




ARTICLE

Indigenous-led conservation: Pathways to recovery for the nearly extirpated Klinse-Za mountain caribou

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Abstract

Indigenous Peoples around the northern hemisphere have long relied on caribou for subsistence and for ceremonial and community purposes. Unfortunately, despite recovery efforts by federal and provincial agencies, caribou are currently in decline in many areas across Canada. In response to recent and dramatic declines of mountain caribou populations within their traditional territory, West Moberly First Nations and Saulteau First Nations (collectively, the “Nations”) came together to create a new vision for caribou recovery on the lands they have long stewarded and shared. The Nations focused on the Klinse-Za subpopulation, which had once encompassed so many caribou that West Moberly Elders remarked that they were “like bugs on the landscape.” The Klinse-Za caribou declined from ~250 in the 1990s to only 38 in 2013, rendering Indigenous harvest of caribou nonviable and infringing on treaty rights to a subsistence livelihood. In collaboration with many groups and governments, this Indigenous-led conservation initiative paired short-term population recovery actions, predator reduction and maternal penning, with long-term habitat protection in an effort to create a self-sustaining caribou population. Here, we review these recovery actions and the promising evidence that the abundance of Klinse-Za caribou has more than doubled from 38 animals in 2013 to 101 in 2021, representing rapid population growth in response to recovery actions. With looming extirpation averted, the Nations focused efforts on securing a landmark conservation agreement in 2020 that protects caribou habitat over a 7986-km² area. The Agreement provides habitat protection for >85% of the Klinse-Za subpopulation (up from only 1.8% protected pre-conservation agreement) and affords moderate protection for neighboring caribou subpopulations (29%–47% of subpopulation areas, up from 0%–20%). This Indigenous-led conservation initiative has set both the

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Indigenous and Canadian governments on the path to recover the Klinse-Za subpopulation and reinstate a culturally meaningful caribou hunt. This effort highlights how Indigenous governance and leadership can be the catalyst needed to establish meaningful conservation actions, enhance endangered species recovery, and honor cultural connections to now imperiled wildlife.

KEYWORDS

endangered species, indigenous protected and conserved area, rights and title

INTRODUCTION

Positionality statement

This statement shares the background, expertise, and contributions of the authorship team to help readers understand how this work came to be. We are a diverse and international group of 13 people with experience as wildlife scientists, community leaders, and land stewards. We are comprised of Indigenous Peoples and non-Indigenous who reside in what is now called Canada and the United States of America. The authors include six members of West Moberly First Nations and Saluteau First Nations with distinct cultures and histories (collectively, the “Nations”). Five of these members form the Nikanêse Wah tzee Stewardship Society (NWSS)—*Nikanêse* is “future” in Cree and *Wah tzee* is “caribou” in Dunne-Za—a collaborative non-profit initiative between West Moberly First Nations and Sauteau First Nations leading the caribou recovery efforts described here (West Moberly First Nations: Chief R. Willson [R.W.], T. Dokkie [T.D.]; Sauteau First Nations: C. Richter [C.R.], N. Owens-Beek [N.O.B.], and E. Lavis [E.L.]). Julian Napoleon [J.N.] is a First Nations land steward and Indigenous Caribou Guardian. Seven authors are scholars and applied ecologists that have worked with the Nations for 2–15 years [B. Muir [B.M.], S. McNay [S.M.], L. Giguere [L.G.], C. T. Lamb [C.T.L.], S. Boutin [S.B.], A. T. Ford [A.T.F.], and M. Hebblewhite [M.H.]]. All co-authors contributed substantial expertise and knowledge to bring this work to life, which cumulatively covers the realms of Indigenous Knowledge (R.W., B.M., T.D., N.O.B., C.R., J.N., E.L.); caribou ecology and conservation action (all); colonial-Indigenous government relations and catalyzing change (R.W., S.M.); as well as local and international contexts (all). The four university-affiliated people (C.T.L., A.T.F., M.H., S.B.) were not involved with the caribou recovery actions conducted here but lead the writing of this work with input and support from all co-authors. The caribou recovery actions were led by the NWSS (R.W., T.F., C.R., N.O.B., E.L.),

guided by technical expertise from Wildlife Infometrics (S.M., L.G.), and implemented collaboratively on the ground by a large group of people, including those mentioned above, Indigenous Caribou Guardians (of which J.N. was one), the Province of British Columbia, and others not represented as authors here but are highlighted in the acknowledgements section. The NWSS, Indigenous Caribou Guardians, and science advisors (R.W., B.M., T.D., N.O.B., C.R., J.N., E.L., B.M., S.M., L.G.) collaborated and engaged with community members from each First Nation and incorporated their knowledge and ideas into management strategies and recovery actions. Co-management of caribou and the land was thus carried out through both Indigenous-led conservation actions such as maternal penning and wolf reductions, and through negotiating terms that allowed shared decision making on the land between Indigenous, provincial, and federal governments. The Indigenous Knowledge shared (R.W., B.M., T.D., N.O.B., C.R., J.N., E.L.) among the co-authors, and now passed onto readers, comes with a responsibility to appreciate and understand the appropriate use of this information. Elders and Knowledge holders have offered key elements of their Knowledge to help readers understand the importance of the reciprocal relationship between caribou and people, and why looking after caribou and the land is an essential act to rekindle and maintain a cultural mode of life.

Background and purpose

Indigenous Peoples and Nations manage or have tenure rights to over one-quarter of the world’s terrestrial land (Garnett et al., 2018). Indigenous rights and title to land, paired with knowledge of that land, make Indigenous leadership and governance critical to the stewardship of global biodiversity and ecosystem services. Indeed, Schuster et al. (2019) showed that vertebrate biodiversity was higher across 5.8 million square kilometers of Indigenous lands in Canada, Australia, and Brazil, compared to

either protected or non-protected areas. The role of Indigenous Peoples in land stewardship and resource management decisions is linked to governance from which self-determination and co-management drive the decolonization of resource extraction practices through restoration of species, cultural traditions, place-based connections, and land stewardship (Moola & Roth, 2019; Popp et al., 2019).

Co-management of natural resources by Indigenous Peoples and colonial governments decentralizes authority and ensures that land management decisions involve the voices, knowledge, and rights of the local people most attuned to the landscape (Assembly of First Nations, 2012). Here we focus on the importance of co-management approaches in Canada, a country with a history of colonial rule (1867 Confederation to current) and attempted extinguishment of Indigenous rights (Joseph, 2018). Co-management approaches provide a more equitable path forward for Indigenous Peoples' self-determination and stewardship of local and national environments (Law et al., 2018; Popp et al., 2019). Co-management may also be an effective approach for the conservation of biodiversity and recovery of endangered species, both vitally important to Indigenous governments, by the very virtue of decentralizing the authority of colonial governments (Assembly of First Nations, 2012; Law et al., 2018; Popp et al., 2019).

In Canada, co-management approaches such as Indigenous Protected and Conservation Areas play a key role in the countries' progress towards Aichi Biodiversity Target 11 (protecting 17% of terrestrial and 10% of marine area; Moola & Roth, 2019) and Target 18 (respecting and incorporating the knowledge, innovations, and practices of Indigenous communities into conservation actions). While some areas of Canada are disturbed, the country is a globally significant stronghold for conservation given its' vast tracts of intact landscapes, freshwater supply, and assemblage of large mammal communities (Cristine et al., 2019). Collaboration with Indigenous Peoples will play an essential role in Canada's efforts towards securing biodiversity protection.

The 1982 Canadian Constitution Act contains a brief but profound and evolving section that is reshaping the legal basis for co-management in Canada. Section 35 of the Canadian Constitution states that: "The existing aboriginal and treaty rights of the Aboriginal Peoples of Canada are hereby recognized and affirmed." Judicial interpretation of Section 35 requires all levels of government to formally recognize and consult with Indigenous Peoples, including on issues related to biodiversity, endangered species recovery, and resource extraction. Despite being signed into law in 1982, Canadian governments often have failed to honor treaty rights and knowledge pertaining to land-use decisions that threaten

biodiversity and Indigenous culture (Collard et al., 2020; Mantyka-Pringle et al., 2015). However, a series of high profile court cases brought forward by Indigenous Peoples have upheld treaty rights to a subsistence livelihood (i.e., continuance of cultural and traditional relationships with the land necessary to sustain life and people), which includes the right to hunt and fish within their traditional territories (R. v. Desautel, 2019; R. v. Sparrow, 1990). The pathway to co-management of resources is complex, particularly where culturally important food and ceremonial resources overlap with areas that have high economic value (forests, minerals, oil, and gas; Hebblewhite, 2017) and where value systems differ between colonial and Indigenous governments.

Few cases of wildlife conservation in Canada demonstrate the promise of reconciling Indigenous and colonial approaches to conservation better than that of caribou (*Rangifer tarandus* spp.). Caribou are a culturally important species to many Indigenous Peoples across Canada and were historically central to Indigenous Peoples' seasonal movement patterns and subsistence (Hummel & Ray, 2008; Sharp & Sharp, 2015). Woodland caribou (*Rangifer tarandus caribou*; hereafter caribou) range, and the structure of the food webs within which they have historically persisted, is being affected by a billion-dollar resource extraction industry and accelerating climate change (Dawe & Boutin, 2016; Festa-Bianchet et al., 2011; Hebblewhite, 2017). Linear features (roads, pipelines, seismic lines, and powerlines), and the extraction of resources (wood, coal, oil, gas, and hydroelectricity) now traverse the secure, old-growth forest habitat that caribou rely on. This habitat alteration creates productive early seral habitat, which in turn increases the abundance of white-tailed deer (*Odocoileus virginianus*) and moose (*Alces alces*), as well as the abundance and movement rates of their predators: wolves (*Canis lupis*), cougars (*Puma concolor*), and bears (*Ursus* sp.) (Dickie et al., 2020; Fortin et al., 2017; Seip, 1992; Wittmer, Sinclair, & McLellan, 2005). Incidental caribou predation from increased predator populations is a leading cause of caribou declines (Serrouya et al., 2021; Wittmer, Sinclair, & McLellan, 2005).

Due to their strong selection for intact, mature forest habitats, caribou have been described as an umbrella species for multiple biodiversity values including many species reliant on old-growth forests (Bichet et al., 2016; Campbell et al., 2020; Falconer & Ford, 2020). Mature forests are being rapidly converted to early seral conditions across Canada, so it is not surprising that caribou populations are also declining by up to 50%–60% in the boreal and mountain populations (Environment Canada, 2012, 2014). The precipitous decline of caribou led to a Threatened designation under Canada's Species at Risk Act

(SARA), an act designed to prevent wildlife extirpation and promote recovery (Government of Canada, 2002). By 2014, experts recommended that the majority of the southern mountain caribou subpopulations should be given the more severe status designation of Endangered (COSEWIC, 2014). Indeed, between 2000 and 2017, 10 subpopulations of mountain caribou were extirpated, including the last caribou in the conterminous United States (Moskowitz, 2019) (Figure 1).

Declining caribou populations stand to precipitate the loss of culturally important caribou hunting by Indigenous Peoples, and violates treaty rights to a subsistence

livelihood (Laird et al., 1899; Mantyka-Pringle et al., 2015; Sharp & Sharp, 2015), highlighting that caribou recovery is at the nexus of legal, ecological, and human-rights issues. Despite a broad profile, caribou recovery is still very much in the aspirational stage with few demonstrated instances of successful recovery in any boreal or southern mountain caribou populations (e.g., delisting from SARA or re-establishment of a subsistence hunt). As a result of steep population declines, and conflicting political and societal priorities between land stewardship and resource extraction, wildlife managers

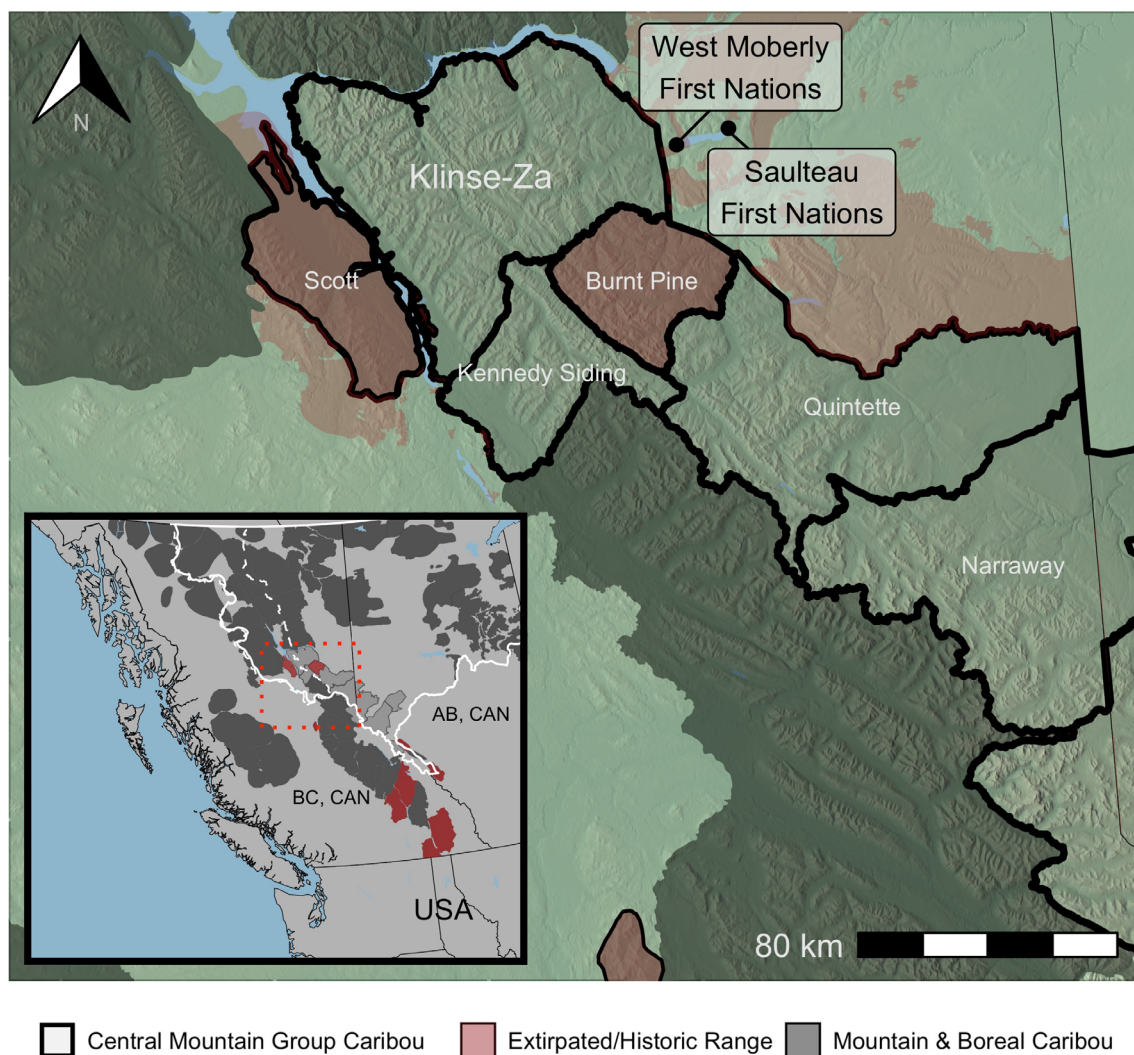


FIGURE 1 Map of British Columbia's Central Group (unshaded, with subpopulations named) of Southern Mountain caribou (subpopulation boundaries circa ~1990 onwards). The Klinse-Za subpopulation is the focus of Indigenous-led conservation and can be found at the top. West Moberly First Nations and Saulteau First Nations communities are found on the shores of Moberly Lake. Inset map shows the western portion of Treaty 8 territory as a white line and the contested line from the British Columbia (BC) government is shown as white dashed line. Boreal and mountain caribou subpopulations not considered here are filled with dark gray. Extirpated caribou subpopulations are filled with red. The extent of the main map is shown as a dashed red line on the inset. The 12 functionally extirpated subpopulations are as follows (north to south): Scott West, Burnt Pine, George Mountain, Maligne, Banff, Duncan, Allan Creek, Purcell Central, Monashee, Purcell South, and South Selkirk (Environment and Climate Change Canada, 2018; Sittler & McNay, 2017; Wittmer, McLellan, et al., 2005). Abbreviations: Can, Canada; AB, Alberta

have shifted their focus from working solely on longer-term strategies of protecting habitat to shorter-term efforts (Nagy-reis et al., 2021). These short-term efforts focus on caribou predators and competitors (i.e., wolf removal or increased deer and moose hunting) (Hervieux et al., 2014; Serrouya et al., 2019), protecting neonate calves via maternal penning (Serrouya et al., 2019), with growing calls for, and concerns of, conservation triage in some cases (Cornwall, 2018; Gilbert et al., 2020; Schneider et al., 2010; Vucetich et al., 2017).

The few examples of successful caribou conservation share one or more of the following characteristics: (1) more than one recovery action is implemented, (2) recovery actions are carried out intensely, and critically (3) there is strong collaboration between Indigenous Peoples, colonial governments, industry, and other parties (Serrouya et al., 2019). However, in spite of evidence that habitat loss underlies caribou declines (Serrouya et al., 2019), there have been no successful examples of sufficient habitat restoration or protection to recover the threatened boreal or endangered southern mountain caribou populations in Canada. Instead, caribou habitat conditions appear to be worsening, even in designated critical habitat (Nagy-reis et al., 2021; Palm et al., 2020).

Here, we present the legal, political, and ecological framework underlying a collaborative, Indigenous-led conservation effort in central British Columbia, Canada, focused on population and habitat conservation of caribou. This case study provides a blueprint for successful caribou recovery in other jurisdictions and illustrates how effective pairing of Indigenous treaty rights (Government of Canada, 1899) with endangered species recovery can synergistically enhance both goals (Mills et al., 2019). Finally, our case study provides a compelling example wherein respecting and supporting Indigenous leadership, knowledge, and values will help to rekindle the connections between people and place, and facilitate more effective and equitable outcomes for people and wildlife.

INDIGENOUS-LED CARIBOU CONSERVATION: HISTORICAL CONTEXT

The Indigenous knowledge shared within this document is a combination of knowledge shared from Indigenous co-authors and from interviews with West Moberly First Nations Elders and knowledge holders (West Moberly First Nations, 2009). West Moberly First Nations (2009) was a community-based, co-produced study. The quotes and methods of collection have been endorsed and accepted by the community and leadership and are detailed within the report.

Indigenous knowledge held by Elders and knowledge holders from West Moberly First Nations (WMFN) and Saulteau First Nations (SFN) provides a glimpse of once abundant caribou, known as *wadziih* or *wah tzee* in Dunne-za and *atihk* in Cree, in central British Columbia (Figure 1). George Desjarlais, a WMFN member recalls that “Big herds would move all in one shot. One Elder said there were so many, they were like bugs” (West Moberly First Nations, 2009). Elders spoke of vast migrations of caribou across the Peace River Valley (West Moberly First Nations, 2009), and of the different migratory behaviors and patterns.

Caribou offered the WMFN and SFN (collectively referred to as the “Nations” hereafter, while also recognizing their distinct cultures, histories, and worldviews) sustenance, clothing, tools, and was utilized for medicinal, spiritual, cultural, community, and ceremonial purposes. (West Moberly First Nations, 2009). Caribou were a particularly important food source especially in the non-winter months, and at times when moose were not available (West Moberly First Nations, 2009). Caribou were hunted by a variety of methods such as snaring, from canoes, at stream crossings, and with dogs. These dogs were also fed caribou, largely due to the abundance and availability of caribou. Caribou meat was preserved by drying the meat. Andy Miller, a WMFN member, describes the reliance on, and appreciation of, dried meat: “Native people no matter where you go they make dry meat. That is our favourite thing: dry meat... We eat a lot of meat and we survive on meat.” (West Moberly First Nations, 2009). Caribou are woven into nearly every part of the Nations sense of place and being (Muir & Booth, 2012). The deeply rooted cultural connections to caribou continue in members of the Nations today, and is best summarized by Julian Napoleon, an SFN member and Indigenous Guardian “For the moose and caribou to thrive, we need to continue to honor them...Eating them is a part of that. There is no way to express deeper gratitude to an animal than when it offers itself to you and you bring it home and share it with people you love.”

During the 20th century, caribou abundance declined due to multiple habitat alterations. For example, caribou migration routes across the Peace River Valley were fragmented by the W.A.C. Bennet Dam (West Moberly First Nations, 2009), which created the 1761-km² Williston Reservoir (Figure 2), the eighth largest dammed reservoir in the world. George Desjarlais said “the migration across the Williston Reservoir doesn’t occur anymore. It left these isolated groups south of the reservoir along the trench” (West Moberly First Nations, 2009). In neighboring areas, the impeding of caribou migratory movements due to habitat alteration is associated with lower survival rates for caribou (Williams et al., 2020a). Today, many

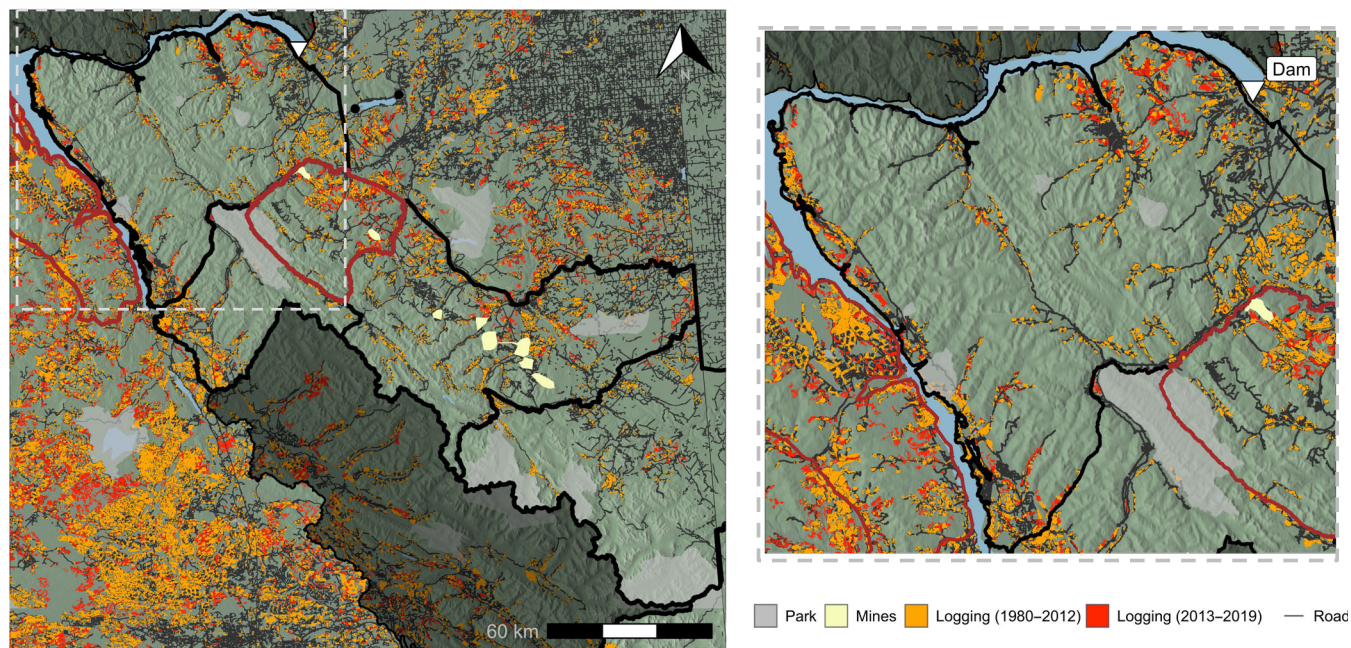


FIGURE 2 Human-induced disturbance (logging, roads, mining, and hydroelectric reservoirs created by damming) within and adjacent to caribou subpopulations (outlined in black, extirpated subpopulations outlined in red) in British Columbia's Central Mountain Group of Southern Mountain Caribou (unshaded). Logging shown in red was conducted during the time of Indigenous-led conservation of the Klinse-Za caribou (2013–current), shown in more detail on right

caribou populations are non-migratory. The loss of migratory behavior due to disturbance, and the resulting implications for survival, likely contributes to compromised caribou persistence in many areas.

The cumulative effects of multiple disturbance types (Figure 2, roads, timber harvest, open-pit coal mines, oil and gas extraction, hydroelectric production, and human settlement) have added to caribou declines. Habitat alteration increased the productivity of habitat and primary prey (moose and deer) for predators (Serrouya et al., 2021), and facilitated predator movement into, and within, caribou habitat (Dickie et al., 2016), and altered migration patterns (Williams et al., 2020b). Clarence Willson, a WMFN member, observed that “the roads and infrastructure and development, created all this access for people to get into places where [caribou] live, and makes it easier for wolves” (West Moberly First Nations, 2009).

As a result of caribou declines due to increased predation, the Nations, under the advisory of Elders, voluntarily stopped hunting caribou in the early 1970s (Muir & Booth, 2012). This cessation of caribou hunting followed traditional laws that instructed hunters not to harvest animals when populations were struggling (Muir & Booth, 2012). However, the Province of British Columbia allowed non-Indigenous Peoples to hunt these caribou until 2003, almost 30 years after the Nations ceased harvest (Ministry of Water Land and Air Protection, 2002). Such asymmetry in the detection of

population concerns for these caribou highlights one difference between stewardship by Indigenous Peoples frequently observing the landscape and western science approaches, which relied on population surveys and collaring that did not occur consistently until 2002 (McNay et al., 2022).

Today, only ~230 animals, a density of ~1 caribou per 100 km², inhabit the area that was once a “sea of caribou” (Environment and Climate Change Canada, 2018; West Moberly First Nations, 2009). Provincial and Canadian governments refer to caribou in this area as the Central Group of Southern Mountain Caribou (hereafter, “Central Group”; Environment Canada, 2017), with smaller separate “herds” defined within (Figure 1). The ability to define distinct herds in this area is an unfortunate symptom of the severe population declines. Chief of the WMFN, Roland Willson, reflects that “today’s population is better understood as separate herds. No longer do members or anyone else use the term ‘sea of caribou’ or reference them as ‘bugs’ on the landscape. The population is a shadow of its former self” (West Moberly First Nations, 2009). Hereafter, we refer to the caribou herds as subpopulations to honor their past, and hopefully future, functioning as one large population.

In 2013, one of the five provincially defined subpopulations in the Central Group, the Burnt Pine, was extirpated (Figure 1). The loss of the Burnt Pine caribou occurred despite repeated attempts by the WMFN to protect the habitat from mining and logging, including

several legal challenges (Muir & Booth, 2012; West Moberly First Nations, 2009). Meanwhile, the neighboring Klinse-Za subpopulation fell from ~250 animals in the 1990s, to critically low levels of 38 animals by 2013 (Figure 3, see McNay et al. [2022] for detailed demographic analysis). A 2013 areal population survey of a portion of the Klinse-Za subpopulation, formerly known as the Moberly subpopulation, counted only 16 animals. The loss of the Burnt Pine caribou, and the observation of only 16 animals remaining in a portion of the Klinse-Za subpopulation, provided the spark for the Nations' aggressive campaign to recover these caribou.

The short-term goal of the recovery effort was to avert the extirpation of the Klinse-Za caribou by growing the subpopulation at the greatest rate possible. The long-term goal includes recovering caribou to an abundance that would allow the Nations to reinstate a culturally meaningful harvest of caribou (McNay et al., 2013). In this way, caribou recovery embodies the restoration of relationships between people and animals, and fundamental links between food security and culture (Muir & Booth, 2012). Despite efforts by the Canadian Government to subjugate Indigenous Peoples and erase their culture and identity, Indigenous Peoples have persisted and affronted such efforts (Joseph, 2018). Re-establishing caribou populations and the nearly lost cultural connection to these animals has important implications for all people, reconciliation between Indigenous Peoples and colonial governments, and wildlife conservation. The significance of these efforts is highlighted in the quote from Julian Napoleon "We're doing so much for [caribou] to survive, because it represents so much more for us as a people ... If [caribou] can survive, maybe we can too" (Gilpin, 2019).

INDIGENOUS-LED CONSERVATION: AVERTING EXTIRPATION

The Klinse-Za subpopulation totaled an estimated 38 caribou in 2013 (24 females) and had been declining at ~11% per year since 1995 (McNay et al., 2022). If action had not been taken, this subpopulation would have been functionally extirpated within the decade based on previous population viability analyses for small, endangered populations of woodland caribou in Alberta and British Columbia (Decesare et al., 2011; Wittmer et al., 2010), and recent projections using Klinse-Za caribou (McNay et al., 2022).

Starting in 2013, several short-term population recovery actions were initiated by the Nations and a wildlife consulting firm (Wildlife Infometrics) to increase the

abundance of caribou. These recovery actions were supplemented through efforts by the Province of British Columbia, and trappers, and were supported with significant funding from provincial and federal governments, industry, and conservation organizations. The Nations adopted two crises-level, short-term recovery actions to halt the caribou decline (Figure 3): (1) wolf reduction starting in 2013 and (2) maternal penning starting in 2014. Wolf reduction was implemented to reduce unsustainable predation on caribou (Serrouya et al., 2019; Wittmer, Sinclair, & McLellan, 2005). Maternal penning, whereby adult female caribou are moved into an enclosure from March–July to give birth to their calves, was used to enhance survival of calves through the high-mortality neonate (<3 months) period (Adams et al., 2019; Gustine et al., 2006). Both recovery actions have been demonstrated to have some effectiveness in previous studies both in this population and elsewhere (Adams et al., 2019; Hervieux et al., 2014; McNay et al. 2022; Serrouya et al., 2019). See permits and ethics approval section for the legal and permitting authorities used in the recovery actions by the Nations, provincial government, contractors, and universities.

Wolf predation was hypothesized to be the leading proximate cause of caribou mortality on adult females (Ehlers et al., 2016; Hebblewhite et al., 2007; Wittmer, Sinclair, & McLellan, 2005) and their calves (Gustine et al., 2006). Wolf reductions were carried out (1) from the ground via trapping and harvesting by members of the Nations between 2013 and 2020 (Owens-Beek et al., 2018) and (2) via helicopter by the Province of British Columbia and associated contractors between 2015 and 2020.

The Federal caribou recovery plan recommends reducing wolves to <3 wolves/1000 km² to achieve recovery goals for caribou populations (Environment Canada, 2014), although recent analyses suggest <1.8 wolves/1000 km² may be required (Serrouya et al., 2021). Nevertheless, before wolf reduction was initiated in 2013, wolf densities were estimated at ~12.6/1000 km² (Bridger, 2019). Following initiation of wolf reduction, wolf densities were reduced to 0.4–1.7/1000 km² each year during intensive removal but rebounded to ~50% of previous years' density each year (Bridger, 2019), similar to other wolf treatments in western Canada (Hervieux et al., 2014). Results suggest that wolf density annually declined by 77%–97% within caribou habitat during the period of intensive wolf removal between 2016 and 2019 (Bridger, 2019), with less intense removal between 2013 and 2015.

A maternal penning program was established by the Nations, and scientists in 2014 under the working hypothesis that calf mortality might be limiting caribou recovery based on examples from previous studies

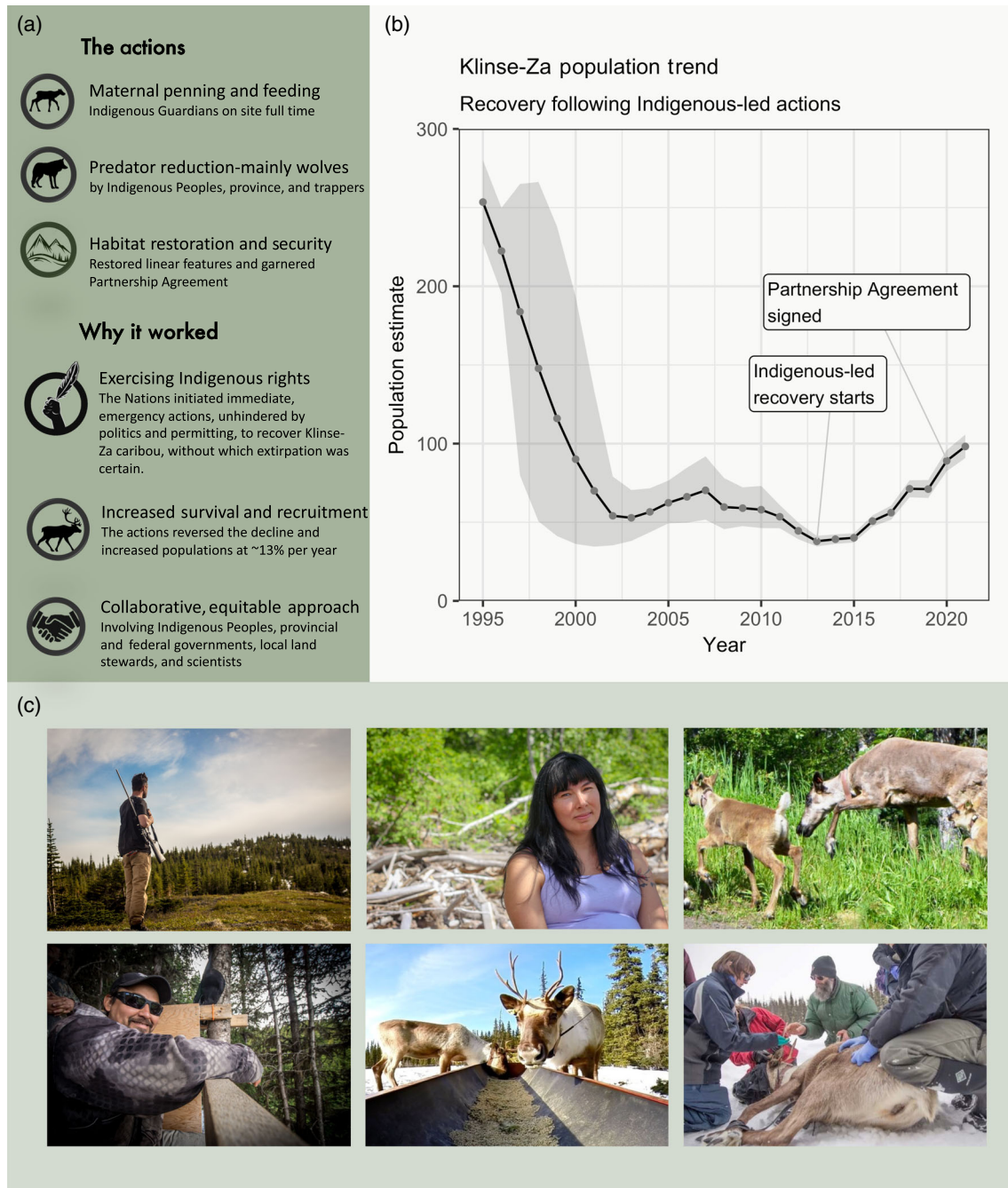


FIGURE 3 (a) Summary of the actions taken to recover the Klinse-Za caribou, and why they were successful.

(b) Population estimates and trend for Klinse-Za caribou over a 25-year period between 1995 and 2021, from McNay et al. (2022) integrated population model. Shaded area represents the 90% credible interval. Further details on the demographics of the Klinse-Za caribou can be found in McNay et al. (2022). (c) Photos showing, top left (photo credit Emilee Gilpin, National Observer), Julian Napoleon, an SFN member, biologist, hunter, trapper, and Indigenous Guardian at the maternal pen. Top center (photo credit Emilee Gilpin, National Observer), Naomi Owens-Beeck, an SFN member, biologist, Director of Saulteau Treaty and Lands Department, and member of the Nikanêse Wah tzee Stewardship Society. Top right (photo credit Wildlife Infometrics), 62 caribou calves have been released from the maternal pen between 2014 and 2020. Bottom left (photo credit Emilee Gilpin, National Observer), Ryan Desjarlais overlooks the maternal penning area. Ryan is a WMFN community member who has been trapping Treaty 8 territory since he was young. Bottom center (photo credit Wildlife Infometrics), caribou are fed twice daily in the pen and acclimatize well to being in the pen. Bottom right (photo credit Wildlife Infometrics), a group of biologists, scientists, veterinarians, and Indigenous Guardians work together to safely capture and transport female caribou to the maternal pen.

(Adams et al., 2019; Smith & Pittaway, 2011). In an adjacent area, 94% of juvenile caribou mortalities occurred during the early neonatal period (0–35 days; Gustine et al., 2006). The maternal penning project was a short-term, 3–4 month in-situ recovery action that consisted of moving 8–20 female caribou into a high-elevation, predator-free enclosure to reduce early season calf mortality. Adult female caribou were captured and translocated into the enclosure in March and generally gave birth to one calf in May–June and were released together in late July.

Indigenous Guardians resided at the enclosure at all times, where they protected caribou from predation, fed them, helped capture and collar newborn calves, and monitored animal health. Indigenous Guardians are Indigenous Peoples who are employed to be the “eyes and ears” on land that their people have long stewarded (Natcher et al., 2021). In this case, each year, Guardians from the Nations lived and worked among the caribou on a weekly rotation, two people at a time. They are known as the Caribou Guardians. The Caribou Guardians were on site to help with capture and transport when the caribou were brought into the enclosure in March, and their watch ended in July of each year when the females and calves were released. Caribou Guardians in concert with veterinarians and biologists worked to create favorable conditions for caribou survival, reproduction, and general well-being.

Maternal penning and predator reduction efforts successfully averted extirpation of the Klinse-Za caribou. Compared to nearby subpopulations without wolf reductions or maternal penning, survival of calves born in the pen was $1.5\times$ higher during May–July (while they were in the pen), and $2.2\times$ higher by the following winter (May–December, Appendix S1: Section S2). Due to increased calf recruitment and adult female survival, the subpopulation grew at a rate of $\sim 13\%$ per year (female-only growth rate = 8% per year) between 2014–2021 and numbered 101 animals in 2021 (Figure 3; see McNay et al., 2022, for details on demographic analysis). In contrast, other southern mountain subpopulations reviewed in Serrouya et al. (2019) declined during a similar time at an average rate of 14% per year (range -35% to -3%) when no recovery actions were taken and declined at 8% (range -36% to $+13\%$) despite a variety of management actions applied such as wolf reductions in isolation, translocations, and moose reductions. In McNay et al. (2022), we estimate that the increased population growth of the Klinse-Za subpopulation can be attributed as approximately one-third due to maternal penning and two-thirds due to wolf reduction. The increases garnered in the Klinse-Za have put the Nations on a path towards their goal of

recovering caribou abundance to a point that will satisfy their legal treaty rights for hunting (Government of Canada, 1899).

Despite the benefits of the short-term recovery actions in the Klinse-Za, as of 2019, there had been no substantive recovery actions taken to address the ultimate reason for caribou declines: habitat loss and fragmentation. Instead, during the same period of short-term recovery actions outlined above, publicly available government data indicates $>11,000$ ha of forest were harvested under BC Provincial permits within the Klinse-Za subpopulation (Figure 2). Effective protection of the necessary habitat to support a sustainable harvest of caribou remains an unresolved endangered species, cultural, and human rights issue.

Logging, under formal approval of Federal and Provincial governments, within the Central Group appeared unlikely to meet endangered species recovery goals or Indigenous treaty rights to “pursue their usual vocations of hunting” (Government of Canada, 1899; Nagy-reis et al., 2021), which included the hunting of caribou. Prior to 2020, the Province provided only a small amount of protected area in the Klinse-Za subpopulation (1.8% , Figure 5), and for the larger Peace region (4.2%) that the Klinse-Za subpopulation is nested within. Although an additional 319 km^2 of land in the Klinse-Za subpopulation (5.8% of area) was in the process of being protected by the Nations and British Columbia as part of the Klinse-Za park expansion. Nevertheless, other legislative and policy tools such as protecting ungulate winter ranges (e.g., see Palm et al., 2020) were also evidently ineffective as implemented in reversing declines. Overall, the degree of habitat protection was much lower than Federal targets of conserving 17% of the terrestrial landscape and the extent of resource extraction in this multi-use landscape was inconsistent with caribou recovery (i.e., $<35\%$ disturbed; Collard et al., 2020; Johnson et al., 2020; Lamb et al., 2018; Figure 2). Prior to 2019, there had been limited improvement in habitat conditions, with habitat loss continuing (Figure 2). Such habitat conditions suggested that recovery was unlikely without long-term effective habitat protection and restoration. Caribou populations would decline as soon as short-term efforts to delay extirpation ceased.

INDIGENOUS-LED CONSERVATION: LONG-TERM SOLUTIONS IN THE PARTNERSHIP AGREEMENT

The Nations, along with the Federal and Provincial governments identified that there was an imminent threat

to southern mountain caribou (British Columbia Mountain Caribou Science Team, 2005; Environment Canada, 2014; Environment and Climate Change Canada, 2018; West Moberly First Nations, 2014), and that levels of resource extraction in the critical habitat of the Central Group caribou were inconsistent with population recovery (Environment Canada, 2017; West Moberly First Nations, 2009). As a result of the lack of undisturbed caribou habitat, the Nations entered into discussions with British Columbia and Canada to protect caribou habitat for the Central Group, of which the Klinse-Za subpopulation is a part (Intergovernmental Partners, 2020).

Wildlife management in Canada is normally the exclusive jurisdiction of provincial governments, however a Partnership Agreement, a Conservation Agreement under Section 11 of SARA, can be used to outline an agreement between two or more parties where the steps required to achieve species recovery are laid out, with roles and responsibilities identified. In this case, the Partnership Agreement is a multilateral agreement between the Governments of the Nations, British Columbia, and Canada, designed to enact habitat protection and short-term recovery actions for Central Group caribou. The Agreement is built around a shared recovery objective of “expeditiously growing the population of the Central Group to levels that are self-sustaining and support traditional aboriginal harvesting activities, consistent with existing Aboriginal and Treaty rights” (Intergovernmental Partners, 2020). Short-term recovery actions (wolf control and maternal penning) will be used to avoid extirpation until habitat restoration is complete, so long as these actions continue to contribute to caribou recovery.

Despite more than a year delay in finalization, the Partnership Agreement was signed by all parties on 21 February 2020 (Figure 4). The Partnership Agreement outlines the formal protection of a 7986 km² area, which includes the expansion (1682 km²) of the Klinse-Za co-managed protected area, and a 4478 km² interim moratorium (30-year) on industrial development while long-term planning occurs (Figure 5). The Partnership Agreement provides a range of habitat security for the Central Mountain Group subpopulations, with the Klinse-Za subpopulation receiving the most protection (86%), and the least protection is found in the Narraway subpopulation (29%, Figure 5; Appendix S1: Section S1).

The Partnership Agreement is the first example of habitat protection for caribou in Canada that creates a viable path to attain Federal caribou recovery targets of >35% of the land being undisturbed and supporting self-maintaining caribou populations. Further, it is

landmark conservation agreement for Canada’s many international agreements such as UNDRIP, which focuses on the rights of Indigenous Peoples, and the Rio Conventions, which aim to safeguard biodiversity while preventing climate change and desertification. In a prior landmark habitat protection initiative, British Columbia protected 22,000 km² of caribou range south of the Central Group (Ministry of Environment, 2009), but most of this protection covered islands of high-elevation forests that were not operationally or economically feasible to harvest (Serrouya & Mclellan, 2016) and the initiative did not provide means to restore habitat at a scale that would ensure caribou persistence, although some recovery of habitat has been detected in this area (Nagy-reis et al., 2021). In contrast, the Partnership Agreement provides funding for the Nations and Province to begin restoring habitat in the region, buy out private resource tenures within the Partnership Agreement area, develop an Indigenous Guardian program, and diversify the economy in the region such that the Partnership Agreement also fulfills local economic needs. The Partnership Agreement stands as testament to the leadership shown by the Nations, their commitment to conserving a landscape to which they are culturally tied, and provides a potential pathway for caribou conservation and Indigenous reconciliation in Canada.



FIGURE 4 Chief Roland Willson, West Moberly First Nations, holds a caribou antler from the recently extirpated Burnt Pine caribou as he speaks about the importance of the Partnership Agreement at the signing on 21 February 2020 in Vancouver, BC. During his speech, Chief Willson said that the Agreement was for the younger members of his Nation, and their grandchildren, who he hoped would one day be able to harvest and utilize a caribou in their traditional ways. Photo Credit: B.C. Government <https://www.flickr.com/photos/bcgovphotos/49566853891/in/album-72157686474934255/>

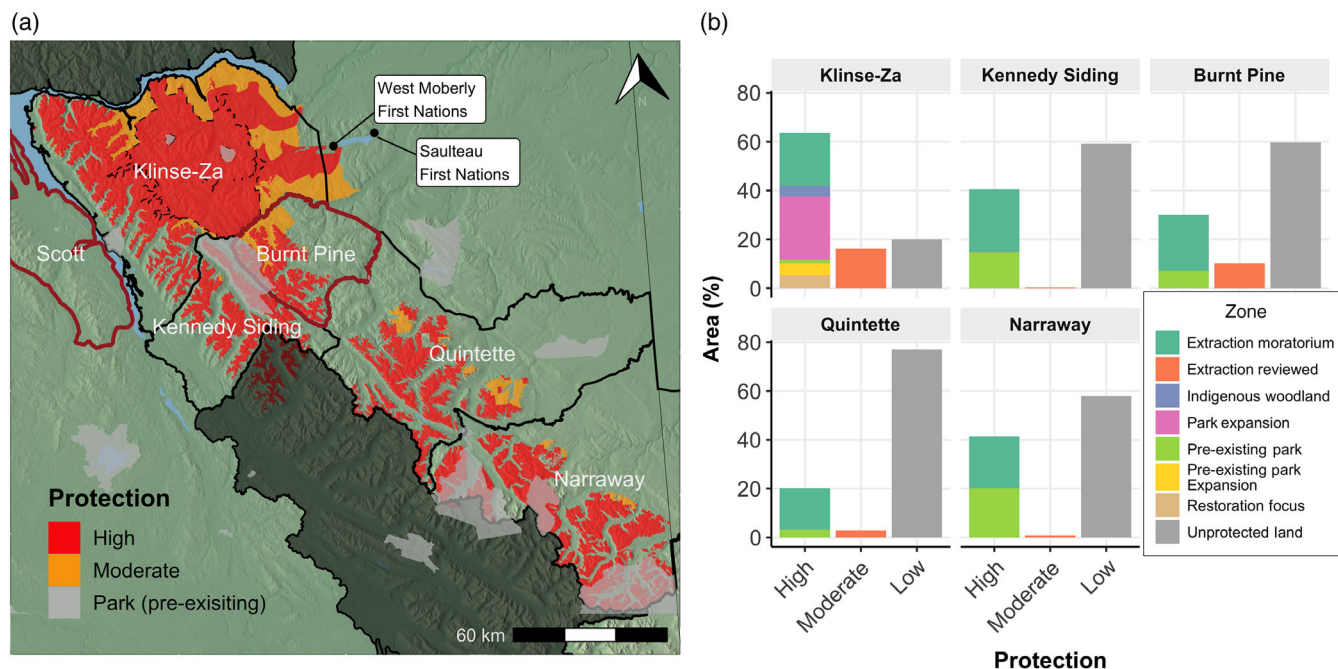


FIGURE 5 The levels of habitat protection afforded by the Partnership Agreement for (a) the Central Group of Southern Mountain caribou and (b) each subpopulation. Black dashed line in the Klinse-Za subpopulation shows the extent of the co-managed Klinse-Za protected area expansion

CONSERVATION IMPLICATIONS

Averting the extirpation of a caribou population is a difficult and expensive task. In the last two decades, caribou have declined by ~73% in Jasper National Park, and have been extirpated in Banff National Park (Canada's flagship protected area) and within nine subpopulations on Provincially managed lands in British Columbia alone (Figure 1; Environment and Climate Change Canada, 2018; Wittmer, McLellan, et al., 2005). Similarly, the last caribou that ranged in the contiguous United States, part of the Canada/U.S. South Selkirk subpopulation, were extirpated in 2019, effectively shifting the southern range of caribou 150 km northward (Moskowitz, 2019).

The Indigenous-led conservation effort described here represents the only successful example of averting the extirpation of boreal or southern mountain caribou via short-term measures, followed by implementation of meaningful habitat protection to increase long-term viability. This grassroots initiative was successful because it brought together committed partners and fostered rapid actions starting in 2013, although the Nations had been working to avert the extirpation of Burnt Pine caribou for many years prior (Muir & Booth, 2012). The Nations have the legal treaty right to self-governance on their territory, and they exercised that right to begin immediate conservation efforts and to mobilize funding to do so. The Nations were able to efficiently exercise self-governance by forming the Níkanêse Wah tzee Stewardship Society,

which guided and oversaw recovery actions (maternal penning and wolf reduction). The Níkanêse Wah tzee Stewardship Society was able to involve community members, Caribou Guardians, and local scientists in the immediately needed recovery actions.

As the signatories of the Partnership Agreement work towards fully recovering these caribou, differences in what recovery means to each group will need to be resolved. The Federal recovery plan lists a subpopulation size of at least 100 caribou as partly satisfying recovery and self-sustaining status, thus potentially warranting down-listing of conservation status. However, from a scientific perspective, population viability analyses for other southern mountain subpopulations suggest that 100 animals may be inadequate to ensure long-term persistence (Wittmer et al., 2010). Further, from an Indigenous treaty rights perspective, 100 animals would likely yield a harvest of fewer than five animals and would be insufficient to fulfill treaty obligations that assured the continuance of a subsistence livelihood.

As part of their traditional way of life, the Nations' people moved with the animals and the seasons in a nomadic "seasonal round." The Commissioners for Treaty 8 (Laird et al., 1899) reported "we had to solemnly assure [the First Nations] ... that they would be as free to hunt and fish after the treaty as they would be if they never entered into it. We assured them that the treaty would not lead to any forced interference with their mode of life." However, the drastic declines of caribou, paired with a multitude of additional consequences from

colonization, have substantially interfered with the seasonal round and mode of life. For the Nations to interact with caribou in a culturally meaningful way, and resolve infringed treaty rights, caribou abundance must be high enough for a sustainable harvest of many animals to occur (Muir & Booth, 2012). Efforts are currently underway to understand what this abundance could be ecologically and from the perspective of the Nations, with a focus on connecting all families in the Nations with caribou harvest opportunities.

The approach to Indigenous-led conservation outlined here is unlike that of provincial Federal species management, where conservation actions can be hampered by conflicting agendas and a lack of political consensus on prioritization, direction, and strategies to conservation (Serrouya & Wittmer, 2010). As a result, the Nations and partners (Wildlife Infometrics, the Province of British Columbia, Treaty 8 First Nations, Industry, and conservation organizations) were able to avert the near extirpation of the Klinse-Za caribou, more than double their abundance in 8 years (Figure 3), and catalyze a landmark conservation agreement. The Partnership Agreement outlines substantial habitat protection measures for the Klinse-Za caribou and extends some modest protections to the rest of British Columbia's extant Central Group caribou (Figure 5).

Increasing the abundance of the Klinse-Za caribou and developing the Partnership Agreement did not come without challenges along the way. On the social side, the desire to provide meaningful habitat protection for caribou created intense debate within local communities in the region. The debate centered around the perception that local non-Indigenous people and their livelihoods would suffer from habitat protection via reductions in available resources to extract (Akman, 2019). Unfortunately, this perception manifested in outward displays of racism directed towards members of the Nations (Cameron & Willson, 2019), highlighting the sharp social conflicts exacerbated by conservation crises.

Further, habitat restoration activities prior to the Partnership Agreement were difficult to conduct due to permitting issues with the Province, as well as the undoing of some habitat restoration by the public. For example, 3 weeks after the Nations successfully deactivated 2.3 km of road that cut through federally identified critical caribou habitat "the work was undone by an unknown individual, who re-installed the road using a bulldozer" (Woods & McNay, 2019). Nevertheless, the leadership and persistence of the Nations prevailed and the road was re-deactivated a few weeks later. A total of 44 km of road has been restored in the Klinse-Za herd area since 2017, reducing disturbance in local caribou habitats by 7%–47%. The designated land protection in

the Partnership Agreement should reduce future conservation vandalism and provide increased protection for future investments in restoration.

Finally, the Partnership Agreement has opened up an opportunity to wonder, and explicitly test, what a restored landscape for sustainable caribou populations looks like, given that none exist yet. The rapid loss of caribou in Jasper and Banff National Parks in the last 30 years hint that habitat protection alone may be insufficient to create self-sustaining populations of caribou (Environment and Climate Change Canada, 2018; Hebblewhite et al., 2010). Despite covering large areas, these parks were not immune to the dynamics of the disturbed lands within which they offer an island of protection, nor the recolonization of wolves in the mid 1980s to these areas. The proximate cause of caribou decline, high predator abundance due to the elevated abundance of prey (elk, deer, and moose), paired with a lack of research or monitoring appears to have caused the loss of Banff caribou (Hebblewhite et al., 2010). As a result, the future of caribou recovery and the Partnership Agreement in the Central Group will in part depend on our ability to answer the following questions: How should habitat restoration be carried out and where should it be prioritized (Figure 2) to attain a self-sustaining caribou population? Under what conditions can wolf reduction and maternal penning be reduced to allow more natural population regulation to take place? And finally, looking within and beyond the Central Group, we seek to know what barriers to equitable partnership development needs to be dismantled to support conservation involving Indigenous Peoples in other caribou and wildlife populations across Canada?

TAKING THIS MODEL TO SCALE

The work we highlight here shows the value of collaborative conservation initiatives that involve, or are led by, Indigenous Peoples. The Nations, provincial and federal governments, scientists, and conservation organizations have collectively made major gains towards the recovery of the Klinse-Za caribou, and other subpopulations in the Central Group following the Partnership Agreement. A broad resurgence of Indigenous land and wildlife stewardship stands to create more equitable and effective conservation actions (e.g., as defined and explored in Law et al., 2018), while allowing local land stewards to contribute to the maintenance of biodiversity and participate in subsistence hunting.

Indigenous Peoples are regaining their rights and title to the land and its stewardship, while often seeking ways to restore culturally important species. The

Indigenous-led work presented here provides insight into a generalizable model that extends beyond caribou and the Indigenous Nations considered here. As Max Desjarlais said of caribou, “they were there when we needed them, and we have to be there for them now” (Chief Roland Willson, personal communication); many Indigenous Peoples are concerned about the erosion of the flora and fauna that they have long depended on in their lands and are grappling with how to effectively conserve these species and their way of life. Although the legal context for Indigenous rights and title differs among Nations, Indigenous Knowledge paired with Indigenous rights to be land stewards stands to help restore and maintain ecosystems and cultural connections.

Indeed, other Indigenous Peoples across British Columbia are stepping in to avert the loss of caribou in their traditional lands. Recently, the T̓silhqot'in Nation announced that they would be devising their own plan to save caribou, as the Itcha-Ilgachuz subpopulation declined by 86% and the province was not doing enough (Stueck, 2019; T̓silhqot'in National Government, 2019). The first action was for the T̓silhqot'in and Ulkatcho Nations to announce an emergency hunting ban on caribou in their territory, including all sustenance hunting (T̓silhqot'in National Government, 2019). Similarly, co-management initiatives are increasing across Canada for other species. For example, (1) grizzly bear and salmon monitoring and management in coastal British Columbia by the Heiltsuk people (Housty et al., 2014) and (2) moose management across parts of Canada by the Unama'ki Institute of Natural Resources, Gwich'in, and Gitanyow Wilp people (Popp et al., 2019). These examples highlight the resurgence and success of Indigenous stewardship of the land and animals to which they are culturally tied.

Beyond Canada, co-management and Indigenous-led conservation initiatives have been successfully applied in other parts of the world. For example, (1) Amazonian Rainforest conservation in Brazil by the Kayapo and Panara people (Schwartzman & Zimmerman, 2005), (2) creation of intercultural space during the Indigenous-controlled planning of protected areas in Australia (Hill, 2011), and (3) Somali co-management of the hirola (*Beatragus huntleri*), the world's most endangered antelope, through restoration of rangeland (Ali et al., 2019). Involving Indigenous peoples in the management of the lands that they occupy offers an opportunity for more effective and equitable conservation. Such inclusion also creates an opportunity to shift from colonial perspectives of land and animals as resources and include Indigenous worldviews where we have shared responsibility to care for and respect the natural world.

Co-management and Indigenous-led conservation initiatives are likely to be successful if many of the

following factors can be incorporated: (1) join knowledge and resources between multiple groups (Indigenous Peoples, colonial governments, scientists, industry, conservation organizations, and users of the land), (2) consider economic issues that may ripple out to the community from the conservation actions (such as resource extraction moratoriums during the creation of parks; Naidoo et al., 2019); negative outcomes can be reduced by supporting the diversification of the local economy in a manner that is consistent with the landscape changes (Gasparatos et al., 2017; Naidoo et al., 2006), (3) implement anti-racism policies and continue to muster the courage to call out the inappropriate and unacceptable racism that may arise, and (4) exercise Indigenous rights and title over the land to reduce political lag in conservation actions. Taken together, co-management and Indigenous-led conservation initiatives stand to increase the success of conservation actions while restoring the connections between people and place.

PERMITS AND ETHICS APPROVAL

Aerial wolf reductions were carried out by contractors to the Province of BC, as well as internal government staff, under the authority of the BC Wildlife Act (Province of British Columbia, 1996) between 2015–2020. The aerial wolf reduction considered here was permitted and received animal care approval through the Provincial Animal Care Review process for Scientific Permits (Wildlife Act Permit Numbers [FJ15-169004, FJ15-165140, FJ-169006, FJ17-264123, FJ17-253645, FJ17-253804, FJ18-286980, FJ18-416476, FJ19-597709]). The BC Animal Care Committee is chaired by the Provincial Wildlife Veterinarian and follows published animal care guidelines (CCAC and AVMA). These actions were exempt from the prohibitions in s.27 of the BC Wildlife Act against herding and hunting wildlife from an aircraft (exempt under s.3(1)(c)(ii) and 3(1)(c)(iii) of the Permit Regulation, B.C. Reg. 253/2000 from the prohibitions in s.27). Indigenous trapping and harvesting of predators (Owens-Beek et al., 2018) was carried out between 2013–2020 under the authority enshrined in treaty rights on traditional territory. Maternal penning was permitted and underwent Provincial Animal Care Review (Wildlife Act Permit Numbers [FJ14-93094, FJ19-568256, FJ18-421458], and Special Use and Free Use Permit Numbers [R14-G1420, 20767, S26316, S25789]). Registered trapping by BC trappers was conducted under the authority of the Wildlife Act (Province of British Columbia, 1996). No university personnel were involved in planning or conducting wolf removal, maternal pens, or caribou collaring, thus obviating the need for university animal care review or approvals.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data and code (Lamb, 2021a) to reproduce the figures and statistics presented here are available in Zenodo: <https://doi.org/10.5281/zenodo.5772856>. Analyses supporting the Integrated Population Model shown in Figure 3b (Lamb, 2021b) can be found on Zenodo at <https://doi.org/10.5281/zenodo.5772880>. The Indigenous Knowledge shared in this paper was collected by West Moberly First Nations and Saulteau First Nations during community-led sharing initiatives. Further information on the reasons for collections, and approvals for sharing are detailed in Muir and Booth (2012). Where appropriate, we have shared citations wherein quotes can be found. Permission to use these data was granted by the West Moberly First Nations and Saulteau First Nations. The Indigenous Knowledge shared here remains the intellectual property of the knowledge holders within the West Moberly First Nations and Saulteau First Nations who safeguard Indigenous Knowledge from ancestors and the ongoing knowledge generation of today.

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REFERENCES

- Adams, L. G., R. Farnell, M. P. Oakley, T. S. Jung, L. L. Larocque, G. M. Lortie, J. Mclelland, M. E. Reid, G. H. Roffler, and D. E. Russell. 2019. "Evaluation of Maternal Penning to Improve Calf Survival in the Chisana Caribou Herd." *Wildlife Monographs* 204: 5–46.
- Akman, P. 2019. "Caribou versus Resources and Recreation Threatens Iconic Canadian Species." <https://www.ctvnews.ca/w5/caribou-versus-resources-and-recreation-threatens-iconic-canadian-species-1.4610500?cache=yes%3FclipId%3D68597>
- Ali, A. H., R. Amin, J. S. Evans, M. Fischer, A. T. Ford, A. Kibara, and J. R. Goheen. 2019. "Evaluating Support for Rangeland-Restoration Practices by Rural Somalis: An Unlikely Win-Win

- for Local Livelihoods and Hirola Antelope?" *Animal Conservation* 22: 144–56.
- Assembly of First Nations 2012. "Co-Management Definitions Guide Appendix to Co-Management Discussion Paper." URL: https://www.afn.ca/uploads/files/env/comanagement_definitions_guide.pdf
- Bichet, O., A. Dupuch, C. Hébert, H. Le Borgne, and D. Fortin. 2016. "Maintaining Animal Assemblages through Single-Species Management: The Case of Threatened Caribou in Boreal Forest." *Ecological Applications* 26: 612–23.
- Bridger, M. Bridger, M. 2019. South Peace Caribou Recovery Following Five Years of Experimental Wolf Reduction. BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development. British Columbia, Canada. URL: https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/wildlife-wildlife-habitat/caribou/south_peace_caribou_recovery_following_five_years_of_experimental_wolf_reduction.pdf
- British Columbia Mountain Caribou Science Team 2005. Mountain Caribou in British Columbia: A Situation Analysis. BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development. British Columbia, Canada. URL: https://www.env.gov.bc.ca/wld/speciesconservation/mc/files/Mountain_Caribou_Situation_Analysis.pdf
- Cameron, K., and R. Willson. 2019. "Joint letter from West Moberly Chief Roland Willson and Sauleau Chief Ken Cameron." https://taylor.civicweb.net/document/42223/LETTERFNChiefstoBradSperlingPRRD_May142019.pdf?handle=701E62264AFE44279FE98EA8278C368E
- Campbell, M. A., B. Kopach, P. E. Komers, and A. T. Ford. 2020. "Quantifying the Impacts of Oil Sands Development on Wildlife: Perspectives from Impact Assessments." *Environmental Reviews* 28: 129–37.
- Collard, R.-C., J. Dempsey, and M. Holmberg. 2020. "Extirpation despite regulation? Environmental assessment and caribou." *Conservation Science and Practice* 2: e166.
- Coristine, L. E., S. Colla, N. Bennett, A. M. Carlsson, C. Davy, K. T. A. Davies, B. Favaro, et al. 2019. "National Contributions to Global Ecosystem Values." *Conservation Biology* 33: 1219–23.
- Cornwall, W. 2018. "Should It Be Saved?" *Science* 361: 962–5.
- COSEWIC. 2014. *COSEWIC Assessment and Status Report on the Caribou Rangifer tarandus, Northern Mountain Population*. Ottawa, ON: Central Mountain Population and Southern Mountain Population in Canada.
- Dawe, K. L., and S. Boutin. 2016. "Climate Change Is the Primary Driver of White-Tailed Deer (*Odocoileus virginianus*) Range Expansion at the Northern Extent of its Range; Land Use Is Secondary." *Ecology and Evolution* 6: 6435–51.
- Decesare, N. J., J. Whittington, M. Hebblewhite, H. Robinson, M. Bradley, L. Neufeld, and M. Musiani. 2011. "The Role of Translocation in Recovery of Woodland Caribou Populations." *Conservation Biology* 25: 365–73.
- Dickie, M., S. R. McNay, G. D. Sutherland, M. Cody, and T. Avgar. 2020. "Corridors or Risk? Movement along, and Use of, Linear Features Varies Predictably among Large Mammal Predator and Prey Species." *Journal of Animal Ecology* 89: 623–34.
- Dickie, M., R. Serrouya, R. S. McNay, and S. Boutin. 2016. "Faster and Farther: Wolf Movement on Linear Features." *Journal of Applied Ecology* 54: 253–63.
- Ehlers, L. P. W., C. J. Johnson, and D. R. Seip. 2016. "Evaluating the Influence of Anthropogenic Landscape Change on Wolf Distribution: Implications for Woodland Caribou." *Ecosphere* 7: e01600.
- Environment and Climate Change Canada 2018. "Imminent Threat Assessment for Southern Mountain Caribou." Government of Canada. Ottawa, ON. URL: https://www.registrelep-sararegistry.gc.ca/virtual_sara/files/ImminentThreatAnalysisSmc-v00-2018Jun-Eng.pdf
- Environment Canada. 2012. *Recovery Strategy for the Woodland Caribou, Boreal Population in Canada*. Ottawa: Environment Canada.
- Environment Canada. 2014. *Recovery Strategy for the Woodland Caribou, Southern Mountain Population (Rangifer tarandus caribou) in Canada [Proposed]*. Ottawa: Environment Canada.
- Environment Canada. 2017. *Canada-British Columbia Southern Mountain Caribou (Central Group) Protection*, 1-113. Ottawa, ON: Government of Canada. https://www.registrelep-sararegistry.gc.ca/virtual_sara/files/ProtectionStudy-Smc-central-v01-0217-Eng.pdf
- Falconer, S., and A. T. Ford. 2020. "Evaluating Policy-Relevant Surrogate Taxa for Biodiversity Conservation: A Case Study from British Columbia, Canada." *Canadian Journal of Zoology* 98: 279–86.
- Festa-Bianchet, M., J. C. Ray, S. Boutin, S. D. Côté, and A. Gunn. 2011. "Conservation of Caribou (*Rangifer tarandus*) in Canada: An Uncertain Future 1." *Canadian Journal of Zoology* 89: 419–34.
- Fortin, D., F. Barnier, P. Drapeau, T. Duchesne, C. Dussault, S. Heppell, M. C. Prima, M. H. St-Laurent, and G. Szor. 2017. "Forest Productivity Mitigates Human Disturbance Effects on Late-Seral Prey Exposed to Apparent Competitors and Predators." *Scientific Reports* 7: 1–12.
- Garnett, S. T., N. D. Burgess, J. E. Fa, Á. Fernández-Llamazares, Z. Molnár, C. J. Robinson, J. E. M. Watson, et al. 2018. "A Spatial Overview of the Global Importance of Indigenous Lands for Conservation." *Nature Sustainability* 1: 369–74.
- Gasparatos, A., C. N. H. Doll, M. Esteban, A. Ahmed, and T. A. Olang. 2017. "Renewable Energy and Biodiversity: Implications for Transitioning to a Green Economy." *Renewable and Sustainable Energy Reviews* 70: 161–84.
- Gilbert, S. L., K. Broadley, D. Doran-myers, A. Droghini, J. A. Haines, A. Hämäläinen, C. T. Lamb, E. W. Neilson, and S. Boutin. 2020. "Conservation Triage at the Trailing Edge of Climate Envelopes." *Conservation Biology* 34: 289–92. <https://conbio.onlinelibrary.wiley.com/doi/10.1111/cobi.13401>
- Gilpin, E. 2019. "First Nations Share Story of Strength and Survival with Caribou Herd Saved from Extinction." National Observer.
- Government of Canada, and Cree, Beaver and Chipewyan 1899. "TREATY No. 8." June 21, 1899. P.C. No. 2749 <https://www.rcaanc-cirnac.gc.ca/eng/1100100028813/1581293624572>
- Government of Canada. 2002. "Species at Risk Act."
- Gustine, D. D., K. L. Parker, R. J. Lay, P. Michael, and D. C. Heard. 2006. "Calf Survival of Woodland Caribou in a Multi-Predator Ecosystem." *Wildlife Monographs* 165: 1–32.
- Hebblewhite, M. 2017. "Billion Dollar Boreal Woodland Caribou and the Biodiversity Impacts of the Global Oil and Gas Industry." *Biological Conservation* 206: 102–11.
- Hebblewhite, M., C. White, and M. Musiani. 2010. "Revisiting Extinction in National Parks: Mountain Caribou in Banff." *Conservation Biology* 24: 341–4.

- Hebblewhite, M., J. Whittington, M. Bradley, G. Skinner, A. Dibb, and C. A. White. 2007. "Conditions for Caribou Persistence in the Wolf-Elk-Caribou Systems of the Canadian Rockies." *Rangifer* 27: 79.
- Hervieux, D., M. Hebblewhite, D. Stepnisky, M. Bacon, and S. Boutin. 2014. "Managing Wolves (*Canis lupus*) to Recover Threatened Woodland Caribou (*Rangifer tarandus caribou*) in Alberta." *Canadian Journal of Zoology* 1037: 1029–37.
- Hill, R. 2011. "Towards Equity in Indigenous Co-Management of Protected Areas: Cultural Planning by Miriung-Gajerrong People in the Kimberley, Western Australia." *Geographical Research* 49: 72–85.
- Housty, W. G., A. Noson, G. W. Scoville, J. Boulanger, R. M. Jeo, C. T. Darimont, and C. E. Filardi. 2014. "Grizzly Bear Monitoring by the Heiltsuk People as a Crucible for First Nation Conservation Practice." *Ecology and Society* 19: 70.
- Hummel, M., and J. C. Ray. 2008. *Caribou and the North: A Shared Future*. 1–288. Toronto, Canada: Dundurn Press.
- Intergovernmental Partners 2020. "Intergovernmental Partnership Agreement for the Conservation of the Central Group of the Southern Mountain Caribou." Victoria, BC, Canada. <https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/wildlife/wildlife-conservation/caribou/partnership-agreement>
- Johnson, C. A., G. D. Sutherland, E. Neave, M. Leblond, P. Kirby, C. Superbie, and P. D. McLoughlin. 2020. "Science to Inform Policy: Linking Population Dynamics to Habitat for a Threatened Species in Canada." *Journal of Applied Ecology* 57: 1314–27.
- Joseph, B. 2018. *21 Things you May Not Know about the Indian Act: Helping Canadians Make Reconciliation with Indigenous Peoples a Reality*. 1–160. Vancouver, BC, Canada: Two Books, Inc.
- Laird, D., J. Ross & J. McKenna 1899. "Treaty No. 8 Report of Commissioners for Treaty No. 8." Government of Canada. Ottawa, ON. <https://www.rcaanc-cirnac.gc.ca/eng/1100100028813/1581293624572>
- Lamb, C. T., M. Festa-Bianchet, and M. S. Boyce. 2018. "Invest Long Term in Canada's Wilderness." *Science* 359: 1002.
- Lamb, C. 2021a. "ctlamb/Indigenous-Led-Caribou-Conservation-KZ: 2021-10-10_acceptedpaper (acceptedpaper)." Zenodo. <https://doi.org/10.5281/zenodo.5772856>
- Lamb, C. 2021b. "ctlamb/KZ_QT_IPM: KZS-accepted (v0.0.2)." Zenodo. <https://doi.org/10.5281/zenodo.5772880>
- Law, E. A., N. J. Bennett, C. D. Ives, R. Friedman, K. J. Davis, C. Archibald, and K. A. Wilson. 2018. "Equity Trade-Offs in Conservation Decision Making." *Conservation Biology* 32: 294–303.
- Mantyka-Pringle, C. S., C. N. Westman, A. P. Kythreotis, and D. W. Schindler. 2015. "Honouring Indigenous Treaty Rights for Climate Justice." *Nature Climate Change* 5: 798–801.
- McNay, R. S., D. Cichowski, and B. R. Muir. 2013. *Action Plan for the Klinse-Za Herd of Woodland Caribou (Rangifer tarandus caribou) in Canada*. Moberly Lake, BC: West Moberly First Nations.
- McNay, S. R., C. T. Lamb, L. Giguere, S. H. Williams, H. Martin, G. D. Sutherland, and M. Hebb. 2022. "Demographic Responses of Nearly Extirpated Endangered Mountain Caribou to Recovery Actions in Central British Columbia." *Ecological Applications*: e2580. <https://doi.org/10.1002/eap.2580>
- Mills, M., M. Bode, M. B. Mascia, R. Weeks, and H. P. Possingham. 2019. "How Conservation Initiatives Go to Scale." *Nature Sustainability* 2: 935–40.
- Ministry of Environment 2009. "Mountain Caribou Recovery Implementation Plan." Victoria, BC. https://www.env.gov.bc.ca/wld/speciesconservation/mc/files/progress_board_update20090213.pdf
- Ministry of Water Land and Air Protection 2002. "Hunting and Trapping Regulations Synopsis 2002-2003." Victoria, BC. https://a100.gov.bc.ca/pub/acat/documents/r22560/BC_Hunt-Reg-2003_1300288531497_1c3c376c6de48faef6de4479800672da80a562aa6b1cb9a0da1974a6df6c2851.pdf
- Moola, F., and R. Roth. 2019. "Moving beyond Colonial Conservation Models: Indigenous Protected and Conserved Areas Offer Hope for Biodiversity and Advancing Reconciliation in the Canadian Boreal Forest." *Environmental Reviews* 27: 200–1.
- Moskowitz, D. 2019. "The Contiguous United States Just Lost its Last Wild Caribou." *Science*. <https://www.science.org/content/article/contiguous-united-states-just-lost-its-last-wild-caribou?cookieSet=1>
- Muir, B. R., and A. L. Booth. 2012. "An Environmental Justice Analysis of Caribou Recovery Planning, Protection of an Indigenous Culture, and Coal Mining Development in Northeast British Columbia, Canada." *Environment, Development and Sustainability* 14: 455–76.
- Nagy-reis, M., M. Hebblewhite, M. Dickie, A. M. Calvert, D. Hervieux, D. R. Seip, and S. L. Gilbert. 2021. "Habitat Loss Accelerates for the Endangered Woodland Caribou in Western Canada." *Conservation Science and Practice* 3: e247.
- Naidoo, R., A. Balmford, P. J. Ferraro, S. Polasky, T. H. Ricketts, and M. Rouget. 2006. "Integrating Economic Costs into Conservation Planning." *Trends in Ecology and Evolution* 21: 681–7.
- Naidoo, R., D. Gerkey, D. Hole, A. Pfaff, A. M. Ellis, C. D. Golden, D. Herrera, et al. 2019. "Evaluating the Impacts of Protected Areas on Human Well-Being across the Developing World." *Science Advances* 5: 1–8.
- Natcher, D., S. Ingram, A. M. Bogdan, and A. Rice. 2021. "Conservation and Indigenous Subsistence Hunting in the Peace River Region of Canada." *Human Ecology* 49: 109–20.
- Owens-Beek, N. S., C. Richter, R. S. McNay & M. Erickson 2018. "Nikanêse Wah Tzee Stewardship Society An Assessment of Wolf Population Control within the Klinse-Za Caribou Herd Area." Moberly Lake, BC. Nikanêse Wah Tzee Stewardship Society.
- Palm, E. C., S. Fluker, H. K. Nesbitt, A. L. Jacob, and M. Hebblewhite. 2020. "The Long Road to Protecting Critical Habitat for Species at Risk: The Case of Southern Mountain Woodland Caribou." *Conservation Science and Practice* 2: e219.
- Popp, J. N., P. Priadka, and C. Kozmik. 2019. "The Rise of Moose Co-Management and Integration of Indigenous Knowledge." *Human Dimensions of Wildlife* 24: 159–67.
- Province of British Columbia 1996. "Wildlife Act General Regulation, BC Reg 340/82." Victoria, BC. http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/00_96488_01
- R. v. Desautel 2019. "BCCA 151 (CanLII)." <https://decisions.scc-csc.ca/scc-csc/scc-csc/en/item/18836/index.do>
- R. v. Sparrow 1990. "CanLII 104 (SCC), [1990] 1 SCR 1075." <https://scc-csc.lexum.com/scc-csc/scc-csc/en/item/609/index.do>
- Schneider, R. R., G. Hauer, W. L. Adamowicz, and S. Boutin. 2010. "Triage for Conserving Populations of Threatened Species: The Case of Woodland Caribou in Alberta." *Biological Conservation* 143: 1603–11.

- Schuster R., R. R. Germain, J. R. Bennett, N. J. Reo, and P. Arcese. 2019. Vertebrate Biodiversity on Indigenous-managed Lands in Australia, Brazil, and Canada Equals that in Protected Areas. *Environmental Science & Policy* 101: 1–6. <http://dx.doi.org/10.1016/j.envsci.2019.07.002>
- Schwartzman, S., and B. Zimmerman. 2005. “Conservation Alliances with Indigenous Peoples of the Amazon.” *Conservation Biology* 19: 721–7.
- Seip, D. R. 1992. “Factors Limiting Woodland Caribou Populations and their Interrelationships with Wolves and Moose in South-eastern British Columbia.” *Canadian Journal of Zoology* 70: 1494–503.
- Serrouya, R. D., M. Dickie, C. T. Lamb, H. van Oort, A. Kelley, C. A. DeMars, P. D. P. D. McLoughlin, et al. 2021. “Trophic Consequences of Terrestrial Eutrophication for a Threatened Ungulate.” *Proceedings of the Royal Society B: Biological Sciences* 288: 20202811.
- Serrouya, R., and B. N. McLellan. 2016. *Next Steps for Southern Mountain Caribou Recovery in Planning Unit 3A*. Revelstoke: The Revelstoke Shuswap Region.
- Serrouya, R., D. R. Seip, D. Hervieux, B. N. McLellan, R. S. McNay, R. Steenweg, D. C. Heard, M. Hebblewhite, M. Gillingham, and S. Boutin. 2019. “Saving Endangered Species Using Adaptive Management.” *Proceedings of the National Academy of Sciences USA* 116: 6181–6.
- Serrouya, R., and H. U. Wittmer. 2010. “Imminent Extinctions of Woodland Caribou from National Parks.” *Conservation Biology* 24: 362–3.
- Sharp, H., and K. Sharp. 2015. *Hunting Caribou: Subsistence Hunting along the Northern Edge of the Boreal Forest*. Lincoln, Nebraska: University of Nebraska Press.
- Sittler, K. L., and R. S. McNay. 2017. *Conservation of Caribou in the Scott West Herd Area*. Mackenzie, BC: Wildlife Infometrics.
- Smith, K. G., and L. Pittaway. 2011. “Little Smoky Woodland Caribou Calf Survival Enhancement Project.” *Rangifer* 31: 97–102.
- Stueck, W. 2019. “First Nation in B.C. to Devise Own Caribou Herd-Management Plan, Blames Province for Not doing Enough.” <https://www.theglobeandmail.com/canada/british-columbia/article-first-nation-in-bc-to-devise-own-caribou-herd-management-plan/>
- T̓silhqot̓in National Government. 2019. *T̓silhqot̓in and Ulkatcho Announce Emergency No Caribou Hunting Ban in their Traditional Territories*. Williams Lake, BC: T̓silhqot̓in National Government.
- Vucetich, J. A., M. P. Nelson, and J. T. Bruskotter. 2017. “Conservation Triage Falls Short because Conservation Is Not like Emergency Medicine.” *Frontiers in Ecology and Evolution* 5: 1–6.
- West Moberly First Nations 2009. “I Want to Eat Caribou before I Die: Initial Submission for the Proposed Mining Activity at First Coal Corporation’s Goodrich Property.” Moberly Lake, BC.
- West Moberly First Nations. 2014. “Population and Distribution Objectives and Identification of Critical Habitat for Seven Herds of Woodland Caribou in the South Peace Area of British Columbia.”
- Williams, S. H., R. Steenweg, T. Hegel, M. Russell, D. Hervieux, and M. Hebblewhite. 2020a. “Habitat Loss on Seasonal Migratory Range Imperils an Endangered Ungulate.” *Conservation Science and Practice* 2: e12039.
- Williams, S. H., R. Steenweg, T. Hegel, M. Russell, D. Hervieux, and M. Hebblewhite. 2020b. “Habitat Loss on Seasonal Migratory Range Imperils an Endangered Ungulate.” *Conservation Science and Practice* 2: 1–14.
- Wittmer, H. U., R. N. M. Ahrens, and B. N. McLellan. 2010. “Viability of Mountain Caribou in British Columbia, Canada: Effects of Habitat Change and Population Density.” *Biological Conservation* 143: 86–93.
- Wittmer, H. U., B. N. McLellan, D. R. Seip, J. A. Young, T. A. Kinley, G. S. Watts, and D. Hamilton. 2005. “Population Dynamics of the Endangered Mountain Ecotype of Woodland Caribou (*Rangifer tarandus caribou*) in British Columbia, Canada.” *Canadian Journal of Zoology* 83: 407–18.
- Wittmer, H. U., A. R. E. E. Sinclair, and B. N. McLellan. 2005. “The Role of Predation in the Decline and Extirpation of Woodland Caribou.” *Oecologia* 144: 257–67.
- Woods, A. D., and R. S. McNay. 2019. *Klinse-Za/Scott East Caribou Habitat Restoration 2018–2019 Annual Report*. Nikanēse Wah tzee Stewardship Society.

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