COSEWIC
Assessment and Update Status Report

on the

Woodland Caribou
Rangifer tarandus caribou

Atlantic-Gaspésie Population
Boreal Population
Southern Mountain Population
Northern Mountain Population
Newfoundland Population

in Canada

ENDANGERED - ATLANTIC-GASPÉSIE POPULATION
THREATENED - BOREAL POPULATION
THREATENED - SOUTHERN MOUNTAIN POPULATION
SPECIAL CONCERN - NORTHERN MOUNTAIN POPULATION
NOT AT RISK - NEWFOUNDLAND POPULATION
2002

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE
IN CANADA

COSEPAC
COMITÉ SUR LA SITUATION DES
ESPÈCES EN PÉRIL
AU CANADA

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Please note: Persons wishing to cite data in the report should refer to the report (and cite the author(s)); persons wishing to cite the COSEWIC status will refer to the assessment (and cite COSEWIC). A production note will be provided if additional information on the status report history is required.

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Thomas, D.C., and D.R. Gray. 2002. Update COSEWIC status report on the woodland caribou *Rangifer tarandus caribou* in Canada, *in* COSEWIC assessment and update status report on the Woodland Caribou *Rangifer tarandus caribou* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-98 pp.

Previous report:

Kelsall, J.P. 1984. COSEWIC status report on the woodland caribou *Rangifer tarandus caribou* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 103 pp.

Production note:

The Dawson's caribou (*R. t. dawsoni,* caribou *dawsoni* subspecies), a woodland form that became extinct about 1935 on the island of Haida Gwaii (Queen Charlotte Island), is not included in this report.

The caribou *dawsoni* subspecies status report was reconfirmed as extinct in 2000, with information provided in a background document prepared by David R. Gray.

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Woodland Caribou — Courtesy of the Yukon Government.

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COSEWIC
Assessment Summary

Assessment Summary – May 2002

Common name
Woodland caribou (Atlantic-Gaspésie population)

Scientific name
Rangifer tarandus caribou

Status
Endangered

Reason for designation
A small isolated population of less than 200 adult animals confined to the Gaspésie region. The population is at risk from predation and habitat loss.

Occurrence
Quebec

Status history
Atlantic-Gaspésie population was designated as Threatened in April 1984. Status re-examined and uplisted to Endangered in May 2000. Status re-examined and confirmed in May 2002. Last assesment based on an update status report.

Assessment Summary – May 2002

Common name
Woodland caribou (Boreal population)

Scientific name
Rangifer tarandus caribou

Status
Threatened

Reason for designation
A widespread population ranging across the boreal forests of northern Canada. Populations have decreased throughout most of the range. Threatened from habitat loss and increased predation, the latter possibly facilitated by human activities.

Occurrence
Northwest Territories, British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Newfoundland-Labrador

Status history
Boreal population was designated Threatened in May 2000. This newly defined population is comprised of a portion of the de-activated “Western population” and all of the de-activated “Labrador-Ungava population”. Status re-examined and confirmed in May 2002. Last assessment based on an update status report.

Assessment Summary – May 2002

Common name
Woodland caribou (Southern Mountain population)

Scientific name
Rangifer tarandus caribou

Status
Threatened

Reason for designation
Local herds in the Southern Mountain population are generally small, increasingly isolated, and subject to multiple developments. Their range has shrunk by up to 40% and 13 of 19 herds are declining. The most southerly herds are likely to disappear. Many herds are threatened by decreasing habitat quantity and quality, harassment and predation.

Occurrence
British Columbia, Alberta

Status history
Southern Mountain population was designated Threatened in May 2000. This population was formerly designated as part of the "Western population" (now de-activated). Status re-examined and confirmed in May 2002. Last assessment based on an update status report.

Assessment Summary – May 2002

Common name
Woodland caribou (Northern Mountain population)

Scientific name
Rangifer tarandus caribou

Status
Special Concern

Reason for designation
Forestry, roads and other developments in the range of this population are beginning to affect some herds, through habitat modification and increased human access. Most of the habitat is currently remote and has changed little. Most of the population of over 3,500 adults appears stable but is particularly dependent on conservation actions, such as management plans. Two of 39 herds within this population are declining and may be at risk from changing predator-prey relationships and greater motor vehicle access.

Occurrence
Yukon Territory, Northwest Territories, British Columbia

Status history
Northern Mountain population was designated Not at Risk in May 2000. This population was formerly designated as part of the "Western population" (now de-activated). Status re-examined and uplisted to Special Concern in May 2002. Last assessment based on an update status report.

Assessment Summary – May 2002

Common name
Woodland caribou (Newfoundland population)

Scientific name
Rangifer tarandus caribou

Status
Not at Risk

Reason for designation
There are about 85,000 adult caribou in Newfoundland, and they are less subject to predation than caribou elsewhere in Canada because of the absence of wolves. Only one of 27 herds is reported as decreasing and most of the habitat appears secure. The recent arrival of coyotes, however, may increase predation pressure in the future.

Occurrence
Newfoundland-Labrador

Status history
Newfoundland population designated Not at Risk in April 1984. Status re-examined and confirmed in May 2000 and in May 2002. Last assessment based on an update status report.

COSEWIC
Executive Summary

Woodland Caribou
Rangifer tarandus caribou

Species information

Woodland caribou (*Rangifer tarandus caribou*) are medium-sized (100-250 kg) members of the deer family. The taxonomy (classification) and systematics (evolutionary history) of caribou in Canada are uncertain. Based on mitochondrial DNA, caribou in North America evolved from two founding groups (clades) that differentiated in isolation during the last (Wisconsinan) glaciation. The southern clade supposedly evolved south of the continental ice sheet, whereas the northern clade was in a glacial refugium in Alaska and adjacent Arctic Canada. Populations that contained unique southern gene types were the Pukaskwa local population in Ontario and two in Newfoundland. In contrast, exclusively northern types occurred in four Yukon populations and in some forest-tundra and tundra ecotypes of barren-ground caribou (*R. t. groenlandicus*) in northern Canada. Most woodland caribou populations in the mountains of southern British Columbia (B.C.) and Alberta and in the boreal forest and taiga across Canada are mixtures of the two types. Some 'mixed' populations in the taiga exhibit two phenotypes and behave like the forest-tundra ecotype of barren-ground caribou.

Despite the recent genetic findings, no official change has occurred in the taxonomy of caribou. For example, all caribou in Quebec and Labrador and on the Hudson Plain are still considered woodland caribou. One strategy at the national scale is to protect geographic populations of caribou within *National Ecological Areas* (NEA) established in 1994 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Those areas were established for all species and are not a perfect fit for ecotypes of caribou in Canada. Consequently, it is necessary to exclude the forest-tundra (migratory) ecotype of caribou from forest-dwelling (sedentary) local populations within the Boreal NEA because of differences in genetics, ecology, demographics, and degree of habitat alteration through human activities.

Distribution

In this report, distribution of extant forest-dwelling woodland caribou is described for four National Ecological Areas (NEA) adopted by COSEWIC in 1994. They are *Northern Mountain, Southern Mountain, Boreal,* and *Atlantic*. Four COSEWIC populations of forest-dwelling caribou are named after corresponding NEAs. The insular Newfoundland population is removed from the Boreal NEA and treated separately.

The present distribution of woodland caribou in Canada, and adjacent southern Alaska and northern Idaho, is much reduced from historical accounts. The *extent of occurrence* in B.C. and Ontario decreased by up to 40% in the 19th and 20th century. Further range reductions are expected across Canada, particularly in southern parts of the current distribution. Within the general extent of occurrence, more than 164 *areas of occupation* now are mapped. Many are viewed as discrete local populations because radio-collared or marked caribou remained within mapped distributions. Some local populations are grouped into metapopulations based on an assumption that some emigration/immigration occurs among them.

This report includes only relatively sedentary woodland caribou located in the boreal forest and mountains of Canada, referred to as *forest-dwelling caribou.* Excluded are forest-tundra migratory ecotypes such as the George and Leaf River populations in Quebec-Labrador and several local populations on the Hudson Plains in Manitoba and Ontario. They are ecologically distinct populations. Also excluded is Dawson's caribou (*R. t. dawsoni*), a woodland form that became extinct about 1935 on the island of Haida Gwaii (Queen Charlotte Island).

Habitat

Forest-dwelling woodland caribou occupy cover types that vary from coniferous forests to alpine tundra. In summer, they frequent open or semi-open habitat such as alpine tundra, upper subalpine, peatlands, islands, and shorelines where nutritious plants such as forbs and sedges are available. Spruce (*Picea* spp.) and pine (*Pinus* spp.) are usually the dominant trees in forested habitats. Balsam fir (*Abies balsamea*) occurs in mature and old forests. Tamarack (*Larix laricina*) is a common tree species in fens. The niche of forest-dwelling caribou is lichen-rich mature and old coniferous forest in a matrix with one or more of alpine/subalpine, subarctic (taiga), peatlands, or lakeshore. There is little overlap with preferred habitats of other large ungulates. Lichen species preferred by caribou are a consistent feature of winter and summer home ranges. Where snow is relatively shallow, caribou paw to uncover terrestrial lichens. Where snow is deep and compacted, such as in the southern Cordilleran Mountains, they eat arboreal lichens. Lichens tend to be most abundant in mature and old forests, consequently fire and logging can displace caribou for decades. Forest-dwelling woodland caribou occur at low density and therefore require large areas with specific habitats for foraging, calving, and avoiding predators. Densities from the Cordilleran Mountains to Labrador often are in the range of 1-4 caribou/100 km.^{2}

Biology

Woodland caribou breed in late-September and October. Most adult (>1 year) females produce one calf in May or early June. The females disperse to calve individually in forests, peatlands, islands, lakeshores, and tundra thereby reducing predation. Death of calves in the first month generally is high and mortality before 1 year usually is 50-80%. Some forest-dwelling caribou migrate short distances (<100 km) between winter and summer ranges. Others are relatively sedentary or they seasonally

shift between winter and summer range and periodically change wintering locations because of unfavorable snow conditions or habitat disturbance.

Population sizes and trends

The Canadian population of forest-dwelling woodland caribou in 2000/2002 is estimated at 184 000. Excluded are up to 1.1 million caribou of the forest-tundra ecotype, most of them in Quebec and Labrador. About 78% of forest-dwelling caribou occur in insular Newfoundland and the Northern Mountain NEA. Their exclusion leaves only about 40 000 caribou distributed across a huge area of the southern Cordilleran Mountains, boreal plains and shield. Those caribou are most at risk from accelerated development and associated increases in abundance of ungulate species and their predators.

Population numbers of forest-dwelling caribou appear to have increased in most COSEWIC NEA since the last status report in 1984. Except for insular Newfoundland, that increase is a result of improved surveys. A good index of the state of knowledge of forest-dwelling caribou is the number of identified local populations — about 55 in 1984, 98 in 1991, and more than 164 in 2001. Numbers have increased sharply in insular Newfoundland, whereas decreases have occurred in many local populations in southern portions of the range across Canada. Much of the concern for the Southern Mountain and Boreal populations centres on direct and indirect effects of accelerated development resulting in small population numbers, small ranges (Southern Mountain), and increasing fragmentation and isolation. Average densities *per* 100 km^2 vary from 150 on insular Newfoundland to 20 in Gaspésie Park, 11 in the Northern Mountain population, 5 in the Southern Mountain population, and about 2 in the Boreal population. It is doubtful that caribou can persist in forests managed primarily for fibre production.

Limiting factors and threats

A summary of threats to four COSEWIC populations reveals that predation and effects of developments are paramount for the Southern Mountain and Boreal populations. Predation and hunting are the main proximate causes of mortality in forest-dwelling caribou. However, increased mortality usually is precipitated by changes in habitat and weather. Predation rate often is linked to factors such as weather, habitat disturbance, occurrence of alternative prey, and trails and roads that facilitate access by predators to caribou habitat. Caribou populations that increased in the 1990s are those where habitats remain relatively pristine and wolves are absent (insular Newfoundland) or at low densities (parts of taiga range).

Habitat changes that favour increases in deer (*Odocoileus* spp.), moose (*Alces alces*), and wapiti (elk) (*Cervus elaphus*) can result in greater predation on forest-dwelling caribou. Loss and degradation of habitat because of fire, logging, and other developments impact forest-dwelling caribou populations across Canada. Local populations associated with alpine, taiga, and large peatland complexes have the best prospect for survival. Local populations on the southern periphery of the range are

vulnerable to the potential effects of climatic warming such as more snow with greater crusting, more area burned in the west, and more and different predators, insects, and disease. Caribou may tolerate limited development if adequate habitat is maintained, predators are managed directly or through management of alternative prey, and hunting is reduced through co-operation with Aboriginal groups. Conservation of declining populations of forest-dwelling caribou will require careful management of a web of interacting factors. More monitoring and research of caribou populations is needed to clarify ecological relationships and responses to developments. Population indicators need to be refined and new ones developed.

Special significance of the species

The subspecies *caribou* is virtually endemic to Canada. Conservation of caribou populations is necessary to maintain biodiversity in coniferous forests across Canada and in the subalpine and alpine ecoregions of the Cordilleran Mountains. Loss of local populations would impoverish biological diversity in all landscapes occupied by caribou. Caribou have symbolic value to Canadians, particularly to Aboriginal groups that co-existed with caribou for centuries. They are a symbol of wilderness areas and are almost mystical because most Canadians have never seen one.

Existing protection or other status designations

Protective measures include protected areas; legislation pertaining to species at risk, developments, and hunting; guidelines for caribou protection when developments occur on caribou range; agreements with Aboriginal people concerning caribou hunting; and societal attitudes and ethics. Many local populations are located partly in protected areas such as parks and wilderness areas. Recreational hunting is banned or not a factor. At-risk designations highlight concern for caribou in parts of Canada. Western woodland caribou were listed as *rare* by COSEWIC in 1984 and *vulnerable* in 1995.

Summary of status report

Forestry and other developments in the Northern Mountain population are beginning to affect a few local populations of caribou. However, the habitat is little changed in remote areas of occupation. Variable weather, changing predator-prey relationships, and greater access by unregulated hunters affect numbers in local populations.

Local populations in the Southern Mountain population are generally small, increasingly isolated, and subject to multiple developments. The range has shrunk by up to 40% and almost half of the local populations (12-14/30) are decreasing in number. Local populations at the southern limit of the distribution (Selkirk, South Purcells, and Banff) and other small, isolated populations (Barkerville, George Mountain, and Telkwa) are likely to disappear. The outlook for habitat quantity and quality and predator management is not favourable.

In the Boreal population, numbers have decreased during recent studies in a majority of local populations where trend data are available (12/1). Decreases may also occur in 65% of the range where no trend data are available. There is a high proportion of small local populations in small ranges at low density. Area of occupancy has shrunk up to 40% in Alberta and Ontario. Several small subpopulations at the southern periphery of the extent of occurrence have disappeared in the past 20 years. Caribou populations in commercial forests are most at risk from habitat loss and degradation, accelerated habitat fragmentation, and increased predation caused indirectly by increased numbers of deer, moose, and elk. Much of the range is in the commercial forest and some of it is in areas with high oil and gas activity. Ranges of some local populations in the commercial forest will decline sharply in quantity and quality as forestry and other developments expand.

The Atlantic (Gaspésie) population is an isolated relic population of caribou that formerly ranged into the Maritime provinces and northeastern U.S.A. Although numbers have varied from 150 to 250 individuals over the past 20 years, it is subject to genetic drift, inbreeding depression, and chance catastrophic events.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) determines the national status of wild species, subspecies, varieties, and nationally significant populations that are considered to be at risk in Canada. Designations are made on all native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fish, lepidopterans, molluscs, vascular plants, lichens, and mosses.

COSEWIC MEMBERSHIP

COSEWIC comprises representatives from each provincial and territorial government wildlife agency, four federal agencies (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biosystematic Partnership), three nonjurisdictional members and the co-chairs of the species specialist groups. The committee meets to consider status reports on candidate species.

DEFINITIONS

Species	Any indigenous species, subspecies, variety, or geographically defined population of wild fauna and flora.
Extinct (X)	A species that no longer exists.
Extirpated (XT)	A species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A species facing imminent extirpation or extinction.
Threatened (T)	A species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Not at Risk (NAR)**	A species that has been evaluated and found to be not at risk.
Data Deficient (DD)***	A species for which there is insufficient scientific information to support status designation.

* Formerly described as “Vulnerable” from 1990 to 1999, or “Rare” prior to 1990.
** Formerly described as “Not In Any Category”, or “No Designation Required.”
*** Formerly described as “Indeterminate” from 1994 to 1999 or “ISIBD” (insufficient scientific information on which to base a designation) prior to 1994.

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list.

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The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

Update
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on the

Woodland Caribou
Rangifer tarandus caribou

Atlantic-Gaspésie Population
Boreal Population
Southern Mountain Population
Northern Mountain Population
Newfoundland Population

in Canada

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2002

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INTRODUCTION

The conservation of woodland caribou (Fig. 1) in Canada is difficult and complex. Major problems are uncertain taxonomy and systematics, uncertainty about which genetic populations must be conserved, lack of knowledge about local populations and caribou ecology, and high natural variation and measurement error in population sizes and trends. There is also large geographic variation in risk of population decline, because of large east-west and north-south variations in climate, topography, vegetation, ecological conditions, and degree of habitat modification by human activities.

Figure 1. Photo of woodland caribou, courtesy of Elston Dzus, Athabasca, Alberta.

The classic taxonomy of caribou was based largely on craniometry of adults (Banfield 1961). To date, there is no official change in the taxonomy of caribou. All caribou in Quebec and Labrador are in the woodland subspecies, as are caribou on the Hudson Plain. Exclusion of the forest-tundra ("migratory") ecotype from forest-dwelling ("sedentary") local populations within the Boreal NEA is justified for conservation and management because of genetic and ecological differences. Ecological differences have resulted in large differences in trends in numbers, reproduction, mortality, etc. Those differences between caribou ecotypes will increase as forestry and other developments expand northward and climate warming affects ecological processes.

Before 1978, little was published on forest-dwelling caribou from B.C. to Newfoundland. Consequently, as studies expanded, numbers of local populations (herds) increased from 55 in 1985 (Williams and Heard 1986), to 98 in 1991 (Ferguson and Gauthier 1992), and to more than 164 in 2001 (Table 2, Appendix 1a-d). The proper group name (subpopulation, local population, population, and metapopulation) of many distributions remains uncertain and arbitrary until members are radio collared and movements recorded over many years.

This update provides information to help COSEWIC designate forest-dwelling populations of the subspecies *caribou*. It excludes another woodland caribou, *R. t. dawsoni*, which became extinct about 1935 on Haida Gwaii (Banfield 1961, Cowan and Guiguet 1965). It was not genetically distinct from present-day caribou in northern B.C. and Alaska based on limited DNA analysis (Byrun *et al*. 2002).

There is justification for separate designation of forest-dwelling woodland caribou in National Ecological Areas (NEA) adopted by COSEWIC in 1994 (Fig. 3). Caribou in four of the eight NEAs are distinct COSEWIC populations*: Northern Mountain, Southern Mountain, Boreal,* and *Atlantic*. A fifth population, *Newfoundland*, is treated separately as an isolated, distinct population (COSEWIC 2000c). This report summarizes, for each COSEWIC population, the historical and current estimates and trends, distribution and range sizes, known threats and limiting factors, degree of monitoring, and protection afforded by parks and other protected areas. That is accomplished by accumulating data for all COSEWIC subpopulations herein termed *local populations*.

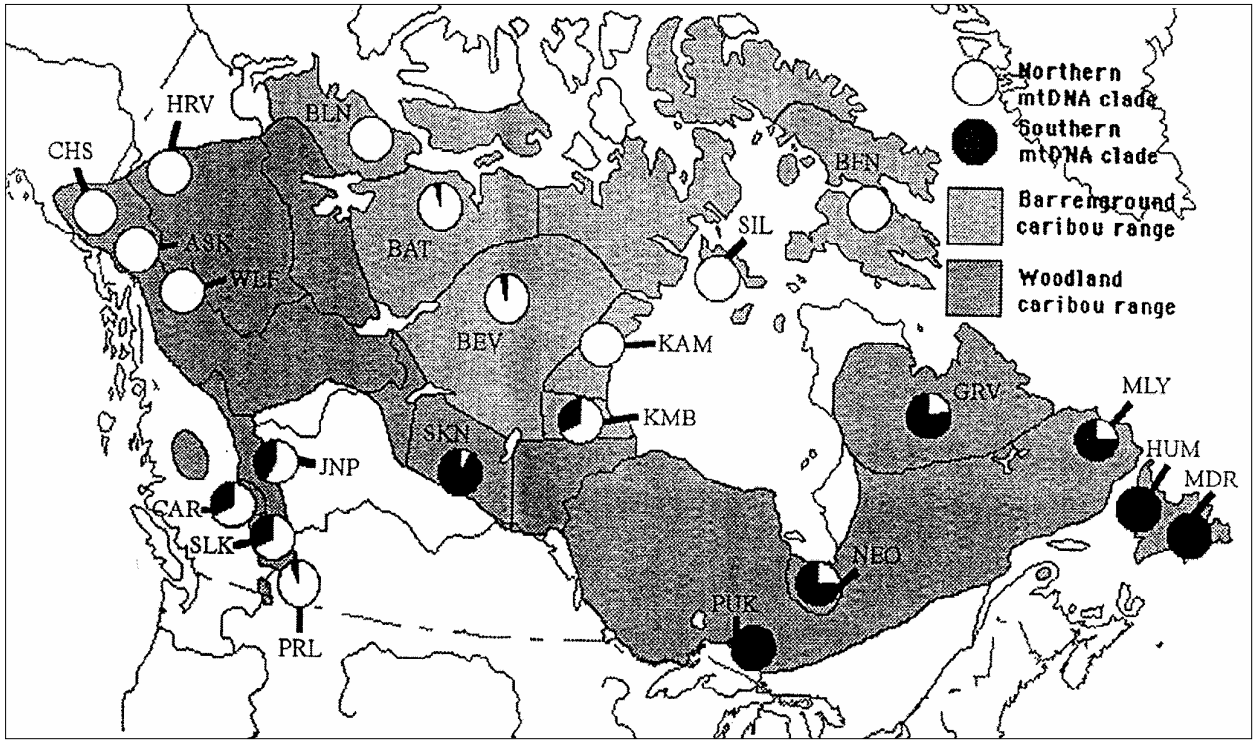

Figure 2. Proportions of southern and northern clades in sampled local populations of caribou in Canada (Dueck 1998, Dueck and Strobeck pers. comm.). Codes for populations: CHS = Chisana, HRV = Hart River, ASK = Aishihik, WLF = Wolf Lake, JNP = South Jasper National Park, CAR = Cariboo Mountains, SLK = Central Selkirk, PRL = South Purcell, SKN = Saskatchewan, PUK = Pukaskwa, NEO = Northeast Ontario, MDR = Middle Ridge, HUM = Humber, MLY = Mealy, GRV = George River, KMB = Cape Churchill, KAM = Qamanirjuaq, BEV = Beverly, BAT = Bathurst, BLN = Bluenose, SIL = Southampton, BFN = South Baffin.

This report does not revise the taxonomy of woodland caribou (Banfield 1961) nor review all existing information. It builds on information in the first COSEWIC status report on woodland caribou (Kelsall 1984). It benefits from reviews published since 1984 (Williams and Heard 1986, Edmonds 1991, Ferguson and Gauthier 1992, Cumming 1998, Edmonds 1998, Farnell *et al*. 1998, Heard and Vagt 1998, Rettie *et al*. 1998, Mallory and Hillis 1998). It also draws on information in reports prepared by or for jurisdictions (Harris 1999, Hatter 2000, Dzus 2001), and tabular information generously provided by provincial/territorial representatives (see Acknowledgements).

This report follows a new format developed in April 2000 (COSEWIC 2000a) and revised in 2001 (COSEWIC 2001). It is shaped by definitions of species and populations-at-risk. The latter conform to the NEA established in 1994 (COSEWIC 1994) and global perspectives (IUCN 1994, 1998, 1999) modified to a national scale (COSEWIC 2000c). It provides additional background information for designations made by COSEWIC in May 2000 (Tables 10 & 11 in COSEWIC 2000b) and May 2002 based on the new NEA and information from the jurisdictions. In summary, this review is limited to:

1. Forest-dwelling woodland caribou, subspecies *caribou*, exclusive of the migratory forest-tundra ecotype: Leaf River, George River, Pen Island, Cape Churchill, and other populations on the northern Hudson Plain.
2. Populations in four of eight NEAS: Northern Mountain, Southern Mountain, Boreal, and Atlantic (COSEWIC 1994).
3. A fifth population in insular Newfoundland is treated separately from the Boreal as a distinct, isolated population.

Local knowledge

Only in the past two decades was there much recognition of the value of local and traditional ecological knowledge. It now is incorporated in COSEWIC guidelines (COSEWIC 2000a) and is required, where available, by the species at risk act (SARA 2002). This knowledge should be incorporated into jurisdictional assessments of caribou status for the next revision of this “living” report (COSEWIC 2001). Authors of COSEWIC reports cannot acquire it for wide-ranging species such as caribou.

Systems for obtaining local knowledge are being explored (e.g., Kofinas 1998, Urquhart 2001). To date, most knowledge is obtained through personal contacts with hunters. In the foothills of Alberta, local people identified two types of caribou and subsequent studies identified mountain and woodland ecotypes (Edmonds and Bloomfield 1984). Similarly, Aboriginal hunters noted two types of caribou in the Cape Churchill population (C. Elliott pers. comm. 2000). That observation subsequently was confirmed by DNA analysis (Fig. 2). Inuit and Cree sources along the western Hudson Bay coast also reported mixing of the Pen Island population with woodland caribou (McDonald *et al.* 1997), presumably the Nelson-Hayes rivers population. The Cree and Inuit of coastal Quebec noted increases in caribou numbers along the coast of James Bay (McDonald *et al.* 1997). The Cree of Lake Mistassini, Quebec, reported that the Caniapiscau population travelled south as far as Val d'Or and Lac Saint-Jean

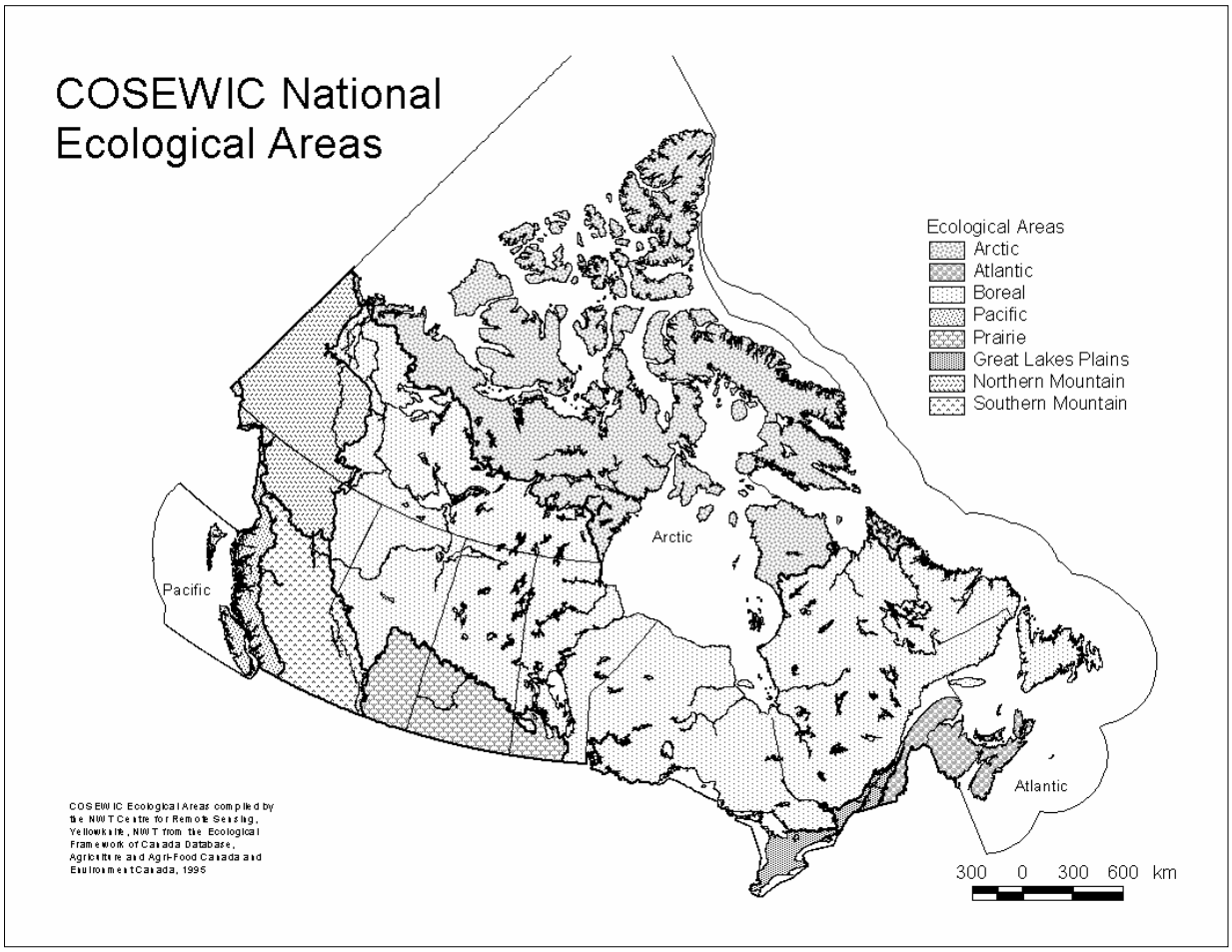

Figure 3. National Ecological Areas established by COSEWIC in 1994.

(Blacksmith pers. comm. 1997). Some information is in printed form (e.g., Novalinga 1997), whereas much information can only be obtained orally through personal contact or interviews. The next COSEWIC status report on forest-dwelling woodland caribou should have more information from Aboriginal and other local people as jurisdictions begin to collect that information.

SPECIES INFORMATION

Name and classification

Woodland caribou in Canada are classified as *Rangifer tarandus* (Lin.), subspecies *caribou* (Gmelin 1788, Banfield 1961, 1974). Definitions are absolutely essential when discussing *species, subspecies, metapopulations, populations, subpopulations, local populations, herds, demes, clines,* and *intergrades*. Lack of definitions in the literature has led to much confusion. Not only are definitions arbitrary and variable among authors but interpretation of them varies even more. The definition for species-at-risk includes "…species, subspecies, or biologically distinct population …" (COSEWIC 2000a, 2000c).

All caribou and reindeer in the world are one species and presumed able to interbreed and produce viable, fertile offspring. One definition of *species* is "*groups of actually or potentially interbreeding populations that are reproductively isolated from other such groups*" (Mayr 1942). One of several definitions of *subspecies* is *a geographically defined aggregate of local populations, which differ taxonomically from other subdivisions of the species* (Mayr 1969). The degree of difference necessary to delineate subspecies has confounded taxonomists. Avice and Ball (1990) suggested that evidence for subspecies should come from concordant distribution of multiple, independent, genetically based traits. O'Brien and Mayr (1991) suggested that subspecies shared a unique geographic range or habitat, a group of phylogenetically concordant phenotypic characters, and a unique natural history. Occasional interbreeding of overlapping (sympatric) distributions or introgression of members of one subspecies into another is consistent with the subspecies definition (O'Brien and Mayr 1991).

The term *biologically distinct population* is also arbitrary but provides some flexibility. We do not have sufficient information on the genetic status of many populations to ascertain if they are genetically distinct, however that is defined. On the other hand, all small local populations, which have been isolated for more than 100 years, are likely to be genetically distinct, based on analysis of microsatellite DNA (C. Strobeck pers. comm. 2000). There are no accepted criteria for what degree of genetic difference constitutes distinct populations. It is not currently possible to translate genetic differences to functional differences. The biological component of *biologically distinct population* allows us to use ecological similarities and differences, phenotype, and behavior to group and separate populations of caribou. Phenotype and behavior have genetic and environmental components, which are difficult to partition. More genetic and behavioral information is needed before there can be any consensus on what conservation units of caribou require special protection.

What is a *population*? A broad definition includes all individuals of a species in a defined geographic area. Such areas should be ecologically significant geographic areas or ecoareas/ecoregions and not political boundaries. Over time, a species may form different ecotypes in different environments such as ecozones, ecoregions, and ecodistricts. Banfield (1961) used the term *geographic population* and Kelsall (1984) followed that terminology. However, Banfield (1961) also referred to statistical populations for grouping measurements of skeletal parts. For clarity, "population" should always be specified with adjectives "biological," "geographic," "ecological," "local," "COSEWIC," "statistical," "sub-," etc.

The term "population" is used variously for an ecotype, a phenotype, and caribou within a specified geographic area, management unit, or jurisdiction. In this report, the definition of population recommended in the *1994 Revised COSEWIC Population Guidelines* is used, i.e., "*A population is considered to be a group of individuals of a single biological species occupying a defined area*." The 2000 (COSEWIC 2000c) definition is "*a geographically or otherwise distinct group (a portion of a total population) of interbreeding individuals which has little interchange of individuals with other such groups*…)." Compare that definition with one adopted by the International Union for the

Conservation of Nature (IUCN) for a regional population at a global scale. "*The portion of the global population within the area being studied*" (IUCN 1994) and their definition of subpopulation as "*geographically or otherwise distinct groups of the global population between which there is little interchange*. " Thus, at a global scale the COSEWIC populations could be considered subpopulations of *Rangifer tarandus* instead of populations. This is a top down approach. With a bottom up approach, the geographically defined local population is the basic unit for conservation.

Demes are a level below species and may substitute for subspecies if the latter cannot be partitioned. A *deme* is *a group of individuals more genetically similar to each other than to other individuals, usually with some degree of spatial isolation as well* (Wells and Richmond 1995). *Metapopulation* is, perhaps, the next grouping using a broad definition, i.e., a *population of populations* with actual or potential immigration/emigration among them. Natural re-colonization is possible should a local population die out. Grouping should be based on geography, ecology, and caribou behaviour. Groupings of metapopulations should be consistent with populations recognized by COSEWIC. Metapopulations along with some isolated local populations constitute the distribution of woodland caribou in Canada. Not enough is known about movements among most geographic groups of caribou to confidently classify and map them into subpopulations, populations, and metapopulations. Furthermore, the status of groups is dynamic. Most collared caribou are adult females that are expected to have fidelity to range where they were born and lived for at least 2 or 3 years before being collared. Young males are more likely to emigrate to another local population. The term *interchange* should rarely be used for it refers to mutual exchange, whereas most movements will be immigrations or emigrations.

A *local population* (geographic population) is the basic unit of conservation. Some authors use the term *subpopulation* to refer to a component of a local population whose individuals remain separate from others for part of a year or for many years. *Populations* are identified geographically though their boundaries may change with time and for many reasons. In reality, researchers seldom know whether they are investigating a subpopulation, a local population, or a metapopulation. Such designations require long-term monitoring of male and female marked caribou of all ages. As with range boundaries, group designation may change with changes in population size, vegetation (e.g., fire, other disturbances, and range overutilization), weather, and human activities (hunting and developments).

The term *herd* refers to a group of caribou that occupies a specific range or geographic area and appears to be separate from other such groups (Banfield 1954). It had a centre of habitation (Skoog 1968) and traditional calving ground (Thomas 1969). Overlap of range in winter was observed and accepted. The degree of mixing with other herds generally was not known but a small degree of emigration or immigration was acceptable to the herd definition. The key point regarding genetic mixing is the location of caribou populations, subpopulations, and individuals during the breeding season in October. What was previously mapped as general *extent of occurrence* of caribou in the boreal forest (Fig. 4) now is being delineated to encompass isolated or semi-isolated herds (local populations) equivalent in most cases to *areas of occupancy* (Fig. 5).

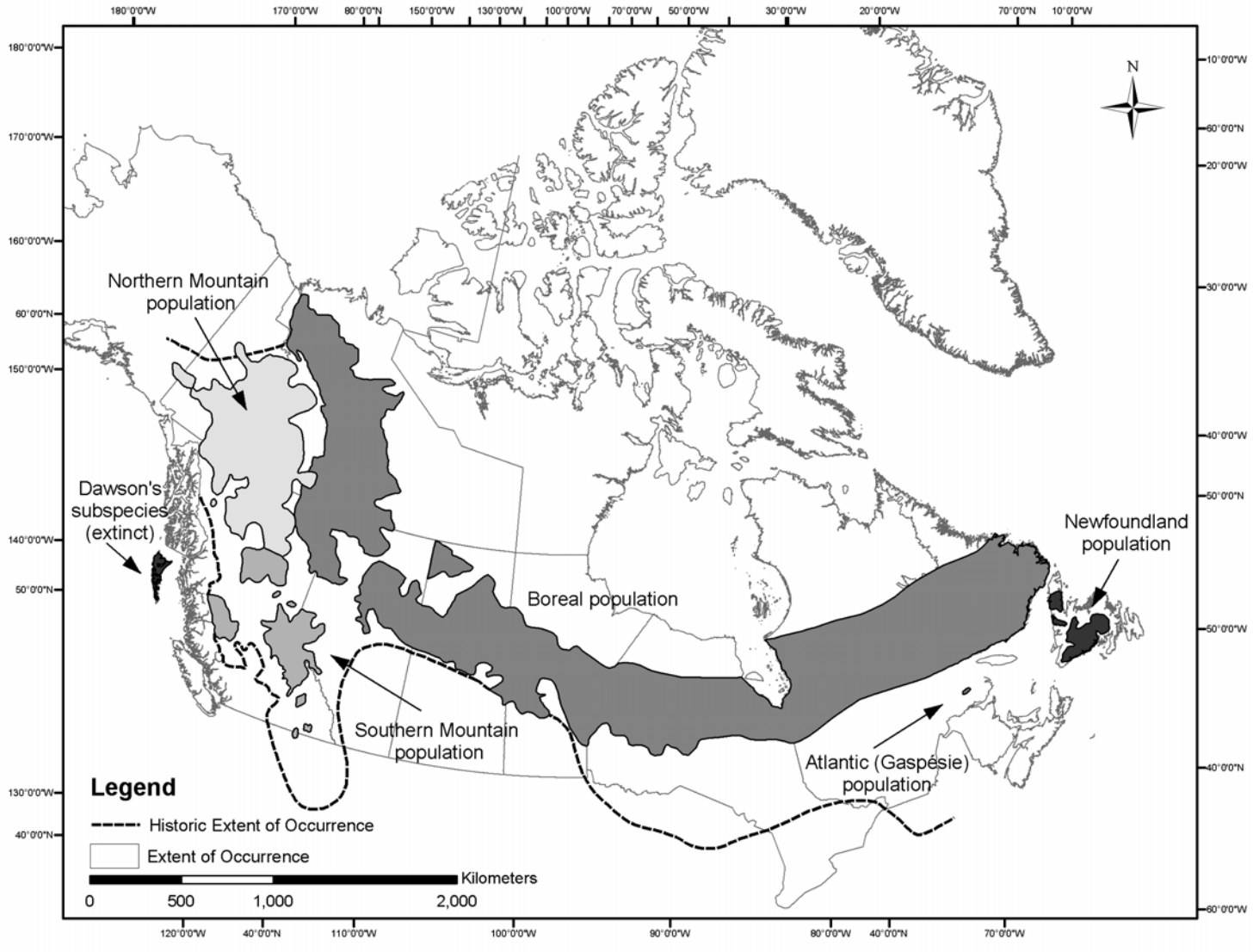

Figure 4. Current (solid lines) and southern limit of historical (dashed line) *extent of occurrence* of forest-dwelling woodland caribou in North America in 2001. Historical data from Kelsall (1984) and Hatter (pers. comm. 2000).

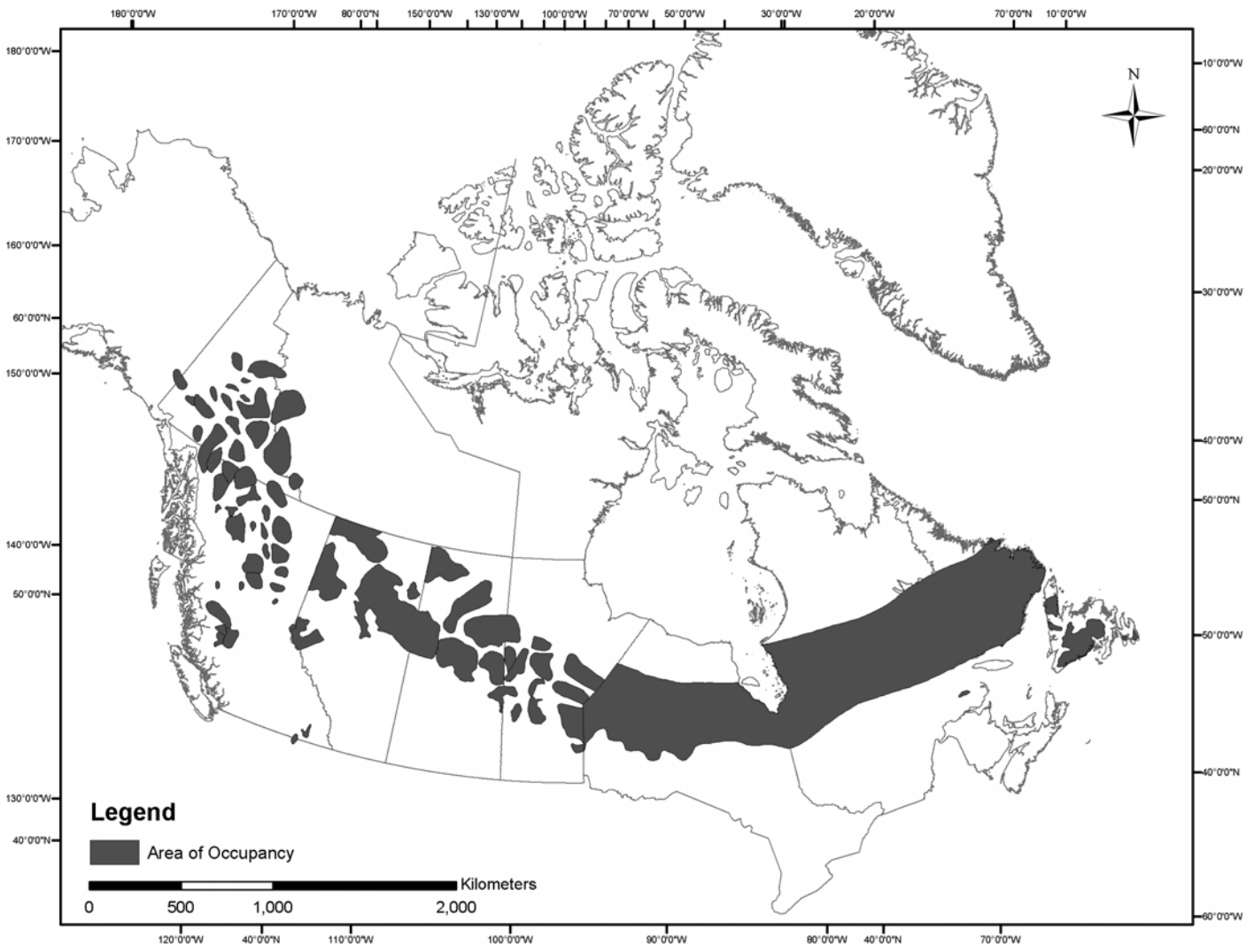

Figure 5. *Area of occupation* (current ranges) of local populations of forest-dwelling woodland caribou in North America in 2000. Data from maps supplied by provincial and territorial jurisdictions in 2000 and 2001.

In this report, we use *local population* and *subpopulation* rather than *herd* and *subherd* to conform to IUCN and COSEWIC terminology and literature on other species. More or less distinct local populations within COSEWIC populations are subpopulations at a national scale. The term *herd* is synonymous with local population, subpopulation, and seasonal component such as winter distribution. Some local populations are migratory, some have seasonal shifts in distribution, and some move little. Consequently, no single term adequately describes them. Though termed *forest-dwelling caribou*, they may occupy alpine tundra and open peatlands during summer and even in winter.

The naming of populations of forest-dwelling woodland caribou after location of calving grounds is less common than for the forest–tundra ecotype. Often population names refer to locations of traditional winter ranges (Farnell *et al*. 1996, Kuzyk *et al.* 1999). Three "mountain" populations in Alberta have overlapping summer range but distinct breeding areas and are named after the location of current winter ranges (Edmonds 1988, Brown and Hobson 1998). However, suitable calving and summer habitat is the most critical component of the range of most local populations.

The concept of *ecotypes* has gained acceptance. It was used to distinguish among three behavioural types of caribou in B.C. (northern, mountain, and boreal), between two in Alberta (mountain and boreal), between two in Ontario (forest-dwelling and forest-tundra), and two in Quebec (sedentary and migratory) (Bergerud 1978, Edmonds 1991, Heard and Vagt 1998, Harris 1999, Caribou Quebec 2000). Ecotypes are classes of populations adapted to different landscapes or environments as expressed primarily by their movements and feeding behaviour (Appendix 3). Thomas (1995) expanded the ecotype classification to include summer and winter habitat, migratory behaviour, winter food, and climate. The two northern metapopulations in the Southern Mountain population in B.C. (Hatter 2000) and populations in the Rocky Mountains and foothills of Alberta are the northern ecotype (Bergerud 1978, Edmonds 1988, Heard and Vagt 1998). Those ecotypes in B.C. and Alberta do not conform with COSEWIC boundaries. However, ecotype criteria are not absolute as terrestrial lichens are supplemented with arboreal lichens in most local populations. Bergerud (2000) recognized sedentary/migratory and montane/boreal ecotypes. Reindeer in Russia were typed as forest montane, forest sedentary, forest migratory, forest-tundra migratory (Baskin 1990), and tundra.

Taxonomy and systematics of caribou

The systematics (evolutionary and genetic relationships) and taxonomy (classification) (Cronin 1993, 1997) of caribou is uncertain below the species level. In 1961, Banfield reviewed the global taxonomy of *Rangifer*. He concluded that all forms would be able to interbreed and therefore were one species, *tarandus*. His main criteria to separate subspecies were antler characteristics and measurements of skulls of fully grown members of both sexes. Banfield (1961) noted clines from south to north in size and pelage tone. He lumped all extant woodland caribou in North America into one subspecies, *caribou.* There were non-significant differences in "statistical populations" that he termed demes and "incipient subspecies." Included were *terraenovae* in

Newfoundland, *caboti* in northern Quebec and Labrador, *sylvestris* in boreal forests from Quebec to the southern mountains in B.C., and *osborni* in mountains of northern B.C., southern Yukon, and NWT. Those were considered to be subspecies by earlier workers (Kelsall 1984). Banfield (1961) viewed former subspecies *osborni* and *caboti* and caribou in the Hudson Bay Lowlands as demes that were intermediate between woodland and barren-ground caribou but placed them with *caribou*. He followed Jacobi (1931) in separating barren-ground caribou from woodland caribou on many semi-objective criteria and named them after the cross-sectional shape of antlers, i.e., *cylindricornus* and *compressicornus*, respectively. The taxonomic value of antlers has received little attention in spite of the potential expressed by Bubenik (1975) and explored by Butler (1986).

Geist (1991) argued that geography and craniometry were not taxonomic criteria and size was a poor one. He proposed that characters of hair color, gland patterns, and antlers, i.e., "social insignia," at breeding should be used to identify subspecies. He proposed that "woodland caribou" (*R. t. caribou*) comprised populations in the mountains of central and southern B.C. and Alberta and in the boreal forest east of the mountains. Included were caribou in deep-snow zones of southern B.C. where long-strand arboreal lichens were the main food. In his opinion, caribou in northern B.C. (north of the Peace River) and Yukon were sufficiently different morphologically to warrant separate subspecies designation (*R. t. osborni*). Newfoundland caribou (*R. t. terraenovae*) differed ecologically through isolation in a different environment, including predation by lynx (*Lynx canadensis*) after wolves (*Canis lupus)* were extirpated early in the 20th century. He considered migratory caribou (*R. t. caboti*) in Labrador an intermediate deme (subsequently known as the George River population). Finally, he agreed with Cowan and Guiguet (1965) that the extinct Dawson's caribou (*R. t. dawsoni*) was a separate subspecies.

Geography and vegetation are important for they can isolate populations, which then become subject to genetic drift and inbreeding, as shown for bighorn sheep (*Ovis canadensis*) (Fitzsimmons *et al*. 1997). In reality, geography/vegetation means islands of suitable habitat. Natural and sexual selection of caribou in different environments may also result in genetic differences. Geographic or political boundaries rather than subspecies can be used in regulations. For example, it is better to stipulate that caribou may not be killed in a defined geographic area rather than specify that a certain subspecies or population of caribou is protected. In the case of animal parts and meat, the best legal tools are chemical differences, including DNA fingerprinting. Management of lands is based on geographic and political boundaries and therefore geographic populations are the most practical entities for caribou conservation and management.

Studies of genetic lineage in caribou

Transferrin (a blood protein) alleles found at a single locus suggested that a single subspecies, *R. t. caribou,* occupied mainland eastern Canada and Newfoundland (Røed 1992). A preliminary genetic analysis of a few samples suggests that the caribou of Gaspé were either isolated for a long period of time or their ancestry was different

(Røed *et al.* 1991, Crête *et al.* 1994). However, a single locus with high variability and subject to rapid change is not a reliable indicator of phylogeny (Røed *et al.* 1991).

Another study found significant variation in transferrin allele frequencies among nine populations throughout the range of woodland caribou (van Staaden *et al.* 1995). Relatively little genetic heterogeneity occurred within populations. Geographic and genetic distance were significantly related. Isolated small populations tended to have four or fewer transferrin alleles.

Cronin (1992) assessed variation in mitochondrial (mt) DNA of woodland caribou from Alberta, northern Labrador (George River), and Newfoundland. He found considerable variation, though the sequence divergence of genotypes was low. He concluded that characteristic genotypes existed in caribou from different geographic areas (Cronin 1992). He concluded that classification below the species level for caribou and other cervids should include mitochondrial and nuclear genetic data, morphology, distribution, and natural history.

Another study of mtDNA indicated that all caribou in Canada originated from northern and southern clades (groups) isolated about 49 000 years ago during the Wisconsinan glaciation (Dueck 1998). Glacial advances occurred in the Canadian Rockies 75 000-64 000 and 20 000-11 000 years ago (Gadd 1986). Two groups of caribou were separated between those early and late Wisconsinan episodes and distinct clades evolved in isolation. Upon melting of the large continental glacier, the two groups spread out across Canada and their distributions overlapped.

The following scenario is deduced from the results for mtDNA (Dueck 1998). The isolated southern clade moved northward, as the continental (Laurentide) glacier wasted, to occupy all boreal forest and taiga in eastern Canada. In the west, they supposedly advanced as far north as the Mackenzie Delta through an inter-glacial corridor east of the Cordilleran Mountains. Caribou in the northern clade were isolated in the Beringia refugium in Alaska, part of Yukon, and Banks and Prince Patrick islands. They spread southward in the ice-free corridor and later in the mountains after the Cordilleran ice sheet melted, to the U.S. border and beyond. In the north, they also spread eastward to occupy all the tundra and taiga and northward into the Canadian Arctic Islands.

Many of the local populations along zones of contact and overlap contain haplotypes from both clades (Fig. 2). For example, the sample from the George River population contained 22% of the northern haplotype (all mtDNA is maternal and therefore haploid). The greatest mix of haplotypes is in the mountains of B.C. and adjacent Alberta where 75% of haplotypes in analysed samples are from the northern clade. Present-day woodland caribou apparently have evolved from both clades and introgression of DNA occurred where the two clades met and overlapped in distribution. Those results support COSEWIC's separation of Mountain and Boreal populations. Caribou in the Cordilleran Mountains may have to be reclassified.

Some taxonomists believe that a subspecies must be monophyletic. The southern haplotype is 95% monophyletic but the northern haplotype is monophyletic or paraphyletic depending on the statistical analysis used to classify it (Dueck 1998, Dueck and Strobeck pers. comm.). Monophyly was more likely than the alternative.

The southern clade was the primary founding source for subspecies *caribou* in boreal and taiga forest east of the Cordilleran Mountains. One possibility is that the southern clade evolved in eastern North America centred on the Appalachians. Caribou from the northern clade travelled south in the ice-free corridor and eventually spread into the Cordilleran Mountains. Introgression of the southern haplotype into caribou in the Rocky Mountains may have occurred long after the ice sheets melted. Preliminary conclusions of another study of mtDNA support the hypothesis that eastern woodland caribou were isolated historically from caribou in the arctic and current subspecies are not consistent with observed genetic variation (Eger and Gunn 1999, J. Eger pers. comm. 2001).

Kushny *et al.* (1996) used microsatellite DNA (msDNA) to survey the genetic variation in populations of caribou across Canada. Four polymorphic loci revealed high levels of heterozygosity (>0.74) in all study populations (Kushny *et al.* 1996). Nuclear msDNA analysis was concluded to have a "very high potential for identifying individuals in respective populations." Subsequently, three local populations of woodland caribou in Yukon were found to differ genetically based on msDNA (Zittlau *et al*. 2000), as did three sub-populations of the Bluenose population of barren-ground caribou (Nagy *et al*. 1999), and others (Zittlau *et al*. 2001).

Caribou in northern B.C. and Yukon may either be included with *granti* or *groenlandicus* or receive subspecies rank once again as suggested by Geist (1991). They have a pelage similar to barren-ground caribou (*R. t. granti*) in the Porcupine population and formerly had subspecies rank as *osborni* (Cowan and Guiguet 1965). Caribou in the Southern Mountain population, where northern haplotypes predominate, may also be included with *granti* based on phylogenetic relationships. Collectively “mountain caribou” in B.C. and Alberta are more closely related to Alaskan barren-ground caribou than to woodland caribou, as concluded by K.H. Røed (pers. comm. 1998).

Caribou are genetically highly variable (polymorphic and heterozygotic) and apparently have evolved convergent behaviour and phenotypes within both clades. A sample from the George River population had 78% southern haplotypes but its appearance and migratory and social behaviour of wintering in the taiga, migrating to tundra range to calve, and forming large post-calving groups is similar to behaviour of the Qamanirjuaq, Beverly, Bathurst, and Bluenose populations of barren-ground caribou. The latter populations collectively have 6% southern haplotypes (Dueck 1998). The migratory behaviour of the George River and Leaf River populations is more likely a behavioural adaptation by resident woodland caribou rather than learned from northern immigrants. All the forest-tundra ecotypes sampled to date are mixed haplotypes. Mixed populations are expected where haplotypes meet and phenotypic differences may or

may not be evident. Cronin *et al*. (1991) suggested that a mixed population of mule and black-tailed deer (*Odocoileus hemionus* spp.) should not be included in either subspecies. So, what about mixed populations of caribou? A pragmatic solution is to place mixed populations in the woodland taxon if southern haplotypes outnumber northern ones.

Though there are exceptions, one can place local caribou populations into two major ecological groups (ecotypes) depending on where they spend most of the summer — alpine/tundra and forest. Those groupings are representative of most current local populations derived from northern and southern clades (Dueck 1998), respectively. This split makes sense ecologically, for tundra and alpine are similar habitats. Some of the alpine/tundra populations spend part of the winter in taiga or subalpine forest. The upper subalpine is analogous to taiga. Most mountain/tundra caribou are migratory but travel distances vary greatly. In the mountains, a caribou can travel from montane through lower and upper subalpine to alpine summer range in as little as 5 km. A forest tundra caribou that wintered in the boreal forest may have to travel 400 km through taiga and another 400 km on tundra to a suitable calving area and summer range.

Exceptions to the above groupings occur within forest-dwelling woodland caribou populations. Because of exceptions to general rules, no behavioural classification system using cover type, or migration/movements, or winter forage clearly stratifies populations of caribou. The George and Leaf river populations in Quebec/Labrador and the Hudson Plain, Pen Island, and Cape Churchill populations fit better in the forest (taiga)-tundra ecotype in terms of their use of ecoregions (Appendix 3). On the plains east of the Cordilleran Mountains, all forest-dwelling populations tend to spend all or part of the summer in open fens, bogs, lakeshore, and islands in lakes and peatlands. Those habitats are analogous to tundra in some respects, for they are rich in succulent forage, are cooler, and provide some relief from predators and insects.

Caribou use taiga and tundra where available within the boreal forest. Forest-dwelling caribou tend to occur at highest regional densities where there are elevational gradients. In Alberta, seven local populations of boreal caribou are associated with elevated terrain termed the *Northern Alberta Uplands* Physiographic Region (Province of Alberta 1993). Vegetation on the top of the Cameron Hills, Caribou Mountains, and Birch Mountains is taiga-like and termed *Boreal Subarctic* in the ecoregions classification. A small upland in Saskatchewan, the Wappaweka Hills, is frequented by a few groups of caribou with links to a large peatland to the south. Other populations such as the Red Wine Mountains (Brown *et al*. 1986) and the Gaspésie (Ouelett *et al*. 1996) include alpine tundra and subalpine or taiga in their ranges. For some populations, availability of suitable summer range appears to be more important than availability of winter range within their distribution. Of course that could change as forests used in winter are exploited.

More DNA samples are required from all populations to establish phylogenetic relationships. The date and location of all samples must be stated in all reports and publications. Some existing results may not be from the purported population because

of overlap in winter distributions. Reliable samples are from calving areas of populations and tissues from dead calves and antlers cast by females about the time of calving, or from radio-collared individuals whose movement pattern is known.

Description

Woodland caribou are dark brown with a white mane and some white on their sides. Height at the shoulder is 1.0-1.2 m and mature females and males usually weigh 110-150 kg and 160-210 kg, respectively. Some characters suggest that *Rangifer* is an ancient member of the deer family, Cervidae (Banfield 1974). Both sexes bear antlers though up to half of females may lack antlers or have one antler. Antlers are flattened, complex, compact, and relatively dense compared with those of barren-ground caribou. A distinctive characteristic of all caribou is large, rounded hooves that reduce sinking in snow and wetlands and act as shovels when digging for food under snow. The 'dew claws' are large, widely spaced, and set back on the foot, which greatly increases weight-bearing area and reduces 'foot loads.' Banfield (1961, 1974), Miller (1982), Kelsall (1984), Geist (1991) and Bergerud (2000) described physical features of woodland caribou.

Nationally significant populations

According to COSEWIC (2001) guidelines, as amended from 1994 guidelines, any group below the species level can be considered for designation when it meets the following criteria:

1. When a population is considered to be genetically distinct based on genetic analysis, taxonomic techniques, or other compelling evidence.
2. When a population is geographically distinct and meets either of the following criteria:
    a. The population represents a significant portion of the historic range of the species in Canada; or
    b. The population is the sole representative of a biological species at risk within any of Canada's major biogeographic zones.

Additionally, the population must be of *national significance*. Populations in the NEAs are assumed to have behavioural adaptations to those environments and therefore are nationally significant (Shank 1998). They are assumed to be evolutionary significant units (Ryder 1986).

COSEWIC populations conform to Banfield's (1961) demes except that he grouped mountain caribou in central and southern B.C. with the boreal deme *sylvestris*. Woodland caribou in Newfoundland were considered an incipient subspecies by Banfield (1961), of subspecies rank by Geist (1991), and were designated as a separate population by Kelsall (1984). They differ from mainland caribou in terms of genetics, ecology, and parasitism (Røed *et al*. 1991, Dueck and Strobeck pers. comm., Ball *et al*. 2001).

With those changes, forest-dwelling ecotypes of subspecies *caribou* can be grouped as follows (relative to Kelsall's 1984 divisions):

1. Northern Mountain population (formerly part of the western population)
2. Southern Mountain population (formerly part of the western population)
3. Boreal population (part of former western population plus boreal and southern taiga populations in Ontario, Quebec, and Labrador).
4. Newfoundland (Island) population (formerly part of eastern boreal).
5. Atlantic (Gaspésie) population (formerly Gaspé population)

The boundary between forest dwelling (*threatened*) and forest-tundra (*not at risk*) ecotypes in Ontario (Harris 1999) bisects the Hudson Plain at about 53^{o} N latitude. In Quebec, the northern boundary of sedentary (forest-dwelling) caribou (Caribou Quebec, 2000) is at about 54^{o} N latitude.

Each jurisdiction has an obligation to conserve caribou. World and national approaches should help governments set priorities for conservation based on how they fit into larger scales. Clearly there is need for inter-jurisdictional cooperation for transboundary populations. Historically, gene flow was possible throughout most of the range of woodland caribou. Fragmentation of habitats now restricts gene flow. Pro-active management of landscapes will be necessary to maintain some degree of connectivity among local populations.

DISTRIBUTION

Global range

Caribou and reindeer are indigenous in arctic, subarctic, and boreal biomes (Banfield 1961, Røed *et al*. 1991). Woodland caribou extend into Alaska and a short distance into northwestern U.S.A. The range of the trans-boundary Chisana population is mostly in Alaska. It was listed at 850 individuals in 1993 (Valkenburg *et al*. 1996) and 325 in 1999 (P. Valkenburg pers. comm. 2000). The South Selkirks population, which ranges in B.C., Idaho, and Washington, is estimated at only 35 individuals in 2002 (I. Hatter pers. comm. 2002) about the same as in 1980 (Williams and Heard 1986). Caribou occurred in most of the northern states in the 19th century (Zager *et al*. 1996). Transplants of caribou from Quebec to Maine and Wisconsin failed because of a parasitic meningeal worm (Dauphiné 1975, Bergerud and Mercer 1989). Therefore, the subspecies *caribou* is essentially endemic in Canada.

Other free-roaming woodland subspecies in the world are the European forest reindeer, *R. t. fennicus*. They were estimated at 600 individuals located on the border between Finland and Russia (Nieminen 1980). There are perhaps 195 000 wild forest reindeer in Siberia (Liakin and Novikov 1999) referred to as *R. t. valentinae* (Gruzdev and Davydov 2001).

Canadian range

Forest-dwelling woodland caribou occur in five of the eight NEAs recognized by COSEWIC (Fig. 3) and 11 of the 16 ecozones on the Ecozone Map of Canada (Ecological Stratification Working Group 1996, National Atlas of Canada 1999). They occur in all jurisdictions in Canada except Nova Scotia, New Brunswick, Prince Edward Island, and Nunavut. Subspecies dawsoni, a peripheral relic, disappeared from the Queen Charlotte Islands about 1935. A reintroduction of 51 caribou in 1968 and 1969 to northern Cape Breton Island failed presumably because of meningeal worm (Dauphiné 1975).

Range reductions of up to 40% were reported for B.C. (MELP 2000, Spalding 2000) and Ontario (Darby et al. 1989). Only about 39% of the generalized maximum historical range in Alberta (Edmonds 1991) is occupied (Fig. 3 in Dzus 2001). Forest-dwelling caribou are associated with large peatlands and coniferous forest cover. Undoubtedly there were large gaps in the historical occurrence where cover was deciduous and mixed forests. Range retractions from historical distributions appear to be proportionally smaller in Saskatchewan and Manitoba but percentage reductions are not available. In eastern Canada, the southern boundary shifted northward during the 19th and 20th century. Formerly, caribou extended into the northern New England States and New Brunswick, Nova Scotia, and Prince Edward Island (Kelsall 1984). Further range retraction across Canada is likely as small local populations disappear along the southern periphery of the range.

The distribution maps of forest-dwelling woodland caribou are based on data received from each jurisdiction in 2000 and 2001. Current extent of occurrence (Fig. 4) has not changed much since Kelsall's review in 1984 but considerable progress was made in delineating areas of occupation (Fig. 5). Enough is known about caribou habitat requirements to estimate historical occurrence using forest cover and wetland data.

Topography, climate, and related winter feeding habits of caribou divide the Cordilleran into two ecotypes of caribou (Bergerud 1978). In the north, snow depths are moderate and caribou feed primarily on terrestrial lichens. In the southern mountains, deep snow causes caribou to eat long-strand arboreal lichens. A third ecotype, boreal, occurs east of the mountains (Heard and Vagt 1998). Alpine and forest winter-feeding types are recognized in Yukon (Kuzyk et al. 1999). The Northern and Southern Mountain boundary in B.C. is approximately between spruce-willow-birch and the englemann spruce-subalpine fir (*P. englemannii-Abies lasiocarpa*) biogeoclimatic zones (B.C. Ministry of Forests 1992).

<u>Northern Mountain population (NMP):</u>

In Yukon, 22 local populations of caribou in the NMP occupy much of the territory south of latitude 65^{o} N. Two NMP populations (Hart River and Bonnet Plume) overlap the winter range of the Porcupine herd of barren-ground caribou. One declining population, the Chisana, straddles the Yukon-Alaska border (Farnell *et al*. 1998). Four

local populations occupy ranges extending to the east slope of the Mackenzie Mountains in the NWT. Another two are also listed by B.C. but six may be transboundary. After accounting for population overlap, 36 local populations constitute the NMP in Yukon, NWT, and northwestern B.C. (Appendix 1a). Caribou distribution in the NMP is little reduced from historical ranges. Gaps between local populations tend to be wider in B.C. than in Yukon. The range of two populations extends eastward a short distance into the Boreal and three overlap the Southern Mountain population (*Caribou in British Columbia*, draft map 2002, I. Hatter, pers. comm.).

Southern Mountain population (SMP)

In B.C., three metapopulations of caribou are recognized in the SMP. They are the isolated *west central* (five local populations), the *north central* (eight local populations with one overlapping the Northern Mountain and one overlapping Alberta), and the *southern* (13 local populations or subpopulations) (Hatter 2000 and pers. comm. 2002, Appendix 1b). The first two metapopulations are the terrestrial feeding ecotype and the third, the southern, comprises what are termed “mountain caribou” (Heard and Vagt 1998). At a national scale, they are better described as the arboreal-feeding ecotype because “mountain caribou” in Alberta eat primarily terrestrial lichens in winter. The Selkirk boundary population, shared with Idaho and Washington, received transplants totalling 60 caribou to 1995 (Compton *et al*. 1995) and an additional 53 in 2000 (J. Quayle pers. comm. 2002). Source populations before 1995 were the Revelstoke and the Itcha-Ilgachuz. Four tagged caribou emigrated from Washington and Idaho to the South Purcell’s population in B.C. (Kinley and Apps 2001). The Selkirk and South Purcell’s populations at the southern periphery of the range contain only 35 and 20 caribou and may disappear because habitat changes cannot be reversed in the short term.

Five local populations in the Rocky Mountains and foothills of Alberta are included in the SMP though they rely primarily on terrestrial lichens in winter (Edmonds and Bloomfield 1984, Thomas *et al*. 1996). They are equivalent in feeding behaviour to the “northern” ecotype in B.C. (Edmonds 1991). The three migratory local populations that summer in the Willmore Wilderness Park, northern Jasper National Park, and adjacent B.C. (Edmonds 1988, Brown and Hobson 1998) could be considered a metapopulation with populations that breed and winter in three separate areas in the foothills. They are considered to be distinct local populations with overlapping summer range, namely the Narraway (Belcourt in B.C.), Redrock/Prairie Creek, and A la Pêche (Brown and Hobson 1998, Dzus 2001). One small population, Little Smoky, borders the SMP. It may be a relic from the southern clade and is considered a forest (boreal) population (Edmonds 1988). Local people detected a difference between two types of caribou that wintered near the Little Smoky River (Edmonds and Bloomfield 1984).

A population with two or three subpopulations exists in southern Jasper National Park and the Whitegoat Wilderness Area to the south. The western subpopulation extends to the Fraser River in B.C. Another isolated population in northern Banff National Park and the Siffleur Wilderness Area (Brown *et al*. 1994, Brown and Hobson 1998) apparently has declined from 20-50 caribou in 1990 to only a few in 1998 (Mercer

pers. comm. 2001). Thus, the southernmost population in Alberta is likely to disappear. In summary, there are 30 local populations in the SMP, excluding the sedentary Little Smoky population.

Boreal population (BP)

This 'ecographic' population covers a huge area from the Mackenzie Mountains in the northwest to southern Labrador in the east and as far south as Lake Superior. The range of the BP in the NWT was enlarged with recent information (Fig. 5) (A. Gunn pers. comm. 2001). No discrete local populations are known for the NWT or northeastern B.C. (Heard and Vagt 1998). Densities are low and there are likely to be large gaps in occupation in what is mapped as potential extent of occurrence. In winter, migratory forest-tundra caribou enter outer portions of the ranges in the NWT.

With the exception of the isolated and precarious Little Smoky local population in the south, the boreal ecotype of woodland caribou occurs north of 55^{o} N in Alberta, (Edmonds 1998, Dzus 2001). The current area of occupation (Fig. 3 in Dzus 2001) is only about 39% of the area north of a line showing historical occurrence in Alberta (Edmonds 1991). However, current extent of occurrence, as shown by observations of caribou mapped in Dzus (2001), is perhaps 50% larger than area of occupation. Enclosing observations with smoothed distributions increases occurrence to about 58% of historical distribution. If unsuitable habitat was removed from the map of historical range, the reduction may approach 40%, similar to that in B.C. and Ontario. Caribou have recently abandoned range or disappeared from parts of Little Smoky, Calahoo Lake, Pinto/Nose Creek, Deadwood, and Slave Lake (Dzus 2001).

After radio collaring more than 300 caribou in the Boreal population in Alberta, 11 local populations were recognized. Tentatively, they can be grouped into three metapopulations currently containing three, two, and five or six local populations (Fig. 1 in Dzus 2001). There was no movement of radio-collared individuals among the local populations with the exception of the east and west Athabasca populations (Dzus 2001). They may be subpopulations divided by the Athabasca River. Analysis of distributions of radio-collared caribou in four study areas revealed that habitat polygons containing more than 30% bogs were selected and those containing more than 50% non-peat were avoided by caribou (Schneider *et al*. 2000).

In Saskatchewan, little was written on woodland caribou distributions up to 1987 (Trottier 1987, 1988a, 1988b). Starting in 1992, 36 radio collars were placed on caribou in four local populations in the Boreal Plain (commercial forest zone) and on another that in summer ranged on the Boreal Shield (Rettie *et al*. 1998, Rettie and Messier 1998, Rettie and Messier 2000). The populations are considered to represent relic, isolated populations of what historically was a more-general distribution (Rettie and Messier 2000).

After work in the 1990s, 18 local populations were mapped (Fig. 5) in 2000 within a generalized extent of occurrence (Fig. 4). Only in the past few years have surveys been

conducted on forest-dwelling caribou in the Boreal Shield of Saskatchewan (Godwin and Thorpe 2000). Data are summarized by three ecoregions (Godwin and Thorpe 2000) because not enough is known about local populations except for four located in the Mid-Boreal Ecoregion (Boreal Plains Ecozone) and one in the Churchill River Upland (Taiga Shield) (Rettie and Messier 2000). Those five local populations are considered to be a metapopulation (Rettie and Messier 2000). A map produced in 2001 shows seven geographic areas of occupancy with some sightings or tracks between them (A. Arsenault pers. comm. 2001). The distribution in Saskatchewan was expanded northward from that shown by Kelsall (1984) to include southern Reindeer and Wollaston lakes and north of Lake Athabasca. Densities around Lake Athabasca are assumed to be extremely low because much of the range has burned in the last 50 years (BQCMB 1994). In winter, forest-tundra caribou in the Beverly population invade that area periodically. There are at least 21 local populations when the two maps are combined.

In Saskatchewan, as in B.C. and Alberta, some of the small local populations or subpopulations along the southern periphery of the range have disappeared or are in a precarious state (Trottier 1988a, Rock 1992). Examples are occurrences near Kazan Lake, Waterhen-Keeley-Canoe Lakes, Sled Lake, Deschambault Lake, northeast Prince Albert National Park, east and south of Montreal Lake, Little Bear Lake, Candle Lake, White Gull Lake, Creighton, Pasquia Hills, and Woody Hills (Trottier 1987, Rock 1992, Godwin and Thorpe 2000, J. Rettie pers. comm. 1998).

In Manitoba, the tillable southern portion of former woodland caribou range is no longer occupied (Johnson 1993). However, caribou continue to occupy most of the traditional range (Larche 1996) and 14 local populations are mapped. All are in a southeast to northwest band across the province except for the Nelson-Hayes population in the northeast. Its distribution overlaps that of the Pen Island population of forest-tundra caribou (Abraham and Thompson 1998). Some caribou may have emigrated from the Nelson-Hayes population to the expanding Pen Island population (Cam Elliott pers. comm. 2002).

In Ontario, the forest-dwelling ecotype occurs in a band below the forest-tundra ecotype (Harris 1999). The ecotype boundary cuts across the centre of the Hudson Plain ecozone. That boundary may change when information is obtained on caribou west of James Bay. The coastal tundra belt combined with the sub-arctic (taiga) lichen belt approximates the Hudson Plain Ecozone in Ontario (Darby *et al*. 1989). Local populations of unknown genotype occur at Cape Henrietta Maria, Shagamu, and Hawley Lake (Harris 1999). Since the turn of the century, when woodland caribou in Ontario were found as far south as Lake Huron, the southern edge of occupied range receded northward to about 50^{o} N. (Darby *et al*. 1989). The cause was loss of groups of caribou in the commercial forest (Racey and Armstrong 2000). At least six small relic populations occur south of the line of semi-continuous distribution. These local populations are Slate Islands (Butler and Bergerud 1978), Pic Island (Ferguson *et al*. 1988), Pukaskwa (National Park), Caramat, Flanders Township, and Hagarty Road (Darby *et al.* 1989). In addition, two of three translocated populations may persist.

In Quebec south of 49^0 N, the Val D'Or and Grands Jardins "sedentary" populations number about 40-90 and 103 individuals, respectively. The Grands Jardins population was extinguished about 1926. From 1966 to 1972, it was restocked with 82 caribou (Vandal and Barrette 1985) raised in captivity.

Local populations of forest-dwelling caribou in the boreal forest and southern taiga between about 51^0 N and 54^0 N include Lac Bienville, Caniaspiscau, La Forge, Nitchicun, Opiscoteo (Belangier and Le Henaff 1985), and Lac Joseph (shared with Labrador). Even though radio collars were put on some of them (Lac Bienville, Caniapiscau, Lac Joseph) in the early 1980s, their ranges are poorly defined. They are thought to be essentially discrete populations (Brown *et al*. 1986). The population status of those sedentary caribou is complicated by invasion in winter of thousands of migratory caribou mostly from the George River population (Brown *et al*. 1986, Couturier 1996). The expanding Leaf River population also overlaps in winter with sedentary caribou in western Quebec. Other local populations may occur between Waskaganish and Nemiscau east of James Bay (Caribou Quebec 2000) and the McPhaden River west of Schefferville (Brown *et al*. 1986). Current studies should clarify the status of caribou in Quebec.

In Labrador, the Red Wine Mountains population occurs in the southern taiga (Brown and Theberge 1985, Schaefer *et al*. 1999), whereas the Mealy Mountain and Lac Joseph (formerly Waco) populations straddle boreal and taiga ecozones (Schaefer 1997).

In summary, to date more than 64 local populations of forest-dwelling caribou have been identified in the Boreal NEA (Table 2). That number will increase as individuals in more populations are radio collared, distributions are delineated, and local populations become isolated by human developments and activities. Additional local populations are likely to be identified in northern Saskatchewan and in the bands of general occurrence in Ontario and Quebec. More-or-less discrete local populations occur in Alberta, Saskatchewan, and Manitoba where populations often are associated with large peatland complexes (Stuart-Smith *et al.* 1997, Rettie and Messier 2000, Brown *et al.* 2000b, Dzus 2001). Peatlands also occur in the boreal forest of Ontario but islands and lakeshores are also used as summer range by small groups of caribou that seemingly range over large areas (Armstrong *et al*. 2000, Racey and Armstrong 2000). This may also be true for forest-dwelling caribou on the Precambrian Shield in Saskatchewan, Manitoba, and Quebec.

Newfoundland population (NP)

Woodland caribou of Newfoundland are found on the Main Island and offshore islands in 15 natural and 22 introduced populations (Mahoney 2000, Doucet pers. comm. 2001). Data are available for the natural populations and for 12 of the introduced populations. After a sharp decline in the early 1900s, the populations became centred in the most inaccessible parts of their range. In the last few decades, however, the range has expanded gradually and woodland caribou now occupy most of their historic range (Mahoney and Schaefer 1996).

Atlantic (Gaspésie) population (AP*)*

This isolated population is the only one south of the St. Lawrence River. Its distribution is largely restricted to Gaspésie Conservation Park (Crête *et al.* 1994, Ouelett *et al*. 1996). The population historically occupied coniferous forest in Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Maine and northern New Hampshire, Vermont, and New York. It should be genetically distinct from all other woodland caribou because of long isolation and small numbers.

HABITAT

Habitat requirements

Fire and succession are natural processes that profoundly affect forested caribou range. Fire is necessary to regenerate some plant species including pine. The average fire-return interval or fire cycle is an important statistic for caribou range. It varies from an average of 200-350 years in winter range in B.C. (B.C. Ministry of Forests 1992) to 40-80 years in the southern boreal forest in Alberta and Saskatchewan. Caribou use mature and old-growth coniferous forests in winter because terrestrial and arboreal lichens are most abundant in those forests. In summer, caribou occasionally feed in young stands after fire (Schaefer and Pruitt 1991) or logging (Thomas and Armbruster 1996b). Obviously, caribou have adapted to shift winter range in relation to successional patterns. However, caribou habitats in commercial forests will be seriously degraded after current mature- and old-growth forest is cut and a cutting rotation is established.

Northern Mountain population (NMP)

Yukon caribou use two contrasting winter habitats. The Chisana, Kluane, Aishihik, and Klaza local populations use alpine ranges, whereas seven populations to the east forage in forests (Kuzyk *et al*. 1999). A significant difference was found in shoulder height of caribou in those groups.

Caribou spend much of the summer in alpine and upper subalpine range and in winter move down to coniferous forest in lower subalpine and, rarely, to the montane. In Yukon and northern B.C., most caribou winter in areas where snow cover is relatively light (Bergerud 1978, Heard and Vagt 1998). They winter at low elevation in either mature lodgepole pine (*P. contorta*) or spruce forests where they feed primarily on terrestrial lichens and secondarily on arboreal lichens. Some caribou also winter on high slopes where wind action allows access to terrestrial lichens (Bergerud 1978, Heard and Vagt 1998, Kuzyk *et al*. 1999). Forestry management recommendations in B.C. include maintaining some old stands, even-aged management, and a mosaic of large harvest units and “leave” areas (Seip 1998). Leave areas are not reserves but are left for future cutting. The average mean fire return interval in the spruce-willow-birch forests in northern B.C. is 200-350 years (range 150-500 years) (B.C. Ministry of Forests 1992).

Southern Mountain population (SMP)

The SMP in B.C. occurs mostly in alpine and englemann spruce-subalpine fir biogeoclimatic zones (B.C. Ministry of Forests 1992). The west-central metapopulation is in a precipitation shadow where sub-boreal forests of pine and spruce occur at lower elevation (Cichowski 1989). The north-central metapopulation is in a wetter climate where spruce-fir and spruce forests predominate. Both central metapopulations feed primarily on terrestrial lichens. In contrast, the arboreal ecotype in the southern metapopulation of B.C. is obligated to consume arboreal lichens over a thick snow pack (Heard and Vagt 1998). Thus, the two ecotypes of caribou do not conform to COSEWIC NEAs. Two metapopulations (13 local populations) in B.C. and five (one listed by both provinces) in the mountains and foothills of Alberta are the terrestrial-feeding ecotype. In the SMP, they are grouped with 13 local populations in the southern mountains of B.C. that are the arboreal ecotype.

Range use by the arboreal-feeding ecotype (B.C. “mountain caribou”) varies seasonally (Stevenson 1991, Simpson *et al*. 1997). In early winter, caribou use valley bottoms and lower slopes, and then move to upper slopes and ridge tops after the snow pack deepens and hardens in mid- and late winter. They survive for 6-8 months feeding almost exclusively on arboreal lichens. Those long-strand lichens are predominantly *Alectoria sarmentosa* and *Bryoria* spp. In spring, caribou descend to access green vegetation. Pregnant caribou move upwards again in May and usually are found in old forests (Simpson *et al*. 1997). Forest management recommendations for biodiversity in southern mountains of B.C. include maintaining a landscape dominated by old and mature forest, uneven-aged tree management, small cut blocks, and mature forest connectivity (Seip 1998). Fire is not a major disturbance factor as the mean fire return interval averages 200-300 years in spruce-fir forest (B.C. Ministry of Forests 1992). It is shorter in the Rocky Mountains east of the continental divide and varies with elevation. The result is many “hanging” old-growth forests in the upper subalpine.

In mountain habitat in southern Jasper National Park, Alberta, caribou crater for terrestrial lichens in winter by descending, as snow deepens and hardens, to progressively feed in alpine, upper subalpine, lower subalpine, and, rarely, the montane ecoregion (Thomas and Armbruster 1996a). Some caribou within subpopulations spend part of the winter in alpine areas if feeding conditions are suitable there. They eat variable amounts of arboreal lichens, depending on availability and snow conditions. Perhaps because of isolation (“island effect”), caribou in southern Jasper National Park are smaller than those in the A la Pêche population that summers in northern Jasper National Park and the Willmore Wilderness Park (Brown *et al*. 1994, Thomas and Armbruster 1996a).

Three local populations (Narraway, Redrock/Prairie Creek, and A la Pêche) generally leave the mountains in October to winter in the foothills, a snow-shadow zone where lichens are abundant (Edmonds and Bloomfield 1984). Feeding is predominantly on terrestrial lichens but short forms of arboreal lichens are consumed (Edmonds 1991). In Alberta’s Rocky Mountains, only very old forests with northern or eastern exposures

produce abundant, long-strand arboreal lichens (Thomas and Armbruster 1996a). Edmonds and Bloomfield (1984) provided detailed information on the standing crop of vegetation in range types on winter range in the foothills of Alberta. Preference is for forests older than 80 years and caribou used old forests in late winter when arboreal lichens constituted part of the diet (T. Szkorupa pers. comm. 2001).

Boreal population (BP)

The woodland caribou of northeastern B.C., east of the Cordilleran Mountains, are considered to live in small, dispersed bands throughout the year, rather than in discrete populations (Edmonds 1991, Heard and Vagt 1998). Similar behaviour may also be the case on the plains in the NWT and on the Shield in Saskatchewan, Ontario, and Quebec. However, further study may reveal discrete populations. Caribou in northern Alberta showed significant preferences for both bogs and fens with low to moderate tree cover and they avoided marshes, uplands, heavily forested wetlands, water, and areas of human use (Brown *et al*. 2000a). The Bistcho and Caribou Mountains populations (Fig. 1 in Dzus 2001) are associated with elevated terrain classified as boreal subarctic (taiga). Canopies of open black spruce (*P. mariana*) and white spruce (*P. glauca*) occur in and around peatlands where terrestrial lichens are abundant. Elsewhere, peatlands are preferred habitats of caribou (Bradshaw *et al*. 1995, Stuart-Smith *et al*. 1997, Rettie and Messier 1998, Anderson 1999). Their use by caribou generally is attributed to an attempt to avoid predators (Stuart-Smith *et al*. 1997, Rettie and Messier 1998, James 1999, James and Stuart-Smith 2000). However, peatlands are also important food sources (Thomas and Armbruster 1996b), have fewer parasitic insects, and create some separation from other ungulates. Predators cause direct mortality and may transmit harmful parasites. Some peatlands and adjacent black spruce and tamarack forest produce terrestrial and arboreal lichens and provide year-round habitat requirements. In northeastern Alberta, calf survival was related to the size of fens in home ranges (Stuart-Smith *et al.* 1997). Burns are less of a factor in large peatlands south of the shield, as indicated by considerable old growth black spruce around their periphery and within them on islands of elevated terrain.

Caribou range in Saskatchewan south of the Precambrian Shield (Thomas and Armbruster 1996b, Rettie and Messier 1998) is similar to that in northeastern Alberta where populations are associated with fens and adjacent coniferous forests (Stuart-Smith *et al.* 1997). Data from satellite collars indicate a distinct preference for peatlands (99% of locations, Stuart-Smith *et al.* 1997) and peatlands and black spruce forests (Rettie and Messier 2000). In contrast, there was relative avoidance of young forests originating from fire or logging.

In the Boreal Shield in Saskatchewan, peatlands generally are small and associated with margins of numerous lakes and intervening streams. Such range is subject to large burns at intervals of 50-100 years, which affects numbers and distribution of caribou. Caribou are more exposed to predation on the shield but moose and resident wolf densities may be relatively low there (Darby *et al*. 1989). In Quebec and central Manitoba, caribou showed fidelity to areas used at calving and in summer

but not to winter locations (Paré and Huot 1985, Brown *et al*. 2000b). The majority of animals in the Manitoba study wintered near their summer ranges, though short movements to wintering locations were also noted. Caribou used peatland complexes and generally avoided clear-cut areas and aspen/poplar-dominated sites.

Caribou winter range in northwest Ontario typically includes open coniferous forest over sandy soils, which produces an abundant ground cover of *Cladina* spp. lichens (Harris 1999). Sites used in winter could be predicted by combined use of forest resources inventory data and Landsat imagery (Antoniak and Cumming 1998). Another study of habitat use in northwestern Ontario, using satellite telemetry, found that caribou selected habitats containing conifer cover and avoided disturbed areas and shrub-rich habitats (Hillis *et al.* 1998). Range in northeastern Ontario is wetter as indicated by an ecoclimatic map (Ecoregions Working Group 1989). Caribou in the Lac Bienville, Caniapiscau, Lac Joseph, and Red Wine Mountains occupied open lichen woodlands (taiga), wetlands (peatlands), and tundra (Brown *et al*. 1986). Black spruce and tamarack were the dominant tree species.

Fire is the major natural disturbance force in boreal forests. Average fire return intervals of only 20 to 60 years are reported for Alberta, Saskatchewan, Manitoba, and western Ontario and 100 and 500 years for Northern Quebec and Labrador (e.g., Table 5 in BQCMB 1994). Only about half of a study area in Manitoba contained forests older than 50 years (Schaefer and Pruitt 1991). Fire suppression is considered to have delayed natural fire succession, though there are contrary views. In 1995, fire in northeastern Alberta and central Saskatchewan swept through all cover types including recent logged sites and young plantations.

Newfoundland population (NP)

Caribou use a mixture of boreal and taiga coniferous forest with some shrub land, peatlands, and ‘barrens.’ Caribou in the Corner Brook Lake area preferred barrens, mature and over-mature forests, and avoided scrub, bog, and immature forest (Snow and Mahoney 1996).

Atlantic (Gaspésie) population (AP)

Range types used by caribou were grouped into alpine, mature spruce, mature fir, immature forest, and hardwood (Ouellet *et al*. 1996). Patches of stunted fir and white spruce occurred on the tundra above 915 m. Mature fir cover along with white spruce in the subalpine was important winter range. Critical summer habitat included tundra of Mont Albert and Jacques-Cartier Mountains (Crête *et al.* 1994). Logging, which occurred in the park until 1977, removed part of the forest habitat including arboreal lichens.

Trends

Monitoring trends in quantity and quality of the food component of habitat is important but very difficult. Generally it is ignored with an assumption that caribou

populations are far below the 'carrying capacity' of the vegetation. Carrying capacity generally refers to food resources for caribou but it should also include other ecological variables such as forage accessibility, space to reduce contact with predators, and specific requirements such as calving and post-calving areas and relative refugia from predators, insects, and thermal stress. That is, distinction should be made between food carrying capacity and ecological carrying capacity. Relative abundance of food may be much lower than absolute abundance because of the effects of snow and ice, predators, insects, and human activities. Caribou usually do not need large areas for feeding but need space to reduce contact with predators and they need certain types of habitats to lessen other limiting factors.

Criteria to estimate food limitations currently are indirect. The most common measure is pregnancy and parturition 'rates'. However, early loss of calves and good summer range can result in high conception rates even though nutritional restrictions in winter may result in weak calves with high mortality from predation or other factors. Consequently, seasonal nutritional deficiencies can be masked. Reproductive pauses every few years in individual forest-tundra caribou suggest a gradual decline in condition after successive pregnancies (Dauphiné 1976, Cameron 1994). It is difficult to determine if declines are food and energy-related, are due to predation, or are caused by an interaction of those factors plus others such as hunting. Furthermore, there may be a lag between habitat deterioration and decline of a local population.

There is incomplete information even on total occupied range of most caribou populations. Usable ("effective") habitat can be calculated once the effects of roads and disturbance are known. For example, 28% to 70% (average = 48%) of study areas may be avoided by caribou (Dyer 1999). Such percentages do not include habitat loss and degradation from logging and other developments.

Results from disturbance studies should be viewed with caution. Caribou at low densities and well below the carrying capacity of their range are likely to withdraw from industrial activities. Whether they have to move and whether their fitness is compromised is speculative. There is a need to measure behavioural responses to gradations of disturbance, accommodation over time, and effects on demographics. If sources of mortality such as wolf predation and hunting are managed, caribou may be able to co-exist with well-managed developments.

Maps of forestry leases across Canada (Equinox 1991, Peterson *et al*. 1998) and particularly in relation to *extent of occurrence* (potential distribution) and *area of occupancy* (currently used range) of forest-dwelling populations reveal the potential for profound changes to caribou habitat. Extent of occurrence is more suitably termed *area of potential occurrence* and data sources should include cover-type analysis and historical information.

Logging and fire can concentrate caribou (Smith *et al*. 2000). After one 'pass' of clear cutting, there is still up to 50% mature and old growth left. After the second pass there is virtually no old forest left unless there are reserves specifically for caribou or

other values. After one complete rotation in a two-pass system there may be only 10-20% in a mature class at any one time and it is just over rotation age. No old growth forest may remain except that around peatlands or at sites commercially non-productive. In terms of caribou habitat, a mature forest may be inferior to an old-growth forest but much depends on tree species, soil, moisture, succession rate, slope and aspect, and how the surface was treated during and after logging (Thomas and Armbruster 1996b). In Alberta the second pass is permitted 15-25 years after the first. That timing is supposed to provide adequate cover for wildlife in the young stand but it is far too short to sustain caribou habitat. A suitable interval between passes to sustain adequate caribou habitat may be 30-60 years depending on cover type, local site conditions, and forestry prescriptions.

Northern Mountain population

Habitat concerns expressed by jurisdictional representatives ranked below non-regulated hunting (70% of local populations) and predation (62% of populations). Most local populations are quite isolated from human activities and forestry operations are a concern for only 35% of the populations and connectivity for 37% (Table 7). Lack of available habitat is of high or medium concern for 32% of the local populations, with wildfire a concern for 56% of 37 populations (Table 7). Seasonal use by caribou of low elevation range in winter conflicts with forestry operations (Cichowski 1989, Stevenson 1991). Oil and gas activity is expected to increase.

Southern Mountain population

Caribou disappeared from 15% (Seip and Cichowski 1996), 20% (Spalding 2000), or 40% (MELP 2000) of historical range in B.C. Range reduction was proportionally greatest in the Southern Mountain population. Hunting was suggested as the main cause of range retraction in central and southern parts of the province. Predation and forestry operations are now the main concern (Table 7). Access/disturbance and forestry operations are of high or moderate concern for 94% and 90%, respectively, of the 30 local populations. Loss of connectivity and lack of available habitat are concerns for 73-74% of populations. Those are high numbers considering that three of the populations are in national parks and several populations are partially in protected areas (Appendix 2b). Forest fire was a concern for 47% of populations.

Use by caribou of low elevation range in winter conflicts with forestry operations (Stevenson 1991). Timber cuts are being made at higher elevation as the first cut is completed in valley bottoms and on lower slopes. Fragmentation of range is a serious consequence of forestry and other developments. In the Purcell Mountains, caribou frequented areas containing at least 40% suitable habitat at fine (250 ha) and coarse (5000 ha) scales (Apps and Kinley 1998). One accepted hypothesis is that increases in moose numbers on caribou range, as a result of re-colonization abetted by logging, has resulted in more wolves and higher caribou mortality (Seip 1992). Thus, predation is a concern for 94% of local populations (Table 7).

Boreal population

Oil and gas activity is increasing in the Northwest Territories and northeastern B.C., where little is known about local populations of caribou. Historical range in Alberta was greater than present (Edmonds 1991) though distributions were undoubtedly patchy because, east of the foothills, the majority of cover is deciduous and mixedwood forest. Caribou range has been lost, degraded, and fragmented by petroleum activities, logging, mining, hydroelectric developments, and associated linear structures. In Saskatchewan, road development associated with forestry and mining resulted in range fragmentation and increased hunting mortality (Rock 1991, 1992). Caribou range in the commercial forest is changing rapidly as forestry operations are widespread across most of the boreal forest (Peterson *et al*. 1998). Concerns for caribou relate to large reductions in proportions of medium and old-growth coniferous forests, increased access and fragmentation, altered predator-prey relationships, a meningeal parasite harboured by white-tailed deer (*O. virginianus*) east of Saskatchewan, and climatic change at regional and local scales.

Landscape-level forest management guidelines in B.C. (Seip 1998) and Ontario (Armstrong 1998) attempt to emulate, to some extent, disturbance caused by fire. In Ontario, large leave blocks should reduce populations of moose, deer, and associated wolves and also reduce access by predators and human hunters. Whether such recommendations are widely instituted, in the light of considerable opposition, remains to be seen.

Newfoundland population (NP)

Commercial logging in summer disturbs caribou (Chubbs *et al*. 1993), though benefit is derived from clearings where caribou obtain some relief from insects.

Atlantic (Gaspésie) population

Habitat in the Gaspésie Park was modified by fire, insect infestations, and logging. There is little use of young stands by caribou and it was recommended that logging cease in the park (Ouellet *et al*. 1996).

Protection/ownership

Forested lands in Canada comprise 418 million hectares of which 235 million hectares (56%) is considered to be commercial forest (CCFM 2000a). Forest-dwelling caribou occur mostly in softwood forests that comprise 67% of forested lands in Canada. The largest numbers of forest-dwelling caribou occur in Newfoundland and Yukon where, respectively, 91% and 79% of forests are classified as softwood. Ownership of forested lands in 2000 in Canada was 71% provincial, 23% federal, and 6% private (CCFM 2000a).

Protection is afforded woodland caribou and their range by protected areas, wildlife acts and regulations, policy and accords, forestry regulations and standards, and

species-at-risk legislation. Protected area within Canadian forests was estimated at 7.6% in 1995 and 8.4% in 1999 (CCFM 2000b). They also serve as important controls for studies that attempt to assess the effects of developments in adjacent areas.

Information was gathered from jurisdictions on proportions of local populations (numbers and occupied range) that were in protected areas such as parks and wilderness areas (Appendix 2). Caribou distributions overlapped about 60 protected areas in B.C.; however, land use plans on adjacent areas were considered to be most important for caribou conservation. For example, protected areas can safeguard habitat but restrict management options such as reducing prey species to manage numbers and distribution of predators.

In the last decade, several initiatives at international, national, and provincial/territorial scales have set guidelines for sustainable forest practices that will help conserve caribou. Included are the *Montreal Process*, criteria and indicators of the *Canadian Council of Forest Ministers* (CCFM), provincial policy, criteria and indicators, and certification at international and Canadian scales. The *Montreal Process Working Group*, consisting of 12 countries, adopted 7 criteria and 67 indicators (CCFM 2000a). In 2000, the CCFM reported progress on 6 criteria, 22 elements, and 83 indicators established in 1997 (CCFM 2000b). Several provinces, notably Quebec, Ontario, Saskatchewan, and Newfoundland-Labrador have developed their own indicators. In 1999, the Senate Sub-Committee on the Boreal Forest provided management guidelines. It recommended three categories of management: intensive for timber (20%), multi-use (60%), and protected (20%).

Forest industry standards include the international *Forest Stewardship Council* (FSC), the *International Organization for Standardization* (ISO), and the *Canadian Standards Association* (CSA). The Canadian standard for sustainable forest management was developed in 1996 in response to growing public opposition to clear-cut logging. The CSA requires that six criteria be addressed including conservation of biological diversity. That provision should help to conserve caribou within forest management areas. It also specifies adherence to 21 “critical” elements in the CCFM criteria and indicators framework (CCFM 2000b) such as ecosystem diversity, species diversity, and genetic diversity.

Certification is not legally required of companies but is driven by the marketplace. By 2003, one retailer will not sell wood products from “endangered areas” and will give preference to wood from certified operations. Another would not sell wood from “ancient forests or other high conservation values forests” unless the forest areas were certified (CCFM 2000a). As of May 31, 2000, certification (mostly ISO) was obtained for 16 million ha (13%) of 120 million hectares under active management (CCFM 2000a). An estimate is that, by 2004, 72 million hectares (60%) of managed forests will be certified.

All jurisdictions have wildlife acts and regulations that are used to close hunting, close hunting on certain road corridors (e.g., Alberta and Saskatchewan), establish limited entry hunts of specific sex and age classes, prohibit night hunting, etc. There is

limited recreational hunting of large local populations of forest-dwelling caribou in Yukon. In B.C., there are limited entry hunting and open seasons for mature bulls (minimum of five terminal tines). The same restrictions apply to six local populations in the central metapopulations of COSEWIC's Southern Mountain population. There is limited hunting in Quebec (Table 9) where there is overlap in winter distribution of forest-tundra and forest-dwelling ecotypes.

There is a trade-off between giving special consideration to individual species at risk *versus* an ecosystem approach with emphasis on preserving biodiversity. Both approaches are required. Not all species can be accommodated, hence the ecosystem approach. Nevertheless, some species will require specific management and, if wide-ranging and representative of an ecosystem type, can provide habitat for other species. In that context, caribou are an *indicator species* in Saskatchewan and a *feature species* in Ontario.

It will be difficult to show that habitat per se is limiting a local population of caribou unless there is agreement on minimum viable population size combined with an average minimum area required per caribou. Ecological carrying capacity should be estimated and projected decades into the future based on land-use plans. Generally, indirect effects of developments, such as increased predation and hunting, initially cause populations to decline in number (e.g., Bergerud 2000).

In all provinces (Maritimes grouped) there are Conservation Data Centres. They all use common criteria formulated by The Nature Conservancy, an international organization, to evaluate species at risk (Table 10). The southern metapopulation in B.C. is Red Listed by the B.C. Conservation Data Centre (Hatter 2000). Although Manitoba, Ontario, and Quebec have endangered species acts they have not listed caribou. Other provinces/territories list endangered and threatened species in their Wildlife Acts or other legislation. In Ontario, a Committee on the Status of Species at Risk has established criteria for population selection and species designation (Harris 1999).

There is some protection from acts, codes, plans, regulations, and guidelines by government forestry agencies that relate to caribou habitat. Other departments and agencies are involved. For example, in 1991, 1994, and 1996, Alberta Energy published procedural guides for oil and gas activity on caribou range (Dzus 2001). The 1991 guidelines state that: *Petroleum and natural gas exploration and development activities can occur on caribou range, provided the integrity of the habitat is maintained to support its use by caribou*. Most forestry operations are conducted on crown land where governments can make changes through long-term (e.g., 20-year) lease agreements with forestry companies.

Also relevant to caribou conservation are federal, provincial, and territorial legislation, regulations, and policies regarding Aboriginal people and treaty rights. In all, 286 forest management plans encompass 726 518 ha on some of the 2 394 Indian Reserves in Canada (CCFM 2000a). Consultation with First Nations will be essential for their local knowledge and to reduce hunting of caribou made accessible because of

roads, seismic lines, and other linear developments. Increases in numbers of other large ungulate species after logging should ensure alternative meat sources.

On the positive side, over the past decade, considerable knowledge of caribou distributions and ecology has been acquired. In many areas there is sufficient knowledge to sustain caribou and limited development. The results of scientific research and other forms of knowledge only lack application. Research results should be presented in a form that can be applied by forest companies and others with power to make changes. Progress must be made towards implementation of current knowledge.

BIOLOGY

General

For more detailed background information on the general biology of caribou, consult (Banfield 1974), the first COSEWIC status report (Kelsall 1984) reviews by Miller (1982) and Bergerud (2000), and recent provincial status reports (Rock 1992, Godwin and Thorpe 2000, Dzus 2001).

Reproduction

Compared with barren-ground caribou, woodland caribou tend to breed younger and have higher calf mortality. Pregnancy was detected in high proportions of yearling females (Rettie and Messier 1998, Dzus 2001) though sample sizes are small. That compares with 12% in the Beverly population of barren-ground caribou (Thomas *et al*. 1998). The difference between ecotypes can be explained by earlier calving in woodland caribou east of the Cordilleran Mountains, an adaptation to earlier growth of green forage. Green-up is as much as 2 months earlier in the boreal forest and southern mountains compared with barren-ground caribou that migrate to northern calving grounds. Pregnancy rate in Peary and barren-ground caribou is correlated with body weight and degree of fatness (Dauphiné 1976, Thomas 1982, Cameron *et al*. 1993).

Pregnant females travel to isolated, relatively predator-free areas to calve. Examples are islands in lakes or peatlands, lakeshores, forests, and tundra. Only one calf is born in May or early June. Caribou in the Cordilleran Mountains appear to calve in the first 2 weeks of June (Edmonds 1991) plus the last week of May (Brown et al. 1994). Such timing is comparable to that of barren-ground caribou. Most calves were born mid-May in Saskatchewan (Rettie and Messier pers. comm.) as in eastern Alberta (Fuller and Keith 1981). Peak calving was 17-21 May in the forest-tundra Pen Island population (Abraham and Thompson 1998) similar to caribou in the Boreal population. Therefore, calving is 2-3 weeks earlier in the boreal NEA than in the Cordilleran Mountains. Calves of barren-ground caribou are able to travel within a day or two of birth but there is some evidence that calves of woodland caribou are cached (Chubbs 1993).

Most breeding is by large males with large antlers, which indicates strong sexual selection among males (Butler 1986). Woodland caribou form harems like wapiti

(Cowan and Guiguet 1965, Banfield 1974, Geist 1991), whereas barren-ground caribou bulls form loose-tended groups of cows. The mating behaviour of caribou is dictated by the social system, which is considered an adaptive response to the environment and particularly to predators (Butler 1986). Group size is lowest at calving and in summer, increases before the rut, and may decline or increase during the winter. Peak group size may occur at the rut or in early and late winter. Group size at all seasons is much larger in forest-tundra caribou than in forest-dwelling caribou.

Survival

On average only 30-50% of calves survive their first year. Typically, about 70 to 74 calves are produced by 100 adult females (>1 year). Population stability occurs when about 30 calves per 100 adult females survive to autumn (Yukon Renewable Resources 1996), which is survival of about 42%. Survival of calves can vary from almost none to 100%, depending on the abundance of predators and forage accessibility during pregnancy and the first year of life (e.g., Bergerud 1983). High rates of survival occur when populations are irrupting after low numbers or after caribou are introduced to new range with few or no predators. Predation is the major cause of death of radio-collared calves and adults (e.g., Bergerud 2000). Much of the behaviour of caribou is related to reducing risk of predation (Bergerud 2000).

High calf mortality implicates poor winter energetics or predation or a combination of both. Terrestrial lichen cover and standing crop is low on some winter ranges relative to taiga ranges of barren-ground caribou (Edmonds and Bloomfield 1984, Thomas and Armbruster 1996a). Caribou in the Southern Mountain population may be nutritionally stressed late in winter before they are able to obtain new-growth vegetation. In B.C., they consume arboreal lichens during mid- to late winter and little or no green forage. In the mountains of Alberta, sparse forage is difficult to access in some winters. Some populations in Saskatchewan rely on arboreal lichens in and around peatlands to supplement food under snow (Thomas and Armbruster 1996b). Caribou that are nutritionally stressed in late winter-early spring are likely to produce weak calves. Such calves are more likely to die from predators, pneumonia, and other causes, which points to an interaction of factors. There are few data on the nutritional status of forest-dwelling caribou. Adult female caribou captured in Jasper National Park in October had little back fat (mean = 7 mm, median = 2 mm) (Brown et al. 1994) compared with caribou sampled in the Qamanirjuaq (mean = 15 mm) (Dauphiné 1976) and Beverly (mean = 13 mm) populations of forest-tundra caribou (Thomas et al.1998).

The adult (>1 year) mortality rate of female caribou usually varies between 5% and 15%, with half to two thirds attributed to wolf predation (Bergerud and Elliott 1998, Yukon Renewable Resources 1996, Dzus 2001). Average annual mortality of adults in Alberta averages 14.5% and 11.0% (females only) in the SMP and BP, respectively (Dzus 2001). In Saskatchewan, average annual mortality of adult females was 14% (Rettie and Messier 1998). The mortality of male barren-ground caribou (38%) was more than double that of females (17%) after sexual maturity at age 4 and 3 years, respectively (Miller 1974).

Population 'stability' occurs when recruitment (addition of calves 1 year old) and annual mortality of adult females is about equal and typically is 10-16%. Demographics and 'equilibria' are dynamic in forest-dwelling populations. Stability cannot be assumed if there is no change in estimated numbers between surveys spaced several years apart. Wide confidence intervals for most surveys almost guarantee that no statistical difference in population size will be found between successive surveys. Similarly, stability cannot be assumed between surveys spaced several years apart even if they yield similar population estimates. Long-term stability is unlikely in caribou populations because major limiting factors such as weather, predation, and hunting are highly variable.

The probability of survival of caribou is age dependent. For example in the Beverly population, the expected 1-year survival of females 3 and 10 years old was 0.89 and 0.78, respectively (Thomas and Barry 1990). The age structure of captured caribou tends to be older than the entire population because cows with calves and cows with large antlers tend to be selected. For example, the average age of females at capture in Jasper National Park was 7.7 years (Brown *et al*. 1994). By the time of death, the age structure has advanced 1-4 years. Expected survival of those relatively old caribou is lower than in the general population. For example, two of five deaths among 24 collared caribou in Alberta were old females (Edmonds 1991), which inflated the mortality rate to 22%. Similarly, in Jasper National Park average annual mortality of adult females and males was 31% and 34%, respectively (Brown *et al*. 1994). However, 5 of 11 females that died were 12 years+ and two of the three males that died were approaching age 10 years. Wolves and a bear accounted for all deaths of those seven old caribou, which were in poor condition when killed in late winter or early spring. Only 2-3% of 2+ year old female and male forest-tundra caribou survive past 12 and 10 years, respectively (Miller 1974, Messier *et al*. 1988, Thomas and Barry 1990). Therefore, the survival of radio-collared caribou should be adjusted by comparing expected survival of each caribou to actual survival.

Physiology

Most of what is known about caribou function comes from literature on reindeer. Through inductive logic and analogy, some of the results can be extrapolated to woodland caribou. Caribou have adapted to feed on lichens, though they also consume a wide array of plant species. They can withstand severe cold because their thick winter coat contains semi-hollow hair but they are susceptible to over heating because cows do not shed their winter coat until after calving. The dark summer coat absorbs all wavelengths and points to the importance of shade and cool forest cover types. Adaptations to snow include large feet and a furred muzzle. Caribou are the most energetically efficient walkers of ungulates tested (Fancy and White 1987).

Movements/dispersal

Caribou are almost always on the move. Consequently, predators and parasitic insects cannot predict where caribou will occur and lichen ranges are not overused and trampled. A negative result of movement is that caribou can travel into areas occupied by

wolves. Some movements are local or elevational, whereas others are migratory (traditional, twice annual movements between two distinct seasonal ranges). Those movements can be explained as responses to specific seasonal habitat requirements, predators, food quantity and quality, snow conditions, insects, thermal extremes, or combinations of those factors. Their mobility and responses to changing environments means that dispersal is most likely when environmental conditions are extremely unfavourable and during range expansion at population 'highs.' Therefore, travel corridors need to be maintained to facilitate inter-population movements and occupation of former range. Forest-dwelling caribou are least mobile in summer and winter with most movement occurring in spring before calving and before the rut and winter (e.g., Brown et al. 1986, Edmonds 1988, Racey et al. 1991, Brown et al. 1994, J. Rettie pers. comm. 2001).

Movement between large fen complexes in northeastern Alberta was only about 5% per year (Stuart-Smith *et al*. 1997). Local populations in Alberta, with one exception, were discrete based on short-term data mostly for adult females (Dzus 2001). Similarly, in Saskatchewan there was no movement of adult females among five contiguous local populations (Rettie and Messier 1998). Strong fidelity of individuals to their home ranges was also noted in Yukon (Farnell and McDonald 1986), B.C. (Hatler 1986, Seip 1992), Manitoba (Brown *et al*. 2000b), and Quebec (Brown *et al*. 1986).

Several authors have noted that radio-collared females will return to the same general area to calve in successive years (Paré and Huot 1985, Brown *et al*. 1986, Edmonds 1988, Seip 1992, Brown *et al*. 1994, Brown *et al*. 2000b). Others have found no fidelity to specific calving sites but definitions of fidelity vary (Rettie and Messier pers. comm.).

Nutrition and inter-specific interactions

Caribou are ruminants that have specialized bacteria and protozoa in their rumens that efficiently digest lichens. They are also able to recycle urea to preserve nitrogen, of which preferred lichens are deficient. During winter, they use fat reserves and catabolize protein from muscle when their diet is nitrogen deficient. Caribou are described as catholic, fine feeders. That is, they can eat a wide variety of plants and they select small parts of plants with high nutritional value that are readily digested. In summer they eat sedges, grasses, forbs, lichens, fungi, and the leaves of shrubs, particularly willow. In winter, they eat large amounts of lichens if they are available. Included are lichens that grow on the ground, when snow depth less than 50-100 cm, and arboreal lichens when the availability of surface lichens is poor.

Most interspecific interactions are with predators, particularly the wolf. There is no evidence that caribou actively avoid other ungulates yet separation usually is the case because their use of habitat differs from that of other ungulates.

Behaviour/adaptability

Caribou have innate behaviour that varies little among populations throughout the world. They often are described as "curious" and will stop and watch a human at a 'safe'

distance. They often circle a person or even approach to within 50 metres. Distances triggering flight (escape) vary with sex and age, physical condition, and population. Caribou can be enticed to approach humans by unusual activities such as periodically waving an arm. Such behaviour may relay an image of a fit and fearless individual to a predator but it makes caribou highly susceptible to hunters. Caribou have not adapted to hunters with modern rifles and are vulnerable because they aggregate in open areas such as frozen lakes and are easily overtaken by snowmobiles.

Caribou have considerable genetic variability and are highly adaptable. They occupy diverse range and habitat types, from coniferous forests to tundra. Some populations migrate for several reasons whereas others remain year round in a small area, such as fens. For sedentary populations, there is no real escape from predators, insects, or heat except for specific cover types where some relief is obtained.

POPULATION SIZES AND TRENDS

Accurate (estimate *vs*. true number) and precise (degree of confidence) estimates are exceedingly difficult to obtain for forest-dwelling caribou. The proportion visible relative to those hidden by trees is difficult to estimate. Observed age and sex ratios may be biased because visible caribou are not representative of the population (Hatler 1986). In alpine/tundra and upper subalpine cover types, minimum estimates are obtained from attempts at total counts. Ratios of observed-to-expected radio collared or painted caribou are used to account for caribou missed on surveys. In forests and peatlands, sample surveys are conducted where standard errors and confidence limits of estimates can be calculated. Confidence limits at 80% probability may be adequate for caribou numbers. Many estimates are guesses based on extent of known distribution, density estimates, occasional sightings, and track counts.

Several problems confound any analysis of caribou numbers and trends. When estimates are obtained by sampling procedures, the confidence limits are wide even at 90% probability. For example, standard errors for 11 surveys in Yukon have averaged 16.5% (R. Farnell pers. comm. 2000), which equates to a 90% confidence interval of about 28%. In insular Newfoundland, the 90% confidence interval averaged 58%, 29%, and 19% of the estimate obtained respectively by strip transect (n = 5), stratified random block (n = 5), and mark-resight survey designs (n = 6) (Mahoney 2000).

Accuracy remains unknown unless sightability indices are estimated for each survey or search intensity is high using a helicopter over relatively open canopies. Even when caribou are visible on the tundra, many counts are inaccurate and imprecise (Thomas 1998). For example, the 90% confidence interval for caribou population estimates in the NWT and Quebec averaged 57% (n = 9) and 32% (n = 5), respectively. Regular counting of all woodland caribou populations is cost prohibitive.

Williams and Heard (1986) summarized the status of 32 of 43 local populations of woodland caribou in the mountains and plains. Trends were 7 increasing, 16 stable, and

9 decreasing (Table 2). Those totals excluded a declining Gaspésie population and insular Newfoundland, where all 11 local populations were increasing. A few years later, reviews appeared on the status of woodland caribou in western Canada (Edmonds 1991) and North America (Ferguson and Gauthier 1992). The latter tallied 71 populations of forest-dwelling woodland caribou and trends for 18 of 46 located in mountains and plains (same exclusions as above) were 5 increasing, 8 stable, and 5 decreasing.

In 1996, Mallory and Hillis (1998) concluded that "populations of woodland or forest ecotypes were declining and threatened throughout the circumpolar region, possibly due to the interaction of human disturbance and predation." In reviews by provinces/territory in 1996, the estimated status of 25 local populations of forest-dwelling woodland caribou in mountain ranges was 3 increasing, 8 stable, and 7 decreasing (Table 2). Corresponding ratios in 2000/2 are 4:15:3, 0:13:12, and 1:6:12 for the Northern Mountain, Southern Mountain, and Boreal populations, respectively.

Short-term changes in numbers can vary considerably due to weather and predators. Consequently, the IUCN has adopted 10 years or three generations, whichever is longer, as a time frame to evaluate changes in numbers. A *generation* is defined as *the average age of parents* (IUCN 1994, COSEWIC 2000b) but should be the average or median age of *females* of breeding age. It can be obtained from a life table but none exist for forest-dwelling caribou. The most reliable life tables are for female caribou in the George River and Beverly populations of migratory, forest-tundra caribou (Messier *et al*. 1988, Thomas and Barry 1990). Survival of 50% of females >2 years old was just over 7 and 5 years, respectively. Therefore, three generations of caribou is rounded to 20 years and one generation is therefore 6.7 years. A 20-year span should be adopted as a standard for all populations.

There is need for standard criteria of what constitutes an *increase, stability*, and a *decrease* in local populations. It is difficult to suggest criteria because it depends on the accuracy and precision of data and the interval between estimates. For periods shorter than 20 years, *stable* could be defined as an average annual change in numbers of less than 2%. The term *decline* should be reserved for a decrease in numbers of 20% or more over 20 years. For periods shorter than 20 years, a decrease should not be inferred on a prorated average of 1% (rounded) change per year. A temporal scaling is required. An average decrease of more than 3% per year over 10 years or 10% per year over 5 years may be suitable *where data are reliable*. Caribou populations fluctuate widely in numbers because recruitment can be low for several years and relatively high in following years. Caribou populations can grow at up to 11-15% per year and decrease faster.

Northern Mountain population (NMP)

The 2001 estimate for the NMP is 44 000 (Table 1). It accounts for about 24% of all forest-dwelling caribou in Canada. Stratified random-quadrat designs and total counts account for 61% of estimates. All populations contain more than 100 caribou and 20 of 36 contain more than 500 (Table 4). Most (72%) of the estimates were made after

1996. Trends in numbers were 4 increasing, 15 stable, 3 decreasing, and 14 unknown (Table 3). Fluctuations were large in both directions, with Ibex up 63% in 8 years and Chisana down 78% in 10 years. Range sizes > 5 000 km^2 predominate (Table 5). Densities averaged 11.3 caribou *per* 100 km^2 and range from 3.0 to 26.9 (Table 6).

In 1991, the Yukon contained about 19% of the Canadian woodland caribou population as defined by Ferguson and Gauthier (1992). Inventory and long-term monitoring of 22 populations suggested that most were about stable (Farnell *et al.* 1998). Trends in numbers were eight stable, four increasing, one decreasing, and one stable or decreasing. The apparent increase from 21 000 in the early 1990s (Ferguson and Gauthier 1992) to 28 000-35 000 in 1997 (Farnell *et al.* 1998) and to 43 150-48 150 in 2001 stems mostly from improved survey methods and better estimates than from growth in numbers. Three populations contained only 180-200 caribou. Trend in numbers in 2001 were 4 increasing, 9 stable, and 2 decreasing (Appendix 1a).

Five populations of woodland caribou in the Mackenzie Mountains of the NWT are shared with and tallied by the Yukon: Bonnet Plume, Redstone, Nahanni, Clear Creek (new), and La Biche (Farnell *et al.* 1998, Gullickson 2000, Farnell pers. comm. 2001).

In B.C., woodland caribou in the Northern Mountain NEA occur in 16 populations with an estimated total of about 11 000, unchanged from 1996 (Table 2). Seven local populations are about stable, one is increasing, one is declining, and seven unknowns. In 1996, seven were stable, one was increasing, and two were decreasing (Heard and Vagt 1998).

Southern Mountain population (SMP)

Numbers in the SMP are estimated at 7 200 (Table 1). This COSEWIC population accounts for about 3.9% of all forest-dwelling caribou in Canada. Counts extrapolated from marked individuals and total-count surveys account for 77% of estimates. Twenty-eight of 30 local populations number fewer than 500 caribou, with eight comprised of 50 caribou or fewer (Appendix 1b, Table 4). Most (77%) of the estimates were made since 2000. Trends in numbers for 25 of 30 local populations are 0 increasing, 13 about stable, and 12 decreasing (Table 3). For 90% of populations, the surveyors expressed high (37%) or moderate (53%) confidence in the trend. Nineteen (63%) of the caribou ranges were relatively small at <5 000 km^2 (Table 5). Densities average 8.3, 5.9, and 3.0 caribou per 100 km^2 in the west central, north central, and southern metapopulations in B.C. and ranged from 4.9-16.4 per 100 km^2 in Alberta (Table 6). However, six small local populations (<51 caribou each) in the southern metapopulation in B.C. occur at densities of only 0.3-2.3 caribou per 100 $km.^2$ The Southern Purcells population may become extinct within 10 years (Kinley and Apps 2001). Only four adult females were found in 2000. Its peculiar male-dominated sex ratio may be caused by mountain lion (*Puma concolor*) predation in fragmented habitats. The Banff population also is reduced to a few caribou.

From 1997 to 2002, the average annual rate of decline of SMP caribou in B.C. was 2.47%. That rate would result in 39.3% decline over 20 years (I. Hatter, unpubl. data, 2002).

Boreal population (BP)

The estimated number of forest-dwelling caribou is 33 000 (Table 1), comprising 18% of the total for Canada. However, numbers and trends for most forest-dwelling populations are poorly known over most of the Boreal NEA. For example, the NWT estimate of 4 000-6 400 was based on estimated extent of occurrence and a density of 2 caribou/100 km^2 in one area intensively surveyed and estimated densities of 1 and 3 caribou *per* 100 km^2 in other areas (A. Gunn pers. comm. 2001). The previous estimate in 1992 was 2 000-5 000 woodland caribou (Ferguson and Gauthier 1992). In northeastern B.C., 725 caribou are estimated in the Boreal NEA (I. Hatter pers. comm. 2000), a density of 1.4 per 100 km^2. The previous estimate in 1996 was 750 (Heard and Vagt 1998).

In Alberta, an estimated 3 285 forest-dwelling caribou occur in 12 local populations in the Boreal Plain ecozone. Most populations are decreasing (Table 3) based on data for female mortality and calf:cow ratios (Dzus 2001). In 1996, numbers appeared to be about stable or slightly decreasing (Stuart-Smith *et al.* 1997, Edmonds 1998). Stability occurs when there is replacement of adult females that die by an equal number of female yearlings. Whether data from radio-collared caribou are representative of the populations is not clear. The growth curves are sensitive to an overestimation of mortality of adult females or underestimation of survival of female calves. Survival of adult females could be underestimated because of age structure differences between sampled caribou and the population. Calf survival could be underestimated if some calves have separated from radiocollared cows by the time of surveys in March. Sex ratio equality cannot be assumed as male calves generally have higher mortality than females. Some male calves were unaccounted for in another study (Stuart-Smith *et al.* 1997). All but 3 of 28 local populations contain fewer than 500 caribou (Table 4). Most local populations occupy ranges larger than 5 000 km^2 (Table 5). Thus, average densities are only 3.3 caribou per 100 km^2 and range from 1.8 to 13.1 (Table 6).

Woodland caribou populations apparently decreased south of the Shield in Saskatchewan after pulp harvesting operations began in the mid-1960s (Trottier 1988a, Rock 1992). They continue to decrease slowly based on recruitment and mortality data and reduced area of occupation (Rettie *et al.* 1998). Former estimates of 2 500 caribou (Ferguson and Gauthier 1992, Rettie *et al.* 1998) are now revised upwards to 5 000, a result of surveys in the Boreal Shield and a larger mapped extent of occurrence (Godwin and Thorpe 2000). Mean densities in favourable habitat in two ecoregions of the Boreal Shield are estimated at 3.5 and 3.0 *per* 100 km^2 compared with 2.8 on the Boreal Plain (Godwin and Thorpe 2000). Numbers include large areas that were not surveyed and where estimated densities of 0.7/100 km^2 and 0.3/100 km^2 were guesses.

Thirteen local populations in Manitoba were estimated to contain 1 840 to 3 125 caribou, rounded to 2 000 and 2 500 by Rebizant *et al.* (2000). No estimate is available for the Nelson-Hayes rivers population, which overlaps with the Pen Island population (Abraham and Thompson 1998). The Pen Island and Cape Churchill populations are the forest-tundra ecotype and are excluded from this review. Caribou numbers are likely to

decrease in local populations at Kississing-Naosap Lakes, Wabowden, Atikaki-Berens, and Owl-Flintstone Lakes unless strategies are developed to reduce impacts of development (R. Larche pers. comm. 1997). Densities average 1.1 to 1.8 caribou per 100 km^2 and range from 0.5 to 4.3 (Table 6).

Improved estimates for caribou numbers along the Hudson Plain (Hudson and James Bay lowlands) increased the estimate for caribou in Ontario to over 20 000 in 1996 (Cumming 1998). Exclusion of the forest-tundra ecotype reduces the number to about 5 000 of the forest-dwelling ecotype relevant to this review (Harris 1999). There are about 500 caribou in remnant populations south of the line of semi-continuous distribution: Slate Islands, Pic Island, Pukaskwa National Park, Caramat, Flanders Township, and Hagarty Road (Darby *et al.* 1989, Cumming 1998). Small numbers of caribou were translocated in the early 1980s from the Slate Islands to Michipicoten, Montreal, and Bowman islands (Darby *et al*. 1989). Caribou persisted on the first two islands to 1989 and all but one disappeared from Bowman Island (Bergerud and Mercer 1989).

In 1990, the total population in Ontario was estimated at 11 000, excluding the Pen Island population of 4 000 caribou that ranged mostly in the taiga (Abraham and Thompson 1998). The boreal population was 6 000-6 700 in the 1970s and 1980s excluding 4 800 in the Pen Island population and 3 500-5 600 in northeastern Ontario (Ferguson and Gauthier 1992). However, the northeastern total may contain some boreal caribou. Many estimates are essentially guesses.

In the boreal forest of Quebec south of 49^0N, there are two isolated, sedentary caribou populations, the Val D'Or (40-90 individuals) and the Grands Jardins. The introduced Grands Jardins population has fluctuated from a low of 38 animals in 1978 to a high of 126 in 1992 (Banville 1998) and 103 in 1998. Farther north, between 49^0N and 55^0N, there are several sedentary populations totalling less than 10 000 caribou (Couturier 1996). They are located in the northern boreal forest and southern taiga. Perhaps the best known is the Lac Joseph population, estimated to number 1 025 in year 2000. This population, shared with Labrador, is subject to range loss and fragmentation (R. Otto pers. comm. 2000). Densities in Labrador average 1.3 caribou per 100 km^2 and range from 0.4 to 2.1 (Table 6). The status of other local populations is poorly known. Since about 1981, in winter thousands of caribou from the expanding Leaf River and George River populations have invaded ranges of sedentary caribou (Brown *et al*. 1986, Messier *et al*. 1988, Couturier 1996) and disrupted them (Schaefer *et al*. 1999).

Since about 1980, local populations in Labrador have declined in number by 80% (Red Wine Mountains and Lac Joseph) and 75% (Mealy Mountains) (R. Otto pers. comm. 2000). Causes were overhunting, predation, or both (Mahoney and Schaefer 1996). However, the Lac Joseph population now is increasing (Appendix 1c). The Red Wine population, which occurs in the taiga, declined presumably from wolf predation and losses when members migrated with George River caribou (Schaefer *et al*. 1999).

Newfoundland population (NP)

Populations of woodland caribou on Newfoundland continue to grow and the total population in 2001 is estimated at 100 000 (Table 1), up from about 25 600 in 1979 (Bergerud 1980) (Table 2). Newfoundland caribou account for 54% of forest-dwelling caribou in Canada. Numbers were estimated for 15 natural populations and 12 introduced ones (Appendix 1d). There are another 10 introduced populations whose status is not known. The population declined sharply from 40 000 in 1900 to 1 000-2 000 in 1930 (Bergerud 1971). That decrease may have been caused by introduction of a parasite with reindeer (Ball *et al*. 2001). Densities now average 150 caribou per 100 km^2 and range from 11 to 634 (Table 6).

Atlantic (Gaspésie) population

This small, isolated population declined in number from 500-1000 in the 1950s to about 200 in the 1970s (Crête *et al.* 1994). It then stabilized at about 200 in 1991 (Ferguson and Gauthier 1992), and 200 to 250 caribou in 1993 and 1996 (RENEW 1994, Crête *et al.* 1994, Boileau 1996, Couturier 1996). In 1992 and 1993, both subpopulations in the Gaspésie Conservation Park contained over 30 calves per 100 females (Crête *et al.* 1994). Densities are 20-25 caribou per 100 km^2 (Table 6). A recent report suggests that the population is decreasing (Fournier 2001).

LIMITING FACTORS AND THREATS

General

Some known threats to forest-dwelling caribou, by COSEWIC population, are summarized in Table 7. They are an interrelated mixture of causes and effects and do not include weather or climatic change. Major limiting factors are discussed separately but with the caveat that all of them interact. Treating factors individually is a reductionist approach, which is antithetical to ecology. Part of the problem is hypothesis generation, which often partitions the ecology of caribou into factors for statistical analysis yet simplifies ecology. Many factors are involved and they interact. For example, weather affects condition of caribou, which in turn affects calf mortality and vulnerability to predation. Forestry operations increase access for wolves and hunters, cause fragmentation of caribou range, change predator-prey relationships, and influence the local climate. Major challenges this century are to learn more about how limiting factors interact, how to assess their cumulative effects, and how to mitigate effects.

Habitat loss, degradation, and fragmentation

Caribou populations cannot exist without habitat of adequate quantity and quality. Loss, degradation, and fragmentation of habitat is caused by the cumulative effects of many factors both natural and of human origin. While predators cause most deaths of forest-dwelling caribou, and predation is of great concern (Table 7), it is a proximate

factor that is influenced significantly by the effect of human developments. Access and disturbance, fragmentation (isolation), and low caribou numbers are of high concern (Table 7) and all are increasingly a result of development and human activities rather than natural causes. We first discuss some theoretical ecological considerations before listing major factors that reduce the amount and quality of caribou habitat.

Hunting and predation are thought to depress most caribou populations to densities well below the vegetative *carrying capacity* of their ranges (e.g., Bergerud 1974, 2000). However, periodic restricted availability of forage because of weather is a component of long-term carrying capacity. Therefore, a distinction must be made between absolute and relative forage availability. With the addition of other ungulates, predators, and habitat disturbance, it is more realistic to discuss *ecological carrying capacity* for caribou. It may be zero in marginal habitats and especially those considerably modified by human activities. Examples are ranges of local population in the South Purcell Mountains of B.C. and northern Idaho, each with less than 35 caribou. Adequate quantity of range can be assessed by considering minimum viable population size and ecological carrying capacity, including critical habitat components and predators. Peak caribou densities may be a crude index of ecological carrying capacity but environmental conditions should be specified and examined critically.

Adequate quality means that nutritious food must be available seasonally as well as calving and post-calving areas and other 'security habitat.' Certain important plant species may be in short supply or over-used even though total forage is superabundant. The effects of inadequate or degraded habitat, whether natural or human caused, may be subtle with lag effects (e.g., Messier *et al*. 1988). A slight decrease in reproduction or increase in mortality can result in population decreases. Erupting populations on new or renewed range are characterized by high pregnancy rates, whereas reproductive pauses (Dauphiné 1976, Cameron 1994) are common in populations that have intensively used range for decades or centuries. Such populations are believed to be below carrying capacity but the concept is largely theoretical and difficult to assess in the real world. It changes with weather, vegetation succession, disease, and other disturbances. It is not an absolute ceiling and is better described as "spongy" or buffered. Long before carrying capacity is reached or overreached there would be a range of density effects such as reduced fertility and higher mortality of calves. Also, density-independent factors such as ice on vegetation could cause density-dependent responses.

Successional changes after disturbance are poorly understood in spite of their importance. One reason is the large variation in succession related to cover type, soil conditions, disturbance characteristics, slope, aspect, elevation, and climate change. Succession after fire to adequate cover of terrestrial lichens preferred by caribou is protracted in Jasper National Park (Thomas and Armbruster 1996a), intermediate in the taiga (Thomas *et al*. 1998), and relatively rapid in central Saskatchewan (Thomas and Armbruster 1996b).

A major paradigm shift in the last decade in forest operations is to emulate, as much as practicable, natural disturbance patterns as a means of preserving biodiversity.

However, fire return intervals are highly variable and mean intervals between fires depend on what time period is selected. Therefore, there is no agreement on the fire cycle before humans attempted to control nature. More importantly, forest succession after fire differs significantly from that after logging. In particular, succession of lichens after logging depends on surface disturbance, surface treatment, and restocking methods. Prescriptions to generate good winter range for caribou must be tailored to several local site and stand conditions. Ecosystem management for diversity of all species (Seip 1998, Euler 1998) is preferable to small block designs but there must be special provisions for caribou.

Availability of habitat is of high or moderate concern for 32%, 74%, and 48%, for local populations in the NMP, SMP, and BP, respectively (Table 7). Fires can remove suitable habitat for 25 to 100 years or longer depending on fire intensity, geography, and type of forage normally consumed by caribou. Temporary loss of range from fire was a concern for 57%, 45%, and 76% of local populations in the COSEWIC populations listed above.

In Yukon, the spread of agriculture, forestry, and mining have affected caribou (Farnell *et al.* 1998). Caribou numbers have decreased significantly in southern B.C. from loss, alteration, and fragmentation of important habitat as a result of wildfire and human activities (Simpson *et al.* 1996, 1997). Management recommendations for the terrestrial feeding ecotype of caribou include maintaining some old forests, even-aged stands, and large harvest units and ‘leave’ areas (areas left for cutting in a future years) (Seip 1998). The mountain/arboreal ecotype of caribou requires a higher proportion of mature and old forests, uneven-aged stands, small cut blocks, and mature forest connectivity (Seip 1998).

Age of forest was the greatest determinant of habitat suitability in the Purcell Mountains of southern B.C. (Apps and Kinley 1998). Low elevations were first subject to developments such as forestry, roads, agriculture, homes, powerlines, pipelines, dams, and recreation. The result was loss and alteration of habitat used by caribou in late winter and spring, changes in predator-prey relationships (Seip 1992), and increased access. Increases in moose, which are more productive than caribou, resulted in greater predation on caribou (Seip and Cichowski 1996). Increased access resulted in increased recreation and more hunting of caribou. Now logging is proceeding at higher elevations and into range used by caribou in winter (Stevenson 1991).

Difficulties in managing caribou range in forest management areas in west central Alberta were chronicled by Hervieux *et al*. (1996). The *Northeast Region Standing Committee on Woodland Caribou* was established in Alberta in 1991 to provide an interactive base for those interested in conservation and development. *The Alberta Woodland Caribou Conservation Strategy Development Committee* was established in 1993 to ensure the survival of threatened caribou in Alberta (Alberta Woodland Caribou Conservation Strategy Development Committee 1996). Still, improved guidelines will have to be instituted in forests to conserve some local populations (Stevenson 1991, Hervieux *et al*. 1996, Rock 1992, Dzus 2001).

Government and industry generated six general principles for caribou conservation but plans for implementation are deficient. There are many overlapping activities in Alberta's caribou range including timber harvesting, oil and gas development, coal mining, and increasing road access (Hervieux *et al*. 1996). The cumulative effects of these disturbances are not understood and have received little attention (Edmonds 1998). Some effects can be mitigated but forest rotation cycles of only 60-100 years and only 15-20 years between cuts can remove most lichen-producing cover types unless there are special prescriptions. Smith *et al*. (2000) recommended that adequate usable and core winter range be retained for the current population along with minimal fragmentation.

In Saskatchewan, forestry operations, other human developments, and fire have fragmented large areas of forested land in the commercial forest. More deer, elk, and wolves are now found on caribou range. Suggested changes include zonal management of caribou and moose, altered moose management, a standard access policy, and involvement of Aboriginal people (Rock 1992). Additional strategies include encouragement of wolf harvest by trappers, management for low moose and deer densities, old-growth forest reserves, protection of lichens with winter harvesting, large-block timber harvest designs, and protection of calving areas and travel corridors (Godwin and Thorpe 2000). Many local populations are associated with fen complexes where timber values are low but adjacent commercial forest must be managed for caribou.

Woodland caribou disappeared from southern parts of their former range in Manitoba as agriculture expanded (Johnson 1993). Concerns include improved access to uncontrolled hunting, forestry, hydroelectric developments, and possible transmission of the meningeal worm from white-tailed deer to caribou (V. Crighton in Edmonds 1991, Rebizant *et al.* 2000).

In Ontario, recommendations for caribou conservation included large block forest cutting designs (Darby and Duquette 1986). Identification of distinct summer and winter range of one local population led to a suggestion that those ranges be managed for caribou (Cumming and Beange 1987) and unaltered by development (Cumming 1992). Loss of mature coniferous forests was recognized as a serious threat to caribou, especially where numbers of moose, deer, and wolves attain relatively high densities after logging (Darby *et al.* 1989). The southern limit of “continuous” caribou range closely approximates the northern limit of forestry operations in Ontario (Armstrong 1998). In light of caribou declines in the 1980s, Ontario reviewed woodland caribou status and ecology (Darby *et al*. 1989, Racey *et al*. 1991, Racey and Armstrong 1996, Armstrong 1998). Favourable winters resulted in a large increase in the deer population since lows in the 1970s. Therefore, weather not only affects caribou directly but also indirectly through changes in densities of other species. Forest management must consider eight “feature species” including woodland caribou. In the northwest, prescriptions to conserve caribou in commercial forests include large block mosaics and protection of winter range, calving habitat, and travel corridors (Racey *et al*. 1991; Racey and Armstrong 1996, 2000; Armstrong 1998). Racey and Armstrong (1996) listed 12 points in a caribou management strategy for northwestern Ontario.

Clear-cutting mature forests on summer and winter range affects the distribution of caribou (Chubbs *et al.* 1993, Smith *et al*. 2000). Overgrazing of forage leading to population declines could become a problem in Newfoundland and an objective is to prevent declines by managing hunting (Mahoney and Schaefer 1996).

The Gaspésie population decline was attributed to habitat loss (agriculture and logging), predation, and hunting (RENEW 1993). Woodland caribou were extirpated in several states of the USA south of 49^{o} with the exception of a few caribou in the Selkirk Mountains in Idaho (Zager *et al*. 1996).

The maximum habitat change tolerable by forest-dwelling caribou will depend on minimum viable population size, the area and quality of the habitat mosaic that is sustained, the ability of caribou to accommodate human activities, management of predators, and little or no hunting. Reindeer in Scandinavia, in the virtual absence of predators and hunting, can persist in highly developed areas. However, wild reindeer in Norway avoid developments (Nellemann *et al*. 2001, Vistnes *et al*. 2001).

Disturbance

Disturbance can mean habitat disturbance or individual caribou being alarmed by some stimulus. Habitat disturbances related to developments were discussed in the previous section. The distinction between natural and human-related disturbance becomes blurred in the case of climatic warming, fire protection, disease and parasites in plantations, and salvage logging of burned areas. Natural disturbances include wildfire, insects and diseases that kill trees, tornadoes and windstorms, extreme weather, predators, and parasitic insects. All those factors can cause caribou to move. Here the emphasis is on the direct effects of human activities on individual caribou rather than indirect effects mediated through habitat changes.

Several examples were noted in previous sections of the effects of human activities on caribou and reindeer (Trottier 1988b, Rock 1992, Chubbs *et al*. 1993, Bradshaw *et al*. 1997, 1998, Dyer 1999, James 1999, James and Stuart-Smith 2000, Smith *et al*. 2000, Dyer *et al*. 2001, Nellemann *et al*. 2001, Vistnes *et al*. 2001). There are three well-documented cases of caribou being displaced by logging activities in Ontario (Darby and Duquette 1986, Darby *et al.* 1989). Construction of a hydroelectric development in Newfoundland displaced some caribou and disrupted the timing of migration (Mahoney and Schaefer 2001). Forest-dwelling caribou are sensitive to disturbance but the cause of their withdrawal from human activity is not clear. They naturally are fearful of unusual activity within their range and avoidance often has survival value. Caribou may associate linear and other developments with predators and hunters.

In Alberta, the A la Pêche caribou population lost 16% to 21% of its members in 1991-92 from collisions with vehicles on Highway 40 north of Hinton (Brown and Hobson 1998). The following year it was 14% to 18%. Broadcast salt attracted caribou to the highway. Mortality was reduced when caribou were scared off the right-of-way by

volunteers on snowmobiles. Since 1997, that population has remained in the mountains (Dzus 2001), perhaps as a response to disturbance along the highway. Hauling logs by truck through winter habitat in Ontario displaced some caribou and caused others to move out of the area (Cumming and Hyer 1998).

Studies were conducted in Labrador on the short-term impacts of low-level jet aircraft flights on caribou populations (George River and Red Wine Mountain). Low-level flying did not significantly affect daily activity of caribou or travel distance, though comparison with 'control' caribou suggested potential effects (Harrington and Veitch 1991). Searches by helicopter for radio-collared caribou in a side valley of Jasper National Park caused two caribou to leave the area immediately and others to depart over the next few hours (Thomas and Armbruster 1996a).

There is an urgent need for more studies to assess the effects of human activities on individual caribou and on populations. How long does it take caribou to accommodate to various stressors? No accommodation to linear developments was detected within 2 years in Alberta (Dzus 2001). Experimental studies are needed in which adequate numbers of marked caribou (collars or paint) are subjected to specific activities and their reproduction and mortality compared with that of undisturbed marked caribou. Empirical observations and experience will be invaluable, including those from Aboriginal peoples.

Predation

Predators influence caribou distribution and limit densities (Bergerud 1974, 1978, 1980, 1983, 1996, 2000; Edmonds 1988, Seip 1992, Brown *et al*. 1994, Crête *et al*. 1994, Boertje *et al*. 1996, Seip and Cichowski 1996, Stuart-Smith *et al*. 1997, Bergerud and Elliott 1998, Rettie and Messier 1998, James 1999, Schaefer *et al*. 1999, James and Stuart-Smith 2000). In a classic study, recruitment of caribou increased 113% and adult mortality decreased 60% when wolf numbers were reduced 80% on the range of the Finlayson population in Yukon (Farnell and McDonald 1986). Removal of 60-90% of wolves over three winters increased recruitment of the Horseranch caribou population to 16.7% from 5.5% (Bergerud and Elliott 1998).

Wolves may reduce or even eliminate caribou populations in areas where habitat has been significantly altered. Increased abundance of other large prey species is one factor. In Yukon, wolves limited densities of moose to 7-12/100 km^2, with each wolf consuming an average of 2.4 moose *per* 100 days (Hayes and Harestad 2000). Caribou prosper in areas where other ungulates and wolves are absent or rare. Alpine habitat enables caribou to reduce contact with wolves. In spring and summer, wolves spend much of their time at low elevation near den sites and numerous large prey (Bergerud 1978, Edmonds and Smith 1991, Seip 1992, Brown *et al*. 1994, Farnell *et al*. 1996, Simpson *et al*. 1997).

On caribou range in central Saskatchewan, moose densities are low and wolves also prey on deer, elk, and caribou. Black bears (*Ursus americanus*) may be a significant predator of caribou calves. More predators combined with increased access

to caribou by wolves, coyotes, and humans can combine to cause declines. Increases in just one prey species, moose, was thought to have caused declines in caribou populations in B.C. (Seip 1992) and possibly in southern Labrador (Schaefer *et al*. 1999). In contrast, caribou and introduced moose populations have grown and expanded in Newfoundland, where wolves no longer occur.

Adverse climate combined with hunting in the late 19th century seemed to drive down numbers of ungulates and predators. Moose expanded out from refugia in western and eastern Canada. People in western Canada still remember when they saw their first moose and white-tailed deer. Wolves and coyotes were poisoned in the 1950s and early 1960s (Cringan 1957, Bergerud 1978, Edmonds and Bloomfield 1984, Edmonds 1988, Rock 1992, Bergerud and Elliott 1998). Some relatively large populations of caribou were recorded in the late 1960s and early 1970s. Large legal harvests of caribou at that time in B.C., Alberta, and Saskatchewan (Bergerud 1978, Edmonds and Bloomfield 1984, Rock 1992) combined with recovering wolf populations and adverse weather probably caused caribou population decreases in the 1970s. The caribou population highs in the 1960s probably were atypical and should not be considered management objectives.

Public and scientific attitudes to predator control changed markedly during the 20th century. Attitudes to hunting and predators combined with firearm regulations mean that the ability of wildlife agencies to manage densities of ungulates and predators is declining. An interesting perspective is that temporary lethal control of wolves may be counterproductive as it could generate a rebound effect (Valkenburg *et al*. 1996, Bergerud and Elliott 1998).

Predation on forest-dwelling caribou by wolves is essentially incidental to the wolf-prey system because low-density caribou populations cannot sustain wolves. Each adult wolf requires about 29 adult caribou annually (Hayes and Russell 1998). A “capital” of about 200 adult caribou is needed to sustain each wolf feeding entirely on caribou, assuming wolves account for all of a 15% average annual mortality of adult caribou. Therefore, a pack of five wolves requires a population of 1000 caribou for sustainability of both species, assuming no other prey. In reality, there are other sources of food for wolves and other forms of caribou mortality.

To sustain densities of 2, 4, and 8 wolves per 1000 km^2 would require sustained populations of 387, 773, and 1 547 caribou in that area to feed each wolf if caribou were their only prey and wolves accounted for all caribou mortality. However, most densities of forest-dwelling caribou are in the range of 10-200 caribou per 1000 km^2 (Table 6). Thus, caribou can only form a small part of the diet of wolves in the forest and other prey such as moose, deer, and beaver (*Castor canadensis*) must form the bulk of their diet. Wolves are likely to concentrate their predation on species with high productivity and biomass. Caribou tend to use areas where moose and deer are absent or rare (Cumming and Hyer 1998), especially in summer when calves are vulnerable to predation. Examples are alpine and subalpine areas, islands, peatlands, and shrub-poor pine forests. Lakeshores provide forage and caribou can escape wolves by swimming.

That predation of caribou by wolves is incidental is supported by density considerations. Wolf densities in the southern boreal forest of Ontario were in the range of 4-8/1000 km^2 and half of that in northern parts of the forest (Darby *et al*. 1989). Bergerud (1988) stated that wolf densities higher than 6.5/1000 km^2 caused caribou to decline whereas moose could persist at densities of 8 wolves per 1000 km^2 (Bergerud and Elliott 1998). In the southern Yukon, wolf densities typically were 8-10/1000 km^2 (Hayes *et al.* 1991). They were 9-10/1000 km^2 in the area of the Wolf Lake caribou population when it grew at an average annual rate of 10.5% (Farnell *et al*. 1996). Wolf control for 7 years in Alaska resulted in caribou population growth for 14 years — from 2 200 to 10 690 — followed by a decline to 3 660 because of predation and deep snow (Boertje *et al*. 1996). The moose populations grew over 19 years from 2 500 to 13 800. The wolf population decreased from 239 to 80-157 during control, recovered in 4 years to 195 and peaked at 267 in the third year of 4 years of weather adverse to moose. Caribou numbers in the Delta population increased when wolf densities were 11-12 *per* 1000 km^2 (Boertje *et al*. 1996). These few examples reveal that predator-prey relationships are extremely complex and generalizations are rife with exceptions.

Predator-prey relationships are not only complex but also dynamic. They involve the distribution and relative densities of multiple prey from moose to snowshoe hare (*Lepus americanus*) and multiple predators from grizzly bears (*Ursus arctos*) to coyotes. Growth of one caribou population while the other declined was attributed to differential wolf predation on moose at different densities, hare densities, skewed sex ratios, and hunting (Farnell *et al*. 1996).

There is speculation that caribou actively maintain low densities (e.g., Bergerud 1992) but more likely it is a passive phenomenon linked to predation rate. Populations will grow at their innate biological capacity unless limited by environmental conditions. High densities of caribou in Newfoundland, where wolves are absent, contradict the hypothesis that caribou self-regulate to low densities. Low densities are more likely a consequence of predation and other limitations rather than an adaptation by caribou.

In Newfoundland, lynx predation limited caribou until lynx numbers declined after fur prices increased and snowmobiles provided access (Bergerud 1971, 1974, 1980, 2000). In the Corner Brook Lake area, there was significant predation on caribou by black bears (Snow and Mahoney 1996). If the wolf was to re-enter Newfoundland after 7-8 decades, it could have a devastating effect on caribou populations because of a dense moose population and naive, sedentary caribou. Observations of calf-hiding behaviour by woodland caribou in east central Newfoundland are the first reported (Chubbs *et al*. 1993).

Between 1987 and 1993, the mortality rate of calves in summer in the Gaspésie population approached 90%. Predation by black bears and coyotes, present in Gaspésie only since the early 1980s, was responsible for the high rate of mortality (RENEW 1993, 1994). The likely cause of death for 11 of 16 radio-collared calves monitored in 1989 and 1990 was predation by coyotes (7 deaths), black bears (3 deaths), and golden eagle (*Aquila chrysaetos*) (1 death) (Crête and Desrosiers 1995).

Between 1990 and 1992, the Gaspésie Caribou Recovery Team removed 70 coyotes and 37 black bears from the Park (Crête and Desrosiers 1995). By 1992, calf survival improved. Human access in the Mont McGerrigle area was restricted to lessen the potential of caribou fleeing to forest cover, where calves were more vulnerable to coyotes (RENEW 1994).

In Idaho and southern B.C., predation by mountain lions is an important limiting factor. That species could become more numerous in other parts of the range of forest-dwelling caribou if other ungulates increase in number and the climate warms. There are few data on the relative vulnerability of ungulates to various predators (Dale *et al*. 1995, Thomas 1995). Caribou in some locations of the Cordilleran Mountains are subject to predation by grizzly bears, black bears, wolves, coyotes, mountain lions, wolverine (*Gulo gulo*), lynx, and golden eagles. The additive effects of mortality from so many predator species must severely limit caribou populations.

Because predation rate can be measured, its influence can be oversold unless one is vigilant to separate proximate from ultimate factors and consider ecological relationships and interaction of limiting factors. For example, predation may become a problem because of habitat fragmentation and alteration, creating abundant food and niches for other ungulate species. Managing ungulates at high populations for hunting increases predator numbers. Studies in Alberta confirm empirical observations that wolves tend to travel roads and other linear corridors through caribou habitat. The same applies to coyotes (*Canis latrans*). Peatlands afford caribou relative security from wolves, which tend to frequent dry ground (Bradshaw *et al*. 1995, James 1999, James and Stuart-Smith 2000). Rate of travel by wolves in winter was 2.8 times faster in linear corridors than in the forest (James 1999). However, wolves travel rapidly through peatlands in spring when an icy crust forms on the snow surface.

Weather

Weather (short term) and climate (long term) are known to be the most important limiting factors for caribou in the High Arctic (Miller 1990, Gunn *et al*. 2000). Adverse weather can suspend reproduction for up to 3 years (Thomas 1982) and cause mortality of calves (Miller 1974) and adults (Adamczewski *et al*. 1993, Miller 1990). Weather is also a significant factor in the Arctic and subarctic (Edmonds and Smith 1991, Boertje *et al*. 1996, Adams and Dale 1998, Finstad and Prichard 2000). A large and growing literature indicates that weather affects all aspects of the ecology of caribou. However, the effects of unfavourable weather on caribou often are indirect and subtle – a small decline in pregnancy rate and survival of calves (Adams *et al*. 1995, Boertje *et al*. 1996) and adults through increased vulnerability to wolf predation (Adams *et al*. 1995, Valkenburg *et al*. 1996). Weather and demographic variables typically are not measured with adequate sample sizes over sufficient time to establish a significant correlation. Establishing cause and effect is even more demanding. Only extreme weather that results in large changes in demographics is recorded. For example, decreases in numbers of woodland caribou in Saskatchewan were associated with deep snow in 1971-72 and 1973-74, combined with unsustainable hunting and predation (Rock 1992).

Caribou can forage through up to a metre of snow or more (Brown and Theberge 1990) but at a cost to energy reserves.

The effect of severe winters may be reduced survival among calves (Miller 1974) but such relationships are difficult to detect because of confounding factors such as predation. Studies of reindeer in Alaska clearly indicate effects of weather because large samples are available and there is some control of confounding factors. Weather affected forage quality, which influenced growth and age of first conceptions in reindeer (*R. t. tarandus*) (Finstad and Prichard 2000). Shallow snow followed by warm weather in May and June and cool temperatures in July were conditions that resulted in calves becoming pregnant. There may be lag effects that dictate that several seasons of weather data and caribou demographics must be evaluated.

Calf survival in caribou and reindeer is related to weight at birth (Boertje *et al*. 1996). Birth weight, in turn, is related to reproductive history the previous year and availability of food in winter (e.g., Adams and Dale 1998) and particularly in the last trimester of pregnancy. Gestation is delayed in undernourished females (Cameron *et al*. 1993, Bergerud 2000). Adaptation to a compressed period of breeding and births (Dauphiné 1976) implies that survival is highest at the peak of calving in most years. Selection for an average optimal time for calving involves multiple factors with energetics and predation being primary. Therefore, weather can have subtle yet significant biological effects that often go undetected.

Forest-dwelling caribou have adapted to a wide range of climate – from areas of high precipitation in mountains of southern B.C. to relatively dry conditions on the central plains of western Canada. Vegetation composition varies primarily with climate and caribou have adapted their winter feeding behavior accordingly. Small populations on the southern periphery of the range are vulnerable to climatic warming and greater weather variability. Detrimental effects could include a greater temporary range loss from fire, freezing rain, thaw periods in winter, deep snow over terrestrial lichens, loss of snowbanks in summer, hot weather in early summer, and changes to food supplies. They were in marginal habitat before climatic change and industrial activity.

Some populations that were protected from development, such as one in south Jasper National Park, declined from the 1960s to the early 1990s (Stelfox *et al*. 1978, Brown *et al*. 1994). However, the relative roles of weather, predation, development, and their interactions could not be partitioned (Brown *et al*. 1994, Thomas and Armbruster 1996a). Snow conditions affected predation by forcing caribou to winter in valley bottoms among other ungulates and wolves (Brown *et al*. 1994). An example of interaction of variables was increased predation of caribou when spring migration was delayed because of deep snow (Edmonds and Smith 1991). Adverse weather for 4 years, combined with high wolf densities, caused the Delta population in Alaska to decline from 10 690 to 3 660 (Boertje *et al*. 1996).

Another example of linked variables is the effect of weather on parasites. Weather affects the abundance of *Elaphostrongylus rangiferi*, which caused a near 3-fold decline

in the Avalon population in Newfoundland (Ball *et al*. 2001). Weather affects all other variables or factors that limit caribou populations. A concern related to climate warming is drying of peatlands, which would increase their probability of burning, would affect food supplies of caribou, and would increase access by predators. Drying of peatlands was noted in the 1980s and early 1990s in Saskatchewan (T. Rock pers. comm. 1995). Dry conditions culminated in many large fires in eastern Alberta and Saskatchewan in 1995 and 2002. Draining peatlands to improve tree growth and extraction of peat are concerns. Mushroom gathering in lichen-rich pine forests is potentially detrimental to caribou.

Hunting

Hunting is implicated in many declines in caribou (Kelsall 1968, Bergerud 1974, 1978). Nevertheless, obtaining accurate harvest data continues to be a major information deficiency. Hunting is generally considered additive to other limiting factors and therefore any reduction in hunting mortality is beneficial to a declining caribou population. Caribou populations in large undisturbed areas, where predators are not managed, can withstand only 2-3% annual mortality from hunting (Yukon Renewable Resources 1996). The huntable proportion is zero in marginal habitats modified by multiple predators and human developments. Hunting mature males will not harm a population provided that an adequate proportion survives to breed females.

Caribou declines in B.C. were investigated in the 1970s (Bergerud 1978) and hunting subsequently was reduced or curtailed in some populations. There are limited entry and open seasons for bulls with at least five tines on one antler in the north central and west central metapopulations. Limited hunting of “mountain” caribou in the Kootenay region lasted until 1996. In 2001, no recreational hunting was permitted in the southern metapopulation.

Recreational hunting of forest-dwelling woodland caribou was closed in Ontario, Alberta, Saskatchewan, and Manitoba in 1929, 1981, 1987, and 1992, respectively (Table 9). Hunting permits are issued for the Cape Churchill population of forest-tundra caribou and, in 1997-98, 178 caribou were killed (Elliott 1998). The Pen Island population of forest tundra caribou also is hunted. In the 1980s, an estimated 600 to 700 caribou were harvested annually under Treaty rights in all of Ontario (Darby *et al.* 1989). No current figures are available. Uncontrolled hunting complicates assessment and management of woodland caribou in Ontario (Harris 1999) and all other jurisdictions.

Forest-dwelling (sedentary) caribou are hunted in northern parts of their general distribution in Quebec. There are limited entry hunts for residents with (zone 23S) and without (zone 22A) outfitters or outfitted hunts for residents and non-residents (zone 22B). Limits are two caribou per hunter (FAPAQ 2002). In winter, areas occupied by sedentary caribou are invaded by the Leaf River and George River populations so the proportionate kill of each ecotype is unknown. Caribou hunting is not permitted in any of Quebec's wildlife reserves (reserves fauniques), hunting reserves, or parks. In 1981, the Grands-Jardins Conservation Park, an area of 310 km^2, was created to conserve an

important part of caribou habitat in the Charlevoix region (Banville 1998). Caribou hunting was banned in the Gaspésie in 1937 (Boileau 1996).

Growth of the Avalon population from 125 in 1956 to 2 500-3 000 in 1979 was attributed to reduction of poaching (Bergerud 1980). Hunting of caribou in Newfoundland is promoted as part of the sports and tourism industry and to manage population growth. Licensed guides must accompany non-resident hunters.

Unregulated hunting was a high or moderate concern for 70% of local populations in the NMP, 30% in the SMP, and 42% in the BP exclusive of Ontario and Quebec (Table 7). In Yukon, the average annual harvest by licensed hunters declined from over 300 in the 1980s to 271 in the 1990s. Harvest has been restricted to bulls since 1984 and six populations were closed to hunting. Hunting by First Nations is suspected to equal that of licensed hunting (Farnell *et al*. 1998).

In the NWT, harvest of the South Nahanni and Redstone populations may not be sustainable (Adamczewski and Veitch 1998). In 1996, Mackenzie Mountain outfitters reported a legal kill of 172 bulls. There is no closed season or limit for holders of a General Hunting Licence in the NWT. Resident and non-resident hunters are permitted one caribou in specific hunting areas south of 68^{o} N (Gray and Panegyuk 1989).

Parasites

Insects are potentially a major limiting factor for caribou. Effects include parasite and disease transmission, harassment, loss of blood, and immune system reactions. Important insects include warble flies (*Oedemagena* spp.), nose bot flies (*Cephenomya trompe*), mosquitoes (*Aedes* spp.), black flies (*Simulium* spp.), horseflies (*Tabanus* spp.), and deer flies (*Chrysops* spp.). Kelsall (1975) noted that the highest average counts of warble fly larvae in infected caribou were in the mountains of Alberta, B.C., and Yukon. Use of snowbanks by caribou in summer is likely to be a response to insect harassment. The severity of insect harassment is weather related and observed climatic warming could add to the problem. Summer behaviour of caribou is greatly influenced by actions to reduce exposure to insects and insect-borne parasites. The effect of insect harassment on the fitness of forest-dwelling caribou is unknown. Physical condition and pregnancy incidence was inversely related to numbers of warble larvae in female barren-ground caribou >2 years old (Thomas and Kiliaan 1990).

Also poorly known are the incidence and prevalence of internal parasites and their effects. Mature and old woodland caribou are likely to have a relatively high incidence and prevalence of hydatid cysts (*Echinococcus granulosis*). The adult tapeworm resides in canids and it cycles through snails, moose, and caribou. A large number of large cysts in the lungs could make a caribou susceptible to predators, thus completing the cycle.

The protostrongylid nematode, *Parelaphostrongylus andersoni*, is widely distributed in woodland and barren-ground caribou of mainland Canada (Lankester and Hauta 1989). Though it may not cause neurologic disease in wild cervids, its eggs and

larvae develop in the lungs and an inflammatory reaction contributes to verminous pneumonia. A related meningeal nematode, *P. tenuis*, causes neurologic disease in cervids, including caribou. That parasite, benign in white-tailed deer, is potentially a limiting factor for woodland caribou (Pitt and Jordan 1994) and may be a threat to caribou in southern Ontario and west to Saskatchewan. Meningeal worms may be artificially spread in western Canada through game ranching (Samuel *et al.* 1992). A protostrongylid nematode introduced with reindeer from Norway, *Elaphostrongylus rangiferi*, has become established in Newfoundland caribou (Lankester and Fong 1998). It does not cause neurologic disease but it can induce pneumonia in young calves (Ball *et al.* 2001) and was implicated in a decline in the Avalon population from 7 000 to 2 500 individuals over 3 years (Lankester and Fong 1998).

Other limiting factors

Accidents always account for a small proportion of deaths though avalanches accounted for most deaths in one study of the Mount Revelstoke population in B.C. (Simpson *et al*. 1985). Caribou are excellent swimmers but drownings occur at rapids, when crossing lakes in rough water, and when falling through thin ice.

Recreational activities such as snowmobiling, boating, horseback riding, hiking particularly with dogs, and hunting modify the distribution of caribou with unknown effects.

SPECIAL SIGNIFICANCE OF THE POPULATIONS

About 99.98% of individuals of the subspecies *caribou* reside in Canada, including about 1.1 million in Quebec/Labrador (Caribou Quebec 2000) and more than 19 000 on the Hudson Plain (Harris 1999, Elliott 1998). However, the forest-dwelling ecotype numbers only 184 000 caribou of which 78% occur in the Northern Mountain and Newfoundland populations (Table 1). Several local populations of forest-dwelling caribou in the Southern Mountain and Boreal populations are likely to disappear over the next few decades. A challenge will be to keep those two COSEWIC populations, now estimated to number 7 200 and 33 000 caribou, from becoming *endangered*.

Humans and caribou evolved together in Asia, Europe, and North America (Banfield 1961, Kelsall 1984). Caribou have a special spiritual and cultural significance to many indigenous people because of a long association where life and death was in delicate balance. Caribou are of great symbolic importance to Aboriginal people. Local knowledge is important in assessments of caribou populations in Canada because scientific studies are few, complex, and expensive.

Recreational hunting of forest-dwelling woodland caribou is of economic importance in Yukon, northern B.C., and Newfoundland. Wildlife tourism is important in many parts of Canada occupied by caribou. For example, caribou are likely to be seen in spring along the Alaska Highway in northern B.C. on the Avalon Peninsula in Newfoundland, and in Jasper National Park.

Woodland caribou have a special significance as an indicator of changes to old-growth forests. They provide food for several predators and scavengers and are a symbol of near-wilderness. Caribou are also symbols of a healthy natural environment and reduced local populations in areas where old-growth forests have been seriously reduced indicate that human activities are altering their range and the ecosystem to a significant degree. Woodland caribou foster cross-border management by provincial and federal agencies and co-management boards.

EXISTING PROTECTION OR OTHER STATUS

The role of protected areas in safeguarding caribou habitat was discussed above and is summarized in Appendix 2. Such areas will not sustain most local populations without special provisions for caribou in landscape management outside them.

In 1984, caribou in the Selkirk Mountains of Idaho and Washington were listed as *endangered* by the U.S. Fish and Wildlife Service under the U.S. Endangered Species Act. Where available, ranks established by provinces and territories and provincial Conservation Data Centres and Natural Heritage Information Centres are given for each COSEWIC population (Table 10).

SUMMARY OF STATUS REPORT

At-risk designators should consider four of eight COSEWIC NEAs, which have distinct populations. The Newfoundland population is treated separately from the Boreal population. The genetics of more local populations must be sampled before the systematics can be clarified. Caribou in the Cordilleran Mountains differ from those to the east. Caribou in the southern mountains are mixtures of two founding clades with the northern clade predominating. Sampled populations in central and southern Yukon are entirely of northern origin. Phenological data suggests that caribou in the Northern Mountain NEA are likely to be of northern origin. They once were given subspecies status. All caribou in the Southern Mountain NEA are likely to be mixed populations, that is, derived from northern and southern clades. That is justification for treating the Northern Mountain population separately from the Southern Mountain. Limiting factors and management concerns also differ markedly between the populations (Table 7). Winter feeding obligations would appear to be less important in separating groups of caribou. For example, caribou in south Jasper National Park adopt both terrestrial and arboreal feeding behaviours.

Caribou in Newfoundland probably have been isolated for thousands of years and therefore have no introgression of genes from the northern clade. The same likely is true for the Gaspésie population, which may be depauperate from inbreeding and genetic drift. Both of these COSEWIC populations can be considered genetically distinct. The Pukaskwa local population also was only of southern origin; however, only four caribou were examined.

Based on results for three local populations in the Boreal population (Fig. 2), it is expected to be a mixed population predominantly derived from the southern clade. This justifies separating it from Southern Mountain and Newfoundland populations.

Justification for excluding forest-tundra (taiga-tundra) caribou includes a mixed origin, migratory behaviour, and differences in demographics, predator prey relationships, and current and future habitat loss and alteration from human activities. Caribou in commercial forests are most at risk. What may conserve some of them is their ecological niche – the use of large peatland complexes where timber values are low. Such complexes require forest buffers and movement corridors. Of concern is desiccation of peatlands from climate warming, peat extraction, and draining to enhance tree production.

Assessment of the status of the five COSEWIC populations should be based on habitat trends, numbers and trends in numbers, areas occupied by local populations, concerns for threats and limiting factors, degree of monitoring, state of current knowledge, and significance of protected areas. Those data were collated from all jurisdictions in an attempt to standardize data. The indicators of population status developed for this report will permit an objective tracking of changes in the next status report. Indicators of population status in this report should be ranked in importance and new ones developed that place more emphasis on past and predicted habitat change (Appendix 4). Monitoring and mapping of distributions in GIS systems is important because demographics are difficult to measure and are highly variable. Predicting trends in habitat supply is a critical data requirement. For example, areas of usable ("effective") habitat will quickly decline as the second pass in two-pass forest harvest system is achieved.

Not enough is known about the ecology of local populations to calculate the probability of survival under specified future conditions. Data requirements for predicting population viability include five "process" variables: demographic, genetic, and environmental stochasticity (variability), density dependence, and catastrophe, as well as five population variables: population size, age structure, sex ratios, life history traits (presumably fecundity and mortality), and habitat quality and availability (Reed et al. 1998). Beissinger and Westphal (1998) list 23 variables of which 4, 10, 19, and 23 must be measured for four increasingly complex models used in population viability analysis. Seldom are data adequate for any of the variables. Therefore, current status of local populations and COSEWIC populations and any prediction of change are accompanied by a high degree of uncertainty. Uncertainty includes demographics of populations, degree of environmental change, and management policy. We can only assume that changes over the past decade or two will continue at the same rate or will accelerate.

Northern Mountain population (NMP)

The population estimate in 2000/2001 is about 44 000 in 36 local populations (Table 2, Appendix 1a). Most local populations are about stable with increases about balancing decreases. Four local populations are up in number, 15 are about stable,

3 are down, and trends for 14 are unknown (Table 3). In 1996, trends in numbers were 5 increasing populations, 11 stable, 3 decreasing, and 19 unknown (Table 2) (Farnell *et al.* 1998, Heard and Vagt 1998). Populations of unknown status generally are in remote areas with few developments. Local population numbers are larger than 250 and 500 for 75% and 56% of the populations (Table 4). All but 3 of 32 local populations have ranges larger than 2 000 km^2 and 20 and 13 are in ranges larger than 5 000 and 10 000 $km,^2$ respectively (Table 5). Greatest concerns are hunting, predation, and fire (Table 7). Population estimates are obtained occasionally for 79% of known local populations and radio collars were deployed on 59% of them (Table 8). The habitat, with a few exceptions, is relatively intact though there is increasing fragmentation from roads and other linear developments. There is a likelihood that the rate of development will increase over the next decades and management of wolves and unregulated hunting and will be difficult.

Southern Mountain population (SMP)

Numbers declined in the 1970s and 1980s from population highs in the 1960s subsequent to wolf control (Bergerud 1978, Edmonds and Bloomfield 1984, Edmonds 1988). They also declined in a protected population in south Jasper National Park (Stelfox *et al*. 1978, Brown *et al*. 1994). In studies of radio-collared caribou, wolf predation was the primary source of mortality.

In B.C, extent of occurrence has shrunk by up to 40% and most of that concerns the SMP. Many local populations are small, highly fragmented, and subject to rapid loss and alteration of habitat because of multiple industrial developments. Altered habitat has subjected local populations to multiple increased threats including predation, more parasitism, and greater unregulated hunting.

The population estimate is about 7 200 (6 300 adults) in 30 local populations. Trend in numbers is down for 12 of 30 local populations and stable in 13 (Table 3). Population status has deteriorated since 1996, when three local populations were considered to be increasing, eight were stable, and seven were decreasing (Table 2) (Heard and Vagt 1998, Edmonds 1998). Numbers are a concern as all but two of the 30 local populations contain fewer than 500 caribou, 21 contain fewer than 250, and 8 contain fewer than 50 caribou (Table 4). Range sizes are relatively small with 63% (19/30) of the populations occupying less than 5 000 km^2 (Table 5). The primary concern is the effects of forestry and other developments including increased access and disturbance, actual and functional loss of habitat, increased isolation of local populations, and increased predation (Table 7). Predator-prey relationships have changed and there is increased access by predators and hunters. The degree of monitoring is high with numbers estimated annually or occasionally for 97% of the local populations (Table 8). Radio collars were used on 87% of the local populations to monitor movements, habitat use, and mortality. Most of the 150+ caribou collared in west-central Alberta (Dzus 2001) were the “mountain” ecotype.

The South Selkirk population, is officially listed as endangered in the United States. Cougar predation, habitat changes from human activities, and wildfires are primary concerns (Zager *et al*. 1996). The South Purcell's population is in dire straits and is unlikely to persist because of habitat changes and increased numbers of predators. Translocation of caribou from another population to the South Purcells is proposed by Kinley and Apps (2001). The Alberta government declared caribou to be threatened in 1985 (Edmonds 1988, Alberta Environmental Protection 1996). In 1991, caribou were placed on the Red List (risk of local extirpation) and in 1996 downgraded to the Blue List (may decline to non-viable population levels).

Concern for caribou in the Southern Mountain and Boreal populations stems partly from current trends in numbers (Tables 2 and 3) and shrinking distributions (Fig. 4 and 5). Assuming continuation of a 2.47% annual rate of decline from 1997 to 2002 in B.C., numbers are projected to decline 39% in the next 20 years. Of great concern is future declines in habitat quantity and quality, increased isolation of small local populations (Table 4) in small geographic areas (Table 5), and increased predation. Caribou are unlikely to persist in areas undergoing extensive and intensive development unless predation and hunting are almost eliminated and there are special provisions to maintain adequate security habitat and food supplies in large blocks of forest of medium and old ages.

Boreal population (BP)

Concerns are similar to those for the Southern Mountain population except that there is even more intense development in some parts of the range because of multiple resource extraction and protected areas make up a small proportion of areas occupied by caribou. Extent of occurrence has shrunk about 40% from generalized historical distributions in Alberta and Ontario. However, some of the range within historical extent of occurrence was unsuitable for caribou. Range retractions are less in Saskatchewan and Manitoba. Areas of current occupancy may be reduced to less than half of historical distributions.

An estimated 33 000 caribou occur in at least 64 local populations that are scattered over a vast area from the Mackenzie Delta to the coast of Labrador. A major challenge is to maintain connectivity among local populations to ensure gene flow and genetic diversity. The provinces and territory must cooperate in that objective for many populations are inter-jurisdictional.

Most (12) local populations of 19 with trend data are considered to be decreasing in number (Table 3). However, those trend data are available only for the Prairie Provinces and Labrador (Table 2) and represent only about 35% of range occupied by forest-dwelling woodland caribou (S. Carriere pers. comm. 2001). There is much uncertainty about what is happening in the remainder of the range, much of it in Ontario and Quebec. Factors that adversely affect woodland caribou (Table 7) are similar across the range of the Boreal population. Development is intense in the commercial forest, in petroleum producing areas, and in mineral-rich areas. Forestry will have

accelerated effects on caribou across Canada as the second pass (cut) is made in 'two pass' systems. Most of the forest then will be too young to produce caribou forage unless special provisions are made for caribou within areas of occupancy. If climatic warming continues, summer forage will be reduced in peatlands and fires reduce winter range in peatlands and upland forests.

The Alberta government declared woodland caribou to be threatened in 1985 (Edmonds 1998). Harris (1999) suggested a ranking of threatened for the forest-dwelling ecotype in Ontario. The status of forest-dwelling caribou in other jurisdictions appears to be similar. Concern for the status of woodland caribou has been a factor considered in the expansion of protected areas in B.C., Alberta (Caribou Mountains), Ontario (Duinker et al. 1998), and other provinces and territories.

Kelsall (1984) considered that woodland caribou were secure in the NWT and threatened in Alberta, Saskatchewan, and along the southern fringes of its range in Manitoba, Ontario, and Quebec. Some small local populations and subpopulations in southern parts of the Boreal NEA have disappeared or are likely to. There are examples in all provinces. Many of the boreal populations occur in areas of intense development, which fragments populations and metapopulations, alters predator-prey relationships, introduces parasites, and provides access for hunters. In sharp contrast, forest-tundra ecotypes within COSEWIC's Boreal NEA are 5-6 times more numerous than forest-dwelling caribou, are not considered to be at risk, and are excluded from designation. Those migratory populations include George and Leaf River in Quebec/Labrador, unnamed local populations primarily in taiga west of James Bay and south of Hudson Bay, Pen Island in Ontario/Manitoba, and the Churchill in Manitoba. We recommend that the forest-tundra ecotype be included in the Arctic NEA or in a new Taiga NEA.

Newfoundland population (NP)

Recent information suggests an increasing population of approximately 100 000 caribou (Mahoney 2000) an increase of 25% over the previous estimate in 1996 (Mahoney and Schaefer 1996). Of 27 local populations, 18 are larger than 500 individuals. There may be another 10 small local populations whose status is not known. The greatest risk may be overexploitation of range.

Atlantic (Gaspésie) population

The Centre de données sur le patrimoine naturel du Quebec (CDPNQ) gave the Gaspésie population a status of *susceptible* (Huot pers. comm. 1997). Crête *et al.* (1994) suggested that "I*t would likely be more accurate to classify the Gaspésie caribou herd as endangered rather than threatened.*" Its low numbers qualify it for *endangered* ranking under COSEWIC guidelines.

This population is protected within Quebec's Gaspésie Conservation Park. Even so, the mining industry wanted to modify park boundaries (RENEW 1993). Of concern was the small size of the population, that is, 200 to 250 from 1993 to 1996. Also of

concern until 1993 was a low survival rate of calves due to predation by coyotes and bears (RENEW 1993). A Recovery Plan, accepted in 1992 and revised and published in 1994, included recommendations for coyote control, studies of coyote ecology, information on caribou demography, and control of tourist activities. A major goal was to ensure that the population remained above 200 caribou (RENEW 1994). The population may persist with predator control leading to improved calf survival (Crête and Desrosiers 1995). In 1995, a recovery team was disbanded after objectives were achieved (RENEW 1999). However, recent information suggests further declines and a need for continued intensive management including reduced forest operations outside the park (Fournier 2001).

The population is geographically isolated in an island of boreal forest south of the St. Lawrence River and it represents the only caribou in the Atlantic NEA. The small population size and small area of occupation mean that it is susceptible to genetic drift and inbreeding depression and chance extinction by rare climatic events.

TECHNICAL SUMMARY 1

Rangifer tarandus caribou
Forest-Dwelling Woodland Caribou Caribou des bois
Northern Mountain Population
Distribution: Yukon and western Northwest Territories and northern British Columbia

Extent and area information	
• *Extent of occurrence (EO)(km²)*	308 000 +
• *Trend (decline, stable, increasing, unknown)*	About stable
• *Extreme fluctuations in EO (> 1 order)?*	No
• *Area of occupancy (AO) (km²)*	308 000
• *Trend (decline, stable, increasing, unknown)*	About stable
• *Extreme fluctuations in AO (> 1 order)?*	No
• *Number of extant locations*	36
• *Trend (decline, stable, increasing, unknown)*	Stable
• *Extreme fluctuations? (>1 order of magnitude)?*	No
• *Habitat trend: declining, stable, increasing or unknown*	Declining
Population information (LP = local populations that comprise Northern Population)	
• *Generation time (average age of parents)*	6.7 years
• *Number of mature individuals (capable of reproduction)*	37 400 (44 000 x 0.85)
• *Trend: (loc. pop. decreasing/ stable/ increasing/ unknown)*	About stable (LP:3/15/4/14)
• *% decline in 20 years (or shorter period)*	Data inadequate
• *Extreme fluctuations in number (>1 order)?*	No (some local pop, yes)
• *Population severely fragmented? (<1 migrant / year)?*	Unknown
• *List each local population & its numbers*	Appendix 1a
• *Trend in no. of populations (decline, stable, etc.)*	Stable
• *Extreme fluctuation in no. of local populations?*	No
Threats to populations or habitats: Unregulated hunting, predation, fire, low numbers, Access and disturbance, isolation (fragmentation), forestry and other developments, and lack of available habitat (in order of estimated magnitude)	
Rescue effect (immigration from an outside source unlikely to be successful if indigenous die out)	
• *Does species exist elsewhere (in Canada or outside)?*	Yes, but differ
• *Status of the outside populations?*	Variable
• *Is immigration known or possible?*	Possible
• *Would immigrants be adapted to survive here?*	Probably
• *Is there sufficient habitat for immigrants here?*	Yes (not applicable)
Quantitative Analysis	None

TECHNICAL SUMMARY 2

Rangifer tarandus caribou
Forest-Dwelling Woodland Caribou Caribou des bois
Southern Mountain Population
Distribution: Central & southern British Columbia and Mountains and Foothills of Alberta

Extent and area information	
• *Extent of occurrence (EO)(km²)*	136 000 +
• *Trend (decline, stable, increasing, unknown)*	Ca. 40% decline in 150 yr
• *Extreme fluctuations in EO (> 1 order=100%)?*	Not extreme but large
• *Area of occupancy (AO) (km²)*	136 000
• *Trend (decline, stable, increasing, unknown)*	Decline (from historical)
• *Extreme fluctuations in AO (> 1 order)?*	No
• *Number of extant locations (local populations)*	30
• *Trend (decline, stable, increasing, unknown)*	Stable (future decline likely)
• *Extreme fluctuations? (>1 order of magnitude)?*	No
• *Habitat trend: declining, stable, increasing or unknown*	Declining
Population information (LP = local populations that comprise Southern Population)	
• *Generation time (average age of parents)*	6.7 years
• *Number of mature individuals (capable of reproduction)*	6 300 (7 200 x 0.88)
• *Trend: (loc. pop. decreasing/ stable/ increasing/ unknown)*	Decreasing (12/13/0/5)
• *% decline in 20 years (or shorter period)*	Inadequate data
• *Extreme fluctuations in number (>1 order)?*	Unknown
• *Population severely fragmented? (<1 migrant / year)?*	Yes, increasingly so
• *List each population & its numbers*	Appendix 1b
• *Trend in no. of populations (decline, stable, etc.)*	About stable, forecast decline in next 20 years
• *Extreme fluctuation in no of local populations?*	No
Threats to populations or habitats: Predation, access and disturbance, forestry and other developments, limited available habitat, isolation (fragmentation), low numbers, and unregulated hunting (in order of estimated magnitude) (magnitude increasing)	
Rescue effect (immigration from an outside source unlikely to survive if indigenous die out)	
• *Does species exist elsewhere (in Canada or outside)?*	Yes (may be different ecotype)
• *Status of the outside populations?*	Variable
• *Is immigration known or possible?*	Possible
• *Would immigrants be adapted to survive here?*	Unknown
• *Is there sufficient habitat for immigrants here?*	Yes, but quality may be inadequate
Quantitative Analysis	None

TECHNICAL SUMMARY 3

Rangifer tarandus caribou
Forest-Dwelling Woodland Caribou Caribou des bois

Boreal Population

Distribution: Northwest Territories and northeastern British Columbia to Labrador

Extent and area information	
• *Extent of occurrence (EO)(km²)*	>1 143 613 (+ ON & QC)
• *Trend (decline, stable, increasing, unknown)*	Decline. (40% decline in AB & ON)
• *Extreme fluctuations in EO (> 1 order)?*	No
• *Area of occupancy (AO) (km²)*	1 143 613 (+ ON & QC)
• *Trend (decline, stable, increasing, unknown)*	Decline from historical; to 60% (AB)
• *Extreme fluctuations in AO (> 1 order)?*	No
• *Number of extant locations excluding Ont. & Que.*	**34-52 (SK 3-21)**[1]
• *Trend (decline, stable, increasing, unknown)*	Decline from historical. Subpop. lost across range
• *Extreme fluctuations? (>1 order)?*	No (yes for local populations)
• *Habitat trend: declining, stable, increasing or unknown*	Declining rapidly where development; outlook poor in commercial forest
Population information (LP = local populations that comprise Boreal Population)	
• *Generation time (average age of parents)*	6.7 years
• *Number of mature individuals (reproductive)*	29 000 (33 000 x 0.88)[2]
• *Trend: (decreasing/ stable/ increasing/ unknown)*	Decreasing (LP: 12/6/1/33)
• *% decline in 20 years (or shorter period)*	Unknown. Loc. pop. declines in Labr. of 75-80%. Also decreases in AB, SK
• *Extreme fluctuations in number (>1 order)?*	Unknown
• *Population severely fragmented? (<1 migrant /yr)?*	Yes, in parts of range
• *List each population & its numbers*	Appendix 1c
• *Trend in no. populations (decline, stable, etc.)*	Increase (more effort)
• *Extreme fluctuation in no. of local populations?*	No
Threats to populations or habitats: Forestry operations, increased predation, other developments, fire, unregulated hunting, isolation and small local populations (fragmentation), and climatic warming (threats of some factors likely to increase)	
Rescue effect (immigration from an outside source unlikely to survive if indigenous die out)	
• *Does species exist elsewhere (in Canada or outside)?*	Yes (different genes, ecotype)
• *Status of the outside populations?*	Variable
• *Is immigration known or possible?*	Possible
• *Would immigrants be adapted to survive here?*	Unknown
• *Is there sufficient habitat for immigrants here?*	Yes, but unlikely to be successful
Quantitative Analysis	None

[1]Saskatchewan reported the status of caribou in 3 ecoregions. Subsequently, 18 local populations were mapped (Godwin and Thorpe 1999) and 7 regional groups of caribou (metapopulations?) were mapped (Arsenault pers. comm. 2001). When maps are combined, there are 21 distributions.

[2]Calves are assumed to constitute 12% of the population.

TECHNICAL SUMMARY 4

Rangifer tarandus caribou
Forest-Dwelling Woodland Caribou Caribou des bois
Newfoundland Population
Distribution: Main Island and offshore islands of Newfoundland

Extent and area information	
• *Extent of occurrence (EO)(km²)*	66 263 +
• *Trend (decline, stable, increasing, unknown)*	Recent stability
• *Extreme fluctuations in EO (> 1 order)?*	Yes (decline then increase)
• *Area of occupancy (AO) (km²)*	66 263
• *Trend (decline, stable, increasing, unknown)*	Yes (decline then increase)
• *Extreme fluctuations in AO (> 1 order)?*	Yes
• *Number of extant locations*	27 with known status
• *Trend (decline, stable, increasing, unknown)*	Yes (decline then increase)
• *Extreme fluctuations? (>1 order of magnitude)?*	Yes
• *Habitat trend: declining, stable, increasing or unknown*	Stable – decline
Population information	
• *Generation time (average age of parents)*	6.7 years
• *Number of mature individuals (capable of reproduction)*	85 000
• *Trend: (decreasing/ stable/ increasing/ unknown)*	Increasing (LP: 0/11/15/0)
• *% decline in 20 years (or shorter period)*	Not applicable
• *Extreme fluctuations in number (>1 order)?*	Yes
• *Population severely fragmented? (<1 migrant / year)?*	Unknown
• *List each population & its numbers*	Appendix 1d
• *Trend in no. of populations (decline, stable, etc.)*	22 introduced
• *Extreme fluctuations in no. of local populations?*	Yes
Threats to populations or habitats: Access and disturbance (moderate for 82% LP), predation (moderate for 74% LP), forestry (moderate for 56% LP), fire (moderate for 41% LP). Introduced parasite caused a sharp decrease in the Avalon local population.	
Rescue effect (immigration from an outside source) (not applicable)	
• *Does species exist elsewhere (in Canada or outside)?*	Yes (genotypes differ)
• *Status of the adjacent populations?*	*Threatened*
• *Is immigration known or possible?*	No
• *Would immigrants be adapted to survive here?*	Yes
• *Is there sufficient habitat for immigrants here?*	Unlikely (not applicable)
Quantitative Analysis	None

TECHNICAL SUMMARY 5

Rangifer tarandus caribou
Forest-Dwelling Woodland Caribou Caribou des bois
Atlantic (Gaspésie) Population
Distribution: Gaspésie Conservation Park, Gaspé Peninsula, Quebec

Extent and area information	
• *Extent of occurrence (EO)(km²)*	About 1 000
• *Trend (decline, stable, increasing, unknown)*	Recent stability
• *Extreme fluctuations in EO (> 1 order)?*	Not in last 20 years
• *Area of occupancy (AO) (km²)*	1 000
• *Trend (decline, stable, increasing, unknown)*	About stable in last 20 yr.
• *Extreme fluctuations in AO (> 1 order)?*	Historically yes, recent stability
• *Number of extant locations*	One (2 subpopulations)
• *Trend (decline, stable, increasing, unknown)*	Recent stability
• *Extreme fluctuations? (>1 order of magnitude)?*	Historically yes, recent stability
• *Habitat trend: declining, stable, increasing or unknown*	Past decline, recent stability
Population information	
• *Generation time (average age of parents)*	6.7 years
• *Number of mature individuals (capable of reproduction)*	<150
• *Trend: declining, stable, increasing or unknown*	Recent decline (variable)
• *% decline in 20 years (or shorter period)*	About stable
• *Extreme fluctuations in number (>1 order)?*	Historically yes, recent stability
• *Population severely fragmented? (<1 migrant / year)?*	Completely isolated
• *List each population & its numbers*	Gaspésie, <200
• *Trend in no. of populations (decline, stable, etc.)*	No change
• *Extreme fluctuations in no. of populations?*	No
Threats to populations or habitats: Low number (inbreeding depression, catastrophe), limited available habitat (no optional range if severe snow or ice), isolation, predation (coyotes and bears), disturbance by hikers, fire, climate change.	
Rescue effect (immigration or translocation from an outside source unlikely to survive if indigenous population dies out. Additions may improve genetic diversity)	
• *Does species exist elsewhere (in Canada or outside)?*	Yes but different genotypes
• *Status of the outside populations?*	Variable – too distant for
• *Is immigration known or possible?*	Not possible naturally
• *Would immigrants be adapted to survive here?*	Unknown
• *Is there sufficient habitat for immigrants here?*	Questionable. Very small range & population size
Quantitative Analysis	None

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Donald C. Thomas

Don was born in North Battleford, Saskatchewan, and spent his early years on a farm. From 1958 through 1962, summers were spent assisting biologists of the Canadian Wildlife Service (CWS). Most of that work was on barren-ground caribou but it also included a survey of wildlife on the Queen Elizabeth Islands. In 1962, he completed an Honours BA in Biology at the University of Saskatchewan under direction of Dr. Donald Rawson. His Ph.D. was on reproduction in black-tailed deer at the University of British Columbia as directed by Ian McTaggart Cowan. While at UBC, he did contract work for CWS involving aerial surveys of the large mainland populations of caribou and on age determination of wolves and bears. After a Post-Doctorate at Cambridge University (UK) with Sir Richard Harrison, head of the Anatomy Department, he was briefly a consultant for F.F. Slaney and Co. before taking a permanent position with CWS in 1982.

His research with CWS involved Peary, barren-ground, and woodland caribou and their habitats from the High Arctic Islands to Jasper and Prince Albert National Parks. Two of those studies involved the effects of forest fires on caribou and their habitat. He served as Environment Canada's representative on the Beverly and Qamanirjuak Caribou Management Board from 1987 through 1999. In 2000, he received the Centenary Medal for northern science from Indian and Northern Affairs Canada. After semi-retirement in 1998, he has continued to write reports and publications when not travelling.

David R. Gray

A researcher and writer, with 30 years' experience in arctic science, David Gray completed a PhD at the University of Alberta in 1973 on the behaviour and ecology of muskoxen. Between 1973 and 1994 he conducted research in Canada's High Arctic on the behaviour of muskoxen, arctic hare, arctic wolves, and red-throated loons for the Canadian Museum of Nature. In conjunction with studies of wolves and muskoxen he also studied the ecology of Peary caribou. Dave has been an independent researcher and consultant since 1994. He has prepared research reports on the Peary caribou and birds of prey of Bathurst Island for DIAND and Parks Canada, completed studies for Parks Canada on the ecological resources of northern Ellesmere Island, the wolves of Alert, and the human and natural history of northern Bathurst Island. He has also made revisions to the vegetation map of Ellesmere Island National Park Reserve and prepared an environmental assessment of an abandoned camp on Ellesmere Island.

David has also completed major reports on the natural and cultural resources of Ellesmere Island National Park Reserve, Aulavik National Park, and Vuntut National Park for Parks Canada. He also wrote a commemorative book, Alert, Beyond the Inuit Lands, on the human and natural history of Canadian Forces Station Alert for DND. David is a Research Associate at both the Canadian Museum of Civilization and the Canadian Museum of Nature and was elected as a Fellow of the Arctic Institute of North America in 1991.

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COLLECTIONS EXAMINED

None

Table 1. Estimated numbers in 2000-2002 of forest-dwelling caribou in COSEWIC populations.

COSEWIC population	Stated number[1]	Rounded number	Stated confidence[2]	Sources[3]
Northern Mountain	41 550-46 550	44 000	Moderate	R. Farnell, I. Hatter, & J. Quayle
Southern Mountain	7 187-7 227	7 200	Moderate-high	I. Hatter & D. Hervieux
Boreal	31 122-34 807	33 000	Low-moderate	Boreal sources below
Newfoundland (Isl.)	100 000	100 000	Moderate-high	Doucet p.c. 2000
Atlantic (Gaspésie)	200	200	High	Ouellet *et al*. 1996

[1]Totals as provided by jurisdictional biologists generally are for adults and calves in winter. Those estimates typically have confidence limits of 20-50% and some are guesses. They are rounded in the text.

[2]This is a general term as expressed by representatives and has no statistical quantification.

[3]Personal communication and other sources: Rick Farnell, Yukon 2001; Ian Hatter and James Quayle B.C., 2000, Hatter 2000. Boreal sources: Anne Gunn, NWT 2001; David Hervieux & Tara Szkorupa, Alberta 2000 (compilers of 18 sources); Earl Wilste, Saskatchewan 2000 & Godwin and Thorpe 1999; David Duncan, Ken Rebizant, and Cam Elliott, Manitoba 2000; Ted Armstrong, Ontario 2000 & Harris 1998; Robert Otto, Newfoundland–Labrador 2000; Christine Doucet, Newfoundland (Island). More details are in Acknowledgements.

Table 2. Estimates of forest-dwelling woodland caribou numbers in Canada by COSEWIC population. In each cell, numbers are in the top row and number of local populations and trend (increasing/stable/ decreasing/unknown), as reported by jurisdictions, are in the second row.

COSEWIC population	Prov. /terr.	1978-1984[1]	1986[2]	1992[3]	1996[4]	2000-2002[5]
Northern Mountain	YT/ NWT	15 550 Guess	21 550-26 550 17: 2/4/1/10	26 742-35 482 20: 2/3/2/13	28 850-34 350 22: 4/7/2/9	32 150-37 150 22: 4/9/2/7
"	B.C.	8 000	3 285 6: 1/3/2/0	9 770-10 270	10 300-11 000 16: 1/4/1/10	11 000 16: 1/7/1/7
N. MTN.	**Total**	**23 550**	**24 835-29 835 23: 3/7/3/10**	**36 512-45 752**	**39 150-45 350 38: 5/11/3/19**	**41 550-46 550 36: 4/15/3/14[6]**
Southern Mountain	B.C.	2 565	3 285 6: 1/3/2/0	3 295-3 405	6 259-6 709 22: 3/7/5/7	6 555 26: 0/11/10/5
"	Alta.	500 (?)	NA	300-400	600-750 3:stable- decl.	732-772 5: 0/2/2/1[7]
"	**Total**	**3 065**	**6: 1/3/2/0**	**3 595-3 805**	**6 859-7 459 25: 3/8/7/7**	**Mean 7 208 30:0/13/12/5[7]**
Boreal	NWT	3 000 (?)	2 000-5 000		Unknown	4 000-6 400 (1 undefined)
"	B.C.	100 (?)	NA		725 Unknown	725 (1 undefined)
"	Alta	1 000-3 000	NA 1: 0/0/1/0	2 700-3 100	3 000-5 995 Stable/decl.	3 285 12: 0/1/5/6
"	Sask.	2 500	2 500 1: 0/0/1/0	2 500	2 500 (1984) 5: declining	5 000 21: 0/0/5/16
"	Man.	3 360	5 000 1: 0/1/0/0	1 400-2 500 excl. Taiga	2 250 (2 000 – 2500)	2 000-3 000 14: 0/5/0/9
"	Ont.	11 000 incl. Taiga	8 400 incl.taiga 4: 1/2/0/1	6 012-6 702 excl. Taiga	3 457 excl. Hudson Plain	5 000 Gen. + 6 relic
"	Que.	8 100	8 197-9 337 4: 1/2/1/0	6 280-18 330	<10 000 + 3 relic (40-200)	<10 000 Gen. + 2 relic
"	Labr. Newf.	2 017 3	1 780-1 920 3:1/1/1/0	2 650-3 100 2		1 407 3: 1/0/2/0
"	**Total**	**31 077-33 077**	**14:3/6/4/1**		**21 575-24 570**	**31 000-35 000 52:1/6/12/33[8]**
Newfound-Land (Isl.)	Newf.	**21 950**	**23 100-44 000 11: 11/0/0/0**	**61 400-64 640 13: 9/3/0/1**	**80 000**	**100 000 27: 15/11/1/0**
Atlantic (Gaspésie)	Que.	**145**	**250 1:0/0/1/0**	**200 (decl.)**	**225**	**150-200 stable/down**

[1]Bergerud 1978, 1980; Kelsall 1984. Kelsall provided estimates for boreal Quebec of 8100 (range 5276 to 8493). Includes Mealy Mountain, Red Wine Mountain, and White Bear populations in southern Taiga of Labrador.

[2]Williams and Heard 1986. Data mainly from 1980-1984. Includes Mealy Mountain and Red Wine Mountain populations in southern Taiga of Labrador. Half of estimate for Lac Joseph population assigned to each of Quebec and Labrador.

[3]Ferguson and Gauthier 1992. Data mostly from 1986-1990. Includes Mealy Mountain & Red Wine Mountain po. in southern Taiga of Labrador. Half of estimate for Lac Joseph population assigned to each of Quebec and Labrador.

[4]Farnell *et al*. 1998, Heard and Vagt 1998, Edmonds 1998, Rettie *et al*. 1998, Larche 1996, Couturier 1996, Cumming 1998 (data mostly from 1994-96. Numbers reported for 12 districts in Ontario).

[5]Reports from jurisdictions for this report (see Table 1).

[6]Two in stable category were listed as stable-decreasing.

[7]After subtracting numbers for local populations common to two jurisdictions.

[8]Includes 21 pop. in SK (see Distribution) of which 5 were considered to be slowly decreasing (Rettie & Messier 1998).

Note: Trend, as reported by jurisdictions. Standard criteria are needed.

Table 3. Frequency distribution of estimated trend in numbers of local populations within Northern Mountain, Southern Mountain, Boreal, and Newfoundland COSEWIC populations of caribou in 2000-2002.

Trend in numbers[1]	Northern Mountain	Southern Mountain	Boreal except ON & QC[2]	Newfoundland (Island)
Increase	4	0	1	15
Stable	15	13[3]	6	11
Decrease	3	12	12[4]	1
Unknown	14	5	33[4]	10

[1]Trend as reported by jurisdictions. Data common to two jurisdictions subtracted. Standard criteria are needed.

[2]No data for local populations in Ontario (ON) and Quebec (QC). Saskatchewan reported the status of caribou in 3 ecoregions. Subsequently, 18 local populations were mapped (Godwin and Thorpe 1999) of which 5 were slowly decreasing (Rettie and Messier 1998) and 7 regional groups of caribou (metapopulations?) were mapped (Arsenault pers. comm. 2001). When maps are combined, there are 21 distributions.

[3]Two populations in the stable category were listed as stable-decreasing.

[4]Includes 21 pop. in SK (Table 2) of which 5 were considered to be slowly decreasing (Rettie & Messier 1998).

Table 4. Frequency distribution of estimated local population sizes within Northern Mountain, Southern Mountain, Boreal, and Newfoundland populations of caribou in 2000-2002.

Number of caribou	Northern Mountain	Southern Mountain	Boreal except ON & QC[2]	Newfoundland (Island)
</= 50	0	8	4	3
51 – 100	0	4[1]	7	2
101 – 250	9	9	7	1
251 – 500	7	7	7	3
501 – 1000	9	1	2	5
>1000	11	1	1	13

[1]Subtracting one for common Belcourt/Narraway (n =100) and excluding Little Smoky (Boreal population).
[2]No data for local populations in Ontario (ON) and Quebec (QC).

Table 5. Frequency distribution of local population range sizes within Northern Mountain, Southern Mountain, Boreal, and Newfoundland populations of forest-dwelling caribou in 2000-2002.

Range area (km^2)	Northern Mountain	Southern Mountain	Boreal except ON & QC[1]	Newfoundland (Island)
< 1 000	0	3	1	14
1 001 – 2 000	3	7	1	3
2 001 – 5 000	9	9[2]	8	5
5 001 – 10 000	7	7	3	3
10 000 – 20 000	10	4	9	1
>20 000	3	0	7	0

[1]No data for local populations in Ontario (ON) and Quebec (QC).
[2]Belcourt/Narraway one population of area 2045 km^2.
Note: Some range sizes are not known and some totals are less than number of local populations.

Table 6. Mean densities of forest-dwelling caribou in COSEWIC populations.

COSEWIC population	Jurisdiction	Mean (no. of local populations)	Range of densities (per 100 km^2)	Source
Northern	YT/NWT	12.0 (18)	3.0 – 26.9	R. Farnell pers.comm. 2002
Mountain	B.C.	10.0 (16)	3.0 – 24.2	I. Hatter pers. comm. 2002
Southern	B.C.	WC: 8.3 (5)	1.9 - 21.1	I. Hatter pers. comm. 2002
Mountain		NC: 5.9 (8)	1.6 – 14.1	"
		S: 3.0 (13)	0.3 - 15.1	"
		All: 7.0 (26)	0.3 – 21.1	"
	AB	Low estim: 9.4 (5)	4.0 – 16.4	
		High estim: 9.9 (5)	6.7 – 16.4	D. Hervieux & T. Szkorupa pers. comm. 2000
Boreal	NWT	0.9 – 1.5 (2)	1 – 3	A. Gunn pers. comm. 2001
	B.C.	1.4 (1)		I. Hatter pers. comm. 2000
	AB	3.3 (12)		D. Hervieux p.c. 2000
	SK	1.8 (3 ecoregions)	1.8 – 13.1	Gdwin & Thorpe 2000
	MB	1.1– 1.8 (13)	0.6, 0.7, & 3.5	Rebizant *et al*. 2000
	ON	Not available	0.5 – 4.3	
	QC	Not available		
	NF, LABR.	1.3 (3)	0.4 – 1.3	R. Otto pers. comm. 2000
Atlantic (Gaspésie)	QC	20 – 25 (1)		Ouellet *et al*. 1996
NF (Island)	NF	150 (26)	11 – 634	C. Doucet pers. comm. 2000

Table 7. Percent frequency of concerns relative to threats to local populations within Northern Mountain, Southern Mountain, Boreal, and Newfoundland populations of caribou in 2000 (*n* = 37, 30, 34, and 27 respectively).

Threat or concern[1]	Northern Mountain	Southern Mountain	Boreal excl. ON & QC[2]	Newfoundland (Island)
Predation	62	94	77	74
Access & disturbance	43	94	65	82
Forestry & other dev.	35	90	62	56
Population isolation	37	73	74	11
Available habitat	32	74	50	29
Fire	57	47	74	41
Low numbers	43	70	32	18
Hunting	70	30	59	00

[1]Concern rated as high or medium by jurisdiction biologists.

[2]No data for local populations in Ontario (ON) and Quebec (QC).

Table 8. Percent of local populations for which types of data are obtained annually (ann.), occasionally (occas.) or rarely, and never within Northern Mountain, Southern Mountain, and Boreal populations of caribou in 2000 (*n* = 37, 30, and 34, respectively).

Data type	Northern Mountain			Southern Mountain			Boreal population[2]		
	Ann.	Occas.	Never	Ann.	Occas.	Never	Ann.	Occas.	Never
Numbers	00	79	21	23	74	03	09	55	36
Recruitment	38	41	21	35	52	13	18	26	56
Ad. Sex ratio	38	41	21	29	39	32	18	23	59
Harvest	94	00	3(NA)	19	00	81	09	26	68
Mortality rate	18	36	46	42	19	39	29	15	56
Weather data	05	49	46	23	22	55	18	03	79
Diet	00	44	56	00	39	61	00	06	94
DNA	00	49	51	00	65	35	00	24	76
Body condition	00	38	62	00	19	81	00	09	91
Movements[1]	38	21	41	42	45	13	40	15	45

[1]Movements monitored with radio collars.
[2]No data for local populations in Ontario and Quebec.

Table 9. History of sport hunting of forest-dwelling woodland caribou in Canada.

COSEWIC Population	Jurisdiction	Reference
Northern Mountain	Yukon: Some closed and some permit hunts	Farnell p.c. 2001
	B.C.: Limited for some populations	Hatter p.c. 2002
Southern Mountain	B.C.: A few adult bulls permitted from large populations. Southern metapopulation closed in 2001.	Hatter (pers. comm. 2002)
	Alberta: closed in 1981	Edmonds 1988
Boreal	B.C.: No recreational hunt.	
	NWT: Hunting by holders of General Hunting Licence	
	Alberta: closed in 1981	Edmonds 1988
	Saskatchewan: closed 1947-61; 1987 – present	Rock 1992
	Manitoba: closed 1947-67; 1992 – present	Johnson 1993
	Ontario: closed in 1942	Darby *et al*. 1989
	Quebec: Limited sport hunt in parts of range	Hunting regulations
	Labrador:	
Newfoundland	Hunting is main management tool to stabilize local populations. Non-residents can hunt with guide.	Mahoney 2000
Atlantic (Gaspésie)	Closed in 1937	Boileau 1996
	Closed in early 1940s	Crête *et al.* 1994
	Closed in 1949	Ouellet *et al*. 1996

Table 10. Designations by COSEWIC, jurisdictions, and the Subnational (S list) and Global (G list) ratings within the new COSEWIC National Ecological Areas.

COSEWIC NEA/Pop.	COSEWIC 2002	Provincial/ territorial[1]	Provincial colour listing[2]	The Nature Conservancy[3]	
				S list	G list
Pacific	*Extinct*	Extinct		SX	G5TX
Northern Mountain	*Special concern*	None	B.C.: Blue	B.C.:S3S4	G5T4
Southern Mountain	*Threatened*	Alberta: *Threatened*	B.C.: Southern metapop. Red[1] AB: Blue 1996[2]	B.C:S2 AB: S2	B.C.: G5T2Q AB: G5T4
Boreal	*Threatened*	NT: *Sensitive* AB: *threatened* 1985	B.C.: Blue AB: Blue 1996[2]	B.C.: S3 SK: S3 ON: S3S4? LB: S2S3	B.C.: G5T? ON:G5('96) LB: G5T4
Newfoundland	*Not at risk*			NF: S5	NF: G5
Atlantic (Gaspésie)	*Endangered*	*Susceptible*		QC:	QC

[1]Alberta Wildlife Act: *Threatened - A species that is likely to become endangered if the factors causing its vulnerability are not reversed*.

[2]Alberta Colour lists: Red: *current knowledge suggests that these species are at risk. These species have declined, or are in immediate danger of declining to a nonviable population*. Blue: *current knowledge suggests that these species may be at risk. These species have undergone non-cyclic declines in population or habitat, or reductions in provincial distribution*.

[3]Nature Conservancy, The 2001 (Canada): <http://www.natureconservancy.ca>:
The Nature Conservancy, USA (Association for Biodiversity Information): http://www.abi.org
Natural Heritage Network Directory (international): <http://www.abi.org/networkdirectory.htm>
Natural Heritage Network Directory (Canada): http://www.abi-canada.ca/english/map.htm
Natural Heritage Element Rarity Ranks (after The Nature Conservancy 2001)
G1/S1: *Critically Imperiled*: Critically imperiled globally because of extreme rarity or because of some factor(s) making it especially vulnerable to extinction. Typically 5 or fewer occurrences or very few remaining individuals (<1 000) or acres (<2 000) (<809 ha), or linear miles (<10) (<16 km).
G2/S2: *Imperiled*: Imperiled globally because of rarity or because of some factor(s) making it very vulnerable to extinction or elimination. Typically 6 - 20 occurrences or few-remaining individuals (1 000 - 3 000) or acres (2 000 - 10 000) (809 - 4047 ha), or linear miles (10 to 50) (16-80 km).
G3/S3 *Vulnerable*. Vulnerable globally either because very rare and local throughout its range, found only in restricted range (even if abundant at some locations), or because of other factors making it vulnerable to extinction or elimination. Typically 21 - 100 occurrences or 3 000 - 10 000 individuals.
G4/S4: *Apparently Secure*. Uncommon but not rare (although it may be rare in parts of its range, particularly on the periphery), and usually widespread. Apparently not vulnerable in most of its range, but possibly cause for long-term concern. Typically >100 occurrences & more than 10 000 individuals.
T = infraspecific taxon (subspecies or variety), X = extirpated, Q = questionable taxonomy.

Table 11. Designations for five COSEWIC populations and component designations adopted by COSEWIC in 1984, modified in 1995, and changed in 2000.

Population name	1984 status	1995 renaming	2000 (May)	2002 (May)
Pacific (Haida Gwaii)	*Extinct*	*Extinct*	*Extinct*	*Extinct*
Northern Mountain[1]	*Rare*	*Vulnerable*	*Not at risk*	*Special concern*
Southern Mountain[1]	*Rare*	*Vulnerable*	*Threatened*	*Threatened*
Boreal[1]	*Rare* (Western)	*Vulnerable* (Western)	*Threatened*	*Threatened*
Newfoundland	*Not at risk*	*Not at risk*	*Not at risk*	*Not at risk*
Atlantic (Gaspésie)	*Threatened*	*Threatened*	*Endangered*	*Endangered*

[1]The Northern and Southern Mountain populations were not recognized until May 2000. Formerly they were part the western Boreal population in 1984 (Kelsall 1984).

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Appendix 1a. Estimates of numbers and trends to 2001 for forest-dwelling woodland caribou in the COSEWIC Northern Mountain population.

Local population name	Prov./Terr. & Ref. no.	Pop. estimate	Survey Year	Trend in nos.[1]	Range area (km^2)	Dens./ 100 km^2	Survey type[2]	Conf. in estimate[3]
Aishikik	YT 20	1 500	1998	Increase	16 119	9.3	SRQ	High
Atlin	YT14/BC	800	1999	Stable	5 999	13.3	Extr.	Mod.
Bonnet Pl.	YT3/NT	5 000	1982	Unknown	18 614	26.9	G	Unkn.
Carcross	YT16/BC	450	1997	Increase	13 419	3.4	SRQ	High
Chisana	YT 22	400	2000	Decrease	13 000	3.1	Extr.	High
Clear Creek	YT 2	900	2001	Stable	4 873	18.5	SRQ	High
Coal River	YT 10/NT	800	1996	Unknown			Extr.	Mod.
Ethyl Lake	YT 4	300	1993	Stable	3 961	7.6	SRQ	High
Finlayson	YT 8	4 100	1999	Stable	24 733	16.6	SRQ	High
Hart River	YT 1	1 200	1978	Stable	17 478	6.9	TC	Low
Ibex	YT 15	400	1998	Unknown	1 979	20.2	SRQ	High
Klaza	YT 19	600	2000	Increase	7 089	8.5	TC	Mod.
Kluane	YT 21	200	1999	Decrease	6 595	3.0	TC	Mod.
La Biche	YT 11/NT	400	1993	Unknown			G	Unkn.
L. Rancheria	YT12/BC	1 000	1999	Increase	4 134	24.2	SRQ	Mod.
Moose Lake	YT 5	200	1991	Stable	1 022	19.6	SRQ	High
Nahanni	YT 9	2 000	1996	Unknown	16 000	12.5	Extr.	Mod.
Pelly herds	YT 17	1 000	2001	Unknown			G	Unkn.
Redstone[4]	YT 7/NT	7 500	1982	Unknown			G	Low
Tatchun	YT 18	500	2000	Stable	7 091	7.1	TC	High
Tay River	YT 6	4 000	1991	Stable	25 148	15.9	SRQ	High
Wolf Lake	YT 13	1 400	1998	Stable	20 013	7.0	SRQ	High
YT/NWTsubt.		**34 650**		**22: 4/9/2/7**	**207 267**	**12.0**		11/ 6/ 2/ 3
Atlin East	BC38/YT	800	1999	Stable	5 999	13.3	SRQ	Mod.
Atlin West	BC 39	350	1998	Stable	4 398	8.0	TC	Mod.
Edziza	BC 27	200	1983	Stable	1 281	15.6	E	Low
Finlay	BC 25	200	1998	Unknown	3 084	6.5	TC	Mod.
Frog	BC 30	150	2000	Unknown	2 421	6.2	G	Low
Gataga	BC 31	250	2000	Unknown	4 436	5.6	G	Low
Horseranch	BC 35	850	1999	Stable	9 499	8.9	SRQ	Mod.
Jennings	BC 37	200	1970s	Unknown	4 080	4.9	G	Low
Level-Kawdy	BC 28	1 650	1999	Stable	12 568	13.1	TC	Mod.
Liard Plateau	BC 34	150	2000	Stable	5 069	3.0	G	Low
L. Rancheria	BC36/YT	1 000	1999	Increase	4 134	24.2	SRQ	Mod.
Muskwa	BC 32	1 250	2000	Unknown	16 786	7.4	G	Mod.
Pink Mtn.	BC 24	850	2000	Declining	11 602	7.3	SRQ	Mod.
Rabbit	BC 33	800	2000	Unknown	5 936	13.5	E	Low
Spatsizi	BC 26	2 200	1994	Stable	16 929	13.0	TC	Mod.
Tsenaglode	BC 29	200	1999	Unknown	3 015	6.6	G	Low
BC subtotal		**11 100**		**16:1/7/1/7**	**111 237**	**10.0**		0/ 9/ 7/ 0
Common[5]	*YT/NT/BC*	1 800		**2:1/1/0/0**	10 133			0/ 2/ 0/ 0
NMP Total		**43 950**		**36:/4/15/3/14**	**308 371**	**11.3**		11/13/9/3

[1]Trend, as reported by jurisdictions. Standard criteria are needed. In subtotals row the coding is number of populations: increasing/stable/decreasing/unknown.
[2]SRQ=stratified random quadrat; Extr=extrapolation; TC=total count; G=guess (few data); E=estimate (some data).
[3]This confidence estimate is a qualitative evaluation in most cases. Totals are high/moderate/low/unknown
[4]The Redstone population is listed as 5 000 to 10 000 and 7 500 is mid-range.
[5]Local population numbers and areas common to Yukon and B.C. are subtracted from the total.

Appendix 1b. Estimates of numbers and trends to 2002 for forest-dwelling woodland caribou in the COSEWIC Southern Mountain population.

Local Population	Prov. & Ref. no.	Pop. estim.	Survey Year	Trend in nos.[1]	Range area (km^2)	Dens./ 100 km^2	Survey type[2]	Conf. in estimate
Chase	BC 22	700	1993	Stable	11 390	6.1	TCe	Low
Graham	BC 23	300	2002	Decreasing	4 734	6.3	TCe	Med.
Kennedy Siding	BC 18	170	2002	Stable	1 470	1.6	E	Med.
Moberly	BC 19	170	2002	Unknown	5 115	3.3	E	Med.
Quintette	BC 17	200	2002	Stable	1 421	14.1	E	Med.
Takla	BC 21	100	2002	Unknown	1 850	5.4	TC	Med.
Wolverine	BC 20	400	1996	Unknown	8 315	4.8	TCe	Low
Belcourt	BC 40/AB	100		Unknown	2 045	4.9		See AB
NC metapop.	**BC 17-23**	**2 140**		**8:0/3/1/4**	**36 340**	**5.9**		7:0/5/2/0
Charlotte	BC 13	50	1999	Decrease	2 650	1.9	TC	Med.
Itcha-Ilgachuz	BC 14a	2 000	2000	Stable	9 457	21.1	TCe	High
Telkwa	BC 16	55	2000	Stable	1 828	3.0	TCe	High
Tweedsmuir	BC 15	300	1982	Decrease	12 811	2.3	E	Med.
Rainbows	BC 14b	125	2000	Decrease	3 804	3.3	TCe	High
WC metapop.	**BC 13-16**	**2 530**		**5:0/2/3/0**	**30 550**	**8.3**		5:3/2/0/0
Hart Ranges	BC 12	450	1999	Stable	10 261	4.4	E	Med.
Narrow Lake	BC 11	65	1999	Stable	431	15.1	TC	High
George Mtn.	BC 10	5	1999	Decrease	441	1.1	TC	High
Barkerville	BC 9	50	2000	Stable	2 535	2.0	Tce	High
N. Cariboo Mtn.	BC 8	340	1999	Unknown	5 911	5.8	Tce	Med.
Wells Gray S.	BC 7b	315	1998	Decrease	10 381	3.5	Tce	Med.
Wells Gray N.	BC 7a	200	2000	Stable	6 346	3.2	Tce	High
Cent. Rockies	BC 6	20	1998	Decrease	7 265	0.3	TC	Med.
Revelstoke	BC 5	210	1998	Decrease	7 863	2.5	TC	High
Monashee	BC 4	10	2000	Decrease	2 082	0.5	TC	Med.
Cent. Selkirks	BC 3	130	1997	Decrease	4 813	2.7	Tce	High
S. Purcells	BC 2	20	2000	Stable	2 962	0.7	Tce	High
S. Selkirks	BC1/I D	35	2000	Stable	1 500	2.3	Tce	High
S. metapop.	**BC 1-12**	**1 850**		**13:0/6/6/1**	**62 791**	**3.0**		13:8/5/0/0
SMP BC Total	**BC 1- 23**	**6 555**		**26:0/11/10/5**	**129 680**	**5.1**		25:11/12/ 2/0
Narraway(Belcourt)	AB1/BC 40	100	1999	Unknown	2 045	4.9	AS	Low
Redrock/Pr.Cr.	AB2/BC	312	1993	Stable-decr.	1 900	16.4	MR	Med.
A la Pêche	AB3/BC	170	1998	Stable-decr.	1 600	10.6	TC	Med.
S. Jasper NP	AB4/BC	[3]138	1998	Decrease	2 200	6.3	TC	Med.
N. Banff NP	AB 5	[4]33	1989	Decrease	600	5.5	TC	Med.
AB Totals	**AB 1-5**	**753**		**5: 0/2/2/1**	**8 345**	**9.7**		5:0/4/1/0
Common	**BC/AB**	**100**		**1:0/0/0/1**	**2 045**			
SMP Total	**BC + AB**	**7 208**		**30:0/13/12/5**	**135 980**	**5.3**		30:11/16/3/0

[1]Trend, as reported by jurisdictions. Standard criteria are needed. In subtotals row the coding is number of populations: increasing/stable/decreasing/unknown.

[2]TCe = total count & extrapolation from collared caribou; TC = total count; E = estimate;

G = guess; AS = aerial survey; MR = mark & resight.

[3]Mid point of 125-150.

[4]Mid point of 25-40.

Appendix 1c. Estimates of numbers and trends to 2001 for forest-dwelling woodland caribou in the COSEWIC Boreal population.

Local population	Prov./ ref. no.	Pop. estim.	Surv. Year	Trend in no.[1]	Range (km^2)	Dens./ 10^2km^2	Surv. type[2]	Conf. in est.
NWT Boreal[2]	**NT 1**	**5200**	**1999**	**Unknown**	**433 504**	**1.2**	**G**	Low
BC Boreal	**BC41**	**725**	**1999**	**Unknown**	**51 541**	**1.4**	**G**	Low
L. Smoky	AB 6/	80	2000	Decrease	1 900	4.2	E	Mod.
Bistcho	AB7/ NT	400	1993	Unknown	11 200	3.6	E	Low
Caribou Mtn	AB8/NT	400	1993	Decrease	22 700	1.8	E	Mod.
Chinchaga	AB 9	200	1993	Unknown	9 300	2.2	E	Low
Hotchiss	AB 10	15	1993	Unknown	600	2.5	E	Low
Deadwood	AB 11	50	1993	Unknown	2 200	2.3	E	Low
Red Earth	AB 12	800	1993	Decrease	17 400	4.6	E	Mod.
Richardson	AB 13	100	1993	Unknown	4 500	2.2	E	Low
Slave Lake	AB 14	50	1993	Unknown	3 000	1.7	E	Low
W. Athabasca	AB 15	360	1998	Decrease	4 700	13.1	E	Mod.
E. Athabasca	AB 16	480	1993	Decrease	9 700	5.0	E	Mod.
Air Weapons	AB 17	350	1993	Stable	11 200	3.1	E	Mod.
AB subtotals		**3 285**		**12:0/1/5/6**	**98 400**	**3.3**		
Mid-Boreal	SK 1	760	2000	Decrease	110 498	0.7	E	Low
Athabasca Plain	SK 2	400	2000	Unknown	63 000	0.6	E	Low
Churchill R.Upl.	SK 3	3 780	2000	Decrease?	108 000	3.5	E	Low
SK subtotals		**4 940**		**3:0/0/2/13**	**281 498**	**1.8**		
Wapisu	MB 2	100	2000	Unknown	6 950	1.4	E	Unkn.
Sisipuk-Kamuch.[2]	MB 3	150	2000	Unknown	12 470	1.2	G	Unkn.
Kississing-Naosap[2]	MB 4	150	2000	Stable	10 060	1.5	V,BT,TC	High
Reed-Clearwater l.[2]	MB 5	125	2000	Stable	10 380	1.2	V,BT,TC	High
Waboden	MB 6	150	2000	Unknown.	17 050	0.9	E	Unkn.
Island Lake[2]	MB 7	750	2000	Unknown	23 240	3.2	G	Unkn.
Gunisao-Hudwin[2]	MB 8	375	2000	Unknown	14 380	2.6	G	Unkn.
The Bog[2]	MB 9	63	2000	Stable	4 610	1.4	V,TC,LK	Mod.
Swan-Pelican[2]	MB 10	63	2000	Stable	4 190	1.5	E	Mod.
William L.	MB 11	25	2000	Unknown	3 750	0.7	V,LK,E	Low
North Interlake[2]	MB 12	63	2000	Unknown	10 330	0.6	V,LK,E	Mod.
Atikaki-Berens[2]	MB 13	400	2000	Unknown	21 140	1.9	V,LK,E	Unkn.
Owl-Flintstone[2]	MB 14	70	2000	Stable	3 640	1.9	T, TC	High
MB subtotals		**2484**		**13:0/5/0/8**	**173 670**	**1.4**		
N. commercial For.	ON	2 277						
In commercial For.	ON	1 328						
Pot. commerc. For.	ON	481						
In parks & islands	ON	839						
ON subtotals		**4 925**			**NA**			
QC 50°N-55°N	QC	<10 000	2000					
Val D'Or	QC 1	65						
Grands Jardins	QP 2	103	1998					
Lac Joseph	QP3/L1	SeeLabr						
QC subtotals		**10 000**			**NA**			
Lac Joseph	NF: L 1	1 025	2000	Increase	50 000	2.1	MR	Mod
Red Wine Mtn.	NF: L 2	129	1997	Decrease	35 000	0.4	BT	High
Mealy Mtn.	NF: L 3	253	1997	Decrease	20 000	1.3	BT	High
Labr. subtot		**1 407**		**3:1/0/2/0**	**105 000**	**1.3**		
Boreal pop.		**32 966**		**33:1/6/9/17[3]**	**1143613**			

[1]Trend, as reported by jurisdictions. Standard criteria are needed. In subtotals row the coding is number of populations: increasing/stable/decreasing/unknown. Footnotes continued below Appendix 1d.

[2]G=guess; E=estimate; V=visual sightings; BT=belt strip transect: TC=total; LK=local knowledge; T=track counts.

[3]Mid points given for NWT Boreal (4000-6400), Sisipuk-Kamuchawie (100-200), Kississing-Naosap lakes (100-200), Reed-Yawningstone-Clearwater lakes (100-150), Island Lake (500-1000), Gunisao- Hudwin lakes (250-500), The Bog (50-75), Swan-Pelican lakes (50-75), North Interlake (50-75), Atikaki-Berens (300-500), Owl-Flintstone lakes (65-75), and Val D'Or (40-90).

Appendix 1d. Estimates of numbers and trends to 2001 for forest-dwelling woodland caribou in the COSEWIC Newfoundland (Island) population.

Local population (I = introduced)	Prov./ ref. no.	Pop. estim.	Surv. year	Trend in nos.[1]	Range (km^2)	Density/ 100 km^2	Survey type[2]	Conf. in estimate
Avalon	NF 1	1 850	1998	Decrease	3 509	52.7	SQR	29%
Baie Verte	NF 2	600	1996	Increase	4 159	14.4	BT	74%
Bay de Verte (I)	NF 3	100	1995	Stable	733	13.6	TC	Mod.
Brunette Isl. (I)	NF 4	75	1996	Stable	22	340.9	TC	Mod.
Buchans	NF 5	7 800	2000	Stable	1 200	650.0	SQR	12%
Burin Pen. (I)	NF 6	500	1995	Increase	501	99.8	BT	66%
Cape Shore (I)	NF 7	1 400	2000	Increase	576	243.1	BT	57%
Corner Brook	NF 8	700	1997	Stable	543	128.9	BT	Mod.
Fogo Island (I)	NF 9	200	1996	Increase	255	78.4	TC	Mod.
Gaff Topsails	NF 10	6 000	1989	Increase	3 334	180.0	MR	23%
Gregory Plat. (I)	NF 11	360	1987	Stable	Unkn.		TC, V	Low
Grey Island (I)	NF 12	600	1992	Increase	141	425.5	TC	Mod
Grey River	NF 13	16 500	1997	Increase	9 375	176.0	MR	10%
Gros Morne	NF 14	2 800	1997	Increase	1 960	142.9	TGC	16%
Hampden Downs	NF 15	850	1994	Increase	584	145.5	BT	57%
Humber	NF 16	4 500	1998	Increase	6 635	67.8	SQR	34%
La Poile	NF 17	10 500	1997	Increase	2 607	402.8	MR	18%
Merasheen Isl. (I)	NF 18	280	2001	Stable	300	93.3	TC	Mod.
Middle Ridge	NF 19	19 800	1995	Increase	5 691	347.9	MR	10%
Mount Peyton	NF 20	1 700	1994	Stable	268	634.3	SQR	29%
Northern Pen.	NF 21	8 200	1996	Increase	17 686	46.4	BT	34%
Port Au Port (I)	NF 22	44	1982	Stable	386	11.4	TC	Mod.
Pot Hill	NF 23	5 200	1997	Increase	1 171	444.1	MR	22%
Random Island (I)	NF 24	20	1995	Stable	141	14.2	TC	Mod.
Sandy Lake	NF 25	1 000	1997	Stable	340	294.1	MR	29%
Sound Island (I)	NF 26	33	1991	Stable	14	235.7	TC	Mod.
St. Anthony (I)	NF 27	8 400	1998	Increase	4 132	203.3	SQR	40%
NFP Totals		**100012**		**27:5/11/1/0**	**66 263**	**150.4**		

[1]Trend, as reported by jurisdiction. Standard criteria are needed (see page 39). In subtotals row the coding is number of populations: increasing/stable/decreasing/unknown.In totals row, the coding is number of populations: increasing/stable/decreasing/unknown.

[2]SRQ= stratified random quadrat; BT = belt strip transect; TC = total count; MR = mark-resight; V = visual; TGC = total ground count.

Appendix 2a. Protected areas that afford some range security for forest-dwelling woodland caribou in COSEWIC's Northern Mountain (NM) and Southern Mountain (SM) National Ecological Areas (NEA).

NEA	Protected area[1]	Local pop. of caribou & numbers	Proportion of caribou range	Proportion of pop. (nos.) in PA	Important range in PA[2]	Security of PA[3]	Source
NM	Ddah Ghro SMA – ex MacArthur GS	Ethyl Lake herd (est. 300)	20% (about 800 km^2 of 4000 km^2 total range)	Seasonally in summer & fall	Some CR & rutting areas	Manage. Plan in dev.	Yukon Prot. Area Strategy
NM	Kluane GS (YT) & Wrangle-St. Elias NP(AK)	Chisana herd (est. 400)	70% (about 9000 km^2 of 13 000 km^2 total range)	Variable but most of the time	Core WR, all CR & most of SR	NH & LD	Farnell, p.c. 2001
NM	Nahanni Nat. Pk. Reserve 4766 km^2	Nahanni (est. 2000 caribou)	12% (ca. 2000 km^2 of total range of 16 000 km^2)	Numbers vary (move in/ out park)	Imp. WR for part of population	NH, LD	Gullickson 2000
NM	N. B.C.	Not available					
SM	Cent./S B.C.	Not available					
SM	Kakwa Wildland	Narraway	18%	Variable	SR	LD	Szkorupa p.c. 2000
SM	Willmore Wilderness	A la Pêche/ N.JasperNP	72%	Variable	SR & recent WR	LD, HA	As above
SM	JNP, Whitegoat Wilderness	South Jasper/ Whitegoat	100%	All	YR range	LD, NH	As above
SM	BNP, Siffleur Wilderness	North Banff/Siffleur	100%	All	YR range	LD, NH	As above

[1]SMA = Special Management Area, GS = Game sanctuary, NP = National Park, PP = Provincial Park
[2]CR = calving range, WR = winter range, SR = summer range. YR = year round range.
[3]HA = hunting allowed, NH = no hunting, LD = limited development

Appendix 2b. Protected areas that afford some range security for forest-dwelling woodland caribou in COSEWIC's Boreal (B) National Ecological Area (NEA).

NEA	Protected area[1]	Local pop. of caribou & numbers	Prop. caribou range in PA	Prop. of pop. (nos.) in PA	Important range in PA[2]	Security of PA[3]	Source
B	Sahyoue, NWT 2894 km^2	NWT	Unknown	Unknown	Annual?	ND	Gunn p.c. 2001
B	Edacho, NWT 2642 km^2	NWT	Unknown	Unknown	Annual?	ND	As above
B	Edehzhie, NWT 24 590 km^2	NWT	Unknown	Unknown	Annual?	ND	As above
B	Wood Buffalo NWT: 9225 km^2	NWT	Unknown	Unknown	Annual?	ND	As above
B	Birch Mtn. Wildland. AB	Red Earth	2%	Variable	Unknown	LD	Szkorupa p.c.2001
B	Marguerite River Wildland, AB	Richardson	7%	Variable	Unknown	LD	As above
B	Stony Mtn. & Grand Rapids Wildlands, AB	ESAR	3%	Variable	Unknown	LD	As above
B	Air Weapons Range, AB	CLAWR	67%	Variable	Unknown	Lim. access/ disturb.	As above
B	Caribou Mtn. Wildland PP 5910 km^2	Caribou Mountains/ Yates	80%				Edmonton Journal 25/07/01
B	Wood Buffalo NP, AB	Caribou Mtns/ Yates	4%	Variable	Unknown	NH, LD	Szkorupa p.c.2001
B	Chinchaga Wildland, AB	Chinchaga	9%	Variable	Unknown	LD	As above
B	Prince Albert NP, SK	PA Nat'l Pk Est. 30	15%	"	Important S/F range	NH, little disturb.	Trottier, p. c. 2001
B	Wildcat Hills Wildern. Area, SK	Est. 5-10	10%	"	"	HA, poor access	"
B	Seager-Wheeler Repr. Area, SK	Est. 10-30	40%	"	Important YR	HA, poor access	"
B	Narrow Hills PP, SK	Est. 15-20	10%	"	Important SR	HA, good access	"
B	Wapawekka Hills Repr. Area, SK	Est. 25-30	60%	"	Important YR	HA, poor access	"
B	Lac La Ronge PP, SK	Est. 60	50%	"	Imp.calving, S & W	HA, some disturbance	"
B	Cold Lake Air Weapons Range	Est. 30-50	30%	"	Unknown	NH little disturb.	"
B	Athabasca Sand Dunes PP Res,SK	Est. 10-15	50%	"	Important YR range	HA, very poor access	"

[1]SMA = Special Management Area, GS = Game sanctuary, NP = National Park, PP = Provincial Park
[2]CR = calving range, WR = winter range, SR = summer range, YR = year round range.
[3]HA = hunting allowed, NH = no hunting, LD = limited development, ND = no development.

Appendix 2c. Protected areas that afford some range security for forest-dwelling woodland caribou in COSEWIC's Newfoundland and Atlantic populations in Canada.

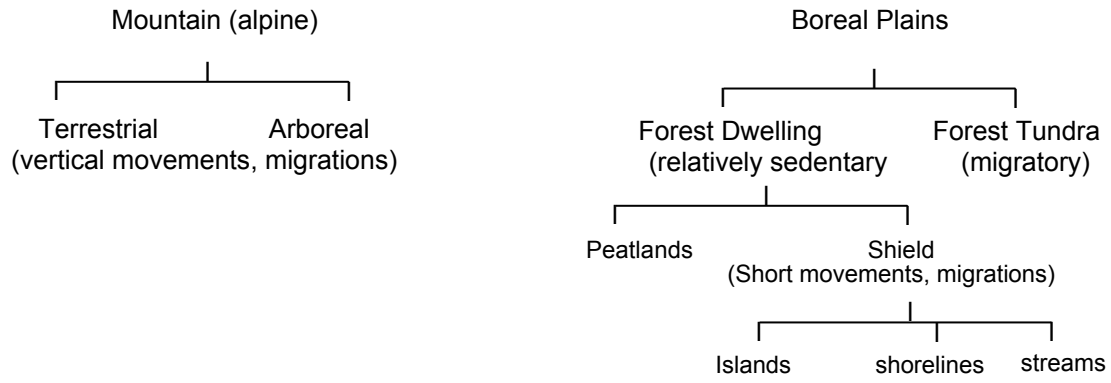
Pop./ NEA	Protected area[1]	Local pop. of caribou and numbers	Proportion of caribou range	Proportion of pop. (nos.) in PA	Important range in PA[2]	Security of PA[3]	Source
NF (Isl.)	Gros Morne NP, 1 960 km^2	Gros Morne (est. 2 800)	75% (seasonal movements in & out)	Proportion varies	Important SR, WR, & CR	NH, Little disturb.	Mahoney 2000
NF (Isl.)	Bay du Nord Wildern. Res. 2 859 km^2	Middle Ridge (est. 20 000)	50% (seasonal movements in-out)	Proportion varies	Important SR, WR, & CR	NH, Little disturb.	As above
NF (Isl.)	Avalon Wildern.Res. 1 070 km^2	Avalon (est. 1 850)	50% (use varies)	Proportion varies	Important SR, WR, & CR	NH, Little disturb.	As above
Atlantic (Gaspésie)	Gaspésie PP	Gaspésie Estimate 200	80-90%	91% of collared	YR range	NH, little disturb.	Ouelett *et al.* 1996

[1]NP = National Park, Wildern. Res. = Wilderness Reserve, PP = Provincial Park
[2]SR = summer range, WR = winter range, CR = calving range, YR = year round range.
[3]NH = no hunting.

Appendix 3a. Types, criteria, and characteristics of ecotypes of woodland caribou.

Primary types	Criterion	Characteristics
Forest-tundra (migratory) or Forest dwelling (sedentary)	Seasonal range use (movement pattern)	Forest-tundra = taiga-tundra. Forest dwelling (boreal) may have short migrations (elevational shifts in mountains, latitudinal shifts on plains), have fixed summer range and variable winter range, or be essentially sedentary
Mountain or Boreal forest (plains)	Occurrence in major landforms (Canada)	Mountain caribou make elevational shifts to alpine in summer from subalpine in winter (exception: some winter in alpine). Plains ecotype
Secondary types		
Terrestrial or Arboreal	Winter lichens eaten	Differentiates northern and mountain ecotypes in B.C. Poles of a continuum, i.e., both lichen types used in many areas.
Peatlands or Shield (islands/ Lakeshore/ streams	Occurrence within boreal forest	Large peatland complexes are most common south of the Shield. Caribou on the Shield are less likely to form local populations than on peatlands

Appendix 3b: Schematic of woodland caribou ecotypes.



Appendix 4. Indicators of the status of COSEWIC populations of caribou

	Indicator	Value	Pros and cons	Report
1.	Total absolute numbers	Low	Effort increasing & better methods. Count accuracy & precision low	Table 1
2.	Trend in absolute numbers	Low	Same as above row. Must partition natural and human effects on local populations	Table 2
3.	Trend in numbers of local pops.	Medium	Trends (increasing/stable/decreasing/unknown) detected by several criteria. Need standard criteria for stable, etc.	Table 3, App. 1
4.	Frequency distrib. of local pop. sizes	Medium	Shape of distribution is important. Small pops. likely vulnerable	Table 4
5.	Frequency distrib. of range sizes	Fair	Potentially premier indicator but expensive (radio collars). Small areas a “red flag”	Table 5
6.	Densities of local pop.	Low	Requires good data for indicators 1 & 4. Need baseline data for habitat type	Table 6
7.	Concerns & perceived threats	High	Usually correct, often subjective. Need weighting of factors. Need long-range models for caribou habitat supply where logging & other development	Table 7
8.	Database & current monitoring	Variable	Relates to indicators 1-6. Pop. demography etc., habitat changes	Table 8
9.	Proportion of range protected	Medium	Limits development. Management options restricted.	App. 2
10.	Subjective designations of risk	Medium	Synthesis of all information. Many unknowns (e.g., warming effect)	Table 10
11.	Land-use plans include caribou	Unknown	Adaptive management. Landscape, stand and site considerations	
12.	Caribou range fragmentation index	Undeveloped	Need to develop criteria specifically for caribou	
13.	Habitat quality (integrity) index	Undeveloped	Need to develop criteria specifically for caribou. Mosaic component minimums	
14.	Genetic diversity & changes w/ time	Unknown	Need to monitor selected local populations. Need to establish effect on caribou fitness	
15.	Local population viability indices	Undeveloped	Need to agree on minimum viable pop. sizes, minimum range sizes including important components etc.	
16.	Level of funding for monitoring/manage	Undeveloped	Need to establish format (categories, sub categories, etc).	