Translocation of southern mountain caribou using a soft-release technique

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Abstract: Southern mountain caribou (*Rangifer tarandus caribou,* SMC) in British Columbia, Canada, are experiencing a precipitous population decline and range recession. In 2019, the two southernmost herds, the South Selkirks and the Purcells-South herds, were functionally extirpated and facing imminent extinction. To rescue the remaining animals, a translocation into the Columbia North herd range was performed using a soft-release method. The translocated animals were released alongside a captive-reared yearling and a resident adult female from the Columbia North SMC herd. A comparison of habitat selection behaviours at the 2nd order of selection demonstrated that the released animals responded to habitat and elevational conditions similarly to resident caribou. The translocation and soft release of Purcells-South and South Selkirks individuals demonstrates that soft release of wild translocated and captive-reared SMC can be successful and should be considered where and when feasible.

Key words: Conservation translocation, functional extirpation, population reinforcement, *Rangifer tarandus caribou*, soft release, Southern mountain caribou

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Introduction

Southern mountain caribou (*Rangifer tarandus caribou*; SMC) have experienced a precipitous population decline and range recession since the 1990s (COSEWIC, 2011). This ecotype of woodland caribou forage during the winter on arboreal lichens in the high elevation mature and old subalpine forests of southeastern British Columbia (BC), Canada. They are classified as threatened under the Canadian Species at Risk Act and assigned to the BC Conservation Data Center Red List. They are also identified as one of the 12 Designatable Units for caribou in Canada (Designatable Unit 9), terminology that acknowledges that SMC are an irreplaceable component of Canada's biodiversity (COSEWIC, 2011). Their population, close to 3000 individuals in the early 1990s, is now estimated at less than 1250 individuals (Government of British Columbia, 2021). Six herds are extirpated, and six of the 10 remaining herds contain fewer than 30 mature individuals. The SMC geographic range, which historically in-

cluded the mountain ranges of east central and southeastern BC, southwestern Alberta, eastern Washington, northern Idaho, and northwestern Montana, is now limited to southeastern BC. The decline of the SMC population is attributed to habitat- or disturbance-mediated apparent competition (COSEWIC, 2014, DeMars *et al.,* 2019, Serrouya *et al.,* 2019). The conversion of old-growth coniferous forests into early-seral stages through forest harvest directly increases cervid populations (e.g., moose (*Alces alces*), deer (*Odocoileus* spp.)). This larger prey base in turn supports the growth of predator populations (especially wolf (*Canis lupus)* and cougar *(Felis Concolor*)), which ultimately increases predation pressure on caribou. This effect is compounded by the presence of linear features (e.g., roads, power lines) and backcountry recreational activities which increase overall predator hunting efficiency and facilitate predator access to and movement within caribou winter range (spatial overlap hypothesis) (DeMars & Boutin, 2018; Dickie *et al.,* 2016; James & Stuart-Smith, 2000; McKenzie *et al.,* 2012). These continuing threats are predicted to lead to the extinction of more than half of the remaining herds within the next 40 years or less (Wittmer, 2004).

In the face of imminent herd extinction, Environment Canada (ECCC) revised the *Recovery Strategy for the Woodland Caribou, Southern Mountain population (Rangifer tarandus caribou) in Canada* (Environment Canada, 2014) in 2018, concluding that the Strategy's objectives were no longer achievable without immediate intervention and ordered that mitigation measures be undertaken to recover SMC (ECCC, 2018). With knowledge of only one individual in the South Selkirks herd and five individuals in the Purcells-South herd, both herds were functionally extirpated (i.e., non-viable) and would disappear without drastic action (Compton *et al.,* 1995; DeCesare *et al.,* 2011; Stronen *et al.,* 2007). To rescue the remaining animals, a translocation into the Columbia North SMC range was performed using, for the first time in BC, a soft-release method.

Conservation translocation is the intentional movement of species from one geographic area to another with the intent to improve its conservation status (IUCN/SSC, 2013). This is a relatively commonly used tool to reinforce, introduce, or re-introduce wild ungulate species and has been used for caribou (Griffith *et al.,* 1989; IUCN/SSC, 2013) with mixed outcomes. Most failed caribou translocation projects have been the result of predation, exposure to the meningeal worm *Parelaphostrongylus tenuis*, poaching, dispersal, low lichen supplies, accidents and other unknown causes (Bergerud & Mercer, 1989; Cichowski *et al.,* 2014; Compton *et al.,* 1995). Most projects have used a hard release approach and immediately released the translocated animals to the recipient site. Because of its simpler logistics and reduced cost, this method is often chosen over a soft release. Soft release consists of holding animals temporarily at the release area, giving them the opportunity to acclimate to the recipient site while protected from predation and provided with feed. However, soft release is preferred for the release of translocated social ungulates such as caribou since it allows animals to recover from the stress of capture and transport, reduces immediate dispersal from the release area, potentially lowers initial predation-caused mortality and encourages the formation of stable social structures among the translocated animals (Kock *et al.,* 2010; Ryckman *et al.,* 2010; Wacher & Robinson, 2008, Gordon & Gill, 1993). Caribou are known to adjust well to living in a predator exclusion enclosures as demonstrated by maternal penning projects in BC and elsewhere (RCRW, 2019; Wildlife Infometrics 2017). The soft release of translocated caribou had not been performed in BC or with SMC.

This study describes the translocation of in-

dividuals from the Purcells-South and South Selkirks SMC herds and the post-translocation movements of the translocated animals.

Materials and methods

Animal capture, transport and release

Five animals from the South Selkirks and Purcells-South caribou herds were identified as candidates for translocation. They were captured and transported to the Revelstoke Caribou Rearing in the Wild (RCRW) maternity pen (i.e., predator-exclusion enclosure used as a soft-release pen; UTM Zone 11, 5735077N, 384202E) within the range of the Columbia North SMC herd in two separate translocation events.

The first translocation occurred on January 14th, 2019, when one adult female and one adult male from the Purcells-South herd were captured near Angus Creek (UTM Zone 11, 5484742N, 560057E), and one South Selkirks adult female was captured on Mount Midgeley (UTM Zone 11, 5446676N, 520257E). The second translocation occurred on March 3rd, 2019, when one female calf and an adult male of the Purcells-South herd were captured near Angus Creek (UTM Zone 11, 5484742N, 560057E). All animals were captured by helicopter net gunning using a Hughes 500D. Medetomidine (10 mg/ml, Chiron Compounding Pharmacy Inc., Guelph, Ontario, Canada; 0.1 mg/kg) was administered intranasally (IN) using a MAD720 laryngo-tracheal mucosal atomization device (Teleflex Inc., Markham, Ontario, Canada) immediately after capture of the animals, while entangled in the net and before hobbles were applied. Animals were blindfolded, hobbled, placed in a custom-made carrying bag with snow, loaded into an A-Star helicopter and airlifted to a processing area where a veterinary crew and a modified horse trailer were located. Weights were estimated as follow: adult male: 200 kg; adult female: 110 kg; female calf: 75 kg. Intranasal administration of medetomidine resulted in light but adequate sedation. Vital parameters were monitored using visual assessment of chest movements (respiratory rate), a stethoscope (heart rate) and a rectal thermometer (rectal body temperature), and oxygen was delivered via intranasal canula at a rate of 2-3 L/min. Animals were sampled following the BC Widelife Health Program standard sampling protocol for caribou (35 ml of venous blood, hair, ear biopsy, feces, ectoparasites) and were equipped with a GPS collar (VERTEX PLUS-2 Iridium collar, Vectronic Aerospace GmbH, Carl-Scheele-Straße 12, 12489 Berlin, Germany) for tracking post-release movements and survival. Midazolam (5 mg/ml, Chiron Compounding Pharmacy Inc., Guelph, Ontario, Canada; 0.2 mg/kg) or zuclopenthixol acetate (Clopixol-Acuphase® 50 mg/ml, H. Lundbeck A/S, Copenhagen 2500, Denmark; 0.8 mg/kg) (depending on drug availability) were administered intramuscularly a few minutes before administration of a reversal drug to provide mild post-anesthetic tranquillization during and/or after transport. Animals were lifted into a modified horse trailer containing a thick bedding of wood shavings and placed in right lateral recumbency for recovery. Atipamezole (25 mg/ml, Chiron Compounding Pharmacy Inc.; 5 mg of atipamezole per milligram (mg) of medetomidine) was administered intramuscularly. Recovery was uneventful and all animals were standing within 6 minutes of atipamezole administration. Animals were opportunistically monitored during the 5–6 hour transport to Revelstoke, BC. The Purcells-South adult male translocated in March 2019 required additional sedation during transport as he became agitated with open mouth breathing early in transport. Midazolam (0.15 mg/kg) was administered via pole syringe and resulted in a mild sedation. On arrival in Revelstoke later that same day, the trailer was parked in a locked government compound and the animals

were provided with lichen and snow. The next morning, the trailer was driven near the RCRW maternity pen, approximately 1 hour north of Revelstoke. The caribou were anesthetized for helicopter transport across the Columbia River to the enclosure. Each animal was administered BAM II (butorphanol tartrate 27.3 mg/ml, azaperone tartrate 9.1 mg/ml and medetomidine hydrochloride 10.9 mg/ml; Chiron Compounding Pharmacy Inc.) intramuscularly via pole syringe. Adult males received 3 ml; adult females received 2 ml; and the female calf received 1.7 ml. Induction was smooth for all animals and a deep level of anesthesia was achieved. Animals were handled as before, provided with intranasal oxygen and airlifted into the enclosure where they recovered from anesthesia following the intramuscular administration of atipamezole (25 mg/ml, 5 mg of atipamezole per mg of medetomidine) and naltrexone (50 mg/ml, Chiron Compounding Pharmacy Inc.; 1 mg of naltrexone per mg of butorphanol). The translocated animals joined a Columbia North female calf that was born in the maternity pen in spring 2018, orphaned shortly after release and readmitted to the enclosure where it lived alone until joined by the translocated animals.

On March 4th, 2019, a radio-collared adult female from the Columbia North SMC herd was captured and placed in the enclosure using the same capture and handling procedures as described above. The intent was that the resident animal would act as a guide for the translocated animals, increasing the likelihood that they would locate the Columbia North herd quickly after release.

The diet of the translocated caribou was gradually transitioned from a lichen to a pelleted ration (Wetaskiwin Co-op Association, Calgary Zoo Winter Herbivore Ration, Formula Code M800710) over 10 days. Animals were fed in feeders made from 20 cm diameter PVC half-pipes placed inside a 3 m long wooden bunk mounted on skids with a waterproof slanted roof. The caribou were fed and monitored daily by on-site staff. All animals were observed to have a good appetite and to consume daily the expected amount of feed (approximately 3.2 kg/day/animal).

Release was first attempted on March 29th, 2019 when a section of the fencing was removed to allow the animals to leave. Some animals walked in and out of the enclosure several times. By the end of the day, they had all returned inside and the fence was re-secured. On April 1st, the fence was re-opened and, by the end of the day, only the South Selkirks and Columbia North adult females had left the pen. The fence remained open throughout the night and, by early morning on April 2nd, all remaining animals had departed. Radio collar data showed that all animals had moved into suitable late winter habitat later that day. At that time, there were 14 active collars within the Columbia North herd.

Resource selection function model development

We used GPS collar data to examine habitat selection patterns of resident Columbia North animals (6872 locations from 14 individuals) and translocated animals (3912 locations from 6 individuals) from April 15, 2019 to March 31, 2020. Differences in habitat selection patterns between the resident herd and translocated animals were assessed using resource selection functions (RSF). The approach was similar to the *k*-fold validation methods of Boyce *et al* (2002), wherein we trained an RSF model using data from translocated animals and tested its performance against data from resident animals to examine similarity of habitat selection patterns between the two groups.

To develop RSF models, we randomly drew available locations from an annual 99% Utilization Distribution (package *adehabitatHR*, R version 4.1.0,) of all collared animals with-

in the resident herd. This effectively represents availability at the population scale (2nd order selection, Johnson, 1980). We selected 20 available locations for each recorded GPS location for each individual and calculated the elevation and habitat type at each point. Habitat types were categorized into seven broad categories for analysis (Table 1) and elevation measures were normalized by subtracting the mean and dividing by the standard deviation. We used these landscape covariates to fit three candidate RSF models for the resident and translocated animals (Table 2). These models were fit using logistic regression with a random intercept for each individual (package *lme4*, R version 4.1.0). We used a Bayesian Information Criterion model competition framework to select the best performing model for each group (Table 2). We calculated Variance Inflation Factors (VIF) for each parameter of the top model to verify the assumptions of logistic regression analysis were not violated by multi-collinearity (Graham, 2003).

We used the methodology of Street *et al* (2021) to assess required sample sizes for reliable estimation of the parameters in the top performing model based on habitat heterogeneity and variation in individual selection

Table 1. Average elevation at each habitat class and the relative composition of each habitat component across the landscape. These habitat classifications were used in logistic regression RSF models fitted to data from resident Columbia North caribou and animals translocated into the population.

Habitat	Mean Elevation (m)	% of Available Landscape
Reference	1777	3.2
Broadleaf Forest	1085	5.3
Coniferous Forest	1327	36.4
Exposed Land	1893	10.7
Grassland	1658	7.4
Mixed Forest	1354	33.6
Shrubland	1503	5.3

Table 2: Model structure and BIC model competition results for competing habitat selection models fit to data from resident Columbia North caribou and caribou translocated from the Purcells-South and South Selkirks populations. All models included a random effect of individual ID. The habitat reference category was comprised of habitat classifications of water, wetland, rock and rubble, snow and ice, herbaceous, unclassified, and developed habitat types. Model 3 was the top performing model for both animal groups and used for subsequent analyses.

Animal Group	Model Name	Model Structure	Parameters	ΔBIC
Resident	Model 1	Use ~ Elevation	2	2230
	Model 2	Use ~ Broadleaf Forest + Coniferous Forest + Exposed Land + Grassland + Mixed Forest + Shrubland	8	968
	Model 3	Use ~ Elevation + Broadleaf Forest + Coniferous Forest + Exposed Land + Grassland + Mixed Forest + Shrubland	9	0
Translocated	Model 1	Use ~ Elevation	2	874
	Model 2	Use ~ Broadleaf Forest + Coniferous Forest + Exposed Land + Grassland + Mixed Forest + Shrubland	8	179
	Model 3	Use ~ Elevation + Broadleaf Forest + Coniferous Forest + Exposed Land + Grassland + Mixed Forest + Shrubland	9	0

patterns. For this process we first fit the model structure of the top performing model to a dataset of all individuals, then used the minimum observed number of fixes per individual (199) to estimate the required number of individuals (M) for the reliable estimation of model parameters.

To test model transferability between resident and translocated animals we examined the pattern of predicted habitat selection strength from the resident RSF against equal-area binned categories of RSF scores from the translocated animals (Figure 2). A Spearman's rank correlation was calculated between the frequency of points within binned RSF scores and the bin rank. Further, we calculated the predicted RSF score from both the resident and translocated RSF at 20000 previously unconsidered available locations and calculated a Pearson's correlation coefficient between the two RSF models.

Results

Release

Collar data indicated that all released caribou joined with members of the Columbia North herd within hours of release. Over the next few weeks, animals were observed to occasionally split into groups containing resident and translocated individuals before rejoining.

Post-translocation survival

On June 6th, 2019, the Purcells-South adult female's radio collar emitted a mortality signal. The telemetry data indicated that the animal had spent four days in Horne Creek (UTM Zone 11, 379914E, 5737263N), where she was assumed to be calving, before moving uphill and dying two days later. The carcass was found approximately 5 km from the enclosure on the north aspect of Horne Creek and retrieved on June 8th, 2019 by helicopter. No signs of predation were identified at the mortality site. Necropsy revealed an emaciated animal with a non-gravid, non-involuted uterus and an under-developed dry udder, indicating that she had calved but the calf had likely not survived. Histopathology was inconclusive given the freeze artefact and autolysis. However, bacterial culture of the endometrium revealed *Escherichia coli* (2+) and *Streptococcus* sp. (2+) growth, suggesting a low-grade post-partum bacterial endometritis. It is also possible there were complications associated with calving.

On June 16th, 2019, the collar of the Purcells-South calf stopped reporting. Her last reported location was near the headwaters of Ruddock Creek (UTM Zone 11, 367861N, 5735909E). Her fate remains unknown.

In early December 2019, the radio collar of the Purcells-South adult male translocated in January 2019, became defective and only intermittently transmitted. A few weeks later, on January 14th, 2020, a mortality signal was received. Retrieval of the carcass was delayed by heavy snow fall. The partial carcass, scavenged and in advanced autolysis, was found washed up on the east shore of Lake Revelstoke (Zone 11, 384648E, 5735441N) on February 1st, 2020. A cause of death could not be determined.

The Purcells-South adult male translocated in March 2019 died on July 12th, 2020 in an area of the Groundhog herd range that is infrequently used by resident caribou (UTM Zone 11, 5724078N, 339837E). While the carcass was scavenged by bears, predation by wolves was suspected.

The South Selkirks adult female, the Columbia North calf and the Columbia North adult female were alive as of October 26, 2020.

Post-translocation movements

Translocated animals adopted elevational migration strategies that closely matched those of resident animals (Figure 1). The most prominent feature of their elevational strategy was a marked elevational drop in early spring, fol-

Table 3. Variance Inflation Factors (VIFs) and minimum number of individuals required (M) for habitat types in the top performing habitat selection model for both resident and translocated caribou in the Columbia North population.

Covariate	Resident	Translocated	M
Elevation	1.54	1.56	6
Broadleaf Forest	1.88	2.69	2
Coniferous Forest	5.08	4.87	2
Exposed Land	2.03	2.14	2
Grassland	2.29	1.84	2
Mixed Forest	4.88	4.47	2
Shrubland	1.62	1.69	2

lowed by an equally rapid elevational climb prior to parturition.

The best performing predictive model of habitat selection included habitat class and elevation for both resident and translocated animals (ΔBIC > 10, Table 2). Area-adjusted frequencies showed positive rank values across RSF bins. An increase in resident RSF bin score rank was related to an increase in selection strength by translocated animals (rho = 0.95, $P < 0.001$, Figure 2). When tested against previously unconsidered available locations, predicted RSF scores from the resident and translocated RSF models showed a Pearson correlation of 0.835.

Following the methodology of Street *et. al* (2021), we estimated M to be no more than six individuals for any of the modelled parameters (Table 3), a threshold which was met by both

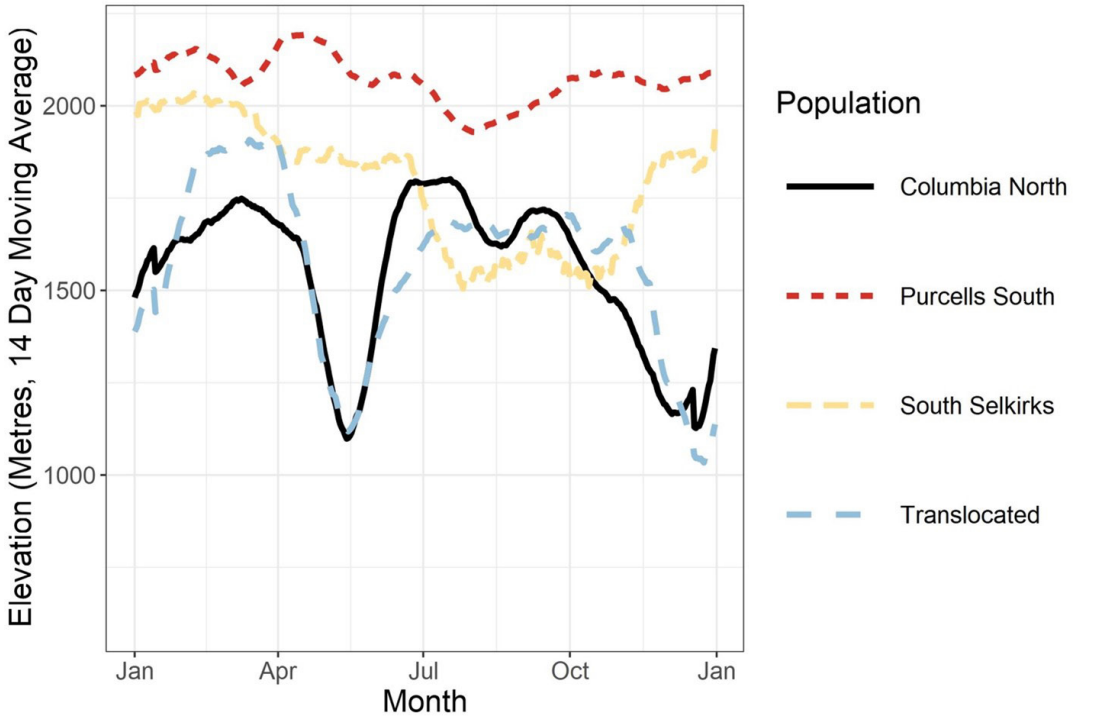

Figure 1. Seasonal elevation profiles for the Purcells-South, South Selkirks and Columbia North caribou populations in southeastern British Columbia. Translocated caribou were moved into the Columbia North range from the Purcells-South and South Selkirks ranges and immediately adopted novel elevational strategies that closely matched of the resident Columbia North population.

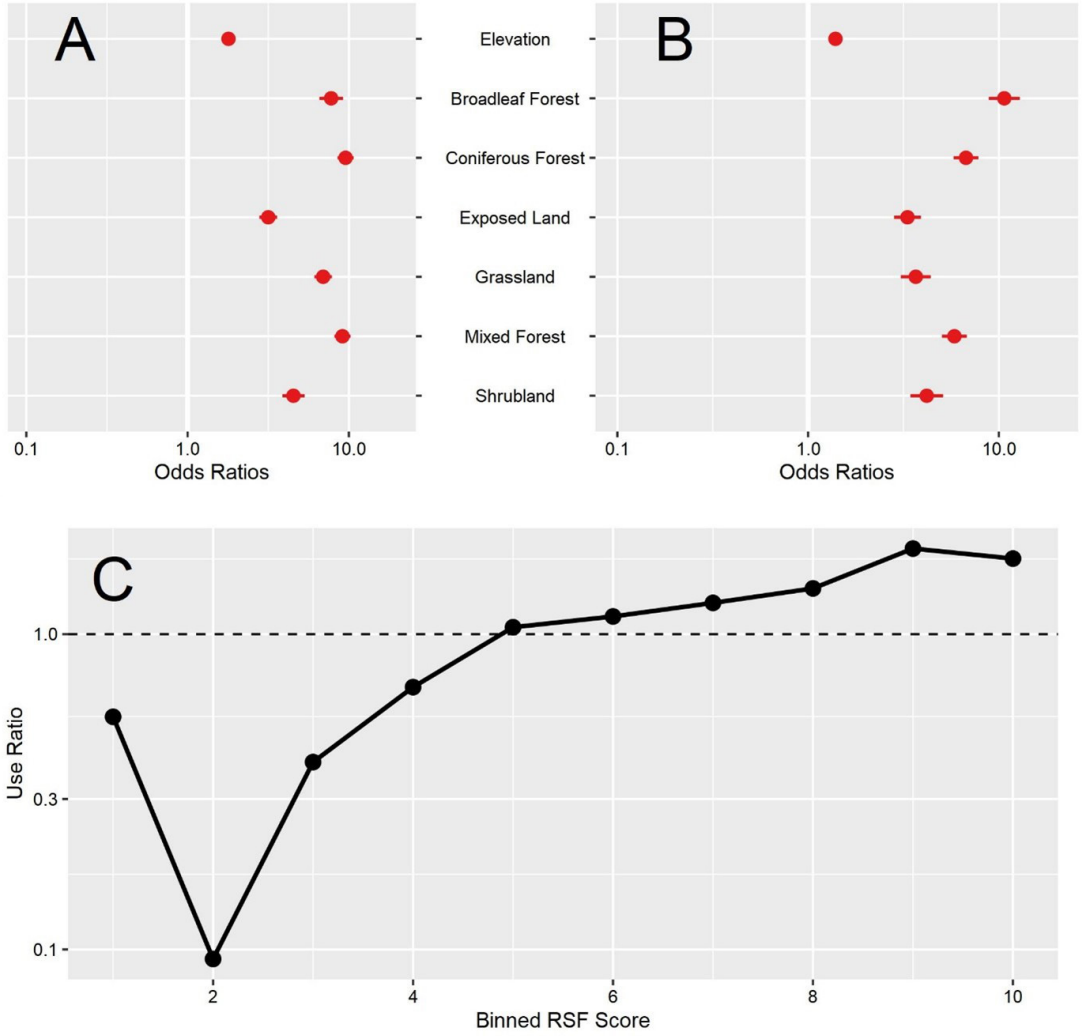

Figure 2. Model results for resident (A) and translocated (B) Southern Mountain caribou in the Columbia North range of southeastern British Columbia. Panel C shows frequency of use by resident caribou of equal-area bins developed from fitted translocated RSF values. Spearman's rank correlation shows strong performance when using habitat selection patterns of translocated animals to predict those of resident caribou (rho = 0.95, P < 0.001).

translocated and resident animal sample sizes (6 and 14 respectively).

Discussion

Small populations have an increased probability of extirpation given their high susceptibility to inbreeding depression and to catastrophic events, and this probability is highest when abundance is below a quasi-extinction threshold (Gilpin & Soulé, 1986; Ginzberg *et al.,* 1982). The quasi-extinction threshold represents the minimum population size at which herd recovery is feasible and beyond which the herd is non-viable, and is established to be eight breeding females for woodland caribou (Compton *et al.,* 1995; DeCesare *et al.,*

2011; Stronen *et al.,* 2007). Without intervention, the extirpation of the South Selkirks and Purcells-South herds was imminent and inevitable. The 2019 Purcells-South and South Selkirks caribou translocation rescued two non-viable herds and reinforced the unstable Columbia North herd, increasing both its size, albeit in a minor way, and likely its genetic diversity with animals from the same Designatable Unit. Increasing the genetic diversity of extant herds is critical as a population decline often results in a genetic bottleneck. Low genetic diversity generally results in reduced fitness and population growth rate reduction via genetic drift, increased inbreeding and a diminished capacity to respond to environmental change (Gilpin & Soulé, 1986; Hansson & Westerberg, 2002; Willoughby *et al.,* 2017).

Results from our model validation approach indicate similar habitat selection patterns between resident Columbia North animals and animals translocated from the South Selkirks and Purcells-South herds. The transferability of habitat selection patterns between translocated and resident animals suggests that the translocated caribou adopted strategies and behaviour similar to those of resident animals. The intent of this work was not to examine all possible factors that may influence caribou habitat selection or develop a definitive model of caribou habitat use. Similarly, our analysis is not intended to answer hypotheses related to group-specific selection for individual habitat covariates, but rather to examine broad scale convergence of the two groups' selection behaviours. This analysis compared the habitat selection patterns between resident and translocated animals at the population scale (i.e., 2nd order selection). Resource selection behaviour at the scale of an individual's range (i.e., 3rd order selection) may provide insights into the variability of fine-scale selection patterns of these two groups. While there may be vestigial differences in fine-scale selection patterns between these two groups, our findings indicate that translocated animals responded to habitat and elevational conditions in similar ways as resident caribou. These similar habitat selection behaviours may increase the odds of productive demographic performance from translocated animals.

Calculations of the minimum number of individuals required for reliable model fitting indicated that both translocated and resident animal groups featured enough collared animals to fit the RSF models used here, particularly in light of our conservative methodology for this calculation. The top performing habitat selection models for both resident and translocated animals featured parameter-specific VIFs greater than 4, a commonly used threshold for assessing multi-collinearity (Graham, 2003). However, the intent of these models was not to identify covariate-specific selection patterns for biological inference, but simply to compare the relative habitat selection strength at similar locations between the two animal groups. Therefore, given that models from the two animal groups were compared at the same locations and therefore subject to the same structural collinearity conditions, we believe our approach here is valid (Graham, 2003).

Variation in seasonal movement patterns occurs across the different regions of the SMC range and is largely attributed to differences in regional topography and snowpack (Simpson & Hamilton, 1997). The Columbia North herd uses the deep snowpack region of the Columbia Mountains and undergoes a bimodal elevation migration (i.e., two elevational movements per year) (Apps *et al.,* 2001; Kinley *et al.,* 2007). Caribou stay at high elevations in late winter where deep snowpack allows them to feed on arboreal lichens. Tracking spring green-up, they then descend to the valley bottom before returning to higher elevations during summer and fall. In early winter, they descend again and wait for the snowpack to accumulate at high elevation. The Purcells-South and South

Selkirks herds also undertake a seasonal elevational migration, but movements are not as pronounced (Stevenson *et al.,* 2001). This is thought to be a result of the drier climate at the southernmost edge of the SMC range and the lesser variation in annual snowpack. Winter forage options are available earlier at higher elevations, negating the need to move to lower elevation habitat (Kinley *et al.,* 2003; Kinley *et al.,* 2007). The elevation analysis showed the translocated animals adopted the bimodal migration pattern of the Columbia North herd (Figure 1).

The outcome (i.e., success or failure) of a caribou translocation is difficult to evaluate since no post-translocation survival threshold has been established. Some authors describe success as the ability of a translocation to achieve the following three phases: 1) Phase 1: The translocated animals successfully occupy and reproduce within the recipient ecosystem, 2) Phase 2: The translocation aid in the short-term stabilization of the population, and 3) Phase 3: The translocation leads to the ultimate recovery of the population (Compton *et al.,* 1995, Stronen *et al.,* 2007). Our analysis show that the released animals responded to habitat and elevational conditions similarly to the residents. In addition, successful recruitment from the orphaned calf was observed in 2022 when she was seen with a calf during a late winter census (Reid personal communication, 2022). These results support the translocation achieved Phase 1. In recent years, the size of the Columbia North herd has increased (McLellan *et al.,* 2021 and 2022) which suggests Phase 2 has also been achieved. However, the effect of this translocation is likely limited compared to that of other recovery actions, including primary prey and predator management. Another indicator of success is the survival and successful recruitment of the South Selkirks adult female. Through this rescue, this animal was given the opportunity to breed and contribute to overall population growth.

Soft release of translocated caribou had been performed four times prior to 2019. The first two projects, the 1938-42 Red Lake caribou herd reinforcement in Minnesota and the 1939 Liscomb Game Sanctuary caribou introduction in Nova Scotia, failed in most part due to exposure of the released animals to the then little known and understood meningeal worm *P. tenuis* (Benson & Dodds, 1977; Karns, 1980). White-tailed deer are the normal hosts for this neurotropic nematode parasite and are not affected by the parasite (Gilbert, 1973). However, in aberrant hosts such as caribou, moose, elk and mule deer, *P. tenuis* causes fatal central nervous system damage (Carpenter *et al.,* 1973; Dauphine, 1975; Smith & Archibald, 1967; Tyler *et al.,* 1980). Inadvertent infections have led to the failure of many caribou population restoration projects in eastern North America where the parasite is endemic (summarized by Cochrane (1996)). Two other projects using soft release, the 1958-1959 Adak Island barren-ground caribou introduction in Alaska and the 1969-1972 Charlevoix herd reintroduction in Québec, were both considered successful (Burris & McKnight, 1973; Jones, 1966). The Adak Island barren-ground caribou population was estimated at 2512-2880 caribou in 2012 (Ricca *et al.,* 2012) and the Charlevoix caribou population peaked at 126 individuals in 1992. However, the Charlevoix caribou population has since decreased to 19 individuals in 2020 because of low recruitment and poor adult survival due to habitat modification and fragmentation (Johnson *et al.,* 2019, Hins & Rochette, 2020).

The 2019 Purcells-South and South Selkirks caribou translocations provided an opportunity to release the orphaned Columbia North calf within a social group. The calf integrated well with the translocated animals in the enclosure and with the resident herd following release. Prior to this event, release of captive-reared caribou had been performed five times and

was successful when *P. tenuis* was not present at the release site (Burris & McKnight, 1973; Jolicoeur *et al.,* 1993; Karns, 1978; McCollough & Connery, 1991). Caribou translocations, whether they used a soft or hard release protocol, have repeatedly failed because animals were released to areas where the factors responsible for the initial population decline or extirpation had not been identified, removed or mitigated (IUCN/SSC 2013). Unsuitable habitat conditions for the release of translocated caribou have included predation, pathogens (i.e., *P. tenuis*), poor forage availability and excessive disturbance (Bergerud & Mercer, 1989; St-Laurent & Dussault, 2012). The 2019 Purcells-South and South Selkirks translocations were in part successful because the habitat conditions within the Columbia North caribou range are suitable. Regulated protection of old forest through ungulate winter range and snowmobile closure areas exist within the Columbia North and are currently complemented by other recovery tools such as primary prey and predator management (Government of British Columbia, 2020). Other factors that contributed to the success of this conservation translocation include knowledge of the basic biology, habitat needs and critical dependencies of SMC as well as the availability of funding and technical expertise.

The IN transmucosal administration of medetomidine produced a fast, predictable and reversible light sedation as well as good muscle relaxation in caribou captured by net gun and transported by helicopter. This protocol has been used successfully since at least 2015 for caribou captures and transport in British Columbia. It was informed by Cattet *et al.,* (2009) who demonstrated that IN administration of xylazine reduces handling stress in net-gunned elk. The IN transmucosal administration of drugs allows for rapid drug absorption and short induction times that compare to that of intravenous administration due to the high permeability, relatively large potential surface area of absorption and proximity to the brain of the nasal mucosa. It is commonly used in children and has recently gained popularity in veterinary medicine, with its use reported in several avian, mammalian and reptilian species (Al-Shebani, 2011; Cattet at al. 2004; Cermakova *et al.,* 2018; Emery *et al.,* 2014; Jafarbeglou & Marjani, 2019; Lahat *et al.,* 2000; Malmros Olsson *et al.,* 2021; Mans *et al.,* 2012; Moghadam *et al.,* 2099; Santangelo *et al.,* 2016; Schnellbacher *et al.,* 2012; Vesal & Eskandari, 2006; Vesal & Zare, 2006). The IN route of administration was chosen over the intravascular route to allow for prompt systemic administration of the drug without needing to access a vein as this can be challenging in a net gunned animal. While the use of nasal atomizer is a simple and effective administration method, it is important to train field staff to limit occurrences of accidental exposure to medetomidine.

While many factors influence the outcome of a caribou translocation, the translocation and soft release of Purcells-South and South Selkirks individuals demonstrated that soft release of wild translocated and captive-reared SMC can be successful and should be considered where and when feasible. This opens the door to the use of *ex situ* tools for SMC conservation, such as the rescue of other functionally extirpated herds (e.g., the Frisby-Boulder, Columbia South and Narrow Lake herds) and the creation of insurance populations to support population reinforcement and reintroduction efforts.

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