Three Decades of Caribou Recovery Programs in Yukon: A Paradigm Shift in Wildlife Management

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2009

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MRC-09-01

Preface

Rick Farnell served as Environment Yukon's caribou biologist from 1978 to 2006. His career spanned a time of growth and change not only for Environment Yukon and wildlife management, but of Yukon society as a whole.

Upon his retirement, Rick was offered the opportunity to look back on his decades of experience and produce a "legacy" paper. While a single document cannot possibly encompass all of the knowledge and wisdom gained over a lengthy career, with *Three Decades of Caribou Recovery Programs in Yukon: A Paradigm Shift in Wildlife Management* Rick provides, in his own words, a lasting record of his understanding of the changes he observed and puts forward some questions that remain unanswered and challenges that have yet to be resolved.

The insights in this paper are important today, but their real value may only be realized in the decades to come.

Three Decades of Caribou Recovery Programs in Yukon: A Paradigm Shift in Wildlife Management

By

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(2009)

Past management practices or lack of management may have contributed to serious declines in ungulate populations to levels that cannot meet various needs and wants which humans have. Occasionally, the reduction of wolf populations has been proposed to increase ungulate populations. Future management efforts and program funding must be increased in order that situations can be avoided where wolf control is considered. **The Yukon Wolf Conservation and Management Plan (1992)**

Systematic inventory studies to obtain vital data on range use, population, and physical characteristics of Yukon's woodland caribou populations began in 1980. By 2008 a total of 23 relatively discrete herds ranging wholly or in part within Yukon had been identified. During this period, the numbers of caribou in some herds were estimated to be declining sharply from causes that were not well understood. It was thought that the manageable factors of human hunting made possible by ease of access through roads and off-road vehicles and predation—principally by wolves—were the driving forces behind these declines. While other potential caribou-limiting factors such as range condition, forage/nutritional status, and climatic affects were known to play a role in population dynamics they were considered realistically unmanageable factors. Hence, the basic premise of past caribou recovery planning was to relieve human-caused and natural predation, anticipating that these measures would be followed by sound regulation and mitigation of human activities to maintain stability in the long-term. It was further thought that these intensive management programs would complement Yukon-wide management by providing research into the relevant biology of Yukon's woodland caribou and test various conservation approaches accordingly.

From 1982 to present five caribou recovery programs have been carried out on the Finlayson, Aishihik, Southern Lakes, Fortymile, and Chisana caribou herds and provide case histories instrumental for future evaluations. The findings from these projects are found in various technical reports, publications, and unpublished data found through the Yukon Department of Environment and Alaska Department of Fish and Game. It is anticipated that this report will give insight into the effectiveness of these programs and hopefully provide a basis for well informed decision making and to ensure that all Yukon's caribou remain secure in the future.

Case History Synopsis

Finlayson Caribou Herd Recovery Program (1982):

Lethal Wolf Control

In 1982, wolf predation and human harvest were suspected of being the primary cause of a declining trend in the Finlayson herd of east-central Yukon (Farnell *et al.* in prep.). A large-scale wolf and harvest reduction experiment was carried out to determine if these manageable factors were responsible for caribou demographic trends. These actions were implemented in the absence of broad public planning beyond the immediate communities involved. Other, umanageable limiting factors, including forage quality on winter range, caribou physical condition at high density, snow depth in winter, and spring snow-melt conditions were also assessed. The wolf population was reduced by aerial wolf control to 58% of the original population size in the first year of wolf reduction and thereafter to 14–17% of the original population size (1984–1989). This corresponded to a reduction in the original wolf density from 10.3 to between 1.4 and 1.8 wolves/ 1000 km² per year over the last 6 of the 7 years of wolf removals. Following wolf control, wolf numbers increased from 29 known survivors in March 1989 to 240 in March 1994, returning to a density of 10.4 wolves/1000 km². The number of caribou increased significantly from 3073 ± 414 in 1986 to 5950 ± 1055 in 1990. As wolves recovered during post-wolf control the herd declined to 4537 ± 540 in 1996, then to 4130 ± 698 in 1999 and to 3077 ± 172 in March 2007. Reduction through harvest and lowered calf recruitment due to predation played a central role in the caribou population decline. No other factors could explain the caribou demographic trends.

This intensive and prolonged reduction of wolves resulted in the following population responses:

(1) The wolf population recovered substantially between wolf control years, and recovered rapidly to pre-reduction density after the reduction ended. The project therefore did not debilitate the long-term recovery of wolves. Noteworthy was that there appeared to be a linear relationship between the number of wolves and caribou calf ratios and mortality rates during wolf decline and recovery periods.
(2) The fact that the recovered wolf population stabilized and plateaued at its pre-reduction numbers may provide evidence that wolves regulate themselves socially at an optimal densitiy (Haber 1977). If this is the case, there could be an upper equilibrium between wolves and prey numbers in which long-term harvestable surplus is attainable.
(3) There was an immediate growth in the caribou population which continued during the wolf control years. Reduced human harvest and favorable environmental conditions appeared to play a role in the rapid recovery of caribou.
(4) The population of caribou appeared to decline, or at best temporarily stabilize, upon full recovery of the wolf population. Human harvest was found to be an additive mortality factor and played a substantial role in depressing caribou numbers. Maintaining a minimum basic need level of harvest on the herd during the recovery program necessitated one additional year of wolf control to attain population goals.

(5) There was no evidence for forage/ nutritional factors limiting caribou numbers as physical condition parameters from large samples of collected caribou following wolf control were highly favourable.

Experiences from the Finlayson herd caribou recovery program provided a foundation on how to implement lethal wolf control and what the implications would be for wolves. It showed a level for population growth potentials for computer modelling and for setting reasonable human expectations from such programs. It also illustrated that harvest reduction strategies that included voluntary compliance by First Nations were reasonable expectations. These results also provided a nucleus for eventually developing an informed wolf management plan.

While the case history of the Finlayson herd provides abundant insight into the relevant biology of woodland caribou—particularly predator-prey relationships (National Research Council 1997)—it failed as a long-term management solution. The failure was largely owing to the lack of a comprehensive long-term management plan endorsed by the Yukon public—one that limited human harvest and land-use activities. Human harvest levels became non-sustainable as wolves fully recovered and greatly accelerated the caribou population decline until 1998 when strong conservation measures (outfitter quotas, permit hunt for licensed resident hunters, First Nation voluntary compliance) were put in place to reduce these effects.

The consequence of not having a comprehensive management plan to set the stage for compatible development became obvious in the summer and fall of 1995. Almost 16,000 new quartz claims were registered in the Watson Lake Mining District, which was up from a previous average of about 5,000/year (Annual Report for the Watson Lake Mining District, Geological Services of Canada). This activity represented one of the biggest mineral staking rushes in the Yukon since 1969. The extent of these claims represented an area of 3,344.5 km^2, all of which was located in important late-summer and fall habitats where about two-thirds of the herd ranges annually. Geological surveys and testing activities in the area included significant increase in helicopter activity, with repeated landing and low elevation flights during the active exploration period, and a marked increase in person-days spent in the area. Although there is no empirical evidence that these activities were disruptive to caribou or had an adverse affect on energetics, distribution patterns, or population dynamics, there is a large body of disturbance studies which imply that these activities are debilitating to caribou (Calef *et al.* 1976, Miller and Gunn 1978, Gunn 1979, Gunn 1983, Gunn *et al.* 1985, Davis and Valkenburg 1985, Harrington and Vietch 1991, Harrington and Veitch 1992). Of concern is that there has been little recognition by land use managers of the long-term needs of the caribou herd and the system in which they live.

Aishihik Caribou Herd Recovery Program (1993):

Lethal to Non-lethal Wolf Control Transition

"… with the increase in public interest and awareness of ethical considerations in wildlife management, there is a need to promote and conduct research into ethical aspects of wolf management." **The Yukon Wolf Conservation and Management Plan (1992)**

In early 1993 a large-scale controlled experiment was conducted to study responses in the declining Aishihik herd of southwest Yukon to a five-year wolf reduction (Hayes *et al.* 2003). Licensed and First Nation harvest was stopped for the Aishihik and the smaller (<300) neighbouring Kluane herd. Three caribou herds (Wolf Lake, Ibex, and Chisana) were monitored as contemporary controls to test the hypothesis that wolf predation was the main factor limiting recruitment, adult survival, and population size. Caribou productivity, winter forage quality, disease prevalence, snow depth, snow-melt phenology, harvest, and migration were also assessed. Wolf reductions using aerial wolf control methods started in February 1993 and extended to March 1997. To augment aerial control, surgical sterilization was introduced in 1994 and 1997 to limit reproduction in six wolf packs each year (Spence *et al.* 1999). The Aishihik area wolf population was held at 68–83% below the 1992 pre-reduction level. After 1997 experimental 'chemical-immuno-contraception' experiments were carried out on wolf alpha pairs, however this data has not been readily made available.

While it was understood in late 1991 that the declining Aishihik herd was an important resource to Yukon and a management concern, recovery efforts were delayed in 1992 for one year to strike a wolf planning team comprising a diverse range of interests to develop the Yukon Wolf Conservation and Management Plan. Following the lethal wolf control experiment on the Finlayson herd, the plan set out principles and guidelines for decisions on wolf reduction programs. Notwithstanding this initiative there was still some public disapproval for the program initially. The plan called for research exploring alternate ways of recovering ungulate populations that did not entail lethal removal of wolves and this became a guiding force in future management decisions.

Important findings of the wolf fertility control experiment were that sterilization reduced the wolf rate of increase by stopping 12 breeding events from potentially producing about 68 pups (based on an average litter size of 5.7) from 1994 to 1997 (Hayes and Harestad 2000, Hayes *et al.* 2003). Wolf sterilization reduced the wolf rate of increase to between 11–58% from 1995 to 1998. Wolf territoriality, pair bonding, and survival rate were found to be not affected by surgical sterilization. This study showed that wolf fertility control using sterilization is a technically feasible management option.

The Aishihik herd showed the greatest difference in changes in rate of increase during wolf reduction compared to the controls, supporting the wolf predation hypothesis. It was concluded that reduced wolf predation and human harvest caused the increase in Aishihik herd numbers. Researchers further observed that woodland caribou herd population trends are linked to the population dynamics of moose in Yukon. It was recommended that, given natural predation, maximum harvest rates for caribou should be conservatively set at 2%. It was further recommended that managers encourage public wolf trapping to sustain higher ungulate densities and thus avoid the need for reactive broad-scale wolf control. As a further alternative, the study found that experimental wolf fertility control was effective in reducing the rate of increase of wolves and that it was more publicly acceptable than lethal control.

Southern Lakes Recovery Program (1993):

Modifying Human Activity

"With more people becoming troubled by reducing wolf populations through methods such as shooting from helicopters, there has been a high priority set by wildlife managers to develop and test alternate methods which do not involve killing animals." **The Yukon Wolf Conservation and Management Plan (1992)**

During January 1993, representatives from six First Nations, local residents, and biologists gathered in Carcross, Yukon to formally discuss what could be done about diminishing caribou numbers in the Southern Lakes area. From these discussions came the Southern Lakes Recovery Plan (O'Donoghue 1996), then conceived as a five-year plan designed to restore caribou numbers.

Southern Lakes caribou consist of three small and fairly distinct herds—the Ibex herd, the Carcross herd, and the Atlin herd (which ranges across the Yukon/ BC border). Over-hunting was thought to play the primary role in caribou declines. For example, population trend counts from 1983 to 1992 detected very high average calf survival (55 calves/100 cows) in the Ibex herd (unpublished data, Yukon Department of Environment). Given this level of productivity the herd should have been doubling in size every four years over this period. Instead, the herd remained static at about 150 animals. Biologists suspected that the growth increment in this and the other Southern Lakes herds was being cropped by hunters. This view was supported by residents of Carcross and Tagish, Yukon who reported excessive shooting of animals in their area by poachers and both local and non-resident First Nation hunters.

Additionally loss of habitat and human disturbance likely played a serious role in limiting Southern Lake caribou numbers and presents a significant management challenge (O'Donoghue 1996, Farnell *et al.* 1998, Florkiewicz *et al.* 2007). This is Yukon's most densely populated area, comprising about 80% of the total population. For example, the Carcross herd winter range has experienced increasing levels of linear development and landscape change associated with timber harvest, residential growth, and industrial development in addition to increasing recreational use. The integrity of this winter range is essential to ensure the availability and ability for caribou to access it because of their reliance on slow-growing lichens.

Fire suppression poses an additional habitat loss threat to Southern Lakes caribou. Because the Southern Lakes district is the most densely populated area in Yukon it is also the most settled and presents the greatest human values at risk to wildfires. As such, the area is mostly classified as 'critical fire management zone' by Yukon Wildland Fire Management, offering it the highest priority level for fire suppression. As a consequence of this necessity there has not been a large wildfire in the Southern Lakes area since 1959. The best winter habitat for caribou is mature forests about 50–200 years old, where lichens are abundant and snow is not deep. The winter areas of the Southern Lakes herds are in the rain shadow of the Coast Mountains which forms ideal winter habitat for caribou. Wildfires usually eliminate lichens in a modest patchwork mosaic of differing ages until forest cover returns. However, it should be recognized that too few ignitions can be just as detrimental to winter habitat as too many. Large scale wildfire prevention could eventually lead to a large scale burn that would not only be damaging to human infrastructure – it could eliminate caribou winter range in single incident.

The Southern Lakes Caribou Recovery Plan set out the following clear and basic objectives to develop meaningful management strategies to achieve the goal of long-term recovery and sustainability of caribou:

1. Increase public awareness.
2. Use local knowledge.
3. Eliminate harvest
4. Discourage human developments that are detrimental to caribou.
5. Monitor predator abundance and harvest.
6. Monitor caribou and alternate prey population patterns.

The project involved the community through regular community workshops, formation of a steering group, interviews with elders, youth outreach through school programs, media features including related public service announcements, and a 24-hour wildlife telephone hotline. To address harvest issues, all licensed harvest was prohibited, the six First Nations voluntarily stopped hunting, First Nation 'game guardians' were hired to patrol the district during winter, alternate sources of game meat was pursued, and signage was used to stop human harvest.

To prevent further loss of habitat the winter range was mapped: this included local knowledge, and detailed caribou habitat use surveys. Compatible land use guidelines were also developed and land use applications within critical range were scrutinized for mitigation, a fire history map was developed, research on snowmobile activity disturbance to caribou was carried out (Powell 2004), and a cumulative effects assessment GIS tool utilizing 'zone of influence' analysis was developed (Florkiewicz *et al.* 2007).

To assess predation effects, trapper workshops were held and an analysis of predator abundance and harvest was carried out. It was generally thought that in this case predation was not a major concern (e.g. Ibex herd's observed growth rate in the absence of predator control) and herd recovery would continue the trend of population increase. Population monitoring was done through annual caribou rut counts to assess calf survival, periodic late-winter census surveys to track growth rates and radio-telemetry studies to better understand seasonal range use. Periodic moose surveys were flown to track abundance as they are considered an important prey species for wolves.

These management actions culminated in fairly continuous population growth in the herds. Growth of these herds in the absence of predator control intervention is noteworthy and could only have been achieved through the collaborative effort of recovery partners with a cessation of all hunting. Vehicle collisions along highways are presently the largest single source of human-caused mortality for Southern Lakes caribou in Yukon.

Fortymile Caribou Herd Recovery Program (1994):

Wolf Fertility Control

"There should be increased emphasis placed on developing cooperative research and management efforts among the Yukon…, academics and biologists and managers from other jurisdictions." **The Yukon Wolf Conservation and Management Plan (1992)**

During the early part of the 20th century the Fortymile herd was one of the largest and most important caribou herds in North America and perhaps the world. In 1920 one of the north's first wildlife biologists, Olaus Murie, tried to estimate its size (Murie 1935). While crude by today's scientific standards, Murie's account of the migrating herd gave substance that it was immense: *" The southeast migration of the herd covered a strip approximately 60 miles wide, 40 miles representing the part traversed by the main body and 20 miles that was covered by scattered bands. The herd took 20 days to pass one spot. During eight of the 20 days about 1,500 animals in the main herd passed each day over a one-mile strip, and during the remaining 12 days about 100 a day."* Based on these observations Murie (1935) estimated the herd contained 568,000 caribou with the following caveat: *"In light of the subsequent experience, this figure seems conservative and it is safe to say that the herd numbered well over half a million, possibly much nearer a million."* Clearly the herd must have been as large as some the arctic herds we see today when it ranged over a massive (240,000 km²) area between Whitehorse, Yukon and Fairbanks, Alaska.

The accounts of the caribou migrations crossing the river were renowned. Caribou were so plentiful that riverboats plying the Yukon River often had to tie up to the riverbank and let them pass for fear of getting them caught up in their paddle wheels. In more recent times a disastrous set of events including severe weather, predation, and overharvest led to a decline of the herd to about 6,000 animals by 1973 (Davis *et al.* 1978). As the herd declined so did its range use until it no longer migrated from its summer habitats in Alaska to its Yukon wintering areas. Fortymile caribou became a distant memory in people's minds. The case history of the Fortymile herd is a perfect example of what can be coined as a "memory trap" – lack of concern due to complacency and, without the knowledge of preceding generations, an acceptance of the present condition as normal. In this case, people assumed that the smaller herd of today is their natural state. This lack of hindsight vision trapped the Fortymile herd as a relic population in the minds of people today.

A poor understanding of caribou population dynamics during a decline in the 1960s and greater human access brought about by changes to the herd's range served to drive the Fortymile herd to a tragic low point. Construction and upgrading of the Taylor and Steese highways in Alaska, and the 'Top of the World' and Klondike highways in Yukon switched emphasis from water routes to roads and bisected the herd's migration routes. The effects of heavy harvesting made possible by these transportation routes along with liberal seasons and bag limits were large. For many years harvest was excessive and wounding losses (associated with crowded hunting conditions along the highways) was high and could have equalled the reported harvest (Valkenburg *et al.* 1994). The hunting season was not closed by emergency order until 1973 when the herd reached its lowest level.

Following a limited wolf control program in the early 1980s, directed at elevating moose numbers on part of the herd's range in Alaska, the herd rebounded to 22,000 animals (Valkenburg *et al.* 1994). However, this program was suspended because of public disapproval of lethal wolf control. Consequently, the herd remained static until the early 1990s when calf mortality studies carried out by the Alaska Department of Fish and Game demonstrated that predation was, in fact, the main limiting factor keeping herd numbers down (Boertje and Gardner 2000).

It was at this point that a diverse International Fortymile Planning Team, representing Yukon and Alaska communities, environmentalists, hunters, and government agencies developed a comprehensive recovery plan for the herd. The primary goal of the plan was simply stated as "to begin restoring the herd to its former range in Yukon and Alaska". The Team judged that the most manageable way to stimulate herd growth was by reducing wolf predation using socially acceptable methods and to prevent hunting. While the latter management action was relatively easy to accomplish through regulation, caribou harvest was limited to ≤ 2% of the estimated population, wolf management required a challenging and experimental approach.

In spring 1997 a wolf fertility control program was implemented. Dominant pairs were surgically sterilized and about 140 subordinate and sub-adult wolves were translocated to other parts of Alaska. In all, 15 wolf packs comprising all the wolves in the Fortymile herd's calving area were treated in this way. Wolf control was carried out for five years until spring 2002. During this time dominant pairs remained and defended their pack territories but failed to produce pups. The sterilized wolves lived longer lives on average, likely because they did not suffer the stress of reproducing and feeding offspring. The herd increased fairly rapidly to 43,375 caribou in 2003.

As the herd increased it began to regularly extend its range eastward into the Yukon. In late October 2002, for the first time in about 50 years, some 30,000 Fortymile caribou migrated into Yukon and crossed the 'Top of the World' highway. Many thousands of these caribou moved eastward down the Fortymile River following a historical migration route and crossed the Yukon River to winter on range not occupied in the time and memory most Yukoners. In the case of the Fortymile herd the 'memory trap' has been overcome. They are no longer greeted by a hail of bullets, in recognition of the interest and support for the longer term gains in bringing this herd nearer to their true historical condition.

Chisana Caribou Herd Recovery Program (2002):

Captive Rearing

"The potential effectiveness of non-lethal methods for use in controlling or reducing wolf populations should be addressed." **The Yukon Wolf Conservation and Management Plan (1992)**

The Chisana caribou herd is a small, genetically distinct (Zittlau 2004), and rapidly declining herd that ranges across the Yukon-Alaska border. The herd numbered 1800 animals in 1987, recruited on average only 6.3 calves per 100 cows from 1988 to 2002 (Farnell and Gardner 2002) and numbered less than 720 ± 15.8% (90% CI) animals in 2003 (L. Adams, USGS Alaska Science Center, unpublished data). Thus, the population was aging and had a highly skewed sex ratio, averaging only 21 males per 100 females. High levels of neonatal predation were identified as the proximate cause of the decline.

The winter range area of the Chisana herd is largely within Kluane Wildlife Sanctuary in Yukon and most of the summer range area lies within Wrangell-St. Elias National Park in Alaska. Management approaches had to therefore conform to stringent legislative and policy mandates of these protected areas that precluded highly invasive forms of management alternatives. Because of the herd's decline, managers and stakeholders agreed that the population should be protected and therefore all forms of hunting were legally prohibited in 1994 (Farnell and Gardner 2002). Other precautionary actions needed to aid the herd's conservation entailed making use of a predator exclosure for captive rearing of calves to increase neonatal survival. This endeavour needed to overcome many technical challenges and risks: the stresses on the caribou to capture and handling, their acclimatization to constrained life within the enclosure, their adaptation to provided forage, and the researchers' ability to maintain a predator-free environment for the cows and their calves.

This project was original applied research with first a small pilot project in 2003 to test the feasibility of rearing caribou in captivity followed by larger applications in 2004 through 2006 to affect population change. Budget and timeframe forecasts for projects are normally based on previous experience, but in this case there was no previous experience using captive rearing for large mammals to draw upon. The Chisana project was novel research that therefore has not been previously published. As such it requires more specifics in this report to describe the case history.

In March 2003 through 2006 8–10 ha of winter habitat was enclosed using a 1.5 m fence of black geocloth as a visible barrier. The enclosure was encircled with a 3 to 5 strand solar-powered electric fence roughly 4–6 meters outside the geocloth fence for predator deterrence. Enclosures were reconstructed annually on undisturbed vegetation, adjacent to preferred post-calving habitats, close to a lake for transport and water, and situated on a side hill for ease of observation. Tree-stands were constructed for observation of animals and the perimeter of the enclosure was regularly patrolled by caretakers for predator surveillance and to monitor captive caribou activity (i.e. calving).

Adult female caribou were captured on winter range by net-gun method from late March to early April. Adult females (>2 years age) were randomly selected for capture. Caribou were restrained in a straightjacket-like 'deer bag' and, to reduce the duration of immobility, following capture individual caribou were rapidly transported to the enclosure by one of two transport helicopters. For light sedation Medetomidine was administered intra-nasally in low dose immediately upon capture (Cattet *et al.* 2004). This was followed by intramuscular/ intravenous administration of reversal Antisedan (Orian Pharma, Turku, Finland) just prior to release.

Once captured caribou were inside the enclosure, blood samples were taken and a radio collar (Telonics Inc.) with a large numbered visual identification band was fitted around the neck. The caribou were weighed and a veterinarian used ultrasound to diagnose pregnancy. Caribou that were diagnosed as not pregnant were released outside the enclosure. An incisor tooth was removed in 2004 and 2005 for cementum aging. Elapsed times and body temperatures were taken throughout capture and handling to evaluate stress parameters

During confinement, natural forage in the enclosure was supplemented with moistened lichens (*Cladina* sp.) and a commercial pelleted reindeer ration. Lichens were gradually removed from the diet in favour of pelleted feed over a two-week period at the beginning of confinement and then restored over a one-week period prior to release. Salt blocks were also made available to the caribou.

Each calf was radio collared, sexed, and weighed to determine patterns of calf survival. Radio collars with the same configuration were placed on free-ranging neonates for comparison. The release date of captive caribou was timed so that the last calf born was at least 6 days old at release.

Twenty one caribou were captured in 2003, 36 in 2004, and 58 in 2005. In October calf survival was markedly higher for captive-reared calves compared to free-ranging calves. In 2003, 77% of captive-reared calves survived to 5-months old as opposed to 13% among free-ranging caribou. This pattern held true for 2004 (76% vs. 7%) and 2005 (82% vs. 23%). Judging by calf weights, captive rearing did not appear to negatively affect nutrition and physical condition of cows.

Captive rearing could be an essential component of caribou conservation measures.

These trials determined that captive-rearing woodland caribou is feasible and holds promise for restoration of small threatened populations. When compared to the Finlayson herd recovery, the Chisana project illustrates a major paradigm shift in management approaches. Breeding in captivity for release back into the wild is a useful management tool for endangered species recovery and, although it can make the difference between survival and extinction for a few species, the technique has fundamental limitations. Problems with achieving self-sustaining captive-bred populations, successful reintroductions, progressive domestication, and genetic erosion, susceptibility to disease, high cost, and continuity restrict the use of captive breeding to a limited number of endangered species where other viable alternatives are unavailable (Snyder *et al.* 1996). Alternatively, captive rearing with natural fostering and release into the wild on the species' native range has potential to overcome many of these limitations and provides another approach. Annual short-term (10 weeks) captive rearing in a semi-wild environment can increase the rate of recruitment to supplement populations by improving the survival of neonates during the early, high-risk stages of life without the risks associated with progressive long-term adaptation to captivity.

Relevant Facts from these Case Histories

Manageable Factors

These case histories show that the population dynamics of caribou herds are driven by multiple factors. When those factors are at least in balance or, in the case of the Southern Lakes caribou herds, acting in a positive direction herds remain stable or increase. When these factors are acting in a negative manner however, wildlife managers are faced with few options to change population declines. Caribou habitat is largely at successional climax so there is little that can be done to habitat to change the direction of a population decline, with the exception of wildfire management and effective mitigation of human development activities. Moreover weather conditions that are known to affect caribou population trends are obviously unmanageable factors in caribou management. The experiences in these cases histories show that human harvest is an additive mortaility factor.

Human harvest and predation combine to cause direct attrition of caribou numbers – thus affecting population trends. The above experiences show that human harvest reduction by licensed hunters and First Nation hunters is a viable and effective management tool. Additionally, relieving predation pressures using various means to control wolves can cause rapid increases in caribou herds or at least stabilize populations so that other negative factors can be dealt with in time. A striking result from the Finlayson experiment was the observation that there was a linear relationship between the number of wolves and caribou calf and adult mortality rates. This finding holds promise for intiatives like sustainable, community-based wolf trapping to hold wolf packs at smaller numbers to reduce predation rates and increase caribou population sustainability.

'Ratchet' Affect Threat

There is a theoretical basis for the interaction of natural and anthropogenic (human-caused) factors relevant to these studies and proposed by Anderson (1997). Known as the 'ratchet' affect, caribou declines can be caused by two anthropogenic factors: 1) losses by hunting and 2) losses by habitat alienation (which includes other human disturbance factors). These declines are also affected—sometimes enhanced and sometimes diminished—by natural population fluctuations. The cumulative degradation of a population is the result of anthropogenic processes, while the recurring fluctuation processes are typically the result of natural ecological and environmental processes.

It is important to separate the impacts of human-caused actions from those population changes that are due to natural fluctuations. When the combined natural and anthropogenic variations have a cumulative adverse affect on caribou populations, the decline will assume an insidious or 'ratchet'-like downward progression. The losses during natural decline periods may be greatly exacerbated by human-caused factors and any gains due to natural positive growth may be dampened leading to the noted downward progression. Without the ability to observe the population changes through a period of natural fluctuation, it is challenging to determine the additive contribution of the human-caused actions. Thus identifying the contributions of the natural and anthropogenic changes to the decline is difficult to assess and for the present there is only these few decades' worth of experience with Yukon's caribou.

The anthropogenic trend evolves in 3 stages

1) **Expansion** in which the caribou population is initially directly affected (overkill) or indirectly affected (habitat loss) without regard to the consequences.

2) **Regulation** control activity is implemented intending to achieve a purpose such as maximizing benefits from the population.
3) **Threatened** follows if the regulation fails to sustain the caribou population and its existence requires mitigation actions for recovery – usually at substantial societal expense.

For caribou populations declining in a 'ratchet' pattern, the threatened stage is entered after anthropogenic affects have acted over the long-term – finally depressing the population to a critically low level – at which point the natural fluctuation can drive it toward extinction.

Human Access Threat

The case histories presented here show that roads have a detrimental affect on caribou herds by facilitating hunting and road collisions and by causing range avoidance. There is a direct correlation between roads and the status of caribou as these highly accessible herds are the most intensively managed herds in Yukon. Many less accessible herds are quite secure. As such, it is largely the occurrence of roads that have culminated in overexploitation and subsequently very expensive long-term recovery programs. This assessment considers the impacts of numerous small spur roads and trails that stem from major arteries and facilitate off-road vehicle access deep into caribou range. As road infrastructure increases, improved access results in further developments, followed by even greater exploitation.

Where winter roads are extended or newly built they should be routed so that somewhere along their course they deadhead at a lake or some other point of difficult passage in summer and fall. This will help prevent off-road ATV access deep into caribou range. Moving equipment and supplies by air transport is preferred and is often a more economical and efficient means. Mainline roads such as mining access roads that bisect important caribou range should be leased and permitted as private industrial roads with a manned gate to prevent unwanted access for both wildlife and project safety and security.

A Managed Harvest Model

There are constant pressures on caribou herds that present on-going challenges requiring continuous management effort. Policies and resulting programs should reflect the need for continuous monitoring and adapting management strategies to prevent herds from declining to abnormal levels. There is a large financial and societal cost to recovering depleted herds that can be avoided in the long run by proactive management. This is particularly true for herds exposed to high rates of human access. A good model for adequate harvest management is provided by the present-day system for the Aishihik herd. The herd is monitored annually by fall rut counts to assess population trend. Population projections are then validated periodically by population estimate surveys or census surveys. If a significant change in numbers is seen, then harvest is managed by quota applied to both licensed and First Nation hunters. In the case of the Aishihik herd, the Alsek Renewable Resources Council has coordinated with the community, the First Nation, and Yukon Government in annual assessments of the post-hunt survey and harvest results. The Renewable Resources Council can make recommendations to the parties to readjust the quota for the subsequent year to bring harvest in line with population trend and sustainability.

Habitat Considerations

Woodland caribou make use of climax habitat, so there is little that can be done to enhance it. Yukon caribou habitat management is therefore more about conserving rather than manipulating habitat. These studies show that predation holds woodland caribou herds at levels below what the range can support, so there is space (another habitat need for caribou) for humans and caribou to coexist. Conserving and protecting key caribou habitat (i.e., rutting areas, migration corridors, and winter range) is crucial to herd health and abundance. Otherwise, disturbance from human activities can lead to range abandonment and fragmentation that can result in a large scale loss of range – a major threat to Southern Lakes caribou. Management experience has shown that human infrastructure that greatly increases access by humans combined with herd fragmentation will lead to an eventual decline in caribou (Wittmer et al. 2005, Nellemann et al. 2003). The implications are that access must be very carefully controlled, particularly where roads and other travel routes bisect caribou winter range or affect free movements between calving, post-calving, and rutting areas.

While a natural wildfire regime is important for regeneration and productivity of the boreal forest, too many ignitions could limit winter habitat available to caribou because lichens take many decades to recover (Klein 1982, Thomas and Kiliaan 1998). Wildfire monitoring is an important consideration for caribou herd management and should be incorporated into long term cumulative affects assessments. There are herds in Yukon, such as the Finlayson, where recent fires have substantially reduced available winter range. Fire suppression on this winter range should be ranked as a high priority for the next decade. On the other hand, there are too few ignitions in the Southern Lakes district. Because it is the most settled area in Yukon all fires are put out; there hasn't been a major burn since 1959.

Thoughts on Moose as Alternate Prey to Woodland Caribou

Seip (1991) and Bergerud (1996) proposed a model showing that the addition of moose into a simple wolf-caribou system will result in higher wolf density and subsequent increase in predation on caribou. In areas where wolves, moose, and caribou use similar habitat in summer, caribou lose the advantage of their 'spacing away' strategy to avoid predation (Seip 1991, 1992). Although this model could apply to small, isolated, and sedentary herds elsewhere, it does not fit the Yukon system and management plans to protect vulnerable caribou herds (by reducing moose numbers) might cause the opposite effect. Yukon caribou use space that overlaps with moose year-round, except perhaps summer. As wolves continue their pattern of home range use when moose numbers decline, predation on caribou could increase because wolf encounter rates with moose should decline. Ultimately, the fate of a caribou herd should depend on how strong the depensatory effect of wolf predation is exerted, and how quickly wolf numbers decline in response to lower prey biomass. Clearly moose and caribou of the Aishihik and Finlayson herd ranges declined and increased in synchrony with each other (Hayes *et al.* 2003, Farnell *et al.* in prep.).

Socio-economic implications

Fish and wildlife are essential to the subsistence way of life in Yukon communities. The importance of these caribou herds includes their economic contribution to the communities as well as people's psychological well-being derived from a sense of economic security and cultural traditions. The loss of access to the caribou resource is equivalent to a loss of monetary income. The benefit of herds that are managed in a sustainable manner can be approximated by the use of replacement cost based on market prices of food produced by intensive southern agriculture. Simple computer modelling can show, for example, that the intrinsic renewable benefit of the Finlayson herd can be worth many millions of dollars indefinitely to Yukon compared to— or at least in complement with—short-term mineral extraction developments.

The amount of energy and chemical fertilizers used in the production of commercial food represents a major component of all non-renewable resource use. The contributions from agriculture to world-wide pollution of the atmosphere, water, and land are immense. Harvest of wildlife by Yukoners on a sustainable basis can represent a commendable model of human compatibility with the global environment through minimal contribution to depletion of the world's non-renewable energy and mineral resources, and the environmental pollution associated with their use (National Research Council 1997).

Further Research Possibilities

Although considerable caribou research has been undertaken with these studies over the last 30 years, much about Yukon woodland caribou biology and ecology remains to be answered. Additional research is needed to address the impacts on caribou from human developmental activities across their range. Most research to date has focused on single biological issues (harvest and predation) or the affects of single developments (e.g. logging, mining, road building). Cumulative effects assessments have not been adequately addressed. A major limitation has been the lack of more information and adequate baseline information for most of the Yukon herds other than the intensively managed herds reviewed here. Responsible agencies should initiate or strengthen steps to insure appropriate monitoring, data collection, and analysis occurs before human developments are undertaken.

Despite substantial progress in understanding the effects of predation as a proximate cause of caribou mortality from these studies, much less is know about the factors that may be the ultimate causes predisposing caribou to high predation rates (e.g. why did the lightly hunted Chisana herd decline). Among these factors the role of long-term climatic trends as it influences caribou survival is an area of focus. As more is learned about the effects of climate change on caribou these findings should be factored into cumulative effects assessments. Long-term case histories of Yukon herds are few, especially of populations in naturally regulated ecosystems, and experimental studies are limited.

In order to develop sound environmental policies as they pertain to Yukon caribou we need to understand them better in an evolutionary context. There is strong historical and paleoenvironmental evidence that Yukon caribou have decreased in numbers and become less widespread since the end of the Little Ice Age (around 1910) (Spalding 1990, Farnell *et al.* 2004). As technologies in genetics advance we should have opportunity to learn more about founding population effects and whether there have been extinction/replacement episodes in the past or if there is a continuum of genetic identity. Through the study of caribou genetics we may learn what the biodiversity cost of a herd extirpation is and whether resources are well spent in maintaining small vulnerable herds.

Thus far we have simply treated caribou as numbers without regard to population structure and social balance, particularly in small caribou herds like Chisana. Relationships between social well-being and caribou population composition need to be quantified. Does social structure influence reproductive timing? Does changing adult sex ratio influence timing and success of reproduction within a caribou herd? How important is the maintenance of 'prime bulls' in a herd? How important are bulls as alternate prey to cows? Lacking knowledge about the behavioural and physiologic mechanisms that regulate them denies understanding caribou as individuals and populations of discrete entities.

There are numerous other topic areas that could be addressed in the future. Research needs to continue on the improvement of survey methodologies as new technologies arise and sampling theory becomes refined. As agriculture spreads north more research is needed on the interactions of Yukon caribou and domestic livestock relative to parasites and disease associations. Caribou should not be studied in isolation; the study of Yukon caribou needs to look at the whole system in a multi-species context and research projects should be designed accordingly. Some herds in protected areas or herds that have very little human influence and are naturally regulated populations should be monitored as controls against those herds that have to be intensively managed. The use of captive rearing as a means to recover small threatened caribou herds needs more experimentation and wider application as a socially acceptable technique to relieve predation. Contaminants monitoring should be carried out routinely to gain a better understanding of natural and human caused atmospheric effects on the caribou/lichen food chain. Quite significantly there needs to be more traditional knowledge workshops – information best gained in map form – with First Nations partners. Finally, the results of the Chisana herd recovery project needs to be published in a peer-reviewed journal for circulation to the scientific community. Likewise, findings from 'chemical-immuno-contraception' experiments on Aishihik wolves should be made available as baseline for future pursuits in this area should new technologies and opportunities arise.

Governing/Public Processes

During the course of these caribou recovery projects today's governing and public input processes in Yukon were developing with the finalization of the Umbrella Final Agreement, First Nation Final agreements, the establishment of the Fish and Wildlife Management Board, the expansion of regional Renewable Resources Councils, devolution of federal government responsibilities to the Yukon, the Yukon Wolf Conservation and Management Plan, and the Committee on the Status of Endangered Wildlife in Canada all bearing influence on the responsible agencies. None of these bodies or processes were in place when the Finlayson recovery project began. In contrast, years later the Chisana project had to—and did—find a common mind among multiple jurisdictions with an interest in the herd that included the Yukon Department of Environment, White River and Kluane First Nations, Canadian Wildlife Service, and Yukon Fish and Wildlife Management Board in Canada, and with the Alaska Department of Fish and Game, Wrangell-St. Elias National Park, and the Alaska Board of Game in Alaska.

In hindsight it is paradoxical to think that the Finlayson recovery project, having no formal management arrangement, really needed stronger guidance from governing processes to realize any long-term goals, perhaps through a tight regional wildlife management plan to guide potentially conflicting resource uses. In contrast, the Chisana project probably would never have gotten off the ground if the team had first pursued a management plan, recognizing complex stakeholder interests that would have required lengthy negotiations for a formal international agreement that conceivably could have been an all-consuming process with no real outcomes. Accordingly, it seems that the needs and approaches of governing and public processes to direct caribou recovery strategies will vary upon circumstances.

In any case, it appears from all cases that management team approaches can garner broad public and therefore government support for projects. While pilot projects are a useful way to start large and expensive projects, large projects such as the Chisana herd recovery can be less of a financial burden to any single agency when multiple co-operators are involved.

Caribou recovery projects do not proceed without controversy. The 1992 Yukon Wolf Conservation and Management Plan still serves its purpose because the document, with its guidelines, was constructed with sufficient past experience and a diversity of public interests. It therefore helped projects carry out needed research and find more socially acceptable ways to recover wildlfe populations. The plan remains useful for proposing new management actions with a wholistic approach and is instrumental in future evaluations of these management actions.

There are large-scale societal costs to mitigating caribou population declines through major recovery projects. To "not go there" in the first place will require revising management strategies that need active population monitoring and regulation of human activity relative to vulnerable herds. Additionally, communication strategies need to emphasize the need for people to moderate their caribou harvest expectations. The implications of our past experience highlight the importance of focusing our perspective on complex and long-term interactions rather than focusing instead on simple short-term explanations and solutions. When dealing with vulnerable caribou herds a narrow focus may lead to misguided thinking on the success and failures of restoration efforts. With a long-term ecological perspective wildlife managers can assess the actual impact of human activities with an emphasis on climatic cycles and realistically identify options and limitations to prevent long-term environmental damage. Alternatively if Yukon woodland caribou become designated 'Threatened' it will have deep negative social and economic consequences.

Conclusion

There has been a clear paradigm shift in Yukon caribou recovery programs over the last three decades. While there was a common thread in that harvest and wolf predation had to be intensively managed the approaches varied over time. The Finlayson program illustrates a profound example of lethal wolf control and its possible outcomes. Yet in the end it did not manage to establish a long-term recovery and failed to deal with competing human uses. From this experience the Aishihik herd recovery program adapted and switched from lethal to non-lethal wolf control and provided valuable research into predator prey relationships not previously documented. Meanwhile the Southern Lakes recovery program established a population recovery for what can be called the 'urban caribou herd' through human constraint and intensive habitat management. It could be that human harvest can never be fully restored on Southern Lakes caribou as this could conceivably exasperate other disturbance factors and could lead to large scale loss of functional range. Building on the Aishihik wolf fertility control experiment, the Fortymile herd recovery program put fertility control into large scale practice and, when coupled with harvest constraint, doubled the size of that herd in five years. The goal of the program 'to restore the herd to its former range in Yukon and Alaska' remains the over-riding multi-jurisdictional policy and management practice to this day. The Fortymile project illustrates an important cautionary aspect of wildlife management by overcoming a 'memory trap' – a condition when we unwittingly neglect past association with a resource. Finally, the Chisana herd project found a way to conform to stringent international policy and legislative mandates. By experimenting with and applying captive rearing this project profiled a new and socially acceptable way to recover small threatened caribou herds throughout North America.

The Chisana project furthermore contrasts markedly with the initial lethal wolf control strategy of the 1980s applied to the Finlayson herd and illustrates a major paradigm shift in management approaches over the last three decades.

Caribou are of ancient design – their fossil record goes back 1.6M years at Ft. Selkirk, YT. There's a good chance that they will still be here long after human civilization has adapted or is gone.

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