

# **State of the Knowledge of Woodland Caribou in Ontario**

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by

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## **EXECUTIVE SUMMARY**

There is a concern about declining woodland caribou populations in Canada. Each jurisdiction, including Ontario, is developing a recovery strategy. The “forest dwelling” ecotype is considered to be at risk in this province. Population dynamics and movements are not well understood. Since the late 1800’s, the area of continuous range has receded northward to approximately 50 degrees latitude, although there are several small isolated herds south of this line. Caribou distribution is directly related to the occurrence of lichen, the animal’s main food, which is associated with nutrient poor environments of pine and black spruce forest.

Several factors may constrain the viability of caribou populations. There is considerable evidence that the primary cause of decline is shift in predator-prey balance. Where retrogression of forest to early successional stages improves habitat for moose and deer, higher wolf densities jeopardise caribou populations.

Although retraction of caribou range has been associated with expanding timber harvest operations, actual cause and effect relationships are difficult to determine precisely. Indirect consequences are predator-prey imbalances, increased human access, and parasite transmission by deer and moose. Before silviculture was prevalent in northern Ontario, clearcutting high value conifers resulted in excessive stand conversion to hardwood species. More recently, smaller cut blocks and other modified approaches have been designed to improve moose habitat. For caribou conservation, measures such as larger cuts emulating the effects of fires will be necessary.

A major challenge for resource managers will be maintaining isolated populations. Although much of the commercial forest is not expected to be good caribou habitat and fire suppression has resulted in more old growth forest, small isolated populations in the southern limits of range are far more vulnerable to local or unique detrimental factors.

Several research initiatives are underway or completed in Ontario, mainly related to habitat.

Recommendations have been made pertaining to policy, research priorities, and procedure.

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## **INTRODUCTION**

The purpose of this report is to scope the current state of knowledge relating to woodland caribou in northern Ontario, make comparisons to other jurisdictions, and offer some recommendations pertaining to management. Of Ontario's indigenous ungulate species, moose and white-tailed deer are perhaps the greatest success stories as their range and populations have expanded considerably since historical times. Woodland caribou have generally received less attention.

The report is organized into five broad sections. The first, BACKGROUND outlines how conservation concerns have been addressed, the problems with caribou classification, pattern of distribution across the province, and the dependence of caribou on lichen. FACTORS CONSTRAINING VIABILITY are those identified by Harris (1999) in his status report for the *Committee on the Status of Species at Risk in Ontario* (COSSARO) where he stated "the primary cause of decline in forest-dwelling caribou is thought to be a shift in the predator-prey balance, and secondarily increased hunting, direct loss of winter habitat, disturbance, road kills and parasites." Habitat alteration by timber harvest activities and the risks faced by isolated populations are discussed as the PRIMARY MANAGEMENT ISSUES which compound the effects of all limiting factors. Next, CURRENT RESEARCH INITIATIVES are listed. In the last section, RECOMMENDATIONS are grouped as they pertain to policy, research and procedure, and are listed in order of importance within each group.

## **BACKGROUND**

### **Conservation Concern**

Woodland caribou are widespread in Canada, occurring in all provinces and territories except Nunavut, New Brunswick, Nova Scotia, and Prince Edward Island. There are concerns about the viability of some small local populations in every jurisdiction where they occur. In 1996, Mallory and Hillis (1998) concluded that populations that primarily inhabit the forest were declining and threatened throughout the circumpolar region, possibly due to the interaction of human disturbance and predation. Many of the boreal populations occur in areas of intense development, where the potential exists to fragment populations, alter predator-prey relationships, introduce parasites, and improve access for hunters.

Declining populations led the Ontario government to ban recreational hunting in 1929. DeVos and Petersen (1951) carried out the first status review of caribou in the province. Since then, there have been periodic updates on population status and a growing concern about demographic trends. Woodland caribou ecology received more attention after declines in the 1980s.

In Kelsall's 1984 status report on woodland caribou for the *Committee in the Status of Endangered Wildlife in Canada* (COSEWIC), he divided the subspecies into five geographical areas. He considered the animals in Ontario as part of the western woodland caribou group. Populations that he ranked as threatened included the Slate Islands in Lake Superior, Pukaskwa National Park, and the Lake Nipigon area. COSEWIC classified the western population as rare in 1984, and renamed the designation to vulnerable in 1995.

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. This province has species-at-risk legislation and COSSARO has established criteria for population selection and species designation.

In 1996, Ontario signed the *Accord for the Protection of Species at Risk in Canada*. Signatories to this agreement are committed to producing *Recovery Plans for Endangered and Threatened Species* in their province.

A report on the status of woodland caribou was prepared by Harris (1999) for COSSARO. Its purpose was to make recommendations on status evaluation and recovery based on uniform scientific criteria. Evidence of decline in Ontario was based on the fact that forest-dwelling caribou were no longer present in approximately 40% of their former Ontario range (Darby *et al.* 1989). The report recommended that the forest-dwelling ecotype of woodland caribou be assigned *Threatened* status, based on the estimate that 54% of Ontario's forest-dwelling caribou are in the commercial forest zone. The definition of Threatened is "any native species that, on the basis of the best

available scientific evidence is at risk of becoming endangered throughout all or a significant portion of its Ontario range if the limiting factors are not reversed”.

At the national level, the COSEWIC updated status report concurred with the COSSARO recommendation and a *Provincial Woodland Caribou Recovery Team* for Ontario was established. A separate dialogue with first nations is being developed. A national *Technical Steering Committee* has been formed with representation from all nine jurisdictions in Canada which contain woodland caribou to formulate a National Recovery Strategy. To assist Ontario’s recovery team, a *Provincial Boreal Woodland Caribou Advisory Committee* was created by the Ministry of Natural Resources.

The Northwest Region Caribou Task Team was formed as the primary facilitator of woodland caribou habitat management in that part of the province, and assist with the implementation of the *Forest Management Guidelines for the Conservation of Woodland Caribou: A Landscape Approach For use in Northwest Ontario*. For the northeast, the role of developing a management strategy has been assigned to the Northeast Region Woodland Caribou Task Team. It has considered developing a Direction strategy, rather than Guidelines.

A Draft Recovery Strategy has been developed and is currently under review. It has a Recovery Goal, seven Short Term Objectives and Specific Steps, prioritized to achieve those objectives. Five recovery zones have been delineated.

Concerns about sustainability of forest resources and ecosystems have been around ever since active forest management began. Environmental stewardship seeks to maintain forest ecosystems from detrimental human intervention, whereas economic stewardship seeks to provide non-declining flow of forest products for human society. A broader view envisions forests as providing multiple values, and degrading the ecosystem imperils the ability of society to maintain living standards.

## **Classification**

### **Genotype**

Although caribou in North America are generally divided into barren-ground and woodland varieties, they are all considered as a single species *Rangifer tarandus*. Taxonomy below the species level is unclear and subject to revision. According to work done on mitochondrial DNA by Dueck (1998), there were two founding clades. The northern one originated in Alaska’s and Canada’s glacial refugium, and the southern clade occurred south of the Wisconsin ice sheet. Almost all barren-ground and woodland populations in Canada are mixtures of the two haplotypes and the Pukaskwa population is the only one in Ontario that contains purely southern haplotypes.

All caribou in Ontario are considered to be of the woodland subspecies. Across Canada, populations of this subspecies, with their rich genetic variability, have adapted to different environments, and convergently in similar environments.

### Ecotype

For management purposes, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has accepted the classification of ecotypes based on habitat use and migratory behaviour as being more appropriate than genotype. Also, ecotype classification satisfies COSSARO's "rationale for eligibility" criteria for listing vertebrate populations. It differentiates the *forest-tundra* populations on the Hudson Plains as ecologically distinct from the *forest-dwelling* populations which occur elsewhere in the province. Key characteristics of forest-tundra caribou such as appearance, predator relationships, quality of its range, human impacts and behaviour more closely resemble those of barren-ground populations.

Ontario's forest-tundra populations appear to be stable or increasing and are not considered to be at risk. **The primary management concern lies with the forest-dwelling ecotype which has been listed as threatened.**

The forest-tundra zone was considered by Ahti and Hepburn (1967) to be the best caribou range in Ontario. Harris (1999) recommended the southern boundary to be Hill's (1958) Site Region 1E. The forest-dwelling ecotype is more or less continuously distributed southward from that line to approximately 50 degrees Latitude.

Forest-dwelling caribou are associated with five National Ecological Areas (NEA) across Canada, and it is only the Boreal NEA that is represented in Ontario.

### Population

The term *metapopulation* was described by Levins (1968) as "a population of local populations which are established by colonists, survive for a while, send out migrants, and eventually disappear." Metapopulations formed by groups of local populations (along with some that are probably isolated) constitute the distribution of woodland caribou in Canada.

Caribou occur across large areas that vary in habitat quality and restrict them into local populations. Generally, movements of these animals are not well enough understood to be able to assign them into populations. Most collared caribou are adult females that are expected to have fidelity to a home range. Young males are more likely to emigrate to another local population (Thomas and Gray 2001). Natural populations occupying large areas are usually comprised of local populations or colonies. **Expansion and contraction may be going on in different localities at the same time**, and the chance of local extinctions is reduced if there is adequate dispersal within the metapopulation (Andrewartha and Birch 1954).

Caribou population dynamics in Ontario are unclear. Are they comparable to mainland – island population structures where the area of continuous distribution of caribou continually provides immigrants to isolated habitat patches that are too small to avoid extinctions? Are they comparable to source – sink population structures where the area of continuous distribution contains high quality habitat and produces surplus

caribou to poor quality habitat patches that only support them during favourable conditions?

### **Distribution**

Until the late 1800's, woodland caribou were known to range from the Hudson Bay coast as far south as Manitoulin Island and Lake Nipissing (Cringan 1957). Retraction of the range northward coincided with increased human activities in the form of agriculture, timber harvesting, hunting, anthropogenic fire and transportation infrastructure construction. Racey and Armstrong (2000) detailed several case histories from the past of caribou range recession in northwestern Ontario that were best described as a series of collapses, rather than gradual declines. **Harris (1999) suggested that they were not continuously distributed within their former range.**

Cumming and Beange (1987) observed that caribou are distributed in scattered small bands that may travel widely and associate with other small groups. Seven herds in Ontario ranged an average of 390 km<sup>2</sup> over a single winter. Some caribou travel as much as 80 km between wintering and calving areas, while others are more sedentary (Cumming 1992). Several researchers have reported that radio-collared females will return to the same general area to calve in successive years, while others have found no fidelity to specific calving sites (Thomas and Gray 2001).

As studies expand and improve across Canada, more (so-called) populations have been discovered and delineated. In 1978, there were considered to be 55 populations of boreal caribou in Canada. This number rose to 98 in 1991, and 161 by 2001 (Thomas and Gray 2001)). The estimate of the total number of caribou in Ontario was over 20,000 in 1996 which was the highest figure ever published (Cumming 1998). Of those 5,000 may be considered the boreal ecotype (Harris 1999). **When comparing estimates for 1990 to 1996, Cumming (1998) found that the number for the commercial boreal forest doubled during that interval, probably because of increased effort at finding caribou bands.**

At least six remnant populations of about 500 animals occur south of the zone of continuous distribution. They include the Slate Islands, Pic Island, Pukaskwa National Park, Caramat, Flanders Township, and Hagarty Road (Darby et al. 1989, Cumming 1998). Small numbers of caribou translocated 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).

### **Caribou-Lichen Relationship**

Certain adaptations have permitted caribou to exploit a nutrient-poor, low productivity niche on the landscape that other ungulates cannot (Thomas 1992). Although they will consume the most nutritional parts of a wide variety of plants, especially during the snow-free season, caribou have a very direct relationship with the occurrence of lichen.

While they select it throughout the seasons, their particular dependence on this plant in winter is reflected in habitat requirements for this time of year.

Caribou have specialised microbes in their rumens that efficiently digest lichens which are high in carbohydrates, but low in protein. During winter, their feeding strategy favours energy maintenance over body growth. Caribou also are able to recycle urea to preserve nitrogen, and catabolise protein from their muscle when their diet is nitrogen deficient.

To understand the ecology of caribou, it helps to understand the ecology of lichen. This organism exists as a symbiotic relationship between fungi and algae that does not compete well in shade or leaf fall of vascular plants; consequently it is generally absent on moist fertile soils. Because it lacks roots and derives moisture and nutrients from the atmosphere, lichen can colonize sand, thin mineral soil, bare rock, dry raised peat, and dead branches (arboreal) and flourish in environments hostile to other plants. Growth can be less than one mm/year interrupted when conditions are unfavourable (Brodo et al. 2001).

**Whereas moose and deer thrive in early successional habitats characterised by fertile soils, plant diversity and high productivity, woodland caribou habitat may be described as late successional, nutrient-poor regimes where lichen has had time to proliferate.** As coniferous forest canopy develops or excessive peat accumulates, the competitive advantages of vascular plants decline. Where lichen is abundant, typically, tree cover is limited to jack pine (tolerant of excessively well-drained substrates), or black spruce (tolerant of deep peat). Closed canopy black spruce forest may provide light and moisture conditions favourable only to feather mosses in the understory.

## **FACTORS CONSTRAINING VIABILITY**

### **Shift in Predator-Prey Balance**

The characteristically low rate of reproduction in caribou has evolved under lower predation pressure than other ungulates native to Ontario. Caribou have developed strategies to minimise predation when calves are most vulnerable. These include dispersing into areas where wolves and alternate prey species such as moose, as well as other caribou are scarce (Bergerud and Page 1987), and calving on islands and peninsulas that offer increased detection and escape options. Much of the behaviour of caribou is related to reducing risk of predation (Bergerud 2000). *Except for innate tendencies for selection of calving areas, the idea that caribou consciously behave this way is speculative and dispersal patterns have more to do with food requirements. Barren-ground caribou wintering in areas of high hunting pressure certainly have not learned much in the way of avoiding human predation.*

Wolves are considered the main cause of mortality in most caribou populations. Predation is the major cause of death of radio-collared calves (e.g., Bergerud 2000). The highest caribou densities occur in the absence of wolves (Thomas 1992). At Quesnel Lake in British Columbia, Seip (1992) reported that when wolves were present and uncontrolled, calf/cow ratios were only 2.5/100, but were up to 39 calves/100 cows when wolves were absent or controlled.

More commonly, woodland caribou and moose share the landscape, though in different ecological niches. Caribou prefer older growth conifer forest, while moose select early successional mixedwoods. If habitat changes favour the more prolific moose in this two-prey system, the wolf population is able to attain higher numbers, and caribou, the smaller, less prolific prey, will be the most vulnerable. In autocorrelation analysis of winter track locations at Wabakimi Lake, Cumming *et al.* (1994) observed habitat partitioning by moose and caribou, and wolf tracks were most often associated with moose tracks. They also suggested that caribou may be able to occupy more diverse habitats where moose and wolves are less abundant.

In northeastern Alberta, where the caribou population is considered to be stable or slightly declining (Stuart-Smith *et al.* 1997), a predator-prey study by James (1999) supported three predictions of a spatial separation hypothesis. He found that caribou and moose selected different habitat types, while moose and wolves selected the same habitat type, wolf predation on caribou was higher near habitats selected by moose, and scat analysis showed that relative predation on caribou was less their relative frequency in the environment. *Deer were also present in the study area as alternative prey. If wolves are able to achieve higher densities in response to additional types of prey in its diet, this would lead to greater predation pressure than would be expected on caribou in Ontario where there is very little overlap in the range of caribou and deer.*

Also in Alberta, roads and other linear corridors receiving little human activity were found to be used more often by wolves than random, and caribou near roads were at a higher risk of predation (James and Stuart-Smith 2000). Radio-tracked wolves were

found to travel almost three times faster on linear corridors than in the surrounding forest (James 1999). Wolf behaviour in relation to linear corridors may result in greater penetration of this predator into caribou habitat, especially on seismic lines or pipeline rights-of-way that are cut straight and long across all vegetation types, including peatland habitat. *These types of linear corridors rarely occur in Ontario where most new roads are created for forestry purposes which are generally less concentrated and shorter. In habitat dominated by peatland, as to be more expected in the northeast region, forestry roads are more restricted to higher ground which is better moose habitat unless the substrate well drained enough to produce abundant lichen.*

Although human induced changes such as global warming and accelerated alteration of habitat seriously disrupts natural processes, Harris (1999) suggested that a shift in predator-prey balance may have been underway before widespread habitat alteration by humans in northern Ontario. Peterson (1955) stated that moose appeared to invade northern Ontario since the late 1800's. If this was also coinciding with the end of the "Little Ice Age", changes in vegetation and habitat types would be expected. A comparison of pre-European and current forest composition along a transect from northwest of Sudbury to north of Sault Ste. Marie shows that the eastern half of the transect was dominated by boreal conifers in 1857, while the western half supported stands typical of the region today (Jackson et al. 2000), which. *Because moose are known to occasionally range to the northern limit of trees and into the taiga, the species probably ranged throughout northern Ontario before the late 1800's, though at lower densities and in smaller patches of good habitat than today. Perhaps predator-prey fluctuations, for and against caribou, have occurred many times in the past, and will continue.*

According to Hayes and Russell (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. 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".

Wolf densities in the southern boreal forest of Ontario ranged from 4-8/1000 km<sup>2</sup> and 2-4/1000 km<sup>2</sup> in northern parts of the forest (Darby et al. 1989). Bergerud (1988) maintained that wolf densities higher than 6.5/1000 km<sup>2</sup> caused caribou to decline whereas moose could persist at densities of 8 wolves per 1000 km<sup>2</sup> (Bergerud and Elliott 1998). Densities of 2, 4, and 8 wolves per 1000 km<sup>2</sup> 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. Estimates of population densities derived from winter surveys in Ontario range from 6 to 42 caribou/1000km<sup>2</sup> with a modal value of approximately 20 caribou/1000km<sup>2</sup> (Darby et al. 1989). **According to these figures, caribou can only form a small part of the diet of wolves in the forest and they must depend on other prey.** Wolves are likely to

concentrate on species with high productivity and biomass. Caribou tend to use areas where moose and deer are absent or rare (Cumming *et al.* 1996), especially in summer when calves are vulnerable to predation.

Throughout most Canadian jurisdictions supporting caribou populations there were very active wolf control programs that continued until the 1970's. In Saskatchewan, Rettie and Messier (1998) found that the decline in caribou and hunter success coincided with, among other things, the end of wolf control. *This raises the question of whether some caribou herds are declining from unnaturally high populations induced by the period of wolf eradication, but there is a lack of evidence.* Racey and Armstrong (1998) documented caribou declines in the Kenora District and north shore of Lake Superior in spite of wolf control.

After caribou declines in Saskatchewan and subsequent protection, Rettie and Messier (1997) expected the trend to reverse unless populations were severely limited by food shortage or predation. They observed high conception rates of cows (indicative of good nutrition), and low calf recruitment probably related to predation. They speculate that black bears may be a predation factor with calves during their first few weeks of life. At calving time, bears and caribou were found to more closely share the same range and food resources, but bears could not be responsible for the high natural mortality of adults. Based on food requirements of wolves (Messier 1985), it was considered unlikely that the caribou population in their study area could sustain a wolf population without alternate prey.

### **Increased Hunting**

Hunting is generally considered additive to other limiting factors and therefore any reduction in hunting mortality is beneficial to a caribou population in decline. Before protection in 1929, the extirpations and range recessions may have been accelerated by excessive hunting and subsistence use. Caribou was an important meat source during increasing resource development in the north (Racey and Armstrong 2000). **In present times, there is concern about new roads providing increased accessibility for poachers and subsistence users.** Populations in large undisturbed areas, where predators are not managed, can withstand only 2-3% annual mortality from hunting (Yukon Renewable Resources 1996).

Based on information from the 1970's and 80's, Darby *et al.* (1989) estimated 610 to 730 caribou were harvested annually under Treaty rights in Ontario, of which at least 200-300 were forest dwelling ecotype. Illegal kills are difficult to gauge. Among the potential problems facing the woodland caribou in Ontario are illegal hunting and uncontrolled hunting by indigenous people using modern firearms (Harris 1999).

Obtaining accurate harvest data continues to be a major information deficiency.

### **Direct Loss of Winter Habitat**

Not to diminish the importance of habitats at other times of the year, winter habitat is particularly critical for maintaining energy reserves when forage quality is at its lowest,

movements are impeded by snow, and cows are in their latter stages of pregnancy. Lichen recovery is very slow compared to vascular plants and quite variable depending on cover type, soil conditions, disturbance characteristics, slope, aspect, elevation, and climate change. Harris (1996) stated that it takes about 40 years to reach predisturbance levels in northern Ontario.

Overgrazing and forest fires are natural processes that can potentially cause widespread loss of lichen cover on the landscape. In the foreseeable future of northern Ontario, forest harvesting is generally seen as having the greatest potential impact on the landscape compared to mining, agriculture, highway and rail construction, urbanization or any other large scale activities that have removed habitat in the past.

### Overgrazing

In the simplest ecosystems, caribou population growth would be limited by the standing crop of lichen, and that would be affected by the standing crop of caribou. Only where predators are absent or rare does food supply become a limiting factor (Bergerud 1996). **In their survey of caribou range in Ontario, Ahti and Hepburn (1967) found no evidence of overgrazing and the caribou population was far below what the range could support.** Cumming and Hyer (1998) estimated that caribou reached habitat potentials as high as 80% in the Nipigon Superior Region and 50% in the Central Highlands.

Thomas and Gray (2001) stated “It is widely stated that hunting and predation depress most caribou populations to densities well below the vegetative carrying capacity of their ranges. However, periodic unavailability of forage because of weather variables is a component of long-term carrying capacity. 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.”

### Fire

Lichen is a very flammable component of the forest floor that dries more quickly than other fine fuels. Because it is most abundant in older coniferous forests which are also highly flammable, caribou are very sensitive to the fire cycle. Although it may be quite detrimental to caribou in the short term, burns may provide conditions for increased lichen growth in the long term (Klein 1982).

After many decades of organized fire control, the average area burned annually in Ontario has dropped from about 700 thousand hectares in the pre-settlement era to 80 thousand in more recent times (Euler 1998). This has resulted in much more old growth forest available to caribou.

Of course, the fire regime will be affected if climate change is occurring. There have been episodes of global warming in the past, but currently it is largely being blamed by human activities. The *Canadian Regional Climate Model* for western Canada (including northwestern Ontario) predicts that, over ten years of simulation, temperatures will

increase by five degrees and precipitation will decrease by 20% (Amiro et al. 2001). While this will be conducive to much greater fire activity in the northwest, northeastern Ontario may actually experience longer fire intervals because if the Great Lakes provide more precipitation in a warmer climate (Flannigan 1998). Longer fire intervals could translate into larger fires when they do occur and have serious impacts on small isolated caribou populations. **These changes are expected to directly affect the vegetative composition of the forest and reduce the boreal zone in Ontario as the limit of temperate forest advances northward.**

Although most fires are small, the largest 2–3 % of fires account for 97–98% of the total area burned in Canada (Stocks 1991). **Areas set aside for caribou habitat must be large enough to contain adequate unburned habitat after large fire events.** Caribou are much more vulnerable to disturbance of their main food supply than other ungulate species whose food supply recovers rapidly from disturbance.

### Timber Harvest

Direct loss of habitat may occur when lichen is destroyed or rendered unavailable. Terrestrial lichen is vulnerable to all-weather road construction, not only in the actual right-of-way, but also where aggregate material is extracted from well drained deposits supporting lichen growth. As resource managers are becoming more aware of caribou requirements, road layouts may be designed to avoid areas of high quality habitat as recommended in the forest management guidelines for Ontario's northwest region.

Residual lichen remaining after logging is also quite sensitive to the amount of mechanical site preparation carried out for regeneration of pine and spruce. These species germinate best on exposed mineral soil normally produced after fire. The Ontario Provincial Silviculture Strategy recognises concerns about high costs and societal disapproval of heavy reliance on mechanical site preparation and herbicide application after harvesting. There is likely to be a greater reliance on low cost regeneration methods, and less on planting. For spruce, this means natural regeneration from seed trees left standing, or advanced growth. *Although this may be beneficial for residual lichen in the short term, it is likely to result in more hardwood competition in the longer term. Intensive conifer silviculture is probably the best option for lichen recovery in cutovers, especially where it was not abundant before logging.*

When trees are harvested, there may be an arboreal lichen component removed. Although it is an important food source for the mountain ecotype (Poole *et al.*), forest-dwelling caribou forage primarily on terrestrial lichen.

Tree extraction may also affect the availability of terrestrial lichen by altering snow conditions. In many areas of Canada characterised by relatively dry climate, snow depth is not usually a vital concern. Although caribou can forage through a metre or more of snow (Brown and Theberge 1990), there is a cost to energy reserves. In moister climates, such as Ontario's northeast, they may be inclined to avoid snow that is deep or crusted, and seek areas with sufficient forest canopy to intercept snow and moderate freeze-thaw cycles.

Cumming and Beange (1993) suggested that the best explanation for caribou decline is displacement by logging into areas where they are more vulnerable to wolves, poaching and accidents. *This implies that caribou are mainly at risk where habitat and refuge are already limited.* The Cliff Lake area of northwestern Ontario shows a close temporal relationship between timber harvest and the disappearance caribou between 1970 and 1982 (Racey and Armstrong 2000). It is not clear whether direct loss of habitat caused the disappearance, or other factors played a role such as expanding white-tailed deer populations, the end of wolf control and increased human activity during that time.

### **Disturbance**

It is difficult to measure the direct effects of developments on caribou individuals or populations. 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). The length of time for caribou to acclimate to various stressors is not well understood. Cumming and Hyer (1998) summarized some contradictory observations, mainly from Newfoundland. No accommodation to linear developments was observed after two years in Alberta (Dzus 2001). Reindeer in Scandinavia can persist in highly developed areas, although recent studies indicate that wild reindeer in Norway tend to avoid developments (Nellemann *et al.* 2001, Vistnes *et al.* 2001).

In his study of disturbance of woodland caribou in northeastern Alberta, Dyer suggested that it is the vehicular traffic associated with development that caribou mainly respond to, and observed that total avoidance was most apparent on heavily used roads. Lowest traffic levels on roads in his study area were less than 100 vehicles per day, while highest levels were at 600-800 per day.

While recognising that caribou declines may be mainly attributable to habitat disturbance and direct mortality, Cumming and Hyer (1998) proposed chronic or severe disturbance as a factor that could displace animals into poor habitat or closer proximity to moose and wolves. In their study area near Lake Nipigon, caribou avoided a log hauling road during trucking activity in Year Two of the experiment when it was used 24 hours a day by 25 logging trucks and other vehicles. Caribou did not change their behaviour during Year One or Year Three when the road was not in operation, nor in a nearby control area.

*There is survival value for caribou to abandon habitat bisected by roads if high traffic is temporary and adjacent habitat is available.*

Thomas and Gray (2001) stated "They may associate linear and other developments with predators and hunters. Caribou at low densities and well below the absolute, vegetative 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 their behavioural response 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.”

Dyer (1999) stated that disturbance studies are usually limited to responses of individuals and there is a lack of documentation on the effects on demographics.

*Although there are abundant references to adverse effects of disturbance, there are too many references to benign effects to ignore. Variations among individual animals and types of disturbance prevent us from knowing, with confidence, what the thresholds are. The main concerns are outright harassment and vehicular traffic.*

### **Road Kills**

In Alberta, the A la Pêche caribou population experienced up to 11% mortality in two winters from collisions with vehicles on Highway 40 north of Hinton, apparently because salt attracted caribou to the highway (Brown and Hobson 1998). 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. *Small populations are most vulnerable to these types of events. This population is mountain ecotype and its behaviour around roads is probably not comparable to forest-dwelling caribou. My observations of woodland caribou around highways have been that, unlike moose or deer, they tend not to linger when there is traffic.*

Mercer *et al.* (1985) knew of only one caribou killed on Newfoundland highways, despite large numbers, while 200-300 moose are killed every year.

### **Parasites**

The effect of insect harassment and parasites on the fitness of forest-dwelling caribou is not well known. The nematode, *Parelaphostrogilis tenuis*, normally invades the meninges in white-tailed deer, and is benign to its main host. Because it readily penetrates the brain of other cervids, it becomes very lethal and is potentially a limiting factor for woodland caribou (Pitt and Jordan 1994). *It is a particularly serious threat in small isolated caribou herds on the southern periphery of the range and there is doubt whether successful reintroductions and range expansions can occur in parts of Ontario where white-tailed deer are common.*

## **PRIMARY MANAGEMENT ISSUES**

Although natural limiting factors have the potential to greatly effect populations, caribou are highly adaptable and have developed strategies for coping with them. Each of the factors listed in the status report to COSSARO is compounded by habitat alteration and the risks faced by small populations.

### **Habitat Alteration by Timber Harvest**

The southern limit of “continuous” caribou range closely approximates the northern limit of forestry operations in Ontario (Armstrong 1998). Caribou range in the commercial forest may be subject to alteration as forestry operations expand across most of the boreal forest (Peterson *et al.* 1998). Harris (1999) stated “Caribou have declined where ever logging and other human activity has modified the landscape and will probably continue to do so as logging activity pushes northward.” There is concern about large reductions in proportions of medium and old growth forests, increased human access, predator prey relationships, and parasites carried by moose and white-tailed deer.

**Despite this concern, there appears to be more forest in the older age classes now than in pre-settlement times.** In unmanaged boreal forest where fires are unsuppressed, Boychuk *et al.* (1995) found that younger age classes dominated the landscape. In Ontario’s managed boreal forest 75% are older than 40 years. Combined disturbance by fire or logging per year amounts to less than 40% of the average annual burn during pre-settlement times (Euler 1998).

The Draft Recovery Strategy states “While direct habitat loss through logging access development or other human development is a concern, the indirect consequences of habitat loss may be as important as habitat loss itself...habitat change resulting from forestry activities often leads to improved habitat conditions for other ungulate species such as deer and moose and other prey species which may increase and thereby allow for greater predator densities.”

The boreal forest is comprised of areas that are almost uniformly coniferous and other areas that are mixedwood. Boreal mixedwoods are sites that support, or could support, good growth of the five main component species which are white spruce, black spruce balsam fir, trembling aspen and white birch. An estimated 45-50 % of northern Ontario’s productive forest land could be classified in this category (McClain 1981). Hardwoods are more common in the warmer, moister south where forest productivity can be many times higher. It is in this southern portion of the boreal forest where merchantable timber is most abundant (Wedeles *et al.* 1995). *Boreal mixedwood usually occurs on fertile landforms and soil types. Considering site conditions that produce abundant lichen, these stands are not expected to be prime caribou habitat. Boreal mixedwoods are usually more associated with moose and become higher quality habitat for this species after logging.*

Boreal coniferous forest occurs on either excessively moist sites with dry hummocks (black spruce and cedar), or on soils at the drier end of the moisture spectrum (jack

pine). These extreme moisture conditions may also be associated with poor nutrient availability (Wedeles *et al.* 1995) and higher quality caribou habitat at the stand level.

**Of key importance to predator-prey relationships would be the spatial arrangement of habitat types and timber harvesting at the landscape level.** A mosaic of small cutovers carried out over a long period of time would produce the edge and young growth to potentially sustain high moose and wolf populations across the entire landscape. In west central Alberta, a two and three pass logging system producing checkerboard pattern resulted in the undesirable effect of increasing alternate prey and concentrating caribou in remaining areas (Hervieux *et al.* 1994). A large cut (or a series of contiguous small cuts extending over a short time interval) carried out to more closely mimic a larger fire event will, in the long term, produce the large even-aged old growth forest beneficial for caribou.

### **Isolated Populations**

There are two perceptions on management needs of small populations of animals that are isolated from main concentrations. One is that satellite populations are normal biological entities, not to be interfered with, that are adapting to local environments, which ultimately leads to speciation. Probability of local extinction may be high, but it is also variable. Mayr (1954) suggested that this process of adaptation in peripheral populations is disrupted by the infiltration of alien genes from the central population that dilute any genetically acquired advantages.

The other perception is that the probability of extinction of small populations is too high to allow them to remain isolated. They are at greater risk of stochastic events such as all remaining females involved in a train accident, or bad weather icing their entire food supply. They are also at greater risk of reduced fitness caused by the loss of genetic variation through inbreeding and genetic drift.

The Draft Recovery Strategy has as its Recovery Goal to “Maintain self-sustaining, genetically-connected forest-dwelling woodland caribou populations where they currently exist; ensure security for and connections (reproductive) among currently isolated populations; and re-establish caribou in strategically selected landscape units in order to achieve self-sustaining populations and ensure connectivity. This is a very ambitious goal which will require enormous effort.

Thomas and Gray (2001) suggest “Managers or regional committees should decide which local populations have a low probability of viability because of modified habitat and concentrate on those populations where probabilities are moderate and high. The failure to re-introduce populations to former range (Bergerud and Mercer 1989) and to augment existing endangered populations along the southern periphery of their former range (Compton *et al.* 1995, Zager *et al.* 1996) indicate that it is not productive to focus limited resources there.”

A case study of success where timber harvest is carried out on the range of a small population involves the Owl Lake herd. It was subject to research and management

strategies developed through the Manitoba Model Forest, and a primary objective was to maintain a minimum of 2/3 of the winter range as high quality habitat (Schindler 2003). After this was identified by using Habitat Suitability Index values, Habitat Units were calculated by multiplying the value by area of the polygon. Caribou were radio collared to estimate their area of home range, and test and refine habitat suitability predictions. As the model predicted, these animals showed a strong selection for high quality habitat, and its availability exceeded its use by caribou.

## **CURRENT RESEARCH INITIATIVES**

The following are the studies being conducted or completed in Ontario.

1. John Wilson completed MSc. at Laurentian University titled *Habitat Characteristics of Late Wintering Areas Used by Woodland Caribou in Northeastern Ontario*. His abstract is as follows.

In 1997, the Ontario Ministry of Natural Resources found large numbers of woodland caribou during routine moose surveys in the Detour Lake area north of Cochrane in northeastern Ontario. In this area, many mature stands had been scheduled for harvest and it was realized that little was known of the caribou populations in this region. As late winter is one of the most stressful times of year for this species identification of the habitat used during this time was deemed important for proper management. For these reasons, the primary objective of this study was to identify snow, vegetation, and habitat characteristics that described late winter caribou habitat in northeastern Ontario. A total of six caribou Use Areas and six Non-Use areas were studied and compared. A total of 180 cratering sites in Use Areas and 180 sampling sites in Non-Use Area were identified and marked for examination. Winter sampling was conducted in early March to identify snow conditions within each area type. Sampling sites visited during the winter in both Use and Non-Use Areas were revisited during the summer to identify vegetative and habitat characteristics present. To aid in the classification of habitat types, the Northeastern Ontario Forest Ecosystem Classification system (NEO-FEC) was used. Mean caribou group sizes and mean snow depths for 1997, 1998 and 1999 were analyzed. Both univariate and multivariate techniques were used to identify differences between Use and Non-Use Areas at the feeding site or microhabitat scale. Analyzes were also done at the macrohabitat scale in an attempt to identify differences between Use and Non-Use Areas at the stand level. Results supported the conclusions that: (1) late winter woodland caribou Use and Non-Use Areas in northeastern Ontario can be distinguished using vegetative parameters at the microhabitat scale, (2) percent cover of terrestrial lichens, relative biomass of arboreal lichens, and relative stand density are the most important vegetative indicators of woodland caribou late winter habitat in the lowland black spruce forest of northeastern Ontario, (3) forage is the primary variable influencing microhabitat use by woodland caribou in this region, (4) late winter woodland caribou Use Areas in northeastern Ontario have lower relative stand densities and may be less valuable as sources of timber, (5) total snow depth is a secondary parameter influencing the identification of late winter caribou ranges in northeastern Ontario, (6) during years when snow conditions approximate or exceed "normal", late winter caribou habitat may be identified using snow thickness data in this region, (7) analysis at the macrohabitat scale (stand level) supports the results of the microhabitat analysis (feeding site level), (8) the NEO-FEC system is unable to distinguish between Use and Non-Use Areas, (9) woodland caribou late winter group size increases with increased snow depths, and (10) forestry and government managers should be able to quickly assess the potential of an area to support woodland caribou in late winter and make management decisions which will sustain woodland

caribou populations in this region.

2. Sarah Proceviat completed her MSc. at Laurentian University titled *Seral Changes in Forage Availability for Woodland Caribou and Moose in Northeastern Ontario Lowland Black Spruce Sites Impacted by Careful Logging*, and will be defending it soon. She studied seral ages 0 to 70 age groups (1-3, 8-10, 30+/-2, 70+/-2). Sites were examined in each group for species composition, % cover, species frequency, canopy cover. Her final report should be available soon once she has defended her thesis. She is currently working at the Regional office in South Porcupine to develop a visual index of arboreal lichen.

Sarah also wrote a paper for her BSc. entitled "Development of a Visual Index to Determine Age of Woodland Caribou."

3. Emilie Lantin should be completing her MSc soon at Quebec University in Montreal. She is looking at developing a model to determine spatial distribution of food resources on a seasonal basis as it relates to female caribou.

4. Glen Brown has another two years for his PhD. at Laurentian titled *Habitat Selection and Behaviour of Woodland Caribou in Harvested and Unharvested Boreal Forest in Northeastern Ontario*. There are five hypotheses he is working on. 1) Landscape Classification - A Macro-Habitat Perspective; 2) Community Classification - A Meso-Habitat Perspective; 3) Site Classification - A Micro-Habitat Perspective; 4) Snow Characteristics of Utilized and Non-Utilized Winter Caribou Habitat in Northeastern Ontario; 5) Impact of Snow on Forage Utilization and Availability for Woodland Caribou in Northeastern Ontario.

5. Susan Miller participated in our collaring project to collect tissue samples for her MSc entitled "Characterization of the Radiation Response of Caribou, White-tailed Deer, and Indian Muntjac Fibroblast Cells." This is related to natural radiation levels in lichens and their bioaccumulation in caribou flesh. (Indian Muntjac is a small deer)

6. Tracy Hillis completed a PhD. titled *Habitat selection and trophic relations of woodland caribou in northwestern Ontario*.

7. D. Wiwchar's MSc. at Laurentian is titled *Prey specialization and morphological conformation of primary predators in a moose/woodland caribou prey system*.

8. A MSc. (Juha Metsaranta) on Manitoba caribou, also at Laurentian, is titled *Habitat selection by woodland caribou in north central Manitoba*.

9. Dr. Paul Wilson from Trent University is investigating the use of DNA for metapopulation analysis.

## **RECOMMENDATIONS**

### **Policy**

#### **1. Build partnerships with aboriginal groups**

Aboriginal communities within the caribou range are important stakeholders and need to be actively involved in wildlife and forest management.

#### **2. Measure change using IUCN-The World Conservation Union standards**

Because short-term changes in numbers can vary considerably due to natural phenomena such as weather, the IUCN has adopted 10 years or three generations, whichever is longer, as a suitable time frame to evaluate changes in numbers. A generation is defined as the average age of parents (IUCN 1994, COSEWIC 2000). Three generations of caribou is approximately 20 years. A decline or increase would be defined as more than a 20% change over 20 years. Anything less should be termed relatively stable or about stable or indiscernible or no statistically significant change between surveys. As few populations have been adequately tracked over the past 20 years, most evaluations of increasing, declining, and stable in the literature are inter-survey changes or qualitative evaluations with variable intervals. Few populations that are described as stable probably are. Caribou populations fluctuate widely in numbers because recruitment and adult mortality is quite variable.

#### **3. Evaluate the success of the *Forest Management Guidelines* for use in northwestern Ontario, and consider implementing its Recommendations under 4.0 across all of northern Ontario**

Although there are ecological, physiographic and climatic differences between northwestern and northeastern Ontario, differences between ecoregions are accounted for in this section of the document. The recommendations pertain to planning at the regional, sub-regional, FMU, and stand levels, and other human activities. They are well described and quite applicable to any part of the caribou range in Ontario.

#### **4. Determine how parks and protected areas will conserve habitat**

Will old growth protection be fixed spatially or moveable across the landscape? Protected Areas can safeguard habitat but restrict management options. They are important as control areas for studies that attempt to assess the relative effects of limiting factors.

#### **5. Avoid rebalancing predator-prey relationships**

Bounty and poisoning methods of predator control prior to the 1970's were largely indiscriminate and inefficient. More recent programs in western Canada and Alaska have had well defined objectives and were promoted by big game outfitter and livestock industries. Boertje *et al.* (1996) documented substantial increases in caribou populations when wolves are reduced. At this time, using wolf control to secure caribou populations does not appear to be in Ontario's public interest. Sponsorship of workshops for trappers interested in increasing their harvest of a valuable furbearer, and increasing the number of moose tags available for harvest by hunters in caribou

range are indirect methods government can use to ameliorate the effects of predation, but they are unlikely to result in actual rebalance.

## **Research Priorities**

### **1. Quantify habitat supply**

Before this can be carried out, there must be a good understanding of the requisite components of caribou habitat. Hillis *et al.* (1996) superimposed radio collar location data on supervised Landsat images to identify preferred habitat in northwestern Ontario. Rettie *et al.* (1996) stated that the best method of characterising their habitat is by using vegetation community types.

The Forest Resource Inventory (FRI) system, developed for mapping the merchantability of timber, has been used for wildlife habitat assessments since they are the only detailed vegetation descriptions available for large areas of the landscape. Unfortunately, it varies in quality and lacks detail on understory vegetation so important to caribou. If late winter habitat is most critical and lichen is the most essential element, the standing crop and its distribution on the landscape will be important.

Antoniak and Cumming (1998) suggest that winter habitat may be predicted by a combined use of FRI and Landsat imagery. There is good signature for lichen in satellite imagery and it may be especially useful where FRI is lacking or poor quality, and for extending habitat mapping to areas without radio telemetry locations.

The Ontario Wildlife Habitat Assessment Model (OWHAM) is being used in the assessment of habitat suitability for selected species and should also be applied to woodland caribou.

### **2. Model changes in habitat**

This would be useful in monitoring the dynamic nature of ecosystems and exploring the effects of resource development. The Strategic Forest Management Model (SFMM) uses FRI data to estimate aspatial habitat supply and changes in forest composition for natural succession and disturbance. The Alberta Landscape Cumulative Effects Simulator (ALCES) is being used to model the response of caribou to natural and human caused disturbances on the landscape. Its strength is in comparing the relative effectiveness of changing various practices, rather than in predicting absolute habitat value at some point in the future.

### **3. Confirm that the decline continues**

This will be required for each of the five recovery zones. Harris (1999) mentioned that the discovery of previous unknown caribou bands has made it difficult to interpret trends. Caughley and Gunn (1996) stated "Determining the factors driving a decline needs an analytical approach founded on scientific method. The initial step is to use trend in numbers, a contraction in range, or an obvious pending threat to determine that there is a problem. The next step is to acquire a basic understanding of the specie's

ecology to devise hypotheses for which factors are pushing it toward extinction. Testing the hypothesis through the rigor and discipline of scientific method leads to the surest diagnosis.”

#### **4. Determine the cause of the decline**

The premise that the northward advancement of logging is causing the decline is too vague. A decline may be caused by a single agent (acting alone or complicated by accelerants) or cumulative effects, and it may differ between recovery zones. Caughley and Gunn (1996) emphasize the importance of accurately diagnosing the cause of a declining population and cite several case histories “...where a shaky diagnosis led to ineffective treatment. Often a decline is not detected until it is well under way and only a small population remains. Even under those circumstances a shotgun approach with a suite of recovery treatments is seldom, if ever, the answer. Diagnosis will reveal the magnitude of how different factors are affecting the decline and that, in turn, will guide priorities for the treatments.” They also say “To save a species, results should be unambiguous and defensible. In the absence of designed experiments, futile arguments can cloud issues such as whether forest fragmentation does cause increased predation or whether corridors should link reserves. Frequently, hard choices have to be made and they increasingly lead to litigation. Controversies over the northern spotted owl, *Strix occidentalis caurina*, ended up in court with arguments over the validity of research results. In the courts, as elsewhere, weak inferences tumble before the evidence rigorously arrived at through sound experimental design.”

Obvious mortality factors may be oversold as the cause of decline, whereas the real cause may be ignored because it is difficult to measure and goes undetected.

#### **5. Determine how caribou are using their habitat**

If caribou are declining, are they abandoning the poorest habitats first, or are they deserting some of the best parts of their range to avoid the agent causing their decline? Are stable populations using the entire prime habitat available or only a portion of it? The most cost effective method of answering these questions is with GPS collars on a small sample of the population. Alberta is shifting its focus towards understanding the habitat needs of caribou in a changing landscape. One approach is a cost-benefit analysis of different habitat types to caribou fitness.

#### **6. Determine proportion of good habitat impacted by logging**

It appears that caribou habitat may be more associated with less merchantable forest types and, at the stand level, logging is not having serious impacts. Smith *et al.* (2000) and Chubbs *et al.* (1993) found evidence of caribou avoiding recent clearcuts. Studies are required to determine caribou use of sites *before* and *after* timber removal. “There is no certainty that conceived forest management strategies will conserve caribou” (Thomas and Gray 2001).

#### **7. Assess breeding isolation**

The gene flow between populations and the degree of isolation may be determined by DNA analysis. In their study of five boreal caribou ranges in Alberta, and one in

northeastern British Columbia, McLoughlin *et al.* concluded that population declines in western Canada could not be attributed to inbreeding depression or genetic drift. Also, DNA analysis should be used to examine how well populations fit with the five recovery zones.

#### **8. Conduct optimization analysis**

Modelling changes in timber revenues in response to forest management treatments to conserve caribou can be used as a valuable decision support tool. Marzluff *et al.* (2002) showed how habitat suitability models could be linked with forest management scenarios in an area of Washington State.

#### **9. Ensure that corridors are effective**

Because recruitment is generally low in boreal caribou populations it is important to ensure that good calving areas (high probabilities of survival) are connected to good winter range. Corridors connecting separate wildlife populations are generally in the form of reserves of natural vegetation through areas of land use, such as agriculture, that are incompatible with the species of concern. Regarding woodland caribou, it may be debatable how much cutblocks actually fragment range if those areas were not providing good habitat before harvesting.

Simberloff and Cox (1987) stated that disadvantages associated with corridors do exist such as spread of disease and forest fire, and increased exposure to poaching and predation. They also mentioned that other conservation methods may be more cost effective than waiting for animals to use corridors. The effectiveness of corridors for caribou should be tested to determine whether movements between central and peripheral populations increase, and compare it connectivity outside of corridors.

#### **10. Determine the rate of decline**

This will allow managers to understand the degree of urgency and time period available for recovery steps.

### **Procedural**

#### **1. Utilize the provincial *Forest Management Guide for Natural Disturbance Emulation***

In this guide, timber harvest operations are designed to resemble patterns of forest fire on the landscape. Fires are known to extend across thousands of square kilometres. Although it is not operationally feasible or acceptable to society to conduct cuts on this scale, very large cuts would be required to eventually create the extensive areas of old growth conditions required for successful caribou management.

#### **2. Communicate forest management improvements that accommodate wildlife**

Woodland caribou habitat is characterized by conifer forest cover. In the early days of timber harvesting when preferred conifer species were extensively logged, reforestation programs did not exist. Under natural conditions, these conifers reproduce optimally from a good seed source and an exposed mineral bed. After logging, they are generally

replaced by hardwoods that reproduce easily by coppicing or root suckering, if there is no silvicultural intervention. Since those days, the *Crown Forest Sustainability Act* has come into force and requires harvested areas to be regenerated to the composition of the previous forest.

In his survey of biologists' opinions on forest wildlife topics, DeStefano found that their main concern was the alteration of forest vegetative structure due to timber harvest and its effects on wildlife populations. He also reported that only 8% of respondents felt that biologists and foresters worked very closely together. Foresters need to promote the message that timber harvest activities for protecting caribou habitat components have been progressive since the 1970's. Extensive research and public consultation lead to the development of the *Forest Management Guidelines for the Conservation of Woodland Caribou: A Landscape Approach, for use in northwestern Ontario*.

In his status report, Harris (1999) stated "...changes in Ontario's approach to timber management are cause for optimism. The shift toward emulating natural disturbance patterns and greater consideration of caribou habitat values in timber management planning are positive steps. The status of forest-dwelling caribou should be recalculated when the revised guidelines have been implemented and their impacts on caribou populations assessed."

### **3. Demonstrate modified timber harvest practices that allow caribou to persist**

A good example of this is the timber harvest prescriptions developed in the range of the Owl Lake herd in southeastern Manitoba.

### **4. Conduct studies over time periods sufficient long enough to answer questions**

Professional biologists, surveyed by DeStefano (2002), ranked their biggest challenge to meaningful research as: securing adequate funding and agency commitments to conduct long-term and large-scale manipulative experiments, which would include accurate estimation of meaningful variables, such as survival and reproduction in a metapopulation framework. The limitation that most studies have been carried out on short temporal and small spatial scales results in considerable understanding of individuals, but progressively less about populations and ecosystems. *Long term* monitoring is not synonymous with *continuous* monitoring. In the absence of accurate and precise information about predicting outcomes, managers have little recourse other than deferring to expert opinion for setting out rules and guidelines.

### **5. Use adaptive management**

It is most efficient to use information as it becomes available in order to test it and provide feedback. Managers need to know which harvest practices are successful in order to continue with them or switch to an alternative treatment. This is only possible when completed research is accessible.

Even though there is a large body of highly experienced researchers and resource managers, it is very difficult to specify prescriptions when high levels of uncertainty exist.

“The results of scientific research and other forms of knowledge must be applied. Too often the results of research are not presented in a form that can be applied by forest companies and others with power to make changes. Progress towards implementation of current knowledge must be a goal for the first decade of the new millennium” (Thomas and Gray 2001).

#### **6. Create a data repository**

There is vast amount of published and internal government reports on caribou that should be warehoused electronically. Much of this valuable information is obscure and may become lost or ignored if it does not become more easily accessible for resource managers. Each report in such a repository should be evaluated according to whether its statements and conclusions are based on sound scientific principles or speculation.

#### **7. Coordinate research and prioritize remedial steps**

Woodland caribou conservation is complex and crosses many disciplines. The research strategy of the West Central Alberta Caribou Standing Committee outlined the danger of fragmented research whereby separate small efforts do not reach the threshold to capture what is relevant.

Thomas and Gray (2001) also cautioned “One problem is the large number of government agencies that are involved in land management and conservation. Another is that several university departments and government agencies conduct caribou research. There is lack of co-ordination among such diverse groups with various objectives.”

Hypotheses need to be proposed and ranked according to what is most urgent for informed decision making. The infinite range and scope of possible studies are too cost prohibitive to study everything and ignore information collected in other jurisdictions that may have relevance to Ontario.

#### **8. Answer questions adequately and then move on to the next**

For example, Bergerud (1974) rejected the hypothesis that caribou declined from the southern edge of their range because of loss of lichen habitat. Has this conclusion been universally accepted, or does the experiment need further replication? If results are ambiguous, they can be debated endlessly.

#### **9. Set range occupancy and population targets**

Because population estimates based on aerial surveys are quite difficult (Thomas (1998), the recovery team has opted to use range occupancy as the main index of population health. There must be agreement on whether the target will be minimum viable population size or a larger number based on other values combined with a minimum area required per caribou.

“Application of the Species at Risk Act to woodland caribou will be difficult unless objective criteria are established for minimum populations and areas, limits to range

fragmentation, designation of critical habitat, and interpretation of the definition for residence” (COSEWIC 2001).

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