Recommendations and Proposed Contributions Towards a Caribou Conservation Plan:

Pasquia-Bog Boreal Caribou Population

Prepared for:

Canadian Boreal Forest Agreement Secretariat (CBFA) SK
and
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EXECUTIVE SUMMARY

The Pasquia-Bog boreal caribou (*Rangifer tarandus caribou*) population range straddles the Saskatchewan-Manitoba provincial boundary. The National Boreal Caribou Recovery Strategy portrays the Pasquia-Bog area as two separate caribou ranges: a potion of the Boreal Plain Range (SK2) and The Bog (MB1). The Canadian Boreal Forest Agreement (CBFA) undertook an assessment of the Pasquia-Bog area to characterize the range using best available science and information. The process of developing a caribou conservation plan involves many steps. Initially, several guidance documents were reviewed to inform the development and structure of the caribou conservation plan. These documents included Canadian Boreal Forest Agreement (CBFA) guidance (Caribou Methodological Framework and Protected Areas Methodological Framework), the federal caribou recovery strategy, the federal critical habitat science review, and provincial recovery strategies (Manitoba and Saskatchewan).

The next foundational steps involved compiling relevant science literature and acquiring jurisdictional data and geobases (i.e. population location and genetic data, habitat data, disturbance data, protected areas, land use/tenure, traditional and local knowledge) and information (ie. local studies publically available reports, and science literature). Collectively, these data sources and information were reviewed to assess utility of Best Available Information, and included a gap analysis of available data and geobases.

The planning area was then defined. This step involved determining the Area of Assessment (AOA) to delineate the range boundary in an ecological context (using the ecodistricts described by the Ecological Framework for Canada), population context (using jurisdictional range plans, caribou range occupancy data and published local studies), and in a habitat context (using information on landscape configuration and caribou habitat preference). The Area of Implementation (AOI) was also delineated, which consists of the overlap of the various Forest Management Area (FMA) tenures with the AOA.

The next stage involved assessing and consolidating the current state of knowledge of the Pasquia-Bog Caribou Range. This involved a number of steps:

1) The Pasquia-Bog local population status was determined using population estimates and minimum viable population analysis from guidance documents and jurisdictional data sources, including relationship with adjacent populations from recent genetic study. The Pasquia-Bog population was estimated to be 225-275 caribou, which is below the federal recommended minimum viable population (MVP) threshold of 300. However, there is a close genetic relationship with the North Interlake population (also below a MVP level). The combined population of both ranges collectively is above the MVP, suggesting the importance of maintaining the linkage of both is important to the maintenance of both populations over the long term.
2) A habitat preference model was constructed using the Ducks Unlimited Enhanced Wetland Coverage (EWC). The coverage is extensively ground-truthed and considered very accurate. Two ecosite classifications were assessed for habitat preference based on value as forage, mortality-risk and refuge. These were then compared to results from

jurisdictional workshops that undertook a similar exercise and had virtually identical results. The ecosite preference ratings were then reconciled with the covertypes in the EWC. The resulting fine scale habitat model was then compared with results from a federal pan-boreal habitat assessment (coarse scale) which indicated significant correspondence, and therefore provided model validation. Population range occupancy data was then overlaid on the habitat preference model, which provided further validation of the habitat model accuracy.

3) Human disturbance data was acquired from Environment Canada, supplemented with natural disturbance data from the National Fire database to determine distribution of both natural and human disturbance across the range.
4) Existing protected area data was acquired from both jurisdictions to determine the location, type and distribution of protected areas within the AOA relative to preferred caribou habitat and occupied range.

Collectively the resulting data, analysis and model development were then used to inform delineation of a land management system. A land management system consisting of three zone types was proposed, with varying levels of recommended disturbance (zone management strategies):

1) Caribou Conservation Zones – caribou conservation emphasis.
2) Development Zones – ecologically sustainable economic emphasis.
3) Special Management Zones – intended either as a buffer between caribou conservation zones and development zones, and/or as movement corridors to ensure connectivity amount caribou conservation zones within the range and with North Interlake.

Analyses were conducted based on relative disturbance threshold levels within each zone type to test and assess the effect of manipulating disturbance levels by zone type on the probability of persistence of caribou, using the federal disturbance threshold model. Through an iterative process, scenarios of low disturbance, current state, and high disturbance were tested each time zone boundaries were altered, until the optimal zonation boundaries were achieved. This provided the Regional Working Group with an understanding of how altering disturbance levels within a particular zone or combination of zones would affect caribou population status and viability and habitat supply relative to the current state of the caribou range. This also ensured that the resulting recommended zonation would provide sufficient functional habitat over the long term, to support a viable caribou population at a natural level of abundance and distribution across preferred habitat types.

Lastly, this caribou conservation plan provides additional detail and management recommendations by zone type, including forestry best management practices. Best management practices (BMPs) in this report are provided at a high level and are specific to forestry; other land use BMPs should also be considered for comprehensive range planning and management.

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1.0 GOAL OF CARIBOU CONSERVATION PLANNING

The goal of Canadian Boreal Forest Agreement (CBFA) caribou conservation planning is to maintain or enhance self-sustaining boreal caribou populations within the plan area, and is directly linked to the factors affecting the "at risk" designation. This is directly linked to CBFA Goal 2 of maintaining viable populations of native species in natural patterns of abundance and distribution across the landscape.

The Methodological Framework for Caribou Action Planning (Antoniuk *et al.* 2012) was used as guidance to develop this document. This guidance was supplemented by information from federal (Environment Canada 2008, 2011, 2012) and provincial (Arsenault 2003, Manitoba Conservation 2005, Saskatchewan Environment 2014) recovery strategy documents, and relevant peer reviewed science literature and other relevant government and non-government works (Strittholt & Leroux 2012).

2.0 PRINCIPLES FOR CONSERVATION PLANNING

The state of knowledge relative to ecological and land use parameters requires careful assessment relative to any key uncertainties in development of a caribou conservation plan (Antoniuk *et al.* 2012).

2.1 FOUNDATION PRINCIPLES

Antoniuk *et al.* (2012) lists the following foundation principles as providing the basis for caribou conservation planning:

1) **Commitment to caribou conservation planning** is critical to achieving the conservation plan goals and is a shared responsibility by all land users on the caribou range, including all affected branches of government
2) **Cumulative effects management** of all factors impacting boreal caribou, their use of habitats and their survival must be addressed in the conservation plan because maintaining the structure and function of the boreal forest system is essential to achieve long-term sustainability of boreal caribou and other dependent species.
3) **Adaptive management** practices support continuous improvement of management policies and practices in the context of uncertainty of planning and implementing caribou conservation actions within current policies and practices.

2.2 GUIDING PRINCIPLES

Development of this caribou conservation plan adhered to the guiding principles defined by CBFA which include:

1) Use the **best available science and information** (including traditional ecological knowledge and local knowledge) to propose strategies and evaluate outcomes.
2) Select actions that are the most **ecologically effective.**

3) Select actions that **minimize social and economic impacts,** and disproportionate timber supply effects, if choices of actions have equivalent ecological outcomes. Therefore, where choice is available for meeting conservation objectives, decisions are guided towards meeting the objectives in areas where the fewest negative socio-economic impacts are incurred (Strittholt & Leroux 2012).
4) Use a **precautionary approach** for caribou conservation where uncertainties exist, but integrate adaptive management to facilitate learning and improve management practices and policies.
5) Within the area of influence, mitigate the effect of applied caribou conservation actions to **address impacts on wood supply and costs.**
6) **Recognize changing forest health and protection circumstances** from natural disturbances (wildfire, disease, insect infestation) that may take precedence over planned actions.

3.0 PLANNING AREA

Woodland caribou were listed in 2003 as "threatened" in Schedule 1 under Canada's *Species at Risk Act* (*SARA* 2002). This requires that they be effectively protected (per *SARA* 2002 section 34(3) and 35(3), including their critical habitat (per *SARA* 2002 section 61(4)b). Critical habitat contains the resources and environmental conditions required for local populations of boreal caribou that are sustainable over the long-term throughout their current distribution (Environment Canada 2008). Therefore, the local population range is the relevant spatial scale for identification of critical habitat and provides the habitat conditions, components, and ecological functions required by caribou at the appropriate temporal and spatial scales (Racey & Arsenault 2007, Environment Canada 2008, 2012). Effective protection at a landscape (i.e. local population range) scale is possible through management of the amount and type of natural and anthropogenic habitat disturbance (Sorensen *et al*. 2008, Arsenault & Manseau 2011, Environment Canada 2012), and is best attained through a hierarchical landscape planning approach (Racey & Arsenault 2007, Antoniuk *et al.* 2012).

The planning landscape should be at scale appropriate to the viability of the species represented (Haufler *et al.* 2002). Antoniuk *et al.* (2012) recommend using the local population range as the foundation for defining a planning area, along with regional variation in caribou ecology and socio-political considerations. Best available information was used to define the planning area and delineate local population range, consistent with guidance from Environment Canada (2012), provincial caribou recovery strategies (Manitoba Conservation 2005, Saskatchewan Environment 2014), guidance documents (Arsenault 2003, Badiou *et al.* 2011, Antoniuk *et al.* 2012), and the precautionary principle (UNCED 1992).

The Pasquia-Bog boreal caribou (*Rangifer tarandus caribou*) population range straddles the Saskatchewan-Manitoba provincial boundary. The National Boreal Caribou Recovery Strategy portrays the Pasquia-Bog area as two separate caribou ranges: the Boreal Plain Range (SK2) and The Bog (MB1).

3.1 ECOLOGICAL CONTEXT

The *National Ecological Framework for Canada* provides an ecologically-based spatial hierarchy for systematic planning of boreal caribou range. In Saskatchewan and Manitoba woodland caribou occur on the Boreal Shield and Boreal Plain Ecozones. The Pasquia-Bog local caribou population occurs on the Boreal Plain Ecozone along the southern periphery of woodland caribou range. Local caribou populations within this ecozone are discontinuously distributed, and associated with predictable habitat features such as preferred habitat patches (lichen-rich habitats, open softwood peatland complexes, upland mature/old open jackpine stands with arboreal and terrestrial lichen) ideally occurring within a matrix of well connected old growth conifer-dominated forest cover (Darby & Pruitt 1984, Rettie & Messier 2000, Schaefer & Pruitt 1991, Bradshaw *et al.* 1995, Dzus 2001, Arsenault 2003, Brown *et al.* 2007, Courtois *et al*. 2007, Fortin *et al.* 2008, Arsenault & Manseau 2011, Environment Canada 2012).

Natural (i.e. wildfire, beaver foraging, blowdowns, forest insect outbreaks) and anthropogenic (i.e. linear and polygonal) disturbance in boreal forest creates early forest successional habitat for several ungulate (i.e. moose, elk, and deer) species. Populations of these ungulate species typically increase in density and extent in response to improved habitat quality for those species

following disturbance, which can result in range overlap and shifts in distribution within ranges occupied by woodland caribou. Landscape attributes affect where predators concentrate their search effort (DeCesare 2012). Predator populations numerically respond to the increase in prey availability by increasing in numbers and distribution in pursuit of ungulate prey (Latham 2009). Increases of predator numbers within caribou range results in an associated increase of predation risk to woodland caribou populations, and trigger caribou population declines because caribou are demographically sensitive to even minor increases in mortality rates. Mature conifer-dominated forests (>40 yrs old) function as a barrier to the influx of other cervid species and their associated predators into preferred caribou habitat patches. This creates a spatial separation from other cervid species and offers limited predator access (Bergerud et al. 1984). Woodland caribou tend to avoid early-succession hardwood-dominated forest covertypes with high quantities of regenerating browse that are preferred by other cervid species and therefore have higher associated predation-risk.

Woodland caribou in the Boreal Plain Ecozone tend to be sedentary, with little to no evidence of seasonal shifts in ranges or aggregation areas for calving or rutting, and with limited exchange of individuals between occupied peatland complexes (Fuller & Keith 1981, Darby & Pruitt 1984, Edmonds 1988, Stuart-Smith *et al.* 1997, Rettie & Messier 2000, Brown 2001, Dyke 2008, Arsenault & Manseau 2011). They undertake their largest seasonal movements during spring and early winter and are most dispersed and least mobile during calving and late winter (Ferguson & Elkie 2004). They typically have large home ranges dominated by habitat that does not support high densities of other ungulate species or their associated predators (Environment Canada 2012).

Within the *National Ecological Framework for Canada*, the Boreal Plain Ecozone is further subdivided into finer scales of ecoregion and then ecodistricts (Acton *et al*. 1998, Smith *et al.* 1998). The ecodistricts occupied by the Pasquia-Bog local population include:

Table 1. Ecodistricts used to delineate the Pasquia-Bog Caribou Range.

Saskatchewan Ecodistricts	Manitoba Ecodistricts
E27 – Pasquia Escarpment	
E28 – Pasquia Plateau	668 – The Pas Moraine
F3 – Saskatchewan Delta (portion south of the Carrot River)	669 – Saskatchewan Delta (portion south of the Carrot River
F4 – Overflowing River Lowland	672 – Overflowing River

The ecological context of the planning area boundary is further modified to reflect:

- physical features that deter movement (such as large rivers, lakes and large patches of unsuitable habitat),
- indirect predation risk in relation to distribution of alternative prey and associated predators,
- habitat similarity, critical or unique features,
- local and traditional knowledge,

- natural disturbance regimes,
- ecological and administrative boundaries.

3.2 POPULATION CONTEXT

Woodland caribou naturally occur at low population densities on the landscape and have a naturally low reproductive rate (Environment Canada 2012) relative to other ungulate species, with parturient females producing only a single calf annually. They typically have large home ranges and therefore are vulnerable to habitat change because of their dependence on large continuous blocks of undisturbed habitat. These characteristics result in caribou predisposition to significant negative population response from even minor increases in mortality-risk from predation as a result of altered predator-prey dynamics resulting from habitat change.

Independent non-spatial population viability analyses (PVA) were conducted for boreal caribou for Saskatchewan (Arsenault & Manseau 2011) and by Environment Canada (2008). The analyses indicate a minimum viable population size for caribou of 238 to 300, respectively. Both analyses assumed an annual adult survival rate of 85% and a calf recruitment rate of 31.4 and 28.9 calves/100 adult females, respectively. Woodland caribou naturally occur on the landscape at low densities (typically 0.02 – 0.07 caribou/km²), with range densities typically averaging 0.02-0.03 caribou/km² (Environment Canada 2012). Assuming a local population density of 0.025/km², a minimum viable population of 238 or 300 would require a well connected functional habitat matrix 9,520 -12,000 km² in size, respectively. Badiou *et al.* (2011) and Environment Canada (2012) both recommend range areas of 10,000-15,000 km² of functional range size for long-term population sustainability. This is also consistent with that reported by Courtois *et al.* (2007). The Pasquia-Bog Caribou Range (see section 3.3) is 12,640 km² in size.

Genetic studies (Figure 1) infer population structure and associations through gene flow that support spatial delineation of the Pasquia-Bog caribou as a local population (Pither *et al.* 2006, Ball *et al.* 2010).

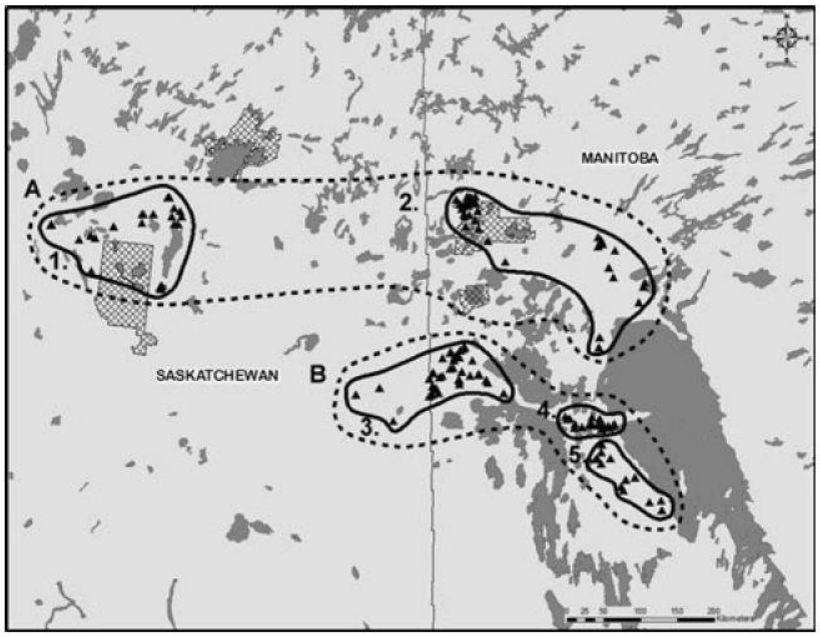

Figure 1. Genetic relatedness of local caribou populations at fine scale (solid line; 3 = Pasquia-Bog, 4 and 5 = North Inter-lake local populations) and coarse scale (dashed line; B = Pasquia-Bog and North Interlake, A represents other boreal plain populations that were sampled) (adapted from Ball *et al.* 2010).

In Saskatchewan, concentrations of historical caribou location data and configuration of landscape features (i.e. ecodistrict boundaries, peatland distribution, large waterbodies, permanent anthropogenic disturbance) were used to ecologically delineate local population distribution (Arsenault 2003, Arsenault & Manseau 2011). In Manitoba, historical caribou location data including satellite telemetry data (2002-2013) were used to delineate local populations (Maria Arlt, Manitoba Conservation, Pers. Comm., 11 March 2013).

The Pasquia-Bog caribou population is located at the southern periphery of caribou range in Saskatchewan (Arsenault 2003) and Manitoba (Manitoba Conservation 2005). Populations at the periphery of their geographical range tend to be most susceptible to environmental change and habitat degradation (Channell & Lomolino 2000, Schaefer 2003, Environment Canada 2012 Murray *et al.* 2012). If population size is small and gene flow is limited, genetic drift effects (loss of genes and genetic heterogeneity) will increase, causing a decreased effective population size and reduced fitness from inbreeding depression (reduced survival and fertility of offspring).

3.3 AREA OF ASSESSMENT

Within the Saskatchewan and Manitoba CBFA planning area, this document defines the Area of Assessment (AOA) for caribou conservation planning to be the local population distribution and surrounding habitat matrix delineated within the ecodistrict areas encompassed by the Pasquia-Bog Caribou Range boundary (Figure 2).

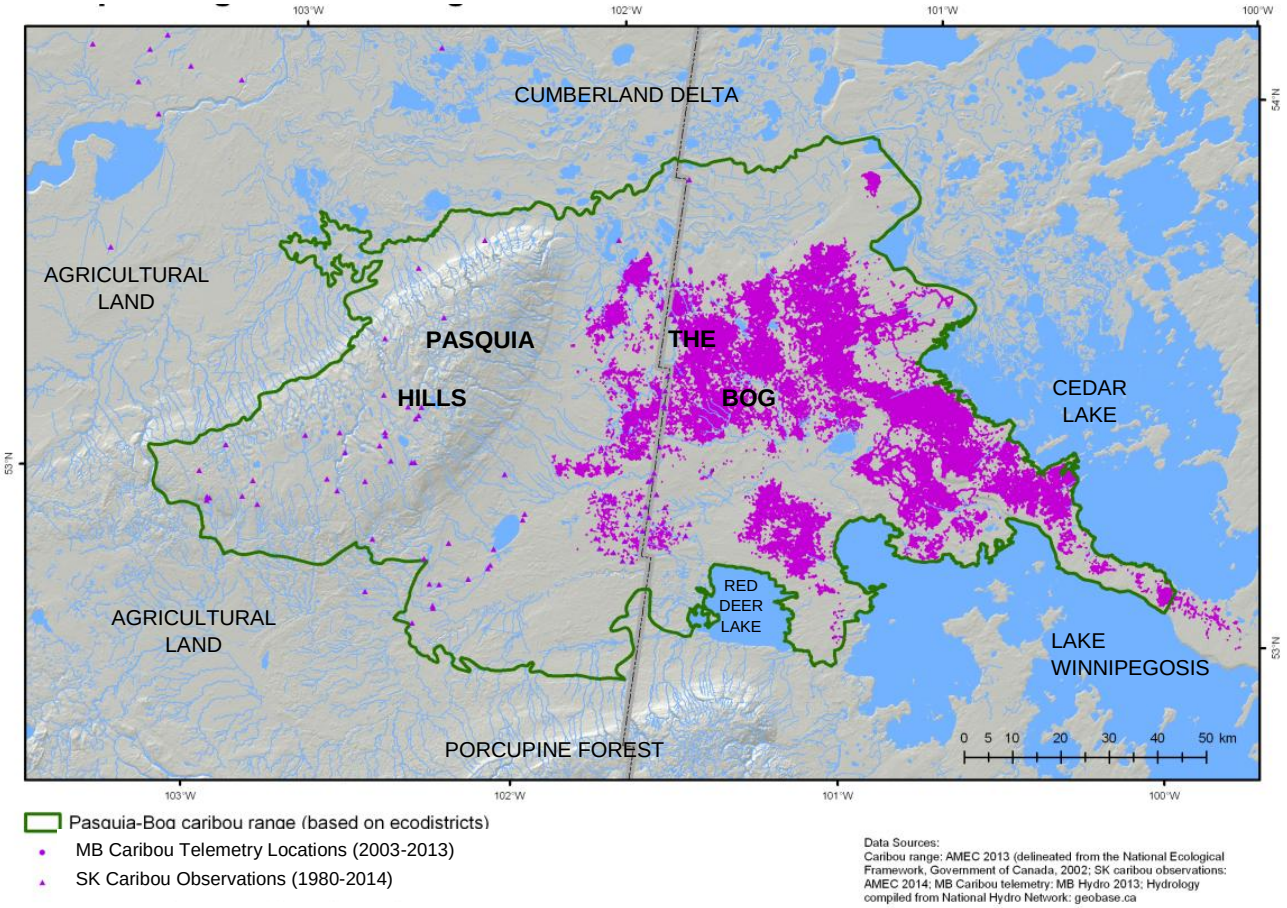

Figure 2. Area of Assessment (AOA) for the Pasquia-Bog Caribou Range Planning Area.

Caribou within the Pasquia-Bog Caribou Range occur along the southern extent of caribou range on the Boreal Plain in Canada (Environment Canada 2012). The Pasquia-Bog Caribou Range is bounded by surrounding agricultural land to the northwest, west and southwest, by the Cumberland Delta and agricultural land along the north, and by large lakes (Cedar Lake/Reservoir, Lake Winnipegosis and Red Deer Lake) along on the northeast and southeast boundary (Figure 2). Collectively the Pasquia-Bog Caribou Range is characterized as isolated by natural and anthropogenic barriers and high risk habitats, with limited landscape connectivity to adjacent caribou population ranges.

The Cumberland Delta (Figure 2; ecodistricts F4 and 669) is a large area of generally unsuitable caribou habitat that historically supported a high density moose population. It represents a high predation-risk landscape to caribou and is a relatively impermeable barrier to connectivity with local caribou populations to the north.

The west and south facing slopes of the Pasquia Hills (Figure 2; ecodistrict E27) largely consists of upland deciduous dominated forest cover that supports high density moose, elk and white-tailed deer populations, representing a high predation-risk zone for caribou.

A narrow corridor of land between Cedar Lake and Lake Winnipegosis (Figure 2; ecodistrict 668) is a probable movement corridor providing genetic linkage of the Pasquia-Bog Caribou Range with the North Interlake Caribou Range.

The Porcupine Forest (Figure 2; ecodistricts E29 and 152) are located immediately south of the Pasquia-Bog Caribou Range. The Porcupine Forest is a hardwood dominated forest landscape almost entirely surrounded by agricultural land, supporting some of the highest densities of moose, elk and white-tailed deer in Saskatchewan. There are some potential preferred caribou habitat patches (particularly on the Manitoba side), but the Porcupine Hills is probably functioning as a population sink for caribou because of the high mortality-risk and relatively limited amount of preferred caribou habitat.

3.4 AREA OF IMPLEMENTATION

The Area of Implementation (AOI) is defined as the overlap between the AOA and forest harvest tenures (Figure 3). This represents the effective portion of the AOA that the CBFA can have a direct influence or affect on forestry-related land use. The forest harvest tenures include:

- Pasquia-Porcupine Forest Management Area (Saskatchewan) – co-managed by Weyerhaeuser Canada Ltd. and Edgewood Forest Products,
- Forest Management Lease Area 2 (Manitoba) – managed by Tolko Industries Ltd.

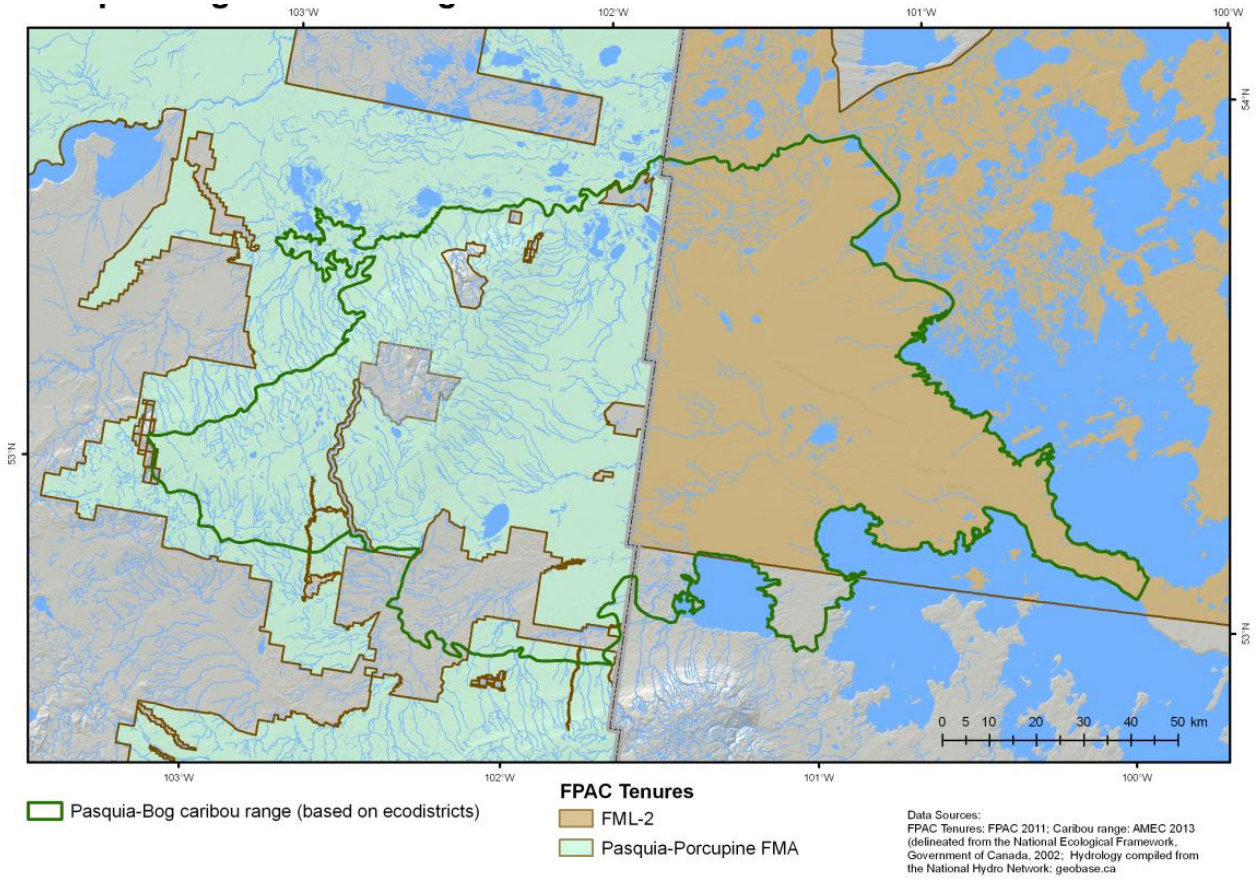

Figure 3. Area of Implementation (AOI).

4.0 CURRENT STATE OF KNOWLEDGE OF RANGE

4.1 PASQUIA-BOG LOCAL POPULATION STATUS

The population for this inter-jurisdictional population is estimated to be 225-275 caribou (Table 2). However, non-invasive genetic mark-recapture methods (see Hettinga *et al.* 2012) are recommended to attain a more precise estimate.

Table 2. Pasquia-Bog Caribou Range population estimate.

Source of Estimate	Saskatchewan	Manitoba
Mid-1990s estimates for Saskatchewan (Godwin & Thorpe 2000, Arsenault 2003)	20-40	
Estimate based on 0.02-0.03 caribou/km² (Environment Canada 2012) for 2,211 km² of occupied preferred habitat	44-66	
Estimate based on provincial mean density (0.037/km^2) for 2,211 km^2 of occupied preferred habitat	81	
Best Guess	**50-75**	
Manitoba Conservation estimate based on minimum counts 2010 (n = 121); 2011 (n = 113) **Best Guess**		**175-200**
Pasquia-Bog Population Estimate (near MVP (238-300) at fine landscape scale)	**225 – 275 (0.030 – 0.037/km²)**	
MVP (Arsenault & Manseau 2011)	238 (Closed Pop)	
MVP (Environment Canada 2012)	300 (Closed Pop)	
Hettinga *et al.* 2012 (n = 180 and declining λ=0.90) Ball *et al.* 2010 (North Interlake is genetically connected to Pasquia-Bog at course landscape scale)	180	
Pasquia-Bog + North Interlake Population Estimate (exceeds MVP (238-300) at coarse landscape scale)	**400 - 450**	

** based on population estimate using area (km²) of CZs + SMs (see section 7.0).

The Pasquia-Bog population estimate (225-275 caribou) approaches the minimum viable population (MVP) threshold of 238 (Arsenault & Manseau 2011) or 300 (Environment Canada 2008) for a closed population (Table 2). However, the Pasquia-Bog local population is genetically linked at a coarse landscape scale to the North Interlake local population in Manitoba (Ball *et al.* 2010). The North Interlake local population is estimated to be 180 caribou with indication of population decline (λ=0.90) (Hettinga *et al.* 2012). Environment Canada (2012) categorizes the North Interlake population and the Manitoba portion of the Pasquia-Bog local populations as stable with a risk assessment of NSS/SS (not self sustaining – self sustaining). Collectively, these local populations (n = 400-450) at the coarse landscape scale are near the MVP threshold (238 – 300) for a closed population. Long-term persistence of the Pasquia-Bog

local population is likely dependent on maintaining genetic connectivity with the North Interlake local population at a coarse landscape scale.

4.2 BEST AVAILABLE HABITAT

Best available habitat is defined as areas of suitable habitat within a caribou range where the probability of caribou persistence is enhanced (Antoniuk *et al.* 2012). These areas would ideally be >250 km², but no smaller than 100 km² in size, contain continuous habitat with no or limited anthropogenic footprint, have a lower perimeter to area ratio, provide spatial separation from predators and high density ungulate species and have low potential for competing human uses (Antoniuk *et al.* 2012). Lesmerises *et al.* (2013) found that caribou occurrence and intensity of use within a patch was influenced by patch size and composition, with probability of use >75% attained at a patch size of 270 km². They also reported that patch sizes <100 km² functioned as ecological traps that resulted in concentration of caribou activities causing increased predation risk.

Maintaining a long-term self-sustaining caribou population is dependent upon maintaining connectivity within and between caribou ranges (Environment Canada 2012). Therefore, protected areas and movement corridors should ensure a high level of functional habitat connectivity.

4.2.1 SCALE EFFECTS

The boreal forest landscape is naturally dynamic with specific habitat components having a functional role at different spatial and temporal scales which are necessary to assure persistence of local woodland caribou populations (Johnson 1980, Rettie & Messier 2000, Racey & Arsenault 2007, Arsenault & Manseau 2012). For example, caribou avoid forest cut blocks at broad scales (1st order selection, which represent the species range or population range spatial scales) and avoid linear features at fine scales (2nd order selection, which represents an individual's home range scale, or 3rd order selection, which represents a habitat patch scale) (DeCesare *et al*. 2012, Johnson 1980).

4.2.1.1 Population Range Scale (Area of Assessment)

The population range is equivalent to the area of assessment in this document. Population range is defined as a large landscape capable of supporting a self-sustaining caribou population over multiple generations. It is composed of one or more phylogenetically indistinguishable, spatially-related local populations occupying an ecologically delineated geographical region.

Best available habitat at this scale provides:

- A sustainable habitat supply to support a self-sustaining caribou population over multiple generations,
- Alternative/redundant habitat to accommodate caribou displacement by disturbance factors,
- Functional landscape connectivity facilitating gene flow and seasonal movements among core use areas within the caribou range through movement corridors,
- Security and space for anti-predator strategies to operate through avoidance of areas on the landscape that support higher densities of alternative prey, thereby reducing predation risk.

Critical habitat function at this scale is related to habitat supply, landscape configuration and connectivity over multiple generations. Population emigration and immigration rates are partly determined by the boundary-crossing probability (i.e. landscape connectivity) among preferred habitat patches and caribou core use areas within the landscape matrix, and are directly affected by the amount and type of habitat fragmentation as well as inter-patch distance (Tischendorf *et al*. 2005). Landscape connectivity is important for animal dispersal and gene flow in fragmented landscapes (Wang *et al*. 2008). Landscape connectivity at the population range scale is crucial to caribou survival. Maintaining a long-term self-sustaining caribou population is dependent upon maintaining connectivity within and between caribou ranges (Environment Canada 2012). The landscape must be large enough to allow for landscape dynamics to operate (e.g. wildfire, vegetation succession, and habitat replacement) and ensure provision of alternative suitable habitat to minimize mortality risk. Minimum reserve size for protected areas for disturbance-sensitive mammals is 5,000 km² (Nudds & Wiersma 2004). Minimum range size for boreal caribou to support a minimum viable population at natural level of abundance and distribution is 10,000 – 15,000 km² (Badiou *et al.* 2011, Environment Canada 2012). Reducing the amount of habitat and habitat connectivity, limits the resilience and capability of a caribou population to cope with landscape disturbances (Vistnes & Nellemann 2008). Caribou seem capable of moving among habitat patches spaces up to about 1,000 m from each other (Johnson *et al*. 2002, O'Brien *et al*. 2006) and use movement corridors as narrow as 300 to 400 m (Courtois *et al*. 2008).

Measures to effectively protect critical habitat at the range scale include landscape management to ensure cumulative disturbance does not exceed thresholds of tolerance, and that there is an adequate supply and function of habitat (present, future and alternate), including protected areas. Therefore, habitat planning targets are required at this scale. Environment Canada (2012) recommends a minimum threshold level of >65% undisturbed habitat within a caribou range to attain a 60% probability of long-term population persistence.

4.2.1.2 Local Population Range Scale (Caribou Conservation Zones)

A local population is defined as a geographically discrete area occupied by a distinct aggregation of potentially interbreeding individuals with overlapping home ranges, and distinguished spatially from areas occupied by other local populations such that population dynamics are primarily driven by local factors affecting birth and death rates, rather than immigration and emigration (Sokal 1973, Fahrig & Marriam 1994, Thomas & Kunin 1999, Schaefer *et al*. 2001, Arsenault 2003, Cronin 2003, Environment Canada 2008, Arsenault & Manseau 2011).

The areas delineated as caribou conservation zones represent the "minimum functional" habitat area required to sustain the caribou population at current size and distribution within the AOA. Functional habitat should be of sufficient age to provide winter forage, have comparatively small areas of young forest with lower levels of disturbance and predation-risk relative to the areas outside of the caribou conservation zones (Antoniuk *et al.* 2012).

Best available habitat at this scale consists of complexes of preferred habitat patches of lichen-rich open softwood peatlands and mature (>60 years) upland open jackpine with arboreal and terrestrial lichen, within a matrix of well connected mature conifer-dominated forest cover, offering the critical habitat functions of:

- Provision of habitat for predator avoidance, home range occupancy and persistence of caribou demes (herd groups),
- Redundancy in habitat availability to respond to local threats or disturbance (e.g. roads, fire),
- Seasonal abundance of forage resources,
- Connectivity to facilitate effective accessibility to preferred habitat patches home range.

Critical habitat function at this scale is related to habitat composition and configuration, and is limited by disturbance. Functionally valuable habitat remnants (>100-250 km²) of contiguous, undisturbed, intact winter habitat that is well connected is of greater value than small (<50 km²) remnants (Gurd *et al.* 2001, Courtois *et al.* 2004, O'Brien *et al*. 2006, Courtois *et al.* 2007, Courtois *et al.* 2008, Fortin *et al.* 2008, Arsenault & Manseau 2012). Boreal caribou use a variety of habitats to avoid predators, including muskegs, bodies of water, as well as mature and old-growth forests (Environment Canada 2012). They also preferentially select lichen-rich habitat patches and avoid early-stage successional forests and recently disturbed areas, which tend to attract other ungulate species and their associated predators (Schaefer & Pruitt 1991, Rettie & Messier 2000, Arsenault & Manseau 2011, Environment Canada 2012).

4.2.1.3 Habitat Patch Scale

A habitat patch is defined as any discrete area that is used by a species for breeding or for obtaining other resources (Fahrig & Merriam 1994). Woodland caribou require large residual forest patches within a relatively undisturbed matrix to achieve the low density of occurrence required for an effective predator avoidance strategy (Lesmerises *et al.* 2013). Preferred habitat patches typically have higher than expected use associated with desirable or effective habitat features in time and space (e.g. calving sites, foraging sites, security). Patch size, shape, quality, inter-patch distance and ease of movement among habitat patches can influence local population persistence, abundance, dispersal, and mortality-risk (Fahrig & Merriam 1994). This scale warrants management prescriptions with a high degree of protection and conservation that are consistent with the expected or planned dynamics of the AOA and local population range scales.

At the **habitat patch spatial scale**, best available habitat would consist of preferred habitat patches that offer critical habitat functions of:

- Security for effective predator avoidance (visibility for predator detection, escape cover),
- Forage quality and quantity for daily nutritional needs (lichen-rich habitat patches),
- Effective habitat for calving (isolation for reduced predation risk during calving and parturition),
- Refuge (for insect avoidance, predator avoidance, and extreme weather).

Factors that negatively affect critical habitat function at the habitat patch scale include disturbances resulting in separation of cows from their calves, or result in unnecessary movement or displacement of caribou into higher risk environments; habitat alteration that increases predation-risk, encourages predator efficiency, and/or increased numbers of alternate prey.

Effective protection measures at the habitat patch scale should encourage access management and habitat management in, and adjacent to, preferred high use areas and calving areas to

maintain the integrity of caribou habitat attributes (i.e. low predation risk/efficiency, low predator numbers enhanced forage abundance). This would include protecting sites or stands of conifers with high biomass of terrestrial lichens (Briand *et al.* 2009) in preferred high use areas. Land use activities at this scale should avoid linear corridor development into, or adjacent to, high use areas (e.g. clusters of preferred habitat patches); avoid displacement of caribou through direct or indirect disturbance during critical periods (e.g. 3rd trimester, calving, winter foraging), and in occupied habitat and high use areas; and avoid habitat alteration that accelerates decline, deterioration or reduction of habitat attributes that make high use areas desirable.

Landscapes with multiple caribou habitat patch clusters, and repeated use, likely indicate important habitat areas and/or movement corridors requiring spatially targeted protection. Clusters of well connected, preferred habitat would form the building blocks of potential protected areas within caribou conservation zones.

4.2.2 HABITAT PREFERENCE

Essential covertypes refer to those that are considered to be an important component for caribou survival and occur in sufficient size and configuration to be suitable and accessible for occupation. Lichen-rich ecosites (treed bogs, upland jackpine) are critical to providing winter forage within lower predation-risk habitats. Spring/calving habitats (upland conifer, poor and rich treed fens) offer greater forage quality.

A modified form of the Ducks Unlimited Enhanced Wetland Classification (EWC) was used for the habitat geobase (30 m resolution) (Smith *et al*. 2007). Two ecosite classifications (Beckingham *et al.* 1996, McLaughlan *et al.* 2010) were assessed for caribou preference based on vegetative characteristics (i.e. forage/lichen production and availability, dominant tree cover, shrub dominance) and suitability as caribou refuge (i.e. mortality risk and preference by other ungulate species). The ecosites were then categorized into EWC covertypes and assigned a caribou preference rating ranging from most preferred (+3) to most avoided (-3). The modified ECW covertypes are presented in Table 3 and are illustrated in Figure 4.

The resulting fine scale EWC caribou habitat preference model (Figure 4 and 5) had significant concordance with a coarse scale habitat model generated by Environment Canada using resource selection functions (Environment Canada 2011), and is also consistent with ecosite ratings derived by the Woodland Caribou Forest Ecosite Habitat Value workshop conducted by Saskatchewan Ministry of Environment in March 2013. Caribou range occupancy data was overlaid on the EWC caribou habitat preference model (Figure 6). The occupancy data was composed of telemetry data (2002-2013) from Manitoba, and long-term (1952-2010) occupancy data for Saskatchewan (per Arsenault & Manseau 2011), supplemented by additional local information compiled by Weyerhaeuser Canada Inc.

Table 3. Caribou habitat preference ratings of the EWC covertypes.

Ducks Unlimited Enhanced Wetland Covertype	Caribou Preference Rating	Caribou Habitat Characteristics
Upland Pine	+3	Lichen-rich mature (>40 yrs old) upland pine for annual forage, predator avoidance, low mortality risk, spatial separation from higher density cervid populations.
Upland Other	0	Matrix
Upland Mixedwood	-1	Low (conifer dominant) to High (deciduous dominant) predation risk
Upland Deciduous	-1	High predation risk
Upland Conifer	+1	Predator avoidance, low predation risk, spatial separation from higher density cervid populations.
Treed Bog	+3	Lichen-rich annual foraging habitat, predator avoidance, low mortality risk, spatial separation from higher density cervid populations.
Shrubby Bog	+2	Seasonal forage (spring, summer, calving), predator avoidance, low predation risk, spatial separation from higher density cervid populations.
Graminoid Bog	+1	Predator avoidance, low predation risk, spatial separation from higher density cervid populations.
Treed Rich Fen	+2	Calving habitat and foraging habitat
Treed Poor Fen	+2	Calving habitat and foraging habitat
Shrubby Rich Fen	+1	Calving habitat and foraging habitat
Shrubby Poor Fen	+1	Calving habitat and foraging habitat
Graminoid Rich Fen	0	Matrix
Graminoid Poor Fen	0	Matrix
Tamarack Swamp	+2	Winter foraging habitat, predator avoidance, low predation risk, spatial separation from higher density cervid populations.
Conifer Swamp	+2	Winter foraging habitat, predator avoidance, low predation risk, spatial separation from higher density cervid populations.
Mixedwood Swamp	0	Low (summer)-moderate (winter) predation risk
Hardwood Birch Swamp	0	Low (summer)-moderate (winter) predation risk
Shrub Swamp	-1	Low (summer)-moderate (winter) predation risk
Meadow Marsh	0	Predator avoidance
Mudflats	0	Moderate-high predation risk
Emergent Marsh	0	Predator avoidance
Aquatic Bed	0	Predator avoidance
Open Water	0	Insect relief, winter travel
Burn	-2	High predation risk (burns <40 yrs old)
Anthropogenic Influenced	-3	High predation risk
Agriculture	-3	No habitat

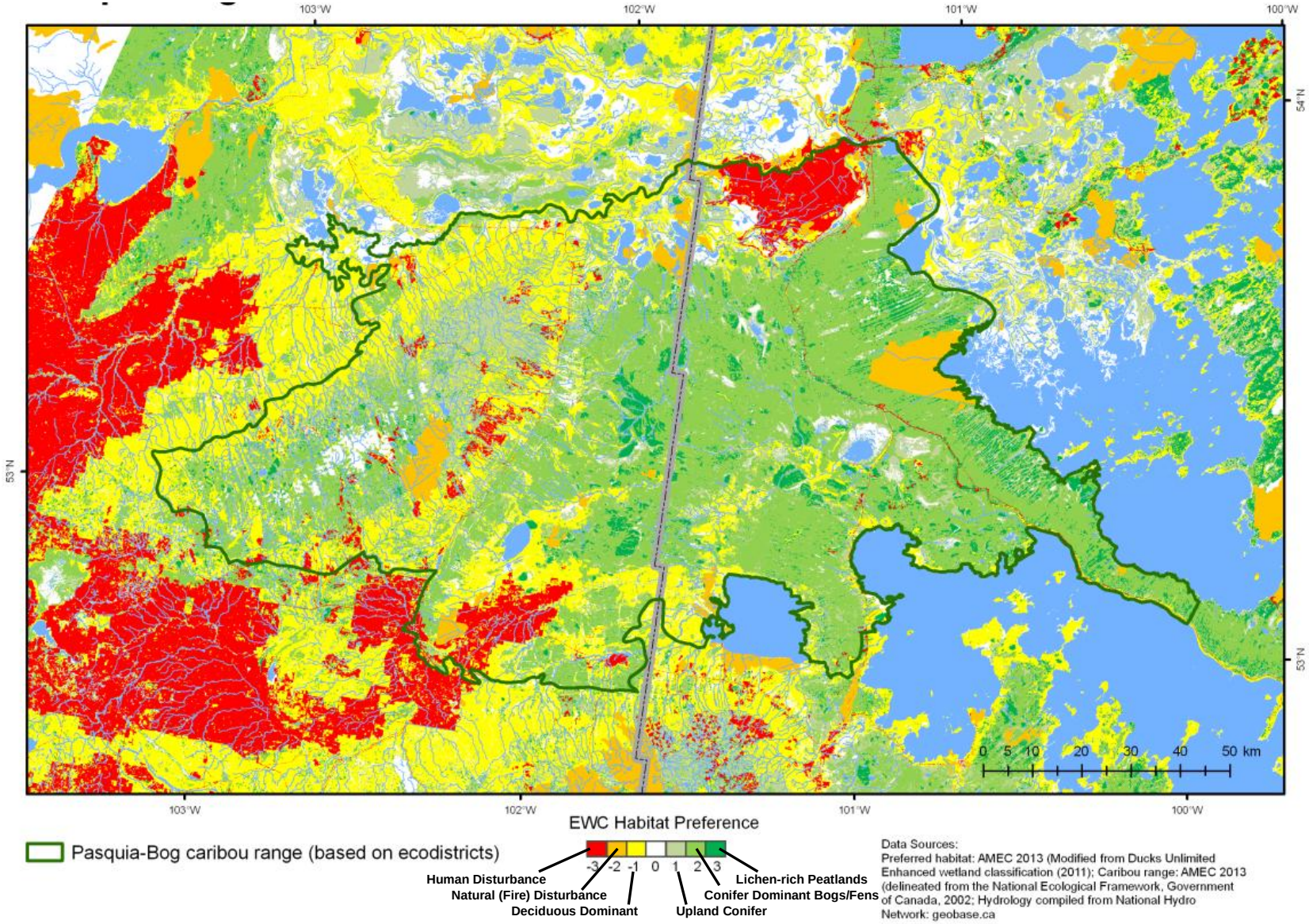

Figure 4. Caribou Habitat Preference Model based on the EWC geobase.

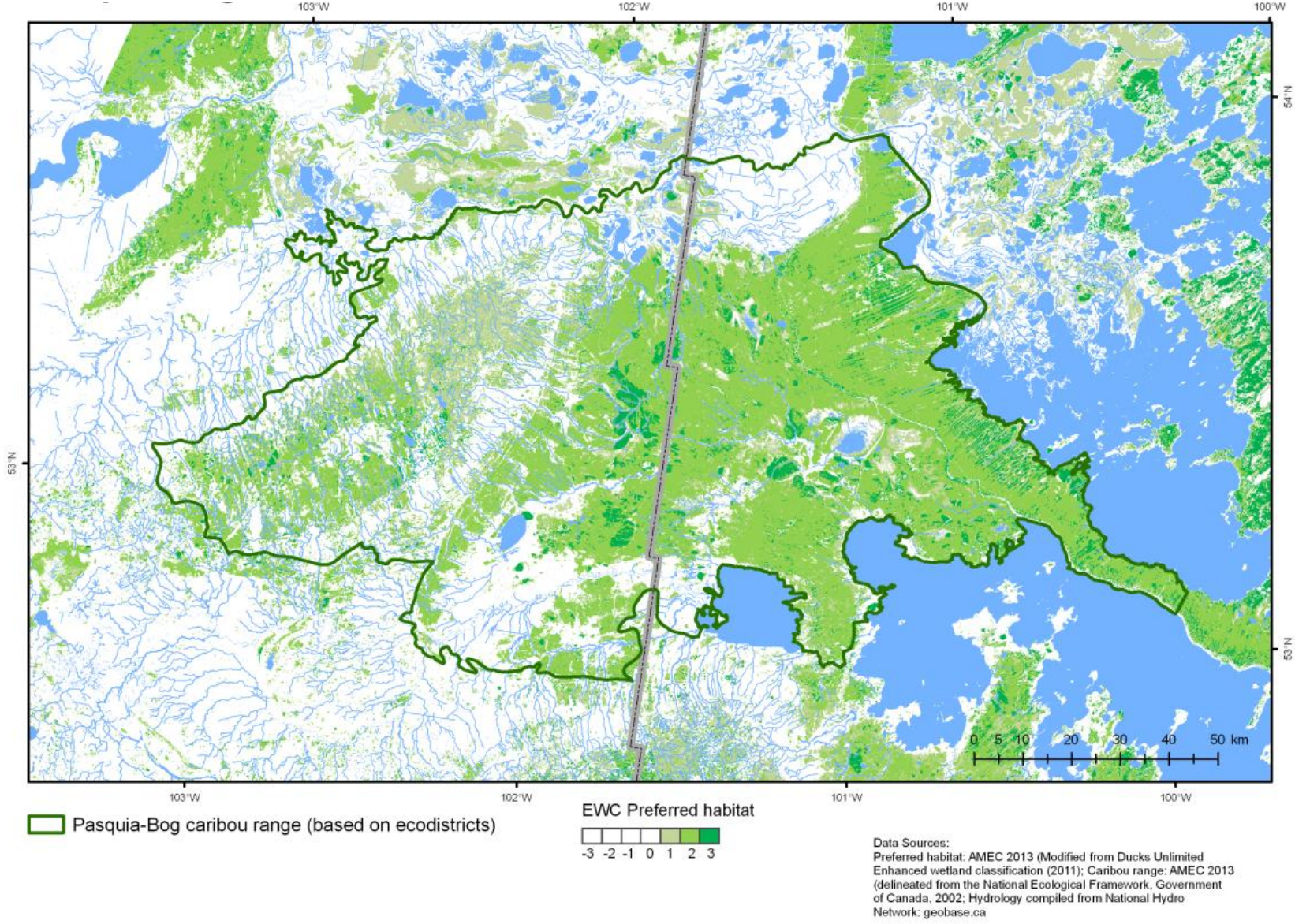

Figure 5. Distribution of preferred caribou habitat within the Pasquia-Bog Caribou Range.

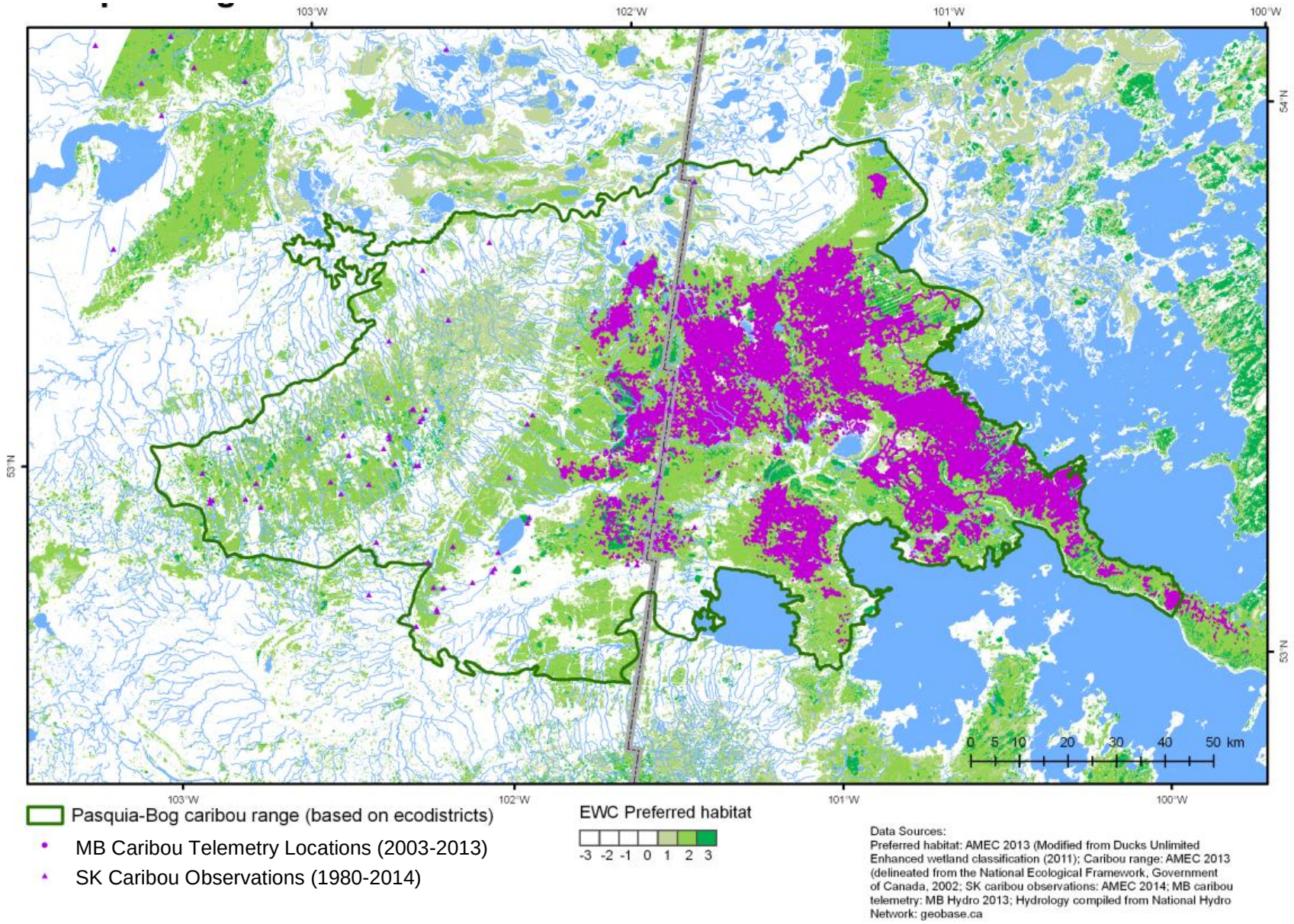

Figure 6. Caribou range occupancy in relation to preferred caribou habitat.

4.2.3 DISTURBANCE

Woodland caribou shift their use of habitat and their distribution within their range in response to various natural processes (wildfire, forage availability, weather) and human activities (development, logging, recreation) (Environment Canada 2012). The influences of natural and anthropogenic landscape alteration and disturbance on woodland caribou range use and occupancy includes documented range shifts following wildfire (Schaefer & Pruitt 1991), logging (Rettie & Messier 1998, Smith *et al.* 2000, Vors *et al*. 2007, Arlt & Manseau 2011), and industrial development (Dyer *et al*. 2001, Nellemann *et al*. 2003, Weir *et al*. 2007), as well as barrier and displacement effects of linear features (Rettie & Messier 1998, Dyer *et al*. 2002), increased predation risk (James 1999, James & Stuart-Smith 2000, James *et al*. 2004), and potentially increased energetic costs (Bradshaw *et al*. 1998). Landscape disturbance affects population growth and long-term sustainability (Sorensen *et al.* 2008, Sleep & Loehle 2010, Environment Canada 2012).

Woodland caribou population declines are characterized by a loss of landscape connectivity accompanied by declines in population size, constrictions in local range occupancy and potentially local extirpation and range recession (Schaefer 2003, Wilkinson 2008, Arsenault & Manseau 2011). Woodland caribou have a protracted time lag response to habitat change (Vors *et al.* 2007, Wilkinson 2008). Habitat fragmentation from disturbance results in habitat patch isolation and reduced patch size, thereby increasing the vulnerability of local populations to environmental and demographic threats. O'Brien *et al*. (2006) have shown the importance of landscape connectivity for woodland caribou and a strong selection for larger clusters of high quality habitat patches over the selection of a given high quality habitat patch.

Natural disturbance (wildfire) within and proximate to the Pasquia-Bog Caribou Range is illustrated in Figure 7. Wildfire is a natural process of habitat disturbance that has always been a dominant force shaping boreal ecosystems. Numerous species (including boreal caribou) have evolved in this fire-driven boreal landscape, and rely on fire as a driver for habitat renewal and creation necessary for long-term boreal ecosystem function, integrity and biodiversity. Wildfires in the boreal forest landscape, and fire burn patterns, are patchy because of variability of several factors which include timing, occurrence, intensity, severity, moisture regime, weather, type (crown versus ground), landscape configuration and available fuel (Dalerum *et al.* 2007, Parisien *et al.* 2004). This patchiness results in retention of areas of significant suitable habitat value for caribou to persist. They include low/wet areas such as lichen-rich peatlands, fens and bogs; lakeshores; riparian habitats and ravines (Dalerum *et al.* 2007, Kelsall *et al.* 1977). These low/wet areas are widespread in the boreal forest and are resistant to the effects of fire, particularly fire frequency and fire intensity (Kelsall *et al.* 1977). These are also habitat patches with the greatest lichen production. At large spatial and temporal scales caribou have evolved to cope with natural disturbances by avoiding them or selectively using them at finer scales. Boreal caribou will make use of lichen-rich patches retained within large burns, and are able to traverse or avoid smaller bum patches to access preferred habitat patches. Small and medium sized-burns are easily traversed by caribou and do not have a direct effect on spatial distribution of local populations (Dalerum *et al.* 2007).

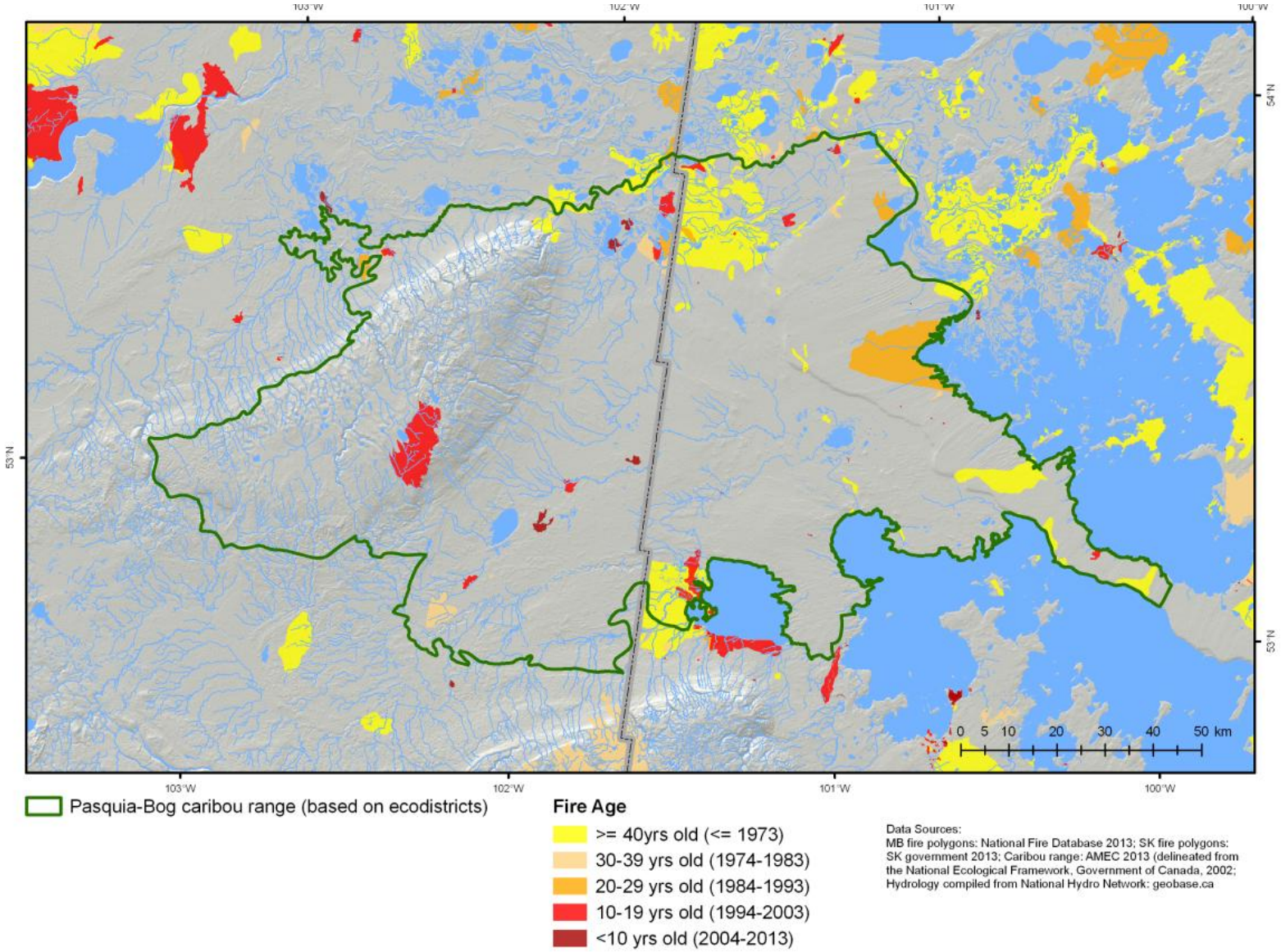

Figure 7. Distribution of fires within and proximate to the Pasquia-Bog Caribou Range.

Anthropogenic linear features are perceived by caribou as semi-permeable barriers, with permeability being a function of amount of human use (e.g. traffic frequency, noise), and obtrusiveness (e.g. width, permanence). Functional caribou habitat loss is associated with linear disturbance (Environment Canada 2012, Dyer *et al.* 2001, Sorensen *et al.* 2008), with the avoidance effects up to 500 m. Dyer (1999) reported maximum avoidance distances of 250m from roads and seismic lines in caribou habitat encroached by resource extraction industries (oil, gas, forestry and peat). Wasser *et al.* (2011) demonstrated that functional habitat loss from linear features was most likely related to the degree of human use of the linear feature, rather than the presence of the linear feature alone. Wasser *et al.* (2011) reported that greatest displacement of caribou from suitable habitat was in proximity to active primary (e.g. highways) roads. Relative to primary roads, Wasser *et al.* (2011) reported a reduced effect on reduction of caribou resource selection proximate to secondary (i.e. all-season) roads, and that this effect was about twice that of tertiary (i.e. seasonal/low frequency use/exploration) roads. Further they report selection of linear features with no (or limited) human use. Linear disturbance density is directly correlated with calf predation risk, with respect to proximity at the (home range) scale (James & Stuart-Smith 2000, Whittington *et al.* 2011), and density at the landscape (population range) scale (Sorensen *et al*. 2008, Dussault *et al.* 2012). Winter habitat with road densities >0.12 km/km² tend to be avoided (Fortin et al. 2008), with highly clustered use of landscapes characterized by road densities of 0.35 km/km² (Arsenault & Manseau 2011). Linear disturbances within caribou range increases predator search and efficiency rates through increased speed, mobility and line-of-sight (James 1999), and increased wolf-caribou encounter rates proximate to linear disturbances (Latham *et al*. 2011, Whittington *et al.* 2011, DeCaesare 2012, Dussault *et al.* 2012, Mckenzie *et al.* 2012).

The Environment Canada disturbance geobase (Environment Canada 2012) was used as the primary basis of applying a disturbance footprint to the Pasquia-Bog Caribou Range (Figure 8). This was supplemented with recent (2010 to present) disturbance information acquired from local data sets that were considered to be comparable to those captured by the Environment Canada methodology. Disturbance types were partitioned into the categories to more precisely characterise the relative effects on caribou (see Table 4).

The Pasquia-Bog Caribou Range (AOA) totals 12,640 km² in spatial extent (Appendix A). Based on the Environment Canada (2011, 2012) disturbance geospatial coverage, there are 3,342 km² of anthropogenic disturbance (i.e. includes a 500 m buffer around linear disturbance) overlapping with 1,088 km² of natural disturbance (i.e. wildfires) resulting in a cumulative total disturbance of 4,130 km² (32.7% disturbed). Based on the Environment Canada (2012) disturbance threshold model, fire $\geq$40 years old are excluded as disturbance. Therefore, removal of these older fires results in a cumulative disturbance level of 27.8%, which equates to a 70% probability of caribou persistence when the Environment Canada (2012) disturbance threshold model is applied.

Table 4. Disturbance types occurring in the Pasquia-Bog Caribou Range.

Type	Natural Disturbance (No buffer)	Anthropogenic Disturbance (500 m buffer)
Permanent	Not applicable	Linear (e.g. highways, railway lines, all season roads, seasonal/snowmobile trails, utility corridors)
	Not applicable	Polygonal (e.g. recreational leases, agriculture, peat mines, oil & gas wells, settlement, hydroelectric reservoirs/no buffer)
Temporary	Wildfire - New, (<10 yrs; 2004-2013)	Cutover (New, < 10 yrs)
	Wildfire - Young Regenerating (10-19 yrs; 1994-2003)	Cutover (Young Regenerating, 10-19 yrs; 1994-2003)
	Wildfire - Intermediate Regenerating (20-29 yrs; 1984-1993)	Cutover (Intermediate Regenerating, 20-29 yrs; 1984-1993)
	Wildfire - Old Regenerating (30-39 yrs, (1974-1983)	Cutover (Old Regenerating, 30-39 yrs, (1974-1983)
	Wildfire - Regenerated (>40 yrs; ≤1973)	Cutover (Regenerated, >40 yrs)
Future Disturbance	Unknown	Mineral exploration claims/dispositions Oil & Gas leases Planned utility corridors (e.g. Bipole III Transmission Line)

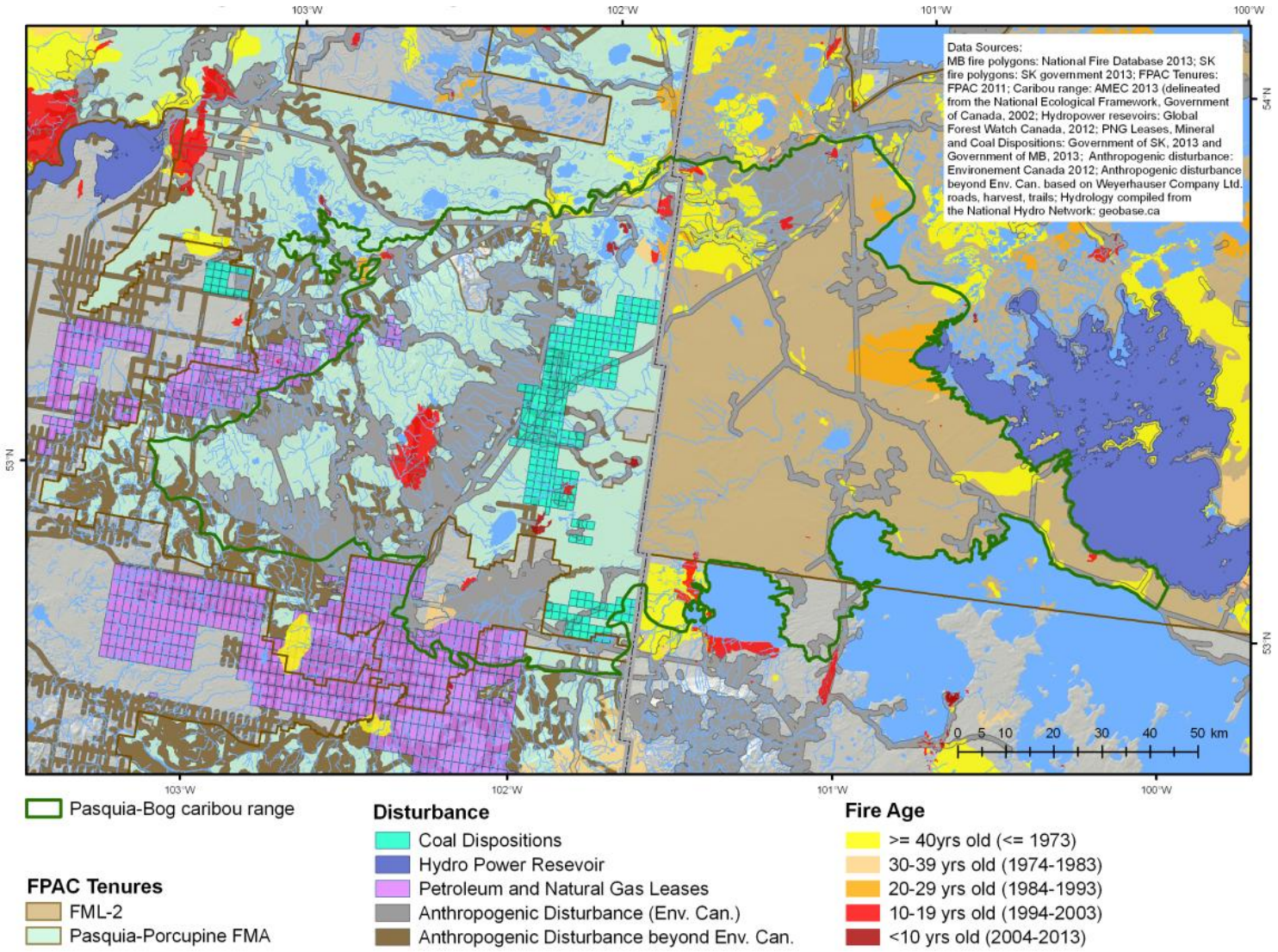

Figure 8. Distribution of anthropogenic disturbance (per the Environment Canada 2011 disturbance layer) and potential land disturbance within and proximate to the Pasquia-Bog Caribou Range.

4.3 PRINCIPLE LAND USE OCCUPANTS

Land use was determined from several provincial geobases that provide information on the distribution of principle land use occupants (Figure 8). Principle land use occupants within the AOA include:

- Forest Industry Weyerhauser Canada Inc. (SK), Edgewood (SK) Tolko (MB),
- Peat Mining Industry – Premier Peat (SK),
- Mining leases, and mineral exploration claims and dispositions,
- First Nations Communities (OCN, Cumberland House, Red Earth, Shoal Lake),
- Recreational cabin owners,
- Provincial Highways (Hwy 9, Hwy 55, Hwy 10),
- Canadian National Railway,
- Utility corridors (Manitoba Hydro Bipole III),
- Local communities (Hudson Bay, Chemong, The Pas).

4.4 PROTECTED AREAS

Protection of caribou habitat is an important component of recovery efforts, given the influence of anthropogenic disturbances in the decline of caribou populations (James & Stuart-Smith 2000, Schaefer 2003, Vors *et al*. 2007, Courtois *et al.* 2007, Sorensen *et al.* 2008, Arsenault & Manseau 2011, Festa-Bianchet *et al*. 2011, Environment Canada 2012, Schneider *et al.* 2012). Protected areas are clearly defined geographical space that is managed for the long-term (or permanent) protection of biological values and ecosystem processes (Strittholt & Leroux 2012). Buffering for uncertainty is essential (Badiou *et al.* 2011), therefore protected areas offer insurance against unfavourable outcomes. Conservation gains can be achieved through integrated conservation planning by preferentially selecting protection units that achieve caribou targets at the caribou range scale, and ecosystem representation targets at the ecoregion scale (Schneider *et al.* 2012).

The CBFA protected areas planning process applies a “whole-landscape” approach using guidance from the Conservation Matrix Model (CMM) developed by the Canadian BEACONs Project (http://www.beaconsproject.ca) to undertake a boreal-wide evaluation of the existing protected areas network in Canada's boreal region with respect to representation of ecosystem diversity and provision of ecological benchmarks. This Pan-boreal Assessment identifies gaps in representation of the existing protected areas network using a suite of broad-scale biophysical indicators and identifies opportunities for establishment of ecological benchmarks based on standardized ecological criteria (Strittholt & Leroux 2012). This process is implemented at a broad landscape scale within the spatial hierarchy of the National Ecological Framework to attain ecological representation, and incorporates caribou in the decision-making criteria through a MARXAN (http://www.ebmtools.org/marxan.html) analysis. However, at a finer-scale (AOA) and caribou-specific focus, additional protected areas assessment is required to ensure protected areas capture critical habitat for caribou.

Woodland caribou tend to select boreal forest habitat types with low biodiversity.

Figure 9 presents protected areas within the Pasquia-Bog Caribou Range (AOA). Existing protected areas within the AOA include lands designated within the following categories for each province includes:

- Saskatchewan Representative Areas Network (RAN) lands designated as ecological reserve, protected area, natural environment park, wilderness park,
- Saskatchewan Crown Lands with a *Wildlife Habitat Protection Act* designation,
- Manitoba lands designated as ecological reserve.

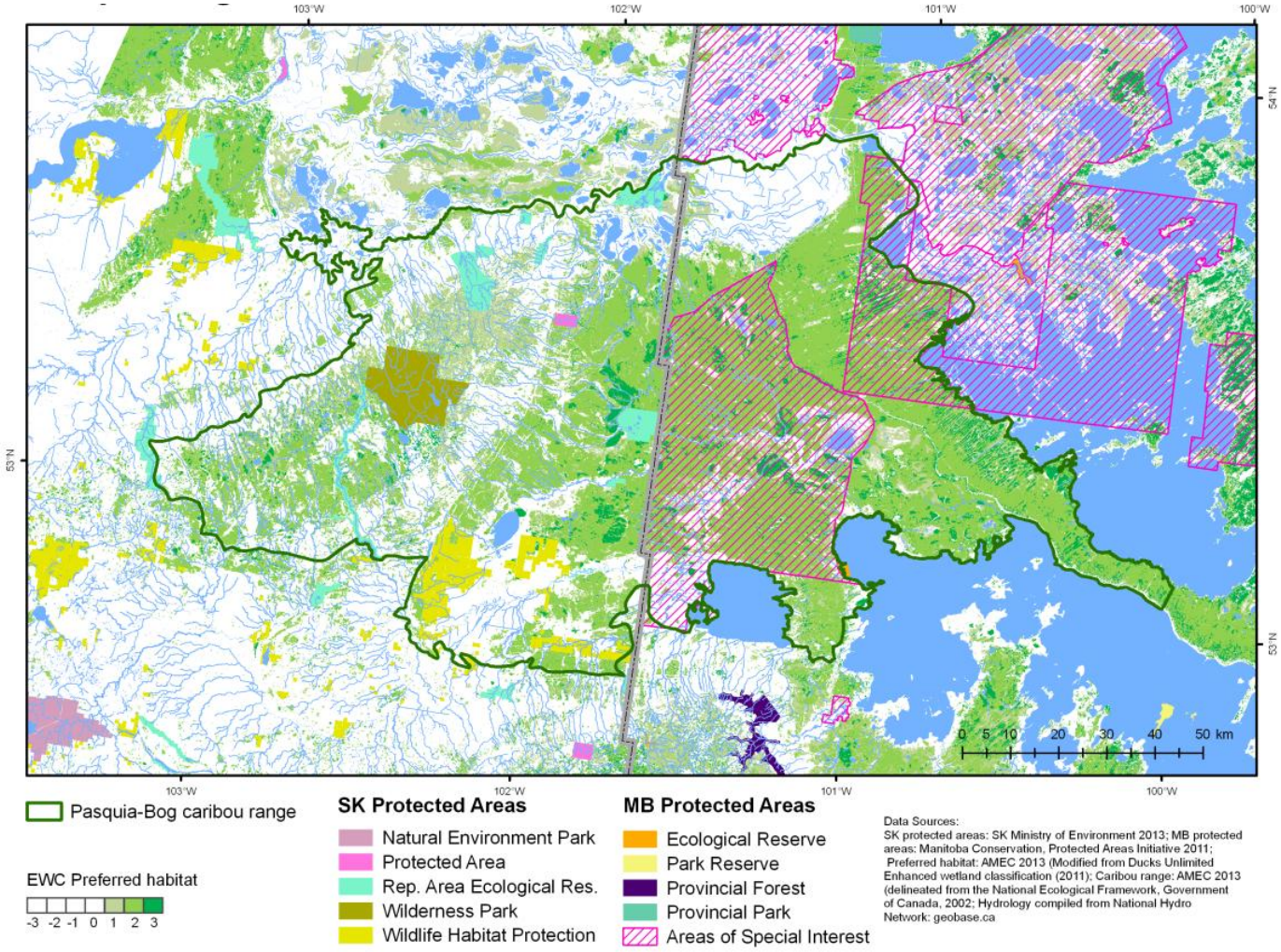

Figure 9. Spatial distribution of existing areas of protection relative to preferred caribou habitat.

5.0 FUTURE CONDITION OF RANGE

Climate change predicts a northward shift or recession of geographic range for caribou. The Pasquia-Bog Caribou Range is at the southern periphery of their geographic range. Wildlife populations (including woodland caribou) at the periphery of their range often are the most susceptible to habitat degradation and environmental change. This can result in compromised population growth, low survival of young and adults, low productivity, nutritional deficiency from a paucity of preferred and accessible forage sources, atypical movements and behaviour patterns from disturbance, and poor genetic diversity because of low landscape connectivity and poor connectivity to other populations (Murray *et al.* 2012).

Climate change, anthropogenic land use and future natural disturbance events are anticipated to continue and likely increase across the Pasquia-Bog Caribou Range (AOA). Therefore, careful and integrated land management is necessary to ensure caribou persist on the AOA over the long-term at natural levels of abundance and occurrence across functionally connected preferred habitats. The current level of human disturbance should be periodically quantified to confirm habitat objectives are being met at the range scale (Arsenault & Manseau 2011).

6.0 NATURE OF PROVINCIAL GOVERNMENT CARIBOU CONSERVATION ACTIONS IN THE RANGE

6.1 SASKATCHEWAN

Saskatchewan has not undertaken specific caribou conservation actions in the Pasquia-Bog Caribou Range, with the exception of the provincial environmental assessment screening and approval process for exploration activities (e.g. oil, gas, coal, minerals), development proposals (e.g. peat extraction), and renewable resource extraction (i.e. timber harvest). Range occupancy assessment and genetic studies have occurred in the Pasquia-Bog range (Arsenault & Manseau 2011, Ball *et al.* 2010). Saskatchewan has shifted from the local population range delineation and management unit structure (Arsenault 2003, Arsenault 2009) to a 2-zone, broad scale ecozone (Boreal Plain, Boreal Shield) range delineation (Saskatchewan Environment 2014, Environment Canada 2012), which includes substantial areas that are not, and are unlikely to ever be caribou habitat. The Saskatchewan portion of the Pasquia-Bog Caribou Range is a small component of the Boreal Plain Caribou Range. Consequently, conservation action planning for this inter-jurisdictional local population is unlikely to be effective at the current broad scale that Saskatchewan currently has implemented.

6.2 MANITOBA

Manitoba has delineated local population distribution within a caribou management unit structure and has undertaken extensive telemetry and genetic studies to inform their local population range delineations (Maria Arlt, Manitoba Conservation, Personal Communication, 11 March 2013). This includes the Manitoba portion of the Pasquia-Bog local population. Manitoba has not undertaken caribou conservation actions in the Pasquia-Bog Caribou Range, with the exception of assessing population size and genetic health. The boundary of the Manitoba portion of the Pasquia-Bog Caribou Range is consistent with the current Manitoba Caribou Recovery Strategy (MBWCMC 2014).

7.0 RECOMMENDED MANAGEMENT MEASURES

7.1 MANAGEMENT SYSTEM – DISTURBANCE THRESHOLD APPROACH

Management choices usually involve manipulation of habitats either to enhance the value of an area for wildlife or for other purposes such as timber harvest that influence the presence of wildlife (Sauer *et al.* 2013). Limitations of land-use based effects on habitat function help to sustain or restore desired landscape conditions while still allowing economic and social objectives to be met (Antoniuk *et al.* 2012). The most effective and practical approach to achieve caribou conservation, economic, and social values is to link disturbance thresholds to land management zones (Antoniuk *et al.* 2012).

A three-zone land management system is proposed for the Pasquia-Bog Caribou Range (AOA) to maximize flexibility in land management options (Figure 10). The three zone types consist of:

1) Caribou Conservation Zones (conservation emphasis),
2) Special Management Zones (conservation emphasis with limited development),
3) Development Zones (economic emphasis).

Within this land management system, disturbance levels are assessed at a resolution consistent with that of the Environment Canada (2012) disturbance threshold model. Specifically, anthropogenic disturbance would be buffered by a specific distance depending on disturbance type, to account for functional habitat loss; natural disturbance would not be buffered. Disturbed areas of former suitable and occupied caribou habitat would not be considered "recovered" until it is suitable to support caribou and re-occupied at least on a seasonal basis. A disturbance threshold approach for each zone type is proposed in the following sections.

7.1.1 Caribou Conservation Zone (CZ)

Caribou Conservation Zones (CZ) represent the "minimum functional" habitat area required to sustain the caribou population at current size and distribution within the Pasquia-Bog Caribou Range (AOA). They would be managed with a protection and conservation emphasis within a natural disturbance regime, to protect the ecological integrity of high quality preferred caribou habitat (lichen-rich treed peatlands, mature upland jackpine, calving habitat, winter habitat), maintain an adequate supply of high quality habitat, and ensure critical habitat function at relevant spatial and temporal scales. The highest priority for active caribou habitat restoration activities and protection within the Pasquia-Bog Caribou Range would be for this zone type.

Current disturbance levels for this zone type are summarized in Table 5. Within this zone type, creation of new permanent anthropogenic disturbance would be avoided and existing anthropogenic disturbance reclaimed to attain:

- **a minimum habitat disturbance threshold of ≤15%** (all disturbance types pooled; all CZs pooled), and
- **no individual CZ exceeding 35% disturbed.**

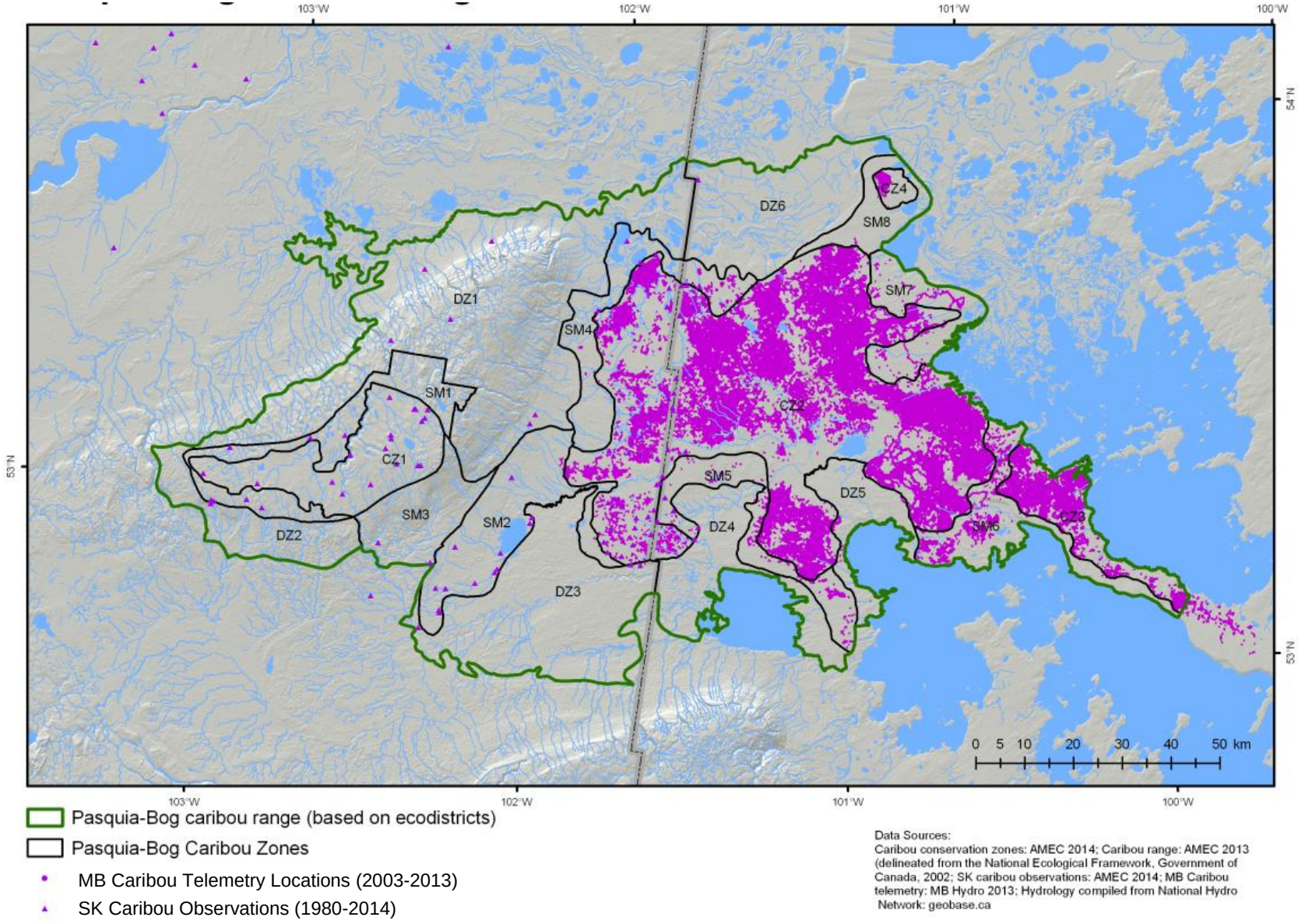

Figure 10. Proposed zones within a 3-zone land management system.

Table 5. Area estimates of preferred caribou habitat and disturbance by Caribou Conservation Zone.

Caribou Conservation Zone	Total Area (km²)	Preferred Habitat		Disturbance (per Environment Canada 2012)						POP (%)
		Area (km²)	% of CZ	Natural (km²)	% of CZ	Human (km²)	% of CZ	Pooled (km²)	% of CZ	
CZ1	612	348	57	83	14	145	24	215	35	59
CZ2	3397	2773	82	75	3	275	8	342	10	89
CZ3	325	271	83	3	1	49	15	52	13	86
CZ4	51	47	92	4	8	0	0	4	8	90
TOTAL	4386	3439	78	165	4	468	11	613	14	84

NOTE: disturbance area (km²) is based on the Environment Canada (2012) disturbance geospatial coverage.

7.1.2 Special Management Zone (SM)

Special Management Zones (SM) are restricted development buffers intended to spatially separate core caribou habitat (CZs) from development zone (DZ) areas. Development activities within SMs would be permitted within limitations of specified disturbance threshold levels. SMs have a relatively higher proportion of preferred caribou habitat relative to DZs but have relatively lower use by caribou as a consequence of proximity to anthropogenic disturbance occurring within the SM and adjacent DZ. The purpose of SMs is to:

- reduce predation/mortality risk within the SM and adjacent CZ,
- provide a spatial buffer from disturbance occurring in an adjacent DZ, and
- ensure structural and functional landscape connectivity within and between CZs and adjacent caribou ranges to facilitate caribou movement (i.e. SM2, SM3, SM6 and SM8).

Permanent anthropogenic disturbance levels within SMs (Table 6) would be managed to ensure the ecological integrity and connectivity of CZs within the following threshold constraints:

- **a minimum disturbance threshold of <35%** (all disturbance types pooled, all SMs pooled),
- **no human disturbance exceeding 25%** of the SM area (all SMs pooled),
- **no human disturbance to exceed 30% within any individual SM** (exception is SM3), and
- **avoidance of large patches of preferred caribou habitat types in SM3** (including a 250 m disturbance buffer) to the extent necessary to ensure connectivity sufficient to facilitate caribou movements between CZ1 and SM2.

Table 6. Area estimates of preferred caribou habitat and disturbance by Special Management Zone.

Special Management Zone	Total Area (km²)	Preferred Habitat		Disturbance (per Environment Canada 2012)						POP (%)
		Area (km²)	% of SM	Natural (km²)	% of SM	Human (km²)	% of SM	Pooled (km²)	% of SM	
SM1	423	182	43	4	1	111	26	115	27	70
SM2	583	304	52	11	2	101	17	110	19	82
SM3	347	72	21	16	5	214	62	214	62	18
SM4	423	224	53	26	6	53	13	78	18	82
SM5	350	298	85	0	0	17	5	17	5	91
SM6	384	270	70	0	0	99	26	99	26	71
SM7	303	219	72	111	37	53	17	160	53	28
SM8	195	133	68	13	7	32	16	45	23	75
TOTAL	3007	1703	57	181	6	681	23	827	27	70

NOTE: Disturbance area (km²) is based on the Environment Canada (2012) disturbance geospatial coverage.
Caribou habitat management priority in SM3 is to retain intra-range connectivity sufficient to facilitate caribou movement between CZ1 and SM2.

BMPs and silvicultural practices within SMs would focus on mitigating anthropogenic disturbance by encouraging an ecological succession trajectory of disturbed preferred caribou habitat patches back to previous condition, minimizing predation-risk, discouraging increase of other ungulate species populations in proximity to preferred habitat patches, supporting maintenance of large contiguous habitat patches and connectivity among patches, and minimizing linear disturbance through access management (e.g. winter access in preference to all season access).

7.1.3 Development Zone (DZ)

Development zones (DZ) are areas within the Pasquia-Bog Caribou Range that are not designated as a CZs or SMs. DZs have an economic emphasis. The DZs are largely not suitable caribou habitat, but may include patches of caribou habitat that have been highly impacted by temporary or permanent disturbance. Larger patches of preferred caribou habitat within a DZ that are adjacent to a SM or CZ may have some value as peripheral caribou habitat, but are more likely to have an associated high mortality risk for caribou and/or function as a population sink. Overall, each DZ would be managed in an environmentally sustainable way, with caribou conservation considerations applied through BMPs only in larger caribou habitat patches proximate to the other zone types.

Table 7 summarizes current disturbance in each DZ. Within a DZ, environmentally sustainable economic activity could occur within the following disturbance threshold constraints:

- **a minimum threshold of <40% disturbed habitat** (all disturbance types pooled; all DZs pooled),

- avoidance or limited disturbance of preferred caribou habitat patches that are contiguous with CZs and/or SMs.

Table 7. Area estimates of preferred caribou habitat and disturbance by Disturbance Zone.

Development Zone	Total Area (km²)	Preferred Habitat		Disturbance (per Environment Canada 2012)						POP (%)
		Area (km²)	% of DZ	Natural (km²)	% of DZ	Human (km²)	% of DZ	Pooled (km²)	% of DZ	
DZ1	2320	374	16	85	4	900	39	940	39	52
DZ2	362	113	31	0	0	154	43	154	43	43
DZ3	1061	296	28	33	3	474	45	491	46	38
DZ4	504	164	33	148	29	27	5	174	11	89
DZ5	271	146	54	7	3	105	38	109	38	52
DZ6	730	67	9	311	1	533	73	674	53	28
TOTAL	5247	1161	22	584	11	2193	42	2541	48	38

NOTE: Disturbance area (km²) is based on the Environment Canada (2012) disturbance geospatial coverage.

7.2 POPULATION

Surveys should be conducted periodically to monitor and document caribou range occupancy. This can be done systematically and formally on a 5-year basis and supplemented with ongoing community-based incidental sightings. Within an adaptive management framework it is necessary to monitor population dynamics and range occupancy in relation to habitat supply to determine if adjustments are necessary to adjust disturbance thresholds and to inform ongoing land use planning initiatives.

Dyke (2008) determined a 29 April – 7 June calving season for caribou in a Saskatchewan boreal plain caribou population. Dyke (2008) observed a strong calving site selection for treed peatlands (particularly those further from hardwood stands, roads and mature upland jackpine). Late winter (March/April) is an energetically challenging period for ungulates because they have been subsisting on lower quality and quantity forage sources over several months, resulting in energy reserves approaching their lowest level. Displacement from winter forage sources during late winter by industry activities would have a significant effect, particularly on a species or population that is sensitive to even minor increases in mortality rate and for pre-parturient females. Within core caribou range it is important to avoid forest harvesting activities from late winter through calf rearing (March 31 through July 31).

7.3 HABITAT

Habitat supply and functional availability should be assessed periodically to determine whether disturbance levels for each zone are consistent with threshold objectives established within this plan. It is important to monitor cumulative effects of natural and anthropogenic disturbance in relation to habitat recovering from previous disturbance and ecosite succession, to inform ongoing land use planning initiatives (including habitat restoration initiatives), and to ensure application of best management practices and implemented land use plans (e.g. Forest Management Plans) within the Pasquia-Bog Caribou Range are effective at conserving caribou.

Caribou conservation requires land management strategies that maintain caribou habitat, favour structural and functional habitat connectivity, and support sustainable caribou populations (O'Brien *et al.* 2006, Arsenault & Manseau 2011). Key habitat management strategies include retention of mature softwood interior proximate to occupied caribou activity and preferred habitat, improved structural connectivity, planning disturbances to minimize anthropogenic footprint, and integration of habitat restoration with land-use planning initiatives (Arsenault & Manseau 2011).

7.4 BEST MANAGEMENT PRACTICES

Effective conservation of caribou and ecologically sustainable land use requires the collaboration of government, industry, first nations, vested interest groups and other land users. Best management practices reduce negative effects on caribou and their habitat whilst considering the implementation costs to land users. Caribou best management practices should include measures to preserve physical connectivity, biological linkages and ecological processes within the AOA at appropriate spatial and temporal scales to ensure a sustainable habitat supply that can support a viable caribou population over the long-term at natural levels of abundance and distribution.

The BMPs presented in Appendix B are at a high level and are specific to forestry. For comprehensive range planning, other land use BMPs should also be considered. Application of BMPs must occur within the context of an acceptable threshold of cumulative disturbance within the Pasquia-Bog Caribou Range. Many caribou BMPs have not been scientifically assessed; therefore the ideal situation would be to apply them across caribou distribution within an adaptive framework to systematically test effectiveness.

Forestry BMPs can be applied to all aspects of forestry activities including access management, operational planning, disturbance design, education and outreach, integrated planning for cumulative effects management, and caribou habitat recovery and restoration efforts.

8.0 CLOSURE

This report has been prepared for the exclusive use by the Saskatchewan Regional Working Group under the purview of the Canadian Boreal Forest Agreement Secretariat. The data and recommendations provided herein should not be used for any other purpose, or by any other parties, without review and advice from a qualified caribou biologist.

The findings and recommendations of this report were prepared in accordance with generally accepted professional biological principles and practice. No other warranty, expressed or implied, is given. Should any questions arise, please contact either of the undersigned, at your convenience.

Sincerely,

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APPENDIX A

Area calculations based on zone delineations within Pasquia-Bog Caribou Range.

Pasquia-Bog 3-Zone Land Management System

Province / Zone		TOTAL ZONE AREA (km²)	DU EWC Preferred Habitat			Environment Canada Disturbance Area (km²)									BASELINE + all Fire History			BASELINE + REGEN Fire	
						Burn Area (km²) no buffer						TOTAL Anthropogenic Disturbance (km²) (500m buffer)	All Disturbance Pooled (km²)	Natural - Human Disturbance Overlap (km²)	Undisturbed (%)	Disturbed (%)	POP (%)	Disturbed (%)	POP (%)
			3 (km²)	2 (km²)	Proportion of Total Zone Area (%)	New (<10 yrs) (2004-13)	Young Regen (10-19 yrs) (1994-2003)	Intermediate Regen (20-29 yrs) (1984-1993)	Old Regen (30-39 yrs) (1974-1983)	Regenerated (≥40 yrs) (≤1973)	All Years Pooled								
Development Zone (Economic Emphasis)																			
SK	DZ1	2,319.6	41.5	333.2	16.2	2.7	15.9	21.1	3.5	41.4	84.6	900.3	940.0	44.9	59.5	40.5	50	38.7	52
SK	DZ2	361.6	10.7	102.5	31.3	0.0	0.0	0.0	0.0	0.0	0.0	154.1	154.1	0.0	57.4	42.6	43	42.6	43
SK	DZ3	1,060.7	29.6	266.3	27.9	7.9	4.3	0.0	21.2	0.1	33.4	474.5	490.9	17.0	53.7	46.3	38	46.3	38
MB	DZ4	504.3	15.4	148.7	32.5	0.2	26.8	0.0	0.0	120.8	147.8	26.7	173.9	0.6	65.5	34.5	59	10.5	89
MB	DZ5	271.3	30.3	115.7	53.8	0.3	0.6	0.0	0.0	6.2	7.1	105.0	108.8	3.4	59.9	40.1	50	37.8	52
MB	DZ6	729.6	7.0	59.9	9.2	0.6	13.0	5.1	2.7	289.2	310.7	532.7	673.8	169.6	7.7	92.3	5	52.7	28
	Total	**5247.2**	**134.5**	**1026.3**	**22.1**	**11.7**	**60.6**	**26.2**	**27.4**	**457.7**	**583.7**	**2193.3**	**2541.4**	**235.6**	**51.6**	**48.4**	**35**	**39.7**	**50**
Caribou Conservation Zone (Protection & Conservation Emphasis)																			
SK	CZ1	612.0	59.6	288.2	56.8	0.0	82.7	0.0	0.0	0.0	82.7	145.0	215.4	12.4	64.8	35.2	59	35.2	59
SK_MB	CZ2	3,397.4	375.2	2,398.1	81.6	3.4	1.0	63.3	7.2	17.3	92.1	274.8	359.6	7.4	89.4	10.6	89	10.1	89
MB	CZ3	325.1	61.9	208.9	83.3	0.0	2.8	0.0	0.0	67.5	70.2	48.6	108.5	10.3	66.6	33.4	60	12.6	86
MB	CZ4	51.1	4.3	42.5	91.8	0.0	0.0	4.2	0.0	0.1	4.3	0.0	4.3	0.0	91.6	8.4	90	8.2	90
	Total	**4385.6**	**501.1**	**2937.7**	**78.4**	**3.4**	**86.5**	**67.5**	**7.2**	**84.9**	**249.4**	**468.4**	**687.7**	**30.1**	**84.3**	**15.7**	**83**	**13.7**	**84**
Special Management Zone (Conservation Emphasis)																			
SK	SM1	422.8	23.6	158.5	43.1	0.0	4.5	0.0	0.0	0.0	4.5	111.1	115.5	0.0	72.7	27.3	70	27.3	70
SK	SM2	582.9	12.9	291.4	52.2	0.0	4.6	0.0	6.6	0.0	11.2	101.3	109.6	3.0	81.2	18.8	82	18.8	82
SK	SM3	346.8	9.2	62.5	20.7	0.0	15.5	0.0	0.0	0.0	15.5	213.6	220.3	8.8	36.5	63.5	18	63.5	18
SK_MB	SM4	422.6	20.0	204.3	53.1	5.8	3.2	1.3	15.1	18.3	43.7	52.9	96.3	0.3	77.2	22.8	74	18.5	82
MB	SM5	350.1	17.2	281.1	85.2	0.0	0.0	0.0	0.0	0.0	0.0	17.4	17.4	0.0	95.0	5.0	91	5.0	91
MB	SM6	384.0	59.1	211.0	70.3	0.0	0.0	0.0	0.0	30.1	30.1	99.1	112.1	17.1	70.8	29.2	70	21.4	79
MB	SM7	303.1	40.9	177.8	72.2	0.4	0.0	110.8	0.0	16.2	127.4	52.9	175.9	4.4	42.0	58.0	23	52.7	28
MB	SM8	195.1	6.7	126.4	68.2	0.0	0.0	11.9	1.1	9.1	22.1	32.4	54.0	0.6	72.3	27.7	70	23.0	75
	Total	**3007.4**	**189.7**	**1513.1**	**56.6**	**6.2**	**27.8**	**124.1**	**22.8**	**73.6**	**254.5**	**680.7**	**901.0**	**34.2**	**70.0**	**30.0**	**67**	**27.5**	**70**
RANGE (AOA)	**TOTAL**	**12640.2**	**825.3**	**5477.1**	**49.9**	**21.3**	**175.0**	**217.8**	**57.4**	**616.2**	**1087.6**	**3342.5**	**4130.2**	**299.9**	**67.3**	**32.7**	**61**	**27.8**	**70**
CZ+SMZ	**TOTAL**	**7393.0**	**690.8**	**4450.8**	**69.5**	**9.6**	**114.3**	**191.6**	**30.0**	**158.5**	**503.9**	**1149.1**	**1588.8**	**64.3**	**78.5**	**21.5**	**77**	**19.3**	**80**

APPENDIX B

Best Management Practices in Caribou Habitat

Linear Disturbances:

Linear Disturbances Within or Proximate (±500 m) to Caribou Habitat		
Attribute	**Best Management Practice**	**Mitigation Intent**
Width	**Minimize corridor width;** where practical, **use variable width and pullouts** to minimize right-of-way width for haul roads.	Limit corridor obtrusiveness (i.e. accessibility for predators, humans, and alternative prey), minimize alteration of local snow condition and to speed vegetation regeneration time for disturbance reclamation.
Line-of-Sight	Use a meandering pattern and vegetation avoidance methods to **minimize line-of-sight to <200 m**.	Reduce barrier effect and predator efficiency
Surface Disturbance	In remote areas, conduct operations using **minimal access on frozen ground**, including **minimize disturbance of the organic soil layer**	Speed vegetation recovery.
	In multi-user areas, use integrated planning of disturbances including use of shared common access and avoidance of preferred caribou habitat (if possible).	Avoid/limit direct habitat loss Minimize linear disturbance density (km/km^2) Minimize the number of times preferred habitat is accessed.
Sensory Disturbance	**Access control** through physical and/or timing restrictions	Reduce functional habitat loss and minimize sensory disturbance and displacement (particularly during sensitive periods such as spring calving and fall rut)
Habitat Recovery	Where practicable, use **temporary frozen access**, **avoidance cutting** of natural vegetation (especially trees and shrubs), and **retain the surface organic layer**.	Reduce the long-term impact and reduce the potential increased access for humans or wildlife
	Use **high-blading and mulchers** for temporary frozen access	Promote rapid vegetation regeneration
	Ensure the forest regeneration strategy is consistent with caribou habitat management objectives and recommended caribou disturbance threshold limit.	Opportunities for recovery should be considered during initial design and construction.
Road / Trail Abandonment	Use **slash roll-back** and **reforest to a shrub-tree successional pathway consistent with the previous vegetation state.** Use slash roll-back to return access to the pre-existing state, or where previously existing access was improved but no longer required.	Speed vegetation recovery. Minimize access (Removes the disturbance footprint and renders the line impassable). Minimize linear disturbance density (km/km^2)
Temporary Roads / Periods of Non-activity	Temporarily block access using bundles of logs, slash roll-back, snow berms or other means between periods of non-activity in excess of 72 hours.	Minimize sensory disturbance Minimize access

Linear Disturbances Within or Proximate (±500 m) to Caribou Habitat		
Attribute	**Best Management Practice**	**Mitigation Intent**
Density	**Minimize footprint.** A single shared corridor has less potential impact and cumulative effects than many corridors; therefore use existing corridors for routing projects. **Linear density threshold in caribou conservation zone and preferred caribou habitat patches = ≤0.1 km/km²**	Increase functional habitat Minimize sensory disturbance Minimize access Minimize loss of landscape connectivity or effects on caribou movement and predator avoidance
Length	**Minimize access.** Shorter corridors have less potential impact than longer corridors. **Minimize creation of new access by optimizing use of existing access.**	Minimize sensory disturbance. Minimize access
Timing	**Commence winter work immediately after freeze-up.** Complete all work occurring in, or adjacent to, preferred caribou habitat patches in early winter**. Avoid activity during calving (15 April – 15 June).** Limit the number of times caribou range is accessed.	Minimize energetic stress and reduce mortality risk - Late winter (low energy reserves) and spring (calving) are the periods when caribou would be most negatively affected by human activity on linear corridors. Minimized sensory disturbance.
Hydrology	**Ensure local hydrology is unimpeded** (watercourses and peatlands)	Avoid habitat loss and speed habitat recovery
Barrier Effects	**Minimize height to maintain line-of-site across the linear disturbance** and minimize unnecessary traffic volume through access control and restrictions	Promotes functional habitat connectivity to facilitate improved caribou movements.
Noise Effects	**Minimize temporally and spatially**	Minimize disturbance Minimize functional habitat loss

Polygonal Disturbances:

Polygonal Disturbances in, or proximate (± 500 m) to, Caribou Conservation Zones and preferred caribou ecosites in Special Management Zones to attain the habitat retention threshold for the caribou range and zone types.		
Attribute	**Best Management Practice**	**Mitigation Intent**
Amount and Pattern of Habitat Disturbance	Disturbance effects depend on the magnitude, duration and timing of the disturbance. Concerns include direct habitat loss, alteration of predator-prey dynamics, functional habitat loss because of displacement and avoidance. **Planned disturbances should incorporate caribou habitat supply requirements** and be developed jointly with industry and government. Integrated planning should include a cumulative assessment and minimization of impacts of planned and natural disturbances at the range scale and zone scales to ensure population and habitat sustainability over the long-term. **Utilize minimal disturbance techniques, low impact methods to access timber supply** (i.e. winter access only) and **apply natural forest patterns in forest harvest event planning** (i.e. ensures continuous supply of large areas of potential future caribou habitat).	Minimize direct and functional habitat loss by manipulating disturbance configuration (magnitude), timing and duration. Ensure long-term sustainable range and zone caribou habitat supply requirements are attained.
Vegetation Succession and Recovery	Effects depend on magnitude, distribution and timing. Concerns include direct habitat loss if preferred habitat is impacted, functional habitat loss if the disturbance occurs adjacent to preferred habitat patches, and potential alteration of predator-prey dynamics if the disturbance results in increased alternate prey and increased mortality risk from associated predators and improved access. **Planned disturbances should be coordinated and consistent with caribou habitat management objectives. Silviculture and reclamation practices on impacted caribou habitat should ensure effective** (e.g. by discouraging deciduous tree growth**) and accelerated** (e.g. through seedling plantings) **vegetation succession back to pre-disturbance condition** (i.e. avoidance of forest ecosite shift from conifer dominant to greater deciduous content). **Post-site development should reclaim areas no longer needed for construction and operations. Reclamation should be initiated within one year of site abandonment**	Maintain an accessible habitat supply that is sufficient to ensure a self-sustaining caribou population can be supported over the long term. Promote rapid restoration of preferred caribou habitat patches directly or indirectly affected by planned disturbances to reduce predation-risk and promote landscape/habitat connectivity.

Polygonal Disturbances in, or proximate (± 500 m) to, Caribou Conservation Zones and preferred caribou ecosites in Special Management Zones to attain the habitat retention threshold for the caribou range and zone types.		
Attribute	**Best Management Practice**	**Mitigation Intent**
Site Disturbance	Effects are variable depending on permanency/duration of use, frequency and pattern of use, activities occurring on site (e.g. machinery use, frequency of human access) and timing. Where possible, **minimize surface disturbance and disruption of organic surface layer to hasten vegetation recovery using minimal disturbance and low impact techniques.**	Minimize habitat loss and promote rapid recovery of planned disturbances
Timing	Late winter (low energy reserves) and spring (calving) are the periods when caribou would be most vulnerable to disturbances (i.e. March 1 – June 30). **Commence work immediately after freeze-up with the objective of completing the work in the earlier part of winter**.	Avoid disturbance of caribou during sensitive periods
Effects on Predator-Prey Dynamics	Where there are overlapping concerns between caribou and other ungulate species, caribou management objectives should be given highest priority in caribou conservation zones and preferred caribou habitat types in the special management zones.	Ensure caribou are prioritized over other ungulate species because they are highly sensitive to even minor increases in predation mortality relative to other ungulate species
Access	Where possible, use integrated planning to **avoid preferred caribou habitat** if possible, or to **minimize the number of times preferred caribou habitat is accessed**. Disturbances that encircle or intersect preferred caribou habitat can affect range occupancy and habitat patch use. Use integrated planning to **minimize the amount of total access necessary** in the caribou conservation zones and special management zones. Where possible, strive to **conduct operations using minimal access on frozen ground. Minimize creation of new access by optimizing use of existing access.**	Minimize sensory disturbance Minimize direct and functional habitat loss Promote rapid recovery from planned disturbances Minimize barrier effects and increase landscape connectivity Reduce cumulative effects of disturbance.