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# Progress towards the experimental reintroduction of woodland caribou to Minnesota and adjacent Ontario

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*Abstract:* Woodland caribou (*Rangifer tarandus caribou*) are native to Minnesota but started to decline in the mid 1800s and disappeared from the state by 1940. Their demise had been attributed to extensive timber harvest and ovethunting; but more recently mortality from the meningeal worm, *Parelaphostrongylus tenuis*, carried by white-tailed deer (*Odocoileus virginianus*), and increased predation by timber wolves (*Canis lupus*) and black bears (*Ursus americanus*) have been suggested as additional causes. We describe a current initiative to explore feasibility of restoring caribou to the boundary waters region of Minnesota and Ontario. Feasibility studies have been conducted under the guidance of the Notth Central Catibou Cotporation (NCCC), a non-governmental organization with representation from relevant state, federal, Native American, and Canadian agencies. Results indicate a) Within Minnesota the most suitable site for woodland caribou lies within the eastern sector of the Boundaty Waters Canoe Area Wilderness (BWCAW), and this is contiguous with a similarly suitable sectot of Ontario's Quetico Provincial Park: Together these comprise the recommended 1300-km$^2$ Boundary Waters Caribou Region (BWCR); b) Vegetation in the BWCR has changed little since the 1920s when caribou were last present other than effects of fire suppression; c) Level of white-tailed deer, hence the meningeal worm, is so low in the BWCR that this factor is unlikely to impede survival of re-introduced caribou; d) While wolf numbers within the wider region are relatively high, their impacts may be minimized if caribou are released in small, widely scattered groups; in addition, an abundance of lakes with islands affords good summer-time predation security; e) Threat to calves from black bears, probably more numerous than in earlier times, appears lessened by the security of lakeshores and islands; and f) A simulation model, combining knowledge from elsewhere with the BWCR assessment, suggests that released animals have a 0.2 to 0.8 chance of increasing in numbers during the first 20 years post-release. Strategies for maximizing success are identified. NCCC has concluded that the only practical approach that remains for determining restoration feasibility is through experimental releases or caribou. While promise of eventual success appears only moderate, the NCCC feels that costs and uncertainties associated with the experiment are justified by the environmental benefits from a success. Even if the effort fails, valuable knowledge would acctue for conservation biologists in general. An action plan is outlined, and progress and problems in selling the caribou iniriative are discussed.

Key words: woodland caribou, restoration, Minnesota, Quetico, survival assessment, agency support.

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## Introduction:

Native woodland caribou of Minnesota began declining in the mid 19th Century and disappeared completely by the early 1940s (Fashingbauer, 1965). The species disappeared earlier from other regions of the northeastern states: northern New England, upper Michigan, Wisconsin, and Isle Royale, Michigan, in that sequence. In the west, a resident herd in the Selkirk Mountains of northeastern Washington and northern Idaho numbered >100 in the 1950s, but declined to about 25 by the 1980s, and these last animals were transient between the U.S. and British Columbia (U.S. Fish & Wildlife Service, 1994). Over the past 15 years, woodland caribou from British-Columbia have been released into both Idaho and Washington in a co-

operative restoration effort among provincial, state, and federal agencies; but there has not been the anticipated increase in population size (U.S. Fish & Wildlife Service, 1996).

This report updates progress in a current effort to determine the feasibility of restoring woodland caribou to a small sector of northeastern Minnesota, and, by proximity, to a sector of adjacent Ontario. The driving justification is a commitment to restore biota that have been lost since European settlement.

## Background

*Disappearance of caribou from Minnesota*

At the time of the first European exploration, woodland caribou were fairly common in northern Minnesota, being found as far south as Mille Lacs and Kanabek counties; however, by the late 1800s they had receded to a region near the Ontario border, from Lake Superior to Red Lake (Fashingbauer, 1965; Bergerud, 1978; 1988). Hunting of caribou was regulated by the state: with declining numbers in the 1880s, limits and seasons were sharply reduced, and by 1904 all hunting was prohibited. By the late 1920s no animals remained in northeastern Minnesota; and the last caribou, centered around Red Lake in the northwest, disappeared in the early 1940s (Fashingbauer, 1965). During the early 1980s, two caribou were seen for about a year around Hovland, Minnesota, some 50 km south of Ontario near Lake Superior (Fig. 1, inset) (Mech *et al*, 1982). At that time, the closest breeding population was 250-300 km north around Armstrong and Lake Nipigon, Ontario (Fig. 1, inset). The subsequent fate of the Hovland caribou is unknown.

Demise of Minnesota's caribou was at first attributed to overhunting (Trygg, 1966 *vide* Heinselman, 1996:164) and to habitat changes from logging, wildfires, and clearing for agriculture (Fashingbauer, 1965). More recently, strong evidence indicates that a parasite may have been a primary factor as well: the nematode, *Parelaphostrongylus tenuis* or the meningeal worm, is normal in white-tailed deer and transmitted through an intermediate gastropod, but is fatal to caribou (Anderson & Strelive, 1968). The decline of caribou coincided with a marked northward extension of whitetails during the past century (Bergerud, 1974). Also, the increase of deer in northern Minnesota apparently expanded the prey base for timber wolves, leading to a rise in their numbers. This in turn, according to Bergerud (1974), would have increased the threat to caribou, particularly to populations already stressed and declining. After 2 decades of legal protection, wolves are now relatively abundant in northern Minnesota, but it is doubtful they played a significant role in extirpation of caribou earlier in the century, because they were then bountied and subject to unregulated trapping and shooting. Another potential predator was the black bear, whose ability to impact caribou was not fully understood until somewhat recently (Ballard, 1993), as in Maine where, during the 1980s, animals released in a restoration project suffered significant losses from bears (McCollough & Connery, 1990). Whether bears contributed to the extirpation of caribou in Minnesota is unknown.

In summary, the loss of woodland caribou from Minnesota will never be explained with certainty. It is likely that human impacts upon populations and, in some regions, upon habitats was the key factor during the 19th Century, while the meningeal worm may well have been the leading cause behind continued loss and ultimate extirpation during the 20th Century.

*Restoration assessment and the status of caribou elsewhere in the region*

Currently several populations of woodland caribou exist within the Lake Superior region of Ontario: the Armstrong-Lake Nipigon herd, 225-250 km north of eastern Minnesota (Cumming & Beange, 1987), and several insular populations in Lake Superior, the closest to the BWCR being on the Slate Islands some 65 km north and 300 km east of Minnesota (Fig. 1, inset). Starting in 1982, Ontario undertook several releases on other islands in Lake Superior (Darby *et al.*, 1989; Gogan & Cochrane, 1994).

Feasibility of caribou restoration was assessed for two U.S. national parks in the region. For Isle Royale National Park in northwestern Lake Superior (Fig 1, inset), where caribou were last known in 1928, it was concluded in the early 1990s that, although white-tailed deer were absent, wolves were too numerous and security habitat inadequate for caribou to succeed there (Cochrane, 1996). For Voyageurs National Park near International Falls, Minnesota, some 90 km east of the BWCR, it was concluded that abundance of white-tailed deer, hence the threat of meningeal worms, was probably too great for caribou to survive (Gogan & Cochrane, 1994).

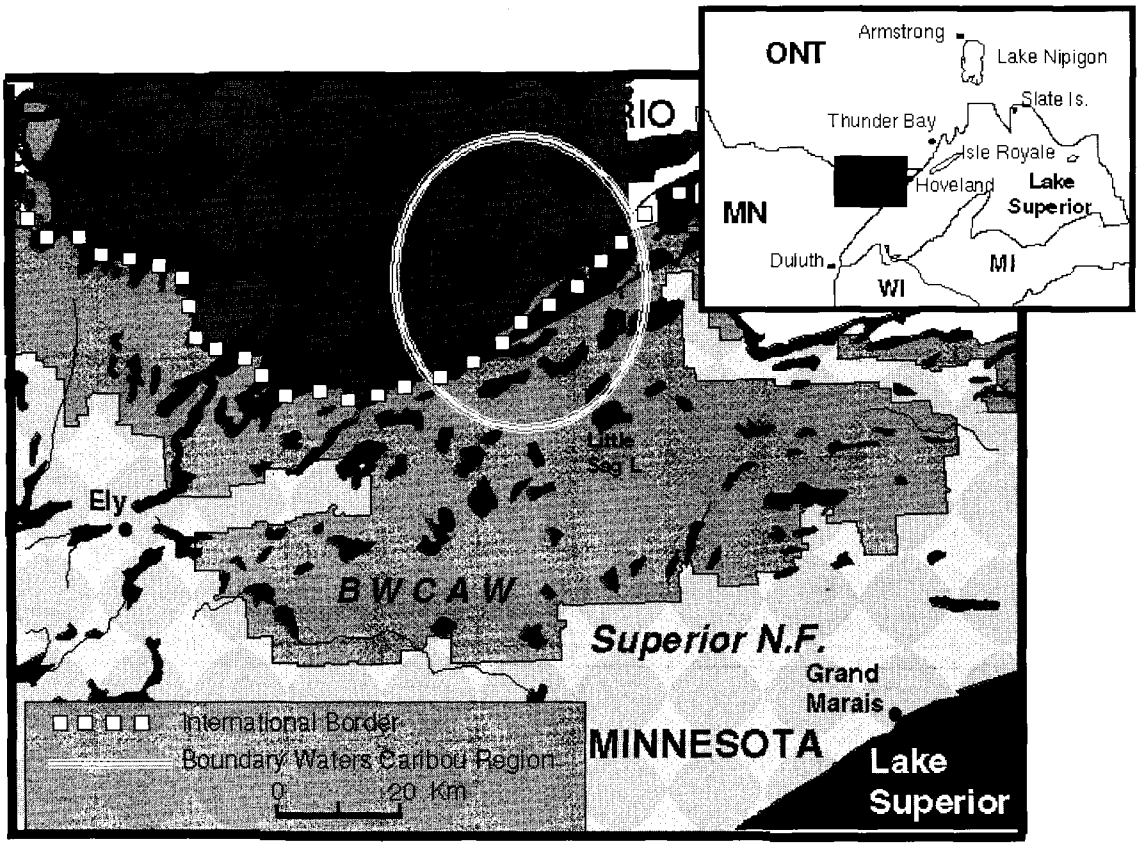


Fig. 1. The Boundary Waters Caribou Region (BWCR), lying across the Minnesota-Ontario border, the southern sector being within the Boundary Waters Canoe Area Wilderness (BWCAW) of the Superior National Forest and the northern sector within Quetico Provincial Park. The 1300-km² BWCR represents the estimated contiguous zone of favorable habitat for caribou.

*An earlier study for restoring Minnesota's caribou*

During the 1970s, a comprehensive assessment of caribou-restoration feasibility was carried out by the Minnesota Department of Natural Resources (DNR) in consultation with several North American caribou experts (Karns, 1980; Karns & Lindquist, 1986; Gogan *et al.*, 1990). From a survey of four regions of northern Minnesota that apparently possessed suitable vegetation and topography, only one, located in the northeastern corner of the state, appeared to have all the required habitat components for caribou. The restoration initiative did not, however, progress further. At that time it was believed that if wild-caught animals were released, they would disperse far from the intended region; consequently it was assumed that animals for release must be captive-reared yearlings. Funding was not available for establishing a nursery herd, so the attempt was terminated. Subsequently, it has been shown elsewhere that released, wild-caught adults will remain localized, as in the Maine restoration attempt (McCollough & Connery, 1990).

## Progress in the current caribou-restoration initiative

*The North Central Caribou Corporation*

In 1988, a group of Minnesota citizens formed the North Central Caribou Corporation for exploring a new effort to restore caribou to the state. The Corporation's board of directors included representation from relevant state, federal, Native-American, and Canadian agencies plus one citizens' organization. While the earlier caribou-restoration assessment (Karns & Lindquist, 1986) setved as an important guide, the NCCC carried out its own feasibility analysis. The work was funded mainly by the Duluth Safari Club (independent of Safari

International), which had disbanded in otder to form the Caribou Corporation. Research was done collaboratively among the U.S. Forest Service, the Natural Resources Research Institute, and the University of Minnesota. These analyses with resultant conclusions and recommendations were compiled as a report by the North Central Caribou Corporation (Raven, 1993) and are summarized below.

*The Boundary Waters Caribou Region*

The site recommended by the NCCC for caribou restoration (Raven, 1993) covers some 1300 km$^2$ (500 mi$^2$) and is referred to as the Boundary Waters Caribou Region or BWCR (Fig. 1). It extends across the international border, from within the Boundary Waters Canoe Area Wilderness (BWCAW) of the Superior National Forest in Cook and Lake counties, Minnesota, to the southeastern portion of Quetico Provincial Park in Ontario. The BWCR coincides with the area in Minnesota that was recommended for caribou restoration in the earlier assessment (Karns, 1980), but it defines more clearly the extent of suitable habitat within the Ontario portion.

Both the BWCAW (Heinselman, 1966; Lewis *et al.,* 1996) and Quetico Park (Anderson & Lime, 1984) are managed as wilderness, a status unlikely to change in the foreseeable future. Human presence within the BWCR is currently restricted to canoeists, skiers, and hikers (Anderson & Lime, 1984). Logging was never intensive within the BWCR, and has been completely banned for some decades.

The Caribou Region is vegetated primarily with upland and lowland boreal forest, but includes some mid-successional upland aspen (*Populus tremuloides*) and paper birch (*Betula papyrifera*). Forest structure, while not strongly affected by past logging, has been altered through prevention of natural fires on both sides of the border (Woods & Day, 1976, 1977; Day, 1990; Heinselman, 1996). Within the BWCAW, the Superior National Forest is now committed to restoring the natural pattern of fire (U.S. Forest Service, 1997), but that will probably be somewhat constrained due to concern for adjacent commercial timber.

*Suitability of vegetation and landform*

Landform and vegetation in Minnesota's northeastern border region were analyzed for presence and juxtaposition of factors critical to woodland caribou as defined by Bergerud (1978) and Bergerud & Mercer (1989). Broschart & Pastor (1992), working with satellite imagery, created a geographic information system (GIS) data base centered on the designated BWCR but including several thousand km$^2$ of adjacent area as well. They analyzed for spatial associations among mature conifers, lowland bogs, and lakes with islands. They concluded that the BWCR not only offered a favorable landscape for caribou, but that it met these criteria better than any other area of comparable size within the region. In particular, the widespread presence of lakes with small islands offered an abundance of potential summer-season protection from both wolves and bears. Bergerud *et al.* (1990) state that such habitat is critical for the security of young calves, as was found by Cumming & Beange (1987) around Lake Nipigon, Ontario. Also, the landscape-suitability analysis of Broschart and Pastor agrees with the conclusions of caribou biologists A.T. Bergerud and V.F.J. Crichton concerning the best region within the state for caribou (Karns & Lindquist, 1986).

*Deer and the meningeal worm*

To estimate the threat of the meningeal worm to caribou, Pitt & Jordan (1995) made wide-ranging, semi-systematic surveys for deer and meningeal-worm larvae within and adjacent to the BWCR. For deer presence, all current sign was recorded, but primary emphasis was on locating fresh fecal dropping (pellets), since they related to both deer densty and source of the patasite. During summers of 1989 and 1990, > 250 km$^2$ of the BWCR within Minnesota were covered, plus a sampling of adjacent regions. LandSteward and Timmermann (1991) made a shorter but similar survey within the Quetico portion of the BWCR in 1990. All evidence from both sectors suggests that summer deer-density within the BWCR was < 0.5/km$^2$. Frequency of encountering current-season pellets outside the BWCR where deer density was reportedly around 5/km$^2$ was about 1 group/hr, while in the BWCR it was roughly 0.1 group/hr. Furthermore, during the snow season, deer were apparently absent from the Minnesota portion of the BWCR according to Nelson & Mech (1992) who made repeated aerial surveys for wolves there. Their report to the NCCC was restricted to winters 1989-90 and 1990-91, but absence of deer in winter there is believed to hold over the longer term.

For estimating levels of meningeal-worm larvae,

deer pellets and gastropods were collected throughout the Minnesota portion of the BWCR; from several sites in which at least some of the BWCR winter; and from scattered intermediate locales having higher summer deer densities than the BWCR (Pitt & Jordan, 1995). Larvae were found in 27% of 15 recent pellet-groups from the BWCR and in 57% of a larger sample of pellets from the wintering areas. In samples of terrestrial gastropods comprising several snail and slug species, none from the BWCR ($n$=56) showed of larvae, while 0,8 % of those from elsewhere within the region ($n$=744) did show larvae.

It was concluded that the low density of deer found within the BWCR, together with the negligible presence of meningeal-worm larvae, indicated that mortality from this parasite would not be great enough to prevent a caribou population from growing within the BWCR, but such would probably not be possible elsewhere in the region. Furthermore, there is an unknown but realistic possibility that habitats used by deer in summer differ sufficiently from those of caribou, so that caribou exposure to meningeal-worm larvae would be even lower than projected from the survey data, e.g., if caribou cows with calves are mainly on islands, while deer do not use these islands. Finally, all caribou being introduced, plus animals subsequently captured for marking or re-marking, could likely be protected temporarily from the meningeal worm with the anti-helminth drug, ivermectin, in a form designed for slow release (see "Capture and Release," below).

*Wolf predation*

As part of intensive, long-term studies of wolf dynamics in northeastern Minnesota (Mech, 1986; Mech & Goyal, 1995), Nelson and Mech (1992) reported that in the early 1990s wolf density within the Caribou Region was around 16-20/1000 km$^2$. While woodland caribou elsewhere have been judged unable to expand their numbers under this level of wolves (Bergerud,1980; Bergerud & Elliot, 1986), in those cases there was not an abundance of lakes with islands providing critical security from predation during summer. During winter, according to A.T. Bergerud (pers. comm.), as long as numbers of caribou in a given locale remain relatively low, e.g. in groups of < 10-20, then wolves are not likely to concentrate on this prey. It is also important that other prey are not locally abundant to attract wolves. In Pukaskwa National Park, Ontario, wolves in winter are apparently localized near moose that are wintering some distance inland from Lake Superior; while a small number of caribou reside along that lakeshore, relatively free of wolf predation (G. Eason, pers. comm.). Absence of deer in the BWCR, plus a relatively low density of moose, may well serve the same function, with wolves being focused mainly on the wintering grounds of deer that lie no closer than 20 km from the BWCR. However, as pointed out below, there remain no reliable means for determining the potential of wolves to severely reduce introduced caribou other than with experimental releases. Before European settlement, caribou had obviously co-existed with wolves, as well as with Native Americans hunters, throughout this region.

*Bears and island security*

Black bears are a potential threat to caribou, particularly where they have easy access to calves (Ballard, 1993). Security from bears would presumably be along lakeshores and on islands when calves are in their early months. However, in the BWCAW and Quetico the many campsites for canoeists are located on islands and lakeshores. Bears regularly visit these campsites, having presumably been conditioned to the availability of campers' food. While the effect of camp-food on bear populations in the BWCR region has not been studied, in nearby non-wilderness areas. Rogers (1987) showed that the bear sows feeding regularly at garbage dumps were significantly more productive than others. Otherwise, lake islands of the region should not have food sources that would particularly attract bears. Almost none have been recently burned or cut-over, hence would not likely have abundant berries, and none have oaks or other good sources of mast.

Pitt & Jordan (1996) documented frequency of black bears using islands and lakeshores, based on visits to stations baited with bacon. They found that bears commonly swim to islands, but only to those with permanent camp sites. Likewise the only stretches of shoreline regularly visited by bears were those with campsites. Regulations in both the BWCA and Quetico restrict canoeists to a limited number of designated camp sites, and bears seem habituated to these. Since the survey indicated that bears did not visit islands or segments of shore lacking campsites, such areas should be relatively safe for caribou calves in summer. And it is assumed that caribou would avoid the proximity of campers.

Furthermore, if and when a bear does encounter a cow and calf along a shoreline, the latter have quick access to the lake for refuge.

*Future hunting*

Since objectives of the NCCC's caribou restoration do not include harvest of caribou, this source of mortality was not considered in the feasibility analysis. That some caribou in the BWCR might be illegally killed is unlikely due to the area's relative inaccessibility. If some animals do disperse into adjacent, non-wilderness regions, they might be subject to poaching. However, such animals should be more vulnerable to the meningeal worm than to being shot because of the high deer levels outside the BWCR.

*Simulations of post-release population dynamics*

To estimate probabilities of survival and increase in caribou after release, a dynamic population model was generated based on mortality factors from our feasibility studies plus studies elsewhere. Precise predictions cannot be expected from such models, but they are valuable for identifying whatever mortality factor(s) may prove most critical. They also serve to identify priorities in ecological research critical to management planning (Starfield & Bleloch, 1991; North & Jeffers, 1991).

Our model was structured to estimate, under varying scenarios, the probability that within 20 years after release, caribou numbers will have increased (Raven 1993; 1994). Several scenarios were used for starting the simulations. Number of releases and numbers of animals per release plus age and sex ratios were set at different levels. Presence of wolves and of bears, plus availability of suitable islands, were also varied. Probabilities of population growth projected by the model indicate that with both bears and wolves present, population success was closely tied to how consistently calving cows moved to islands or suitable shorelines, and whethet wolves would swim out to islands, a behavior not well understood. Multiple releases increased the estimated probability of achieving a self-sustaining population. Overall, the modeling suggests that caribou released into the BWCR have a 0.2 to 0.8 probability of surviving and increasing in numbers over ther first 20 years. As a postscript, the inputs here do not reflect information subsequently discovered concerning a caribou release in Grands Jardins, Quebec (formerly called Laurentides Park), where caribou restoration succeeded in the presence of both wolves and bears, but with deer being absent (Cantin, 1991).

The modeling for this analysis addressed the potential for population growth rather than a quantification of total numbers that might be supported within the BWCR. Estimating the total potential of the BWCR to support caribou would require knowledge of an average carrying capacity for the region, plus the total expanse of suitable landscape, i.e. just how accurate the estimate of 1300 $km^2$ actually is. Consequently, the model's estimates of an increase within the first 20 years were based simply on natality minus mortality, without regard to total habitat capacity. For example, if 75 animals were introduced, and the area's total capacity was only 75, the model's predictions on growth would not be applicable. However, the model's output can still be used as an indication of long-term viability within whatever expanse of habitat there may be.

*Summary and conclusions from the feasibility studies*

Despite serious uncertainties about success in restoring caribou to the Boundary Waters Caribou Region, the majority of NCCC Board of Directors agreed in 1996 that it was still fully reasonable and worthwhile to undertake experimental releases. Their conclusion reflected the following considerations: a) After the comprehensive feasibility studies, the only practical means left for better estimating whether this restoration will succeed is through experimental releases and follow-up monitoring; b) Considering the high environmental benefits from a successful restoration, the estimated level of risk is judged fully acceptable; and c) Regardless of outcome, such experimentation would provide important scientific information for restoration efforts in general; and, should released animals fail to sustain themselves, habitat deficiencies– apparently not present 70 years ago– could be identified.

## Proposed experimental restoration

In 1996 the NCCC prepared a draft strategy for experimental release of caribou under a set of broad guidelines:

a) Stock for release should come from one or more free-living caribou population whose habitat is closely similar to the BWCR, and preferably that has been exposed to some predation;
b) Multiple releases should be made over 3 years, involving up to 20 mature cows and 5 mature bulls each year; and

c) Within and among years, releases should be spaced widely, with no more than 4-6 animals released at any one locale.

*Source of animals for release*

The most reasonable source of woodland caribou for a Minnesota release is from the Slate Islands, Ontario, an isolated archipelago in northern Lake Superior (Fig. 1, inset). Either the NCCC would formally request a donation of Slate-Islands caribou from the Ontario government, or, more likely, such a request would be made by an agency of the United States government. NCCC Board member, H.R. Timmermann (pers. comm., 1996), a former Ontario Natural Resources biologist, believes this would be acceptable because the Slate-Islands population has long been judged too numerous for its forage resources (Euler *et al.,* 1976).

In winter 1994-95, 2-3 wolves dispersed to the Slate Islands where wolves had not previously been known (Euler *et al.,* 1976). For 1 or 2 years these wolves reportedly preyed heavily on caribou, particularly calves. However, after winter 1995-96, none were seen there (Bill Dalton, pers comm.). Thus, being exposed to wolf predation should have improved the adaptability of Slate-Islands caribou for the BWCR environment, but then the subsequent disappearance of wolves should lead to the previous circumstance of over-abundance, hence the reasonableness of this herd being a source of stock.

Because caribou on the Slate Islands have most likely been genetically isolated, at least since 1907 (Euler *et al.,* 1976), the population may now be inbred. To insure satisfactory genetic diversity in the BWCR, caribou stock from elsewhere should be added. Possible mainland sources for this include the Lake Nipigon-Armstrong herd, Ontario, or, less likely, the Sasaginnigak Lake population in southeastern Manitoba, since that herd was recently given endangered status (V.F.J. Crichton, Manitoba Ministry of Natural Resources, pers. comm.).

In making the request to Ontario for a donation of animals, it would be argued that restoration of caribou immediately south of Quetico Provincial Park should serve to create a new population within Ontario as well, since some animals would undoubtedly disperse across the border. This is also in line with the current provincial commitment to protect caribou in northwestern Ontario (Racey & Armstrong, 1996), as reflected the policy statement: "..this can be achieved by supplementing small existing populations and establishing new ones in areas of former range, where they could be self-sustaining, through relocation of animals." (Darby *et al* , 1989).

*Capture and release*

Caribou could be captured on the Slate Islands in box traps or by netting of swimming animals from a boat (Timmermann, 1985). Captured animals would be tranquilized and, as soon as practical, transported by float plane directly to the release sites. For capture of adults on the mainland, procedures would be under advisement of Ontario or Manitoba biologists, who have recently had good success with helicopter-netguns (Carpenter & Innes, 1995).

For importing animals from Canada, a prolonged quarantine might be required by the U.S. Department of Agriculture. However, a waiver would be requested on the basis that caribou in northwestern Ontario or southeastern Manitoba were unquestionably contiguous with those present in Minnesota just 60 years ago, or those that apparently dispersed from Ontario into northeastern Minnesota just 20 years ago (Mech *et al.,* 1982). It is similar to the caribou-restoration project in Washington state where animals were imported from British Columbia without a quarantine-holding requirement (U.S. Fish & Wildlife Service, 1996). Apparently a similar agreement was reached by the U.S. Fish and Wildlife Service for the recent "hard release" of wolves from western Canada into Idaho. Furthermore, when moose from Ontario were used for restoration into Upper Michigan in 1985, each animal was treated with antibiotics against bacterial infection and ivermectin against nematodes and ticks (Schmitt & Aho, 1988). Blood was sampled to test for a wide variety pathogens considered threatening to livestock. Thus, after release, any animal found positive for a threatening pathogen could be relocated and destroyed, since all were radio-collared – as would be the case for all releases in this project.

Transporting of caribou to release sites within the roadless BWCAW would be practical only by float plane. Because landing planes is currently prohibited in the BWCAW, a waiver would be needed from the U.S. Forest Service. Should a waiver for float-plane landing (or quarantine-holding) be denied, then release just across the border in Canada would be considered. In an ecological sense, this would be little different from a release in Minnesota. However, were all releases made in Canada, the ability to

attract needed public and financial support could be considerably reduced in Minnesota and elsewhere in the U.S.

To provide some relatively short-term protection from the meningeal worm, all animals released or recaptured would be treated with the anti-helminth drug, ivermectin, in the form of a slow-release implant that should be effective for over a year. While such technology had not been investigated at the time of this report, a consultant veterinarian (T. Kreeger, pers. comm.) indicated that it should be feasible.

*Monitoring and research*

For comprehensive monitoring, all experimentally released caribou would be equipped with highly dependable radio transmitters. These would be equipped with a mortality-mode function that permits rapid location of newly dead animals to determine cause of death. Such monitoring should continue at for least a decade after the last releases to document not only survival and mortality of released animals, but also their reproductive success andtheir seasonal use of the landscape.

Monitoring radio-marked large mammals in remote regions has in the past involved periodic relocation by searching for transmitter signals from a small aircraft, with maximum range of reception generally < 25 km. Disadvantages of this method include cost of frequent flights, interruptions by bad weather, and general inability to account for individuals that disperse far from the study region. Advantages are relatively lower cost of equipment, good precision in locations, and opportunities for direct observation. A newer system involves signals from transmitters being received by satellites and then forwarded as ground-location points to the investigator. Locational precision with this system is only within a few km, but it has the advantage of giving readings at a prescribed interval so, regardless of flying weather, mortality information is regularly available. Also, regardless of how far some animals may move, they can always be located. Although equipment and satellite charges make telemetry costs higher, this is partly offset by greatly reduced flying costs. A more recent and quite expensive system is based on Geographic Positioning System (GPS) technology: the animal's radio automatically accumulates information that is received from satellites and then is converted into precise location coordinates. The animal is periodically located by direct telemetty, usually from a small plane, and, upon radio-interrogation, the collar transmits the stored location data (Moen *et al.*, 1997). This system provides the most precise location data; however, of greatet importance in a restoration experiment is having rapid access to mortality information and knowledge of animals moving far from the study region, as with the satellite system.

To monitor reproduction, each marked cow would be located for direct observation during late spring and again in late summer to determine birth and subsequent early survival of a calf. This would initially be from the air for a general locale, followed by radio-tracking on the ground or from canoes in the known vicinity of each radioed cow.

For evaluating the population over a sufficient time span, a sample of offspring should be radio-collared during the decade of continued monitoring. Under BWCAW and Quetico regulations, such capture would be most practical from canoes. From mid-spring into summer, locations of known radioed cows with calves would be identified; then such animals, presumably on islands or along lake shores, would be radio-located by a canoe party. If telemetry location from the water proved difficult, the search could be aided by communication with airborn telemetry operators. The animal pair would be pursued on foot into the water, where the calf would be hand-captured from a canoe, as done elsewhere from motor boats (Timmermann, 1985), and towed to shore for processing; immobilization should not be necessary.

## Developing agency and public support for caribou restoration

*Legal status of caribou*

For Minnesota, the woodland caribou is surely a species in jeopardy, having completely disappeared some 55 years ago. However, since there were no animals extant in 1973 when the U.S. Endangered Species Act took effect, this species is not under mandate to be listed. In contrast, caribou in Washington and Idaho are "endangered," since a few animals were still present in the 1970s. In Minnesota, any animals released for restoration would be classified as "experimental" under provisions of the Endangered Species Act; this circumvents responding to federal regulations requiring special protection or habitat enhancement on public lands. For a restoration, the inconsistency of not listing locally extirpated species has mixed impli-

cations. Caribou have no federal status in Minnesota, so it would be less complicated for both state and federal agencies, since they would not be faced with constraints and expenditures associated with a listed species. On the other hand, there is no legal mandate for agencies to work towards restoration of a non-listed species.

*Partnerships and support*

Today the primary effort towards caribou restoration in the BWCR has moved from research on ecological feasibility to building of partnerships for governmental agreements and public support. First, among key agencies, the Minnesota DNR and the Superior National Forest must consent to restoring caribou to the BWCR. Then the Province of Ontario would hopefully agree to contribute the caribou stock. Concomitant permits from federal agencies are needed for importation of wild animals. In patallel, a major program will be undertaken to inform the public and to seek political and funding support from a diversity of sources. High among such groups are Native Americans of the region, who are considered partners in the caribou restoration, since this animal was an important component of their environment prior to European settlement.

Detailed planning for the restotation and monitoring would be directed by a full-time coordinator. State and federal funding would be sought, particularly since caribou restoration would conform with responsibilities under current policies for protection and restoration of natural biodiversity and endangered species on public lands. At the same time, due to uncertainty about state or federal funding, the NCCC will vigorously seek financial support and volunteer help from the private sector.

*Issues of possible concern by government or private interests*

While a formal announcement, along with detailed public information about the proposed restoration, has not been released by the NCCC, some reports have appeared in the media, and relevant agencies have been kept abreast through participation on the NCCC boatd. The points that follow are not in response to any formal statements from government or private sources, but they do address questions that have been informally raised or may be as planning proceeds:

a) Timber harvest: Unofficial comments from leaders within the Minnesota timber industry suggest there is fear that habitat protection for restored caribou may entail restrictions on timber harvest, particularly within the Superior National Fotest. Unlike potential conflict between the forest industry and caribou management in northwestern Ontario (Racey & Armstrong, 1996), this fear has no basis. Allthough release sites would be within the Superior National Forest, all these sites plus the region in which caribou could survive are managed entirely as wilderness – on both sides of the border: rhus there could be no logging or opportunity for logging within the BWCR. Furthermore, the NCCC surveys clearly indicate that, were caribou to disperse from the BWCR into areas of managed forests in either Minnesota or Ontario, their survival would be in jeopardy from the meningeal worm (Pitt & Jordan, 1995) rather than from any possible timber practice. Consequently it is not possible to foresee any alteration of timber-harvest regulations regardless of where released caribou may wander.
b) Tourism Industry: Many resort owners and outfitters in northern Minnesota are aligned with groups opposed to almost any government tegulations of natural resources or wildland uses. In the case of caribou within the BWCR, however, a successful restoration should have nothing but positive effects upon tourism. There would be no restrictions whatsoever upon tourism's current operations, while restoration of a native large mammal should markedly increase the attractiveness of these areas to canoeists. Hence, if anything, tourism-related businesses should be improved by successful establishment of caribou in the boundary waters country.
c) Sport Hunting: Concern that presence of caribou might restrict legal hunting within the BWCR is without basis. First, current hunting in that portion of the BWCAW is extremely low, since access requires at least 1 day of canoeing and portaging. Second, since the legal, large game, deer and moose, are relatively sparse, the area offers little attraction to most hunters, even those willing to deal with the wilderness challenge. And, third, those few hunters who do venture far into such wilderness tend to be environmentally knowledgeable, hence would be sensitive to possible disturbance of caribou, perhaps even more than many non-hunter canoeists in summer. Furthermore, any reduction of either deer or moose by hunting within the greater region would be in the best

interests of caribou, as it would reduce both the meningeal worm and the quantity of prey for wolves. Finally, there are good indications that Minnesota hunting groups will support the return of caribou, not as a future game animal, but simply to restore a native large mammal.

d) The Minnesota Department of Natural Resources: The DNR administets statewide programs for non-game, natural heritage, scientific and natural areas, and endangered species. Minnesota ranks high among U.S. states in the scope and effectiveness of conservation programs. At the same time, the DNR has indicated significant reservations about caribou restoration. This hesitancy may reflect one or more of the following:

i) Some DNR biologists feel that chances of restoration are poor, and a failed attempt, even if identified as a necessary experiment, would reflect badly upon that department despite the current initiative being of private origin. Citizens can and do mistakenly associate the catibou initiative as originating with the DNR rather than the NCCC.

ii) In 1979 a caribou restoration initiative by the DNR was based on the assumption that rearing a nursery herd was necessary (see "..recent restoration study.." above), and funding for this could not be raised. The DNR then removed caribou restoration from its agenda, perhaps reflecting frustration over having nothing to show for a considerable investment.

iii) A small herd of introduced elk or wapiti (*Cervus elaphus*), originating 100 years ago with a transplant from Yellowstone National Park into Itasca State Park in northwestern Minnesota, subsequently moved into farmland. These animals have caused minot but conspicuous damages that have led to annoying political problems for the DNR. Such experience leaves the DNR less than enthusiastic for experimenting with another ungulate restoration, even though caribou are never likely to disperse into farm areas.

iv) With funding problems typical of most state agencies, the DNR assumes that long-term management of a possible caribou population would become their responsibility, regardless of the future role of the NCCC. However, a restored caribou population should require minimal management expenditure. The species would not be listed as endangered (see "Developing agency and public.." above), hence no habitat attention would be required. In addition, even if desired, no habitat manipulations could be done because caribou would be within designated wilderness areas. Also, as discussed above, there would be no hunting to administer. Administrative costs should be confined to reporting whether the population is persisting or not. Data for this might well come from a systematic index generated voluntarily by a non-governmental organization that solicited and summarized canoeists' sightings of caribou.

On the other hand, the Minnesota DNR has contributed extensively to restoration of the peregrine falcon (*Falco peregrinus*) and the trumpeter swan (*Cygnus buccinator*); it has an active program of returning river otters (*Lutra canadensis*) to regions from which extirpated; and in 1993 the agency seriously considered releasing wolverines (*Gulo gulo*), another species long absent from the state. In a report of the Minnesota Endangered Species Technical Advisory Committee (Coffin & Pfannmuller, 1988), woodland caribou are listed as of "special concern," but it is stated that, "The difficulties inherent in maintaining a permanent population of caribou in Minnesota must be addressed before any serious consideration is given to reintroduction.." The NCCC believes it has now addressed these concerns.

e) The Superior National Forest: In general, U.S. Forest Service guidelines call for restoration of natural biodiversity and a natural-resource management approach based on ecosystem principles. In the most recent plan for the Superior National Forest (U.S. Forest Service, 1986), woodland caribou are listed as a species of "concern;" also in the plan is the statement, "Reintroduction of native species is desirable and acceptable."

However, administrators of this Forest have been relatively neutral towards bringing caribou back. They may be concerned that establishment of caribou in the BWCAW might lead to tecommendations for reducing campgrounds or visitor numbers. Summer usage is already so great that reservations for entry are required. The plan prepared by NCCC does not recommend any change in visitor policy.

On the other hand, successful restoration of caribou within the Superior National Forest would attract national attention to that forest's

environmental accomplishments. It would also add a new dimension to the experience of visitors in the BWCAW. In Idaho and Washington, close cooperation by the U.S. Forest Service in interagency programs for caribou restoration has contributed positively to the image of that agency.

d) Native Americans: Several bands of Native Americans reside in northeastern Minnesota. In recent years, native peoples have developed a renewed interest in the fauna present before Europeans so thoroughly altered their home region. While NCCC has a representative from one band on its board, detailed discussions with regional tribes need to be expanded. It is the intention of NCCC to actively involve Native Americans in the process of restoring an important animal that was once part their wildlife heritage.

## Summary and conclusions

A thorough feasibility analysis for restoration of woodland caribou to the Boundary Waters Caribou Region of Minnesota and Ontario has been carried out. The North Central Caribou Corporation believes that an experimental release of woodland caribou in Minnesota is justified based on two general criteria: a) Its comprehensive assessment indicates a reasonable chance for successful restoration; and b) The valuable environmental benefits from successful restoration of caribou to the Boundary Waters region clearly outweigh the uncertainties surrounding this proposal.

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