Caribou and the National Boreal Standard: Report of the FSC Canada Science Panel

Prepared for FSC Canada

By:
(in alphabetical order)

Elston Dzus, Justina Ray, Ian Thompson, and Chris Wedeles

Elston Dzus, Ph.D., Environmental Sciences Team Leader, Alberta-Pacific Forest Industries Inc.
Justina C. Ray, Ph.D., Executive Director, Wildlife Conservation Society Canada
Ian Thompson, Ph.D., Private Consultant
Chris Wedeles (Consultant), ArborVitae Environmental Services

July 26, 2010

Table of Contents

1 EXECUTIVE SUMMARY

FSC Canada convened a Science Panel to undertake a structured review of the adequacy of the National Boreal Standard (FSC 2004, hereafter referred to as the NBS or Standard) in addressing caribou conservation issues, and to provide recommendations on appropriate measures to improve the Standard's consideration of the integration of caribou and forest management. This report fulfills the Panel's mandate. The recommendations provided in this report are the result of a substantial amount of contemplation and deliberation and it is now the role of FSC Canada and its stakeholders to consider implementation of the Panel's findings.

In general, the Panel found that the NBS is a very thoughtful document, but that it could be improved with some additions and modifications to address concerns regarding caribou conservation. The Panel has recommended that 18 of the Standard's existing indicators be modified and that five new indicators be developed. The new indicators focus on: decline in relative abundance of conifer forest communities (especially in eastern Canada), planned aggregation of landscape disturbances, collaborative efforts related to caribou management, and addressing the forest companies' roles in gathering and using caribou-related information. Ideally the recommendations suggested by the Panel will be adopted as a suite of changes; as a whole they have the potential to result in a greater evolution of the Standard than would occur if they were to be adopted piecemeal.

In undertaking this task, the Panel found it useful to consider potential improvements to the Standard by reviewing a number of mechanisms thought to influence caribou habitat and populations. Through that exercise, the Panel reviewed the hypothesized impacts of climate change, predation, hunting, fire, habitat loss, habitat change, linear features, and cumulative effects. The topic of deepest concern to the Panel, not presently addressed in the Standard, is that of cumulative disturbances. Several indicators should be modified to incorporate concerns related to cumulative effects. Threats to the continued persistence of boreal caribou are heightened in situations where multiple disturbances exist and where substantial portions of their range exists in a disturbed state. In many, if not most areas in which forest management overlaps with boreal caribou populations, the populations are affected by multiple management plans that are rarely coordinated. Several of the Panel's recommended changes to the Standard deal with

cumulative disturbances, including the development of a framework to evaluate relative risk to caribou populations.

Generally, the Standard does not explicitly address the state of wildlife populations. It instead relies on the assumption that a focus on habitat management should provide a sufficient means to conserve populations, recognizing that forest managers do not have direct responsibility for managing populations. Further, the Panel recognizes that other (non-forestry) activities on the same landbase can add to (or even dwarf) the impacts of forest management. In this light, there is a limit to how much can reasonably be expected of forest companies with respect to the long-term maintenance of caribou populations. While the Panel recognizes that the primary management domain of forest companies is habitat, it believes that to address concerns regarding caribou and other species at risk (SAR), some evolution of the traditional bounds of forest company activities is necessary. Therefore, in several instances, the Panel recommends incorporation of requirements into the Standard specifically intended to foster management of caribou. In addition, some of the Panel's recommended changes require companies to 'work within their sphere of influence' to achieve progress in various aspects of population management (e.g., monitoring, modelling), emphasizing an important role that forest companies can play in helping safeguard caribou populations, not just caribou habitat. The Panel has been careful not to burden forest companies with excessive requirements, while at the same time recognizing that, in their role as managers or co-managers of FSC-certified forest lands, there is scope for companies to broaden somewhat the role they usually play in resource management. Consistent with the Panel's recommendations, FSC Canada must reconcile the need to develop Standards that raise the bar with regards to forest management and contribute to sustainability while still being achievable. It is, however, vital that in the process FSC make clear any trade-offs to caribou conservation that might occur as a result of this balancing process.

The Panel recognizes that caribou are only one of a number of SAR, about which forest managers must be concerned and that the process of reviewing the Standard through the lens of a single species will be viewed as precedent-setting by some. The Panel stresses that conservation dividends will be realized by adopting a caribou perspective for resource management by virtue of the sensitivity of this species to large-scale disturbance and its requirement for management

regimes that are broad in time and space. After careful review of the Standard, the Panel believes that its recommended revisions will benefit many species other than caribou.

In addition to recommending changes to the Standard itself, this review identified a number of ways in which the assessment and auditing process should be strengthened. These include: providing training to assessors to help them understand and take caribou issues into account in assessments; developing means to address comparability among assessors in their interpretation of key elements of the Standard; and clarifying linkages between planning and implementation components of the Standard.

2 INTRODUCTION

Over the last several years it has become increasingly apparent that the continued existence of caribou (*Rangifer tarandus*) is uncertain in many parts of Canada's boreal forest (Vors et al. 2007; Sorenson et al. 2008; Environment Canada 2008; Athabasca Landscape Team 2009). Within Canada, there are three broadly-recognized caribou ecotypes – boreal forest, migratory tundra, and mountain. Most caribou dwelling in the boreal forest are the boreal forest ecotype of the woodland caribou subspecies (*R. t. caribou*). However, migratory caribou populations also share much of the northern boreal forest during winter months, but move to coastal and tundra habitats during calving and post-calving seasons (Hummel and Ray 2008). This report focuses on all caribou residing in boreal forests of Canada, and therefore while most are of the boreal forest ecotype[1], also included are other caribou ecotypes that may use certain portions of the boreal biome on a seasonal basis.

Considerable scientific and public concern exists regarding the fate of caribou in Canada. Because forest management remains a dominant human activity in the boreal forest, FSC Canada has recognized the need to ensure that the National Boreal Standard (FSC 2004, hereafter referred to as the NBS or Standard) is attuned to the interaction between forest management and boreal caribou and that "FSC Certification will effectively address concerns with respect to caribou management" (FSC Canada 2007). To help ensure that its efforts are guided by scientific knowledge, FSC convened a Science Panel. The Panel's objective, as identified in its Terms of Reference, was: "To provide well-summarized and specific science advice with regards to the NBS as it pertains to the conservation of woodland caribou as an example of a species of risk. The science-based guidance and recommendations will provide advice to FSC Canada in the spirit of continuous improvement and adaptive management of the NBS."

In this document, the Panel has attempted to consider the variety of concerns regarding how caribou and caribou habitat may be affected by forest management. The document is intended to have a logical flow that emulates the process through which the committee addressed the

[1] At times this report refers to 'woodland' caribou rather than 'boreal' caribou, in discussing effects cited in the literature for which the designation 'woodland' caribou has been used.

challenge of meeting its objective. Section 3 of the report reviews the precautionary principle and adaptive management, to emphasize the appropriateness of those management philosophies and approaches. Section 4 provides a very brief review of caribou ecology and hypotheses for their decline to underscore those aspects that are most in need of management (and scientific) attention. Section 5 provides a review of the present Standard and the extent to which various aspects of caribou ecology identified in Section 4 are addressed. Section 6 reviews existing conservation measures intended to address the interaction of caribou and forest management. With that context, Section 7 identifies changes to the Standard that the Panel believes are required to more fully address the suite of conservation concerns regarding forest management where caribou reside. In recognition that interpretation of the Standard will be key, no matter how robust the wording, Section 8 identifies some issues related to the assessment and audit process that the Panel believes are in need of attention. Section 9 reviews the role of Principle 9 (High Conservation Values) in ensuring that concerns regarding species at risk (SAR), such as caribou are captured in the assessment and auditing process. Finally, Section 10 identifies key uncertainties and Section 11 presents our conclusions.

2.1 WHY FOCUS ON CARIBOU?

Habitat loss[2] as a result of land use change is the principal driver of biodiversity erosion globally (Sala et al. 2000) and is the main driver of SAR designation in Canada (Ventner et al. 2007). Individual species react differently to the same levels of habitat loss and/or degradation, with responses lying on a continuum (Periera et al. 2004). Caribou is one of the boreal species most sensitive to land use change (Festa-Bianchet et al. in press). Several aspects of caribou ecology make the species very challenging to manage, including:

- the range of a caribou population is often thousands of square kilometres, and while individual habitats are used differently, factors that ultimately influence population persistence act at the range scale (rather than the scale of a habitat patch);

[2] The term “habitat loss” is used in a number of places through this document. We make an important distinction between habitat loss and habitat change based largely on whether the shift is temporary or permanent. Loss occurs when habitat is altered to such an extent that it will be permanently unavailable when there is no management intention to revert the habitat to a usable state, or when cumulative impacts circumvent intentions to return it to a usable habitat. Change occurs when habitat becomes unavailable, but management intention exists to return the habitat to a useable state within timelines outlined in existing management plans.

- individuals require large expanses of mature coniferous forests and do not generally occupy forests that are less than 50 years old;
- females space away from one another to calve in isolation in areas that are difficult to locate or predict and that are generally collectively dispersed throughout the population range;
- females have low reproductive rates that impede the ability of populations to rapidly recover from declines; and
- individuals are long-lived, such that population-level responses may lag behind landscape change by up to 1-3 decades.

Although maintaining caribou does not itself guarantee the persistence of other elements of biodiversity in a given area, the disappearance of any large mammal is generally representative of human impact on biodiversity. Caribou are among the world's 20 large mammal species that have experienced the greatest documented area of range retraction over the past several centuries (Morrison et al. 2007). That said, North American caribou range still comprises a significant proportion of the remaining approximately 20% of the planet that has an intact large-mammal fauna. Nevertheless, the present range of caribou has been recently identified by Cardillo et al. (2006) as one of several areas in the world with a high proportion of species that are at high risk of "latent extinction". This means that, in spite of as-yet minimal human pressures overall, inherent biological characteristics will predispose caribou and other species to human impact as more intense development arrives, resulting in an elevated potential for future species losses.

The collapse or disappearance of a caribou population may herald the fate of other less visible elements of the same ecosystem. With mounting evidence for the substantial role of biological diversity in maintaining ecosystem resilience in a world increasingly modified by human activities, conserving species is essential insurance for coping with the uncertainty of such change (Elmqvist et al 2003; Bengtsson et al. 2003; Carpenter and Folke 2006, Thompson et al. 2009). Striving to manage for the persistence of a species in a changing world will involve both being able to meet their baseline ecological requirements as they relate to habitat and movements within a given landscape and preventing the threatening processes from incurring undue risk to the population. Adopting a caribou perspective for resource management requires a far-sighted

vision spanning decades, and thousands of square kilometres – scales of time and place that often exceed traditional horizons of planning. Because this is such a demanding set of requirements for managers, and necessitates an approach that differs rather dramatically from most management systems in place today, managing landscapes with a caribou-centric perspective should 'raise the bar' on the sustainability of boreal forest management activities in general.

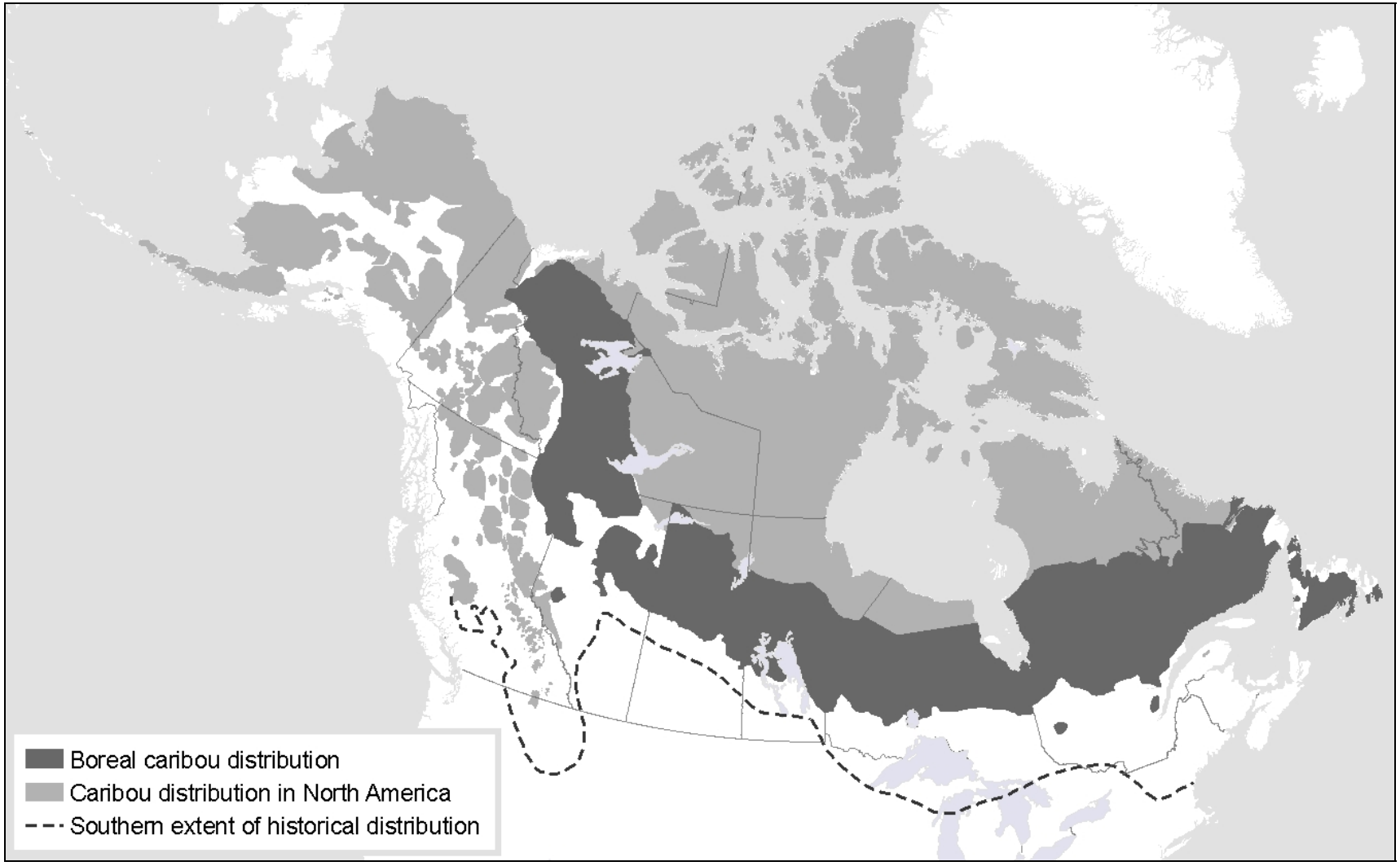

Figure 1. Present and historical distribution of caribou. Distribution of boreal caribou is the darker shade. (Adapted from Hummel and Ray 2008).

2.2 WHAT FSC CAN / CANNOT DO FOR CARIBOU

Understanding what FSC certification can do for caribou conservation involves examining the factors influencing caribou recovery and the interactions among certification, well-managed forests[3], and SAR conservation. One of the primary purposes of FSC certification is to provide a level of assurance to consumers that forest products have been produced "from healthy forests providing an equitable sharing of benefits from their use, while respecting natural forest processes, biodiversity and harmony amongst their inhabitants" (FSC Canada 2010). A fundamental component of forest management in Canada and an expectation of the National Boreal Standard is proactive engagement of SAR conservation. Forestry companies control their own actions (within bounds set by government regulations) and can collaborate with, or have influence over the actions of others. However, ultimate success will depend on the combined actions of the companies, governments, and other stakeholders engaged in SAR conservation on the same landbase. This collaborative effort will depend on adequately addressing the limiting and regulating factors affecting caribou survival, movements, and reproduction in an integrated fashion.

The proximate and ultimate factors limiting recovery of a given SAR (caribou in this case) may vary in time and space. In Section 4.3, the leading hypotheses regarding the decline of boreal caribou are discussed along with how these factors may vary across Canada. The ability of any certification scheme to positively influence conservation of SAR thus lies at the intersection of those factors that can be influenced by the management actions of the certified company. Forest management actions that influence conservation of caribou largely relate to habitat loss or change, and access (i.e., road building, reclamation and management). Accordingly, through their planning and operational practices, companies can cause both detriments to habitat suitability and facilitate the long-term habitat needs of caribou. To minimize the impact of their activities and contribute to caribou conservation, companies can limit the extent and distribution of habitat loss and influence habitat recovery through silviculture and other activities. The creation of roads is required by most industrial operators; thus, access development, management, and subsequent reclamation is another key area where forest companies must strive

[3] We note that the National Boreal Standard uses the term "well-managed" to refer to forests worthy of certification. Although different in syntax from the commonly used "sustainable forest management," we infer that in principle there is little difference between the two terms.

to minimize impact of their activities, collaborating with other industrial users where relevant. In many areas across boreal Canada where forestry is the predominant industry, forest companies have a heightened responsibility for road planning, because forestry roads provide access to new areas that lead to ensuing cumulative effects.

Caribou conservation in many parts of Canada will require a focus on habitat and aspects of population management. In this document, an important distinction is made between two aspects of population management: monitoring, and manipulation. Monitoring is the measurement of various population metrics at regular intervals to track the state of selected populations. Manipulation is the more dynamic aspect of population management, encompassing activities intended to change the density and/or distribution of populations. Manipulation activities could include management of hunting by setting hunting seasons or quotas, predator control to regulate natural mortality, and importation of animals to establish or supplement populations. It is not within the mandate or management responsibility of forestry companies to engage directly in manipulative aspects of population management and it is normally beyond the realm of company activities to engage in monitoring as well. However, in some cases, depending on local circumstances (related to government capacity, co-management arrangements, etc.), companies could play a role in assisting in monitoring activities.

Depending on geographic location and the biota involved, the agency responsible for recovery planning is either the provincial, federal, or territorial government. In some jurisdictions, this involves co-management with aboriginal peoples. Government or co-management boards play a paramount role in providing strategic direction and incorporating socio-economic concerns on issues related to population management. Forest company staff should participate with other specialists to build comprehensive recovery action plans, carry out practices with specificity to management responsibility, monitor results, and build adaptive management processes towards achieving stated objectives and agreed upon outcomes. Through their influence on the actions of a forestry company, certification systems can influence, but not guarantee, the ultimate success of SAR conservation. Forest management practices implemented to aid in caribou conservation should lead to overall improvements in forest stewardship and associated ecological and social benefits.

3 PRECAUTIONARY PRINCIPLE AND ADAPTIVE MANAGEMENT

Adaptive management is a popular theme in stewardship of natural resources, and most managers attempt to practice it in some form. The notion of adaptive management has broadened considerably since the original seminal description from Holling (1978), in which it was described as a process for the design of creative resource management and policy alternatives by integrating the scientific method into management approaches. Since then, it has been broadened to embrace the notion of continual improvement, which does not require the rigour of adaptive management as originally conceived. Walters (1986) described three ways to structure management as a adaptive process: 1) "trial and error" in which improvements occur through a rather unstructured approach of assessing what works and what does not, but where the management alternatives are not identified in advance 2) "passive" adaptive management, which makes use of historical data on the results of management , and 3) "active" adaptive management, in which management is conducted as a series of experiments that involve the testing of hypotheses. This latter version of adaptive management is consistent with the original concept and is also that advanced by the existing NBS, which states that: "Adaptive management is much more than learning by trial and error. It refers to the structured process of adjusting management in response to implementation of a monitoring program to test stated hypotheses, and revision of management based on the monitoring results." In practice, this has been a high bar to reach and many certifications have balanced the demands of this definition with the practicality of its implementation.

The focus of the precautionary principle is to tread cautiously while managing to avoid unintentional and deleterious impacts[4]. The NBS defines the precautionary principle as "an approach that tends to refrain from actions where the outcome is not known." Management must demonstrate that there will be no, or very limited impact, rather than proceeding with ambiguous or unknown results. Both adaptive management and the precautionary principle are means of dealing with uncertainty (Taylor 2000, FSC Canada 2004), but their emphases are different. Adaptive management seeks to learn from actions themselves; the precautionary principle

[4] Lee (1993) points out that claims of practicing the precautionary principle are often stated without consideration of whether alternative approaches would be more cautious.

essentially assumes the worst and recommends a strategy that errs on the side of caution, where the likelihood of undesirable impacts is minimized.

Taylor (2000) notes that the precautionary principle is best suited to circumstances in which the consequences of a particular outcome are irreversible and unacceptable, or where it is impossible or impractical to design an informative strategy that will resolve uncertainties. This may be the case where response times are as long as decades away, or where the key indicators have very high levels of natural variability or measurement error, as is the case for caribou. The approach works best where the risk of a particular outcome is high and where one of the proposed strategies is much less likely than the others to lead to deleterious outcomes. The downside of the precautionary principle, in this context, is that when the ultimate outcome will not be known for decades, the perception of risk often appears unnecessarily restrictive and costly in the short term.

The NBS positions the precautionary principle and adaptive management as complementary, putting primacy on prudence and caution in dealing with uncertainty and avoiding severe negative effects. The NBS notes that adaptive management is appropriate only after the condition of precaution is satisfied. In considering boreal caribou, there are situations in Canada in which the precautionary approach should override desires to engage in active adaptive management. These are primarily (but not exclusively) circumstances in which populations are small and isolated, such as in Puskaskwa National Park in Ontario and the Val d'Or region in Québec (Environment Canada 2008), or where caribou ranges are otherwise highly disturbed. The consequences of errors in management may be drastic (i.e., extirpation), and so management efforts there must, of necessity, focus on precaution. For less disturbed contiguous boreal caribou range in Canada, adaptive management, (tempered by elements of precaution as described in the NBS) is the appropriate management regime. As described in this report, there remain many uncertainties in managing for caribou and there is a need to refine the suite of management practices currently viewed as preferred options.

There are several hurdles to deal with in attempting adaptive management for boreal caribou:

- there are many inter-related factors affecting caribou (as discussed in Section 4, below), necessitating experimental management designs that have the capacity to incorporate uncertainty associated with such factors;
- response times are likely to be relatively long and so the impact of a management regime will not be fully apparent for many years (perhaps decades) after its implementation;
- experimental management is costly, in terms of the manipulation of management practices and the equipment and effort needed to detect caribou responses; and
- the potential for unforeseen complications is large (e.g., logistical difficulties in carrying out prescriptions, changing regulatory regimes, and unpredictable market forces).

In light of these factors, it is apparent that active adaptive management provides the most comprehensive route to an increased understanding of caribou-forestry dynamics. This is not to suggest, however, that trial and error or passive adaptive management are without value. Given the cost, logistical demands, and experimental constraints associated with active adaptive management, simpler approaches should be embraced when they offer practical alternatives. From a certification perspective, therefore, although the present definition of adaptive management provided in the Standard is consistent with active adaptive management, a dogmatic approach (i.e., rejection) of the relative value of other forms of adaptive management could result in forgone learning opportunities. Furthermore, there are circumstances, such as described above (e.g., very small or otherwise at-risk populations) where, in adherence to the precautionary principle, the risks from active adaptive management may be too great, but opportunities for learning are still provided by passive adaptive management. As described earlier, trial and error is clearly the most basic form of adaptive management; it requires little forethought, but has less value. Therefore in instances in which active adaptive management is impractical, passive management is the preferred alternative.

4 CARIBOU CONSERVATION CONTEXT

The intent of this section is to briefly identify those aspects of caribou ecology that are important in understanding sensitivity to habitat conditions and population influences. Section 4.1 discusses habitat requirements, and Section 4.2 discusses several hypotheses that attempt to explain the population and range declines that have characterized the species' ecology in Canada over the last several decades. As described earlier, this section is intended to set the stage for discussions of the content of the existing Standard (Section 5), and science-based conservation measures (Section 6).

Status

While all boreal caribou in Canada, except Newfoundland, are listed as' Threatened' under the federal Species at Risk Act, and most provinces have similar designations, the condition of individual populations is highly variable (Environment Canada 2008). These listings are a function of population-based traits that have arisen as an expression of habitat conditions at the local level, and the nature and intensity of combined human and natural disturbances in a given range. Where threats to caribou are most intense and the extent of the human disturbances is correspondingly pervasive, the probability of persistence of populations tends to be low (Environment Canada 2008; Sorenson et al. 2008). By the same token, where caribou persist naturally at very low densities, one would expect them to have low resistance to disturbance on their ranges. Most populations, particularly throughout central and eastern Canada, have not received adequate survey attention, hence the status of these populations is poorly known.

Uncertainties

One of the key constraints in working towards caribou conservation is the extent of uncertainty around many aspects of their ecology and interactions with forestry. Science can inform the questions surrounding the management of caribou only over considerable time. Boreal caribou have been the focus of research in Canada for nearly 40 years, with the most intensive effort occurring since the mid 1990's. Currently, considerable research on various populations is ongoing in Alberta, Manitoba, Ontario, Québec, and Labrador to improve knowledge for several key local populations and for the species in general. The results of this research will improve the

capacity to manage caribou considerably after the next 3 to 5 years. However, some key uncertainties with respect to their habitat ecology will only be addressed or reduced over time; for example, their responses to habitat changes that are linked to the time it takes a forest to recover from disturbances are largely unresolved. Key uncertainties include: minimum timber harvest area (block size) to leave or cut, caribou perception of landscape connectivity, diet and nutrition, ecological energetics, and the capacity of caribou to adapt to second-growth forest types and landscape structure that have developed after forest harvesting. These issues are further confounded by regional differences in caribou behaviours and habitat selection. For example, in boreal Alberta, caribou rarely move out of bogs and fens, whereas in Ontario the animals are well-known to use upland habitats, especially in winter (e.g., Stuart-Smith et al. 1997, Courtois et al. 2008). Furthermore, there is as yet a lack of sufficient second-growth forest of old-enough age and composition for caribou to re-occupy. As a result, habitat management for boreal caribou must be viewed as an ongoing experiment and while managers may make choices based on the available information, only long-term monitoring under an experimental design will provide information to address these uncertainties over time.

4.1 CARIBOU HABITAT REQUIREMENTS: SPATIAL AND TEMPORAL SCALING

The boreal forest is a disturbance-driven landscape, with fire, insect outbreaks, and wind as the major driving factors. All these factors operate at multiple spatial scales and over long time periods. Hence, species that live in the boreal forest must have adapted under, and to, these unpredictable conditions. Among the disturbances, fire is the most important, burning from <200,000 to >7,000,000 ha of boreal forest in a given year, during the period 1960-2004 (Martinez et al. 2006). Fires in boreal forests are sometimes large, stand-destroying crown fires that may burn tens of thousands of hectares (Johnson 1992). Small fires that burn areas <100 ha are most frequent but it is the largest fires that are primarily responsible for landscape structure (Johnson 1992, Li 2000). Similarly, insects may affect large areas of mature pine or spruce, as the mountain pine beetle has done in British Colombia during the past decade. Insect damage and fire often interact, with insect-killed forests being highly prone to wildfire for several years following an outbreak (e.g., Bergeron and Leduc 1998). Further, all of these disturbances have a temporal scale as well as the spatial scale. For example, depending on forest type and local

climate, mean fire return interval may be short, measured in several decades, to very long, measured in a few centuries (Bergeron and Harvey 1997, Harper et al. 2005, Ter-Mikaelian et al. 2009). As a result, the boreal forest is neither static nor in equilibrium, and although resilient, it is constantly changing owing to disturbances, resulting in an interspersion of large and small forest stands of different ages (e.g., Suffling 1995, Harvey et al. 2002, Drever et al. 2006).

Because the boreal forest changes in time and space, in response to relatively frequent disturbances, so too does the condition and extent of caribou habitat. Caribou have always lived with a measure of uncertainty in the spatial and temporal distribution of their habitats. If fire or other disturbance eliminates current habitat, the animals are forced to move to new locations, if possible. Such broad landscape changes are documented as far back as the early 1800s in the Hudson Bay Company (HBC) records. For example: "the country from the River Ouinipic [Winnipeg] to the head of Osnaburg Lake [Lake St, Joseph] is nothing but one vast devastation of burnt woods" (HBC Osnaburg Factor record, 1827) and this corresponded to a complete lack of caribou skins traded in the same records from the early 1800s, but caribou reappeared in the records during the 1860s (R. Suffling, Univ. Waterloo, pers. comm., Fritz et al. 1993), probably in response to the forest having sufficiently regenerated to support caribou. Such large fires have probably always caused caribou populations to fluctuate over time and have broadly influenced habitat availability across large landscapes (Schaefer and Pruitt 1991). The time for recovery of burned habitats for caribou appears to be 40-60 years depending on the ecosystem (Schaefer and Pruitt 1991, Bradshaw et al. 1995, Dunford et al. 2006). Hence, planning for caribou habitat, even in managed landscapes, clearly needs to recognize the probability that large fires will occur and the associated multi-decadal habitat recovery period associated with both natural and anthropogenic habitat change.

Caribou use of habitat is hierarchical; that is, the animals select habitat at a range of scales, from landscapes to individual sites (e.g., Rettie and Messier 2000, Mayor et al. 2009). They use and require large landscapes that have had limited recent disturbance, forest stands that provide shelter and escape cover from predators, and individual sites that provide food, especially lichens in winter (Dyer et al. 2001, Courtois et al. 2007, Courbin et al. 2009, Hins et al. 2009, Mayor et al. 2009). Bergerud et al. (2007, 2008) have suggested that caribou habitat selection is largely

influenced by wolves and that they use a strategy of spacing out at low densities in relatively unproductive habitats to avoid predation. In particular, a mixture of open fens and bogs along with expanses of older upland conifer, much of it sufficiently open to allow growth of arboreal and terrestrial lichens, are characteristic of habitats selected by boreal caribou (Schaefer and Pruitt 1991, Bradshaw et al. 1995, Stuart-Smith et al. 1997, Courbin et al. 2009). Caribou also avoid landscapes with multiple forest ages and considerable amounts of edge with young or deciduous forests (Stuart-Smith et al. 1997, Smith et al. 2000). Generally, caribou avoid early seral stage forests, whether they are created by logging or fire (Schaefer and Pruit 1991, Chubbs et al. 1993, Hins et al. 2009).

Like fire, forest management and other resource developments have a strong influence on caribou habitat selection at coarse scales (Schaefer and Mahoney 2007, Fortin et al. 2008, Hins et al. 2009; Bowman et al. 2010) and fine scales (Fortin et al. 2008). After harvesting, the forest reverts to a young stage for at least 40 years and caribou alter movements and occupancy, tending to avoid the open areas and young forest (e.g., Ferguson and Elkie 2004). There is only minimal evidence, so far, that caribou re-occupy managed forests. Courtois et al. (2007) found a negative relationship between caribou density and area logged <30 years ago, in part as noted above because so little second-growth boreal forest is >40 years old. This reflects caribou behaviours to avoid predators (Barten et al. 2001, Bergerud et al. 2007, Briand et al. 2009), open areas (Chubbs et al. 1993), and possibly continual noise (Chubbs et al. 1993, Cummings and Hyer 1998). Work from Alaska also suggested noise avoidance by caribou (e.g., Murphy and Curatolo 1987). An associated problem is that forest management planning almost always occurs at a scale that is inappropriate for long-term caribou conservation. Most local populations of caribou occupy ranges from 10^4 to 10^5 km^2 (although most ranges are $<5 \times 10^4$), while most forest management units[5] (FMUs) are substantially smaller. Hence local caribou populations are often affected by multiple independent management plans that are not usually coordinated, resulting in range degradation. Further, developments in other sectors, especially energy, mining, and hydro are typically not coordinated in any way through large-scale land management planning, resulting in multiple impacts on caribou ranges.

[5] In this context, 'unit' means the area of forest administered as a single managed area. Comparable terms used in various parts of Canada include 'forest management agreement area', 'forest management area', and 'sustainable forest licence area'.

Local populations of caribou also require redundancy in habitat availability over large scales, not only because of the potential removal of large areas of habitat by fire or logging, but also because the animals do not necessarily use the same areas to meet their habitat needs year-after-year (e.g., Schaefer and Pruitt 1991, Dalerum et al. 2007). Snow conditions, weather patterns, predator density, and food availability may alter their movements and use of summer and winter ranges between years (e.g., Stuart-Smith et al. 1997, Dalerum et al. 2007). This compounds the scale issue for caribou management because it means that their persistence cannot be guaranteed by some simple minimum amount of habitat derived from an area relationship relative to population size and density (See Section 6.2). Removing or fragmenting expanses of caribou habitat through various developments leads to lowered probability of persistence depending on area of habitat lost or changed (Environment Canada 2008). However, forests will eventually age and either burn or break up, also resulting in temporal changes in caribou habitat. Informed caribou management could maintain habitat in time and space by considering all scales, but with a specific focus on the largest landscape scale (i.e., the range of a local population), while recognizing the need for habitat redundancy.

4.2 Hypotheses of Population and Range Decline

Range (distribution) decline and population decline are often strongly linked, although it is possible for the distribution of an animal species to change with little population decline. Further, population fluctuation in response to 'normal' environmental changes must be considered, especially in the context of the boreal forest, where large natural disturbances are common. In the case of boreal caribou, many local populations are declining (Environment Canada 2008), so it is likely that range and population decline are linked at least during the recent past. Nevertheless, several independent hypotheses can be proposed to suggest why caribou population size and/or range have declined in Canada.

Ultimate causes of decline are largely related to condition and extent of habitat as influenced by anthropogenic and natural forces. Proximate causation for decline of woodland caribou range is the subject of some debate. The historical area occupied by woodland caribou has receded across Canada (Figure 1), except on Newfoundland, mostly from south to north, presumably

starting around the time of European settlement (Schaefer 2003), by between ca. 25 to 40% depending on province (COSEWIC 2002, Environment Canada 2008). The precise former distribution of caribou and the rate of decline has also been a matter of considerable conjecture and debate. This is partly because historical information about its distribution is not accurate but also because many factors affect distribution. Nevertheless, most authors agree that much of the caribou range decline is anthropogenic-related (Bergerud 1974, Dyer et al. 2001, Schaefer 2003, McLoughlin et al. 2003). Most early declines may have been in large part the result of hunting (some of it commercial) and deforestation for settlement, including for town-sites, agricultural lands, roads, and railways (Bergerud 1974, Fritz et al. 1993, Courtois et al. 2003, Schaefer 2003) and associated wildfires. Later declines (i.e., the last 60 yrs) have been increasingly associated with various and cumulative habitat disturbances (directly or indirectly) including climate warming, forest clearing for oil and gas exploration, habitat change associated with forest management, multiple linear features (roads, pipelines, seismic lines, transmission lines, etc.), flooding from hydro-power developments, increased rates of predation as wolf populations responded to increased deer and moose populations, and possibly high hunting mortality when new roads entered previously undisturbed habitats (Courtois et al. 2003, Voigt et al. 2000, McLoughlin et al. 2003, Vors et al. 2007). Given the variety of changes that have affected caribou and their habitats, it is probable that the cumulative effects of multiple inter-related factors are responsible for woodland caribou population and range decline. These factors vary in magnitude among local populations (e.g., Sorensen et al. 2008; Environment Canada 2008).

Following, we suggest a number of hypotheses (factors) that could explain the historical, long-term, large scale decline in boreal caribou populations across Canada. While some are more important and more well-supported in the literature than others, we present them in no special order because their relative importance may vary regionally and in the future.

Climate change: Canada has been in a general warming trend since the mid-1800's, except for certain periods of time, such as the 1850s and 1950s to 1970s, when the climate was colder than average (e.g., Gillett et al. 2004). A warmer climate could have several important effects on boreal caribou. Reindeer are known to suffer heat stress at about 25 C (Soppela et al. 1986). Woodland caribou are adapted to cool climates and their original southern distribution could

have been limited by climate. Boreal caribou distribution is inversely related to mean annual temperature (Environment Canada 2008) and positively related to total precipitation for mountain caribou (Apps and McLellan 2006). While caribou can tolerate severe cold, other extreme winter events such as freezing rain or very deep snow can reduce their capability to obtain food (e.g., Klein 1968). Such extreme events in successive winters could cause local populations to decline through starvation and/or lack of reproduction. As the climate warms, plant phenology changes possibly influencing the quality of food available to caribou, especially during spring calving (Post and Forschhammer 2008). Caribou may have responded to a warmer climate, especially in southern former range areas, because of altered phenology, heat stress, or adverse winter conditions. Some evidence of negative caribou response to climate change was suggested from analyses by Voigt et al. (2000) and Vors and Boyce (2009).

An associated mechanism for caribou decline, under a warming climate, may be an increase in a fatal disease in caribou caused by a brainworm (*Paralaphostrongylus tenuis*) carried by white-tailed deer (*Odocoileus virginianus*). Unlike moose, which can co-exist with low-density white-tailed deer populations, sympatry between caribou and white-tailed deer appears impossible because of this parasite (Anderson 1972, Trainer 1973). Deer have moved north in response to milder winters and overlap caribou range, resulting in caribou contracting the disease (Anderson 1970, Lankester and Hauta 1989, Voigt et al. 2000). In addition, climate-induced expansion of the range of deer may lead to increased competition and predation on caribou (see next discussion on apparent competition).

Finally, a drier climate may result in increased fire, with shorter fire cycles, reducing the amount of old forests (Thompson 1988) that are preferentially used by caribou in winter. If climate change is a key factor affecting their distribution, then efforts at caribou recovery in southern areas may be increasingly impossible.

Apparent competition (increased predation): Conversion of old forest conifer habitat to mixedwoods and young forest through logging and oil and gas developments has resulted in increases in deer and moose populations near caribou habitat (e.g., Seip 1992, Voigt et al. 2000; Bowman et al. 2010). This higher biomass of primary prey supports higher populations of

wolves (and other predators), which alternatively also prey on caribou (Seip 1992, Rettie and Messier 1998; Hayes et al. 2003; Latham et al. in press). Also, black bears (*Ursus americanus*) are most common in young forest habitats and are well-known to prey on caribou (e.g., Rettie and Messier 1998, Mosnier et al. 2008). Predation is advanced by numerous authors as the major proximate cause of boreal caribou range and population decline (Bergerud 1974, Seip 1992, McLoughlin et al. 2003, Wittmer et al. 2005) and this theory has become a paradigm within the science and management communities.

Hunting: Caribou have a limited capacity to reproduce and so populations may respond dramatically to even moderate increases in levels of mortality (Bergerud 1974). Like many North American large mammals, caribou populations declined considerably in the late 1800s and early 1900s, corresponding to the time when improved firearms (repeating rifles) became widespread and when thousands of workers lived in the forest each winter, working at logging camps, early mining ventures, and railway construction camps (Voigt et al. 2000, Schaefer 2003). Hunting pressure over many years, including by aboriginals, may have caused caribou declines in accessible areas (Bergerud 1967, 1974, Voigt et al. 2000, Courtois et al. 2003). For example, the Manitoulin Island sub-population was likely extirpated by hunting (de Vos and Peterson 1951).

Fire: As described earlier, fire can reduce the amount of preferred habitats available for long periods of time (e.g., Joly et al. 2003, Dalerum et al. 2007). The late 1700s, the late 1800s, and early 1900's were times of some exceptionally large forest fires (e.g., Thompson 2000, Fritz et al. 2003, McIntyre 2003, Girardin et al. 2006). These huge fires would have altered caribou habitat suitability during those periods and possibly fragmented some local populations. In Canada generally, there has again been an increase in annual forest area burned during the past 30 years, compared to the previous 50+ years (Stocks et al. 2003, Gillett et al. 2004, Balshi et al. 2008). Hence the possibility exists that caribou populations have always fluctuated dramatically over time in response to changes in habitat availability, and that fire is a recently increasing causal agent of current decline.

Habitat loss (deforestation): Habitat loss has been caused by various developments within some caribou range. Deforestation for settlement and agriculture has been especially important along southern areas of caribou range but also in some northern areas, such as the Ontario-Québec claybelt (Abitibi) region, and the Peace River District of Alberta. Oil and gas exploration and development in Alberta, BC, and Saskatchewan has fragmented caribou habitat on individual ranges (Sorensen et al. 2008). This cumulative loss of habitat, discussed in detail in Section 6.2 may be the factor that has caused caribou populations to decline and their distribution to be reduced (e.g., Bergerud 1974, Environment Canada 2008, Sorensen et al. 2008).

Habitat change: The "grand assumption" (Thompson and Welsh 1993) of sustainable forest management is that second-growth forests will support the same biodiversity, within bounds of variation, as did the original natural-origin primary forests. This concept relates to inherent resilience of the boreal forest to recover to, or converge on, the pre-harvesting condition. Ecological resilience is a property of ecosystems that is a function of their biodiversity at multiple scales (Gunderson 2000, Thompson et al. 2009). Because boreal forests are disturbance-driven, they exhibit generally high resilience to natural disturbances, such as fire, windthrow, and insects. Although various recognizable stable states may exist over the course of recovery following disturbance, most boreal ecosystems recover to initial states or similar states over time (e.g., Drever et al. 2006, Thompson et al. 2009). Forests do not always exhibit resilience, however, and may occur in altered states that may not be caribou habitat. Logging removes the old forest habitats used by caribou for long periods of time, and can result in habitat loss if the forests regenerate to deciduous species (Smith et al. 2000, Courtois et al. 2007, Courbin et al. 2009). Post-logging (or managed) forests may differ fundamentally and functionally in the quality of habitats that they provide (Lindenmayer and Franklin 2002, Thompson 2004). Surrounding uncut areas are also affected, as caribou avoid habitat near recently logged areas and access roads (e.g., Chubbs et al. 1993). Changes may occur, in terms of food and/or cover at small or large spatial scales, so caribou may not be supported.

This forest convergence hypothesis is impossible to test fully until sufficiently large areas of second-growth forests occur near continuous caribou range. Anthropogenic habitat change has been cited by many authors as a major cause of range decline (e.g., Bergerud 1974, McLoughlin

et al. 2003, Schaefer 2003, Vors et al. 2007). Mechanisms for caribou decline as a result of habitat change include: altered diet availability, differential movement costs, predator avoidance, and increased predation. Habitat change is intrinsically linked to the apparent competition hypothesis.

Linear features: Development in the southern portion of former caribou range has been accompanied by an extensive network of pipelines, seismic lines, hydro corridors, roads, and railways. Fortin et al. (2008) found a negative relationship between road density and caribou occurrence in Québec. In Alberta, and to a lesser extent Saskatchewan and BC, a very large number of corridors are associated with oil and gas exploration and development. Linear corridors appear to facilitate movements of predators, and hence exacerbate predation (James and Stuart-Smith 2000, Dyer et al. 2001). Collisions between vehicles and caribou may result in a number of accidental caribou deaths, sometimes as a result of caribou eating salt along roads (Johnson 1985, Brown and Hobson 1998). Further, caribou may be sensitive to noise, and studies indicate that they may abandon areas where there is excessive and/or repetitive noise (seismic exploration, hauling roads, snowmobile trails, pipeline pumping stations, etc.) (Chubbs et al. 1993, Bradshaw et al. 1998, Cumming and Hyer 1998, Seip et al. 2007). Linear features per se cannot be easily separated from other aspects of anthropogenic disturbance, since all forms of development are accompanied by access. Roads built for one project can often result in additional development, thereby causing cumulative impacts in an area.

Decline in distribution with minimal population decline: Animals generally occur in lower densities toward the edges of their distributions, as is well-illustrated for woodland caribou in Ontario during 1956-62 and showing a gradation of increasing caribou density from south to north (Ontario Dept. Lands and Forests 1963). Woodland caribou occur discontinuously across their current range and historically were not reported continuously across southern areas of their distribution (e.g., de Vos and Peterson 1951, Courtois et al. 2003). It may be, therefore, that some of the decline in range correlates to only a small reduction in the historical woodland caribou population, with the extirpation of some scattered southern sub-populations.

Cumulative effects: The hypotheses described above are not mutually exclusive and many caribou populations have been affected by multiple stressors and various habitat changes (Figure 2), most likely to varying degrees depending on the individual circumstances. Hence, the cumulative effects of more than one disturbance type may be responsible for range loss and the decline of individual local populations. Further, these cumulative effects may be additive or synergistic.

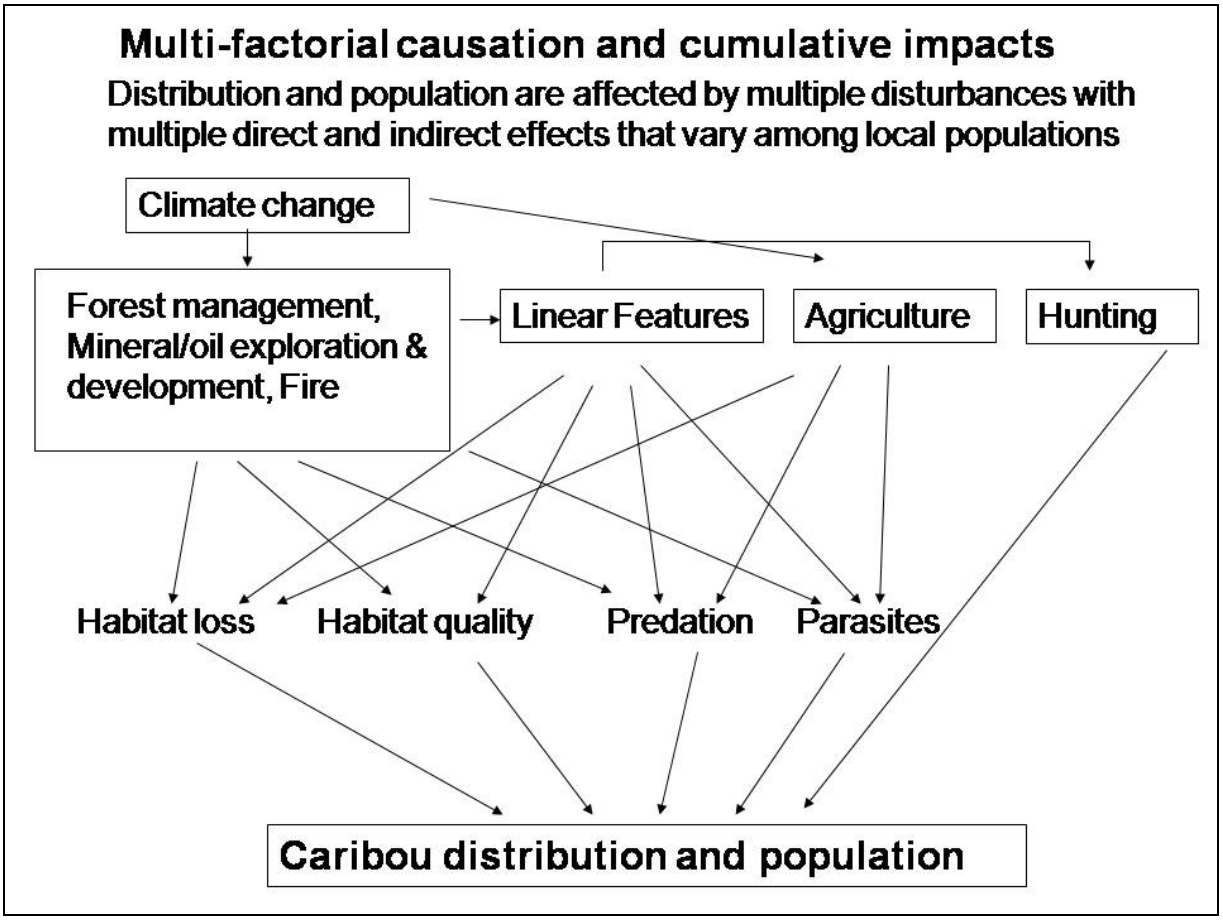

Figure 2. Interrelation between factors related to the decline of caribou distribution and populations.

Factors responsible for caribou decline vary across the extent of caribou occurrence. For example, linear effects through seismic lines for oil and gas exploration are more common in Alberta and perhaps Saskatchewan, than in Manitoba and east. Similarly, wildfire has historically been more common in certain areas than for others. Few of these hypotheses have

been directly tested, except habitat change (in various formats) and apparent competition, and so determining which are most important for a given population requires careful consideration of the available evidence, as opposed to assuming cause and effect. Nevertheless, most caribou populations are being influenced by at least two or more factors and all are possibly being affected by climate change, suggesting that cumulative effects must be considered in any model attempting to partition variance among possible causes of decline.

5 REVIEW OF THE CURRENT STANDARD

None of the existing indicators in the NBS specifically mention caribou. In fact, the word "caribou" occurs only twice in the Standard – both in Appendix 5, where the species is mentioned as one of several that may be considered focal species in a High Conservation Value (HCV) context. The fact that caribou do not have more prominent mention in the Standard is consistent with its general approach, which focuses on forest structure and planning/process requirements rather than species-specific requirements per se. It is also consistent with the implicit recognition that the actions of forest management companies cannot alone guarantee the safety and continued existence of SAR (as discussed in Section 2.2). Even in Criterion 6.2, which deals specifically with SAR, the Standard's requirements are highly process-oriented (i.e., development of plans, provision of training, etc.) The implicit strategy of the Standard can be characterized as 'by ensuring that good planning is carried out and that the forest continues to have a distribution of types and ages comparable to that which would occur naturally, the habitat of species which depend on the forest will be managed appropriately'.

Table 1 identifies 32 indicators of varying importance to caribou in the current Standard and categorizes their topic area based on whether they include consideration on habitat and/or population management, and on the phase of management to which they relate (i.e., planning, implementation or monitoring). Several important habitat-related measures identified in Table 1 require that specific habitat conditions be met. In other words, they do not simply require that habitat considerations be included in planning, but that the forest condition is in a state, or progressing towards a state, addressed by the indicator. The most prominent of these are in Criterion 6.3, where several indicators address forest conditions known to be important to boreal caribou, including:

- old-forest (6.3.5);
- landscape pattern and fragmentation (6.3.6);
- large core areas of contiguous old and mature forest (6.3.12); and
- connectivity (6.3.13).

The indicators that relate to populations almost all include an element of habitat management; in some the topic of population status is implicit, rather than explicitly identified. For example, among the required planning objectives noted in indicator 7.1.5 is "biodiversity conservation." The inference is that population objectives should be included under this broad heading. Only one indicator (6.3.9) focuses completely on populations. It requires that proponents "not knowingly put at risk" the viability of native species, subspecies, or recognized taxonomic groups or species assemblages. The relatively low prominence of population-related indicators, as noted earlier, is consistent with the general approach of the NBS, which focuses on forest structure rather than species-specific requirements.

More indicators in the NBS are related to planning than to implementation or monitoring (Table 1). In particular, there are a number of indicators that rely on habitat modelling to provide assessors with benchmarks and acceptable levels of various qualities of habitat. It is important to note that the predictions of such tools, while useful, should not be taken as guarantees that desirable outcomes will be achieved by adhering to their implied or explicit direction. While the importance placed on planning in the Standard is high, the requirements related to implementation of habitat-related measures are demanding (e.g., Indicators 6.3.5 and 6.3.12 related to old forests and core areas respectively) and indicate that the Standard recognizes that planning alone does not suffice as evidence of wise forest management.

In addition to the indicators identified in Table 1, there are several others of importance to caribou that do not fit the categorizations used in the table. These indicators include those that address the overall importance of monitoring and the use of adaptive management and the precautionary principle (indicators 7.1.3, 8.1.2, 8.4.1 and 9.3.3), those that require collaboration with neighbouring forest managers to address large-scale landscape dynamics (7.1.4, 9.3.2), and those that require the use of "outside" experts and/or peer review (i.e., not staff of the forest management company) in key aspects of decision making (5.6.3, 6.2.4, 6.3.13, 6.3.14, 6.3.16, 9.3.1). (Several of these indicators are included in Table 1 by virtue of the topics that they address; their requirement to use outside expertise is therefore an important quality.)

Table 1. Review of indicators in the NBS of relevance to caribou. Shaded cells indentify topic areas of individual indicators.

Indic. No	Indicator	Habitat			Population		
		Plann-ing	Imple-ment'	Monit-oring	Plann-ing	Imple ment'	Monit-oring
5.6.1	Analysis and calculation of harvest rates	■					
6.1.2	EA considers neighbouring lands	■			■		
6.1.3	Landscape inventory information	■					
6.1.5	Pre-Industrial Condition Analysis	■					
6.2.2	Habitats of SAR identified by field surveys	■					
6.2.3	Landscape management and SAR	■					
6.2.4	Plans for species at risk	■	■		■	■	
6.2.5	Use of precautionary approach for SAR		■				
6.3.1	Spatial modelling	■					
6.3.2	Silvicultural prescriptions accom. wildlife	■	■				
6.3.4	Under-represented forest communities		■				
6.3.5	Old forests	■	■				
6.3.6	Landscape patterns based on PIC	■	■				
6.3.9	Viability of native species or subspecies				■	■	
6.3.12	Provision of core habitat	■	■				
6.3.13	Provision of connectivity		■				
6.3.14	Quantitative habitat objectives	■	■				
6.3.16	Access management	■	■				
6.3.19	Overlapping tenure	■	■				
7.1.2	Use of appropriate expertise in planning	■					
7.1.5	Management objectives in planning	■			■		
7.1.7	Management plan contents	■			■		
8.1.1	Comprehensive monitoring plan			■			■
8.2.4	Up-to-date inventory	■					
8.2.5	Monitor flora and fauna						■
8.2.6	Monitor environmental impacts			■			■
9.1.1	Identify HCVs	■			■		
9.1.3	Credible outside review of HCV report	■			■		
9.3.1	HCV strategies in plan	■			■		
9.4.1	Monitoring for HCVs			■			■
9.4.2	Monitoring program characteristics			■			■
9.4.3	Evaluation based on monitoring results			■			■
	Total	**22**	**11**	**5**	**8**	**2**	**6**

Another useful way of reviewing the Standard is to examine the extent to which the hypotheses of population and range decline described in Section 4.3 are either implicitly or explicitly addressed through the indicators.

Climate Change – There are no indicators in the standard that address climate change, in any context.

Hunting – No indicator addresses issues related to hunting as a responsibility of the applicant. It is identified as a right of Indigenous Peoples (Principle 3), and a customary use of the forest (Principle 2). Also Indicator 6.2.7 requires applicants to cooperate fully in efforts to control illegal hunting, trapping, etc.

Fire – Fire is most relevantly incorporated in Indicator 6.1.5 which requires consideration of fire dynamics (e.g., fire return interval) in development of the pre-industrial condition report, and indicator 6.3.5 which requires the pre-industrial condition (PIC) analysis be used to guide age-class distribution of forest, thereby incorporating natural fire cycles into the age-class structure of the forest. In addition, Indicator 6.3.6 requires that targets for landscape pattern (disturbed and undisturbed patches) be set based on the characterization of the pre-industrial condition, thereby also incorporating the natural impact of fire. Finally, Indicator 6.3.7 requires that strategies do not attempt to mimic extreme events of low frequency, meaning that large clear-cuts should not be used in an attempt to mimic the spatial patterns of large fire.

Habitat loss (deforestation and conversion) – Habitat loss is not well-addressed by the Standard. Maintenance of habitat (and therefore avoidance of habitat loss) is a component of several indicators, including:

- 6.3.5 addresses the need to maintain a natural amount of old forest (as noted above);
- 6.10.1 prohibits conversion of forest to plantations or non-forest land; and
- 6.10.4 limits the extent of conversion to non-forest land associated with access and infrastructure.

Habitat change – The standard discusses habitat change through several indicators, but none of these is attuned to the possible fallacy of the "grand assumption" identified in Section 4.3 that second-growth forests will support the same biodiversity, within bounds of variation, as did the original forests. Relevant indicators include:

- 6.3.6 requires targets for landscape patterns;
- 6.3. requires that large areas of contiguous core forest be maintained; and
- 6.3.16 requires that access be managed so as to "maintain remoteness in areas with sensitive biological or cultural values;"

Apparent competition (increased predation) – There are no indicators that incorporate consideration of changes in predation in the Standard. Indirectly perhaps, indicator 6.3.16, which addresses the need for a comprehensive access management plan, may relate as roads may provide travel routes for predators.

Linear feature effects – Indicator 6.3.16, described above, addresses the need for an access management plan. The need for habitat connectivity is addressed in indicators 6.3.13 and 9.3.1.

Minimal population decline – There are no indicators that incorporate consideration of this into the Standard.

Cumulative effects: There are no indicators in the standard that address cumulative effects.

Taken as a whole, few of the possible factors to explain caribou decline are well-addressed in the Standard, and in particular cumulative effects is not addressed. The Panel's recommendations (provided in Section 7) strive to deal with this problem

One issue noted by the Panel is the redundancy and duplication among indicators in the present Standard. This quality was also identified in a recent analysis of the Standard conducted in anticipation of its forthcoming revision (ArborVitae Environmental Services 2009). The original reasons for incorporating redundancy into the Standard were to ensure that multi-dimensional issues are addressed from different perspectives, and to provide a means for assessors to understand the extent of integration of a company's activities. ArborVitae Environmental Services (2009) noted that while addressing redundancy could streamline the Standard and provide some relief in auditing and preparation, but there would be no appreciable reduction in effort associated with conducting an assessment or meeting the requirements of the Standard.

6 SCIENCE-BASED CONSERVATION MEASURES

Having reviewed the ecological needs/context of caribou (Section 4), and the content of the present Standard (Section 5), this section discusses the present state of science-based conservation measures for caribou as a means of building the case for the modifications suggested to the Standard presented in Section 7.

6.1 HABITAT

6.1.1 Amount

Mean estimates of individual caribou home ranges vary considerably from 571 km^2 (Schneider et al. 2000) to >4700 km^2, with some individuals using >9000 km^2 in a given year (Brown et al. 2003). Small home ranges were mostly for caribou in Alberta tied to small peatland complexes of 3000-4000 km^2 (Stuart-Smith et al. 1997, Brown et al. 1998, Schneider et al. 2000). Large home ranges tend to be for animals that live in areas where habitat distribution is more continuous and where seasonal movements (ca. 20+ km) occurred (e.g., Brown et al. 2003).

Coarse-level of guidance for the spatial extent of range for local populations within a continuous distribution can be derived by determining the area required to support an enduring population, under density and target population size assumptions. Literature and heuristic population viability analysis results (Environment Canada 2008) suggested >300 animals are required for long-term population viability, given moderate rates for calf and female survival. As an example, if range-wide densities of boreal caribou are 2-3 per 100 km^2 in good habitat, and if a population is 300 animals, then a reasonable guideline for area required may be in the order of 10,000 to 15,000 km^2 currently in good habitat condition. Courtois et al. (2007), for example, found three separate populations using areas between 10,000 and 15,000 km^2 over a >42,000 km^2 area in Québec. This population range size is larger than many forest management units and so presents a serious dilemma for the provision of caribou habitat on individual forest management units. In Canada, many ranges and suspected ranges are smaller than 10,000 km^2 (27 of 52 in the Environment Canada 2008 report) but there was a low probability of long-term persistence for caribou on these ranges, and the majority of these small local populations is declining (Environment Canada 2008).

6.1.2 Distribution

O'Brien et al. (2006) indicated that 'patch clusters' (adjacent or connected forest stands) should be at least 50 to100 km^2. Courtois et al. (2004, 2007) proposed that several intact and connected forest blocks of 100 to 250 km^2 would be needed to conserve caribou in managed landscapes, although these were abandoned when surrounded by managed forest (Courtois et al. 2008). A common conclusion from virtually all studies is that large areas of continuous caribou habitat are preferred to a fragmented distribution of habitat patches (e.g., Schaefer 2003, O'Brien et al. 2006, Courtois et al. 2008, Fortin et al. 2008).

6.1.3 Connectivity

During parts of the year when caribou are normally sedentary, they seem to be capable of moving among patches located up to about 1 km from each other, regardless of the landscape (Johnson et al. 2002, O'Brien et al. 2006). Patches much beyond 1 km are less likely to be used. Several studies have shown that, depending on the scale of selection (sensu Johnson 1980), caribou avoid disturbances (Smith et al. 2000, Stuart-Smith 2000; Dyer et al. 2001, Courtois et al. 2007, 2008, Hins et al. 2009). Moreover, Hins et al. (2009) showed that the configuration of forest remnants and cutovers influence caribou habitat selection at large scales. While moving across a forest landscape, caribou tend to use conifer forests while avoiding deciduous forests, although they use other habitats, including disturbed habitats, in proportion to their availability (Ferguson and Elkie 2004). Courtois et al. (2008) suggested that caribou would use corridors as small as 300 to 400 m wide, while noting that connectivity among protected blocks should be increased by increasing the width of corridors, thereby reducing the distance among or between them and nearby continuous forest. Likewise, other authors have found that caribou avoided edge habitats (Stuart-Smith et al. 1997, Smith et al. 2000). Inconsistencies among studies suggest that 1) uncertainty exists over how caribou move across landscapes, 2) connectivity is context-dependent, and 3) maintaining continuous blocks of forest to accommodate movement is advisable. Nevertheless, maintaining or restoring connectivity in highly disturbed landscapes is not going to maintain caribou persistence; the absolute amount of suitable habitat available is of primary importance.

6.1.4 Habitat Recovery

The alteration of caribou habitat by resource management/extraction activities, can lead to circumstances whereby remedial actions are required to facilitate habitat recovery. Remedial actions can be necessary in circumstances in which a single activity is being conducted, but are more likely to be required where different activities are being conducted by overlapping tenure holders or other land-users. Achieving recovery of habitats can be challenging, as most jurisdictions require an individual company to be responsible only for their own disturbances. In some instances, (e.g., linear corridors) there may be no regulated requirement for reforestation[6]. In Alberta, recognition of the challenges of recovery on landscapes affected by such cumulative effects has been recognized and 'coordinated reforestation' has been recommended as a solution (e.g., Athabasca Landscape Team 2009). While there is uncertainty about the ultimate effectiveness of coordinated reforestation, it is a logical way forward from a forest stewardship perspective that should promote habitat recovery for caribou and the forest in general.

Implementation of a habitat recovery strategy, either in a single industry case or under a coordinated reforestation approach would require:

- a spatial evaluation of anthropogenic habitat alteration across the caribou range;
- prioritization of areas for coordinated reforestation or restoration (as in restoring composition, configuration or age structure);
- assessment of areas needing active intervention (some areas may be on a forest trajectory based on natural regeneration);
- assessment of types of reclamation required (replanting, site preparation, herbicide application, access controls, etc);
- implementation of habitat restoration activities (in a coordinated fashion) based on priorities and techniques (above); and
- monitoring.

[6] In this document, a distinction is made between the terms 'reforestation' and 'habitat recovery'. Reforestation is the act of planting trees or ensuring re-growth of trees after a disturbance. Habitat recovery is the product of reforestation (or other reclamation activities) and indicates return of habitat to a state suitable for caribou use, comparable to that which existed prior to disturbance.

To maximize success in habitat recovery, overlapping and adjacent tenure holders would either have to cooperate on the afore-mentioned areas or collectively place funds into a 'reclamation fund' that might be administered by an independent body.

A challenging aspect of the current standard related to habitat recovery is its direction to continually reduce pesticide use with the objective of eventual phase out (Indicator 6.6.3). In the context of caribou conservation, herbicide application to maintain conifer forests on caribou range will be an important silvicultural tool to minimize the amount of deciduous regeneration (and hence, reduce suitable habitat for primary prey such as deer, moose or elk). The use of herbicides may pose challenges to gain 'social license', but may be required in specific cases for conservation of boreal caribou habitats.

6.2 CUMULATIVE DISTURBANCES

The hypotheses of range decline described in Section 4.3 provide an indication of the role of cumulative effects in affecting caribou. Here these factors are reviewed from a somewhat different perspective, as a basis for identifying conservation measures for caribou.

Measures to conserve caribou and other SAR have traditionally emphasized those aimed at ensuring adequate habitat supply, either through outright protection of key areas or habitat management actions. In the case of caribou, it is becoming increasingly clear that condition of the population range as a function of extent of cumulative disturbance has a very strong empirical basis (Environment Canada 2008, Sorensen et al. 2008, Athabasca Landscape Team 2009). Of course, this does not suggest that managers need not be concerned about the amount of caribou habitat in a given range. Instead, disturbance level is a more robust predictor of the ability of a given range to support a self-sustaining local population than is the amount of suitable habitat alone. Accordingly, management actions need also to be guided by consideration of how much cumulative human disturbance poses an unacceptable risk to the persistence of a caribou population.

Any element of industrial development, ranging from roads and other linear features to cutblocks to hydrocarbon facilities, tends to result in reduced habitat use by caribou. More fundamentally,

however, cumulative disturbances can translate into population-level effects by incurring higher mortality risk than a less disturbed landscape. Cumulative disturbances are associated with natural or human-induced landscape conditions that favour early seral stages, higher densities of primary prey and predators, and associated higher rates of predation (see Section 4.3).

Roads and other linear features are key contributors to cumulative disturbance, not only through the physical land clearing, but as a vector for additional development. The first road in particular has the largest relative effect on inducing new development from which effects tend to cascade and multiply. Relatively dense networks of linear features are customarily planned on the basis of economic need and access to resources as part of operational planning and can arise in areas of low human density, where resource extraction is the prevailing land use (Hunt et al. 2009). Environmental considerations specific to linear features tend to concentrate on mitigating impacts of individual roads rather than on controlling overall densities of linear features (Thorne et al. 2009). An additional challenge arises with the removal of linear features once they have been established. For example, although many logging roads were originally intended to be temporary in nature, the reality is that they are often kept open following the completion of forestry operations to accommodate the needs of other industrial operations and/or recreational user groups (Hunt et al. 2009). For caribou in particular there is uncertainty on this issue, since road recovery strategies have not been well-tested even while several different approaches are currently employed. Good conservation measures must not only have a demonstrated ability to prevent human access (itself an increasing challenge with all-terrain vehicles and snowmobiles able to traverse seemingly- inaccessible terrain), but also to return habitat conditions along linear openings to those that favour caribou rather than moose or deer, while at the same time reducing ease of travel for wolves.

For boreal caribou, two recent meta-analyses provide empirical evidence for a direct relationship between total disturbance (anthropogenic and natural) and caribou population persistence. Sorensen et al. (2008) examined the relationship between range condition (as a function of disturbance) and population growth rate for six caribou populations in Alberta, predicting "sustainable caribou populations" at a maximum of 61% of the range within 250 m of industrial development. A nation-wide meta-analysis of recruitment rates as a function of range

disturbance for 26 populations across a broader spectrum of disturbances than the Sorensen et al. study, suggested a higher population-level sensitivity to range disturbance, although the different measures of independent and dependent variables preclude direct comparison between the two studies (Environment Canada 2008). Both studies, however, emphasized the variability in response rates owing to local factors and other issues such as lag times in population response that must be carefully considered in the development of quantitative guidelines for limiting disturbance. Recruitment, for example, might be a more sensitive indicator of disturbance than population growth rate, which is more reliant on adult female survival and subject to time lags. Because there is generally a direct relationship between linear feature density and overall anthropogenic disturbance (Antoniuk 2007), linear features might be considered as a surrogate for cumulative disturbance. Yet linear feature thresholds are not always possible to derive from research on road effects, mainly because these studies have emphasized distance measures from individual openings, with responses focusing on avoidance rather than population persistence.

Both Environment Canada (2008) and Sorenson et al. (2008) provide important guidance for limiting the extent of cumulative disturbances within caribou ranges. Where caribou population persistence is a management goal, it will be important to avoid exceeding tolerances for disturbance beyond which conservation outcomes are much less certain. In this case, there is enough knowledge about the relationship between caribou and land change to set precautionary targets to human induced change. However, decision-making systems must be sufficiently flexible to manage on the basis of risk rather than absolute thresholds, and to be able to adapt in response to new information.

The following framework (Table 2) provides a basis for incorporating risk related to caribou population persistence into management considerations in forest management units where caribou conservation is mandated. The Panel advocates adopting the framework, or a similar one, into the Standard's indicators. Ideally, the measures of cumulative disturbance, linear feature density and wolf density[7] would be accompanied by population status and trend measures for the

[7] The biomass of other co-occurring ungulates on the landbase is a very important driver for caribou recruitment and mortality, yet thresholds have not been elucidated beyond moose, for which Bergerud (1992) has argued that a density ≥ 0.10 moose/km² can support a wolf population > 6.5 wolves/1,000km² (the high risk zone for caribou in this table. See also Bergerud et al. (2008).

caribou population(s) that overlap with the forest management unit. Even if such information is not available, evaluating and monitoring these threats can still be used as a means to evaluate risk to resident caribou. It is important to note that the metrics identified in Table 2 may be refined in response to new information with the sustained and heightened research focus on caribou and should be refined to the extent possible for the specific ranges to which they are being applied. Accordingly, adoption of this framework must occur in a manner that is nimble enough to be adjusted with any new information.

Table 2. Example of a framework for incorporation of risk of caribou population persistence into management considerations in FMUs where caribou conservation is mandated. Specific thresholds should be validated based on regional considerations.

Threat to caribou population persistence	Range of Values relative to 'risk zone' for caribou	Management Considerations
Low Risk		
Cumulative disturbance[a]	0-20% of caribou population range[b]	Carefully and proactively planned expansion of industrial effect is possible.
Linear feature density	<0.6 km/sq. km[c]	
Wolf density	< 4/1000 sq. km[d]	
Moderate Risk		
Cumulative disturbance[a]	20-40% of caribou population range[b]	Consider contribution of additional development to cumulative effects. Coordinated habitat recovery of industrial features should be made a priority.
Linear feature density	0.6- 1.2 km/sq km[c]	
Wolf density	4-6/1000 sq. km[d]	
High Risk		
Cumulative disturbance[a]	>40% of caribou population range[b]	Net expansion of industrial effect by applicant that adds to cumulative disturbance must not occur. Coordinated habitat recovery of industrial features must be undertaken.
Linear feature density	> 1.2 km/sq. km[c]	
Wolf density	>6/1000 sq. km[d]	

[a] proportion of the landscape with human-induced and natural disturbances of < 50 years (including infrastructure and linear features).
[b] Environment Canada (2008)
[c] Athabasca Landscape Team (2009)
[d] Bergerud (2007) and Hayes et al. (2003)

Because the probability of caribou persistence decreases as the extent of anthropogenic and natural disturbance increases in their range, management of industrial effects is key to caribou conservation. Such management should be accomplished through a two-pronged approach by minimizing land disturbance that accumulates in a piecemeal fashion and by encouraging timely habitat recovery of existing disturbances for which forest managers are directly responsible

(Antoniuk 2007). The ultimate responsibility lies with governments to manage cumulative disturbances with multiple industries on the same landbase. Nevertheless, when it comes to certification, forest companies face the challenge of: 1) planning in isolation when other industrial players on the same or neighbouring lands are contributing to overall effects, and 2) the general insufficiency of planning at the scale of a typical FMU. As emphasized throughout this report, consideration of scale is fundamental to caribou conservation, so the most effective caribou and forest management may need to consider neighbouring land bases in evaluating caribou range condition. In addition, there is the reality that some forest managers will find themselves in an FMU where range condition is already poor and cumulative disturbance is already at unacceptable risk levels. Regardless of whether drivers of such change are outside the FMU, within the FMU by other industrial players, or a result of short fire return intervals (the latter an increasing risk under many climate change scenarios), companies should demonstrate that their own contribution to the risk of caribou persistence is kept as low as possible.

6.3 Regional Considerations (Zonation and collaborative management)

In many cases, management of SAR involves a multitude of factors and so must encompass a suite of organizations with different areas of resource management interest and responsibility. As should be apparent from the discussions earlier, caribou conservation is a classic example of such a scenario where complex cumulative effects exist at the core of the conservation dilemma. The degree of overlapping resource tenures varies across the country, from extensive overlap of forestry and energy sector activities in western Canada to comparably challenging overlap with mining and hydroelectric operations in central and eastern Canada. While extent of overlapping tenures may complicate management actions, it is obvious that some form of collaborative management is required for caribou conservation, as frequently there are several/many interested parties working or living on the landbase of concern.

Collaborative management may take various forms across the country depending on the local socio-economic and ecological factors limiting the SAR. In most tenures where caribou reside, a minimum suite of collaborators should include representatives from the forestry companies, the government agency responsible for wildlife management, and aboriginal peoples with

constitutional rights to harvest wildlife. In some jurisdictions or locations, engagement with other overlapping forestry or non-forestry tenure holders may be required to allow for coordination of industrial activities, including reforestation and access management. Integrated landscape management programs engaged through the collaborative process should seek to minimize the amount, distribution, and duration of human-caused industrial effects, using a framework such as the risk-based thresholds (e.g., Table 2). For such collaborative forums to be effective, they need to have management authority and not be strictly advisory in nature.

As a component of conservation plans for caribou, the concept of zonation is a highly relevant approach to bridge wood supply needs of the forestry companies and maintaining biodiversity. As mentioned in Section 4.1, caribou habitat selection and movement patterns vary across the country. However, a common theme across their national distribution is that caribou populations require large areas of suitable habitat. Environment Canada (2008) identified the importance of managing caribou over the range of a local population, while considering regional specificities and the difficulties in some areas of identifying or defining local populations. The extent of overlap of a given caribou range with a forest management unit varies greatly. Some management units encompass completely one or more ranges; while in other areas one caribou range may be overlain with multiple FMUs. Zonation of land use relative to caribou conservation (which may be applied across or within caribou ranges) may include combinations of areas with differing land use priorities (e.g., Athabasca Landscape Team 2009). Examples of such zones include:

- areas where caribou conservation is the priority land use (industrial development is either excluded permanently or through long-term deferrals of activity);
- areas where significant restrictions on land use activities are applied (e.g., management thresholds for the amount and distribution of industrial operations); and
- areas with fewer limitations.

6.4 POPULATION-BASED CONSIDERATIONS

Because population management per se is the responsibility of government or co-management agencies, science-based measures for population management are not reviewed in this document. Discussed briefly below are the relative roles of the parties involved.

As described in Section 2.2, this document makes an important distinction between population monitoring and manipulation. Although ultimate responsibility for both activities typically rests with governments, forest companies can participate in collaborative monitoring (Section 6.6 below).

Management strategies for conservation of caribou (and other SAR) may in extreme cases require intervention with the species itself (e.g., reintroductions; Fischer and Lindenmayer 2000) or other species (e.g., predators; Hayes et al. 2003). If the responsible wildlife management agency deems population management to be a required 'safeguard' for 'protection' of the species, it seems implicit in criterion 6.2 that such action would be consistent with the FSC International Principles and Criteria and the NBS. However, it is not explicit in FSC documentation that such action on an FSC-certified tenure is 'allowed.' FSC International and FSC Canada need to reconcile such actions in their 'corporate philosophy,' particularly as some population management actions (e.g., culling, predator control) may not be universally socially palatable. The extent to which such actions are acceptable should be clearly stated by FSC.

6.5 TIMING

Sensory disturbance from direct human activity[8] may affect wildlife by altering energetic demands or predation risk (e.g., Frid and Dill 2002). There is evidence of sensory disturbance effects of human activity on caribou (e.g., Murphy and Curatolo 1987, Dyer et al. 2001, Seip et al. 2007) and reindeer (e.g., Vistnes et al. 2008). For boreal caribou, there is limited evidence (e.g., Chubbs et al 1993, Cumming and Hyer 1998) to suggest sensory disturbance associated with forestry operations is an important limiting factor relative to the other issues *hypotheses) discussed earlier. As an application of the precautionary principle, however, it is advisable that forestry activities be reduced during the late third trimester of pregnancy through early calf rearing (6 weeks post-calving is the time period of greatest mortality). Trade-offs exist when decisions must be made between ceasing late-winter forestry operations and having to come back the next winter. Restrictions of activities during the breeding season may also be warranted

[8] The focus of this section is on direct effects of human activity as opposed to effects associated with industrial infrastructure such as roads, transmission corridors or timber harvest areas which are considered elsewhere in this report.

depending on the habitat associations of a given caribou ecotype (e.g., if breeding activities occur in merchantable forests, restricting forestry activities during the breeding season is advisable).

6.6 MONITORING

Section 3 of this document provides an expanded discussion of adaptive management and the precautionary principle. Monitoring is a core component of adaptive management that forest companies need to actively conduct in their forest stewardship activities (including SAR conservation).

Monitoring must include components of implementation monitoring and effectiveness monitoring. For the former, monitoring as applied to SAR conservation should relate to those activities in the recovery action plan for which the company has engagement (e.g., habitat supply, silviculture, access development and access management). Effectiveness monitoring related to SAR conservation includes both evaluating aspects of habitat management and SAR population dynamics. Companies can directly engage in aspects of effectiveness monitoring related to habitat management. With regard to effectiveness monitoring of population dynamics, the accountable agency is typically the government wildlife management agency. Companies can assist in population monitoring in a variety of ways such as assisting in planning, providing logistical support, contributing to personnel needs, providing information based on knowledge of the forest, and providing financial support. The results of monitoring must then be incorporated into a company's adaptive management system.

7 RECOMMENDED CHANGES TO THE NATIONAL BOREAL STANDARD

The Panel recommends 23 changes to indicators of the Standard (Table 3). This review found that, while many aspects of caribou ecology are addressed in the current Standard, there is need for revision to achieve a more integrated approach to maintaining caribou in managed landscapes. Ideally the changes recommended by the Panel would be adopted as a package of changes because, taken together, they have the potential to result in a significantly greater evolution of the Standard than would occur if they were to be adopted only in part.

The present Standard relies on the assumption that habitat management should suffice to deal with populations, and recognizes that forest managers do not have direct responsibility for managing wildlife populations. Most of the changes that are being recommended are consistent with this perspective. However, the Panel believes that, to be confident that the Standard adequately incorporates measures for the appropriate management of caribou, some evolution of this approach is required. Therefore, in several instances the Panel is recommending incorporation of requirements into the Standard specifically intended to foster management of caribou. In addition, some of the recommended changes require companies to 'work within their sphere of influence' to achieve progress in various aspects of population management (e.g., monitoring, modelling), emphasizing an important role that forest companies can play in helping to safeguard caribou populations. The notion of 'working within a sphere of influence' exists in the present version of the Standard related to parks and protected areas and has proven quite useful in motivating companies to become involved in aspects of resource stewardship normally outside their management domain.

As described earlier, there is considerable redundancy in the indicators of the existing Standard. Most of the changes identified in Table 3 suggest that existing indicators should be supplemented with considerations to make them more relevant for caribou. Therefore, redundancy in the indicators will likely still exist (or possibly be exacerbated by the recommended changes). There was no attempt made to address the redundancy issue here because opportunities to address

overlap between indicators will exist during the upcoming revision to the National Boreal Standard.

Of the topics reviewed in Section 6, the strongest need is to address the issue of cumulative disturbances. Although it is mentioned in the Standard's preamble on overlapping tenures, it does not appear in any of the present Standard's indicators. Of the 23 recommended revisions, nine related either entirely or partially to cumulative disturbances. The changes proposed expand the focus of selected indicators from habitat supply to management of cumulative disturbances, including linear features, where relevant. In the case of caribou and other SAR, this involves evaluating range condition as a function of relative risk to population persistence. Additional emphasis is placed on the importance of reforesting linear features, in particular with methods that have demonstrated efficacy relating to caribou population persistence. Several of the proposed changes to the Standard identify the need to incorporate risk into considerations of cumulative disturbances. Although we have not specified the precise means by which this should occur, we suggest that a structure similar to that identified in Table 2, should be incorporated into the Standard.

Most of the issues raised in this review can be dealt with by modifying existing indicators to broaden their scope to ensure that issues of greatest relevance to caribou are addressed. For example, recommendation # 6 (Table 3) notes that indicators 6.3.16 and 6.5.1 address the topics of access management and loss of productive land. The Panel recommends that these indicators be revised to draw attention to the need to appropriately regenerate conifer forests on linear features to facilitate recovery of caribou habitat.

The Panel has identified the need for the development of five new indicators to address the following issues:

1. **Decline in relative abundance of conifer forest communities.** This is important as there has been a history of conversion of conifer forests (which are preferred caribou habitat) to deciduous and mixedwood forests, especially in eastern Canada (Hearnden et al. 1992, Carleton and Maclellan 1994, Carleton 2000).

2. **Aggregation of landscape disturbances.** As noted above, cumulative disturbances are a key factor limiting caribou populations. Management practices that address this concern may be contrary to existing government direction related to cut-block layout. An indicator should be developed requiring applicants to work within their sphere of influence to move management direction towards the aggregation of landscape disturbances, as a means of avoiding or forestalling the creation of new disturbances in unmanaged caribou habitat.
3. **Collaborative efforts related to population management.** An indicator should be developed requiring applicants to work within their sphere of influence to advance collaborative management of SAR
4. **Monitoring of species at risk.** An indicator should be developed requiring applicants to work within their sphere of influence to facilitate monitoring of SAR, if it is not being addressed by the responsible agency. Such an indicator would recognize that, while forest management companies are not normally responsible for this activity, certified companies should play a lead role if no monitoring is being conducted..
5. **Population modelling.** Comparable to the new indicator suggested above (#4), an indicator should be developed requiring applicants work within their sphere of influence to facilitate population modelling of SAR, if it is not being addressed by the normally-responsible agency.

In addition to the recommendations identified in Table 3, the Panel also believes that some revisions to components of the Standard not directly related to its indicators are necessary:

1. The Standard should recognize the need for incorporation of risk into applicants' measures for assessing and managing caribou habitat. Table 2 provides an example of a risk assessment framework, however other means/frameworks may also be developed. It is not the intention of this document to require that the exact framework provided in Table 2 be universally used.
2. The Standard should include a 'caribou' appendix. The appendix should highlight the requirements of the Standard's indicators that are of importance to caribou. A means of assessing risk to caribou (similar to Table 2) should be included in this appendix. The Panel believes the appendix would be of use to applicants in ensuring that they

understand the importance of caribou considerations in the Standard and that their management actions are appropriately attuned. The appendix would also be of considerable use to assessors and auditors in ensuring their attention is drawn to appropriate indicators for forests in which caribou management is a concern.

3. The introductory section of the Standard should: a) briefly draw attention to the significance and social importance of caribou in the boreal forest, including why a focus on the status of this species is merited in the Canadian boreal context, and b) identify that this review has been undertaken as one of the processes involved in the revision of the Standard.
4. The revised Standard should contain a description of adaptive management, as does the present version, but more emphasis should be placed on distinguishing active adaptive management from both trial and error, and passive adaptive management. The revised Standard should make it clear that active adaptive management will provide the most effective means for further integration of caribou conservation and forest management and therefore that the approach used by applicants should follow the principles of active adaptive management where practical.
5. Given the relative importance of peer review and independent assessment in a number of the Standard's indicators, the definition of peer review provided in the glossary should be improved so as to make certain that that the reviews are conducted by individuals removed from direct management of the forest, including from the responsible government authority.
6. The Standard (or more specifically FSC) should consider articulating a position on the acceptability of unconventional population management measures, such as control of predators and primary prey, to facilitate persistence or recovery of caribou populations in rare circumstances where habitat options alone will not succeed. While these measures are outside the realm of forest management and the companies, and therefore the direct interest of FSC, the Panel anticipates that, due to their controversial nature, issues may arise if such measures are deemed necessary on FSC-certified forests to further caribou conservation.

Table 3. Recommended changes to Indicators of the National Boreal Standard

No.	Aspect of Caribou Conservation	Issue/Concern	Current Emphasis of Standard	Suggested Modification
1	Habitat Amount/ Collaborative Management	The size of most managed forests is too small to accommodate a caribou population, and so management activities must be coordinated with neighbouring forests.	This topic is dealt with in Indicators 6.1.2 (landscape-scale assessments), and 7.1.4 and 9.3.2, both of which require attempts to coordinate management activities with best neighbouring forests.	The wording of the existing indicators should to be strengthened/revised to: a) specifically note the relevance to caribou, and b) make the coordination of management activities imperative such that any actions taken in concert with adjoining forests are adequate to maintain habitat levels above some benchmark (such as within the range of natural variation)
2	Habitat Amount/ Distribution/Cumulative Disturbances	Habitat blocks should be as large and contiguous as possible, and should incorporate consideration of cumulative disturbances	The need for core areas is dealt with in indicator 6.3.12, which requires large areas of contiguous forest to be maintained on the landbase.	Indicator 6.3.12 should be modified to specify that the core forest areas should be as large and contiguous as possible. Note: see #11 below regarding creation of future core areas. Given that there is significant regional variation in caribou habitat use patterns, the indicator should specify that appropriate independent expertise be used to help design core areas across the landscape.
3	Habitat Amount	Present boreal forest management practices may convert preferred caribou habitat (i.e., conifer) to poor quality (i.e., deciduous/mixed wood) habitats	Indicator 6.3.4 requires that under-represented communities be appropriately managed, but there is not comparable requirement that prohibits large decreases in abundance of natural forest units.	An indicator should be developed that addresses the need to maintain, natural forest communities (especially conifer) within a reasonable range (such as the range of natural variation) and demonstrates that they are not decreased in abundance as a result of management activities.
4	Habitat Recovery	Efforts may be needed to return preferred habitat (i.e., conifer-dominated forests) to their pre-harvest conditions.	Indicator 6.3.2 lists the appropriate objectives of silvicultural prescriptions.	Indicator 6.3.2 should be amended to include implementing silvicultural prescriptions that restore or enhance habitat for SAR (e.g., caribou).
5	Habitat Recovery	Conifer regeneration is facilitated by use of herbicides, which at present are required to continually decline by the NBS	Indicator 6.6.3 requires a continual reduction in the use of chemical pesticides and that their use is only permitted when they	Indicator 6.6.3 needs to be modified to permit the use of herbicides in the recovery of caribou (and other wildlife) habitat

No.	Aspect of Caribou Conservation	Issue/Concern	Current Emphasis of Standard	Suggested Modification
			are essential to meet silviculture objectives and when non-chemical management practices are not available, ineffective or too expensive.	
6	Habitat Recovery	Reclamation of linear features is an important element of habitat recovery. Reclamation may require a suite of silvicultural interventions (e.g., decompaction, tree planting, herbicide application) and access control measures to support successful reforestation.	Indicator 6.3.16 describes requirements for an access management plan, and Indictor 6.5.1 describes the requirements for ground rules for managing loss of productive land	The indicators should be revised to address the need to reforest linear features so that travel is not facilitated for humans or wildlife predators.
7	Cumulative Disturbances	Cumulative effects should be incorporated into analysis of harvest rates	The Standard currently emphasizes the need to protect habitat, however the requirement to deal with cumulative effects is not specifically identified in any of its indicators.	Indicator 5.6.2 should be modified to specifically require that cumulative effects be considered in the calculation of harvest rates. As incorporation of cumulative effects in modelling is a tremendous challenge, the indicator should not be dogmatic in this objective, but should be sufficiently clear to ensure that companies are making progress on this issue.
8	Cumulative Disturbances	Cumulative effects should be incorporated into environmental assessment required for management activities	Indicator 6.1.2 identifies the need to conduct environmental assessment at the landscape scale. This indicator will be key to identifying the point at which cumulative disturbances place the FMU in a particular category of 'threat to caribou persistence' (Table 2).	The indicator should be modified to specifically incorporate consideration of cumulative effects following assessment of relative risk to caribou persistence (Table 2).
9	Cumulative Disturbances	The Standard does not specifically identify information requirements associated with cumulative effects.	Indicator 6.1.3 identifies the requirement for applicants to assemble inventory information for regional and landscape-level assessments.	Additional verifiers should be added to the indicator to address the extent of cumulative disturbance and the population status of SAR.
10	Cumulative	Results of environmental	Indicator 6.1.11 addresses the	The indicator should be modified to

No.	Aspect of Caribou Conservation	Issue/Concern	Current Emphasis of Standard	Suggested Modification
	Disturbances	assessments need to incorporate cumulative effects	need to incorporate the results of environmental assessments into management planning, but does not specifically identify the need for incorporation of consideration of cumulative effects. This indicator is key to applying the 'zone of risk' concept (Table 2)	incorporate consideration of cumulative effects following assessment of relative risk to caribou persistence (e.g., Table 2).. For example, it could be modified to read "The results of environmental assessment are incorporated into management planning…..pose significant risk and/or cumulative effects exceed **categorized risk levels identified for values of interest (i.e., caribou or other species at risk**), then…". The Indicator's bullet points should also be revised to include "**management activities do not occur that increase cumulative disturbance**"
11	Cumulative Disturbances	The Standard should address the need to aggregate landscape disturbances and limit their spread.	No indicator addresses this issue directly at present, although Indicator 6.3.7 does direct managers not to "mimic extreme events of low frequency" so as to put bounds on very large harvest blocks.	Management practices that address this concern may be contrary to existing government direction related to harvest area (cut-block) layout. A new indicator should be added requiring applicants to work within their sphere of influence to move management direction towards aggregation of landscape disturbances. In addition, the Standard should clarify direction related to indicator 6.3.7 to ensure that it is not contrary to management intended to aggregate landscape disturbances.
12	Cumulative Disturbances	The issue of cumulative disturbances should be discussed and documented in forest management plans to ensure that applicants are informed and that plans are in place to address the relevant issues.	Indicators 7.1.6 and 7.1.7 are the most comprehensive of those requiring specific content in the forest management plans.	One or both of the indicators should be modified to incorporate the need to include the extent and nature of cumulative disturbances (anthropogenic and natural) in the forest management plan following assessment of relative risk to caribou persistence (e.g., Table 2)..
13	Cumulative Disturbances	Cumulative disturbances need to be monitored	Indicator 8.2.3 identifies monitoring requirements related	The indicator should be modified to encompass monitoring of cumulative

No.	Aspect of Caribou Conservation	Issue/Concern	Current Emphasis of Standard	Suggested Modification
			to several topics, including "disturbance"	disturbances (anthropogenic and natural).
14	Cumulative Disturbances/ Habitat Connectivity	Roads and linear features contribute to cumulative disturbances.	Indicator 6.3.16 addresses requirements related to development and implementation of an access management plan, but it does not adequately address concerns related to cumulative disturbances.	The indicator should be modified to a) make it clear that road construction should not take place in areas that would contribute to cumulative disturbance beyond specified thresholds relative to zone of risk (Table 2), and b) habitat recovery strategies are incorporated into the management plan.
15	Cumulative Disturbances / Collaborative Efforts	Overlapping tenure creates challenges in ensuring that management is undertaken consistently. Where there are overlapping tenure holders it will be critical to work cooperatively on access management	Indicator 6.3.19 addresses overlapping tenure holders.	The indicator should be revised to note the necessity of collaborative efforts in developing an access management strategy that reduces risk of cumulative industrial effects to caribou. A sphere of influence approach may be appropriate to advance collaboration while recognizing limits in a company's ability to affect change of other companies or individuals.
16	Collaborative Efforts	Collaborative efforts between government, First Nations, and local interests should play a significant role in caribou management	No indicators address this at present, although Indicator 6.4.7 (related to protected areas) provides a good model.	An indicator should be developed requiring applicants to work within their sphere of influence to advance collaborative management of SAR.
17	Collaborative Efforts	Overlapping tenure is a fact of life for many management units and should be integrated into the Standard's requirements	Overlapping tenure is recognized as an important component of forest management in indicators 6.3.12, 6.3.19, 6.10.6 and elsewhere.	It may be necessary to consolidate the indicators that include consideration of overlapping tenure and make clear that a) the requirements of the Standard are understood by all major tenure holders, and b) it is expected that the applicant plays a lead role in attempting to facilitate the activities of overlapping tenure holders so as to satisfy the requirements of the Standard
18	Population Management (Monitoring)	As indicated by its planning documents, the applicant should be aware of the status of populations.	Indicator 6.2.1 requires that a list of SAR be developed, but this is not a sufficient basis upon which to undertake management	The indicator should be revised to require the list to include the best available information on status and trends of the populations of SAR. However, it is not a requirement that the applicant collect the

No.	Aspect of Caribou Conservation	Issue/Concern	Current Emphasis of Standard	Suggested Modification
				data.
19	Population Management (Monitoring)	Population monitoring is a key component of management of wildlife populations, which must be undertaken, even if the responsible agency is not fulfilling its normal obligations.	Although the standard recognizes that the responsibility for population management is not held by the forest managers, they should play a role in facilitating population management through collaboration, and if necessary, provision of information not being gathered by the appropriate responsible agencies.	An indicator should be developed that requires applicants to work within their sphere of influence to facilitate monitoring of SAR, if it is not being addressed by the responsible agency.
20	Population Management (Monitoring)	Modeling of populations is a key component to identifying appropriate management actions and must be undertaken even if the responsible agency is not fulfilling its normal obligations.	As above	An indicator should be developed that requires the applicant to work within its sphere of influence to facilitate population modelling (distinct from habitat modelling) if it is not being undertaken by the responsible agency.
21	Population Management	The Standard should recognize the need to attempt to ensure persistence of local populations (not just species and subspecies as is presently the case in the Standard).	Indicator 6.3.9 requires that "the viability of any native species or subspecies …will be maintained". Ideally the focus should be more local and clear.	The indicator should be modified to identify the need to maintain local populations. It could be modified so as to read "**The persistence of local populations**… is not put at risk by the applicant through activities related to forest management". In addition, verifiers should include measures of population trend and cumulative disturbance level relative to the zone of risk (as described in Table 2).
22	Population Management	Population persistence should be included among the factors required for consideration in HVCs	Indicator 9.3.1 identifies the planning requirements related to HCVs	The indicator should be modified to require that management plans take into account risks to population persistence.
23	Timing	Forestry operations during the times of particular sensitivity may disturb caribou	Indicators 6.5.1 and 9.3.1 include elements of seasonality of operations, but neither specifically addresses the issue of possible caribou sensitivity.	Indicator 6.5.1 should be revised to incorporate the requirement to avoid operations during times of year when sensitive wildlife may be disturbed in their use of known aggregation areas (e.g., calving locations).

8 STRENGTHENING THE ASSESSMENT AND AUDIT PROCESSES

This report, and the mandate of this Science Panel, has concentrated specifically on the National Boreal Standard as it relates to caribou. There are, however, other elements of the certification process that fall outside the direct responsibility of FSC but are still significant contributors to the certification process and deserve attention. Notably, the auditing process itself represents the application of the standard, as it is the independent accredited certification body that determines whether a particular operation meets the defined standard or not, by verifying performance. The success of the standard, is reliant on the manner in which it is interpreted and applied to achieving certification. Several factors are important in determining the quality of the auditing process, including the competence and areas of expertise of the personnel on the auditing teams, the appropriateness of the indicators being applied, and the consistency of interpretation of the standard itself among auditors. These are discussed below and include a number of recommendations that fall outside those related to revision of the Standard itself, but will be nevertheless key determinants of the ultimate performance of the standard as it relates to caribou conservation.

8.1 THE AUDITING TEAM: TRAINING AND EXPERIENCE

The Forest Stewardship Council has identified requirements related to education, training, interpretation of indicators, and many other topics related to conducting certification assessments (e.g., FSC 2005a, 2005b). FSC Canada itself has not offered training on any elements of certification; therefore the onus for meeting these standards and for providing training as to how they are to be met is on the certifiers. Although this is not uncommon among regional or national FSC bodies, there are precedents for FSC offering training on aspects of certification standards of significant interest or importance (e.g., HCVs). The Panel believes it would be appropriate for FSC Canada to provide training related to the manner in which assessments should take caribou needs into account, with particular attention to the specific amendments to the NBS that follow from this exercise. This training need not be in-person training but could be delivered through published guidance for Certification bodies, WebEx sessions, etc.

The FSC has typically attempted to strike a reasonable balance between providing detailed direction as to how assessments and audits are to be carried out, and recognizing that certifiers and applicants need a practical amount of discretion in organizing and carrying out these activities. In one of its policy documents, the FSC identifies the training and experience requirements necessary for assessors and auditors (FSC 2005a), and describes the key considerations for selection of auditors for main forest evaluations. The considerations include: "***Environmental issues****: The evaluation team shall include auditor(s) with experience and knowledge to recognise the presence of ecological High Conservation Values (HCV) in the area to be evaluated, as well other environmental issues that are likely to be of importance during the evaluation. Qualification or professional experience in the area of forest ecology for the forest ecosystems under evaluation (whether natural or planted) is likely to be of key importance. General knowledge of the management of rare or endangered species that are likely to be present in the forest area, or knowledge about key environmental impacts such as those on hydrology or soils may also be required*."

This is appropriate direction, however, the Panel suggests it needs reinforcement as there are indications of imbalanced effort (based on confidential information regarding the number of days spent conducting assessments). In the case of caribou, if the appropriate expertise is not on the auditing team, then more guidance from outside experts is advisable.

8.2 Ensuring Comparability across Auditors

While it is natural to have some variability in judgment across the suite of assessors and certifiers who take on certification assignments, it is crucial to have comparable results reached for critical issues and challenging circumstances and to uphold as much consistency as possible in interpretation of the standard. There is some evidence that this desirable result is not being achieved. For example, in an analysis of results across a suite of certifiers, Johnson (2008) found a notable discrepancy in the average number of CARs issued per certifier. Although this analysis suffered by having a disproportionate number of case studies from on one certifier, it nonetheless highlights the need for FSC to remain attuned to this issue. Having circumstances in which there is imbalance in important elements of judgement across certifiers not only weakens the FSC

'Brand' but is frustrating for companies seeking certification and may have implications for competition across certifiers.

Modification of the Standard itself, as recommended for caribou, will help in this regard. First, there is a multitude of indicators that could be (and generally have been) interpreted as relevant for caribou, and the Panel has recommended that a subset of these deserve specific attention, which should streamline the auditing process relative to caribou. Second, the Panel has also attempted to clarify the indicators and related requirements themselves, which should further improve the consistency of results across certifiers. Third, the Panel recommends that following the revision of the standard for caribou, attempts to address comparability across auditors should concentrate on:

- an assessment of indicators that have been inconsistently applied;
- consultations with assessors and applicants to identify issues and indicators most in need of improvement/clarification; and
- continued use of explanatory and interpretational material in the body of the Standard, similar to the Intent Boxes used in the present standard.

8.3 PLANNING VS. IMPLEMENTATION

As noted in Section 5, many of the Standard's indicators focus on planning. For indicators related to SAR, such planning indicators are disproportionate to those focused on implementation. While it may be implicit that plans and intentions will translate into appropriate on-the-ground actions, this is by no means a certainty. For assessors, the monitoring component closes the link between planning and implementation; however it can be some time before monitoring requirements become relevant to planning direction and reveal if appropriate implementation has occurred or not. The message here should be that "good intentions are not enough." Without adequate indication that applicants have the institutional capacity, approved mandate, understanding, and logistic and scientific expertise (if necessary), assessors should be wary about accepting evidence based simply on the fact that plans indicate that appropriate actions are anticipated.

It is common in the case of caribou, for example, for auditors to accept as evidence of performance, plans that have been developed according to the guidelines of the relevant government agency. Without accompanying measures of performance of this plan (e.g., monitoring results of caribou population condition) and critical examination of the plan itself, the auditor makes a leap of faith that the goals of the well-intended plan will be met.

For development of the revised NBS, the relevant point is that indicators that rely on planning as a means of fulfilling requirements must be linked to comparable aspects of the Standard that require implementation of the planning components. Examples here include Indicator 6.5.1, which includes long lists of components of forest management that are to be included in planning-related documents, and Indicator 9.3.1, which identifies components of HCV management that are to be included in plans. Both of these indicators have relevance for caribou and SAR in general.

9 ROLE OF PRINCIPLE 9

There is considerable overlap between the issues relevant in Principle 9 and those of the first 8 Principles, relating to social, economic and environmental values. A strong HCV assessment is a chance for forest managers to take a broad view of the effects of their management. Principle 9 is the opportunity for sober second thought about all of the special values in the forest. It means the manager must be sure that those special values are identified and validated by a broad range of experts and forest users. It means that if management is needed, it will not diminish the value. Finally, it means that all forestry activities around HCVs are monitored, and that monitoring must show that the management is effective

Considerable effort has been put into a practical approach to HCVs in Canada. In practice, the four indicators in P9 require that managers must:

1. assess the values on the forest using the National framework (or another method that meets the intent of the framework), and designate those values that are special – High Conservation Values, or HCVs as they have become known;
2. consult with specialists, indigenous people, and directly affected people;
3. implement management activities, if required, that will maintain, enhance, or restore the value; and
4. monitor management activities to show that they are effective – this means meeting the precautionary approach that, to paraphrase, requires the manager not to take unwarranted risks.

Species at Risk are HCVs and are addressed in Criterion 6.2 and again in P9. In the HCV report, which is required on all large public forests in Canada, the manager must outline the assessment that was done and review the management activities related to the HCVs. The HCV report is not the actual planning document, or the regulatory document. Instead, when it is made readily available to the public, the HCV report provides a more accessible explanation of how SAR are safeguarded. The Forest Management Plan, or in some cases “specific strategies” (9.3.1), or recovery plans, provide the technical explanation of how management will occur, and what is its basis. The HCV report is the explanation for non practitioners, for a more global audience, and it

provides the transparency that is needed so that managers can "be seen" to be doing the right thing.

When caribou are considered through the lens of Principle 9, one would hope that this high profile species would receive appropriate conservation measures. Under the FSC standard, the forest managers have the discretion to designate HCVs, with the guidance of experts and the public. As far as we know, there has not been a case where caribou that are affected by forestry activities have not been designated as HCV[9].

A word on the role of the auditor in evaluating P9 HCVs may be useful. An auditor's job is to assess the HCV process. They must determine whether the plan has been properly reviewed or not, and that the reviews say the plan is reasonable. It is not the job of the auditor to be the technical specialist and evaluate the effectiveness of a caribou recovery plan (unless there are obvious shortcomings). If there has not been an adequate review, as required by Criteria 9.1 and 9.2, then the auditor can reject the plan on that basis – the auditor needs to have the consultation information to determine that the plan is appropriate.

[9] Some managers do not readily distribute their HCV reports, so we cannot confirm this to be the case.

10 CHALLENGES AND KEY UNCERTAINTIES

Forest certification is being sought by an increasing number of forestry companies whose forest management unit(s) overlap(s) boreal caribou range. Unfortunately caribou population size and or distribution in many areas of Canada are in decline. Hypothesized causes of decline have been described (in Section 4.3) and conservation measures have been outlined in Section 6. In some caribou ranges the conservation measures required to maintain, enhance, or restore caribou will require necessitate implementation of management actions relating to habitat and populations. Manipulation of populations, e.g., caribou, predators, or primary prey, is outside the responsibility of forestry companies. (Although monitoring is typically outside the management responsibility of forest companies too, they can play roles in monitoring in their capacities as contributing stewards of the forest.) So, while forest management certification may be able to influence a variety of habitat variables, it cannot directly influence manipulative aspects of population management. As noted above, this disjuncture between a habitat-based management responsibility for forestry companies and the potential requirement for interventions (e.g., predator control) relative to caribou population ecology creates a significant challenge for forest certification schemes.

More specifically on the topic of management responsibility, the vagaries and complexities of provincial management and politics add an additional challenge. Funding, management decisions, and even 'political will' often vary in concert with political cycles and political sensitivity to perceptions of, or real, voter responses. Decisions to implement management or monitoring actions may change with budgets, ministers, or other aspects of political cycles (e.g., the red zone of no decision-making preceding an election). Further, there is an enormous difference between jurisdiction and state of knowledge about caribou ecology. Government decisions regarding funding, policy, population monitoring and implementation of management actions can create uncertainty for companies seeking (or maintaining) certification.

Overlapping tenure(s) in various regions of Canada creates a variety of challenges and uncertainties relative to SAR conservation. In some cases the activities of other sectors contribute to further alteration or degradation of habitat. Actions by the forest management

company to implement ecosystem-based management on the ground may be compromised by the activities and industrial effects of other sectors (e.g., Dzus et al. 2009). The certified company (or candidate) may be able to influence (or collaborate on) minimizing impacts of other's activities, but this is not the management responsibility of the company. Auditors face difficult decisions when assessing company actions (planning, implementation and monitoring) in the context of overlapping tenures relative to a habitat-based standard. FSC Canada (and FSC International) and the chambers therein must reconcile the need to develop standards that raise the bar with regards to forest management while still being achievable. It is however, vital that in the process FSC make clear any trade-offs to caribou conservation that might occur as a result of this balancing process.

One of the greatest challenges facing SAR conservation globally relates to the increasing and often additive effects of with climate change. Caribou conservation in Canada's boreal forests is a classic example of the uncertainty associated with the impacts of climate change, requirements for conservation under provincial and federal SAR legislation and certification systems, and company commitments regarding biodiversity. Managing for such conservation actions under relatively stable climate scenarios is one thing, but managing our actions relative to SAR conservation in the face of climate change creates great uncertainty, for the species in question and the forestry company. Given such uncertainty, neither the forest company nor the certification system(s) can address maintenance of SAR or HCV's with a high probability of assurance as is suggested in indicator 9.3.3.

11 CONCLUSIONS

The Science Panel undertook a structured review of the National Boreal Standard to fulfill its mandate of providing advice to FSC as it pertains to the conservation of caribou in the boreal forest.

In general, the Panel found that the NBS is a very thoughtful document, but needs some additions and modifications to address concerns regarding the integration of forestry, SAR, and especially caribou management. The Panel has recommended that 18 of the Standard's existing indicators be modified and that five new indicators be developed. In addition, the Panel has recommended that several other modifications to the Standard, specifically related to caribou, be considered. The topic of greatest concern to the Panel, not presently addressed in the Standard, is cumulative disturbances. Several of the Panel's recommended changes to the Standard deal with this issue, including the development of a framework to specifically incorporate concerns related to relative risk to caribou populations.

Another important theme in this review is that of uncertainty. Because many aspects of caribou ecology are unknown, the recommended changes to the Standard are intended to recognize this uncertainty and address broad concerns related to management of caribou habitat. The Panel stresses the importance of a continued role for adaptive management in the Standard related to caribou management.

Although habitat management is undoubtedly a key factor in caribou conservation, important aspects of caribou management, specifically related to population manipulation, are clearly beyond the responsibilities and management domain of forest companies. The Panel also recognizes that other (non-forestry) activities on the same landbase can add to, or even dwarf, the impacts caused by forest management. In this light, therefore, the fate of boreal caribou is not entirely dependent on the manner in which forest habitat is managed. Ultimately this fact can limit the extent to which forest companies can be held responsible for the fate of caribou populations. Nevertheless, forest companies can play a role in some aspects of population

management, specifically for monitoring, and several suggested modifications to the Standard deal with this.

Finally, this review has identified a number of ways in which the Panel believes that the assessment and auditing process should be strengthened. These include: providing training to assessors to ensure they understand and take caribou issues into account in assessments; developing means to ensure comparability amongst assessors in their interpretation of key elements of the Standard; and clarifying linkages between planning and implementation components of the Standard.

12 LITERATURE CITED

Anderson, R.C. 1970. Neurologic disease in reindeer introduced into Ontario. Canadian Journal of Zoology 49:159-166.

Anderson, R.C. 1972. The ecological relationship of meningeal worm and native cervids in North America. Journal of Wildlife Diseases 8: 304-310

Antoniuk, T. 2007. Snake – Sahtaneh Boreal Caribou Study: Cumulative Effect Component. Report prepared for: Science and Community Environmental Knowledge Fund Fort St. John, British Columbia.

Apps, C.D., and B.N. McLellan. 2006. Factors influencing the dispersion and fragmentation of endangered mountain caribou populations. Biological Conservation 130: 84-97.

ArborVitae Environmental Services. 2009. Analysis of the FSC's National Boreal Standard Survey Results. Report prepared for FSC Canada and WWF Canada. 113 p.

Athabasca Landscape Team. 2009. Athabasca caribou landscape management options report. Alberta Caribou Committee, Edmonton AB. Available at: http://www.albertacariboucommittee.ca/PDF/Athabasca-Caribou.pdf

Balshi, M.S., A.D. McGuire, P. Duffy, M. Flannigan, J. Walsh, and J. Melillo. 2008. Modeling historical and future area burned of western boreal North America using a multivariate adaptive regression splines (MARS) approach. Global Change Biology 15: 578-600.

Banfield, A.W.F. 1961. A revision of the reindeer and caribou genus *Rangifer*. National Museum of Canada Bulletin No 177.

Barten, N.L., R.T. Bowyer, and K.J. Jenkins. 2001. Habitat use by female caribou: tradeoffs associated with parturition. Journal of Wildlife Management 65: 77-92.

Bengtsson J., P. Angelstam, T. Elmqvist, U. Emanuelsson, C. Folke, M. Ihse, F. Moberg, and M. Nystrom. 2003. Reserves, resilience and dynamic landscapes. Ambio 32, 389-396.

Bergeron, Y., and B. Harvey. 1997. Basing silviculture on natural ecosystem dynamics: an approach applied to the southern mixedwood boreal forest of Québec. Forest Ecology and Management 92: 235-248.

Bergeron, Y., B. Harvey, A. Leduc, and S. Gauthier. 1999. Forest management guidelines based on natural disturbance dynamics: stand-and forest-level considerations. Forestry Chronicle 75: 49-54

Bergeron, Y., A. Leduc, B.D. Harvey, and S. Gauthier, S. 2002. Natural fire regime: a guide for sustainable management of the Canadian boreal forest. Silva Fenn. 36: 81–95.

Bergerud, A.T. 1967. Management of Labrador caribou. Journal of Wildlife Management 31: 621-635.

Bergerud, A.T. 1974. Decline of caribou in North America following settlement. Journal of Wildlife Management 38: 757-770.

Bergerud, A. T. 2007. The need for management of wolves-An open letter. Rangifer Special Issue 17: 39-50.

Bergerud, A. T., W. J. Dalton, H. Butler, L. Camps and R. Ferguson. 2007. Woodland caribou persistence and extirpation in relic populations on Lake Superior. Rangifer Special 17: 57-78.

Bergerud, AT. 1992. Rareness as an antipredator risk for moose and caribou. p 1008-1021 In "Wildlife 2001 Populations" D.R McCullough and R.H. Barrett (eds), Elsevier Applied Science, New York.

Bergerud, A.T., S.N. Luttich and L. Camps. 2008. The Return of Caribou to Ungava. McGill-Queen's University Press. Montreal and Kingston.

Bowman, J.E., J.C. Ray, A.J. Magoun, D.S. Johnson, and F.N. Dawson. 2010. Roads, logging, and the large mammal community of an eastern Canadian boreal forest. Canadian Journal of Zoology 88:454-467.

Bradshaw, C.J.A., S. Boutin, and D.M. Hebert. 1998. Energetic implications of disturbance caused by petroleum exploration to woodland caribou. Canadian Journal of Zoology 76: 1319-1324.

Bradshaw, C.J.A., D.M. Hebert, A.B. Rippin, and S. Boutin. 1995. Winter peatland habitat selection by woodland caribou in northeastern Alberta. Canadian Journal of Zoology 73: 1567-1574.

Briand, Y., J.-P. Ouellet, C. Dussault, and M.-H. St. Laurent. 2009. Fine-scale habitat selection by female forest dwelling caribou in managed boreal forest: empirical evidence of a seasonal shift between foraging opportunities and antipredator strategies. Ecoscience 16: 330-340.

Brown, W.K., and D.P. Hobson. 1998. Caribou in west-central Alberta: information review and synthesis. Terrestrial and Aquatic Environmental Managers Ltd., Calgary, Alta.

Brown, G.S., F.F. Mallory, and W.J. Rettie. 2003. Range size and seasonal movement for female woodland caribou in the boreal forest of northeastern Ontario. Rangifer 14:227-233.

Cardillo, M., G.M. Mace, J.L. Gittleman, and A. Purvis. 2006. Latent extinction risk and the future battlegrounds of mammal conservation. Proceedings of the National Academy of Sciences 103:4157-4161.

Carleton, T.J. 2000. Vegetation responses to the managed forest landscape of central and northern Ontario. Pages 179-197 in A.H. Perera, D.L. Euler and I.D. Thompson (eds.) Ecology of a managed terrestrial landscape: patterns and processes of forest landscapes in Ontario. UBC Press, Vancouver, BC.

Carleton, T.J. and P. MacLellan. 1994. Woody vegetation responses to fire versus clearcut logging: a comparison study in the central Canadian boreal forests. Ecological Applications 6: 763-773.

Carpenter S.R. and C. Folke. 2006. Ecology for transformation. Trends in Ecology & Evolution 21: 309-315.

Chubbs, T.E., L.B. Keith, S.P. Mahoney, and M.J. McGrath. 1993. Responses of woodland caribou to clear-cutting in east-central Newfoundland. Canadian Journal of Zoology 71: 487-493.

COSEWIC. 2002. Assessment and update status report on the woodland caribou. Environment Canada, Ottawa.

Courtois, R., A. Gingras, D. Fortin, A. Sebbane, B. Rochette, and L. Breton. 2008. Demographic and behavioural response of woodland caribou to forest harvesting. Canadian Journal of Forest Research 38: 2837-2849.

Courbin, N., D. Fortin, C. Dussault, and R. Courtois. 2009. Landscape management for woodland caribou: the protection of forest blocks influences wolf-caribou co-occurrence. Landscape Ecology: DOI 10.1007/s10980-009-9389-x.

Courtois, R., J.-P. Ouellet, L. Breton, A. Gingras, and C. Dussault. 2007. Effects of forest disturbance on density, space use, and mortality of woodland caribou. Ecoscience 14: 491-498.

Courtois, R., J-P. Ouellet, A. Gingras, C. Dussault, L. Breton, and J. Maltais. 2003. Historical changes and current distribution of caribou in Québec. Canadian Field Naturalist 117: 399-414.

Cumming, H.G., and B.T. Hyer. 1998. Experimental log hauling through a traditional caribou wintering area. Rangifer Special Issue 10: 241-258.

Dalerum, F., S. Boutin, and J.S. Dunford. 2007. Wildfire effects on home range size and fidelity of boreal caribou in Alberta, Canada. Canadian Journal of Zoology 85: 26-32.

de Bellefuille, S. 2001. Le caribou forestier et la sylviculture: revue de littérature etsynthèse de la recherche et de l'aménagement en cours au Québec. Ministère des Ressources Naturelles du Québec, Québec. 86 p

De Vos, A., and R.L. Peterson. 1951. A review of the status of woodland caribou in Ontario. Journal of Mammalogy 32: 329-337.

Drever, C.R., G. Peterson, C. Messier, Y. Bergeron, and M.D. Flannigan. 2006. Can forests management based on natural disturbances maintain ecological resilience? Canadian Journal of Forest Research 36: 2285-2299.

Dunford, J.S. P.D. McLoughlin, F. Dalerum, and S. Boutin. 2006. Lichen abundance in the peatlands of northern Alberta: implications for boreal caribou. Ecoscience 13: 469-474.

Dyer, S.J., J.P. O'Neill, S.W. Wasel, and S. Boutin. 2001. Avoidance of industrial development by woodland caribou. Journal of Wildlife Management 65: 531-542.

Dzus, E., B. Grover, S. Dyer, D. Cheyne, D. Pope, & J. Schieck. 2009. Setting, implementing and monitoring targets as a basis for adaptive management: a Canadian forestry case study. Pp. 352-392. In: Villard, M.-A., and B.G. Jonsson (Editors). Setting Conservation Targets for Managed Forest Landscapes. Cambridge University Press, Cambridge, UK.

Elmqvist T., Folke C., Nystrom M., Peterson G., Bengtsson J., Walker B. & Norberg J. 2003. Response diversity, ecosystem change, and resilience. Frontiers in Ecology and the Environment. 1: 488-494.

Environment Canada 2008. Scientific Review for the Identification of Critical Habitat for Woodland Caribou (Rangifer tarandus caribou), Boreal Population, in Canada. August 2008. Ottawa: Environment Canada.

Ferguson, S.H., and P.C. Elkie. 2004. Habitat requirements of boreal forest caribou during the travel season. Basic and Applied Ecology 5: 465-474.

Festa-Bianchet, M., J. C. Ray, S. Boutin, S.D. Côté and A. Gunn. In Press. Caribou conservation in Canada: an uncertain future. Canadian Journal of Zoology.

Fischer, J. and D. B. Lindenmayer. 2000. An assessment of the published results of animal relocations. Biological Conservation 96: 1-11.

Forest Stewardship Council Canada Working Group. 2004. National Boreal Standard. August 6, 2004. 181 p.

Forest Stewardship Council 2005a. Qualifications for FSC Certification Body Auditors. FSC-STD-20-004 (Version 2-2) EN. 7 pp.

Forest Stewardship Council 2005b. FSC Qualifications for Certification Bodies. FSC-GUI-20-200 EN. Revised March, 2005. 69 pp.

Forest Stewardship Council of Canada. 2007. Managing caribou in FSC-certified forests in Canada. Issues for Consideration. August 2007. 2p.

Forest Stewardship Council of Canada. www.fsccanada.org/visio.htm Last accessed July 22, 2010

Frid, A. and L. M. Dill. 2002. Human-caused disturbance stimuli as a form of predation risk. Conservation Ecology 6(1): 11. [online] URL: http://www.consecol.org/vol6/iss1/art11/

Fritz, R., R. Suffling, and T.A. Younger. 1993. Influence of fur trade, famine, and forest fires on moose and woodland caribou populations in northwestern Ontario from 1786 to 1911. Environmental Management 17: 477-489.

Fortin, D., R. Courtois, P. Etcheverry, C. Dussault, and A. Gingras. 2008. Winter selection of landscapes by woodland caribou: behavioural response to geographical gradients in habitat attributes. Journal of Applied Ecology DOI 10.1111/j.1365-2664.2008.01542.x.

Girardin, M.P., J. Tardif, and M.D. Flannigan. 2006. Temporal variability in area burned for the Province of Ontario, Canada during the past 200 years inferred from tree-rings. Journal of Geophysical Research - Atmosphere 111: D17108. doi:10.1029/2005JD006815

Gillett, N.P., Weaver, A.J., Zwiers, F.W., and Flannigan, M.D. 2004. Detecting the effect of climate change on Canadian forest fires. Geophysical Research Letters 31(18), L18211. doi:10.1029/2004GL020876

Gunderson, L. 2000. Ecological resilience: in theory and application. Annual Review of Ecology and Systematics 31: 425-439.

Harper, K.A., Y. Bergeron, P. Drapeau, S. Gauthier, and L. de Grandpré. 2005. Structural development following fire in black spruce forest. Forest Ecology and Management 206: 293-306.

Harvey, B.D., A. Leduc, S. Gauthier, and Y. Bergeron. 2002. Stand-landscape integration in landscape-based management of the southern boreal forest. Forest Ecology and Management 155: 369-385.

Hayes, R.D., R. Farnell, R.M.P. Ward, J. Carey, M. Dehn, G.W. Kuzyk, A.M. Baer, C.L. Gardner, and M. O'Donoghue. 2003. Experimental reduction of wolves in the Yukon: ungulate responses and management implications. Wildlife Monographs No. 152.

Hearndon, K.W., S.V. Millison, and W.C. Wilson. 1992. A report on the status of forest regeneration. Ontario Independent Forest Auditor Commission, Toronto. 116 pp.

Hins, C., J.-P. Ouellet, C. Dussault, and M.-H. St. Laurent. 2009. Habitat selection by forest-dwelling caribou in managed boreal forest of eastern Canada: evidence of a landscape configuration effect. Forest Ecology and Management 257: 636-643.

Holling, C.S. 1978. Adaptive Environmental Assessment and Management. John Wiley and Sons. London

Hummel, M. and J.C. Ray. 2008. Caribou and the North. A Shared Future. Dundurn Press, Toronto. 288 p.

Hunt, L.M., Lemelin, R.H., and Saunders, K.C. 2009. Managing Forest Road Access on Public Lands: A Conceptual Model of Conflict. Society & Natural Resources 22: 128-142.

James, A.R.C., and K. Stuart-Smith. 2000. Distribution of caribou and wolves in relation to linear corridors. Journal of Wildlife Management 64: 154-159.

Johnson, D.R. 1985. Man-caused deaths of mountain caribou *Rangifer tarandus*, in southeastern British Columbia. Canadian Field Naturalist 99**:** 542-544.

Johnson, E.A. 1992. Fire and vegetation dynamics: studies from the North American boreal forest. Cambridge Univ. Press, Cambridge, UK.

Johnson, L. 2008. FSC Certification as a Driver of Positive Change in Forest Management in Canada. Oct. 15th 2008. The Boxfish Group. 27 p.

Joly, K., B.W. Dale, W.B. Collins, and L.G. Adams. 2003. Winter habitat use by female caribou in relation to wildland fires in interior Alaska. Canadian Journal of Zoology 81: 1192-1201.

Klein, D.R. 1968. The introduction, increase, and crash of reindeer on St. Matthews Island. Journal of Wildlife Management 32: 350-367.

Latham, A.D.M., and others. In Press. Invading white-tailed deer change wolf-caribou dynamics in northeastern Alberta. Journal of Wildlife Management

Lankester, M.W., and P.L. Hauta. 1989. Parelaphostrongylus andersoni (Nematoda: Elaphostrongylinae) in caribou (Rangifer tarandus) of northern and central Canada. Canadian Journal of Zoology 67: 1966–1975.

Lee, K.N. 1993. Compass and Gyroscope. Integrating Science and Politics for the Environment. Island Press. Washington D.C. 243 p.

Li, C. 2000. Fire regimes and their simulation with reference to Ontario. Pages 115-140 In A. Perera, D. Euler, and I. Thompson, eds., Ecology of a managed terrestrial landscape: patterns and processes of forest landscapes in Ontario. University of British Columbia Press.

Lindenmayer, D.B., and J.F. Franklin. 2002. Conserving forest biodiversity. Island Press, Washington, DC, USA.

Martinez, R., Stocks, B.J., and Truesdale, D. 2006. Global Forest Resources Assessment 2005: Report on Fires in the North American Region. United Nations FAO Working Paper FM/15/E, FAO, Rome, Italy. 32p.

Mayor, S.J., D.C. Schneider, J.A. Schaefer and S.P. Mahoney. 2009. Habitat selection at multiple scales. Ecoscience 16: 238-247.

McIntyre, T. 2003. Canada's incendiary past: Fires that have burned their way into Canadian history. Canadian Geographic (January). http://www.canadiangeographic.ca/magazine/ja03/indepth/timeline.asp

McLoughlin, P.D., E. Dzus, B. Wynes, and S. Boutin. 2003. Declines in populations of woodland caribou. Journal of Wildlife Management 67: 755-761.

Morrison, J.C., W. Sechrest, E. Dinerstein, D.S. Wilcove and J.F. Lamoreux. 2007. Persistence of large mammal faunas as indicators of global human impacts. Journal of Mammalogy 88:1363-1380.

Mosnier, A., D. Boisjoly, R. Courtois, and J.-P. Ouellet. 2008. Extensive predator space use can limit the efficacy of a control program. Journal of Wildlife Management 72: 483-491

Murphy, S.M., Curatolo, J.A., 1987. Activity budgets and movement rates of caribou encountering pipelines, roads, and traffic in northern Alaska. Canadian Journal of Zoology 65: 2483–2490

O'Brien, D., M. Manseau, A.Fall, and M.-J. Fortin. 2006. Testing the importance of spatial configuration of winter habitat for woodland caribou: an application of graph theory. Biological Conservation 130: 70-83.

Ontario Department of Lands and Forests. 1963. Ontario resources atlas. 4th Edition. Queen's Printer, Toronto. (map p. 30)

Periera, H.M., G. C. Daily, and J. Roughgarden. 2004. A framework for assessing the relative vulnerability of species to land-use change. Ecological Applications 14: 730-742.

Post, E.C. and M.C. Forschhammer. 2008. Climate change reduces reproductive success of an arctic herbivore through trophic mismatch. Phil. Transactions of the Royal Society B. 363: 2367-2373.

Hummel, M., and J. C. Ray. 2008. Caribou and the North. A Shared Future. Dundurn Press. Toronto.

Rettie, W.J., and F. Messier. 2000. Hierarchical habitat selection by woodland caribou: its relationship to limiting factors. Ecography 23: 466-478.

Rettie, W.J., and F. Messier. 1998. Dynamics of woodland caribou populations at the southern limit of their range in Saskatchewan. Canadian Journal of Zoology 76: 251-259.

Sala O.E., F.S. Chapin, J.J. Armesto, E. Berlow, J. Bloomfield, R. Dirzo, E. Huber-Sanwald, L.F. Huenneke, R.B. Jackson, A. Kinzig, R. Leemans, D.M. Lodge, H.A. Mooney, M. Oesterheld, N.L. Poff, M.T. Sykes, B.H. Walker, M. Walker, and D.H. Wall. 2000. Biodiversity - Global biodiversity scenarios for the year 2100. Science 287: 1770-1774.

Schaefer, J.A., and S.P. Mahoney. 2007. Effects of progressive clearcut logging on Newfoundland caribou. Journal of Wildlife Management 71: 1753-1757.

Schaefer, J.A. and W.O. Pruitt. 1991. Fire and woodland caribou in southeastern Manitoba. Wildlife Monographs 116: 1-39.

Schaefer, J.A. 2003. Long-term range recession and the persistence of caribou in the taiga. Conservation Biology 17: 1435-1439.

Schneider, R.R., B. Wynes, S. Wasel, E. Dzus, and M. Hiltz. 2000. Habitat use by caribou in northern Alberta, Canada. Rangifer 20: 43-50.

Seip, D. 1992. Factors limiting woodland caribou populations and their interrelationships with wolves and moose in southeastern British Columbia. Canadian Journal of Zoology 70: 1494-1503.

Seip, D.R., C.J. Johnson, and G.S. Watts. 2007. Displacement of Mountain caribou from winter habitat by snowmobiles. Journal of Wildlife Management 71: 1539-1544.

Smith, K.G., E.J. Ficht, D. Hobson, T.C. Sorensen, and D. Hervieux. 2000. Winter distribution of woodland caribou in relation to clear-cut logging in west-central Alberta. Canadian Journal of Zoology 78: 1433-1440.

Soppela, P., M. Nieminen, and J. Timisjàrvi. 1986. Thermoregulation in reindeer. Rangifer, Special Issue 1: 273-278.

Sorensen, T., P.D. McLoughlin, D. Hervieux, E. Dzus, J. Nolan, B. Wynes, and S. Boutin. 2008. Determining sustainable levels of cumulative effects for boreal caribou. Journal of Wildlife Management 72: 900-905.

Stocks, B.J., J.A. Mason, J.B. Todd, E.M. Bosch, B.M. Wotton, B.D. Amiro, M.D. Flannigan, K.G. Hirsch, K.A. Logan, D.L. Martell, and W.R. Skinner. 2003. Large forest fires in Canada, 1959-1997. Journal of Geophysical Research 108: 8149. doi:10.1029/2001JD000484.

Stuart-Smith, A.K., C.J.A. Bradshaw, S. Boutin, D.M. Hebert, and A.B. Rippen. 1997. Woodland caribou relative to landscape patterns in northeastern Alberta. Journal of Wildlife Management 61: 622-633.

Suffling, R. 1995. Can disturbance determine vegetation distribution during climate warming? Journal of Biogeography 22: 501-508.

Taylor, B. 2000. An Introduction to Adaptive Management. Background Report produced for the North Coast LRMP. 9 p.

Ter-Mikaelian, M.T., S.J. Colombo, and J. Chen. 2009. Estimating forest fire return interval in northeastern Ontario, Canada. Forest Ecology and Management 258: 2037-2045.

Thompson, I.D. 2004. The importance of superior quality wildlife habitats. Forestry Chronicle 80:75-81.

Thompson, I.D. 2000. Forests vegetation in Ontario: factors influencing landscape change. Pages 30-53 In A. Perera, D. Euler, and I. Thompson, eds., Ecology of a managed terrestrial landscape: patterns and processes of forest landscapes in Ontario. University of British Columbia Press.

Thompson, I.D., M. Flannigan, M. Wotton, and R.Suffling. 1998. The effects of climate change on landscape biodiversity: an example from Ontario forests. Atmosphere and Environmental Monitoring 49:213-233.

Thompson, I.D. and D.A. Welsh. 1993. Integrated resource management in boreal forests: problems and solutions. Forestry Chronicle 69:32-39.

Thompson, I., B. Mackey, S. McNulty, and A. Mosseler. 2009. Forest Resilience, biodiversity, and climate change. A synthesis of the biodiversity/resilience/stability relationship in forest ecosystems. Secretariat of the UN Convention on Biological Diversity, Montreal. Technical Series no. 43

Thorne, J.H., Huber, P.R., Girvetz, E.H., Quinn, J., and McCoy, M.C. 2009. Integration of Regional Mitigation Assessment and Conservation Planning. Ecology and Society 14.

Trainer, D. 1973. Caribou mortality due to the meningeal worm (*Paralaphostrongylus tenuis*). Journal of Wildlife Diseases 9: 376-378

Venter O., N.N. Brodeur L. Nemiroff, B. Belland, I.J. Dolinsek, and J.W.A. Grant. 2006. Threats to endangered species in Canada. Bioscience 56: 903-910.

Vistnes, I.I., C. Nellemann, P. Jordhøy, and O-G. Støen. 2008. Summer distribution of wild reindeer in relation to human activity and insect stress. Polar Biology 31:1307–1317

Voigt, D., J. Baker, I. Thompson, and R. Rempel. 2000. Forest vertebrate responses to landscape-level changes in Ontario. In A. Perera, D. Euler, and I. Thompson, eds., Ecology of a managed terrestrial landscape: patterns and processes of forest landscapes in Ontario. Univ. of British Columbia Press.

Vors, L. and M. Boyce. 2009. Global declines of caribou and Reindeer. Global Change Biology 15: 2626-2633.

Vors, L.S., J.A. Schaefer, B.A. Pond, A.R. Rodgers, and B.R. Patterson. 2007. Woodland caribou extirpation and anthropogenic landscape disturbance in Ontario. Journal of Wildlife 71: 1249-1256.

Walters, C.J. 1986. Adaptive Management of Renewable Resources. McGraw-Hill, New York, N.Y.

Wittmer, H.U., A.R.E. Sinclair, and B.N. McLellan. 2005. The role of predation in the decline and extirpation of woodland caribou. Oecologia 144: 257-267.

Wolfe, S. A., B. Griffith, and C. A. Graye Wolfe. 2000. Response of reindeer and caribou to human activities. Polar Research 19: 63-73.

13 ACKNOWLEDGEMENTS

The Science Panel is grateful to a number of people for providing assistance in the development of this review. Martin von Mirbach provided helpful background information and context to the Panel at the start of this undertaking. Dr. Brad Stelfox helped arrange a productive meeting for the Panel in Alberta. Several reviewers provided very helpful input in response to a draft report; the reviewers were Mr. Tom Clark, Dr. Martin-Hugues St-Laurent, Dr. Fiona Schmiegelow, Dr. David Euler, and Dr. Kari Stuart Smith. The Panel is also very grateful to FSC Canada for its financial and logistic support, and to the staff of FSC Canada for their patience throughout this undertaking.