Intensive Wolf Reduction and Caribou Recovery in British Columbia: Resource List

Pacific Wild

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Intensive Wolf Reduction in British Columbia:
Resource List

Note to the reader:

This resource list was compiled based on a file review in addition to a literature review and comprises a collection of references including research articles, books, and resources pertinent to the decline of woodland caribou (*Rangifer tarandus caribou*) due to loss of critical habitat to resource extraction activities and the intensive reduction of the Grey Wolf (*Canis lupus*) in British Columbia. It is not an exhaustive inclusion of references or topics related to caribou decline, habitat destruction and the wolf kill program, in acknowledgment of financial and other limitations. However, this document provides a considerable collection of information as a concrete starting point, which can evolve and be expanded upon further.

The resources list is intended to provide the scientific evidence which supports the dire necessity for seriousness and sincerity in dedication to protection of critical habitat required by woodland caribou (*Rangifer tarandus caribou*). Further, this resources list absolves the Grey Wolf (*Canis lupus*) from being portrayed as the scapegoat by the Government of British Columbia, by substantiating the cull as unscientific, unsustainable, unethical, unacceptable and unjust with considerable evidence documented within the literature.

Chapters topics within the resources list pertain to threats to caribou, Indigenous conservation, current wolf management, insufficient protection of caribou habitat, inadequate scientific evidence for the wolf control effectiveness, unintended consequences of predator removal, preferred non-lethal methods, and ethics research and public disapproval. The document contains over 50 reference summaries from research articles, books, and government documents which are updated on a regular basis.

1 Threats to Caribou

1.1 Health Stressors (Nutritional Inadequacies and Disease)

1.1.1 Animal-defined resources reveal nutritional inadequacies for woodland caribou during summer–autumn.

This study fills research gaps related to the role of nutrition in the decline of woodland caribou populations. In particular, the adequacy of habitat to support nutritional demands during lactation was assessed for caribou in northeastern BC. Tame caribou were used to quantify dietary quality and intake rates (digestible protein and energy) among predominant BC plant communities, with focus on requirements during lactation. Findings demonstrated that tame caribou could not satisfy protein and energy requirements during lactation. The magnitude of nutritional inadequacies was severe as greater than 33% of sites failed to meet 50% of protein and energy needs and >60% did not meet 80% of daily requirements. Simulations applied to wild caribou provide evidence of widespread nutritional inadequacies from their habitat ranges. Due to the low availability of vegetation communities having high nutritional value (i.e., old growth forests), calf production, growth and maternal body fat replenishment is likely suppressed. This study, in conjunction with documented caribou body fat measurements, established that the nutritional environment does not meet the needs of lactating caribou. Moreover, the researchers point to another study indicating widespread low body condition for caribou in southern and central mountains of BC, adding that 30% of the reported female caribou carcasses had marrow and body fat levels indicative of vulnerability to predation, disease and parasites. Concluding discussion states: 'Bottom-up and top-down forces undoubtedly act simultaneously on prey populations, and thus either-or perspectives regarding both forces are unduly limited and probably artificial.' Nutritional deprivation in lactating caribou has consequences for caribou populations, recovery and conservation. Furthermore, the authors assert that this work adds to a growing body of literature illuminating nutrition as a limiting factor for caribou populations.

Denryter, K., Cook, R. C., Cook, J. G., and Parker, K. L. (2022). Animal-defined resources reveal nutritional inadequacies for woodland caribou during summer–autumn. *Journal of Wildlife Management* 86:e22161. https://doi.org/10.1002/jwmg.22161

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See also:

Cook, J. G., Kelly, A. P., Cook, R. C., Culling, B., Culling, D., McLaren, A., ... & Watters, M. (2021). Seasonal patterns in nutritional condition of caribou (Rangifer tarandus) in the southern Northwest Territories and northeastern British Columbia, Canada. *Canadian Journal of Zoology*, *99*(10), 845-858. https://doi.org/10.1139/cjz-2021-0057

1.1.2 Seasonal patterns of mortality for boreal caribou (Rangifer tarandus caribou) in an intact environment

Seasonal variation of boreal caribou vulnerability to mortality was investigated. Survival and mortality data on radio-collared adult female caribou was used to evaluate patterns across the year. Results showed a trimodal mortality pattern, characterized by three peaks across the year. The two highest mortality peaks occurred in late spring (pre-calving) and mid-summer, followed

by a smaller peak in late autumn. Generally, the risk of mortality was elevated from late spring (pre-calving) to mid-summer. The mid-summer peak could not be explained by increased predator encounter rate as may be predicted for the other peaks due higher caribou movement rates during those times. Evidence was apparent for the mid-summer peak that mortalities were driven by caribou nutritional condition. The greatest depletion of body reserves occurs from spring to mid-summer. Further, mortalities identified as predation followed the same trimodal pattern across the year, while those definitively attributed to starvation (i.e., carcass intact) were clustered between the calving and mid-summer period. Bone marrow fat has been found to be lower in caribou killed due to predation. The researchers suggest a variety of factors interact to display the seasonal pattern of mortality. Seasonal changes in both predator and prey movements and encounter rates likely contribute to variation in the pattern. However, this study expands on research demonstrating that other non-predator factors mediate and contribute to predation. Specifically, prey vulnerability (i.e., malnutrition and demanding reproductive stages of late gestation and lactation) is a significant factor to caribou mortality. Seasonal variations in the dominant pressures to caribou (predator encounters, energy demands, and nutrition) all need to be considered when attempting the difficult task of discerning bottom-up and top-down mechanisms.

Kelly, A. (2020). Seasonal patterns of mortality for boreal caribou (Rangifer tarandus caribou) in an intact environment. https://doi.org/10.7939/r3-qgdp-kh61

See also:

Brown, G. S., Landriault, L., Sleep, D. J. H., & Mallory, F. F. (2007). Comment arising from a paper by Wittmer et al.: hypothesis testing for top-down and bottom-up effects in woodland caribou population dynamics. *Oecologia*, *154*(3), 485–492. https://doi.org/10.1007/s00442-007-0855-3

The above in response to / refuting:

Wittmer, H. U., Sinclair, A. R., & McLellan, B. N. (2005). The role of predation in the decline and extirpation of woodland caribou. *Oecologia*, *144*(2), 257-267.

1.1.3 British Columbia Boreal Caribou Health Program, Progress Report: Year 2

Health of caribou is an indicator of vulnerability that represents the capacity to cope with external stressors such as natural and human disturbance. Therefore, the health status of species-at-risk such as caribou has important implications to conservation and management decisions. The Boreal Caribou Health Research Program (BCHRP) reported the health status of boreal caribou in northeastern BC. Bacterial, viral, and parasitic diseases along with other health indices (i.e., chronic physiological stress, immunity, and nutrition) were evaluated. Notable health threats included pathogenic bacterium *E. rhusiopathiae*, the protozoan parasite *N.caninum*, and severe winter tick *(D. albipictus*) infestations. Also identified were changes in bone marrow fat and nutrient deficiencies. Evidence demonstrated that the pathogen *E. rhusiopathiae* may have contributed to unusually elevated mortality observed in 2013. Findings determined that health and disease could be of great importance to the long-term sustainability of boreal caribou.

Schwantje, H., Macbeth, B., Kutz, S., and Elkin, B. (2016). *British Columbia Boreal Caribou Health Program, Progress Report: Year 2* (February 1, 2015–March 31, 2016) (British Columbia Boreal Caribou Health Research Program Working Group). 49. Available online at http://www.bcogris.ca/sites/default/files/bcip-2014-05-boreal-caribou-health-study-final-report-year-2.pdf

See also:

Forde, T. L., Orsel, K., Zadoks, R. N., Biek, R., Adams, L. G., Checkley, S. L., Davison, T., De Buck, J., Dumond, M., Elkin, B. T., Finnegan, L., Macbeth, B. J., Nelson, C., Niptanatiak, A., Sather, S., Schwantje, H. M., van der Meer, F., & Kutz, S. J. (2016). Bacterial Genomics Reveal the Complex Epidemiology of an Emerging Pathogen in Arctic and Boreal Ungulates. *Frontiers in Microbiology*, *7*. https://doi.org/10.3389/fmicb.2016.01759

See also:

Bondo, K. J., Macbeth, B., Schwantje, H., Orsel, K., Culling, D., Culling, B., Tryland, M., Nymo, I. H., & Kutz, S. (2019). Health Survey of Boreal Caribou (*Rangifer tarandus caribou*) in Northeastern British Columbia, Canada. *Journal of wildlife diseases*, *55*(3), 544–562. https://doi.org/10.7589/2018-01-018

1.2 Habitat Disturbance and Linear Features

1.2.1 Witnessing extinction – Cumulative impacts across landscapes and the future loss of an evolutionarily significant unit of woodland caribou in Canada

Research on Central Mountain caribou provided evidence that the cumulative effects of industrial development strongly influenced patterns of caribou habitat selection and availability. Using 11 years of Central Mountain caribou location data, the relationship between disturbance and caribou response was characterized to develop species distribution models. Caribou habitat avoidance was modelled as zones of influence (buffer areas of avoidance around disturbance features) for roads, seismic and pipelines, oil and gas features, cut blocks, burns, and coal mines. Using the models, habitat loss over a period of 22 years was calculated based on a loss of functional habitat (reduction in the relative probability of use due to avoidance of zones of influence). Habitat change was then correlated with measured population decline. Results demonstrated a maximum loss in high-quality habitat of 66%. The accelerated loss of habitat was strongly correlated with caribou population decline. Habitat selection by caribou was impacted as the availability and quality of habitat diminished. Studies on boreal woodland caribou had similar findings. Considering these dramatic declines and herd extinctions, there is an immediate need for habitat protection and restoration. Further extinctions are imminent at the current rates of habitat alteration and population declines.

Johnson, C. J., Ehlers, L.P.W., Seip, D.R. (2015). Witnessing extinction – Cumulative impacts across landscapes and the future loss of an evolutionarily significant unit of woodland

caribou in Canada. *Biological conservation (186)*. 176–186. https://www.sciencedirect.com/science/article/abs/pii/S0006320715001160?via%3Dihub

See also:

Courtois, R., Ouellet, J. P., Breton, L., Gingras, A., & Dussault, C. (2007). Effects of forest disturbance on density, space use, and mortality of woodland caribou. *Ecoscience*, *14*(4), 491-498. http://www.jstor.org/stable/42902586

1.2.2 Boreal Caribou (Rangifer tarandus) in British Columbia: 2017 Science Review

This science review summarizes research results on British Columbia's (BC) Boreal Woodland Caribou and habitat between 2010 and 2016. Boreal caribou are listed as threatened under the federal Species at Risk Act and provincially (BC) are on the red list (S1: Imperiled).[1] Research results demonstrated BC's Boreal caribou population in decline. The report indicated adult caribou mortality was primarily from changes to predator-prey dynamics caused by human footprint. Specifically, increased density of wolves, however information on distribution and abundance of wolves was noted to be lacking. Further, 'no formal studies of causes of calf mortality have been conducted in BC's Boreal Caribou Ranges' and calf mortality to date was best explained by black bear predation. Health threats to Boreal Woodland Caribou included parasite and bacterial infections, winter tick infestations causing hair loss, nutrient deficiencies, and high levels of cortisol indicating physiological stress. Additional threats include fire, weather and climate change. Cumulative and interacting factors impacting Boreal Caribou population dynamics are depicted in Figure 1. As shown, landscape level habitat alterations including linear features and changes to habitat vegetation are the ultimate main drivers of caribou declines. The report identified knowledge gaps including wolf abundance and diet, the primary cause of calf mortality, and level of habitat restoration requirements.

[1] Northern Mountain caribou are assessed under SARA as special concern (2005). Southern Mountain caribou (which under SARA also includes the Central Mountain populations) are listed as threatened (2003).

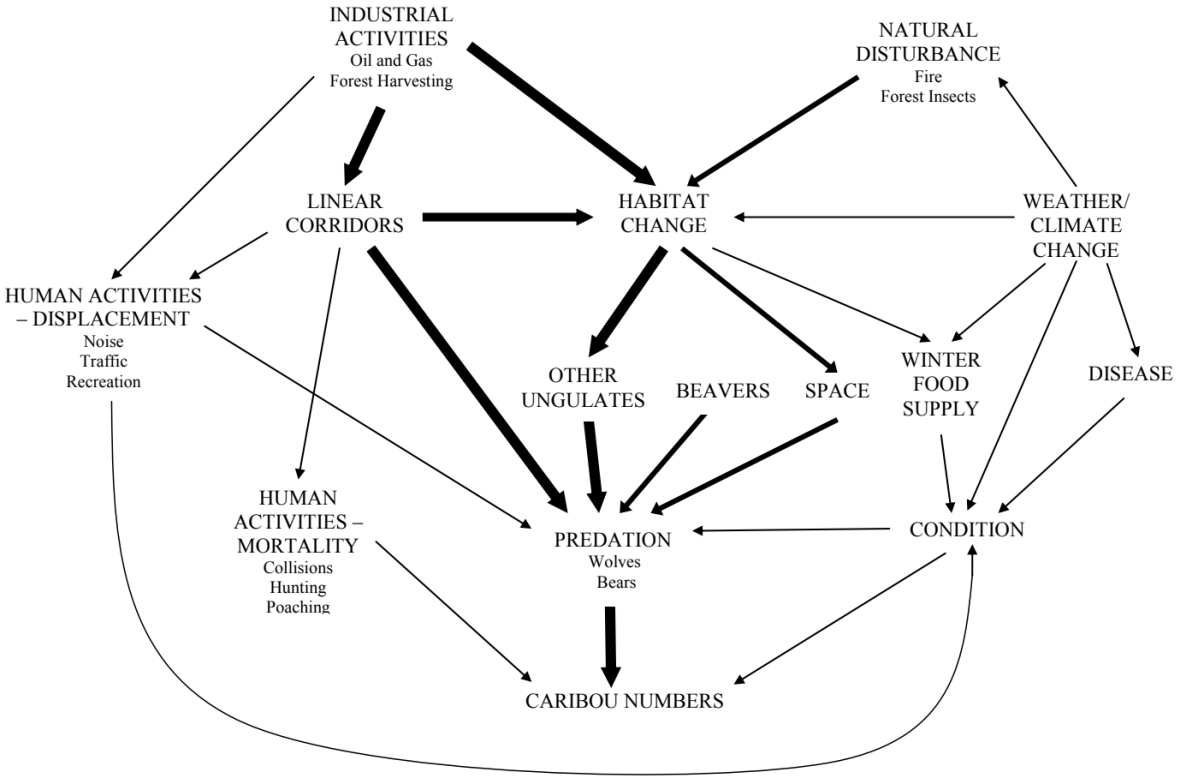

Figure 1: Cumulative impacts to Boreal Caribou and linkages between interacting factors. Adopted from Culling and Cichowski (2017), pp. 63. Thickness of arrows is intended to represent relative contribution.

Culling, D. E., and Cichowski, D. B. (2017). *Boreal Caribou (Rangifer tarandus) in British Columbia: 2017 Science Review. 141*. Prepared for the BC Oil and Gas Research and Innovation Society, Victoria, BC. Available online at: http://www.bcogris.ca/sites/default/files/bcip-2016-21-science-review-2017-final.pdf

See also:

B.C. Ministry of Forests, Lands, Natural Resource Operations, and Rural Development, and B.C. Ministry of Environment and Climate Change Strategy. (2018). Science review for the South Peace Northern Caribou (Rangifer tarandus caribou pop. 15 and pop. 18) in British Columbia. Victoria, BC. 71pp. https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/wildlife-wildlife-habitat/caribou/2018_science_review_for_the_south_peace_northern_caribou.pdf

See also:

Government of British Columbia. (n.d). *Caribou in British Columbia*. Retrieved June 6. 2022, from https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/wildlife/wildlife-conservation/caribou

See also:
Government of Canada. (2021). *Caribou in Canada*. https://www.canada.ca/en/environment-climate-change/services/species-risk-education-centre/caribou.html

1.2.3 Nowhere to hide: Effects of linear features on predator-prey dynamics in a large mammal system

Researchers demonstrate how linear features (e.g., roads, pipelines and resource exploration / seismic lines reduce the ability of boreal woodland caribou to successfully find refuge from predators (i.e., grey wolves and black bears). Linear features can facilitate predator movement to increase special overlap of predator and prey species. Peatlands such as bogs provide refuge for caribou and are therefore a preferred habitat. However, linear features were found to increase predator selection for peatlands. Results showed despite attempts, most caribou are unable to entirely avoid high-density linear feature peatlands. Furthermore, it was demonstrated that use of linear features by female caribou increased mortality of newborn calves. Mitigation efforts should be focused on limiting or restoring linear features that contribute to predator–prey spatial overlap.

DeMars, C. A., & Boutin, S. (2018). Nowhere to hide: Effects of linear features on predator-prey dynamics in a large mammal system. *The Journal of animal ecology*, *87*(1), 274–284. https://doi.org/10.1111/1365-2656.12760

1.2.4 Predation risk for boreal woodland caribou in human-modified landscapes: evidence of wolf spatial responses independent of apparent competition

For caribou in northeast British Columbia, modeling research found stronger support for direct effects of linear features to caribou-wolf co-occurrence and predation risk than for the commonly held hypothesis of apparent competition[2]. In order to understand the human-mediated decline of boreal caribou, three hypotheses were evaluated: (1) numeric apparent competition / increased moose prey density; (2) spatial apparent competition / altered moose prey distribution; and (3) wolf spatial responses /altered wolf distribution independent of prey. Findings demonstrated no relationship between disturbances, moose density, and caribou survival. Further, both positive and negative relationships were evident between disturbance and caribou-moose co-occurrence. By contrast, positive correlations were demonstrated between wolf-caribou co-occurrence with predation risk and linear features. Recommendations suggest limiting future and restoring existing linear features for caribou recovery in northeastern British Columbia. The need for region-specific solutions is highlighted for recovery of wide-ranging species.

Mumma, M. A., Gillingham, M. P., Parker, K. L., Johnson, C. J., & Watters, M. (2018). Predation risk for boreal woodland caribou in human-modified landscapes: evidence of

[2] It has been hypothesized that early seral stage forest attracts alternate prey such as deer and moose, which thereby attract wolves, increasing encounters and the predation threat to woodland caribou (habitat mediated apparent competition).

wolf spatial responses independent of apparent competition. *Biological Conservation*, *228*, 215-223. https://doi.org/10.1016/j.biocon.2018.09.015

See also:
Mumma, M. A., Gillingham, M. P., Johnson, C. J., & Parker, K. L. (2017). Understanding predation risk and individual variation in risk avoidance for threatened boreal caribou. *Ecology and evolution*, *7*(23), 10266–10277. https://doi.org/10.1002/ece3.3563

See also (independent summary below):
Johnson, C. J., Mumma, M. A., and St-Laurent, M. H. (2019). Modeling multispecies predator–prey dynamics: predicting the outcomes of conservation actions for woodland caribou. *Ecosphere (Washington, D.C)*, *10*(3), e02622–n/a. https://doi.org/10.1002/ecs2.2622

See also:
Droghini, A., & Boutin, S. (2017). Snow conditions influence grey wolf (Canis lupus) travel paths: the effect of human-created linear features. *Canadian Journal of Zoology*, *96*(1), 39–47. https://doi.org/10.1139/cjz-2017-0041

See also:
Dickie, M., Serrouya, R., McNay, R. S., & Boutin, S. (2017). Faster and farther: wolf movement on linear features and implications for hunting behaviour. *Journal of Applied Ecology*, *54*(1), 253-263. https://doi.org/10.1111/1365-2664.12732

See also:
Finnegan, L., Pigeon, K. E., Cranston, J., Hebblewhite, M., Musiani, M., Neufeld, L., Schmiegelow, F., Duval, J., & Stenhouse, G. B. (2018). Natural regeneration on seismic lines influences movement behaviour of wolves and grizzly bears. *PLoS ONE*, *13*(4). https://doi.org/10.1371/journal.pone.0195480

See also:
Dabros, A., Pyper, M., & Castilla, G. (2018). Seismic lines in the boreal and arctic ecosystems of North America: environmental impacts, challenges, and opportunities. *Environmental Reviews*, *26*(2), 214-229.

1.2.5 Predation risk for boreal woodland caribou in human-modified landscapes: evidence of wolf spatial responses independent of apparent competition

The decline of caribou in many parts of Canada is attributed to 'human-mediated predation.' Focusing on the Chinchaga caribou (Boreal Caribou Designatable Unit) population in British Columbia, multispecies modelling of predator-prey dynamics was applied to explore the effectiveness and cost of various conservation actions and then contrasted with a different boreal caribou population in Quebec. The decline in the Chinchaga population was found to be due to seismic lines and resource roads, thereby mediating the risk of wolf predation. Wolf density alone does not have a significant impact on population decline, but does have an effect when

linear features are present. Long-term wolf-culling was identified (via modeling) as the most cost-effective recovery action for the Chinchaga caribou ($25,665/caribou) , followed by a large-scale predator exclosure ($170,767/caribou), and the aggressive restoration of roads, seismic lines, power lines, pipelines, railroads, cut lines, and recreational trails ($531,675/caribou). The model did support the general principle of first addressing the root cause of decline before insecurely investing in short-term stop-gap measures that are intensive, invasive and expensive. The model shows that an increase in linear features (roads etc.), lead to extirpation (local extinction) of caribou within a year while removal of linear features was effective in reducing population decline; however this method is very expensive and would require long-term commitment to be successful. The results indicated that a high degree of variation in recovery actions should be expected for woodland caribou; a one-size solution will not fit all populations.

Johnson, C. J., Mumma, M. A., and St-Laurent, M. H. (2019). Modeling multispecies predator–prey dynamics: predicting the outcomes of conservation actions for woodland caribou. *Ecosphere (Washington, D.C)*, *10*(3), e02622–n/a. https://doi.org/10.1002/ecs2.2622. Retrieved from https://esajournals.onlinelibrary.wiley.com/doi/10.1002/ecs2.2622

2 Indigenous Knowledge and Management

2.1.1 Intergovernmental Partnership Agreement for the Conservation of the Central Group of the Southern Mountain Caribou.

Signed in February 2020 under SARA section 11, the Saulteau First Nations and West Moberly First Nations partnered with both the Government of British Columbia and the Government of Canada to advance a collaborative approach for the protection of southern mountain caribou in the northeastern extent of their range. The Partnership Agreement commits to protect over 700,000 hectares of caribou habitat through moratoria on resource development and permanent protection. For Indigenous partners, Saulteau and West Moberly First Nations continue to lead recovery actions for the central group and the agreement enhances their decision-making with regards to lands and resources related to caribou recovery. The Partnership Agreement establishes a Caribou Recovery Committee with officials from the four governments. Long-term financial support will be provided for recovery efforts, including funding for maternal penning, habitat restoration, collaborative knowledge sharing and research, and an Indigenous Guardians Program.

Government of Canada, Government of BC, Saulteau First Nations, & West Moberly First Nations. (2020). Intergovernmental partnership agreement for the conservation of the central group of the southern mountain caribou. Retrieved from https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/conservation-agreements/intergovernmental-partnership-conservation-central-southern-mountain-caribou-2020.html. Also available from: https://wildlife-species.canada.ca/species-risk-registry/virtual_sara/files/Ca-SthnMtnCaribouMtgnsSud-AccordPartnAgrmt-v00-2020Feb-Eng.pdf

2.1.2 Support for BC First Nations' Territorial Management and Protection of Caribou and Wolf Populations

The Union of BC Indian Chiefs (UBCIC) passed a resolution calling for First Nations' management and protection of caribou and wolf populations by territory. The resolution emphasizes that First Nations have long protected and managed their territories and that the endangered status of caribou is due to mismanagement of caribou habitat by the provincial government. The importance of wolves is stated, as a keystone species as well as sacred animals with spiritual connection to Indigenous peoples. Wolves were targeted by inhumane aerial killings despite failure to protect habitat. Commitments under the *United Nations Declaration on the Rights of Indigenous Peoples* are outlined. First Nations uphold the right to make decisions regarding land and wildlife management. Due to lack of Provincial priorities to restore habitat, remove linear features and reduce development, the only option for many First Nations it to move forward with their Caribou Recovery Plans. The resolution calls for a stop to unilateral state decisions on wolf culling and caribou recovery. Finally, the UBCIC Chiefs Council directs members to work with organizations to ensure the provincial government undertakes a selective approach that respects First Nations jurisdiction and territorial management.

Union of British Columbia Indian Chiefs Council. (2022, February 23-24). Resolution no. 2022-09 Support for BC First Nations' Territorial Management and Protection of Caribou and Wolf Populations [Virtual meeting]. Final Resolutions of UBCIC Chiefs Council February 23rd-24th, 2022. Retrieved from https://assets.nationbuilder.com/ubcic/pages/132/attachments/original/1646354635/2022_02_UBCIC_CC_FinalResolutions_Combined.pdf?1646354635

See also:

Union of British Columbia Indian Chiefs Council. (2021, February 25). Ending the Wolf Cull Program and Addressing Misguided Wildlife Management Policy. Letter to Minister of Forests, Lands and Natural Resources. Retrieved from https://pacificwild.org/wp-content/uploads/2021/10/Union-of-BC-Indian-Chiefs-Letter-of-Support.pdf

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

This research paper reviews the success of Indigenous leadership in conservation. Specifically, the leadership demonstrated by the West Moberly First Nations and Saulteau First Nations on short-term and long-term recovery efforts on the Klinse-Za subpopulation. The population declined from 250 individuals in the 1990's to 38 in 2013 leading to a non-viable indigenous caribou harvest with implications for treaty rights to subsistence living. Short-term recovery actions included a maternal penning program established in 2014 by the West Moberly First Nations and Saulteau First Nations. This was implemented since calf mortality was suspected to be limiting caribou. Wolf reductions (trapping by First Nations and helicopter culling by the Provincial government) were also carried out. Evidence showed that the Kilnse-Za caribou population rapidly increased in eight years by more than double, with 101 individuals in 2021.

The authors credited the population increase to both short-term actions of maternal penning and predator reduction. The success of this initiative underscores the integral role of Indigenous governance and leadership in stimulating meaningful conservation for endangered species recovery. Understanding that these efforts could not persist toward the recovery of a self-sustaining caribou population without long-term habitat protection and restoration fostered implementation of the Partnership Agreement in 2020 between the two First Nations, Provincial and Federal governments (see section 5.1). The framework of decentralized co-management and Indigenous-led conservation demonstrates the effectiveness of merging Indigenous treaty rights, traditional knowledge, and endangered species recovery to advance synergistic goals. Through collaboration and Indigenous leadership, there is a greater opportunity to restore ecosystems and cultural connections to the land, having implications for reconciliation and wildlife conservation.

Lamb, C.T., Willson, R., Richter, C., Owens-Beek, N., Napoleon, J., Muir, B., McNay, R.S., Lavis, E., Hebblewhite, M., Giguere, L., Dokkie, T., Boutin, S. and Ford, A.T. (2022), Indigenous-led conservation: Pathways to recovery for the nearly extirpated Klinse-Za mountain caribou. *Ecological Applications*. Accepted Author Manuscript e2581. https://doi.org/10.1002/eap.2581. Retrieved from https://esajournals.onlinelibrary.wiley.com/doi/10.1002/eap.2581 Full text: https://esajournals.onlinelibrary.wiley.com/doi/epdf/10.1002/eap.2581

2.1.4 Medzih action plan: Fort Nelson First Nation boreal caribou recovery plan

Fort Nelson First Nation (FNFN) implemented the Medzih Action Plan (MAP), founded on principle of habitat protection for caribou recovery. FNFN developed this recovery strategy due to the current state of caribou, as well as little or no change and overall lack of faith in federal and provincial governments. The MAP clearly outlines several strategies including: protection zones, restoration zones, restoration actions, fund establishment, moratorium, an ecosystem management approach to development, improving population trends, management paradigm that ensures decisions are precautionary, habitat protection that meets SARA, appropriate monitoring (habitat, population, and restoration success), and building a stable economic future (not boom/bust approach). FNFN developed this plan based on traditional knowledge, science and mapping and aims to work with provincial and federal governments for implementation.

Fort Nelson First Nation. (2017). Medzih action plan: Fort Nelson First Nation boreal caribou recovery plan. http://www.fortnelsonfirstnation.org/uploads/1/4/6/8/14681966/2017-sept-29_fnfn_medzih_action_plan_final_medres.pdf

3 Wolf Management in British Columbia

3.1.1 Management Plan for the Grey Wolf (Canis lupus) in British Columbia

This document described the status and management of the Grey Wolf (*Canis lupus)* in British Columbia. Population trends were described as likely stable or increasing and the objectives of wolf management outlined, such as for the purposes of species at risk recovery. Wolf reductions

that had occurred to date (2014) were unsuccessful for caribou recovery as caribou populations continued to decline. In particular, although wolf densities were reduced, "a correlation between wolf densities and caribou recovery could not be substantiated." Furthermore, it is noted that fragmentation of packs can lead to high birth rates (also see section 6.1). Future management suggests constraining actions related to mitigation of wolf populations to areas as small as possible in order to minimize conservation risks to (a) the broader wolf population and (b) unintended ecological consequences (e.g., trophic cascades) (also see section 6.2 and 6.3). In addition, management actions need to align with expectations of the public (also see section 8.0), maintain transparency, and continually be monitored, reassessed and adjusted as necessary.

B.C. Ministry of Forests, Lands and Natural Resource Operations. (2014). *Management Plan for the Grey Wolf (Canis lupus) in British Columbia.* B.C. Ministry of Forests, Lands and Natural Resource Operations, Victoria, BC. 48 pp. Retrieved from: https://www.env.gov.bc.ca/fw/wildlife/management-issues/docs/grey_wolf_management_plan.pdf

3.1.2 Predator Management to Support Caribou Recovery: 2020-2021 Summary. Caribou Recovery Program

This report summarizes predator management over the 2020-2021 winter. Aerial shooting of wolves occurred in 13 of 54 caribou populations in British Columbia. Ground tracking and hunting of cougars also occurred in two of the 13 caribou population ranges. In total, 237 wolves and eight cougars were killed. Costs were approximately $1.6 million that year and are summarized by herd within the report. Intensive wolf reduction aims for annual removal of >80% of wolves to achieve government targets of less than 3 wolves per 1000 km^2 in caribou recovery areas. Entire wolf packs are removed using GPS/VHF radio collars. The figure below depicts predator reduction areas and number of predators killed. The report states the Caribou Recovery Program assesses the effectiveness of predator reduction on caribou herds during the following year and adapts if necessary. Wolf populations have shown to recover at rates ranging between 30-100% by the following winter. The wolf kill program is intended to be a short term recovery action for woodland caribou. This document acknowledges that the 'ultimate cause' of the decline in caribou is landscape modifications, due primarily to forestry and that the wolf kill program "*will not address the ultimate cause of caribou population declines if habitat protection and restoration does not occur concurrently.*"

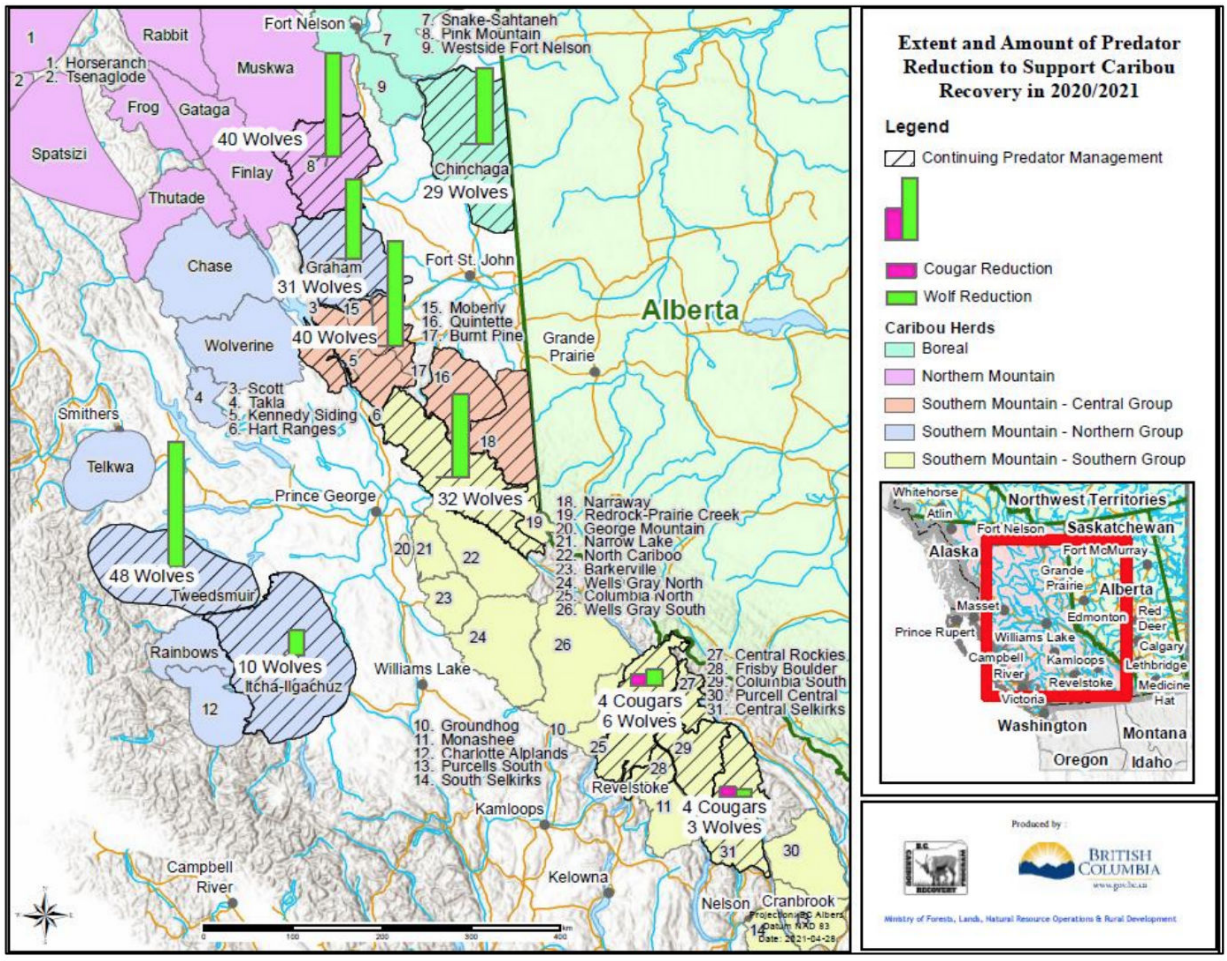

Figure 1. Distribution of predator reduction to support caribou recovery in 2020/2021.

BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development. (2021). *Predator Management to Support Caribou Recovery: 2020-2021 Summary.* Caribou Recovery Program. https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/wildlife-wildlife-habitat/caribou/predator_management_to_support_caribou_recovery.pdf

See also:

Government of British Columbia. (n.d). *Caribou Projects and Management Activities: Predator management*. Retrieved June 6. 2022, from https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/wildlife/wildlife-conservation/caribou/management-activities#predatormanagement

See also:

Government of British Columbia. (n.d). *Provincial Caribou Recovery Program*. Retrieved June 6. 2022, from https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/wildlife/wildlife-conservation/caribou/recovery-program

Environment Canada. (2014). Recovery Strategy for the Woodland Caribou, Southern Mountain population (Rangifer tarandus caribou) in Canada. Species at Risk Act Recovery Strategy Series. Environment Canada, Ottawa. viii + 103 pp.

3.1.3 Predator Reduction to Support Caribou Recovery: 2021-2022 Summary. Caribou Recovery Program

This report summarizes predator management over the 2021-2022 winter. Aerial shooting of wolves occurred in 13 of 54 caribou populations in British Columbia. Ground tracking and hunting of cougars also occurred in two of the 13 caribou population ranges. In total, 279 wolves and seven cougars were killed. Costs were approximately $1.7 million that year and are summarized by herd within the report. Intensive wolf reduction aims for annual removal of >80% of wolves to achieve government targets of less than 3 wolves per 1000 km^2 in caribou recovery areas. Entire wolf packs are removed using GPS/VHF radio collars. The figure below depicts predator reduction areas and number of predators killed. See 3.1.2 for additional and repeated information from previous the years summary report.

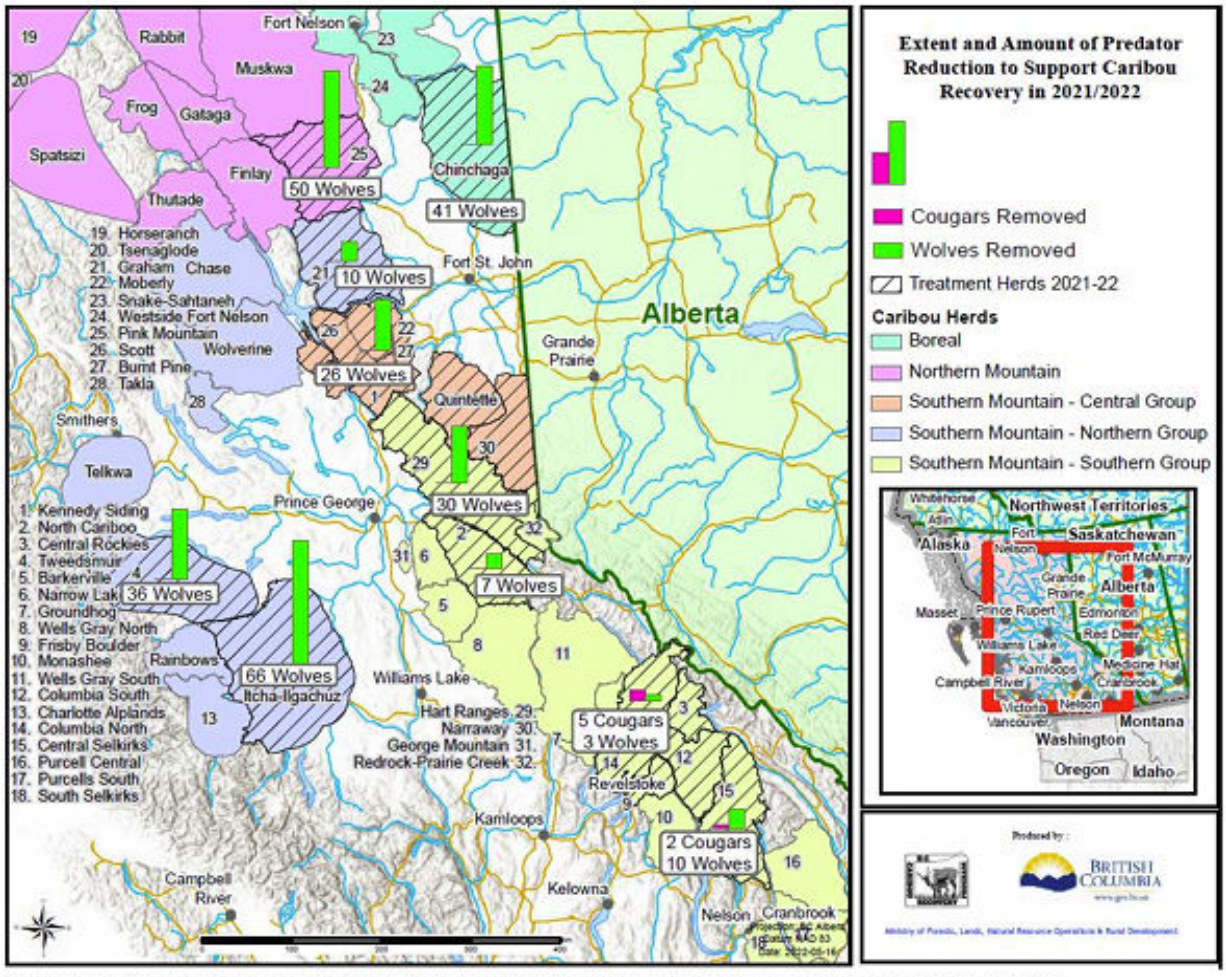

Figure 1. Distribution of predator reduction to support caribou recovery in 2021/2022.

BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development. (2022). *Predator Recovery to Support Caribou Recovery: 2021-2022 Summary.* Caribou Recovery Program. https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/wildlife-wildlife-habitat/caribou/predator_reduction_to_support_caribou_recovery_2021-2022.pdf

4 Insufficient Protection of Caribou Critical Habitat

4.1.1 Habitat loss accelerates for the endangered woodland caribou in western Canada

Considerable discrepancies between habitat recovery planning and protection actions were highlighted for woodland caribou in British Columbia and Alberta. Changes in forest cover were quantified, demonstrating that between 2000 to 2012, caribou lost twice as much habitat than gained over the 12 years. Fire significantly impacted Boreal and Northern Mountain habitat, while forest harvest was the main driver of habitat loss for the Southern Mountain ecotype. The researchers findings affirm that "short-term recovery actions such as predator reductions and translocations will likely just delay caribou extinction in the absence of well-considered habitat management." With dire undertones given the current state of caribou populations, the scientists assert that the cumulative impacts to the land must be addressed in order to achieve self-sustained caribou populations. Long-term commitments are imperative including sufficient reduction in habitat degradation combined with restoration.

Nagy‐Reis, M., Dickie, M., Calvert, A. M., Hebblewhite, M., Hervieux, D., Seip, D. R., ... & Serrouya, R. (2021). Habitat loss accelerates for the endangered woodland caribou in western Canada. *Conservation Science and Practice*, *3*(7), e437. https://conbio.onlinelibrary.wiley.com/doi/full/10.1111/csp2.437

4.1.2 The long road to protecting critical habitat for species at risk: The case of southern mountain woodland caribou

This paper demonstrated that classification as critical habitat does not guarantee protection for woodland caribou. First, provisions under the Species at Risk Act (SARA) to protect critical habitat on non-federal lands were reviewed. Second, critical habitat maps and timber harvest maps were overlaid to determine the extent to which critical habitat was protected five years after being identified in the 2014 recovery strategy. Analysis revealed that logging occurred on 909 km^2 of legally protected critical habitat under SARA. Current policy tools are clearly inadequate to protect caribou critical habitat and British Columbia has yet to implement provincial species at risk legislation, which could be effective. Recommendations made in light of this analysis, included leveraging policy tools under existing provincial legislation, employing the provincial Cumulative Effects Framework (CEF) to limit development, and collaboration with Indigenous peoples.

Palm, E. C., Fluker, S., Nesbitt, H. K., Jacob, A. L., & Hebblewhite, M. (2020). The long road to protecting critical habitat for species at risk: The case of southern mountain woodland caribou. *Conservation Science and Practice, 2*(7). https://doi.org/10.1111/csp2.166

See also:
Dawe, C. (2019, March 14). B.C. approves 314 cut blocks in caribou critical habitat while negotiating conservation plans. *Wilderness Committee.* Retrieved here with map1 and map 2.

4.1.3 Conservation constrained : protecting British Columbia's endangered caribou in a political-economy of extraction

This dissertation explores how woodland caribou herds are facing extirpation due to extraction-driven habitat destruction, primarily from oil and gas development and forest harvest. This thesis explores how caribou declines are occurring despite existing legal protections (under the Species At Risk Act) by examining how the province's economic reliance on resource extraction shapes available conservation solutions. This paper quantifies the extent to which the province subsidizes oil and gas activities in federally designated critical caribou habitat. Public funds are being used to subsidize the extinction of caribou. Active oil and gas wells are present in the critical habitat of endangered woodland caribou across B.C. Half (54%) of these wells are run by companies receiving publicly-funded royalty credits. There are 3,114 active oil and gas wells within critical caribou habitat in B.C. Of these, 1,678 wells are run by companies that have received publicly funded royalty assistance (subsidies) in the past 3 years. This is a direct contradiction to federal and provincial commitments to protect caribou and critical habitat. Furthermore, the province's dominant conservation solution to caribou endangerment, wolf culling, is examined and its relationship to B.C.'s extractive regime is unpacked. This work demonstrates that the apparent economic imperative of resource extraction in British Columbia both undercuts the potential for comprehensive solutions to caribou declines, such as habitat protection, and constrains the realm of possible interventions to those that do not inhibit further extraction.

DiSilvestro, A. M. (2022). *Conservation constrained : protecting British Columbia's endangered caribou in a political-economy of extraction* (T). University of British Columbia. Retrieved from https://open.library.ubc.ca/collections/ubctheses/24/items/1.0417553

See also (re: publicly funded active oil and gas wells in critical habitat):
DiSilvestro, A., Irvine-Broque, A., and Amron, Y. (2021). Fossil Fuel Subsidies: Big Problem for BC's Woodland Caribou. The University of British Columbia, Department of Geography. Retrieved from: https://storymaps.arcgis.com/stories/0f0d7dd828cc4b35973e5e188b733023?utm_source=north%2520shore%2520news&utm_campaign=north%2520shore%2520news%253A%2520outbound&utm_medium=referral&play=true&speed=medium

For more context:
https://geog.ubc.ca/news/student-research-finds-publicly-subsidised-oil-and-gas-wells-in-endangered-caribou-habitat/

4.1.4 Extirpation despite regulation? Environmental assessment and caribou

Despite federal and provincial legislation to protect caribou, industrial developments are permitted. In this paper, scholars examined 65 Canadian environmental assessments (EAs) with potential adverse impacts to caribou; 64 of which were approved. Findings from this review determined that project approvals were granted based on three main justifications. First, assured mitigation of adverse effects. However, proposed mitigation strategies were unsubstantiated by evidence. Second, mitigation was insufficient but benefits (i.e., jobs, tax, revenue and economic) would outweigh impacts. Finally, rationale claimed that an area was already degraded and devoid of caribou. Considering these findings, Collard et al. (2020) contend that the EA process is failing caribou (Figure 1), whereby governments unjustly grant approval to major projects, disguised as insignificant harm to caribou. Conservation biology should recognize this tension between economic growth and environmental protection.

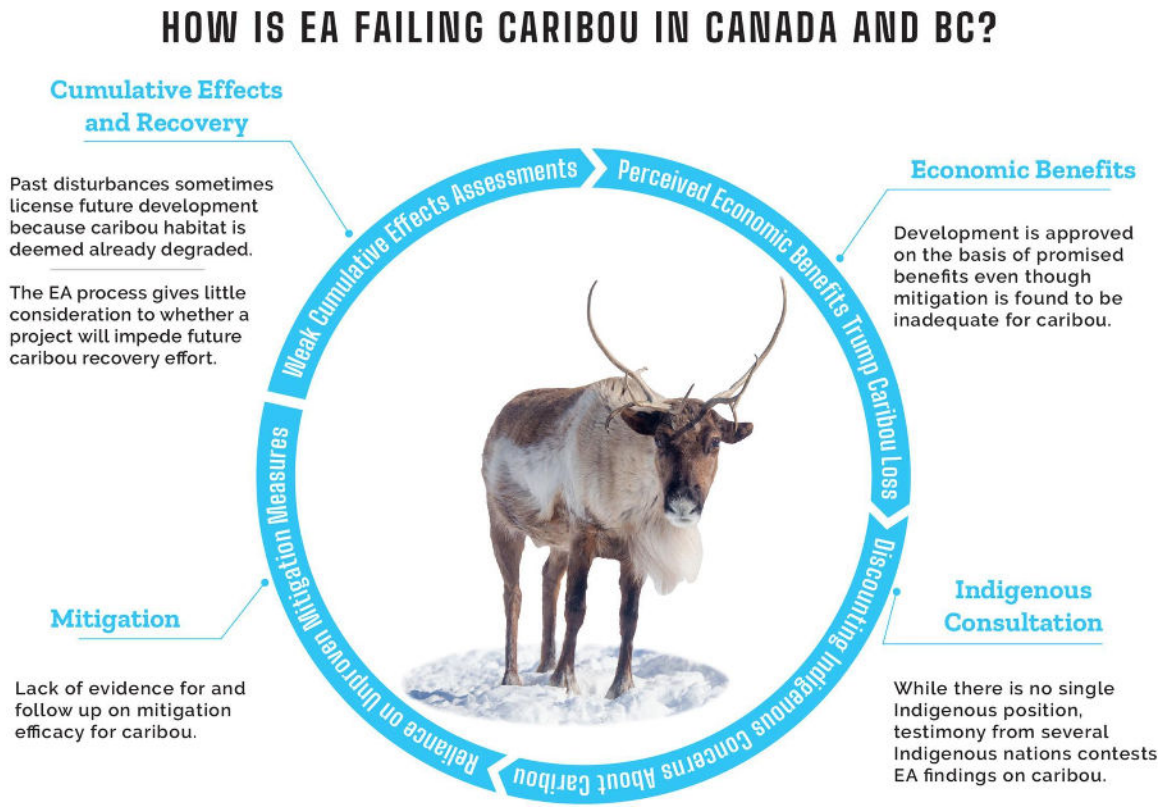

Figure 1: The ways in which environmental assessment fails to protect caribou. Adopted from Collard et al. (2020) (figure by Hugo Tello).

Collard, R-C, Dempsey, J, Holmberg, M. (2020). Extirpation despite regulation? Environmental assessment and caribou. *Conservation Science and Practice*, *2*(4); e166. https://doi.org/10.1111/csp2.166

See also:
Hebblewhite, M. (2017). Billion dollar boreal woodland caribou and the biodiversity impacts of the global oil and gas industry. *Biological Conservation*, *206*(Complete), 102–111. https://doi.org/10.1016/j.biocon.2016.12.014

4.1.5 Science to inform policy: Linking population dynamics to habitat for a threatened species in Canada

Scholars have questioned the robustness of the science to inform the critical habitat definition for the boreal caribou recovery strategy. Critical habitat was defined in the 2012 federal recovery strategy based on a threshold of 65% undisturbed habitat that is intended to achieve the recovery goal (0.60 probability) of maintaining self-sustaining boreal caribou populations. To investigate this further, this research used modelling scenarios to compare two contrasting caribou landscapes: high anthropogenic vs. high fire disturbances. The caribou population subjected to high fire disturbance was self-sustaining under the current scenario, however under the scenario with small increases in anthropogenic disturbance (8-9%) on top of the fire-dominated landscape, the caribou population could fail in meeting the recovery goal (0.60 probability of self-sustaining herds). Therefore, the 65% threshold defining critical habitat cannot be extrapolated to all populations, as some populations are more vulnerable due to cumulative effects of pressures such as fire. Maintaining a threshold of 65% undisturbed habitat was identified as a minimum acceptable level necessary to support recovery. However, the effectiveness of this threshold becomes diminished with considerations of climate change. Achieving higher than the minimum requirement is essential to improving caribou resilience to climate change.

Johnson, C. A., Sutherland, G. D., Neave, E., Leblond, M., Kirby, P., Superbie, C., & McLoughlin, P. D. (2020). Science to inform policy: Linking population dynamics to habitat for a threatened species in Canada. *Journal of Applied Ecology*, *57*(7), 1314–1327. https://doi.org/10.1111/1365-2664.13637
Also see: https://register.gotowebinar.com/recording/1588131705501771791

See also:
Kunegel-Lion, M., Neilson, E. W., Mansuy, N., & Goodsman, D. W. (2022). Habitat quality does not predict animal population abundance on frequently disturbed landscapes. *Ecological Modelling*, *469*(Complete). https://doi.org/10.1016/j.ecolmodel.2022.109943

See also:
Superbie, C., Stewart, K. M., Regan, C. E., Johnstone, J. F., & McLoughlin, P. D. (2022). Northern boreal caribou conservation should focus on anthropogenic disturbance, not disturbance-mediated apparent competition. *Biological Conservation*, *265*(Complete). https://doi.org/10.1016/j.biocon.2021.109426

4.1.6 Southern Mountain Caribou critical habitat: A review of maps and data to support recovery plans

Important gaps were identified in the 2014 recovery strategy for Southern Mountain woodland caribou. Specifically, detailed maps of critical habitat were absent, which must be included to satisfy the Species at Risk Act. This report details the available data and mapping pertaining to critical habitat for southern mountain caribou in an effort to inform federal scientists of the missing information. The discussion section of this report offers a clear summary of data insufficiencies, which have resulted in below minimal critical habitat for caribou populations. Main points include: (1) uncollared caribou or those that winter in forest where they are difficult to see in aerial surveys were likely under-sampled, thus impacting delineation of herd boundaries; (2) early winter / low elevation habitat locations were excluded as 'core habitat'; (3) high suitability habitat occurs outside of mapped boundaries; (4) harmful activities (e.g., snowmobiling and timber harvest) were permitted within core critical habitats; (5) management of matrix habitat (forest surrounding caribou habitat) must be a management goal; (6) matrix habitat to provide a buffer from wolves and other activities as well as caribou corridors may need to be extended and extent required to reduce predation has not been studied or mapped; (7) herd boundaries are limited to recent distributions and exclude historical areas; (8) caribou population targets are unclear, relevant to the importance of connectivity in delineation of critical habitat due to herd isolation, low genetic diversity, and potential in-breeding depression; (9) mineral licks and associated corridors should be considered critical habitat. Recommendations are provided for the Northern, Central and Southern groups.

Harding, L. E. (2014). Southern Mountain Caribou critical habitat: A review of maps and data to support recovery plans. SciWrite Environmental Services Ltd. Retrieved from: https://www.researchgate.net/publication/344059206_Southern_Mountain_Caribou_critical_habitat_A_review_of_maps_and_data_to_support_recovery_plans

See also:

Environment Canada. (2014). Recovery strategy for the woodland caribou, southern mountain population (Rangifer tarandus caribou) in Canada. Environment Canada, Ottawa, Ontario. 78 pp.

5 Inadequate Scientific Evidence for Wolf Control Effectiveness

5.1 Compensatory Predation and Wolf-Prey Uncertainties

5.1.1 Cumulative effects and boreal woodland caribou: How bow-tie risk analysis addresses a critical issue in Canada's forested landscapes

Risk analysis tools were used to quantitatively evaluate cumulative effects of risks and management scenarios for boreal woodland caribou herds in northeastern British Columbia. In addition to findings pertaining to risk mitigation and risk prevention detailed in section 8.1.5, the researchers also conducted calculations of compensatory predation[3] and identified additional

[3] Compensatory predation, in which prey would have died even in the absence of a particular predator, due to illness, starvation, other predators, etc., versus additive predation, in which healthy prey are killed.

research gaps. Specifically, across all three herds, it was determined that a significant proportion of both adult and juvenile caribou mortality may be attributed to compensatory predation. This finding was consistent with the view of a number of other experts; that other factors may be contributing to caribou decline, hidden behind compensatory predation. The analysis by Winder et al. (2020) separated the direct effect of wolf predation and compensatory predation. High levels of compensatory predation were determined across all three herds of boreal caribou. For example, in the Chinchaga herd, compensatory predation accounted for 53.3% of adult female and 25.1% of juvenile predation events. Therefore, compensatory predation had a larger effect on adult survival than did direct wolf predation. Similarly, in the Snake-Sahtahneh herd, compensatory predation had a larger impact on juvenile survival than direct mortality by wolves. The authors point out that these very high levels of compensatory predation may be one explanation as to why the extremely high wolf reduction intensity of 80 % was necessary to see any changes in caribou population trend. The compensatory predation may be attributed to other predators (bears, cougars, wolverines, immigrating meta-population wolves not targeted by the cull) or caribou health stressors and disease. Furthermore, research gaps are highlighted in terms of habitat appropriation, caribou health stressors and disease, and increasing climate change implications, in addition to the effect of compensatory predation on mortality events. Improvement in these knowledge gaps and how they relate to risk management would aid in assigning appropriate management actions. Finally, the accurateness of our understanding and sampling of caribou density and abundance is identified as a knowledge gap due to the ever-changing monitoring methods, which may not be comparable to past methods.

Winder, Stewart, F. E. C., Nebel, S., McIntire, E. J. B., Dyk, A., & Omendja, K. (2020). Cumulative Effects and Boreal Woodland Caribou: How Bow-Tie Risk Analysis Addresses a Critical Issue in Canada's Forested Landscapes. *Frontiers in Ecology and Evolution*, *8*. https://doi.org/10.3389/fevo.2020.00001

5.1.2 The impact of wolf predation on western Canada boreal woodland caribou populations: a critical review of the evidence

Expert wildlife biologist, Dr. Gilbert Proulx, conducted a critical review of the evidence used to support wolf control in Alberta, demonstrating with supporting analytical evidence that the impact of wolf predation on boreal woodland caribou has been overstated. In the review, several issues are identified which may be paralleled with justification of wolf control programs in British Columbia. It was noted that the studies that were used to justify wolf culling programs reported that predation by wolves represented <15% of boreal caribou mortalities. Further, the studies used as the basis for wolf culling included recognition that the underlying assumptions of predator-prey models (i.e., multi-prey wolf numeric responses, wolf kill-rates of caribou, and caribou mortality by other predators) required further research. In addition, information on different ecotypes was used to inform management decisions for another ecotype (i.e., mountain caribou differ from boreal caribou). The author reports that the wolf control program implemented in Alberta, killing more than 800 wolves in 7 years, failed to stabilize the Little Smoky boreal caribou population. Based on analysis of wolf scats and wolf tracks described in Proulx (2017), it was concluded that woodland caribou were not an important food source for wolves, also in agreement with other noted studies. Dr. Proulx expresses concern that wolves

have been wrongly assigned as the proximate cause for caribou decline, due to lack of demonstrative evidence. In agreement with several scientists, the paper attributes the lack of certainty in caribou declines to inherent methodological limitations and non-replicated treatments. The Little Smokey range as a case study, it is highlighted that there were no studies on food habits, rates of predation and or wolf densities. In conclusion, expressing that cases are similar for many other populations, the author contends that associations made between wolves and caribou trends have been qualitative, anecdotal, and prejudicial. Moreover, the author cautions against wolf killing programs and appeals for the ultimate cause of caribou decline to be addressed: habitat loss and disconnection. Citing several wildlife biologist recommendations as early as 1988, it is again recommended by this expert that a comprehensive caribou recovery program be implemented to conserve, restore, expand and connect critical habitats across landscapes.

Proulx, G. (2017). The impact of wolf predation on western Canada boreal woodland caribou populations: a critical review of the evidence. Canadian Wildlife Biology & Management 6: 89–96. https://www.researchgate.net/publication/321600086_The_Impact_of_Wolf_Predation_on_Western_Canada_Boreal_Woodland_Caribou_Populations_A_Critical_Review_of_the_Evidence_Point_to_Ponder

See also:

Proulx, G., Alexander, S., Barron, H., Bekoff, M., Brook, R., Bryan, H., Darimont, C., Dubois, S., Lukasik, V., McCrory, W.P., Paquet, P., Parr, S., Powell, R., Stronen, A.V., Wallach, A. (2017). Killing wolves and farming caribou benefit industry, not caribou: a response to Stan Boutin. *NatureAlberta, 47* (1), 4-11. https://www.researchgate.net/publication/317592636_Killing_wolves_and_farming_caribou_benefit_industry_not_caribou_a_response_to_Stan_Boutin

See also:

Clark, T. J., & Hebblewhite, M. (2021). Predator control may not increase ungulate populations in the future: A formal meta‐analysis. *Journal of Applied Ecology*, *58*(4), 812–824. https://doi.org/10.1111/1365-2664.13810

5.1.3 Wolf–prey relations

This book chapter details how the wolf interacts with its prey for food, survival and reproduction. Included is discussion on the disagreement regarding wolf effects on prey numbers. There is no scientific consensus on the significance of wolf predation in prey dynamics. The reasoning for this is that ecological systems are incredibly complex. Another reason for disagreements is varied scientific interpretations due to great variation in measured wolf predation rates, as well as often imprecise and inaccurate population data on wolf and prey densities. Finally, studied wolf-prey systems are all unique. They are each distinctively characterized by a combination of key factors including: (1) prey diversity and abundance; (2) other predators; (3) human effects on predators and prey; (4) level of habitat productivity supporting prey; and (5) snow conditions. This information and the deficient scientific consensus are reiterated in the 2014 *Management Plan for the Grey Wolf (Canis lupus) in British Columbia*.

Mech, L.D. and R.O. Peterson. (2003). Wolf–prey relations. Pages 131–160 in L.D. Mech and L. Boitani, eds. Wolves: behavior, ecology and conservation. Univ. Chicago Press, Chicago, IL. Retrieved from: https://core.ac.uk/download/pdf/189478015.pdf

See also:

B.C. Ministry of Forests, Lands and Natural Resource Operations. (2014). *Management Plan for the Grey Wolf (Canis lupus) in British Columbia.* B.C. Ministry of Forests, Lands and Natural Resource Operations, Victoria, BC. 48 pp. Retrieved from: https://www.env.gov.bc.ca/fw/wildlife/management-issues/docs/grey_wolf_management_plan.pdf

See also:

Prugh, L. R., Sivy, K. J., Mahoney, P. J., Ganz, T. R., Ditmer, M. A., van de Kerk, M., ... & Montgomery, R. A. (2019). Designing studies of predation risk for improved inference in carnivore-ungulate systems. *Biological Conservation*, *232*, 194-207. https://doi.org/10.1016/j.biocon.2019.02.011

See also:

Theberge, J. B. (1990). Potentials for Misinterpreting Impacts of Wolf Predation through Prey: Predator Ratios. *Wildlife Society Bulletin (1973-2006)*, *18*(2), 188–192. http://www.jstor.org/stable/3782135

See also:

Burgar, J. M., Burton, A. C., & Fisher, J. T. (2019). The importance of considering multiple interacting species for conservation of species at risk. *Conservation biology : the journal of the Society for Conservation Biology*, *33*(3), 709–715. https://doi.org/10.1111/cobi.13233

5.2 Statistics and Study Design Uncertainty

5.2.1 No statistical support for wolf control and maternal penning as conservation measures for endangered mountain caribou

Harding et al. (2020) invalidates the work of Serrouya et al. (2019) reported in the paper titled *Saving endangered species using adaptive management*.

First, to summarize the work of Serrouya et al. (2019), a mathematical model was used to assess the effectiveness of different woodland caribou management practices that have been implemented including reductions of predators such as wolves, reductions of primary prey such as moose, translocations, and maternal penning. They compared population growth between each of the different areas where intervention had occurred (treatments) and also compared each of the treatments to control areas where no management interventions had been implemented. This was done based on population data across large spatial scales. They selected 18 caribou populations mainly in British Columbia and some in Alberta, spanning four recognized caribou ecotypes: boreal caribou, northern mountain caribou, central mountain, and southern mountain. Of the18

caribou populations selected for the study, 12 of these were treatments (with interventions), and 6 were controls. The authors specified that they only chose 6 control populations to best match ecological conditions as closely as possible to the treatment populations. Serrouya et al. (2019) found that before interventions were implemented, 16 of 18 populations were in decline and that after treatments began, 6 of 12 treated populations showed stable or increasing population growth. None of the control populations had positive population growth during treatments. The authors found that the greatest population growth occurred where combinations of treatments (or multiple recovery strategies) were applied simultaneously. They also determined that the degree of ecosystem alteration (as measured by early seral forest cover) did not explain variation in changes to population growth. One of the main takeaways highlighted throughout the paper was that treatments must be applied intensively to produce a measurable effect. So, for example, wolf culling can't be done in low numbers, a large portion of the population must be killed (e.g., wolf cull program target 85%). The authors suggested lethal wolf control and maternal caribou penning as the most effective methods. This paper had profound implications because it was relied upon by the BC government and was influential to forming the basis for increasing the intensity of the wolf cull.

Harding et al. (2020) re-evaluated the same data and findings of Serrouya through a critical statistical lens by drawing on the principles of strong inference. They deemed that the work of Serrouya warranted close examination, considering the policy implications and costs of error. Their work shifts the focus toward the influence of the varying ecotypes. Throughout the paper, Harding et al. (2020) refers to the Southern Mountain Caribou instead as 'Deep-Snow' Mountain Caribou, as other researchers have in the past. This is because of their distinctive ecological and behavioural characteristics. Boreal, Northern, and Central ecotypes forage on ground-dwelling lichen that are easily accessible due to relatively shallow snow depths. In contrast, the Southern Mountain, or 'Deep Snow' ecotype must rely on lichen only from old growth trees due to snow depths of 3-4 metres, which they access atop the snowpack. This makes the Deep Snow Mountain Caribou distinctive. Harding et al. (2020) outline 5 major issues pertaining to study design and statistical practices.

1. Serrouya et al. (2019) *did not report the results of a null model, which performs equally as well as the treatments*. Including a null model is standard practice in order to determine if a pattern truly exists or if it could be attributed simply to random chance/processes. So, in this case, what can we expect to see for caribou population growth without any predictors such as wolf culling. Harding ran a null model and found that there was little difference from the other models that consider management interventions or habitat alteration. The difference was so small that it was not considered statistically meaningful. *So, what this means is that the wolf culling and maternal penning treatments from Serrouya explain population dynamics of caribou no better than either habitat alteration or random chance alone.*

   Harding went a step even further, to find out what could better explain change in population growth. They knew that there are differences in behavior and habitat use among ecotypes, so they evaluated some additional model scenarios that considered *ecotypes*. They thought it is plausible that the intrinsic characteristic differences in ecotypes could explain the change in caribou population growth. What is profound is

their finding that the *ecotype model outperformed all others*, with meaningful differences between the *northern mountain and central mountain caribou* as well as between the *deep-snow mountain and central mountain* ecotypes. This means that ecotype accounted for more variation in caribou population growth than did wolf culling or maternal penning treatments, habitat alteration, and random chance. Ecotype was the strongest indicator of caribou population growth.

2. *The study design was not balanced*. Wolf reduction treatments were drawn from the Central Mountain ecotype (n = 5) and Boreal population (n = 1), whereas the six controls were drawn from Deep-Snow Mountain (n = 3), Northern Mountain (n = 2) and Central Mountain (n = 1) ecotypes. So, most of the treatments were from the Central Mountain ecotype. Treatments and controls aren't distributed evenly or even represented in some ecotypes. This all even though Serrouya et al. (2019) states controls were selected based on ''matching ecological conditions as closely as possible to the treatment populations''. Further, wolf density associated with different ecotypes or populations is another variable that cannot be accounted for since it is unknown for most areas. These study design issues make it difficult to infer causality and apply the results across ecotypes.

3. *More than half of the populations in the study area were omitted and not discussed*. Serrouya et al. (2019) used only 18 of 42 mountain caribou populations in the study area. The 24 excluded populations included populations which had management interventions, and 9 populations which became functionally extinct during the study. Population data were available for all 24 populations representing treatments and controls. Harding et al. (2020) highlights using several examples that **strangely, several the population trajectories of the excluded populations would contradict the inference made in Serrouya et al. (2019).** So, for some of the excluded populations with treatments, population growth declined during or after the treatment (wolf cull, wolf sterilization, moose reduction), while areas that would be considered controls increased in population growth. These omitted populations would have allowed for a more comprehensive analysis of adaptive management approaches, but they were not even acknowledged.

4. *Additional adaptive management measures were neither included in analyses nor discussed.* Management interventions including closures to snowmobiling and heliskiing within large areas within the study area were not evaluated or discussed by Serrouya. Similarly, the habitat protections of the 2008 provincial Mountain Caribou Recovery Implementation Plan were not included. These may have slowed downward trajectories of some populations, thus representing potentially confounding variables.

5. *Habitat alteration analysis cannot be replicated.* An important characteristic of good quality evidence is the ability for other scientists to be able to take the same data and reproduce the findings. In this case, Harding et al. (2020) indicated that they used the same data on forest loss, derived from Global Forest Change estimates, to estimate habitat alteration. Serrouya et al. (2019) found that the degree of habitat alteration (as measured by early seral forest cover) did not influence changes in caribou population

growth. Harding et al. (2020) were unable to achieve the same habitat alteration results, deducing that an additional step was taken that was not included in their methods. Harding et al. (2020) further questioned the source of the forest loss data used. The data did not match the time period for before treatment for 9 of the 18 populations and other available sources dating back to 1980s are more suitable for characterizing forest loss in the before-treatment period. Further, this type of satellite data does not fully account for roads and infrastructure, and these features can influence population growth.

Overall, the reanalysis of available data carried out by Harding et al. (2020) shows that ecotype identity is a better predictor of population trends than any adaptive management treatments considered by Serrouya et al. (2019). The key message from Harding et al. (2020) based on their re-examination of the data is that differences among ecotypes in behavior and response to human disturbance indicate that we cannot assume that adaptive management strategies that benefit one ecotype would be beneficial to another. The success of mountain caribou recovery efforts is contingent on ecotype-specific solutions. Therefore, future research should focus on developing mitigation measures separately for each ecotype.

Harding, L. E., Bourbonnais, M., Cook, A. T., Spribille, T., Wagner, V., & Darimont, C. (2020). No statistical support for wolf control and maternal penning as conservation measures for endangered mountain caribou. *Biodiversity and Conservation*, *29*(9–10), 3051–3060. https://doi.org/10.1007/s10531-020-02008-3

See also:

Serrouya, R., Seip, D. R., Hervieux, D., McLellan, B. N., McNay, R. S., Steenweg, R., Heard, D. C., Hebblewhite, M., Gillingham, M., & Boutin, S. (2019). Saving endangered species using adaptive management. *Proceedings of the National Academy of Sciences of the United States of America, 116*(13), 6181–6186. https://doi.org/10.1073/pnas.1816923116

See also:

Pete, A. (Host). (2022, February 14). Lee Harding: Biologist on Wolves & Caribou in BC (No. 42) [Audio podcast episode]. In *Bigger than me*. Aaron Pete. Retrieved from:https://podcasts.apple.com/ca/podcast/42-lee-harding-biologist-on-wolves-caribou-in-bc/id1517645921?i=1000551079176
Also available from: https://www.youtube.com/watch?v=ka36Hf8EfCY&t=4051s

5.2.2 A causal modelling approach to informing woodland caribou conservation policy from observational studies

Acknowledging cause-and-effect limitations of observational studies in managing at-risk species, and weak inferences of past studies, this research explored the utility of causal modelling. Using the conservation example of woodland caribou and expanding further on Serrouya et al. (2019) and Harding et al. (2020), the authors call for a higher standard of evidence when forecasting the effects of management interventions that form the basis for policy decisions. Causal models are visual drawings showing relationships of multiple variables within a system, which are analyzed to parse out or isolate the strength of each relationship in order to understand the influence of

various factors. Essentially, they are conceptual representations of the behaviour of a system and aim to improve the rigour of causal inferences. Using this approach allows researchers to be more explicit about assumptions to ensure the best available structural understanding of a system, where the gold standard of randomized controlled trials is not possible. This is particularly important to urgent issues like woodland caribou recovery where strong confidence of ecological dynamics is essential to inform conservation policy decisions. Wilson et al. (2021) makes several suggestions to aid in more reliable analysis of cause and effect. In agreement with Harding et al. (2020), Wilson et al. (2021) highlight the issue of selection bias where only certain caribou populations (i.e., those declining or undergoing treatment intervention) were selected for in Serrouya et al. (2019). Further, Wilson et al. (2021) expands on the inappropriate way in which the effect of habitat condition on caribou population trend was analyzed in relation to predator density. Specifically, predator density was incorrectly controlled for as a separate variable (i.e., in a way confounding variables are) when it cannot be since it is seen as an intermediate mediator of change between habitat condition and caribou population trend. It's important to understand what's happening in between and not controlling for them (mediators of change). Wilson et al. (2021) concludes with a discussion on the increasing importance of causal identification in ecology where urgent conservation decisions need to be derived from observational data. Finally, the authors point out that causal modelling has been used in a new study (Serrouya et al., 2021), however the approach has not been used for any woodland caribou recovery policy. The authors suggest that our current path should be reconsidered. Forecasting management interventions by extrapolating observations is poor evidence and current models may be confounded given heterogeneous caribou range habitat and disturbance characteristics. Causal models should be an essential component of structured decision-making and conservation policy.

Wilson, S. F., Nudds, T. D., & de Vries, A. (2021). A causal modelling approach to informing woodland caribou conservation policy from observational studies. *Biological Conservation*, *264*(Complete). https://doi.org/10.1016/j.biocon.2021.109370

See also:

Serrouya, R., Dickie, M., Lamb, C., van Oort, H., Kelly, A. P., DeMars, C., McLoughlin, P. D., Larter, N. C., Hervieux, D., Ford, A. T., & Boutin, S. (2021). Trophic consequences of terrestrial eutrophication for a threatened ungulate. *Proceedings. Biological sciences*, *288*(1943), 20202811. https://doi.org/10.1098/rspb.2020.2811

5.3 Caribou Population Assumptions and Uncertainties

5.3.1 Lines on a map: Conservation units, meta-population dynamics, and recovery of woodland caribou in Canada

This journal article describes the differing definitions of population conservation units for woodland caribou in Canada and associated challenges for recovery planning. Under the Species-at-Risk Act, caribou populations are identified broadly as Designatable Units (DUs). However, the Boreal DU and the Southern Mountain DU were subdivided into dissimilar smaller conservation units for recovery planning (e.g., local population, subpopulation). Weckworth et al. (2018) contended that the scientific rationale for inconsistent conservation units between the two

recovery strategies is unclear and lacks supportive genetic or demographic evidence. Protecting caribou on the basis of subpopulations within DUs was argued to be inappropriate for the long-term recovery of woodland caribou. Alternatively, ensuring metapopulation dynamics, which considers genetic structure and connectivity, is crucial and highlighted as a scientifically defensible conservation unit that is evolutionarily and ecologically relevant.

Weckworth, B. V., Hebblewhite, M., Mariani, S., & Musiani, M. (2018). Lines on a map: Conservation units, meta‐population dynamics, and recovery of woodland caribou in Canada. *Ecosphere, 9*(7). doi:https://doi.org/10.1002/ecs2.2323

5.3.2 Which caribou? misnaming caribou population units leads to conservation errors

The author highlights the issues that arise from contrasting definitions of British Columbian caribou populations between the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) with the federal and provincial governments. COSEWIC divides Southern Mountain caribou into three designatable units (DU) for conservation purposes, which are considered as separate species under the Species at Risk Act. Namely, the Northern Mountain (DU7), Central Mountain (DU8), and Southern Mountain (DU9) caribou populations. Contrastingly, the federal and provincial governments amalgamated Southern Mountain, Central Mountain, and nine of the 45 subpopulations of Northern Mountain caribou into a single artificial population. One provided example of where this is problematic for caribou is issuance of an emergency order, which is dependent on a determination of imminent threat of survival to a population. In 2018, the federal government's imminent threat analysis determined there was a risk to Southern Mountain caribou recovery but not survival, and thus the emergency order was not issued. However, this decision was incorrectly based on 3,764 caribou, while there are actually only 1,240 in the Southern Mountain (DU9) population, effectively diluting survival risk. There were also implications for wolves. The threat analysis stated: “Wolves are the primary predator of southern mountain caribou across the range.” While true for Northern and Central Mountain caribou, it is not true for Southern Mountain. It is well documented that cougars, bears, and wolverines contribute to higher mortality percentages of Southern Mountain caribou. Even when all wolves were culled in the South Selkirk subpopulation range, caribou declined from 11 in 2017 to zero in 2018. The author suggests how this problem can be rectified, particularly abiding by COSEWIC population designations.

Harding, L. E. (2020). Which caribou? misnaming caribou population units leads to conservation errors. *Journal of Ecosystems and Management, 19*(1). Retrieved from https://subzero.lib.uoguelph.ca/login?URL=?url=https://www.proquest.com/scholarly-journals/which-caribou-misnaming-population-units-leads/docview/2450516584/se-2

See also:

Wilson, S. F. (2010). Estimating the short-term benefit of wolf management to mountain caribou herds. https://www.env.gov.bc.ca/wld/speciesconservation/mc/files/Estimating%20the%20short-term%20benefit%20of%20wolf%20management%20to%20mountain%20caribou%20herds.pdf

Also related:

Weaver, Andrew. (January 16, 2015). [Letter from MLA to Minister Thomson regarding wolf culling in the South Selkirk Mountains and in the South Peace]. Retrieved from: https://www.andrewweavermla.ca/2015/01/19/aerial-culling-wolves-save-endangered-caribou/

5.4 Scientific Integrity of Wildlife Management Plans

5.4.1 Hallmarks of science missing from North American wildlife management

Researchers defined a framework for science-based management and used it to study the status of North American natural resource management systems. Wildlife conservation policy is regularly justified by governments on the basis of 'science-based management', however this is often ambiguous and not explicitly defined. The framework identifies four fundamental hallmarks of science-based management: measurable objectives, evidence, transparency, and independent review. To facilitate assessment of the four hallmarks, they were associated with 11 indicator criteria. The presence of indicator criteria in hunt management plans were examined across 667 U.S. and Canadian management systems (62 states and provinces). Findings showed that over half of the criteria (<5 of 11) were absent from 60% of management systems. Only 10% of systems contained at least 8 of 11 criteria. Supplemental material for this study was also reviewed for information specific to caribou and wolves in British Columbia. Caribou and wolf management in British Columbia met only 4 and 6, out of the 11 criteria, respectively. Noteworthy, neither the caribou nor wolf management systems met the 'measurable objectives' criteria, two of the 'transparency' criteria (explain technique for setting quotas nor respond to public inquiry), or the two 'independent review' criteria (subject to any/internal review nor subject to external review). Overall, these results do not support the notion that wildlife management in North America is guided by science. This work illuminates critical issues concerning the scientific basis of hunt management in Canada and the United States. Agencies and managers can adopt this assessment framework to ensure scientific integrity upholds conservation policy decisions.

Artelle, K. A., Reynolds, J. D., Treves, A., Walsh, J. C., Paquet, P. C., & Darimont, C. T. (2018). Hallmarks of science missing from North American wildlife management. *Science Advances*, *4*(3). https://doi.org/10.1126/sciadv.aao0167

5.4.2 Predator control may not increase ungulate populations in the future: A formal meta‐analysis

Researchers gathered studies from the literature pertaining to predator removal and effects on ungulate populations in order to carry out a meta-analysis of predator control effectiveness. Ungulate demographic responses (i.e., survival, recruitment, abundance, and population growth) were quantified and study design was reviewed. Most of the predator experiments included in the meta-analysis review were canids with wolves representing 37% of studies. Caribou represented 12.9% of the North American ungulate experiments. Although only two studies were included on predator removal for endangered woodland caribou, discussion and conclusions of predator control provide insight. Overall, findings showed a slight positive effect (weak) of predator

removal on ungulate populations (8% to 13%). Comparatively, effects of predator removal on endangered woodland caribou were found to be only slightly higher (14%); again, only two studies were included so further analysis was limited. It is unclear why only two studies of wolf control for endangered species (i.e., caribou) were included, but a similar meta-analysis focusing only on wolf control for caribou in western Canada would benefit our understanding. The researchers included deliberations on compensatory predation/mortality, noting the small positive increase in ungulate populations despite very high percentages of predators removed. This suggests multiple factors are likely responsible for this disparity and thus compensation is often at play. Discussed factors included predation as compensation for late-born, low weight calves that would have otherwise starved. Further, when wolves are removed, compensatory mortality may occur, where bears, cougars and other predators predate on prey that would have otherwise been killed by wolves. An obvious compensatory factor is habitat productivity (bottom-up pressure), which surprisingly the authors of this study noted few of the experiments attempt to quantify. Regardless, the weak ungulate responses to predator control support partial compensatory mortality/predation. Also discussed is the difficulty in effectively removing high numbers of predators due to compensatory immigration of predators from neighbouring populations. Shortfalls in experimental rigour and design were reported, as well as publication bias (under-reporting negative effects of predator removal experiments). Recommendations were made for better scientific rigour in experimental design; appropriate evaluation of predator control practices in accordance the National Research Council's 2007 recommendations (sociological, economic and ecological considerations); in addition to establishment of a decision-making framework to determine if predator removal will be ecologically, economically and ethically sustainable.

Clark, T. J., & Hebblewhite, M. (2021). Predator control may not increase ungulate populations in the future: A formal meta‐analysis. *Journal of Applied Ecology*, *58*(4), 812–824. https://doi.org/10.1111/1365-2664.13810

6 Countervailing Impacts and Unintended Consequences of Predator Removal

6.1 Pack Dissolution and Compensatory Reproduction

6.1.1 Impacts of breeder loss on social structure, reproduction and population growth in a social canid

The population level consequence of removing reproductive individuals from a highly social species is poorly understood. Population growth could be reduced, or alternatively, not impacted due to compensatory mechanisms. This study evaluated effects of breeder loss on social stability, recruitment and population for grey wolves in Alaska using data from 1986 to 2012. Breeder loss occurred in 77% of pack dissolution cases. Loss of a female breeder or both breeders, and small size packs were factors for increased likelihood a pack dissolved. Although removal rates were low, findings showed that breeder mortality did not have any statistically meaningful effects on population dynamics (short- nor long-term). This demonstrates that population growth of grey

wolves can be resilient to breeder mortality disruption due to strong compensatory mechanisms. It should be noted that this is context dependent, and the resilience of some Grey Wolf populations could be suppressed where wolf reduction intensity is high and wolf dispersal is low. Nonetheless, this research illustrates the propensity of Grey Wolf populations to recover and rebound.

Borg, B. L., Brainerd, S. M., Meier, T. J., & Prugh, L. R. (2015). Impacts of breeder loss on social structure, reproduction and population growth in a social canid. *Journal of Animal Ecology*, *84*(1), 177-187.

6.1.2 The Effects of Breeder Loss on Wolves

The impacts of breeder loss on wolf pup survival, reproduction, and territorial social groups were investigated by analyzing pooled data from the literature. In terms of territorial social groups, eliminating breeders from wolf packs is detrimental to pack social structure and stability, but this also has implications for overall wolf densities. Findings showed pack dissolution after breeder loss occurred in 38% of total cases. Comparing breeder loss cases where some breeders remained verses complete absence of breeders, only 26% dissolved of the cases where some breeders remained, while 85% dissolved of cases where breeders were absent. Dissolved wolf territories became re-established in 74% of cases, either by recolonizing or influx by neighbouring wolves. Budding and splitting tended to occur in larger packs. Similarly, it was noted that in Alaska, USA, and Canada, wolf populations that were almost eliminated through intensive culling rebounded within 2-4 years, attributed to breeder replacement by immigration of wolves from surrounding territories. Discussion is included on disruption of packs in relation to population growth. When wolf packs subdivide existing territories, this can result in increasing overall wolf densities. Management recommendations point to the difficulties of selective removal of non-breeders.

Brainerd, S. M., Andrén, H., Bangs, E. E., Bradley, E. H., Fontaine, J. A., Hall, W., Iliopoulos, Y., Jimenez, M. D., Jozwiak, E. A., Liberg, O., Mack, C. M., Meier, T. J., Niemeyer, C. C., Pedersen, H. C., Sand, H., Schultz, R. N., Smith, D. W., Wabakken, P., & Wydeven, A. P. (2008). The Effects of Breeder Loss on Wolves. *The Journal of Wildlife Management*, *72*(1), 89–98. http://www.jstor.org/stable/25097506 Retrieved from: https://www.researchgate.net/publication/227823841_The_Effects_of_Breeder_Loss_on_Wolves

6.1.3 Kill rate by wolves on moose in the Yukon

This study analyzed the kill rate by wolves on moose prey, post intensive wolf removal. Kill rates increased with decreasing pack size, and were not related to prey density nor snow depth. Results supported earlier findings that the best predictor of wolf predation rates was wolf organization (number and size of wolf packs). Higher kill rates of prey were evident when wolves were organized into many smaller packs, therefore removing a larger proportion of the prey population. The kill rates of some smaller packs were comparable to that observed in large sized packs.

Hayes, R. D., Baer, A. M., Wotschikowsky, U., & Harestad, A. S. (2000). Kill rate by wolves on moose in the Yukon. *Canadian Journal of Zoology*, *78*(1), 49-59. Retrieved from: https://www.researchgate.net/publication/229193102_Kill_rates_by_wolves_on_moose_in_Yukon

See also:

Ballard, W. B., and R. O. Stephenson. 1982. Wolf control - take some and leave some. Alces 18:276–230. Retrieved from: https://www.adfg.alaska.gov/static/home/library/pdfs/wildlife/research_pdfs/alces/6010.pdf

See also:

Sand, H., Vucetich, J. A., Zimmermann, B., Wabakken, P., Wikenros, C., Pedersen, H. C., Peterson, R. O., & Liberg, O. (2012). Assessing the influence of prey–predator ratio, prey age structure and packs size on wolf kill rates. *Oikos*, *121*(9), 1454–1463. https://doi.org/10.1111/j.1600-0706.2012.20082.x

See also:

Metz, M. C., Vucetich, J. A., Smith, D. W., Stahler, D. R., & Peterson, R. O. (2011). Effect of Sociality and Season on Gray Wolf (Canis lupus) Foraging Behavior: Implications for Estimating Summer Kill Rate. *PLoS ONE*, *6*(3). https://doi.org/10.1371/journal.pone.0017332

See also:

Wielgus, B., Robert, Peebles, K. A. (2014). Effects of Wolf Mortality on Livestock Depredations. *PLOS One, 9*(12). doi: 10.1371/journal.pone.0113505

6.1.4 Killing wolves and farming caribou benefit industry, not caribou: a response to Stan Boutin

Dr. Proulx condemns predator control in Alberta. Included is discussion concerning compensatory reproduction. They argue that removal of reproductive wolves leads to a division of packs, which increases wolf densities, a response due to compensatory reproduction. This occurs because smaller packs are required to hunt at a higher rate to feed more reproductively compensated young than larger packs. Even with intensive wolf removal programs, the subsequent net abundance of wolves may not change and could plausibly increase. Dr. Proulx also points out that in one study, there was a 50% increase in trapped wolves in the area of culling, further highlighting the resilience of wolves from influx of other territories.

Proulx, G., Alexander, S., Barron, H., Bekoff, M., Brook, R., Bryan, H., Darimont, C., Dubois, S., Lukasik, V., McCrory, W.P., Paquet, P., Parr, S., Powell, R., Stronen, A.V., Wallach, A. (2017). Killing wolves and farming caribou benefit industry, not caribou: a response to Stan Boutin. *NatureAlberta, 47* (1), 4-11.

https://www.researchgate.net/publication/317592636_Killing_wolves_and_farming_caribou_benefit_industry_not_caribou_a_response_to_Stan_Boutin

See also: Proulx, G. (2017). The impact of wolf predation on western Canada boreal woodland caribou populations: a critical review of the evidence. Canadian Wildlife Biology & Management 6: 89–96. https://www.researchgate.net/publication/321600086_The_Impact_of_Wolf_Predation_on_Western_Canada_Boreal_Woodland_Caribou_Populations_A_Critical_Review_of_the_Evidence_Point_to_Ponder

6.2 Trophic Cascades

6.2.1 Human activity mediates a trophic cascade caused by wolves

Experimental evidence in Banff National Park, Alberta provides an example to support the wolf trophic cascade hypothesis. Researchers investigated the predation effects on elk, aspen, willow, beaver, and riparian songbirds in a low-wolf area where wolves were excluded by human activity compared to a recolonizing high-wolf area of Bow Valley. Wolf exclusion had substantial effects on elk demography, vegetation and animal communities. In the area of predator exclusion, elk survival, recruitment, and population density were significantly greater, which in turn reduced aspen recruitment and willow production. Beaver lodge density decreased, and increased elk herbivory diminished riparian songbird community structure and abundance. Depressing habitat use by wolves demonstrated alternating patterns of cascading effects, supporting the wolf trophic cascade hypothesis. Thus, removing wolves from the landscape may have serious implications for ecosystem dynamics.

Hebblewhite, M., White, C.A., Nietvelt, C.G., McKenzie, J.A., Hurd, T.E., Fryxell, J.M., Bayley, S.E. and Paquet, P.C. (2005). Human activity mediates a trophic cascade caused by wolves. *Ecology, 86*: 2135-2144. https://doi.org/10.1890/04-1269
Also available from: https://www.researchgate.net/publication/228636301_Human_activity_mediates_a_trophic_cascade_caused_by_wolves

6.2.2 Saving large carnivores, but losing the apex predator?

Researchers argue that persecution of large carnivores alters behaviour and ecosystems, thereby contradicting conservation goals. Using scientific information about carnivore behaviour, ecology, trophic interactions, and the effects of human exploitation and control, the case is made that hunted carnivore species cannot fulfil their vital ecological roles at the top of food webs. Altering large terrestrial carnivore populations, such as wolves or bears, reverberate throughout ecological communities. Changes in distribution and population decline, even with sustained numbers, have caused transformations to community assemblages and loss of biodiversity. Evidence to support ecological effects of large carnivores, without and with human intervention, are depicted in Figure 1. Both direct (density-mediated) and indirect (trait mediated) predator-prey interactions drive trophic cascades. Reduced predator numbers may not be able to control primary prey species (direct). Increased vigilance of predators due to the unnatural fear

of 'predation' risk by humans alters foraging and resting behaviour (indirect). Apex predators are effectively demoted to a lower trophic level. Humans cannot replace the ecological role of large carnivores by also attempting to control primary prey species, since indirect influences on prey behaviour and habitat use cannot be controlled. Primary prey species then elicit impacts to plant communities and so on. Management impacts to predator behaviour and particularly social structures, and thereby to ecosystems, requires attention. In conclusion, long-term impacts of predator removal can reduce the quality of traits defining apex predators, with consequences for their ecological functionality, genetics and evolution.

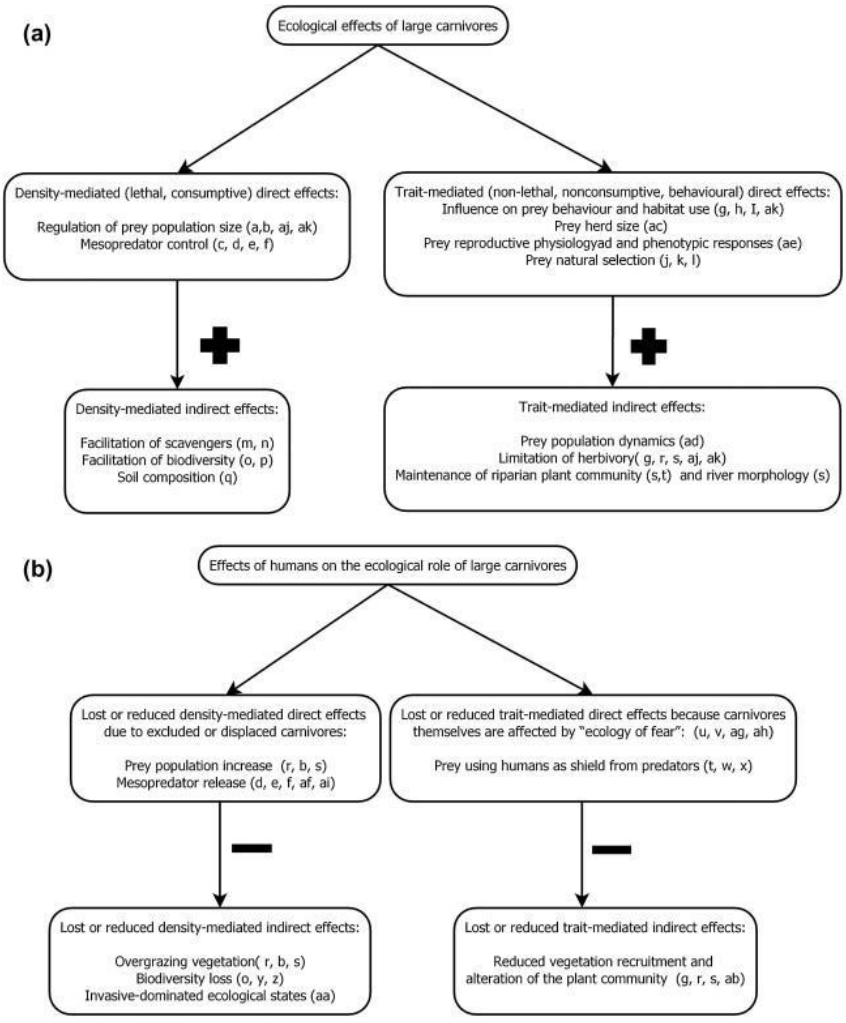

Figure 2. (a) Pathways of large carnivores' ecological effects in ecosystems. (b) Reduced ecological effects of large carnivores under human persecution. Adopted from Ordiz at al. (2013). See journal article for effects letter citations.

Ordiz, A., Bischof, R., & Swenson, J. E. (2013). Saving large carnivores, but losing the apex predator? *Biological Conservation*, *168*, 128–133. doi:10.1016/j.biocon.2013.09.024

See also:

Ripple, W. J., Estes, J. A., Beschta, R. L., Wilmers, C. C., Ritchie, E. G., Hebblewhite, M., ... & Wirsing, A. J. (2014). Status and ecological effects of the world's largest carnivores. *Science*, *343*(6167), 1241484. https://www.science.org/doi/abs/10.1126/science.1241484

See also:

Ripple, W.J. and R.L. Beschta. (2012). Trophic cascades in Yellowstone: the first 15 years after wolf reintroduction. *Biol.* Conserv. 145:205–213.

See also:

Ripple, W. J., Beschta, R. L., Fortin, J. K., & Robbins, C. T. (2014). Trophic cascades from wolves to grizzly bears in Yellowstone. *The Journal of animal ecology*, *83*(1), 223–233. https://doi.org/10.1111/1365-2656.12123

See also:

Ripple, W.J., L.E. Painter, R.L. Beschta, and C.C. Gates. 2010. Wolves, elk, bison, and secondary trophic cascades in Yellowstone National Park. Open Ecol. J. 3:31–37.

See also:

Berger, J., P.B. Stacey, L. Bellis, and M.P. Johnson. 2001. A mammalian predator-prey imbalance: grizzly bear and wolf extinction affect avian neotropical migrants. Ecol. Appl. 11:947–960.

See also:

Painter, L. E., Beschta, R. L., Larsen, E. J., & Ripple, W. J. (2018). Aspen recruitment in the Yellowstone region linked to reduced herbivory after large carnivore restoration. *Ecosphere*, *9*(8), e02376. https://doi.org/10.1002/ecs2.2376

6.3 Mesopredator Release

6.3.1 The rise of the mesopredator

In a global context, this paper provides an overview of mesopredator release due to decline in apex predators, which can occur from human persecution. Removal of top predators results in increases in abundance of smaller predators, known as mesopredator release. Consequently, associated prey populations decline which can have devastating impacts to community assemblage stability and lead to extinctions. The researchers show that in North America, 60% of mesopredator ranges have expanded, whereas all apex predator ranges have contracted. Ecological, economic, and social costs are evident from this trophic interaction.

Prugh, L.R., C.J. Stoner, C.W. Epps, W.T. Bean, W.J. Ripple, A.S. Laliberte, and J.S. Brashares. 2009. The rise of the mesopredator. BioScience 59:779–791. https://doi.org/10.1525/bio.2009.59.9.9

7 Preferred Non-Lethal Methods (ranging long- to short-term)

7.1 Habitat Protection

7.1.1 Proactive conservation of high-value habitat for woodland caribou and grizzly bears in the boreal zone of British Columbia, Canada

Conservation planning priority areas were explored for two at-risk species in northeastern British Columbia in order to determine most effective conservation solutions. Specifically, a decision-support software was used to evaluate four scenarios to conserve high-value habitat for woodland caribou as well as grizzly bears. Scenarios were run that 1) maintained connectivity of high-value habitat without economic considerations (Maintain Connectivity); 2) conserved high-value habitat in areas with low resource potential (Minimize Conflict); 3) conserved high-value habitat in areas with high-resource potential (Reduce Development); and 4) designated areas where predation risk was potentially lower (Avoid Predation Risk). To determine effectiveness of each scenario, landscape metrics (i.e., functional habitat loss, habitat fragmentation, and edge effects) were compared. The Maintain Connectivity scenario preserved more high-value habitat than any other scenario and was characterized by a smaller total number of habitat patches. Previous research supports this finding as 'maintaining connectivity among habitat patches across landscapes has been the cornerstone of conservation strategies for large mammal species with high mobility, such as caribou'. Only slightly higher resource opportunity costs would be realized under this scenario compared to the Minimize Conflict scenario. This research provides insight into making effective habitat conservation decisions in terms of how and where to allocate land.

Suzuki, N., & Parker, K. L. (2019). Proactive conservation of high-value habitat for woodland caribou and grizzly bears in the boreal zone of British Columbia, Canada. *Biological Conservation*, *230*(Complete), 91–103. https://doi.org/10.1016/j.biocon.2018.12.013

See also:
Lamb, C. T., Festa-Bianchet, M., & Boyce, M. S. (2018). Invest long term in Canada's wilderness. *Science*, *359*(6379), 1002-1002. DOI: 10.1126/science.aat1104

7.2 Habitat Restoration

7.2.1 Cumulative Effects and Boreal Woodland Caribou: How Bow-Tie Risk Analysis Addresses a Critical Issue in Canada's Forested Landscapes

Risk analysis tools are used to quantitatively evaluate cumulative effects of risks and management scenarios (risk mitigation and risk prevention measures) for three northern boreal woodland caribou herds. The provincially accepted level of a 60% chance of caribou herd self-sustainability is used as a threshold of risk (corresponding to a herd growth rate > 1.025). Like studies supporting wolf control, the analysis of *risk mitigation* showed that a combination of mitigation strategies would provide the best outcome for caribou recovery. While the analysis found that predator control alone could achieve sustainable herds, it was also found that seismic restoration combined with maternal penning would achieve the 60% herd sustainability

objective. Maternal penning alone was found to achieve this objective for the Snake-Sahtahneh herd. Moreover, in contrast to *risk mitigation*, findings showed that *risk prevention* is another viable option. The analysis showed that if two barriers preventing predation (efforts of caribou to avoid predators and management of early seral forest[4]) were improved by 50%, there may be a chance for success. The authors suggest threat prevention could be combined with mitigation tools for enhanced outcomes and that more work is needed to understand the potential utility of threat prevention barriers.

Also see this journal article discussed in section 5.1.1 regarding compensatory predation.

Winder, Stewart, F. E. C., Nebel, S., McIntire, E. J. B., Dyk, A., & Omendja, K. (2020). Cumulative Effects and Boreal Woodland Caribou: How Bow-Tie Risk Analysis Addresses a Critical Issue in Canada's Forested Landscapes. *Frontiers in Ecology and Evolution*, *8*. https://doi.org/10.3389/fevo.2020.00001

7.2.2 Multispecies modelling reveals potential for habitat restoration to re‑establish boreal vertebrate community dynamics

Restoration effectiveness of seismic lines was tested in disturbed oil and gas landscapes in Alberta. Camera traps were used over four years to develop species distribution models in order to understand the response of large vertebrate habitat use to restoration of seismic lines. The research demonstrated that restored lines (i.e., decreasing line-of-sight and line density) led to shifts in species community structure and reduced use by wolves and coyotes. Such evidence indicates that restoration of linear features reduces predator-caribou encounter rates. The methods of this study (camera traps and distribution models) can be applied to other areas where caribou are impacted by linear features in order to predict the outcomes of restoration.

Beirne, C., Sun, C., Tattersall, E. R., Burgar, J. M., Fisher, J. T., & Burton, A. C. (2021). Multispecies modelling reveals potential for habitat restoration to re‑establish boreal vertebrate community dynamics. *Journal of Applied Ecology*, *58*(12), 2821-2832.

See also:
Dickie, M., McNay, R. S., Sutherland, G. D., Sherman, G. G., & Cody, M. (2021). Multiple lines of evidence for predator and prey responses to caribou habitat restoration. *Biological Conservation*, *256*, 109032. https://doi.org/10.1016/j.biocon.2021.109032
Also see: https://register.gotowebinar.com/recording/546939272736055564

See also:
Spangenberg, M. C., Serrouya, R., Dickie, M., DeMars, C. A., Michelot, T., Boutin, S., & Wittmann, M. J. (2019). Slowing down wolves to protect boreal caribou populations: a spatial simulation model of linear feature restoration. *Ecosphere*, *10*(10), e02904. https://doi.org/10.1002/ecs2.2904

[4] It has been hypothesized that early seral stage forest attracts alternate prey such as deer and moose, which thereby attract wolves, increasing encounters and the predation threat to woodland caribou (habitat mediated apparent competition).

See also:
Dickie, M., Serrouya, R., DeMars, C., Cranston, J., & Boutin, S. (2017). Evaluating functional recovery of habitat for threatened woodland caribou. *Ecosphere*, *8*(9), e01936. https://doi.org/10.1002/ecs2.1936

See also:
Wilman, E. A., & Wilman, E. N. (2017). Fast, slow, and adaptive management of habitat modification–invasion interactions: woodland caribou (Rangifer tarandus). *Ecosphere*, *8*(10), e01970. https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/ecs2.1970

7.2.3 Prioritizing restoration of fragmented landscapes for wildlife conservation: A graph-theoretic approach

Reducing habitat fragmentation through restoration of seismic lines is imperative to recover of caribou. Researchers applied an optimization model to the Cold Lake Area (CLA), Alberta as a case study, in order to determine the best strategies for restoration that maximizes habitat connectivity. In the case study, the eastern and central regions of CLA were prioritized using the model. Two strategies were explored, one involving short-distance connections between forest patches and the other involving corridors between areas where species are known and large tracts of suitable habitat. The optimal mix of these strategies can be explored to determine the best restoration solution while considering budget. This approach can be applied in other regions to aid in prioritizing which seismic lines should be restored to improve caribou habitat connectivity.

Yemshanov, D., Haight, R. G., Koch, F. H., Parisien, M.-A., Swystun, T., Barber, Q., Burton, A. C., Choudhury, S., & Liu, N. (2019). Prioritizing restoration of fragmented landscapes for wildlife conservation: A graph-theoretic approach. *Biological Conservation*, *232*(Complete), 173–186. https://doi.org/10.1016/j.biocon.2019.02.003

7.3 Blocking Linear Features / Linear Deactivation

7.3.1 Managing Animal Movement Conserves Predator–Prey Dynamics

Researchers tested the effectiveness of reducing encounters between wolves and caribou, thereby managing caribou predation. The study took place across the Parker Caribou Range in northeastern British Columbia, conducted as a before-after control-impact experiment over 2.5 years. Using camera traps, coincident habitat use was quantified in space and time, as a measure for species encounters. Midway through the study, mitigations designed to impede predator movement were deployed on anthropogenic linear developments (seismic lines and roads). Soil mounding, tree planting, and tree felling mitigations were implemented on 61 km of 166 km of linear developments in the treatment area. Animal use was monitored on all linear developments. Findings showed that by deploying obstacles to disrupt ease of movement on human developments, wolf-caribou encounters were reduced by 85% and black bear-caribou encounters by 60%. Moreover, treating less than 40% of linear developments was enough to achieve the 85% reduction of wolf-caribou encounters in the treated area. This research demonstrates that

managing animal movements that regulate predator-prey encounters, risk to endangered species can be reduced without the disruptive trophic effects caused by intensive carnivore removals. Since wolf densities are typically dependent on moose and white-tailed deer populations, encounter-based management is likely to redistribute wolves with little or no impact on wolf populations. Implications of this study show that managing coincident habitat use by predators and prey provides an immediate benefit to vulnerable prey and a cost-effective alternative to predator removals or awaiting long-term habitat restoration.

Keim, DeWitt, P. D., Wilson, S. F., Fitzpatrick, J. J., Jenni, N. S., & Lele, S. R. (2021). Managing animal movement conserves predator–prey dynamics. *Frontiers in Ecology and the Environment*, *19*(7), 379–385. https://doi.org/10.1002/fee.2358 https://wolfwatcher.org/wp-content/uploads/2021/07/Keim-etal-2021.pdf

See also:
Keim, J. L., Lele, S. R., DeWitt, P. D., Fitzpatrick, J. J., & Jenni, N. S. (2019). Estimating the intensity of use by interacting predators and prey using camera traps. *Journal of Animal Ecology*, *88*(5), 690–701. https://doi.org/10.1111/1365-2656.12960

See also:
Keim, J. L., DeWitt, P. D., Wilson, S. F., Fitzpatrick, J. J., Jenni, N. S., & Lele, S. R. (2019). Designing and Monitoring the Efficacy of Functional Restoration of Linear Features for Boreal Woodland Caribou. https://www.bcogris.ca/sites/default/files/bcip-2019-02-final-report-keim-et-al-ver-1a.pdf

See also:
Tattersall, E. R., Burgar, J. M., Fisher, J. T., & Burton, A. C. (2020). Mammal seismic line use varies with restoration: Applying habitat restoration to species at risk conservation in a working landscape. *Biological Conservation*, *241*(Complete). https://doi.org/10.1016/j.biocon.2019.108295

7.4 Silviculture and Forest Management

7.4.1 Can partial‑cut harvesting be used to manage terrestrial lichen habitat?

Where forestry does occur, best practices can be implemented to maintain lichen forage for caribou. Research studies have demonstrated that partial-cut harvesting, in contrast to clear-cut logging, is a technique that can be used to help maintain terrestrial lichen mats by modifying the successional trajectory in pine- and spruce-lichen woodlands. Trials carried out in the caribou range of the Itcha-Ilgachuz herd in British Columbia tested different types of cuts (treatments) compared to no harvest and to clear-cuts. The most successful treatment was the group selection technique, which ‘called for 33% removal in canopy openings about 15 m in diameter.’ Measurements for this treatment showed that after harvest in 1998, lichens declined to 53%, but recovered to nearly preharvest levels by 2004. Therefore, lichen cover was characteristic of an undisturbed forest. Although the study in BC has been the most comprehensive, similar findings have been shown in Quebec and Alberta. Certainly, a partial-cut harvest design would require a strategy to address deactivation of linear features. The authors suggested that using partial-cut

logging reduces canopy closure and acts as a short- to mid-term solution for maintaining the availability of lichen to caribou.

Stevenson, S. K., & Coxson, D. S. (2015). Can partial‐cut harvesting be used to manage terrestrial lichen habitat? A review of recent evidence. *Rangifer*, 11-26. DOI:10.7557/2.35.2.3461. https://www.researchgate.net/publication/291010680_Can_partial-cut_harvesting_be_used_to_manage_terrestrial_lichen_habitat_A_review_of_recent_evidence

See also:
Coxson, D. S. (2015). Using partial-cut harvesting to conserve terrestrial lichens in managed landscapes. *Canadian Wildlife Biology & Management 4*: 150–162. https://cwbm.ca/wp-content/uploads/2016/04/6-Vol-4-Issue-2-Coxson.pdf

See also (above mentioned BC study):
Waterhouse, M.J., Armleder, H.M. & Nemec, A.F.L. 2011. Terrestrial lichen response to partial cutting in lodgepole pine forests on caribou winter range in west-central British Columbia. — Rangifer Special Issue 19: 119- 134. http://dx.doi.org/10.7557/2.31.2.1996

See also:
Courbin, N., Fortin, D., Dussault, C., & Courtois, R. (2009). Landscape management for woodland caribou: the protection of forest blocks influences wolf-caribou co-occurrence. *Landscape ecology*, *24*(10), 1375-1388. https://link.springer.com/article/10.1007/s10980-009-9389-x

7.5 Aversion Conditioning

7.5.1 Shock collars as a site‐aversive conditioning tool for wolves

Researchers tested the ability of shock collars to reduce use of a site by wolves and lead to aversion conditioning, in order to reduce livestock losses. They also wanted to understand whether this behaviour was transferred to other uncollared pack members. Findings showed that collared wolves visited less and spent less time in shock zones, and stayed away for more days, than uncollared wolves. Shock collars lead to aversion conditioning which was also behaviourally transferred to other pack members. This study was validated for free-ranging wolves at the scale of livestock farms; however, it would be interesting for further research to explore if and how this technology could have application for protection of an endangered species such as woodland caribou. Perhaps this technology could lend in protecting caribou from predation in some design arrangement (e.g., known caribou refuge areas, or even receptor collars fitted to 1-2 individual herd members, as a travelling shock zone, to mitigate predation from collared wolves/packs). In terms of suitability as a management tool, this paper cites literature confirming that nonlethal methods are generally more acceptable by the public than lethal methods.

Rossler, S. T., Gehring, T. M., Schultz, R. N., Rossler, M. T., Wydeven, A. P., & Hawley, J. E. (2012). Shock collars as a site‐aversive conditioning tool for wolves. *Wildlife Society Bulletin*, *36*(1), 176–184. https://doi.org/10.1002/wsb.93

See also:

Hawley, J. E. (2005). *Experimental Assessment of Shock Collars as Non-lethal Control Method for Free-ranging Wolves in Wisconsin* (Doctoral dissertation, Central Michigan University). http://people.se.cmich.edu/gehri1tm/ms%20theses/jason%20hawley%20thesis.pdf

8 Ethics Research and Public Disapproval

8.1.1 Maintaining Ethical Standards during Conservation Crises

Ethical and animal welfare concerns are deliberated in the context of experimental implementation of emergency lethal wolf culling. The researchers contend that methods of extermination (aerial shooting, strychnine, and strangling neck snares) are not in accordance with the Canadian Council of Animal Care (CCAC) guidelines because they cause long and painful deaths of wolves and of the many non-target animals that are also killed. Shooting moving animals from helicopters is challenging, prone to error, and often fails to achieve deaths that are quick and painless. The American Veterinary Medical Association (AVMA) states that the objective of the shooter is a gunshot to the head causing destruction of brain tissue, and that shots to the heart or neck do not cause instant loss of consciousness. Generally, evidence to support the effectiveness of euthanasia by aerial shooting as a humane method is not adequately documented in the scientific literature. Also discussed is adherence of wolf control studies to scientific journal ethical animal care standards. Issues of wolf control studies include insufficient data regarding animal welfare outcomes, average time to death, wounding rate, escape rate, instantaneous death rate, and location of bullet wound tracts, as well as type of helicopter, firearm, ammunition and shooter proficiency. These shortcomings of standard animal care suggest improper consideration of humane animal deaths. It is held that experiments of intentional inhumane killing of wildlife violate the fundamental principles of ethical science. Recommendations are that CCAC guidelines be updated to provide further clarity on field methods in wildlife studies such as shooting animals from helicopters. In addition, audits should be conducted on researchers, studies, and publishing journal institutions.

Brook, R.K., Cattet, M., Darimont, C.T., Paquet, P.C., & Proulx, G. (2015). Maintaining Ethical Standards during Conservation Crises. *Canadian Wildlife Biology and Management, 4*(1), 72-79. https://www.raincoast.org/wp-content/uploads/2015/01/Brook-et-al-2015_wolf-caribou-CWBM.pdf

See also:

Johnson, C. J., Ray, J. C., & St-Laurent, M.-H. (2022). Efficacy and ethics of intensive predator management to save endangered caribou. *Conservation Science and Practice*, e12729. https://doi.org/10.1111/csp2.12729

8.1.2 International Consensus Principles for Ethical Wildlife Control

Global perspectives and experiences were drawn upon to develop seven principles of ethical wildlife control. Facilitated through a process of engagement and discussion, 20 international experts established the stepwise principles for ethical decision-making as follows:

1. efforts to control wildlife should begin wherever possible by altering the human practices that cause human–wildlife conflict and by developing a culture of coexistence.
2. be justified by evidence that significant harms are being caused to people, property, livelihoods, ecosystems, and/or other animals.
3. have measurable outcome-based objectives that are clear, achievable, monitored, and adaptive.
4. predictably minimize animal welfare harms to the fewest number of animals.
5. be informed by community values as well as scientific, technical, and practical information.
6. be integrated into plans for systematic long-term management.
7. and be based on the specifics of the situation rather than negative labels (pest, overabundant) applied to the target species.

This inclusive approach would help alleviate controversy and opposition by considering diverse perspectives grounded in science and ethics. It was recommended that these principles guide the development of standards at all levels of government and decision-making in human-wildlife conflict management.

Dubois, S., Fenwick, N., Ryan, E. A., Baker, L., Baker, S. E., Beausoleil, N. J., Carter, S., Cartwright, B., Costa, F., Draper, C., Griffin, J., Grogan, A., Howald, G., Jones, B., Littin, K. E., Lombard, A. T., Mellor, D. J., Ramp, D., Schuppli, C. A., & Fraser, D. (2017). International consensus principles for ethical wildlife control. *Conservation Biology*, *31*(4), 753–760. https://doi.org/10.1111/cobi.12896

See also:

Proulx, G. (2018). Concerns about mammal predator killing programs: scientific evidence and due diligence. *Canadian Wildlife Biology & Management*, *7*, 59. https://www.researchgate.net/publication/325010192_Concerns_About_Mammal_Predator_Killing_Programs_Scientific_Evidence_and_Due_Diligence

8.1.3 Wildlife conservation and animal welfare: two sides of the same coin

This paper integrates ethics in wildlife conservation and animal welfare in order to establish the principle of 'wildlife welfare' in conservation. Ethical foundations are deficient in wildlife conservation, even though wild animals within anthropogenically-disturbed habitats are subject to suffering. Grey wolves are used as a case study, but in the context of degraded wolf habitat and displacement in human-dominated landscapes, such that their distribution, movements, survival, or fecundity may be impaired. Nevertheless, a doctrine of wildlife welfare principles, such as that presented here, remains applicable to all species levels of all systems where suffering is endured due to degraded habitat as the root cause. Paquet and Darimont (2010) adapt

the Five Freedoms of Animal Welfare to reflect human-rooted suffering borne by wildlife: Freedom from thirst, hunger, and malnutrition caused by humans; freedom from discomfort due to environmental disruption caused by humans; freedom from fear and distress caused by humans; freedom from pain, injury, and disease caused by humans; freedom to express normal behaviour for the species.

Paquet, P. C., & Darimont, C. T. (2010). Wildlife conservation and animal welfare: two sides of the same coin. *Animal Welfare*, *19*(2), 177-190. Retrieved from: https://www.researchgate.net/publication/228621252_Wildlife_conservation_and_animal_welfare_Two_sides_of_the_same_coin

See also:

Nunny L. (2020). Animal Welfare in Predator Control: Lessons from Land and Sea. How the Management of Terrestrial and Marine Mammals Impacts Wild Animal Welfare in Human-Wildlife Conflict Scenarios in Europe. *Animals : an open access journal from MDPI*, *10*(2), 218. https://doi.org/10.3390/ani10020218

8.1.4 Predator Reduction for Caribou Recovery Engagement Survey: What We Heard

The Province of B.C. carried out a public engagement survey to seek input from British Columbians on a five-year approval for continued predator reduction to support woodland caribou recovery. The questionnaire was open from September 15th to November 15th, 2021, and focused on caribou recovery, predator reduction, and participant demographics. Results were published in a 'What We Heard' report. In total, 15,196 people participated in the survey. Key findings include:

- Overall, 59% of respondents were against predator reduction for caribou recovery and 37% support predator reduction.
- The overwhelming majority of respondents (98%) feel that caribou recovery is important.
- Among stakeholder groups, those opposed to predator reduction were more likely to be concerned citizens, scientists, or those associated with environmental/ecosystem protection, the ecotourism industry, and First Nations and/or Indigenous stakeholder groups.
- Hunters and/or trappers, guide outfitters or those associated with resource extraction were more likely to support predator reduction.
- Among those who disagreed with predator reduction (59%), the most frequently mentioned reason was because they felt there were better options to achieve the same end (83% of those who disagreed with predator reduction).
- Additionally, 60% who disagree with predator reduction indicated they were opposed to the killing of wolves as a means to immediately stop caribou decline and 56% felt that predator reduction was inhumane.
- The top three caribou recovery actions selected by respondents were habitat protection (regulating land use), habitat restoration, and habitat management-beneficial management practices for recreation and industry.

Ministry of Forests, Lands, Natural Resource Operations and Rural Development. (2021). *Predator Reduction for Caribou Recovery Engagement Survey: What We Heard*. R.A. Malatest & Associates Ltd. https://engage.gov.bc.ca/app/uploads/sites/121/2022/01/WWHR-Predator-Reduction-For-Caribou-Recovery-Final-Report-JAN2022.pdf

See also:

Sara Dubois & H. W. Harshaw (2013): Exploring "Humane" Dimensions of Wildlife, Human Dimensions of Wildlife: An International Journal, 18:1, 1-19. http://dx.doi.org/10.1080/10871209.2012.694014