important avenue of research via modelling is to determine the trade-off between penning an adult with a 10-month-old-calf, compared to selecting a cow without a calf. The cow with the calf might have a lower likelihood of pregnancy (our 2014 and 2015 capture suggest 1 of 3 of such animals was pregnant). However, increasing the 10-month-old-calf's survival may have a similar or greater benefit as recruiting a neonate calf to 10-months.

Even under optimal conditions, penning is unlikely to recover caribou unless it is done in conjunction with other recovery measures, including habitat and predator-prey management. This generalization is particularly relevant when dealing with small and declining populations that are subject to random events (i.e. demographic and environmental stochasticity). With a higher number of pregnant caribou currently in the pen, we hope that many sources of uncertainty highlighted in this report will be resolved in 2016.

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