

Revelstoke Caribou Maternity Pen Project
Annual Report, Year 3
April 1st 2016 to March 31st, 2017
Version 1.2

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Executive Summary

Southern Mountain caribou are listed as endangered by the Province of BC and threatened by the Federal Species at Risk Act. Several caribou subpopulations are declining at a rate that will likely result in extirpation in the near future (Wittmer, Ahrens and McLellan, 2010), largely because of excessive predation (Wittmer, Sinclair and McLellan, 2005) due to altered predator-prey dynamics resulting from habitat loss. Predation is listed as an “urgent” threat in the Federal Southern Mountain Caribou Recovery Strategy (2014).

Revelstoke Caribou Rearing in the Wild Society (RCRW) is a community-led initiative that launched a 5-year maternal penning pilot project in March 2014. The aim is to determine if penning can improve the survival of calves and adults by protecting them in a secure enclosure until calves are larger and more capable of avoiding predation. The pen is located approximately 100 km North of Revelstoke, B.C., within the range of the Columbia North caribou subpopulation.

The goal of maternal penning is to increase calf survival by a factor of 2 to 3 (from a recent rate of 20%). The project will require 1-3 years to demonstrate feasibility and multiple years to increase the population.

10-20 pregnant caribou are placed in a remote enclosure safe from predators, for 4 months (March –July) until calves are approximately 4 weeks old. Adult caribou and a sample of calves are fitted with radio-collars to monitor movements and survival after release, and wild calf recruitment is estimated annually in March. During pen operations, two staff members live on-site, provide animal care and patrol the area for predators using professionally reviewed protocols. A veterinarian is on-call throughout operations, and on site during capture and calving. All mortalities in the pen, and of collared animals post-release, are investigated to determine the cause.

In the first year of the project (2014-15) adult survival in the year after capture was 100% (n=10), but only 22% of calves born (2/9) survived. This survival rate was similar to the rate estimated in this year (2014-15) for wild calves (20%). In the second year of the project (2015-16) calf survival to ten months of age in March 2016 was ~ 3-fold higher (60%, n=15) than estimated wild survival (22%), but three adults died (of 18 captured) in the year following capture. Mortality within the pen was higher in the second year of the project (4/15 calves and

1/18 adults).

In response to in-pen mortalities in 2015, a review of the pen facilities and protocols was conducted by a wildlife veterinarian. The pen was expanded from 6.4 to 9.3 ha and a solar-powered flow-through water system was constructed at two stations in the pen in fall 2015. Staff received additional animal husbandry training, protocols were revised to refine biosecurity measures, calf capture and record keeping methods. In addition, a wildlife veterinarian was hired to be on-site for 2 weeks of calving during the 2016 season. In addition to these measures, fecal material in high use areas was reduced in fall 2016.

On March 25th, 2016, twelve adult female caribou were captured from the North Monashee Mountains and transported by helicopter to the pen for year 3 of the project. Eleven of 12 adults were pregnant and birthed 11 live calves between May 19th and June 12th. Three calves died within 48 hours of birth. Cause of mortality was thoroughly investigated and not entirely conclusive, but highly suggestive of a combination of failure of passive transfer of immunity and infection. One calf sustained a fractured femur in late June and was transferred to the Calgary Zoo, but did not recover despite surgery. 12 adults (all collared) and 7 calves (4 collared) were released from the pen on July 16th, 2016.

Post-release, one cow (2016-09) was killed by wolves on December 31st, 2016. This cow lost her calf prior to release from the pen. One collared calf (2016-22) perished due to ice buildup on the collar. Three adult, and one calf collar failed, and the fate of these animals is not known. Two of three calves without collars were seen “at heel” of their cows in March. Penned calf survival to March 2017 was 40% (4/10 calves we could track) which compares to a wild calf survival rate of 26% for this year (Serrouya et al. in prep.). A census in April 2017 confirmed that the Columbia North subpopulation has been roughly stable since 2003 (Serrouya et al. in prep).

Project progress to March 31st, 2015 is summarized in the first annual report (R. Serrouya *et al.*, 2015) (<http://rcrw.ca/media-2015/>) and progress to March 31st, 2016 in the second annual report (Furk and Serrouya, 2016) available on request. A 2016-17 final report will be available in July 2017.

Introduction

Southern Mountain caribou (SMC) are listed as endangered by the Province of BC and threatened by the Federal Species at Risk Act (Environment Canada 2014). Several caribou subpopulations are declining at a rate that will likely result in extirpation in the near future (Wittmer et al. 2010), largely because of excessive predation (Wittmer et al. 2005b) due to altered predator-prey dynamics resulting from habitat loss. Predation is listed as an “urgent” threat in the Federal Southern Mountain Caribou Recovery Strategy (2014).

Southern mountain caribou declined across the province between 1997 and 2000, and most herds continue to decline (Environment Canada 2014). The Columbia North herd (located north of Revelstoke in the Selkirk, Rocky and Monashee Mountains) declined by roughly 25% between 1997 and 2002 and has not recovered (Serrouya, Furk and Legebokow, 2014) but has been approximately stable for 14 years, since 2003 at approximately 150 animals (Serrouya et al. in prep). In the Columbia north herd, calf recruitment has been low since the late 90s (8.9 -14.3%) and below the (19-20+%) recorded in the early 80s and mid 90s (Simpson and Woods, 1987; McLellan, Serrouya and Flaa, 2006; Serrouya, Furk and Legebokow, 2016).

It is increasingly clear that addressing several limiting factors simultaneously will be needed to recover caribou (Environment Canada, 2014; Boutin and Merrill, 2016). In the Columbia North area, wolf numbers have been reduced by about 70% because of an experimental moose reduction (Robert Serrouya *et al.*, 2015). Bears and wolverine are also common predators of mountain caribou (Wittmer et al. 2005a), and are likely an important source of calf predation, particularly within the first month of life (Adams, Singer and Dale, 1995; Gustine *et al.*, 2006).

Our goal is to use maternal penning in the Revelstoke area to increase calf survival and contribute to population recovery. Maternal penning addresses the threat of predation by protecting young caribou calves and their cows in an enclosure during between March and July, when calves are particularly vulnerable. Adults may also benefit from penning during a time of year when mortality is high (Wittmer et al. 2005a). Maternal penning has increased calf survival in the Yukon of 5-month-old calves to 0.74, much greater than that of wild calves (0.15) (Chisana Caribou Recovery Team, 2010), though this increase had no influence on the population trend because too few females were penned (Layne Adams, US Fish & Wildlife

Service, in prep.). Survival rates of calves while in the pen were 0.95 (n = 96 calves). However, results were less clear in another pilot area in Alberta (Smith and Pittaway, 2011).

This technique is recommended by the Federal SMC Recovery strategy and the BC Provincial Government as one option to recover caribou. We acknowledge that additional conservation actions will be required to increase the Columbia North subpopulation move towards a self-sustaining population.

Goals and Objectives

The project is collaborative, and engages a diverse group of stakeholders, including recreationalists, environmentalists, First Nations, industry and biologists to work together to deliver the project. Benefits of this model are long lasting and include relationship building, increased awareness and cross- sector communication. RCRW also aims to engage the public to increase awareness and engagement in caribou conservation through volunteer opportunities, school education programs, presentations and media engagement.

There are two main operational objectives, these are:

Objective 1 is to determine if maternal penning can improve the survival of captive-reared calves, relative to unpenned calves, in the Columbia Mountains Ecosystem. Our measure of success will be 90% survival of adults and calves in captivity, and an increase in survival relative to unpenned calves, by a factor of 2 – 3 in March. The multi-year target is 45% survival of calves to ten months of age. Associated biological questions will also be addressed:

1. Are parturition rates as high as pregnancy rates in the CME? Caribou pregnancy rates in BC are 92% (Wittmer et al. 2005a), but it remains unknown whether pregnant cows give birth to viable calves.
2. Will the survival rate of penned calves be higher than recent survival rates of wild calves for this area?
3. Will 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 elevation migrations that occur in this area (*sensu* (Apps *et al.*, 2001)).

Objective 2 (population-level, future years) is to increase recruitment, and to stabilize and then increase the Columbia North caribou subpopulation. If the first objective is successful, meeting

this objective will require penning approximately 20 caribou (1/3 of the female adult population).

Study Area

The project focuses on the Columbia North Caribou subpopulation, located North of Revelstoke, BC. This subpopulation lives in the North Selkirk and North Monashee Mountains, and a small portion of the Rocky Mountains near the Wood River. This area is part of the Columbia River Watershed. The maternal pen is located approximately 100-km north of Revelstoke, BC, near Ruddock Creek, beside the Columbia River (Lake Revelstoke Reservoir) in the Interior Cedar Biogeoclimatic Zone at 580m ASL. The pen was expanded from 6.4 to 9.3ha in 2015 and includes portions of a regenerating clearcut and old growth cedar hemlock forest. Caribou in this region use low elevation old growth forests in late fall and for a short part of spring. They calve at tree line or above, and spend summer and winter in upper elevation and subalpine Engelmann spruce and subalpine fir forests(Apps *et al.*, 2001).

Methods

A summary of methods is provided here. For details, please refer to the operational protocols for capture, husbandry, calving, release and monitoring that are outlined in a living document titled *Protocols and Guidelines for the Revelstoke Caribou Rearing Caribou in the Wild Maternity Penning Project February 2017, Version 2.1*.

The caribou enclosure (6.4 ha) was constructed in fall 2013 and was expanded to 9.3 ha in fall 2015. The fence (Figure 1) consists of a 12-foot high visual barrier of black landscape cloth, surrounded by a 14-strand high-tensile electric fence that is powered 24 hours per day during operations (for construction detail see Serrouya et al. 2015). The fence has performed well in the deep snows of the Columbia Mountains, but requires annual maintenance to fix broken welds and bent posts caused by heavy snow-load.

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; 3) it was operationally feasible because it was adjacent to a hunting camp; where sleeping, power and communications were readily available and 4) the site had flat topography with good lines of sight, and a source of

water. In 2015, a solar powered flow through water system (source: Lake Revelstoke) was installed at two sites in the pen at the SE corner and near the main entrance gate.



Figure 1 The pen fence, including electric wires and visual barrier. Taken from the NW corner of the pen.

Capture

Up to 20 adult females are captured annually. The number of caribou captured is re-evaluated every year to determine if we have successfully met our goals under objective 1 (90% calf and adult survival in pen, and a 2-3 fold increase in penned calf survival compared to wild calves) before moving into the higher densities required to meet objective 2 (population level effect).

Avalanche and weather conditions were monitored for suitable conditions, and possible capture locations were evaluated for suitable caribou and terrain with minimal avalanche hazard prior to capture. The RCRW avalanche safe work procedure was followed for staff working in avalanche terrain and included a short rescue training session, a team leader with avalanche safety training, and avalanche safety equipment. All staff (24) attended a capture meeting prior to the operation to review protocols in detail.

Caribou were captured by a professional crew (Bighorn Helicopters Inc.) using a net gun deployed from a helicopter when temperatures were cool (to reduce the chance of hyperthermia), and the snow deep (to prevent injuries). Capture attendants immediately attended to the captured animal, detangled the net, hobbled, blindfolded, and administered an intranasal sedative (medetomidine; under the direction of a wildlife veterinarian).

Each caribou was placed in a capture bag and transported via helicopter (2 at a time; with an

attendant) to a location 200-m away from the enclosure (to avoid disturbing caribou already in the pen). Transport times were a maximum of 25 minutes. Caribou were carefully transferred to the pen in a toboggan pulled by snowmobile with their heads on the lap of an attendant.

A Wildlife Veterinarian (Bryan Macbeth, DVM, PhD) supervised handling at the pen and was assisted by Caeley Thacker (DVM). Once in the enclosure caribou were weighed on a platform scale, and assessed at two processing stations by veterinarians for depth of sedation, age estimate, physical condition, injury, presence of external parasites. A blood sample was drawn (for serum progesterone to confirm pregnancy) and for future analysis (as indicated) of serum antibodies, serum chemistry, complete blood count, and analyses following Murray et al. (2006). Progesterone levels were determined by Prairie Diagnostic Services lab using standard assays. Hair and tissue samples (ear plugs) were collected and dried in paper envelopes for DNA archiving and feces were collected and frozen. A standard protocol of prophylactic treatment was administered (an anti-inflammatory, larvicidal anthelmintic, vitamin E, selenium, and antibiotics (only if required)).

A biologist specializing in assessment of body condition (Rachel Cook) estimated Ingesta Free Body Fat by collecting body conditions scores, and ultrasound of fat (results in prep.). Technicians applied bilateral ear tags, and a satellite-linked GPS radio collar with a UHF proximity detector (Vertex Plus, 670g, Vectronic Aerospace GmbH). Once processing was complete a Veterinarian administered a drug antagonist (Atipamezole) and caribou walked away from the processing site.

Husbandry

Staff (minimum of one, usually 2) lived on-site approximately 200-m away from the pen at a pre-existing facility and they patrol the pen, make repairs, feed and observe caribou for 7-8 hours/day. Staff used dedicated footwear in the pen, hand sanitizer, and disinfectant boot washes when entering the pen. Dedicated clothing, as well as gloves were used when handling animals. Visits to the pen were minimized, and visitors were restricted to the main blind. Visitation was pre-approved and is limited to funders, media (rarely), and scientists.

Staff received a day of training at the beginning of the season with two wildlife Veterinarians that included a review of protocols, animal health records, how to evaluate condition, identify abnormal behaviour, and information on the need for biosecurity measures. Observation

protocols required that all animals were visually confirmed within the pen at least twice a day and observed feeding and drinking. Each caribou was closely observed daily with a scope from “tip to tail” and a body condition score is assigned every few days. Photos were taken frequently to track condition and veterinarians are regularly updated.

After capture, caribou were fed arboreal lichen and transitioned to a pelleted ration developed specifically for caribou. Caribou were then fed ad libitum pellets in 5 troughs twice per day. After snowmelt, water was provided in 5 troughs (total) at two stations in the south of the pen from a solar powered pump. Water usually ran from 8am-5pm, and was available in the troughs through the evenings. Troughs were cleaned every 3-4 days. A platform scale was placed at one of the troughs with a motion-triggered camera to record weights, however few caribou could be enticed to step on the platform despite several re-designs, and feed options provided.

Five infrared motion triggered cameras were positioned at roads and trails around the pen to monitor predators and are checked every 2nd day. Staff patrol the pen perimeter 1-2 times per day to ensure the fence is functioning, and to detect sign of predators.

During calving, 2 staff and one Veterinarian (from May 22nd-June 5th) were on site to monitor progress, and assist with capture of calves. Calves were captured 12-24 hours after birth, sexed, weighed, and fitted with a small, expandable VHF/UHF transmitter collar (25cm diameter, with four 4-cm stitched folds and a rot-off (expanded size 41cm), weight 64g; Vectronic Aerospace, GmbH), 1 small ear tags (All-Flex Sheep Tag, Orange, applied in right ear) and a hair sample was taken for DNA archiving. The pair was left alone to reunite and was observed at a distance to ensure this occurred.

All mortalities were necropsied by a wildlife veterinarian and/or a certified Veterinary Pathologist from the BC Ministry of Agriculture Animal Health Centre, or veterinarians at the Calgary Zoo.

Once calves were 4-6 weeks old, and there was no recent predator activity, all caribou were released from the pen by opening the NW gate and placing lichen and water outside the gate. 1-2 staff members observed from a blind to ensure all caribou have left, and then sweep the pen to ensure there are no caribou inside.

Monitoring

All collared animals were monitored daily for mortality and calf separation messages by satellite transmission. Adult collars deployed in 2016 are scheduled to drop off using a timed release mechanism on 29.03.2018. Calf collars are expandable and have a cotton rot-off designed to fall off after 1 year. The VHF pulse rate changes if there has been no movement (mortality signal) for 12 hours (adults) and 3 hours (calves). Adult collars also transmit a mortality message via satellite. When collars were off air, or calves were missing, monitoring flights using a fixed wing aircraft or small helicopter were used to locate animals and check for status.

We aimed to investigate mortalities as soon as possible and within 48 hours of detection. Signs of struggle, predator sign (hair, tracks, feces), the position and state of the carcass, are all noted and photographed/videotaped to determine cause of mortality. If possible, the carcass is removed for necropsy (by long line), or a thorough inspection of the carcass (for bruising, deformity, punctures, condition etc.) is conducted and samples (where present) are collected using a list developed by Bryan Macbeth (DVM, PhD) for the Foothills Institute.

At adult caribou mortality sites, a femur is collected for marrow fat analysis along with an incisor to estimate age per. (McLellan *et al.*, 2012). Fat deposits decline in periods of food shortage, and the relationship between marrow fat and body fat is linear below about 9% body fat in adult caribou ((Chan-mcleod, White and Russell, 1995; Allaye Chan-McLeod, White and Russell, 1999)). Very low marrow fat indicates starvation. We followed the methods of (Neiland, 1970) to determine marrow fat content and no correction was made for mineral residue (Davis, Valkenburg and Reed, 1987).

Adults with calves that were released from the pen without collars were located in March using a helicopter. Staff landed at a distance to avoid triggering a flee response, and used a scope to determine if the cow in question still had a calf at heel.

The Province of BC conducted a full census of the Columbia North herd including an estimate of calf recruitment. Methods are outlined in a separate report.

Outreach

Outreach and engagement activities are outlined in a communications plan updated annually. Activities include once annual press release (after capture) and at least twice annual “factsheet” updates posted to the website. RCRW maintains a website, and presence on facebook. RCRW communicates with the Klinse-Za Maternal Pen to share information. The Province of BC is regularly updated with progress, and the group maintains links to academics, biologists and resource managers in BC in order to share progress and advice.

Results

Capture, Husbandry and Monitoring

On March 25th, 2016, twelve adult female caribou were capture from the North Monashee Mountains and transported by helicopter to the pen. In addition to two wildlife veterinarians to assess health and monitor, a biologist specializing in wildlife condition was present to estimate body fat using standardized body condition scores and ultrasound (analysis in prep.). Caribou weighed an average of 115kg (range 101.5-133.5). Cow Y2016-07 weighed 101.5kg in 2016 at capture, and 112.7kg in 2015. Two of the caribou were recaptures, from 2015 and 2014 respectively.

Eleven of 12 adults were pregnant and birthed 11 live calves (5 male, 6 female) between May 19th and June 12th. The cow that was not pregnant was the only one noted lactating at capture. Four calves died in the pen. Three died within 48 hours of birth. Cause of mortality was thoroughly investigated and not entirely conclusive, but highly suggestive of a combination of failure of passive transfer of immunity and infection (detailed pathology reports available on request). One calf sustained a fractured femur in late June and was transferred to the Calgary Zoo, but did not recover despite surgery. 12 adults (all collared) and 7 calves (4 collared) were released from the pen on July 16th, 2016. Of calves that were captured, or died, they weighed an average of 9.9kg (range 8.9-12.6kg).

In 2016 caribou consumed 3.4kg pelleted ration/adult/day and this includes any feed the calves

ate, wasted feed and is averaged over the whole period from capture to release. 175kg of lichen (in 200 hours) was collected in winter 2016-17 for caribou captured in April 2017.

Between capture and release 2016, photographs of a cougar, wolves and bears were captured on remote-triggered cameras and recorded on track traps. A cougar stalked the pen over a period of weeks in late June and July, but was not successful in gaining access. The Province of BC attempted to remove this cougar, but it was never successfully located.

Post-release, one cow (2016-09) was killed by wolves on December 31st, 2016. Little was remaining at the site, other than a few clean bones, and lots of wolf sign. This cow appears (based on GPS data) to have been chased from the subalpine down to near the valley bottom where she was killed. A long bone collected is pending marrow analysis. This cow had lost her calf prior to release. One collared calf (2016-22) perished due to ice buildup on the collar on January 25th, 2017 and subsequent quick suffocation, an event previously unreported in BC for ungulate calf collars (H. Schwantje DVM, pers. comm.). The status of each caribou captured or born in the pen in 2016 is outlined in Figure 2 and Figure 3.

Three adult collars failed due to low battery (likely due to an error in programming that resulted in too many transmissions of proximity data). Cow 2016-01 last reported on December 16th, 2016, and was not with her calf (2016-13) that was found alive at Fernie Creek on March 23rd, 2017. The collars on Cow 2016-10 and 2016-11 were last detected on a monitoring flight on December 8th, 2016; both in low battery mode. The collared calf (2016-21) of 2016-10 was last detected on December 9th, 2016 (proximity detected on 2016-12). None of these collared caribou were detected during monitoring flights or during the population census in early April, or during a thorough monitoring flight on January 30th, 2017.

During monitoring flights on March 17th, 20th, 23rd two of three calves that were released without a collar were detected at the heel of their cow (2016-07, 2016-04); one was not detected with the cow (2016-05) and presumed dead. Overall, 4 of 11 calves born in the pen were alive in March and one was lost.

RCRW ID	Capture Name	Last Known Alive Date	Pregnant April 2016?	Status March 23, 2017	Collared?	Other Capture Year ID
53	Y2016-01	8-Dec-16	Y	Lost	Y	
54	Y2016-02		Y	Alive/on-air	Y	
55	Y2016-03		Y	Alive/on-air	Y	
56	Y2016-04		Y	Alive/on-air	Y	
57	Y2016-05		Y	Alive/on-air	Y	
58	Y2016-06		N	Alive/on-air	Y	
25	Y2016-07		Y	Alive/on-air	Y	Y2015-05
59	Y2016-08		Y	Alive/on-air	Y	
60	2016-09	31-Dec-16	Y	Mortality - Wolves	Y	
8	Y2016-10	8-Dec-16	Y	Lost	Y	Y2014-08
61	Y2016-11	8-Dec-16	Y	Lost	Y	
62	Y2016-12		Y	Alive/on-air	Y	

Figure 2 Fate and pregnancy status of adult female caribou captured in 2016 for the maternal pen.

RCRW ID	Capture Name	Maternal Cow	Last Known Alive Date	Birth Date	Status March 23, 2017	Collared?
68	Y2016-13	Y2016-01		19-May-16	Alive/on-air	Y
69	Y2016-14	Y2016-02		12-Jun-16	Alive/on-air	Y
70	Y2016-15	Y2016-03	28-May-16	26-May-16	Mortality (neonatal)	N
71	Y2016-16	Y2016-04		27-May-16	Alive/on-air	Y
72	Y2016-17	Y2016-05	16-July-16 (release)	31-May-16	Mortality/not "at heel"	N
73	Y2016-18	Y2016-07		24-May-16	Alive/ "at heel"	N
74	Y2016-19	Y2016-08	25-May-17	23-May-16	Mortality (neonatal)	Y
75	Y-2016-20	Y2016-09	2-Jul-16	30-May-16	Mortality (fractured femur in pen)	Y
76	Y2016-21	Y2016-10	9-Dec-16	27-May-16	Lost (collared)	
77	Y2016-22	Y2016-11	23-Jan-17	25-May-16	Mortality (collar ice buildup)	Y
78	Y2016-23	Y2016-12	22-May-16	20-May-16	Mortality (neonatal)	N

Figure 3 Fate of caribou calves born in the maternal pen in 2016.

Outreach

A press release was issued in April 2016 updating capture and 2015 project results, with subsequent local and regional media coverage through June 2016. A 2016-17 update on project results was released on the RCRW website in late March 2017. RCRW representatives participated in the Columbia Mountains Institute for Applied Ecology Predator Prey Conference in fall 2016 and the Columbia Basin Environmental Education Network workshop in April 2016. Approximately 210 volunteer hour have been dedicated to harvesting lichen in winter 2017.

Discussion

Wild calf 10-month survival³ for the 2016 cohort was estimated at 27%, which is slightly higher than estimated for 2015 (22%) and 2014 (20%) (Serrouya et al. in prep). This compares to known values for penned calf, 10-month survival, for the 2014 (22%, from n=9 pregnant cows), 2015 (56%⁴, n=16 pregnant) and 2016 (40%⁵, n=11 pregnant) cohorts. Overall the maternal pen project has added 6 additional calves to the population in three years of operation.

Pregnancy rates for all adult female caribou captured for the maternal pen are high (90% in 2014 (9/10), 89% in 2015 (16/18), 92% in 2016 (11/12)). It is worth noting that we are targeting groups for capture where there are few or no calves, so this rate may be high if a calf at heel results in decreased chance of pregnancy. Over the course of the project so far, 35 of 36 pregnant cows have given birth to live calves. All cows were successfully released from the pen in 2016. Over the course of the project, only one cow has died in the pen (of 40 captured), possibly due to complications from calving.

³ The wild calf 10-month survival estimates should be viewed with some caution since they are back-calculated using an estimate of bull:cow ratio and pregnancy rather than a sample of wild collared caribou. The bull:cow ratio (50:100) is what might be expected in a non-hunted population but it is not a local, empirically derived value. The pregnancy rate we used (92%) is empirically derived from local data over multiple years (mostly prior to 2005, (Wittmer *et al.*, 2005), and may not adequately reflect variability in any single year.

⁴ There were 18 female adults captured in 2015, 16 were pregnant, 15 calves were born, and 9 survived to 10 months.

⁵ There were 12 female adults captured in 2016, 11 were pregnant and parturient, 4 survived to 10 months and one was lost (fate unknown) but survived to at least Dec. 2016.

This is the second year in a row where several calves have died in the pen. The proportion of calf mortalities occurring prior to release have increased year over year, though the absolute number has been the same in 2015 and 2016 (0% of calves born in 2014 (0 of 9), 4 of 15 (27%) in 2015 and 4 of 11 (36%) in 2016). This is despite a thorough review of operations in 2015 by a wildlife veterinarian (B. Macbeth DVM, PhD) and implementation of the recommendations including expanding the pen in fall of 2015 from 6.4 to 9.3 ha, (this included some old-growth and thus shade- providing forest), construction of two flow-through watering stations, improving staff training, having a veterinarian on-site during calving and improvements to biosecurity measures. Additional measures implemented for 2017 to improve husbandry are a reduction in density of fecal material in high use areas the pen (completed fall 2016), and one additional water station in the north half of the pen to be on line by May 2017.

Most of the caribou, once released from the pen, have stayed on the ridges above the pen until significant snowfall results in larger movements away from the area (although one caribou made large movements immediately after release in 2016). Predation events (where the cause is known) have occurred in the early winter (Nov-Jan) in proximity (within 6km) to the pen. In early winter, caribou in this area use lower elevation old growth forest to access limited forage, where they are more likely to encounter predators. Much of the best habitat early winter habitat has been lost to forest harvest. Mortalities after release (where the cause is known), from July 2014-March 2017, are a cow and calf predated by wolves (2 incidents), 2 cows and 2 calves predated by a cougar, and one calf perished because of ice buildup on a collar. One of the two cows killed by a cougar in 2015 was in poor condition (41% marrow fat). Marrow fat is not a reliable indicator of condition for sub adults. It is unclear why a cow released from the pen would be in such poor condition. Wild adult female survival ranged from .783 to .873 between 1993-2008 (Serrouya *et al.*, 2017) and penned adult annual survival is higher than this value over the course of the project (detailed analysis pending).

Given the current population size for Columbia North subpopulation, modeling indicates (updated in Furk and Serrouya 2016) that the number of female caribou penned must be approximately 20 to have a population-level effect. Both penned calf and adult survival will impact the effect size of maternal penning on population growth. A decision was made not to increase the density of caribou in the pen in 2017 due to continued issues with in-pen mortalities (8/35 calves born). The cause of these issues is unknown, and may be related to conditions inherent to the site (low elevation, warm, some noise), and/or may be an indication of issues with neonate survival in the wild. For comparison, In the Chisana maternal pen

project, 10 calves died prior to release out of 146 born over 4 years of the project (6.8%) (Chisana Caribou Recovery Team, 2010). In an ongoing maternal pen project started in 2014 near Chetwynd BC (Klinse-Za) few calves have died in the pen after birth (2/27) but several cows that were pregnant at capture, aborted or had a stillborn calf (95% pregnant, 77-80% parturient, n=35). The number of calves released from the pen is similar for the Revelstoke (27 calves/40 cows captured), and Klinse-Za (27 calves/35 cows captured) projects.

Maternal penning has had a net positive impact but to date the principle increase in lambda units (from 0.95 to 1.02) for this herd has been caused by the moose reduction treatment (Serrouya *et al.*, in review; Serrouya, 2013; Robert Serrouya *et al.*, 2015). Alternate prey (moose) have been reduced by >70% with hunting, with a concomitant reduction in wolves from 25-30 (in 2007) to 11-13 (2015) along Lake Revelstoke (Corey Bird *et al.*, 2015). In contrast, deer populations have not been reduced. Forest harvesting continues in caribou habitat and it is unclear what the rate of loss is, in comparison to historic levels and habitat recovery (as mid-aged forests become caribou habitat). A population census of the Columbia North herd was conducted on April 3rd and 4th, 2017 (Serrouya *et al.* in prep.) indicating a stable population, in contrast to several other caribou herds in the region that continue to decline such as Columbia South (Serrouya *et al.* 2014) and Central Selkirks (Leo Degroot pers. comm).

Recommendations

- If in-pen calf mortalities continue to exceed our target (10%) a selection process for determining an alternate site should be considered.
- Cows captured in 2016 will continue to be monitored into 2018 to get additional information on wild adult female survival and recruitment. We will consider that the effect of the pen may last beyond one year after release, and that rearing a calf to 10-months may impact the ability to successfully recruit a calf the following year.
- Update an analysis to compare movements (rate of movement, elevation use, seasonal range comparison) of penned caribou to older data from wild cows with GPS collar data to determine if movements are unusual.
- A detailed analysis of survival data will be completed in Summer 2017.

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