

In search of a critical habitat concept for woodland caribou, boreal population

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Abstract: A hierarchical approach to critical habitat identification has been proposed in the draft *National Recovery Strategy for the Woodland Caribou (Rangifer tarandus caribou), Boreal Population*. This approach proposes that critical habitat for boreal caribou be identified as equivalent with caribou ranges and their composite range components, and that it be consistent with the biological needs of a wild, self-sustaining local population of woodland caribou. These components include seasonal ranges, high use areas and calving sites, each of which provide for important ecological functions and are subject to specific risks from human development activities. Protection of critical habitat is accomplished through management of the amount and type of human developments and potential natural disturbances, not by prohibiting all activity. This approach to critical habitat sets the stage for management and monitoring of habitat at spatial and temporal scales appropriate for conservation of a wide ranging species such as woodland caribou.

Key words: boreal forest, management, population, range, recovery, species at risk.

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Introduction

The Committee on the Status of Endangered Wildlife in Canada first assessed the Boreal Population of Woodland Caribou as a Threatened species in May 2000, confirmed in May 2002 (COSEWIC, 2002). Five provinces have listed the boreal population of woodland caribou as a Threatened (or Vulnerable, in Quebec) species under their respective wildlife legislation and the federal government has listed it as Threatened under the Species at Risk Act (SARA) (Statutes of Canada, 2003).

A coordinated national approach for the conservation of species at risk among federal, provincial and territorial governments was committed to in the 1996 *Accord for the Protection of Species at Risk*. Under the auspices of the Accord as well as SARA, a multi-jurisdictional National Boreal Caribou Technical Steering Committee (TSC) was established in February 2002 to develop the national recovery strategy and action plan for 'boreal caribou' consistent with the requirements of SARA, to provide collective advice to the 10 jurisdictions responsible for boreal caribou recovery, and to coordinate recovery planning and implementation among the jurisdictions. In recog-

nition of the broad distribution of boreal caribou in Canada and regional variability in ecology, issues and threats, recovery planning is being undertaken at both provincial/territorial and national scales. It is in this collective context that issues surrounding recovery planning such as goals, objectives, and higher-level consideration of threats and critical habitat are proposed and discussed.

The national Recovery Handbook (National Recovery Working Group, 2005) defines recovery as the process by which the decline of an endangered, threatened or extirpated species is arrested or reversed, and threats removed or reduced to improve the likelihood of the species' persistence in the wild. The recovery goal in the recovery strategy sets out what can realistically be achieved for a particular species. Not all species can be recovered to a level where long-term persistence in the wild is secured.

In the case of boreal caribou, the proposed national recovery goal encompasses the notion of achieving both national and local population levels that are self-sustaining or capable of long-term persistence in the wild. The draft strategy links this goal to the

sustained availability of quality habitat at a scale and over a time period consistent with a desirable population-level response. SARA defines habitat as “the area or type of site where an individual or wildlife species naturally occurs or depends on directly or indirectly in order to carry out its life processes, or formerly occurred and has the potential to be reintroduced”.

SARA requires that the ‘critical habitat’ of endangered, threatened, and extirpated species be identified to the extent possible in the recovery strategy and/or action plan(s), and includes provisions to protect such habitat. Critical habitat is defined in SARA as: “the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species’ critical habitat in the recovery strategy or in an action plan for the species”. Critical habitat is legally identified when the final recovery strategy or action plan containing the critical habitat description is posted on the SARA public registry. This triggers a process to ensure that the critical habitat is effectively protected. Identification of the critical habitat should be consistent with the recovery goal for the species. For a widespread species such as boreal caribou, identification of critical habitat is an ambitious undertaking made more difficult by lack of experience with the new Act and with application of the concept of critical habitat.

This paper describes a proposed approach to critical habitat for boreal population woodland caribou that meets SARA requirements, is biologically sound, and is consistent with recovery planning underway in the provinces and territories. It elaborates on the approach to identification of critical habitat within the draft National Recovery Strategy for the Woodland Caribou (*Rangifer tarandus caribou*), Boreal Population, in Canada (Environment Canada, 2006). Much of the science-based rationale for boreal caribou recovery is referenced in that document. However, the proposed approach to identification and conservation of critical habitat is predicated upon the hypothesis that habitat selection is inherently hierarchical and that caribou have distinct habitat requirements at different spatial and temporal scales (O’Brien *et al.*, 2006; Johnson *et al.*, 2001; Rettie & Messier, 2000). They tend to select habitat to avoid predation at coarser scales (Bergerud, 1988; Johnson *et al.*, 2001) and then select habitat to meet forage requirements at finer scales (Schafer & Pruitt, 1991; Rettie & Messier, 2000). Within most of their national range, predation is the major proximal factor affecting boreal caribou populations (Bergerud, 1988; Stuart-Smith *et al.*, 1997; Rettie and Messier, 1998; Schaefer *et al.*, 1999; James and Stuart-Smith, 2000; Wittmer *et al.*, 2005). Land use practices resulting in habitat degradation and that increase predator numbers or facilitate higher rates of predation and legal and illegal hunting are

ultimate factors influencing caribou populations. Enhanced predation risk through increased predator numbers may significantly reduce or even eliminate local boreal caribou populations (Seip, 1991; 1992). Human developments such as industrial infrastructure and timber harvest blocks may reduce effectiveness of habitat adjacent to these developments (Chubbis *et al.*, 1993; Smith *et al.*, 2000; Dyer *et al.*, 2001). Factors that influence the predator-prey system anywhere in the range can affect the caribou population and must be addressed at that scale and be consistent with the natural background dynamics of the boreal forest.

Methods

Organizational involvement

Eight provinces and territories (Newfoundland and Labrador, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, British Columbia and the Northwest Territories), the Canadian Wildlife Service, and the Parks Canada Agency participate in recovery planning for the boreal population of woodland caribou. Each jurisdiction has one or more representatives on the TSC, which has developed a draft National Recovery Strategy meeting the requirements of SARA (Environment Canada, 2006). This strategy will evolve in response to comments received during targeted consultation and peer review.

The draft National Recovery Strategy includes sections dealing with threats, recovery goals and objectives, and recommended approaches for achieving the objectives. However, the TSC struggled with the concept of critical habitat as it would apply to a wide-ranging species such as woodland caribou. Thus the group initiated a process to examine regional variations in woodland caribou biology and threats, seek over-arching conservation concepts, and reach consensus on a national approach that would support conservation and allow for implementation in all jurisdictions.

Analysis

In October 2004, the TSC reviewed the concept of critical habitat for applicability to boreal caribou across Canada. Agreement was reached on a biologically-based, spatial and temporal hierarchical approach to describing critical habitat, in order to address both the wide-ranging behavior of the species and the complex nature of conservation issues expressed at various spatial and temporal scales. A broad approach to critical habitat would be described in the draft National Recovery Strategy but specific delineation and identification would occur within each provincial/territorial jurisdiction. The agreement on a hierarchical approach was complicated by different individual inter-

pretations of the nature of the hierarchy. It could be nested, with smaller spatial units contextually arranged within larger spatial units. It could reflect progressively increasing levels of protective measures. It could reflect temporal consideration of immediate and future habitat needs to be satisfied for caribou conservation. It could reflect an incremental approach or gradual refinement of definition and delineation. All these variants of a hierarchical approach were important and needed to be rationalized within a consistent framework.

Two workshops in 2005 provided opportunities to refine the approach to critical habitat. The first was a workshop hosted by the Manitoba Model Forest on April 26-27 in Winnipeg Manitoba, in which 38 invited participants from across Canada conducted an analysis of over-arching principles in caribou ecology reflected in conservation strategies from all jurisdictions. The second was a TSC workshop held on October 24-26 in Saskatoon, during which the TSC and invited supporting experts examined and refined a critical habitat approach suitable for the National Recovery Strategy. The concept was evaluated and explained by describing delineation and definitional criteria, critical habitat functions, factors that “destroy” or compromise critical habitat functions, and examples of measures that provide for effective protection. These are all criteria consistent with Environment Canada guidelines (2005a, 2005b).

Proposed approach

The TSC has determined that critical habitat for boreal caribou should be equivalent to caribou ranges and their components. In this paper, range refers to historic and current distribution of boreal woodland caribou and is defined as a geographical area partially or fully occupied by a defined local population of caribou. This definition is essential to acknowledge the spatial and temporal complexities of conserving a wide-ranging species on a naturally dynamic forested landscape. It also recognizes an appropriate functional role for specific habitat components, at different spatial and temporal scales, that are required to assure persistence of boreal caribou populations in the wild (consistent with the recovery goal). The primary ecological function that allows caribou to survive in a range is the provision of effective refuge from predation, although other risk factors are recognized. Each of the components of caribou range, including winter, summer and calving habitat, contributes to this refuge value and collectively allow caribou recruitment (births and immigration) to equal or exceed deaths and emigration. Persistent populations meet this criterion.

A range capable of supporting a self-sustaining population of boreal caribou is invariably composed of a number of components, each satisfying the life requirements for boreal caribou at specific times (diurnally, seasonally, inter-generationally and perpetually), such that collectively, overall range occupancy is continuous and uninterrupted. Thus there is recognition that these habitat components are also treated as critical habitat within the context of a range and long-term habitat and population dynamics. These range components are referred to as seasonal ranges, high-use areas and calving sites and may require progressively increasing levels of protection for more geographically localized habitat components.

Range

Delineation/definitional criteria:

Large landscape unit encompassing the known or inferred current local population, or the portion of the boreal forest landscape within which a local population is to be sustained (diffuse and/or wide ranging populations on highly dynamic landscapes). Delineation and size is consistent with local population sustainability objectives.

Critical habitat functions provided at this scale:

Sustainable habitat supply to satisfy all life requirements of local populations over multiple generations, including provision of present suitable habitat, future habitat and alternate habitat; adequate space for predator avoidance strategies to operate.

Activities likely to result in destruction of critical habitat:

Resource management actions that fail to provide for future habitat or alternate habitats which allow caribou to account for temporal and spatial dynamics of the landscape (fire, logging, succession); large human “footprint” contributing to increased predator numbers or hunting efficiency; landscape arrangement that reduces ability of caribou to evade or avoid predator encounters.

Example measures contributing to effective protection:

Manage present and future forest cover and composition to ensure an adequate and sustainable supply of seasonal and year-round habitat. Strategically plan access and linear feature development to avoid present and anticipated high use areas or seasonal ranges. Define and manage towards a habitat planning target across the range that allows for achievement of desired local population response. Ensure number, spatial arrangement and timing of resource development, extraction and human activities are appropriate to manage risk at pre-defined levels.

Special notes:

A range represents critical habitat for a local population, and a portion of critical habitat for the boreal population of woodland caribou. It includes land and

water area providing for present and future local population objectives. Range-specific evaluation of threats and conservation opportunities is required to determine acceptable level and extent of industrial activities. Caribou habitat values are met within a managed and dynamic forest condition where present and future seasonal ranges and high use areas are sustained. It may include dedicated protected areas, commercial forest or some combination of the two.

Seasonal ranges

Delineation/definitional criteria:

Component of a range typically described as winter range or summer range but may also include specific travel linkages or spring/fall transition habitats. Usually associated with predictable landform, topographic, or hydrological landscape features and forest cover or compositional criteria.

Critical habitat functions provided at this scale:

Provides for predator avoidance and forage availability best suited for specific seasonal life requirements. Large enough to provide for alternate habitat selection attributable to different levels of seasonal stress such as severe seasonal weather patterns (precipitation, snow depth, crusting, etc) or direct human or predator harassment.

Activities likely to result in destruction of critical habitat:

Resource development activities that result in reduction of area in suitable vegetative condition (age class, patch size, spatial arrangement and species composition) required to provide effective refuge or forage required for the number/density of animals using the range or the number of animals that must use this range in order to have a self-sustaining population.

Example measures contributing to effective protection:

Promote seasonal range conservation through protective measures such as fire suppression; precautionary allocation (forest management/mineral exploration) and avoidance of adjacent development activities that may encourage habitat for alternate prey species or otherwise increase the relative abundance, distribution or mobility of predators within or near seasonal ranges. Manage density and rehabilitation of linear features that may increase predator mobility.

Special notes:

Seasonal ranges may or may not exist for some local populations or within some ranges. Where they do exist, they tend to be more dynamic in space and time than the overall range depending on the specific biological functions being met. These areas are generally suitable for current use and typically receive more rigorous prescriptions for conservation or management than the portion of a range between seasonal habitats.

High use areas

Delineation/definitional criteria: Component of a range or seasonal range regularly exhibiting higher than expected use, likely associated with especially desirable or effective habitat features such as forage or the absence of human, insect or predator harassment.

Critical habitat functions provided at this scale:

Nursery or calving areas facilitate summer calf survival by providing refuge from predation in the vicinity of forage resources during this high risk period. Reduction in calf mortality or improvement in body condition prior to winter will increase probability of recruitment into the local population. High use winter areas may provide high abundance or quality of forage, or efficient access to refuge or forage during extreme weather conditions. They may be associated with forest conditions that provide abundant lichen availability, lower snow depths or high visibility.

Activities likely to result in destruction of critical habitat:

Human disturbance that forces caribou cows and calves to become separated, forces cows with calves into unnecessary movement (increases potential for predator encounters), or displaces cows with calves into higher risk environments. Habitat alteration that increases actual or potential predator activity in the vicinity of winter or summer high use areas including food subsidies; forest management practices that create and maintain high diversity, browse-rich or early seral stage forests. Reduction or elimination of forage values due to changes in forest stand composition, structure or spatial arrangement. These changes may result from forest harvesting, natural disturbance (fire, blow-down, insects and disease), or from forest plant succession. Infrastructure or human activity that displaces caribou away from resources or into areas of greater risk of predation. Any infrastructure development (roads/trails) that encourages or increases efficiency of predator activity in or around high use areas.

Example measures contributing to effective protection:

Encourage direct or indirect forest management or access management practices in and around nursery areas to ensure appropriate balance between forest conditions that discourage predator numbers or hunting efficiency, enhance the ability of caribou to detect and escape from predators or enhance forage abundance and availability. Avoid factors that accelerate decline, deterioration, reduction of the habitat attributes that make high use area desirable. Avoid linear corridor development into or adjacent to present and potential high use areas. Manage human activities, including research activities, to minimize displacement of caribou.

Special notes:

Degree of use may vary with extent or intensity of weather, disturbance or other events. Use may be

related to quality of neighboring habitats or range components. High use areas warrant management prescriptions with a high degree of protection/conservation consistent with the expected or planned dynamics of the range and the type and magnitude of threats to the local population.

Calving sites

Delineation/definitional criteria:

Typically very small, localized and discrete geographic units with demonstrated evidence of repeat successful calving activity. May represent islands, peninsulas or other specific topographic features.

Critical habitat functions provided at this scale:

Provide for effective predator avoidance during parturition and vulnerable early calf development period. Significant until calf is fully mobile and can travel freely with cow.

Activities likely to result in destruction of critical habitat:

Human infrastructure or activity that could displace cows before or during calving or cows with calves in early parturition period. Campsites, shore lunch fish cleaning locations or recreational activity that create an increased food supply that could attract predators; or alteration of vegetative cover (succession, harvest, fire) that might cause cows to select a higher risk environment for calving.

Example measures contributing to effective protection:

Prohibit alteration of forest cover, human disturbance/activities during high risk period, or human infrastructure development within a functionally effective radius.

Special notes:

Very high level of precautionary principle applied at this scale. If a functioning and repeat use calving site, then prohibitions to development and human use may be appropriate.

Discussion and rationale

The relationship between the local population, its range and critical habitat implies that critical habitat must be delineated based on the known or inferred distribution of caribou. This may include land and water that is currently unoccupied but has the capacity to provide for caribou life requirements in the future as part of a dynamic natural or managed landscape for the existing population size, or for a larger future population that might be deemed self-sustaining. Various components of a range may exist in some jurisdictions but not in others, and may or may not be explicitly defined as part of the overall critical habitat identification and delineation within the jurisdictional recovery strategy or action plan.

This range-based concept of critical habitat is biologically defensible and could perhaps apply to other wide-ranging species in addition to boreal population woodland caribou. The progressively increasing levels of management and protection at finer scales have a high likelihood of success and are capable of supporting a desirable population response only if broader, range-wide habitat outcomes are achieved. Therefore, more geographically localized components of a caribou range are inadequate as critical habitats by themselves, because full protection of any or all of these has a low expectation of caribou conservation at the population level unless higher-level range-wide threats are also addressed. In seeking an approach to critical habitat it is prudent to ask the question "critical for what"? Ultimately the only answer is, critical for achieving the recovery goal set out in the recovery strategy: of achieving long-term persistent populations in the wild.

Traditional thinking about the concept of critical habitat for species at risk often revolves around specific habitat components essential to the provision of a specific life requirement such as a nest, den or spawning area. To a large degree these very specific and often discrete habitat components may be adequately addressed through the residence provision under SARA. Traditional caribou calving sites may warrant very specific protection measures, but specific protection of the calving sites does not necessarily ensure calf recruitment if calf mortality is due to high endemic predation rates on the landscape (Seip, 1991; 1992). The proposed critical habitat approach also promotes rigorous protection for traditional calving sites but only within the context of the larger range.

Boreal forest landscapes across Canada are inherently dynamic within parameters determined by many natural bio-physical processes such as wildfire, forest succession, insects, disease, and climate. In large portions of caribou range, populations are also influenced by human developments such as agriculture, forestry, mining, roads, recreation and urbanization. Natural and human-caused disturbances vary over time, and vary in magnitude, periodicity and extent of influence. Consequently, the boreal forest landscape is a mosaic of patches representing different ages and conditions, only some of which are suitable for occupancy at a given time. The patchiness and temporal nature of caribou ranges and range components results in the need for caribou to occupy large boreal forest landscapes to ensure sufficient amounts of quality habitat and free movement amongst suitable habitat patches. These are sound reasons for critical habitat to be broadly delineated with consideration of specific habitat requirements at multiple spatial and temporal scales (Environment Canada, 2006). The

spatial distribution of habitat components changes through time, although the overall critical habitat requirements of a given caribou population may remain static (Environment Canada, 2006). Habitat components in an earlier successional stage may become important contributors to the range and critical habitat in the future. Critical habitat must provide enough space and mix of appropriate habitat components to accommodate seasonal variation in habitat use, movement (connectivity), predator avoidance, and dispersal of self-sustaining populations existing at naturally occurring low population density levels.

Caribou are well adapted to cope with a dynamic landscape but only within the intrinsic limits of their biology. The TSC promotes the range as critical habitat because of the wide-ranging effects of local activities that might influence the biological functions of predation, predator avoidance, migration, genetic exchange, reproduction and growth. Ultimately it is the population that is the measure of recovery effort success, and it is the ecological functions at the scale of the range that are either supported or compromised by the cumulative effects of human activities. The temporal scales envisioned exceed the longevity of individual animals, forest stands and temporary human infrastructure, to ensure the long-term persistence of caribou populations in the wild. This suggests that it is as important to plan for renewal of habitat components, as it is to preserve or protect existing habitat components. It is as important to maintain alternate, unused but suitable habitats as it is to maintain currently used habitats. It is also as important to consider cumulative impacts from human activities many years in the future, as it is to consider human activities or developments that may be established this decade and abandoned the next. The range concept, applied as intended, is large enough to accommodate the management of habitat components within a dynamic landscape while accepting the uncertainties of a background natural disturbance regime.

The proposed hierarchical approach is consistent with the need to address cumulative effects at a scale relevant to caribou biology. Ecosystems are inherently hierarchical with processes at one scale interacting with processes at other scales to influence landscape structure, composition and function (Ecological Stratification Working Group, 1995; Wiken, 1986). Caribou habitat selection is hierarchical (Rettie & Messier, 2000) with predation avoidance being addressed at coarser spatial scales (Bergerud, 1988; Stuart-Smith *et al.*, 1997) and foraging being addressed at finer spatial scales (Schaefer & Pruitt, 1991; Rettie & Messier, 2000). Threats that seem local, such as roads or linear corridors, can have far-reaching effects at the landscape or population level (Dyer *et al.*, 2001, 2002; Smith *et al.*, 2000),

while forest harvesting or forest fire patterns at the landscape scale may alter the distribution and abundance of prey species over broad areas (Telfer, 1978; Schwartz & Franzmann, 1989), the effects of which may not be demonstrated by the local population for a period of many years or even decades (Vors, 2006).

The proposed hierarchical approach is also consistent with caribou population responses to biotic and abiotic factors at different scales. At the landscape scale, natural and human-caused disturbance influence the spatial and temporal distribution and connectivity of local caribou populations, by affecting the amounts, size and configuration of preferred habitat types. The effect on the landscape is a function of the frequency, magnitude and duration of disturbance factors (Haufler *et al.*, 2002). At the landscape level, the quality, quantity, structure, juxtaposition, connectivity and function of habitats influence home range size, productivity and survival. At a more local scale, the spatial distribution of forage and microclimate influences movements, foraging behavior, calving site choice, and resting site locations.

Critical habitat has been biologically defined as a perpetual supply of large, contiguous areas of suitable summer and winter habitat, allowing self-sustaining viable population(s) to disperse at low densities over a large area to avoid predators (Arsenault, 2003; Bergerud, 1992; Environment Canada, 2006; Seip & Cichowski, 1996). This biological definition includes calving habitat, and acknowledges the implications of human access and disturbance. Arsenault *et al.* (2006) concluded that the range, described as critical habitat, may be the land base required through time to effectively conserve boreal caribou, and which may require special management considerations or protection.

By biologically defining the critical habitat as the range, we recognize that local mitigation of threats is only effective if the cumulative mitigation effort reduces the risk of extirpation at the local population or range level. Using a biologically derived hierarchical approach to critical habitat allows us to consider those physical and biological features that are essential to boreal caribou conservation, and that may require special management considerations or protection within a spatial and temporal hierarchical context.

Management implications

The proposed approach to critical habitat is well suited to envisioning a practical and effective management regime to satisfy recovery goals. It is robust and flexible. As a general approach, it can be readily adapted to accommodate new knowledge to support caribou conservation. Of particular significance is new knowledge on cumulative effects, effective scales of habitat selection, quantitative analysis of threats and resulting

population level consequences, and the interaction between human development and natural disturbances. This might be particularly relevant when other factors such as climate change add uncertainty (Racey, 2005) to our understanding of natural processes and caribou. Future growth of caribou biology and management knowledge should allow for progressively more certainty in setting criteria for range delineation or for describing effective resource management practices consistent with conservation of boreal caribou populations.

There is jurisdictional flexibility, while working within this approach, to develop local procedures in support of critical habitat identification and delineation that suit the specific biophysical environment within which their caribou populations live. Managers believe that the relative importance of different habitat components across the country varies with the specific climate, geology, forest growth patterns, disturbance regimes, and human development pressures. Thus, the resulting range delineations and the specific treatment of habitat components may differ between areas with relatively continuous range as opposed to areas with smaller, relatively discrete populations near the southern edge of caribou distribution.

Protection of the range as critical habitat may be achieved through formalized management or conservation agreements setting out the amount and type of human development and potential natural disturbances; rarely would all commercial activity be prohibited. Thoughtful and targeted management actions that influence forest composition or structure (i.e., logging) may prove useful for the renewal of some range components and ultimately for the provision of alternate habitats within the range, to provide insurance against loss of existing habitat components from wildfire. This approach has been acknowledged for piping plovers (*Charadrius melodus circumcinctus*) (Martens & Goosen, 2005), where water level manipulation in reservoirs might be used to maintain or enhance critical habitat, or for Canada lynx (*Lynx canadensis*) in the United States (Department of the Interior, 2005), where special forest management practices may be used to ensure boreal forest landscapes provide a mosaic of forest stands of various ages to maintain critical habitat.

A very important management implication of the proposed approach is that effective protection for the range may be achieved through the combined contributions of parks, protected areas, reserves and managed lands. There is a certain amount of risk and uncertainty in using landscape management approaches and we recommend this risk be addressed by applying the precautionary principle (Cooney, 2004). There is a very clear obligation assigned to the resource management

community to apply measures that ensure the biological processes are achieved at the range level and realized in a persistent caribou population. This means:

- select and apply harvest and silviculture practices that do not just maintain current habitat values, but renew and enhance habitat components for the future,
- develop management strategies in protected areas that contain caribou that recognize the role of natural processes in sustaining range values and functions,
- develop range delineations for some local populations that exceed the documented area of occupancy in order to provide for a larger population, alternate areas for natural disturbance contingency, or renewal of currently unused potential habitats,
- rehabilitate temporary human infrastructure such as roads and seismic lines,
- mitigate direct human disturbance and food subsidies for predators caused by industrial and recreational human activities and dumps.

As ranges are shared across jurisdictional or corporate license boundaries, it is essential that there be cross-boundary cooperation in delineating critical habitat and applying effective protection measures. This may only happen if governments create policies and guidance that encourage such cooperation.

Caribou conservation requires management strategies across large areas and long time periods. The proposed hierarchical approach to critical habitat not only facilitates management actions, it facilitates effectiveness evaluation of management strategies by providing a framework for setting and monitoring numerical objectives. It discourages decisions made about individual habitat components such as high use areas, or seasonal ranges independent of their context within the larger range and the total local population. It helps prevent a piecemeal approach to caribou habitat management that will ultimately lead to continued recession of caribou range as described by Racey & Armstrong (2000). Finally, it facilitates the use of range-wide management approaches that meet the needs of the species while avoiding conflicting management direction caused by inconsistent reference conditions at specific temporal or spatial scales (Haufler *et al.*, 2002).

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