# A Conservation Status Assessment of the Mountain Caribou Ecotype Based on IUCN Red List Criteria

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**Abstract:** Mountain caribou are an ecotype of woodland caribou (*Rangifer tarandus caribou*) that live in the mountainous regions of southeastern and east central British Columbia. In 2002, the British Columbia Conservation Data Centre placed the mountain caribou on the provincial Red List based on NatureServe ranking criteria, while the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated the mountain caribou as Threatened based on International Union for Conservation of Nature and Natural Resources (IUCN) Red List criteria. The COSEWIC designation, however, applies to all woodland caribou within the Southern Mountains National Ecological Area, a region that includes both the mountain caribou and northern caribou ecotypes. The objective of this assessment was to recommend an 'at-risk' designation specifically for the mountain caribou based on IUCN Red List criteria and to compare IUCN and NatureServe threat classifications. The mountain caribou was classified as Endangered under IUCN criterion C1, which was consistent with the provincial Conservation Data Centre assessment. For contentious species, such as the mountain caribou, it may be useful to conduct conservation status assessments using both IUCN and NatureServe status assessment criteria.

**Key Words:** mountain caribou, woodland caribou, *Rangifer tarandus caribou*, conservation status, IUCN Red List, NatureServe, endangered species

## Introduction

All caribou in British Columbia (B.C.) are 'forest-dwelling' woodland caribou (*Rangifer tarandus caribou*) (Thomas and Gray 2001), but because of differences in foraging behavior, migration patterns, habitat use, and/or geographic distribution, three ecotypes[1] have been recognized (Heard and Vagt 1998). The arboreal lichen-winter-feeding ecotype, more commonly referred to as 'mountain caribou', lives primarily in the Interior Wet Belt, a region of unusually high precipitation in southeastern and east central British Columbia. Mountain caribou are characterized by their use of high elevation old-growth forests in late winter where the deep snow

[1]An ecotype is defined as a subdivision (e.g., a population or group of populations) within a species or subspecies that has adapted to specific landscapes or environments as expressed primarily by its movements and feeding behavior.

pack provides a platform that allows them to feed on arboreal lichens (primarily *Bryoria* spp.) in tree canopies (Stevenson et al. 2001). The entire distribution of mountain caribou occurs within British Columbia, although a small international local population also ranges into northern Idaho and Washington. The woodland caribou is listed as Endangered under the U.S. *Endangered Species Act* (U.S. Fish and Wildlife Service 1993).

Historically, mountain caribou were more widely distributed throughout the mountainous region of east central and southeastern B.C., eastern Washington, northern Idaho, and northwestern Montana (Hatter 2000). Widespread habitat alteration, past overhunting, and increased predation are believed to have contributed to the disappearance of mountain caribou from portions of their historic range in B.C. (MCTAC 2002). Currently, mountain caribou exist as a number of discrete local populations, which collectively form a metapopulation[2]. Today, the primary threat to mountain caribou appears to be fragmentation of their habitat. Associated with this fragmentation are potential reductions in available winter food supply (Stevenson et al. 2001), increased human access and associated disturbance (Simpson and Terry 2000), and alteration of predator-prey relationships (Kinley and Apps 2001). Forest harvesting is considered to be the greatest habitat management concern (Stevenson et al. 2001; MCTAC 2002).

In May 2000, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated the woodland caribou within the Southern Mountains National Ecological Area (SMNEA) as Threatened. This area includes all local populations of mountain caribou, plus local populations of the terrestrial lichen-winter-feeding ecotype ('northern caribou') from west central B.C. and western Alberta. COSEWIC reconfirmed their designation in May 2002, and in 2003, woodland caribou in the SMNEA were listed under Schedule 1 of the federal *Species at Risk Act*. The British Columbia Conservation Data Centre (CDC) has identified the three ecotypes of woodland caribou in B.C. for conservation status assessments and has placed the mountain caribou on the provincial Red List (candidate for Endangered or Threatened designation) based on NatureServe ranking criteria (Master et al. 2003). The other ecotypes are on the provincial Blue List and are considered to be of Special Concern.

COSEWIC designations are based on IUCN Red List criteria that, in the case of wide-ranging species like caribou, are applied to National Ecological Areas (NEAs) in Canada (e.g., the SMNEA). COSEWIC does not recognize smaller subdivisions (such as ecotype distributions) within NEAs, even though they may be of potentially higher conservation concern than nationally designated populations. Thomas and Gray (2001) note that there is still much uncertainty in caribou taxonomy and suggest that conservation focus on ensuring that genetic diversity and behavior are preserved. The authors also note that COSEWIC NEAs are a good start, but that the division between Northern and Southern Mountain NEAs does not conform to the distribution of woodland caribou ecotypes.

[2]A metapopulation is defined as a group of local populations with actual or potential immigration and emigration among them (Thomas and Gray 2001). A local population may be isolated due to barriers to dispersal, or semi-isolated, where some immigration/emigration occurs among populations.

The objective of this assessment was to recommend an 'at-risk' designation specifically for mountain caribou based on IUCN Red List criteria, and to compare IUCN and NatureServe threat classifications.

## Methods

IUCN criteria for assessing species at risk include (1) population reduction; (2) small distribution decline or fluctuation, (3) small population size and decline; (4) very small size or restricted distribution; and (5) quantitative analysis of extinction risk (IUCN 2001a). Only one of these criteria needs to be met for a species to be designated as Threatened or Endangered by COSEWIC (COSEWIC 2003). The computer program RAMAS® Red List was used to assign an 'at-risk' status for mountain caribou based on IUCN Red List criteria (Akçakaya and Ferson 2001). Data inputs were specified as 'fuzzy numbers' (i.e., minimum, most likely, and maximum estimates). This enabled uncertainty in the input parameters to be propagated and thus assign mountain caribou to either a single at-risk category, or to a range of plausible categories, depending on the nature and extent of the uncertainties (Akçakaya et al. 2000).

The following factors were considered in the IUCN Red List status assessment. Some factors such as estimation of mature individuals were used by both the IUCN and NatureServe systems (Master et al. 2003), while others were specific to classification based on IUCN Red List criteria (e.g., quantitative analysis of extinction risk).

### *Population Size and Structure*

Mountain caribou were considered to comprise a metapopulation which through range reduction and habitat change has resulted in isolated or near-isolated local populations (MCTAC 2002). The size of the metapopulation has been estimated periodically from aerial surveys of each local population. Early estimates, which were based on fewer surveys and poor or incomplete knowledge of local population distribution, were less reliable than current estimates. More recent radio-telemetry studies have allowed biologists to better define local population boundaries, and to incorporate factors to correct sightability bias based on the proportion of missed radio-collared animals (Seip and Cichowski 1996), thus improving the reliability of local population estimates. The survey methodology for mountain caribou was standardized across B.C. in the mid-1990s (RISC 2002).

### *Estimation of Mature Individuals*

The population size used in the assessment was the estimated number of mature individuals within the metapopulation. Mature individuals are defined as the number of individuals known, estimated or inferred to be capable of reproduction (IUCN 2001a). Woodland caribou calves do not breed, only a portion of adult females breed, and most adult males do not breed until they are 3–4 years old (Bergerud 2000). Stable woodland caribou populations consist of about 15% calves in late winter (Thomas and Gray 2001). For these reasons, mature individuals were estimated at 75% of the non-calf population, or 64% (0.75 x 0.85) of the late winter population estimate.

### *Past Population Reduction*

Past reductions were estimated for each local population using IUCN guidelines for multiple populations (IUCN 2001b). This method assumes a constant rate of change (λ) between population estimates, and interpolates values between estimates based on λ, i.e.,

$$\lambda = (N_t/N_0)^{(1/t)}$$

where $N_0$ denotes an initial population estimate and $N_t$ denotes the population estimate at time $t$. Interpolated values during intervening years were calculated as

$$N_{t+1} = \lambda\, N_t$$

The frequency of population estimates and surveys varied among local populations. Generally, populations were surveyed more frequently and trends were more reliable after 1995.

In order to evaluate a population reduction, it was necessary to estimate the percentage decline over the last three generations. Generation length is defined as the average age of parents of the current cohort. Using existing life tables, Thomas and Gray (2001) determined generation length to be about 6.7 years for woodland caribou, or 20 years for three generations; thus, a population estimate for 1982 and 2002 was required to calculate population reductions over three generations. All local populations were surveyed in 2002, but few were surveyed on or before 1982. If an estimate for 1982 was not available, the 1982 estimate was assumed to be equal to the first population estimate. This assumption (λ = 1) underestimated past reductions for local populations that were declining prior to the first population estimate. Conversely, it overestimated past reduction if the population was increasing between 1982 and the first estimate.

Because of the sensitivity of this assumption to estimates of past reduction, population reduction was also estimated from log-linear regression, i.e.,

$$\log N_t = \log N_0 + t \log\lambda$$

where a constant λ was assumed for the time series. Regression estimates of abundance (e.g., $N_{t-1} = N_t/\lambda$) before the first population estimate in the time series were capped at a ceiling or

stabilizing density of 50 caribou/1000 km$^2$ (Seip and Cichowski 1996), unless surveys indicated otherwise.

### *Future Population Reduction*

The IUCN Red List requires estimates of future population reduction (over three generations) and an estimate of a 'moving window' reduction (the maximum potential reduction where the time period may include any three-generation period, as long as it includes both the past and the future). Both future (2002–2022) and 'moving window' (1995–2015) reductions in the metapopulation were modeled using RAMAS® Metapop software (Akçakaya 1997). Environmental (SE($\lambda$) = 0.05) and demographic stochasticity were included, as well as dispersal between local populations. Local population growth was exponential until the ceiling density of 50 caribou/1000 km$^2$ was reached, i.e.,

$$N_{i,t+1} = \min(\lambda_i \bullet N_{i,t}, 0.05 \text{ caribou/km}^2)$$

where $N_{i,t+1}$ is the size of local population $i$ in year $t+1$, $N_{i,t}$ is the local population size in the current year, and $\lambda_i$ is the survey estimate of the finite rate of change for each local population. Density was calculated as the local population size, i.e., $N_{i,t+1}$/current range (km$^2$) where current range was based on known or suspected occupancy. Metapopulation reduction was the sum of local population reductions. Metapopulation reductions were estimated for one (7 year), two (13 year), and three (20 year) generations.

Three scenarios were considered for future reduction: average $\lambda_i$ from 2000–2002 with no dispersal (pessimistic), average $\lambda_i$ from 1995–2002 with 1% dispersal for adjacent local populations (most likely), and average $\lambda_i$ from 1982–2002 with 2% dispersal (optimistic). A total of 1000 replications were performed with RAMAS® Metapop to calculate the average metapopulation trend and reduction over three generations.

### *Habitat Suitability and Capability*

Habitat suitability and capability maps (1:250,000 scale) have been prepared for mountain caribou based on ecosections, biogeoclimatic zones, subzones, and variants (MCTAC 2002)[3]. Differences in suitability and capability were intended, for this analysis, to provide a first approximation of the possible extent of decline in the abundance and quality of mountain caribou habitat within the Southern Interior Mountains Ecoprovince[4] from a time when habitat was pristine to the present. Six classes of suitability and capability (Very High, High, Moderate,

[3]Habitat capability is what a given habitat is capable of supporting, assuming management for maximization of caribou, and expresses habitat quality under ideal conditions. Habitat suitability is the current state of a given habitat and indicates what is available to caribou under current conditions.

[4]The Southern Interior Mountains Ecoprovince (Demarchi et. al. 2000a, 2000b) was used to delineate the Interior Welt Belt.

Medium, Low, and Very Low) were recognized for mountain caribou habitat. Habitat capability ratings were made on the assumption that pristine, old-growth forest provides optimal caribou habitat (Demarchi et al. 2000b). Ratings for suitability were adjusted downward from those for capability, based on estimates of current remaining old-growth forests and broad-scale alteration of the landscape (e.g., habitat fragmentation associated with industrial development) (Demarchi et al. 2000a). A Geographic Information System (GIS) was used to calculate the $km^2$ of habitat by suitability and capability class.

### *Distribution and Habitat Quality*

Mountain caribou distribution was expressed as extent of occurrence (EOO) and area of occupancy (AOO). The EOO is defined by the IUCN (2001a) as the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all of the known, inferred or projected sites of present occurrence of a taxon, and may exclude discontinuities or disjunctions within the overall distribution (e.g., large areas of obviously unsuitable habitat). The EOO for mountain caribou was the sum of the current ranges identified for each local population (MCTAC 2002). Extreme values were estimated from habitat suitability classes (*min* = $km^2$ of Moderate to Very High classes; *max* = $km^2$ of Very Low to Very High classes). The AOO is defined by the IUCN (2001a) as the area within the 'extent of occurrence' which is occupied by a taxon. The AOO was the area ($km^2$) comprising 18 subpopulation ranges identified from female radio-collared caribou (Wittmer 2004). The minimum value was estimated as the area ($km^2$) of the 18 subpopulation ranges with > 140-year-old forest (Wittmer 2004).

### *Quantitative Analysis of Extinction Risk*

RAMAS® Metapop was also used to estimate long-term (up to 100 year) reduction, metapopulation occupancy (number of local populations remaining), local occupancy (proportion of runs where the local population did not go extinct), and probability of metapopulation extinction. The threshold for local population occupancy (i.e., the number of caribou at which a local population was no longer considered viable) was 5 animals. Metapopulation extinction was defined as < 2 animals remaining after 20, 33, or 100 years, while quasi-extinction was defined as < 1000 animals remaining.

### *Incorporating Dispute and Risk Tolerance into the IUCN Classification*

RAMAS® Red List was used to assess different attitudes toward risk and uncertainty in the IUCN Red List assessment based on dispute tolerance (DT) and risk tolerance (RT). DT ranges from 0 (inclusion) to 1 (consensus). When DT = 0, the full range of truth values for a fuzzy number are considered, but when DT = 1, only those truth values where possibility =

1 are considered (Akçakaya et al. 2000). Similarly, RT ranges from 0 (precautionary) to 1 (evidenciary). When RT = 0, classifications are risk adverse, meaning the assessor has a precautionary view and is more willing to put the species into a higher at-risk category because of uncertainty. When RT $\simeq$ 1, classifications are risk prone as the assessor requires much stronger evidence to place a species into a higher at-risk classification (Akçakaya et al. 2000).

## Results and Discussion

### *Population Size and Structure*

The current metapopulation size, based on surveys of all 13 local populations in 2002, was 1905 animals (Table 1), or 1214 mature individuals (range: 968–1589). Thirteen was used as the 'most likely' estimate of the number of local populations as this was the number used in the Mountain Caribou Recovery Strategy (MCTAC 2002) and in the COSEWIC and CDC assessments (Fig. 1). Twelve was considered to be the minimum number of local populations (Heard and Vagt 1998), while 18 was considered to be the maximum (Wittmer 2004).

**Table 1. Estimated size of local populations of mountain caribou in 1982, 1995, 2000, and 2002 based on population interpolation and estimated rates of population change (λ). SE(λ) = 0.05.**

| *Local population* | $N_{1982}$ | $N_{1995}$ | $N_{2000}$ | $N_{2002}$ | $\lambda_{1982–2002}$ | $\lambda_{1995–2002}$ | $\lambda_{2000–2002}$ |
|---|---|---|---|---|---|---|---|
| South Selkirks | 30 | 52 | 35 | 35 | 0.96 | 0.98 | 0.90 |
| South Purcells | 100 | 83 | 20 | 20 | 0.94 | 0.86 | 0.88 |
| Central Selkirks | 268 | 268 | 215 | 130 | 0.97 | 0.92 | 0.85 |
| Monashee | 35 | 21 | 15 | 10 | 0.94 | 0.91 | 0.85 |
| Revelstoke | 277 | 367 | 350 | 225 | 0.99 | 0.94 | 0.91 |
| Central Rockies | 50 | 50 | 50 | 20 | 0.97 | 0.91 | 0.76 |
| Wells Gray South | 275 | 336 | 350 | 325 | 1.01 | 1.00 | 0.96 |
| Wells Gray North | 262 | 311 | 200 | 220 | 1.00 | 0.98 | 1.07 |
| N Cariboo Mtns | 425 | 425 | 425 | 350 | 0.99 | 0.98 | 0.94 |
| Barkerville | 40 | 43 | 50 | 50 | 1.01 | 1.03 | 1.00 |
| George Mtn | 20 | 20 | 10 | 5 | 0.94 | 0.85 | 0.74 |
| Narrow Lake | 51 | 57 | 65 | 65 | 1.01 | 1.03 | 0.97 |
| Hart Ranges | 521 | 521 | 495 | 450 | 0.99 | 0.98 | 0.53 |
| Metapopulation | 2354 | 2554 | 2280 | 1905 | 0.99 | 0.96 | 0.91 |

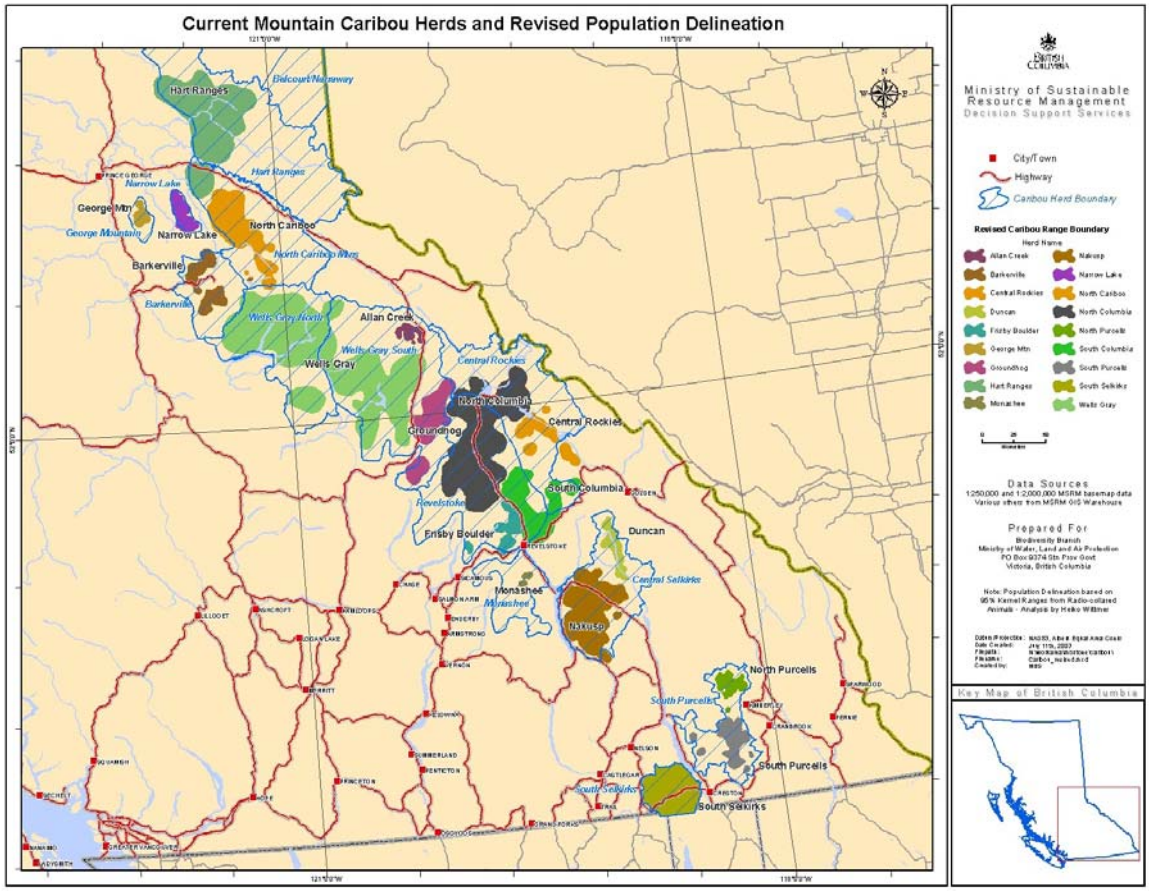


**Figure 1. Local populations of mountain caribou and revised subpopulation delineation by Wittmer (2004).**

### *Past Population Reduction*

Using the population interpolation method, the metapopulation appeared to increase between 1982 (2354) and 1995 (2554), but then declined to 1905 in 2002 (Table 1). Based on log-linear regression, the metapopulation progressively declined from 1982 to 2002, although more rapidly after 1995. Metapopulation estimates from both methods were substantially higher than those reported previously (Fig. 2). Most of the 'apparent' increase in previous estimates was likely from increasing survey intensity in later years which, in combination with the more recent radio-telemetry studies, contributed to more accurate estimates of mountain caribou numbers. The best estimate of past population reduction was 19% (range: 0–60%).

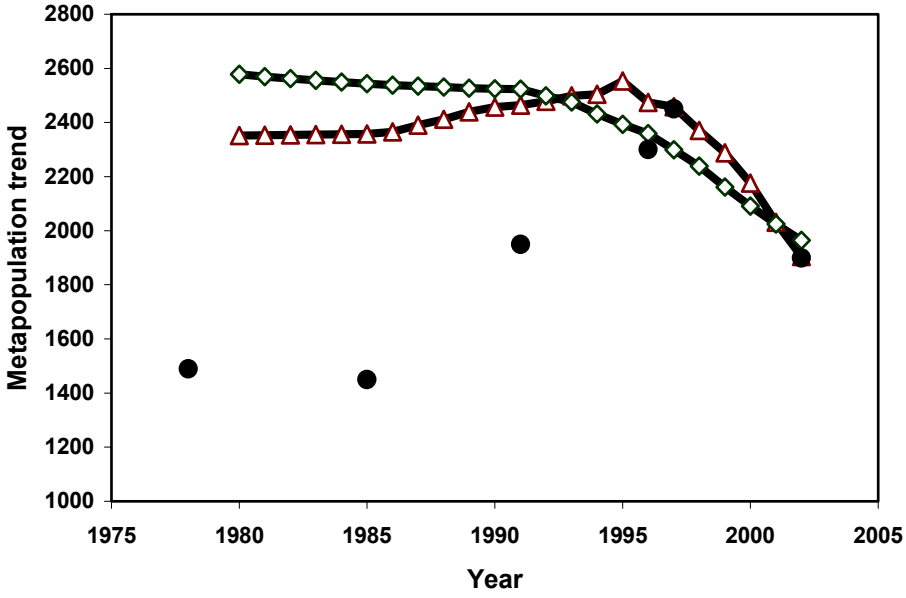


**Figure 2. Metapopulation trends from reconstructed (triangle) and log-linear-ceiling (diamond) models. Also shown are previously reported estimates (solid circles) from 1978 (Bergerud 1978); 1985 (Stevenson and Hatler 1985); 1991 (Edmonds 1991); 1997 (Hatter 2000); and 2002 (MCTAC 2002).**

### *Future Population Reduction*

All three modeling scenarios indicated substantial declines in future metapopulation size and occupancy (Fig. 3). The metapopulation declined from 1905 caribou in 2002 to 1534 (optimistic), 1169 (most likely), or 820 (pessimistic) caribou over the next 20 years. Metapopulation occupancy declined from 13 local populations in 2002 to an average of 10.9 (optimistic), 9.9 (most likely), or 7.9 (pessimistic) local populations over 20 years. Local occupancy was highest for Revelstoke, Wells Gray North, Wells Gray South, North Caribou Mountains and Hart Ranges and lowest for the South Purcells, Monashees and George Mountain (Table 2). The estimated future population reduction was 38% (range: 0–67%). The greatest (moving window) reduction was 47% between 1995 and 2015 (range: 7–72%).

### *Distribution and Habitat Quality*

The current range of mountain caribou, based on current range size (EOO), was 62,790 $km^2$ (range: 31,016–102,622 $km^2$). The current area occupied by radio-collared females (AOO) was 29,749 $km^2$, while the area occupied in >140-year-old forest was 12,131 $km^2$ (Wittmer 2004). Mountain caribou distribution was considered to be severely fragmented, with projected future declines in local occupancy (Table 2).

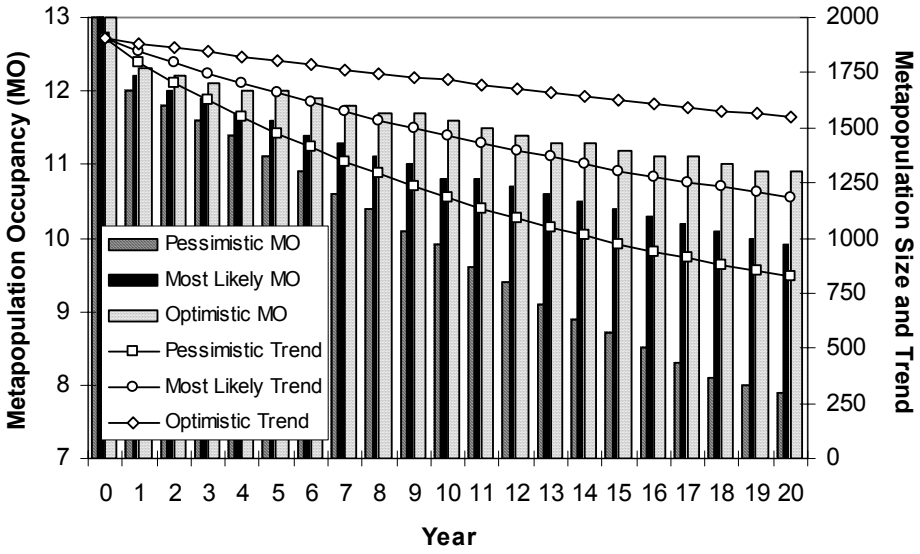


**Figure 3. RAMAS® Metapop projections for pessimistic, most likely, and optimistic scenarios for mountain caribou in British Columbia. Average population trend is shown as lines, while metapopulation occupancy (MO) is shown as histograms.**

**Table 2. Current range and future local occupancy of metapopulation based on three modeling scenarios. A value of 20.0 indicates the local population persisted for 20 years (≥ 5 animals remaining) in all 1000 stochastic replications.**

| *Local population* | *Range ($km^2$)* | *Optimistic scenario* | *Most likely scenario* | *Pessimistic scenario* |
|---|---|---|---|---|
| South Selkirks | 1500 | 18.5 | 17.6 | 13.6 |
| South Purcells | 2962 | 17.2 | 9.5 | 9.0 |
| Central Selkirks | 4813 | 20.0 | 19.5 | 16.5 |
| Monashee | 2082 | 17.6 | 10.3 | 4.2 |
| Revelstoke | 7863 | 20.0 | 20.0 | 20.0 |
| Central Rockies | 7265 | 20.0 | 18.8 | 4.4 |
| Wells Gray North | 6346 | 20.0 | 20.0 | 20.0 |
| Wells Gray South | 10,381 | 20.0 | 20.0 | 20.0 |
| N Cariboo Mtn | 5911 | 20.0 | 20.0 | 20.0 |
| Barkerville | 2535 | 20.0 | 20.0 | 19.8 |
| George Mtn | 440 | 3.7 | 1.4* | 0.5 |
| Narrow Lake | 431 | 20.0 | 20.0 | 19.5 |
| Hart Ranges | 10,261 | 20.0 | 20.0 | 20.0 |

*A survey in March 2003 failed to find any evidence of caribou on George Mountain. This population may now be locally extinct.

Habitat suitability was substantially less than habitat capability, with a reduction of approximately 19,200 $km^2$ (38%) of Very High, High, and Medium classes (Table 3). The greatest difference between habitat capability and suitability occurred within the High class (−71%).

**Table 3. Estimated area ($km^2$) of historic and current habitat suitability for mountain caribou within the Southern Interior Mountains Ecoprovince (from MCTAC 2002).**

| *Historic habitat capability* | | *Current habitat suitability* | | *Percent change* | *Change in area* |
|---|---|---|---|---|---|
| *class* | *$km^2$* | *class* | *$km^2$* | *%* | *$km^2$* |
| Very High | 12,261 | Very High | 7726 | - 37% | - 4535 |
| High | 12,357 | High | 3602 | - 71% | - 8755 |
| Medium | 25,607 | Medium | 19,688 | - 23% | - 5919 |
| Low | 34,584 | Low | 30,909 | - 11% | - 3675 |
| Very Low | 22,146 | Very Low | 40,697 | + 84% | + 18,551 |
| Nil | 8314 | Nil | 12,647 | + 52% | + 4333 |

### *Quantitative Estimate of Extinction Risk*

The probability that the metapopulation would become extinct over 20, 33, and 100 years was virtually zero for all three scenarios; however, severe reductions in metapopulation size were apparent. The average time to quasi-extinction (< 1000 caribou in metapopulation) was 26 years, 84 years, and > 100 years for the pessimistic, most likely, and optimistic scenarios, respectively. These estimates may be conservative as a stage-structured PVA model for mountain caribou, based on evidence of inverse density dependence in female adult survival, suggested that all local populations were likely to become extinct over 100 years (Wittmer 2004).

### *IUCN Classification for Mountain Caribou*

The mountain caribou was classified as Endangered under various IUCN criteria depending on the level of dispute and risk tolerance used in RAMAS® Red List (Table 4, Appendix 1). Mountain caribou were classified as Endangered under criterion C1 with neutral values (DT = 0.5 and RT = 0.5), as well as with different attitudes toward dispute tolerance and risk tolerance. This was because the best estimate of the number of mature individuals was 1214 (IUCN endangered criteria: < 2500 mature individuals) with an estimated continuing decline of 28% over the next 13 years (IUCN endangered criteria: ≥ 20% decline over two generations). The classification of Endangered for mountain caribou based on IUCN criteria was consistent with the NatureServe ranking of S2 (imperiled) for mountain caribou (MCTAC 2002, Appendix 1).

**Table 4. Classification of mountain caribou based on IUCN Red List criteria (EN = Endangered, VU = Vulnerable).**

| *Dispute tolerance* | *Risk tolerance* | *IUCN criteria* | *Classification* | *Plausible categories* |
|---|---|---|---|---|
| 0.5 | 0.2 | A3b+4b; C1 | EN | |
| 0.8 | 0.5 | A4b; C1 | EN | |
| 0.5 | 0.5 | C1 | EN | |
| 0.2 | 0.5 | A2a+3b+4b; C1+2a(i) | EN | EN, VU |
| 0.5 | 0.8 | C1 | EN | |

**A2a** - a population size reduction of > 50% over the last 20 years where the reduction or its causes may not have ceased
**A3b** - a population size reduction of > 50% projected to be met within the next 20 years (by 2022) based on an index of abundance
**A4b** - an observed, estimated, inferred, projected, or suspected population size reduction of > 50% over 20 years, including both the past and the future (1995–2015), and where the reduction or its causes may not have ceased, based on an index of abundance
**C1** - population size estimated to number fewer than 2500 mature individuals, and an estimated continuing decline of at least 20% within 13 years
**C2a(i)** - population size estimated to number fewer than 2500 mature individuals, and a continuing projected decline, and no subpopulation estimated to contain more than 250 mature individuals

### *Priorities for Conservation*

The primary recovery goal for mountain caribou is to establish a viable metapopulation of 2500–3000 animals (MCTAC 2002). This goal cannot be achieved unless recovery actions are undertaken to halt declines and facilitate positive population growth. A first step will be to ensure the maintenance of the larger populations within the core of their current range (i.e., Revelstoke, Wells Gray North, Wells Gray South, North Cariboo Mountains, and Hart Ranges) as well as connectivity between them; however, even if these local populations were managed for 50 caribou/1000 $km^2$, they would not support a metapopulation of 2500 caribou. Thus, recovery planning must also consider the enhancement of smaller, more peripheral local populations and the possibilities for connecting these isolated populations to core populations. Enhancing caribou viability will likely require improving habitat suitability, managing access and human disturbance, and intensively managing the predator-prey system (MCTAC 2002). Establishing priorities for mountain caribou conservation will ultimately require considering the socio-economic costs and benefits of recovering each local population, its viability in the long term, and its contribution towards long-term metapopulation persistence.

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**Appendix 1. Mountain caribou conservation status, evaluated with RAMAS® Red List version 2.0.0.7**

**Taxon name:** Mountain caribou
**Taxon type:** Population
**Assessment:** Regional
**Assessor(s):** Ian W. Hatter
**Date of assessment:** 28/02/2004

**INFORMATION**
**Taxonomic information:** Mountain caribou are an ecotype of the woodland caribou (*Rangifer tarandus caribou*)
**Life history:** rate of increase rarely exceeds 1.26 or 26% per year
Mean pregnancy rate of females ranges from 82.5% for animals > 1.5 yrs to 85% for animals > 3 yrs
Calf mortality during the first few month of life > 50%
Calves make up 27–30% of population at birth
By recruitment age (1 yr old) calves comprise < 20%, with 15% considered necessary for stability
Females live 10–15 yrs, males live 8–12 yrs
Adult female mortality rates average 15% but vary from 0–30%
Wolf predation is the major limiting factor. Other causes of mortality include poaching, starvation, accidents, collisions, and unknown causes
Mortality is greatest during summer
**Distribution:** occupy the 'Interior Wet Belt' of southeastern B.C.
Exist in 13 local populations comprising a metapopulation
**Habitat:** Early Winter— Interior Cedar–Hemlock (ICH) and lower Engelmann Spruce–Subalpine Fir (ESSF)
Late Winter—upper ESSF including subalpine parkland habitats
Spring—move to lower elevations than in late winter
Summer—upper elevation ESSF forests, ESSF parkland and alpine
**Threats:** The major threat is fragmentation of habitat areas. Effects of fragmentation may include reduction in winter food supply (arboreal lichens), human access and associated disturbance, and alteration of predator-prey relationships.
**Conservation:** The conservation approach is based on maintaining the metapopulation structure, adopting the precautionary approach relative to disturbance and land use impacts, practicing adaptive management, and employing ecosystem management principles.
**Comments:** generation length from Thomas and Gray (2001)
99%+ of the mountain caribou ecotype occur in B.C. Most of the South Selkirks international herd resides within B.C.

**RESULTS**

**Status:** EN (EN)

**Listed under:** C1

**Contribution:**

**Minus A:** EN (EN)

**Minus B:** EN (EN)

**Minus C:** EN* (EN-LC)

**Minus D:** EN (EN)

**Minus E:** EN (EN)

**Only A:** EN* (EN-LC)

**Only B:** LC (LC)

**Only C:** EN (EN)

**Only D:** LC (LC)

**Only E:** VU (VU-LC)

**OPTIONS**

**Dispute tolerance:** 50

**Risk tolerance:** 50

**Burden of proof:** 50

**Justification for attitude options:**

**DATA**

**Generation length:** 6.7 years (Qualifier: Observed; Uncertainty: )

**Population size:** [968,1214,1589] mature individuals (Qualifier: Estimated; Uncertainty: Min/max)

mat indiv = 75% of noncalf (15%) pop = .75*.85

best = 64% of best local winter population estimate

min = 64% of min local winter population estimate

max = 64% of max local winter population estimate

**Past population size:** [892,1500,2425] mature individuals (Qualifier: Estimated; Uncertainty: Min/max)

**Future population size:** [524,754,987] mature individuals (Qualifier: Projected; Uncertainty: Min/max)

**Extreme fluctuations:** no (Qualifier: Observed; Uncertainty: Subjective judgment)

***Population Notes:***

Based on comprehensive assessment of long-term (20 yr), short-term (7 yr) and current trends of all 13 local populations. Long-term trend reliability is low, while short-term and current trend is moderate-high.

**Current trends:** decreasing
**Past reduction:** [0,19.1,60.1] percent (Qualifier: Observed; Uncertainty: Min/max)
**Past reduction basis:** a
**Future reduction:** [0,37.9,67] percent (Qualifier: Projected; Uncertainty: Min/max)
**Future reduction basis:** b
**Moving window reduction:** [6.7,46.5,71.9] percent (Qualifier: Projected; Uncertainty: Min/max)
**Moving window reduction basis:** b
**Are the causes of reduction reversible?** Yes
**Are the causes of reduction understood?** Yes
**Have the causes of reduction ceased?** No
**Continuing decline:** [0.45,0.95,1] (Qualifier: Inferred; Uncertainty: Min/max)
**Continuing decline in 7 years:** [7.5,17.4,29.2] percent (Qualifier: Estimated; Uncertainty: Min/max)
from RAMAS® Metapop
**Continuing decline in 13 years:** [13,28.3,44.9] percent (Qualifier: Estimated; Uncertainty: Min/max)
from RAMAS® Metapop
**Continuing decline in 20 years:** [18.7,37.9,56.9] percent (Qualifier: Estimated; Uncertainty: Min/max)
from RAMAS® Metapop

**Extent of occurrence:** [31016,62790,102622] km² (Qualifier: Observed; Uncertainty: Min/max)
best = range ($km^2$) of 13 local populations
min = area ($km^2$) of mod to very high suitability habitat in Southern Interior Mountain (SIM) ecoprovince
max = area ($km^2$) of very low to very high suitability habitat in SIM ecoprovince
**Continuing decline:** yes (Qualifier: Inferred; Uncertainty: Subjective judgment)
guess
**Extreme fluctuations:** no (Qualifier: Inferred; Uncertainty: Range of opinion)
**Area of occupancy:** [12131,29749,29749] km² (Qualifier: Observed; Uncertainty: Min/max)
best = area ($km^2$) occupied by 18 identified subpopulations
min = area ($km^2$) of > 140-year-old forest in 18 identified subpopulation ranges
**Continuing decline:** yes (Qualifier: Inferred; Uncertainty: Subjective judgment)
guess
**Extreme fluctuations:** no (Qualifier: Inferred; Uncertainty: Range of opinion)
'forest dwelling' woodland caribou do not undergo extreme fluctuations in numbers
**Continuing decline in habitat:** yes (Qualifier: Inferred; Uncertainty: Subjective judgment)
guess
**Very restricted:** no (Qualifier: Observed; Uncertainty: Min/max)

***Extent and Area Notes:***

Extent of Occurrence = range of 13 local populations ($km^2$)—MCTAC 2002

Area of Occupancy = range of 18 identified local populations ($km^2$)—Heiko Wittmer

**Number of subpopulations:** [12,13,18] (Qualifier: Observed; Uncertainty: Min/max)

min = 12 (from Heard and Vagt 1998)

best = 13 (from MCTAC 2002)

max = 18 (from Wittmer 2004)

**Number of locations:** [12,13,18] (Qualifier: Observed; Uncertainty: Min/max)

same as number of subpopulations

**Subpopulations (name and size):**

| | |
|---|---|
| South Selkirks | [22,22,22] |
| South Purcells | [12,13,13] |
| Central Selkirks | [67,83,132] |
| Monashee | [3,6,6] |
| Revelstoke | [112,143,171] |
| Central Rockies | [8,13,13] |
| Wells Gray North | [126,140,192] |
| Wells Gray South | [137,207,334] |
| North Cariboo Mtns | [191,223,287] |
| Barkerville | [29,32,39] |
| George Mtn | [2,3,3] |
| Narrow Lake | [39,41,45] |
| Hart Ranges | [220,287,332] |

**Continuing decline in the number of subpopulations or locations:** yes (Qualifier: Projected; Uncertainty: Range of opinion)

**Extreme fluctuations in the number of subpopulations or locations:** no (Qualifier: Observed; Uncertainty: )

**Size of the largest subpopulation:** [220,287,334] mature individuals (Qualifier: Estimated; Uncertainty: Min/max)

Hart Ranges

**All individuals in one subpopulation:** no (Qualifier: Observed; Uncertainty: Min/max)

**Severely fragmented:** yes (Qualifier: Observed; Uncertainty: Range of opinion)

***Fragmentation Notes:***

Based on 2002 population estimates and range of mature adults in population

7 of 13 subpops are considered isolated with minimum or no dispersal between subpops

**Extinction probability in 20 years:** [0,0,0] (Qualifier: Projected; Uncertainty: Min/max)

**Extinction probability in 33 years:** [0,0,0] (Qualifier: Projected; Uncertainty: Min/max)

**Extinction probability in 100 years:** [0,0,1] (Qualifier: Projected; Uncertainty: Min/max)

**PVA model filename-Pessimistic:** cari_pes.mp

**PVA model filename-Best Estimate:** cari_bes.mp

**PVA model filename-Optimistic:** cari_opt.mp

***Risk Notes:***

Non-age structured model using RAMAS® Metapop