KEEYASK GENERATION PROJECT

September 2013

Report # 13-02

Habitat Relationships and Wildlife Habitat Quality Models for the Keeyask Region

Draft

ENVIRONMENTAL STUDIES PROGRAM

KEEYASK GENERATION PROJECT

Environmental Studies Program
Report # 13-02

HABITAT RELATIONSHIPS AND WILDLIFE HABITAT QUALITY MODELS FOR THE KEEYASK REGION

Draft Report Prepared for Manitoba Hydro

by

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1.0 INTRODUCTION

1.1 OVERVIEW

The Keeyask Hydropower Limited Partnership is proposing to develop the Keeyask Generation Project (the Project), a 695-megawatt (MW) hydroelectric generating station and associated facilities, at Gull (Keeyask) Rapids on the lower Nelson River upstream of Stephens Lake in northern Manitoba. The Project includes an access road, permanent infrastructure, temporary borrow, camp and work areas, and would result in approximately 45 km^2 of terrestrial flooding.

Construction and operation of the Project would have a variety of direct and indirect effects on terrestrial ecosystems and ecosystem components such as terrestrial habitat and species. Terrestrial ecosystems in the Project area provide numerous benefits such as: food and shelter for all terrestrial animals; cultural, social, spiritual and economic benefits to people; and perform ecological functions such as cleaning the air and water for all people and animals. Some components of the terrestrial ecosystem are of particular interest because they are highly valued by people, are rare and are in danger of disappearing in some areas, are highly sensitive to disturbance, play a prominent role in ecosystem function or are protected by legislation under the federal Species at Risk Act (SARA) and the Manitoba Endangered Species Act (MESA).

An ecosystem-based approach was used to understand the terrestrial environment and to evaluate the potential effects of the Project on it (see the Terrestrial Environment Supporting Volume (TE SV) Section 1.1 for a description of the ecosystem-based approach). The ecosystem-based approach recognized that the terrestrial environment is a complex, hierarchically organized system in which changes to one component directly and/or indirectly affect other components. The ecosystem-based approach to assessing Project effects on ecosystem components considered direct and indirect effects in combination with other past, existing and reasonably foreseeable future developments and activities at multiple spatial and temporal scales. Anticipated Project effects on ecosystem components, including wildlife species, would extend varying distances from the Project Footprint and for varying lengths of time, depending on the ecosystem components, impact type and local conditions (see Section 1 of the TE SV for an overview).

A key element of the ecosystem-based approach was identifying the ecosystem components (*i.e.*, elements, patterns, linkages, processes and functions) that are particularly important for maintaining terrestrial ecosystem health. It is neither practical nor necessarily instructive to decision-making to investigate and assess the possible effects of the Project on every component of the terrestrial environment. The terrestrial environment assessment addressed the key ecosystem health issues of concern, or the terrestrial key topics. That is, the ecosystem components, patterns, processes and functions that could experience substantial Project effects and are particularly important to maintaining overall ecosystem function and the long-term benefits that these functions provide to present and future generations. High importance to the Keeyask Cree Nations (KCNs) was one of the criteria used to select the key topics. While all of the key topics are evaluated in the terrestrial assessment, the focus was on the key topics selected as valued environmental components (VECs) because they were of particularly high ecological and/or social interest.

Studies to develop a better understanding of local terrestrial ecosystems and to help predict potential project effects were conducted. These studies were essential because little information for terrestrial ecosystem components was available for the Project region when the studies commenced. Among other purposes, these studies were used to identify local variations on, or exceptions to, generalizations in the literature regarding terrestrial habitat dynamics and wildlife-habitat relationships, and to develop models to predict potential Project effects on terrestrial habitat and wildlife habitat availability. The terms used for habitat classification in this report reflect the habitat classification system outlined in Section 2.2.4.4 of the TE SV: land cover type, coarse habitat type, broad habitat type, and fine habitat type.

This report presents results from Project studies conducted to improve our understanding of and predictive capability regarding the potential Project effects on terrestrial habitat and selected wildlife VECs. The report objectives are to describe the key models used to predict potential Project effects on terrestrial habitat and selected wildlife VECs, and to provide evaluations of these models. Depending on the model, this includes summarizing results already presented in the EIS and technical reports, presenting information utilized but not previously published, or a mixture of the two.

The remainder of this report first provides an overview of what modelling is, general approaches to modelling and model evaluation and a description of the methods that were generally used for the terrestrial habitat relationships and wildlife habitat quality models. This is followed by an ecological overview of the Project region to provide the context for the models presented in this report. Next the terrestrial habitat relationships models are presented (Section 3.0). The mammal models occupy the next three sections, which are then followed by the three bird VEC models.

2.0 MODELLING

2.1 MODEL TYPES AND MODELLING APPROACHES

A model is any simplification of reality. Models can range from the images we carry in our minds of how things work (sometimes called "mental models"; Ford 2009) to a set of numerous, interrelated mathematical equations that simulates ecosystem states, mechanisms and processes to predict ecosystem change over time.

Models can be classified in many ways, depending on perspective (*e.g.*, scientist, land manager, philosopher), model purpose (*e.g.*, prediction, improved understanding) or other criteria. The Stanford Encyclopedia of Philosophy (Frigg and Hartmann 2012) notes that:

> "Probing models, phenomenological models, computational models, developmental models, explanatory models, impoverished models, testing models, idealized models, theoretical models, scale models, heuristic models, caricature models, didactic models, fantasy models, toy models, imaginary models, mathematical models, substitute models, iconic models, formal models, analogue models and instrumental models are but some of the notions that are used to categorize models."

For models such as those used to predict changes to the Keeyask terrestrial environment, this report defines an empirical model as one in which the structure is determined by the observed relationship among data obtained from conditions relevant for the phenomenon of interest[1], and a process model as one that uses one or more equations to simulate the states, mechanisms and processes that produce the phenomenon of interest[2].

There are various approaches to developing and evaluating models. Swannack *et al.* (2012) describe the following steps, which are somewhat iterative, as the general approach to ecosystem restoration model development used by the U.S. Army Corps of Engineers.

> "Once a specific problem has been identified and both the planning and modelling objectives have been clearly defined, the basic approach is as follows:
>
> - Develop a conceptual model identifying the specific cause-effect relationships among important components of the system of interest.
> - Quantify these relationships based on analysis of the best information possible, which can include scientific data or expert opinion.
> - Evaluate the information yielded by the model in terms of its ability to yield information that describes or emulates system behavior.
> - Apply the model to address questions regarding the effects of particular project alternatives.

[1] While some authors call these statistical models, statistical models are a subset of empirical models by this definition.
[2] Some authors call these mechanistic models.

- Perform periodic post-audits of model applications to manage confidence in the model and the information it yields (this will be incredibly important as adaptive management practices are implemented)."

A fundamental decision during model development is determining how complex the model will be. Swannack *et al.* (2012) recommend choosing the simplest approach that can address the problem sufficiently. For land use management decisions, an ecosystem process model might not provide better answers than a much simpler qualitative habitat quality model, which requires less time, effort and cost relative to a more complex model. They also note that in cases where no quantitative data are available, qualitative information from the literature or expert opinion can be used to establish assumptions on which to base estimates of model parameters.

As identified in the third step above, models used for management purposes should be evaluated. Model evaluation typically includes two components: verification and validation. Verification evaluates how closely model structure reflects intentions while validation evaluates how well the model performs relative to its intended use. No model can be fully validated; it can only be proven that it has not been invalidated to date. Ultimately, the goal of model validation is to make the model useful in the sense that it addresses the intended purpose (Ford 2009).

2.2 MODELS IN THE PROJECT EFFECTS ASSESSMENT

2.2.1 INTRODUCTION

In the terrestrial environment assessment, various types of models and modelling approaches were used to improve the understanding of terrestrial ecosystems and wildlife species in the Project area and to predict potential Project effects. During the initial stages of the assessment, literature reviews and professional judgment were used to create checklists and conceptual models. Conceptual models were formalized as conceptual diagrams (*e.g.*, Figure 3-1), pathway diagrams (*e.g.*, Figure 3-3) and network linkage diagrams (*e.g.*, Figure 3-5). These checklists and conceptual models were used to identify the potential issues of concern for the Project, to identify data gaps and to design field studies to address data gaps. Subsequently, confirmation and enhanced understanding of local relationships was obtained through field studies, statistical analysis, computer modelling and information received from the Keeyask Cree Nations. This enhanced understanding was used for a variety of purposes such as to select the key topics, recommend mitigation measures, incorporate the effects of other projects into the assessment or to identify changes to contextual and other non-Project factors.

The general model types used to improve the understanding of the Project area terrestrial ecosystems and wildlife species, and to predict potential Project effects were:

- Simple conceptual models (*e.g.*, land animals will be affected because flooding reduces available habitat);

- Complex conceptual models based on literature reviews and local information (*e.g.*, network linkage diagrams that show the web of indirect Project effects);
- Expert information qualitative numerical models based on changes in habitat area, literature reviews and observed changes in the environment following similar developments in northern Manitoba and in other northern environments (*e.g.*, classify terrestrial habitat types into primary and secondary habitat for beaver and then calculate the amount of beaver habitat affected by the Project);
- Simple empirical models based on observed changes with no explicit linkage to underlying processes (*e.g.*, data from existing reservoirs and regulated areas indicates that the zone of edge and elevated groundwater effects on terrestrial habitat is generally less than 50 m wide); and
- Complex multivariate quantitative models based on local data, observed changes in the environment following similar developments in comparable northern environments and literature reviews (*e.g.*, multivariate clustering and ordination analyses that identify vegetation types and associate these vegetation types with environmental attributes).

For the terrestrial assessments, the specific model type and modelling approach varied with each key topic depending on the question of interest, the degree of existing understanding of local relationships and the ability to collect suitable data with a level of effort that is reasonable for an EIS.

Regarding questions of interest, the potential spatial extent of indirect Project effects on terrestrial habitat was a key question for terrestrial ecosystems and habitat. Given the potential degree of Project effects and the lack of existing long-term monitoring data for the effects of reservoir creation and water regulation on terrestrial habitat and ecosystems in northern Manitoba, considerable effort was expended on developing datasets from historical information for areas in northern Manitoba previously exposed to similar impacts (*i.e.*, proxy areas).

For a number of wildlife species assessed, a habitat quality model was developed that would be used to quantify available habitat in the existing environment and to predict how available habitat would change with the Project in place. With the exception of rare species, typical habitat associations and the factors influencing the distribution and abundance of the wildlife VECs are generally well understood. For rare species, obtaining sufficient field observations for the species to conduct statistical analysis was a challenge for confirming generalizations or developing associations for the Project region .

The remainder of this section describes the general approach and steps taken to develop and evaluate the terrestrial habitat zone of influence models and habitat quality models for selected wildlife VECs (*i.e.*, moose, beaver, caribou, olive-sided flycatcher, rusty blackbird and common nighthawk).

2.2.2 MODELLING STEPS

2.2.2.1 OVERVIEW

The modelling completed for the terrestrial environment Project effects assessment essentially followed the first four steps of the basic approach outlined by Swannack *et al.* (2012; reproduced in Section 2.1. The fifth and final step is not discussed further since it is not relevant for the pre-Project phase.

The general steps taken to develop and evaluate a habitat quality model for each of the wildlife VECs included in this report (referred to as Steps 1 to 6) were:

1. Summarize habitat associations from relevant literature, existing information for the VEC's Regional Study Area, and from professional judgment;
2. Verify the expected habitat associations for the VEC's Regional Study Area by conducting field studies within it;
3. Iteratively refine the expected habitat associations as results from studies conducted in the VEC's Regional Study Area become available;
4. Use available information and professional judgment to create an expert information predictive model that is applied to study area terrestrial habitat mapping. That is, assign each of the mapped terrestrial habitat types into primary, secondary or non-habitat for the VEC;
5. Validate the predicted categorization of mapped habitat types as primary, secondary and non-habitat for the VEC using relevant field data and other information; and
6. Use the expert information habitat quality model to quantify the total amount of VEC habitat in the existing environment and post-Project.

While the overall modelling approach was the same for the terrestrial habitat relationships and wildlife habitat quality models, the implementation was somewhat different for the terrestrial habitat relationships models because the primary focus for the former modelling was on predicting the Project's zone of indirect effects rather than on classifying terrestrial habitat types into habitat quality classes for wildlife species (see Section 3.3 for details).

2.2.2.2 STEPS 1 TO 3

The models presented in this report implemented Steps 1 to 3 of model development through a responses-linkages-most influential driver (R-L-MID) conceptual approach. The objective of the R-L-MID conceptual approach was to elucidate the factors that have the strongest influence on the response of interest (*i.e.,* the most influential drivers). By focusing on the linkages and the most influential drivers for the response of interest (*e.g.*, a species' population, habitat composition), the conceptual approach identifies attributes that best evaluate and monitor:

- the factors that control patterns and dynamics for the response of interest;
- future trends in the response of interest; and
- likely pathways for potential Project effects on the response of interest.

The R-L-MID approach was fashioned after other widely used cause-effect, stressor-response or controlling factors approaches developed to evaluate or monitor species or ecosystems for other purposes. While the cause-effect, or driver-response, theme is common to all of these approaches, the approaches differ on where the emphasis is placed since they were developed to meet different purposes. For example, the Millennium Ecosystem Assessment (2003) emphasizes ecosystem services rather than ecosystem functions because this was thought to be the best strategy for influencing policy at the international level.

The R-L-MID conceptual approach can be represented by a linkage diagram such as Figure 2 1, applicable when an animal population is the response of interest. The R-L-MID pathway diagram identifies all but the least important potential drivers for a regional population. The presumed degree of influence these drivers have on the ecosystem response of interest is indicated by linkage arrow thickness and color, with the most influential drivers represented by thick, orange linkage arrows.

There are many drivers that influence the ecosystem response of interest. Some drivers have more direct or rapid influences than others. A harsh storm can severely erode a shoreline. While the storm may have completely removed existing wetland vegetation, it also initiates primary vegetation succession. The plant species that eventually colonize and become most abundant in the eroded shore zone will somewhat depend on the type of substrate, which is the joint product of sediment deposition processes in the beach zone and on the glacial processes that deposited the bank materials. Sediment deposition may occur over weeks to years whereas glacial periods occur over and are separated by millennia.

Effects pathways for many drivers of the ecosystem response of interest are indirect. In fact, the driver that initiates a change can be many steps removed from the response of interest. In theory, the chain of indirect causality for the response of interest can be traced backwards in time to the origin of the universe. Figure 3-3 is a linkage diagram for vegetation dynamics that illustrates how the chain of causality for site level vegetation dynamics is ultimately traced back to factors that largely resulted from glaciation (*e.g.*, surface materials, regional landscape configuration).

While including all indirect drivers going back to glaciation is important for understanding how ecological regions were created and current species distributions developed over the ages, these drivers have limited utility for evaluating individual organism and site-level habitat responses given the high discord in time frames between these responses and the assumed life span of a hydroelectric development in northern Manitoba. Although Ice Age glacial processes produced the initial mosaic of surficial materials, landforms and drainage patterns that provide the context for individual organisms, glacial processes operate over a much longer time frame than the life span of an individual organism or habitat patch. Causal theory (Cook and Campbell 1979; Saris and Stronkhorst 1984) provides the basis for designing a study to include only those causal variables which are "ultimate" in nature vis-à-vis the question at hand. Ultimate causal variables, or drivers, are essentially those variables in the causality chain that are one step forward of the causes that do not have a substantial influence on the object of study. For example, although climate has substantial influences at the plant community level in terms of constraining which vegetation types can develop, the variables which determine climate do not, and need not be measured.

The R-L-MID pathway diagram (Figure 2-1) identifies the drivers that are proximate, ultimate and contextual relative to the ecosystem response of interest (*e.g.*, populations or other ecosystem components). Proximate drivers are those that change easily or quickly relative to the response of interest, and are among those most

readily influenced by a development. Contextual drivers (shown in blue font and blue box outlines in the figure) are the ultimate drivers that change so slowly or infrequently relative to the response of interest that they typically do not need to be included in a predictive model. For example, most plants need soil to grow. Very different soils and vegetation will develop on clayey material than on sand. These surface materials were deposited by processed related to the last glaciation, and the next glaciation is not expected during the life of the Project or the time periods relevant for stand level ecosystem dynamics. Contextual drivers need not be considered for analyses where the question of interest relates to stand and site level dynamics (note that it is possible for a project to affect a contextual driver such as when it alters the species pool by introducing a highly invasive non-native species). The remaining ultimate drivers (shown in red font and red box outlines) are the most indirect drivers that need to be considered for the ecosystem response of interest.

In terms of Swannack *et al.* (2012), identifying the ultimate drivers is a means of "bounding the system of interest" – that is, differentiating between those components that should be included in the model from those that should be excluded. It is also a component of moving toward the simplest model that works to meet the purpose for which the model is being developed.

Of the drivers that remain after the filtering described in the previous paragraphs, some have much higher influences than others on the ecosystem response of interest. This generally arises because the driver has either a keystone or limiting effect. For example, fire is the keystone driver in the boreal forest (Payette 1992, Weber and Flannigan 1997) for the temporal scale that corresponds with forest stand dynamics. Fire rejuvenates and maintains boreal ecosystems at all spatial levels spanning from the site to the region. For species, hunting pressure or habitat availability may be the dominant factor limiting population size in a particular region.

See ECOSTEM 2012b Section 2.1 for further details regarding the R-L-MID approach.

An R-L-MID linkage diagram was developed for each wildlife species included in this report using a combination of literature review and expert opinion. While Figure 2-1 can be generalized into a generic model for other ecosystem components such as terrestrial habitat composition, more detailed diagrams were used for terrestrial habitat composition due to the greater number and complexity of drivers and mechanisms.

A component of model verification was the confirmation of the relationships identified by the R-L-MID conceptual approach. As indicated by modelling steps themselves, implementing steps 1 to 3 was an iterative process during Project studies. This report presents verification for R-L-MID relationships where suitable data were available. As noted above, this was less feasible for rare species due to the small number of individual animals that were observed during field studies.

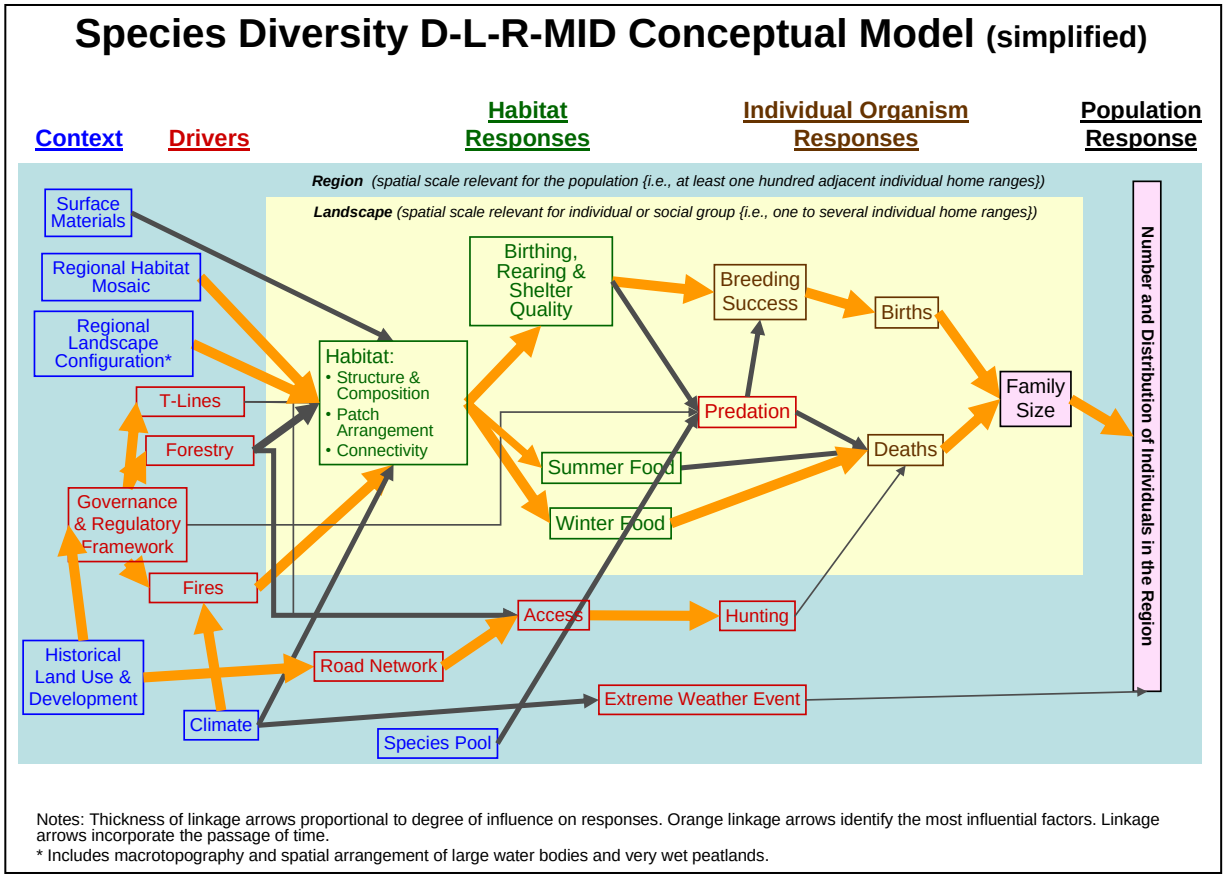


Figure 2-1: Responses-Linkages-Most Influential Drivers (R-L-MID) generic pathway model for an animal species

2.2.2.3 STEPS 4 TO 6

For wildlife species, modelling Step 4 initially translated the associations developed through Steps 1 to 3 into quantified available habitat by using professional judgment to relate the most influential drivers information to each of the mapped terrestrial habitat types. These translations were subsequently iteratively refined using data and information from the VEC's Regional Study Area as it became available. The extent to which the Step 5 validation could be performed depended on the rarity of the species. For rare species, very few observations were available to evaluate the degree to which the various mapped terrestrial habitat types were being used in the Regional Study Area. Model evaluation for rare species necessarily relied more heavily on literature generalizations and professional judgment.

2.3 ECOLOGICAL OVERVIEW OF THE PROJECT REGION

The Project is located near a transitional area of northern Manitoba. The transitional area overlaps three Ecozones (Boreal Shield, Taiga Shield and Hudson Plains), four Ecoregions (Churchill River Upland, Hayes River Upland, Hudson Bay Lowland, Selwyn Lake Upland), and six Ecodistricts (Smith *et al.* 1998).

Geologically, the Project is within the Canadian Shield. This Precambrian bedrock is dominated by greywache gneisses, granite gneisses and granites (Betcher *et al.* 1995). Multiple glaciations have deposited four till layer types containing cobbles and boulders, which are overlain with sands and gravels (JDMA 2012). After the last glaciation, thin layers of silts and clays were deposited on the bottom of glacial Lake Agassiz, forming varved clay and silt deposits, which can be quite thick in low-lying areas and thin or locally absent on ridges and knolls (JDMA 2012). Peat veneer and peat blanket deposits have developed on the poorly drained flatlands and depressions left after Lake Agassiz drained into Hudson Bay and the Beaufort Sea (JDMA 2012).

While the overall terrain is gently sloping, steep sloping drumlins and glaciofluvial ridges occur throughout the area. Lakes of various sizes are common across the landscape. Drainage is generally towards the north and east into Hudson Bay through the Nelson and Hayes Rivers (Smith *et al.* 1998).

Peats of varying thicknesses overlay the fine-grained glaciolacustrine clay and silt which is found on the gently sloping terrain. Veneer bogs, peat plateau bogs, and fens generally overlay clayey glaciolacustrine sediments (ECOSTEM 2012b). Veneer bogs are common on gentle slopes, while shallow to deep peat plateau bogs and fens are common in depressions and potholes (ECOSTEM 2012b).

Discontinuous permafrost is typical of the study area. Melting permafrost in peat plateaus has created thermokarst features called collapse scars, which are visible across the landscape (Smith *et al.* 1998).

Organic soil material derived from woody forest and sedge peat dominates the study area (ECOSTEM 2012b). The Crysolic soil order is the most common followed by the Organic and Brunisolic orders. The remaining soil orders are uncommon. Fibrisols and Mesisols, which are the dominant great groups in the area, are generally associated with very poorly drained fens and Sphagnum bogs (ECOSTEM 2012b). Mineral and organic soils in the study area frequently contain permafrost extending to varying depths. Cryosolic soils are mostly found in Sphagnum bogs, and to a lesser extent feathermoss bogs, and are generally very poorly drained (ECOSTEM 2012b). Permafrost activity contributes to surface topography and deeper soil layer processes.

Mineral soils tend to occur on drumlins, glaciofluvial ridges and along the Nelson River. Brunisols tend to be found on gently to strongly rolling topography and are associated with deep dry sites. Brunisols are most commonly associated with glacio-lacustrine and till deposition modes, and moderately well drained soils (ECOSTEM 2012b). Luvisolic soils are also present within the study area, especially on nearly level terrain. The Luvisols are most commonly found on rapid to moderately well drained soils developed on till or glacio-fluvial deposits (ECOSTEM 2012b).

The region lies within a cold, subhumid to humid, Cryoboreal climate and experiences short, cool summers and long, very cold winters. The mean annual temperature for this region is approximately –4.1°C and the mean annual precipitation is approximately 500 mm, with one-third of the precipitation falling as snow

(Smith *et al.* 1998). The average growing season is 131 days, with approximately 880 growing degree-days (Smith *et al.* 1998).

Wildfire has been the dominant natural driver for ecosystem patterns and dynamics for time periods of less than a century. Human impacts, global change and fire regime changes have been the primary factors driving habitat and ecosystem changes in the broader region over the past few hundred years. Other widespread human alterations such as spreading invasive plants and the airborne deposition of pollutants have also contributed to change. Aboriginal people have lived on the land for thousands of years. Although Europeans are thought to have first visited the Keeyask Regional Study Area in the 1600s, most of the cumulative historical change in the human footprint found in this region was derived from the settlements, infrastructure and hydroelectric projects developed over the past 50 to 100 years. Human influences on the fire regime such as fire suppression and accidentally started fires have also indirectly affected habitat and ecosystems.

ECOSTEM (2012b) provides a more detailed description of the regional context.

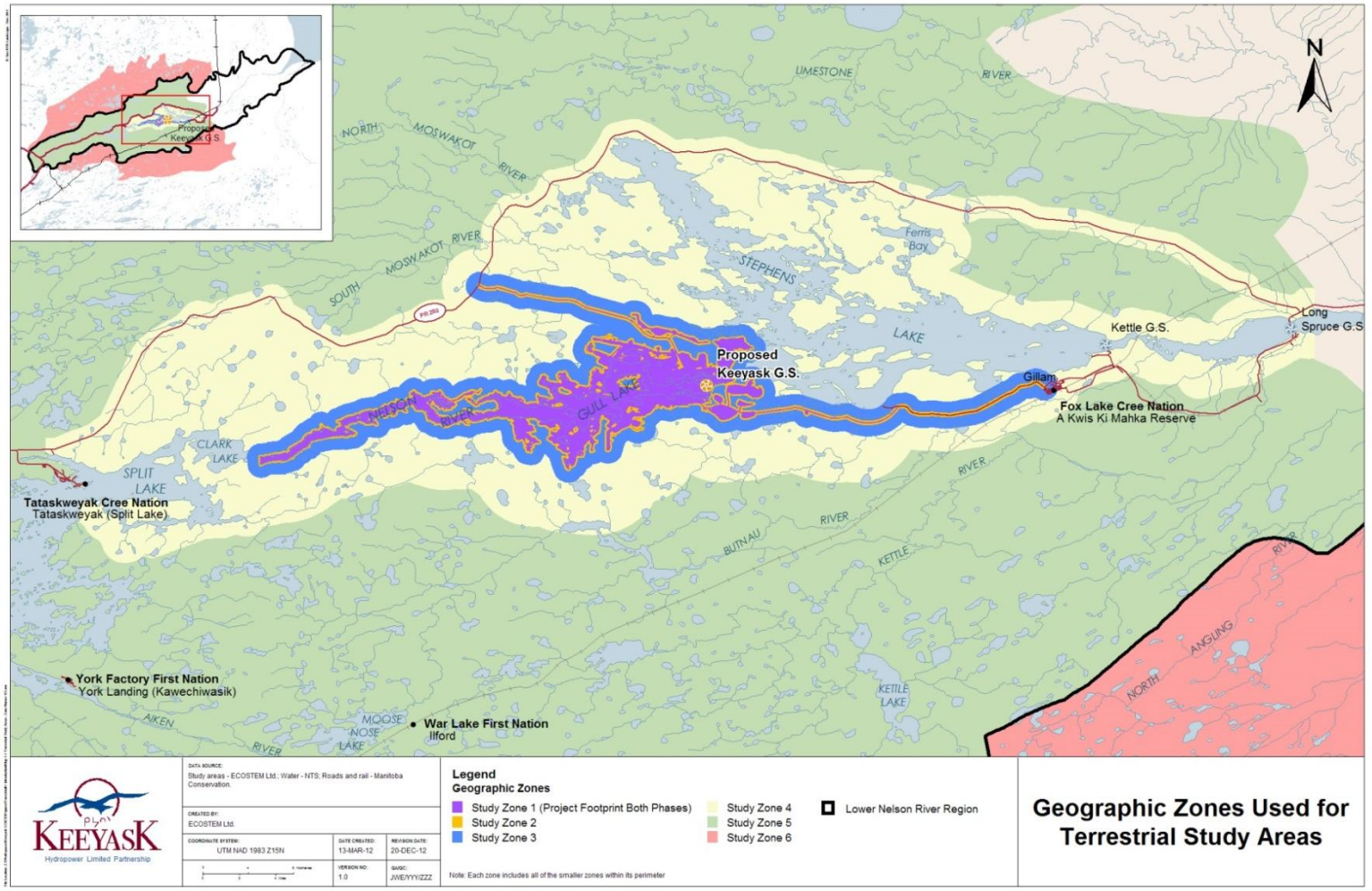
2.4 STUDY AREAS

The study area approach, which is part of the overall regional, ecosystem-based approach to the terrestrial assessment, has two key elements: delineating a regional ecosystem that encompasses the Project impact areas (*e.g.*, clearing, flooding, noise, traffic, improved access); and delineating ecologically meaningful regional study areas for the VEC populations that overlap the Project impact areas.

A defined regional ecosystem was needed for the ecosystem VECs (*e.g.*, ecosystem diversity, intactness) to implement a regional, ecosystem-based approach to the effects assessment. A regional ecosystem is an area that is large enough to support the dominant natural disturbance regime and populations of most resident wildlife species. A regional ecosystem spans an area that is relatively homogenous in ecological terms and is large enough to maintain a relatively stable habitat composition in the context of the wildfire regime so that one large fire is unlikely to substantially change the proportion of any habitat type, which means that alternative habitat is available for animals to move to when large fires occur.

Five other study areas were also delineated, either on the basis of capturing other ecosystem levels or the maximum expected potential Project zone of influence on terrestrial habitat. Map 2-1 shows the resulting six nested study zones. Study Zone 5 represents the Keeyask regional ecosystem. Local and Regional Study Areas for all of the terrestrial key topics were selected from these six study zones, where appropriate.

2.5 MAPS



Map 2-1: Study Zones used when selecting topic-specific regional and local study areas

3.0 HABITAT RELATIONSHIPS MODELS

3.1 INTRODUCTION

Construction and operation of the Project would have a variety of direct and indirect effects on terrestrial ecosystems and habitat. Many of the Project effects predictions are based on predictions about how the Project is expected to change the amounts and spatial distribution of the various terrestrial habitat types. Reliable predictions of potential Project effects on terrestrial ecosystems and habitat depended on: (i) a detailed terrestrial habitat map for the existing environment; (ii) an adequate understanding of local relationships between each of the major habitat components (*e.g.*, vegetation, soils, permafrost, groundwater) and the factors that could have a substantial influence on ecosystem composition, structure and dynamics (*e.g.*, water regime); and, (iii) a good understanding of how the various Project impacts lead to direct and indirect effects on terrestrial habitat. The terrestrial habitat map depicts what currently exists in the Project area, while the remaining knowledge was used to predict and map how the Project is expected to change the amounts and spatial distribution of the various habitat types.

Studies to support predicting and assessing potential Project effects on terrestrial habitat were conducted in the Terrestrial Habitat Regional Study Area (Study Zone 5 in Map 2-1). The purposes of these studies were to confirm the broad ecosystem and habitat relationships reported in the literature, identify local variations on or exceptions to literature generalizations and to document terrestrial ecosystem and habitat responses to past hydroelectric development in northern Manitoba.

Terrestrial habitat effects predictions included potential direct and indirect effects arising from linkages between Project impacts and terrestrial ecosystem components. Project impacts that will create direct and indirect effects include clearing, disturbance, excavation, soil compaction, flooding, reservoir expansion and access-related effects such as producing road dust, spreading invasive plants and/or causing accidental fires.

Direct Project effects on terrestrial habitat include habitat loss and disturbance within the Project Footprint. Modelling was not required to map the spatial extent of direct Project effects on terrestrial habitat since these effects could be easily determined from GIS overlays of the Project Footprint and reservoir on the terrestrial habitat map.

The Project impacts expected to account for the majority of potential indirect Project effects on terrestrial habitat are:

- Clearing and excavation; and,
- Reservoir flooding and water regime changes.

This report section presents the modelling used to predict indirect Project effects on terrestrial habitat arising from these two sources. Effects from other broad types of impacts (*e.g.*, permanent infrastructure that alters ecological flows, construction traffic that spreads invasive plants, accidental fires that alter the fire regime) are not included in this report because they are predominantly effects or risks that will be managed by standard design practices (*e.g.*, sufficient culverts in roads to maintain drainage) and environmental protection plans

(*e.g.*, measures that minimize the risk of large accidental fires) rather than expected effects to be modeled. ECOSTEM (2012a) provides reservoir expansion predictions.

3.2 LITERATURE OVERVIEW

3.2.1 BOREAL ECOSYSTEMS AND HABITAT

In global terms, the Project is located within the circumpolar boreal biome, which is also referred to as the boreal forest, taiga, northern taiga forest, temperate needleleaf forest/woodland biome or boreal zone in various classifications of the earth's ecosystems and life zones. Because forests dominate the boreal landscape, the zone is often referred to as the boreal forest in North America or the taiga in Russia (Canadian Forest Service 2013). The boreal forest includes non-forested terrestrial areas such as shrublands, sparsely treed bedrock outcrops or sedge- and moss-dominated wetlands.

3.2.2 DISTRIBUTION AND ABUNDANCE

3.2.2.1 GLOBAL

The boreal biome is one of Udvardy's (1975) thirteen terrestrial biomes. Despite being one of the world's largest and most important biomes, historically its boundaries have not been well defined and scientists have disagreed as to the extent of boreal forest within it (Brandt 2009). Map 3-1 shows Udvardy's global boreal biome and Brandt's recent delineation of the North American boreal zone. Four latitudinally arranged zones are generally recognized within the boreal zone: tundra-forest; open boreal woodland; main boreal; and, the boreal-mixedwood forest ecotone (Oechel and Lawrence 1985).

3.2.2.2 PROVINCIAL

Brandt's (2009) boreal forest zone covers most of Manitoba (Map 3-1).

3.2.2.3 PROJECT REGION

All of the Regional Study Area falls within Brandt's (2009) boreal forest zone.

3.2.3 FACTORS THAT INFLUENCE DISTRIBUTION AND ABUNDANCE OF BOREAL HABITAT TYPES

3.2.3.1 INTRODUCTION

As noted above, the factors that influence terrestrial habitat composition and distribution depend on the spatial scale being examined. This section describes key drivers for terrestrial ecosystem and habitat patterns and processes that operate from the biome to the site ecosystem levels. Some of these factors are primary drivers at more than one ecosystem level, with the difference between levels being how coarsely the associated attributes are defined. For example, the temperature and precipitation ranges that produce biomes are considerably broader than those that produce regions within a biome.

The key driver descriptions are followed by an identification of the most influential drivers at various ecosystem levels spanning from the biome to the site. Much of the information in this section is summarized from Bailey (2009) and ECOSTEM (2012b). The latter source includes literature citations for the content summarized below.

GLACIATION

Glaciation is the driver that occurs at the slowest rate and longest return interval in the boreal biome. Ice Age glaciation deposited surface materials and reshaped the land. The resulting topography largely determined where lacustrine deposits from post-glacial lakes and seas were thickest and created watersheds. Glaciation in combination with the effects of water draining from Lake Agassiz, determined the existing locations of major waterbodies and waterways. Peat developed through biological processes on the poorly drained flatlands and depressions left after Lake Agassiz drained into the Hudson Bay and the Beaufort Sea.

LANDFORM

Landform refers to geologic substrate, surface shape and relief. A coarse scale grouping of relief separates mountainous from prairie regions. Landform can modify climate in regions with high relief in the sense that high altitude locations can produce terrestrial habitat types that are characteristic of colder and/or wetter/drier regions. At a more local scale, different vegetation and soils typically occur on the north and south sides of a ridge due to differences in temperature and evapotranspiration over the growing season.

CLIMATE

Climate is the long-term or generally prevailing weather. All natural ecosystems are shaped to some degree by climate because climate is a source of energy and water. Climate limits which plant and animal species can survive and become abundant. Temperature is a key influence on the overall distribution of permafrost. Temperature and evapotranspiration rate influence soil and wetland development. Precipitation influences erosion and sedimentation. Climate is also the key determinant for the wildfire regime so that different regions can have different wildfire regimes, which in turn influences regional habitat composition.

HYDROLOGY

Climate, surface materials and landforms interact to produce a drainage network, waterbody and range of soil moisture conditions. For example, large wetlands are not expected in desert regions even if the dominant surface material is impervious to water percolation. Through precipitation and evaporation, climate influences the typical amount of surface water runoff and groundwater recharge. Depth to water table, water level fluctuations, water flows, waves and ice scouring are highly influential on vegetation and soil patterns and dynamics. These latter factors are discussed at length in ECOSTEM (2012b).

SOIL AND PEATLAND DEVELOPMENT

Soil type is a key determinant for vegetation distribution and abundance. The five natural factors that influence soil formation are climate, parent materials, topography, biota and time (Brady 1974). With the exception of the last two, the basic nature of these factors was introduced above. Biota refers to influences of vegetation, microbes and soil animals on soil development. Due to the climate, boreal vegetation and fungi (a type of microbe) are the dominant biological factors in the boreal forest. Vegetation is predominant among these for organic soil and peatland formation. The processes and drivers for peatland formation are of particular interest for the Project effects assessment because most of is covered by peatlands.

Peatlands have developed over millennia in the boreal forest, through the processes of terrestrialization and paludification. Paludification is the process whereby vegetation (primarily *Sphagnum* mosses) on mineral soils progressively creates a wetter moisture regime that eventually leads to the formation of a surface organic layer that expands laterally over time (Figure 3-1). Paludification can be initiated outside of lacustrine basins or riverine valleys in lower slope areas. In upland areas, paludification can occur in wet depressions or in areas with a moist to wet moisture regime. Paludification can progressively blanket an area in an upslope direction. Factors that currently promote paludification in new areas include climate change, geomorphological change, beaver dams or forestry practices.

Terrestrialization refers to the process whereby all or portions of a waterbody are filled in by the horizontal expansion of peat from the shore towards the center of the water body and by organic sediment deposition (Figure 3-1). A riparian peatland that was initiated through terrestrialization often expands inland and paludifies adjacent mineral ecosites.

The non-riparian components of the peatland mosaics in the Project region (Photo 3-1 is an example mosaic) are thought to have formed from a combination of terrestrialization and paludification. Paludification may or may not have been initiated by riparian terrestrialization. In the north, paludification usually commences once *Sphagnum* spp. have established. As organic material accumulates, the water table of peatlands can slowly elevate over time, causing peatland encroachment onto upland areas. The elevated water table can lead to forest flooding and eventual stunting or killing of trees.

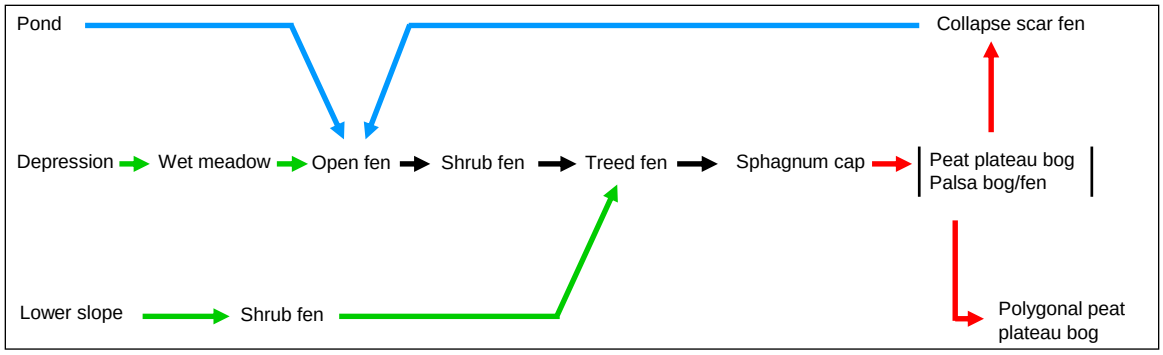


Figure 3-1: Pathways of wetland development in Northern Canada (after Zoltai *et al.* 1988a). Arrow legend: blue=terrestrialization; green=paludification; black=terrestrialization or paludification; red=permafrost dynamics.

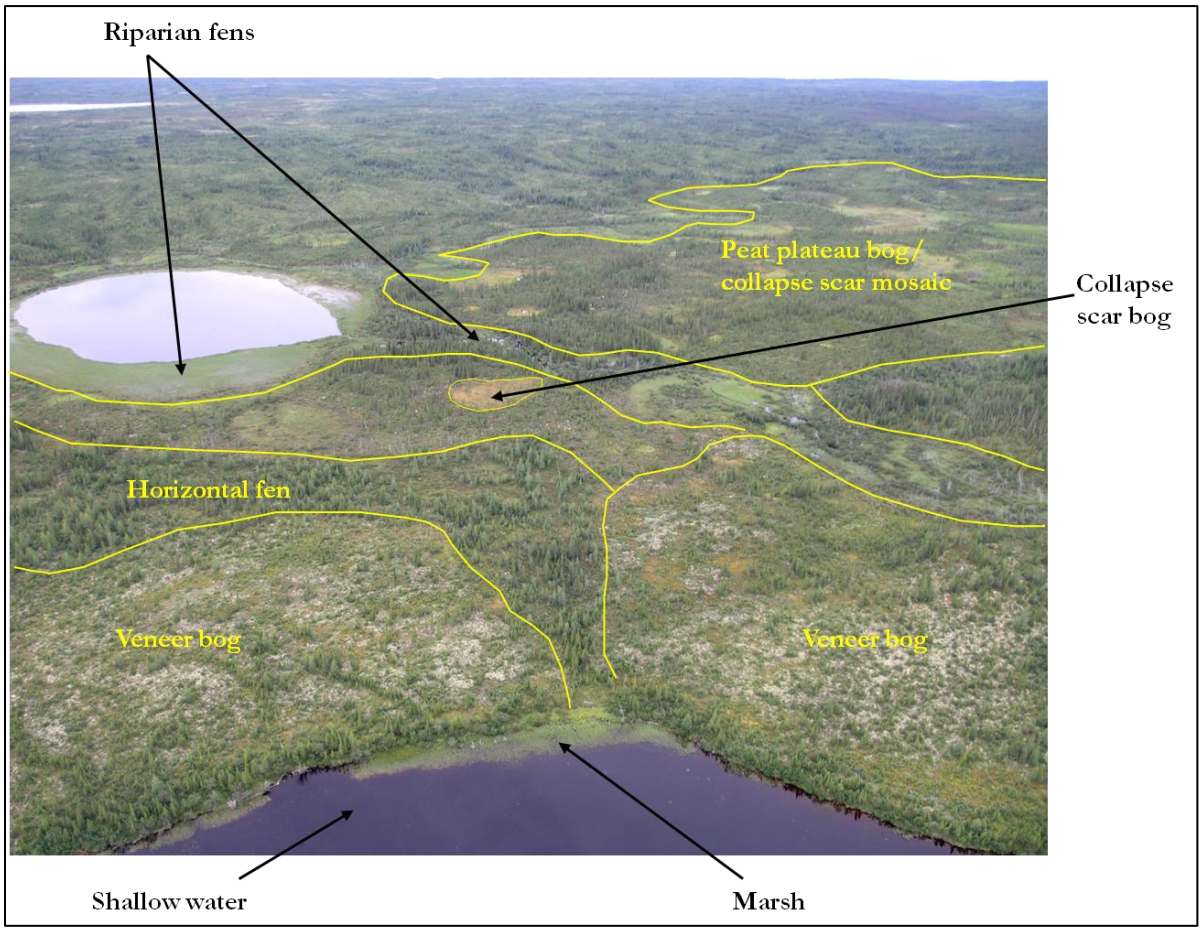


Photo 3-1: Photo from the Project region showing four of the five wetland classes

Climate has an importance influence on the distribution and abundance of different peatland types. One of the pathways for these influences occurs through permafrost. Peatlands with ground ice (*i.e.*, peat plateau bogs) are the most pronounced permafrost peatland type. Ground ice can elevate their surfaces several meters above the surrounding area, which produces vegetation more similar to upland than typical peatland conditions. The southern edge of peat plateau bog distribution generally corresponds with the -1˚C isotherm (Vitt *et al.* 1994). Permafrost may have reached its maximum spatial extent during the Little Ice Age (1550-1850 AD; Turetsky *et al.* 2000).

The effects of climate warming that occurred at the end of the Little Ice Age are still ongoing for peat plateau bogs. Several studies document a reduction in the total area of permafrost peatlands since the end of the Little Ice Age (~ 150 years ago) with no evidence of subsequent aggradation. Ongoing permafrost degradation and permafrost melting is thought to be a lagged response to the general warming trend that occurred at the end of the Little Ice Age. This climate change disequilibrium in permafrost melting may be attributed to the buffering capacity of local factors (*e.g.*, presence of insulating layer of *S. fuscum*) to mediate the effects of regional climate change. Vitt *et al.* (2000) estimated that, of the permafrost that remains in boreal western Canada, 22% is still in disequilibrium with the climate.

WILDFIRE REGIME

Fire is the keystone driver in the boreal forest for the temporal scale that corresponds with forest stand dynamics. Relative to other global forest ecosystems, boreal vegetation is young due to frequent, large stand-replacing fires. Fire rejuvenates the ecosystem at all spatial levels spanning from the site to the region.

The fire regime is highly dependent on climate. Climate change that increases evapotranspiration rates has been associated with higher fire frequency and total area burned. Humans have altered the fire regime in several ways. Fire suppression and possibly roads have reduced the total area burned by natural and human caused fires. In contrast, the human contribution to fire starts and total burned area has likely increased.

A boreal wildfire drastically changes habitat but generally only for the short-term. Boreal plant species are well adapted to regenerate from the individuals that were there when the fire occurred, and this imparts inherent resistance and resilience to fire at the plant community level. An important function performed by fire is rejuvenating site conditions by arresting the successional decline in nutrient availability, pH and, in some cases, soil temperature and elevating these factors to levels that are more favourable for plant growth.

Boreal plant and animal adaptations to frequent disturbance by large wildfires impart some resistance and resilience to novel types of disturbance provided they are within the ranges of natural variability. Even beyond this, it is generally thought that ecosystem functions can be maintained with the loss of one or a few species due to ecological redundancies.

INSECT AND DISEASE OUTBREAKS

Although other disturbances such as windthrow or insect and disease infestations can also affect large areas in some parts of the boreal forest, there is no evidence that stand-replacing disturbances of these types are important in the Project region based on photo-interpretation and field surveys.

TIME

Similar to the soil forming factors, time is a driver for change at all spatial scales. Plant maturation and vegetation succession are examples of how the passage of time changes patterns.

3.2.4 MOST INFLUENTIAL DRIVERS

3.2.4.1 METHODOLOGY

The primary ecosystem drivers depend on the ecosystem level (Section 1.1) of interest, which determines the relevant temporal and spatial scales. Thus, ecosystem levels need to be identified.

Ecosystem hierarchy theory uses differences in the rates or frequencies of processes to delineate ecosystem boundaries at multiple nested levels (Allen and Starr 1982, King 1993 and Rowe 1961 for components or Ehnes 1998 and Waltner-Toews *et al.* 2008 for a synthesis). Causal linkages between ecological states and factors lead to natural functional breaks in spatial and temporal scales that facilitate the identification of an ecologically meaningful nested hierarchy of ecosystem levels. For a given phenomenon, a large differential in process rates or frequencies effectively isolates the fast manifestation of the phenomenon from its next slower level. For example, although precipitation fluctuates on a daily basis, this occurs around a long term mean. The growth of an annual or biennial plant is affected by monthly or annual fluctuations in precipitation but not by changes in long-term mean precipitation. The latter dynamic occurs over a period that exceeds the life span of individuals for most species. On the other hand, long-term change in average precipitation is associated with changes in the geographic distribution of the species that the individual represents.

The various levels in an ecosystem hierarchy (*e.g.*, site, stand, region, the biosphere) are levels of biological organization that are delineated by substantial differences in the rates or frequencies of change in the key ecosystem drivers (Allen *et al.* 1987; King 1993). Relative to the object of interest, higher ecosystem levels provide the context and constraints while the lower ecosystem levels are the components and mechanisms (Allen *et al.* 1987; King 1993; Bailey 2009). Figure 3-2 provides a sample classification of hierarchical ecosystem levels. Sites form stands, stands form landscapes, landscapes form subregions, subregions form regions and so on up to the biosphere (*e.g.*, Bailey 2009; Ehnes 2011). As examples, climate and fire regime, which manifest meaningful spatial variation at the zone, region or sub-region ecosystem levels, constrain which plant species can survive and become abundant within a site, stand or landscape. Because higher ecosystem levels result from decreasing rates or frequencies for ecological phenomena, they tend to correspond with larger spatial extents and longer temporal periods.

The following quote from Bailey (2009) is illustrative of how ecosystem levels are identified and then used for land use management.

> "(T)he land is conceived as ecosystems, large and small, nested within one another in a hierarchy of spatial sizes. Management objectives and proposed uses determine which sizes are judged important. The aim of useful land classification and mapping is to distinguish appropriately sized ecosystems. . .

> (W)e must examine the relationships between an ecosystem at one scale and ecosystems at smaller or larger scales to predict the effects of management prescriptions on resource outputs."

The stand and site ecosystem levels are the most relevant ones for hydroelectric generation project effects assessment, since the rates and frequencies that produce stand level ecosystems correspond with the assumed Project life span. Site level ecosystems provide the mechanisms for the stand level patterns. The regional ecosystem is the appropriate level to provide the ecological context for Project effects (Miller and Ehnes 2000).

The following section describes the most influential drivers at each ecosystem level, with emphasis on those relevant for the site, stand and landscape ecosystem levels.

3.2.4.2 MOST INFLUENTIAL DRIVERS AT VARIOUS ECOSYSTEM LEVELS

Much of the information in this section is summarized from Bailey (2009) and ECOSTEM (2012b). The latter source includes literature citations for the content summarized below. Information from additional sources is cited where applicable.

BIOME TO ZONE

All natural ecosystems are delineated to some degree by climate since climate is a source of energy and water. Progressively broader groupings of climate attributes are relevant for progressively higher ecosystem levels in the Figure 3-2 hierarchy. Macro-climate, which is the coarsest grouping of weather attributes, is an ultimate driver and primary factor creating biomes (Figure 3-2). Other factors modify macro-climate controls within a biome, leading to the zonation associated with the next lower ecosystem levels. Major terrestrial ecosystem types are arranged in a predictable pattern based on the interplay of climate and surface features arranged with reference to latitude, elevation and continental position.

As described in Section 3.2.3.1, the relevant terrestrial ecosystem and habitat drivers at the highest ecosystem levels are the slowest rate or lowest frequency processes, the slowest of which are those that formed the earth and the continents. Geologic substratum creates boundaries within biomes and realms. In the boreal forest, Quaternary glaciation created the most influential large scale geologic differentiation. Glacial and post-glacial processes in North America deposited differing thicknesses of overburden on the underlying pre-Cambrian bedrock. The Boreal Shield occurs where glacial and post-glacial deposits form a relatively thin cover over the underlying bedrock.

For the boreal biome to region ecosystem levels (the millennia and centuries temporal scales), the key drivers are climate, glaciation and soil formation because they create the surface materials, topography, fire regime and peatlands. A finer resolution grouping of long-term weather attributes separates the North American boreal shield zone into ecological regions (*i.e.*, finer variation of macro-climate). Bailey (2009) identifies landform as the secondary driver to climate at this ecosystem level.

Within a particular North American boreal shield region, the key drivers are those that occur at intermediate rates or frequencies relative to biome and stand level drivers. Less than a century is the temporal scale for stand and site level dynamics since this is longer than the life span of most terrestrial plants species living in

boreal shield ecosystems. The drivers at this level are landform and macro-climate (attributes measured more finely than for biomes), since these attributes change or recur much more slowly than the life span of the characteristic tree species.

REGION TO SUB-REGION

Frequent, large wildfires characterize most of the boreal forest. The nature of fires within a large area over time can be characterized in terms of attributes such as their frequency, size, intensity, severity, patchiness, seasonality and type (*e.g.*, ground versus canopy), which are collectively referred to as the fire regime. A fire regime is largely a function of climate and surface materials (which determines the landscape level configuration of flammability). Surface material is an ultimate constraining driver for the fire regime because its composition changes very slowly relative to climate and the length of the fire cycle.

Different fire regimes produce different vegetation patterns which is among the reasons why fire is the keystone driver in the boreal forest at the century time scale. Consequently, fire regime is a key factor used to delineate regions. Sub-region delineation is primarily based on substantial differences in dominant surface materials and the overall amount and spatial configuration of surface water.

LANDSCAPES TO SITES

Landscapes, landscape elements, stands and sites are the ecosystem levels nested within a sub-region (Figure 3-2). Bailey (2009) refers to these levels as the microscale and identifies topography, specifically slope and aspect, as the primary driver. Topographic differences create distinct soil moisture and temperature regimes, which in turn contribute to producing different vegetation types.

At the site and stand levels, the vegetation dynamics linkage diagram included as Figure 3-3 indicates that the ultimate causal factors in site to stand level vegetation dynamics are site type (physical and chemical properties of the site), landscape configuration (spatial arrangement of landforms, water bodies and vegetation types), disturbance type, climate, soil organisms, plant functional type (genotypic limitations on the transformation of resources into growth and reproduction), herbivory and disease. Although age does not appear as a causal variable, it is implicitly included via the temporal dimension of the arrows that represent pathways linking the variables to each other. The age driver incorporates the effects of autogenic processes such as plant population dynamics, which are sometimes disrupted by disturbances at the stand and gap scale. Vegetation, which is the ecosystem response of interest in Figure 3-3, has feedback effects on other ecosystem components through pre-disturbance vegetation, competition, interactions with soil processes and canopy effects on understory light intensity and microclimate.

The effect of age, or time, is closely linked with stand replacing disturbance in the boreal forest. Since the central Canadian boreal forest is a disturbance driven system, most of its area is continually undergoing wildfire initiated vegetation succession. A typical post-fire succession can be divided into developmental stages such as establishment, shrub, canopy closure, maturity and senescence. These stages represent conspicuous differences in physiognomy and species composition. The shrub stage occurs when tree saplings have over-topped and shaded vegetation in the ground and herb layers. It marks the end of the post-fire ephemeral invasion period. With canopy closure begins the period of asymmetric competition for light and self-thinning. Community maturity occurs when the rate of density dependent tree mortality has declined

substantially and species composition is relatively stable. Senescence is poorly understood since disturbance usually recurs prior to this stage but evidence suggests that regression to an open shrubland may occur rather than self-replacement.

Climate and plant functional type can be ignored when a community scale study occurs within an ecological region since relative homogeneity of these and other variables are the basis for region delineation. In a community level study, the plant functional type box refers to the pool of species available to colonize sites in the study area.

Research demonstrates that site type, age, disturbance type and pre-disturbance conditions influence the species composition of boreal communities. At the landscape to site levels, the proximate overriding influence on boreal vegetation composition is usually ecosite type. Of the ecosite attributes, moisture regime appears to be the most influential factor on vegetation composition. Nutrient availability and light intensity gradients become influential when the focus narrows to variability among sites with a similar moisture regime or to temporal changes on particular sites. In contrast with the very different vegetation types created by moisture and nutrient availability gradients, wildfire typically initiates a succession of vegetation types with similar species composition to what was there prior to fire. That is, boreal post-fire vegetation dynamics generally involve immediate regeneration of the vascular plants that were present prior to the fire, the rapid growth and demise of post-fire thrivers (*e.g.*, green-tongue liverwort (*Marchantia polymorpha*), Bicknell's geranium (*Geranium bicknellii*), fireweed (*Chamerion angustifolium*)) and gradual changes in the moss and lichen community. Most herbaceous post-fire pioneers disappear within about ten years of the fire leaving a group of plant species that is similar to what was there prior to fire.

3.2.4.3 MOST INFLUENTIAL DRIVERS FOR A PROJECT EFFECTS ASSESSMENT

The stand and site levels are the most relevant ones for hydroelectric generation project effects assessment because these are the levels where the mechanisms for regional ecosystem patterns and dynamics occur (Section 3.2.3.1). Linkage diagrams were created to identify potential pathways of Project effects, including feedback effects. Figure 3-4 is a linkage diagram for vegetation clearing effects on terrestrial habitat, while Figure 3-5 is a linkage diagram for reservoir creation and water regulation effects. These linkage diagrams synthesize literature information and professional judgment to identify the anticipated most influential drivers for Project effects (thicker arrows) following a particular type of Project impact. Additionally, these diagrams identify which types of effects should be searched for when conducting Project studies.

Section 3.2.4.1 explained how substantial differences in the rates or frequencies of change for the key ecosystem drivers facilitated the spatial delineation of a terrestrial ecosystem hierarchy.

Major differences in the nature of the most influential drivers also produce a major ecological zonation that cuts across all ecosystem levels: aquatic versus terrestrial; and the terrestrial zone is structured into two major types: wetlands and uplands. Wetlands are land areas where periodic or prolonged water saturation at or near the soil surface shapes ecosystem patterns and processes (National Wetlands Working Group 1997). Uplands are all land areas that are not wetlands. Large wildfires are the dominant natural driver for uplands in the Regional Study Area. Groundwater, surface water and water nutrient regimes are the key drivers in most wetlands, and among the driving factors in the remaining ones (Keddy 2010).

According to hydrological connections criteria (National Wetlands Working Group 1997), the two major types of wetlands in the Regional Study Area were shoreline and inland wetlands. Shoreline wetlands were located along the shorelines of a waterbody (*i.e.*, surface water areas larger than 0.5 ha) while inland wetlands were all remaining wetlands. The dominant drivers for inland wetlands were depth to groundwater and wildfire, whereas water level fluctuations, water flows and waves were the dominant drivers for shoreline wetlands. Ice scouring was also important for Nelson River shoreline wetlands.

Regional Study Area terrestrial habitat and ecosystems were classified into three major ecological zones referred to as upland, inland wetland and shore zone (illustrated in Photo 3-2; note that only shoreline wetland portion of shore zone is labeled) because their dominant drivers, or controlling factors, were dramatically different. Dominant drivers were critical to understanding ecosystem dynamics and predicting potential Project effects.

At any given shoreline location, different plant species are typically arranged into bands that reflect a transition in the typical range of growing season water depths (Hellsten 2000; Cronk and Fennessy 2001; Keddy 2010; see Photo 3-3 for an example from the Regional Study Area). To capture the strong influence that the water regime has on shoreline wetland ecosystems, the shore zone was subdivided into water depth duration zones (*i.e.*, littoral, lower beach, upper beach, inland edge and inland) using the number of days that growing season water depths exist over a particular depth range. The shore zone also included areas where ice scouring extended into the upland ecological zone (note that some authors refer to the inland edge as the riparian zone). Figure 3-6 provides a conceptualization of the water depth duration zones, including the types of plant species typically found within each zone. Photo 3-3 illustrates the water depth duration zones and the dominant type of vegetation that is typically found within each duration zone. Photo 3-3 also shows the wetland classes used to map wetlands in the Regional Study Area (see ECOSTEM 2012b for definitions of the wetland classes).

Sampling design, analytical methods and modelling techniques for the inland studies differed from those used for shoreline wetlands due to the dramatic differences in the most influential drivers and Project linkages. For example, inland habitat data were collected in plots located in relatively homogenous portions of stands whereas shoreline wetland data were collected along transects that spanned the entire water depth gradient in the shore zone.

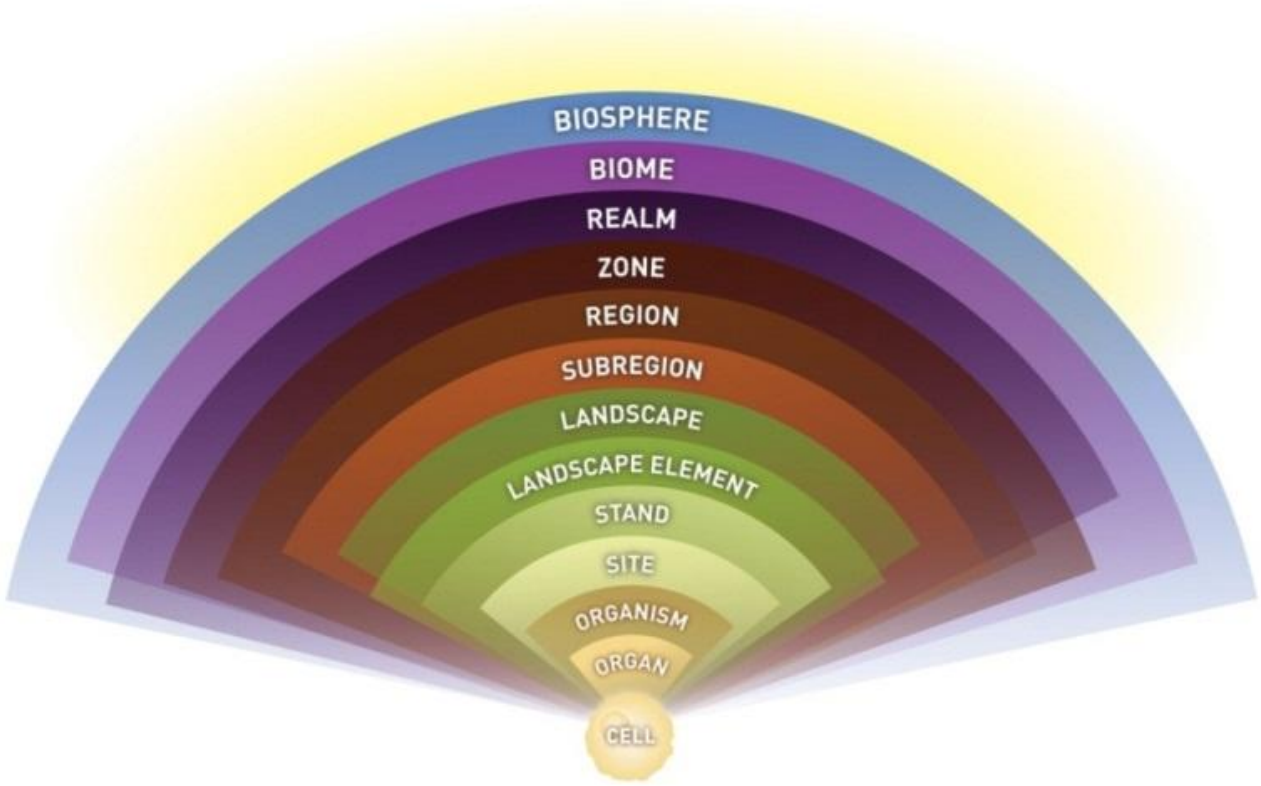


Figure 3-2: Hierarchical ecosystems levels

Source: Ehnes (2011)

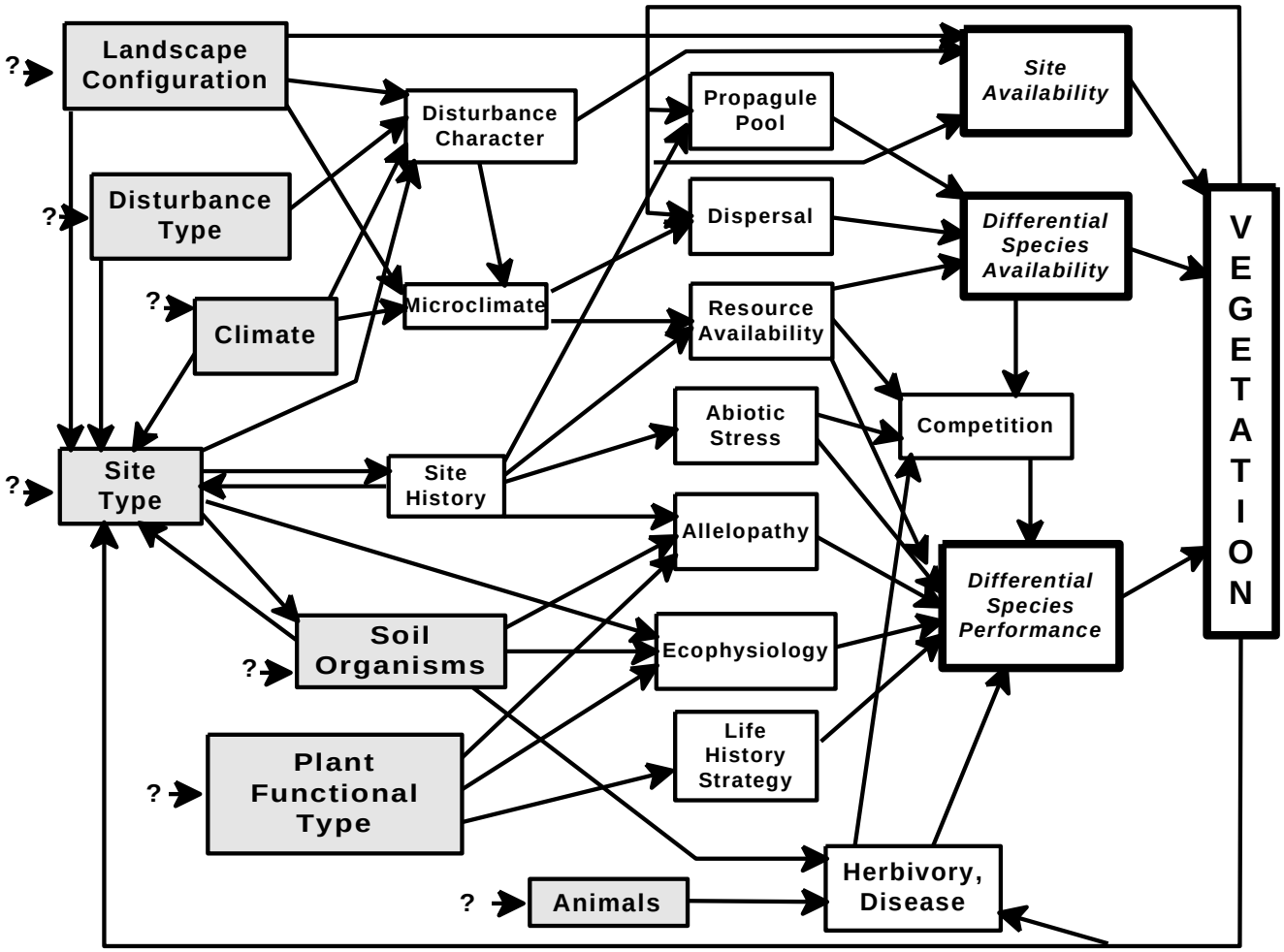


Figure 3-3: Linkage diagram for vegetation dynamics.

Shaded boxes identify causal variables which are "ultimate" at the site scale. Arrows depict the hypothesized direction of cause and effect. Some variables and linkages are not shown. A few of the feedback effects of vegetation on ecosystem attributes are also identified. Source: Ehnes (1998).

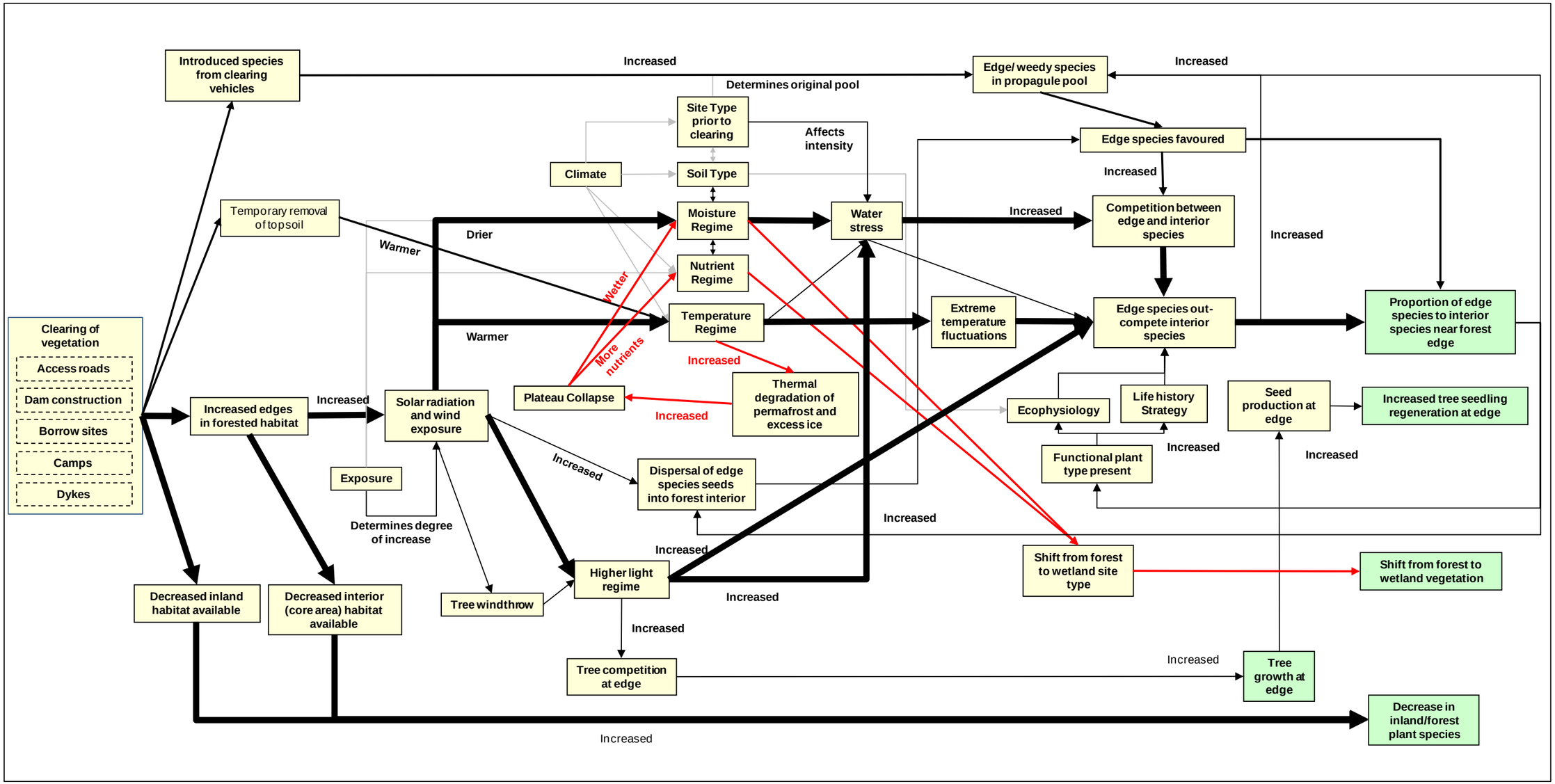


Figure 3-4: Network Linkage Diagram for Terrestrial Vegetation Changes Caused by a Clearing for Temporary Project Footprint Components.

Linkage diagram not intended to capture every theoretically possible pathway of effects. Arrow thickness represents relative degree of influence.

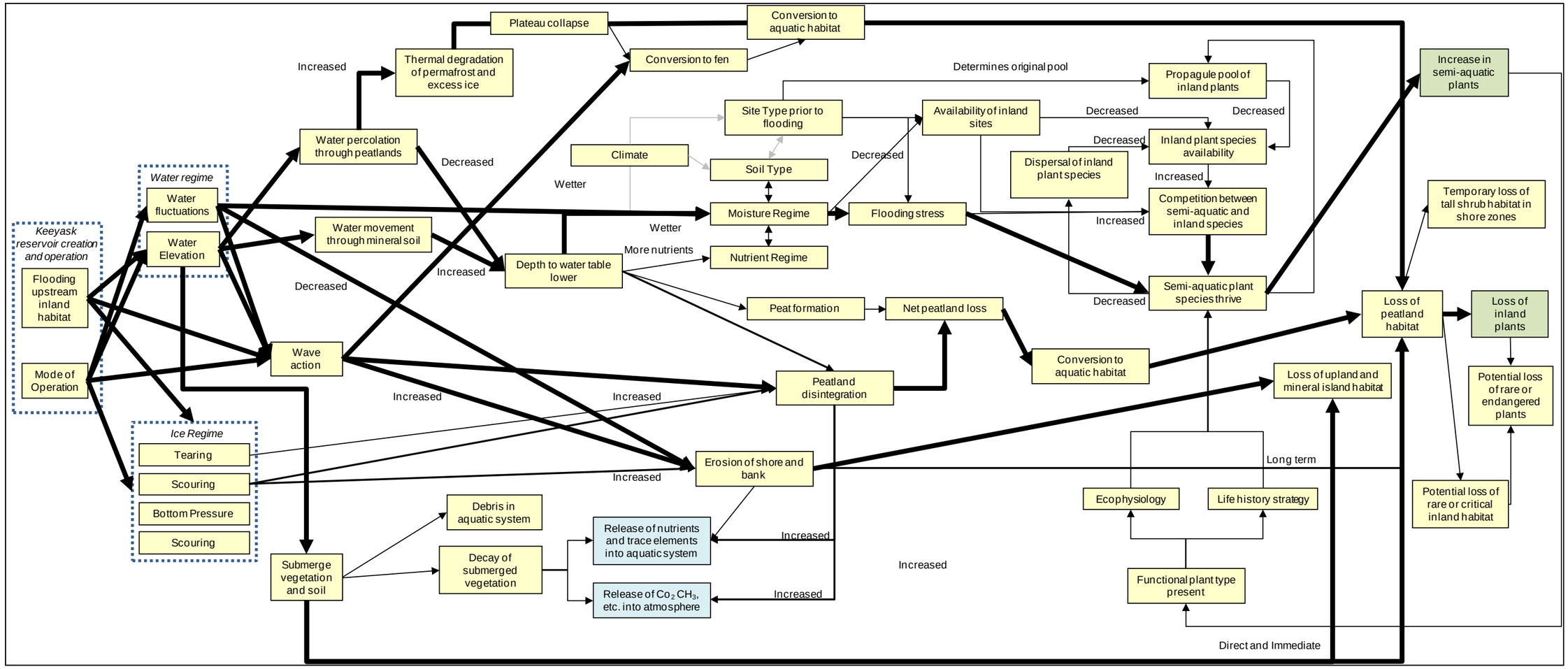


Figure 3-5: Network linkage diagram for reservoir flooding and water regime effects on terrestrial habitat.

Linkage diagram not intended to capture every theoretically possible pathway of effects. Arrow thickness represents relative degree of influence.

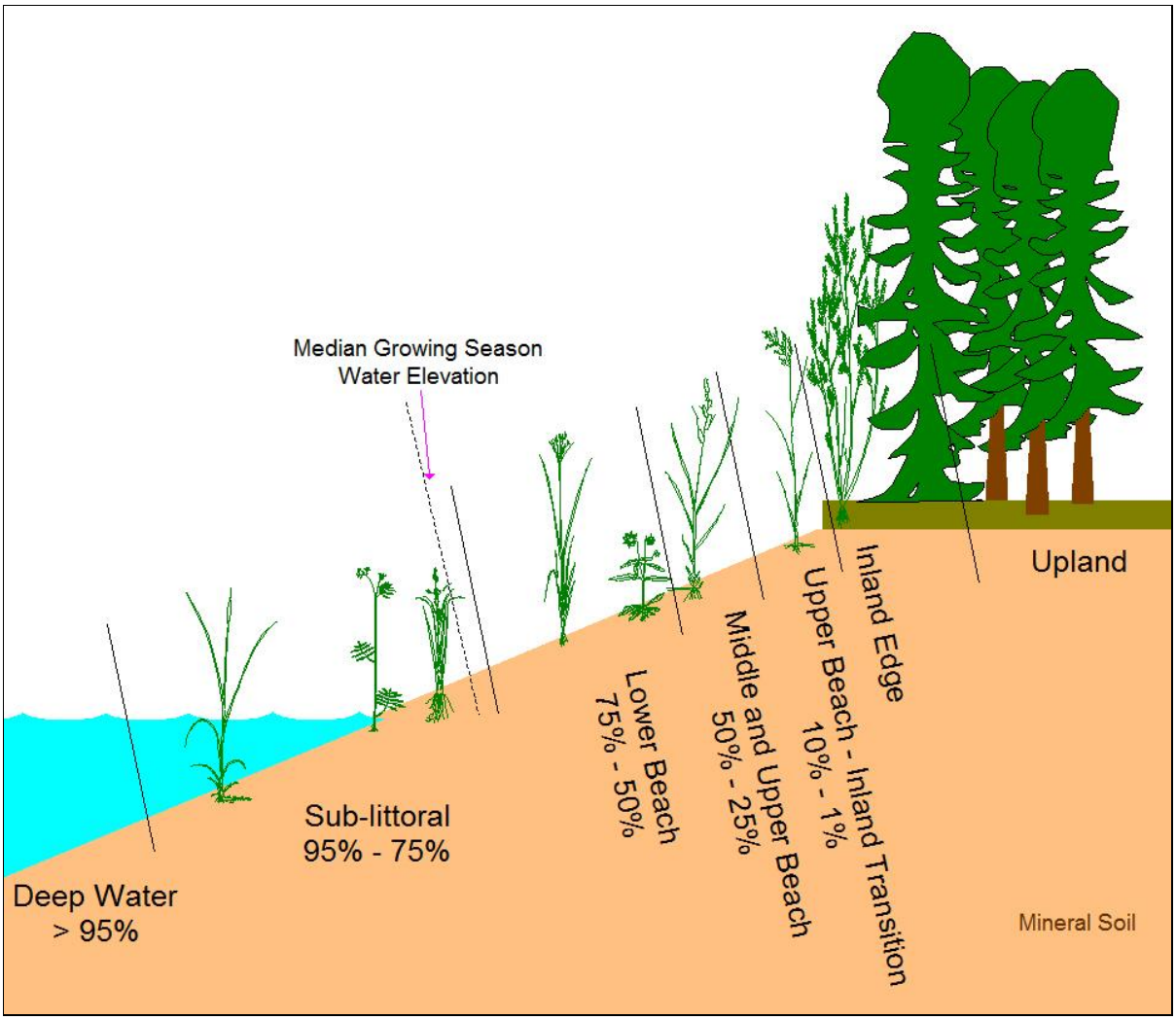


Figure 3-6: Water Depth Duration Zones and the Types of Plants Found in Each Zone

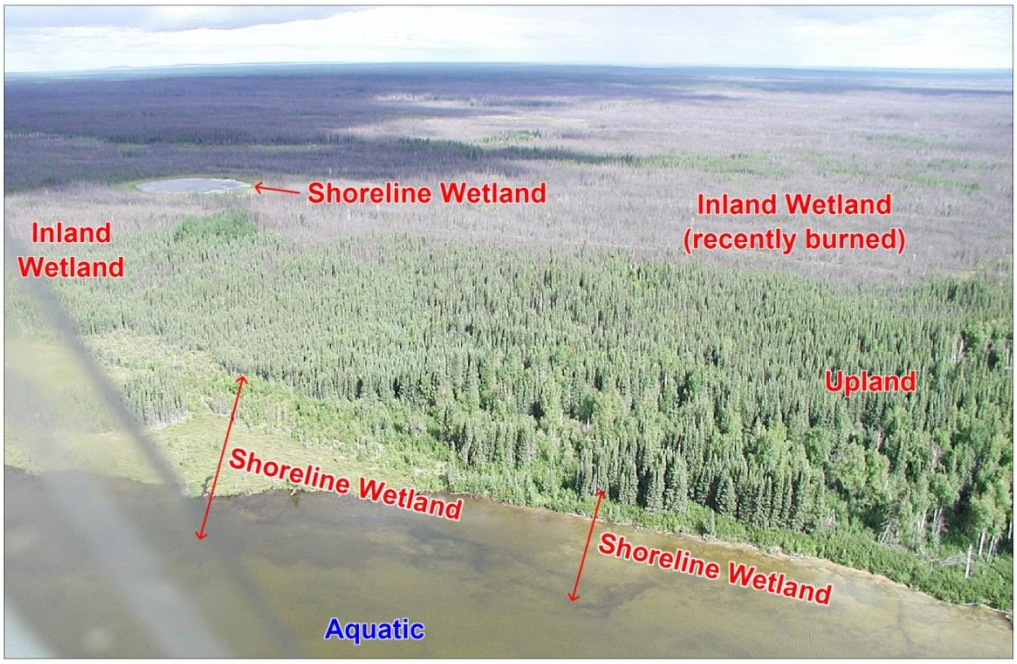


Photo 3-2: Broad ecological zones in the Lower Nelson River region

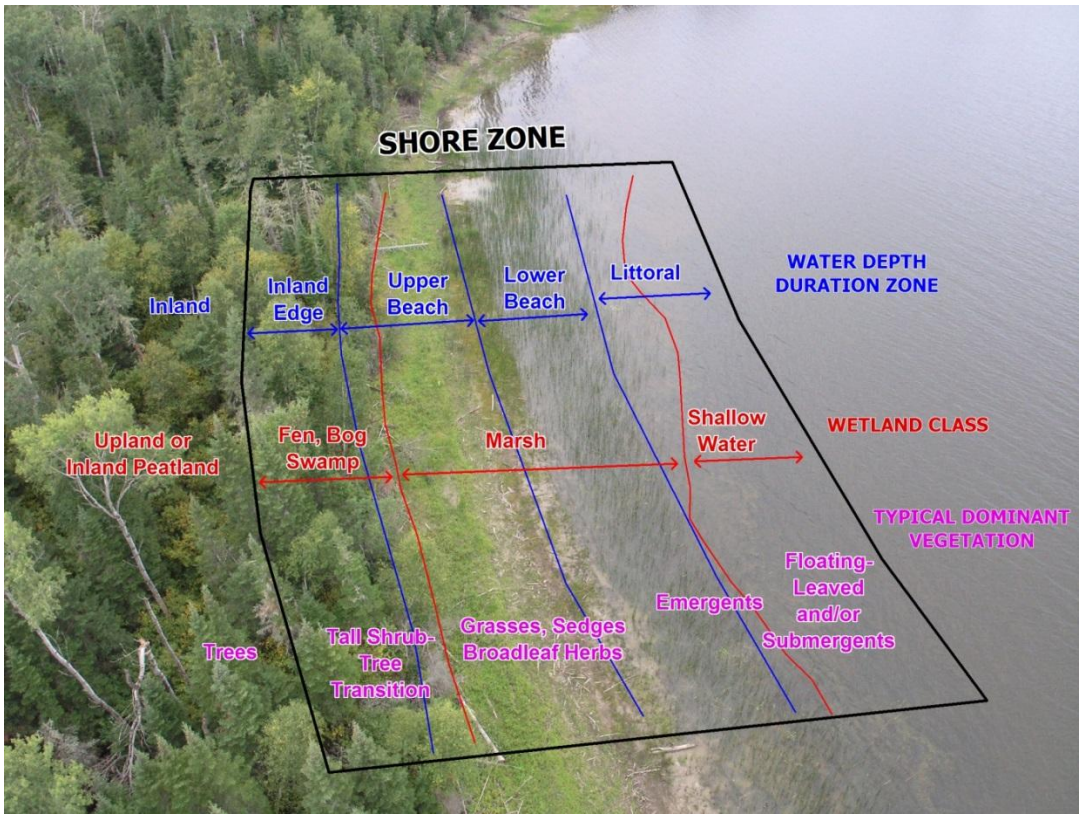


Photo 3-3: Photo illustrating shoreline wetland water depth duration zones, vegetation bands and wetland classes in an off-system waterbody

3.3 MODELS

3.3.1 INTRODUCTION

Project impacts (*e.g.*, clearing, flooding, noise, traffic) will create indirect effects, both within the Project Footprint and in some surrounding areas. That is, a Project impact will have a zone of influence surrounding its physical footprint. The manifestation of a particular indirect terrestrial habitat effect may be several stages removed from the direct Project effect. For example, vegetation clearing on permafrost soils will generally lead to higher soil temperatures, both within the cleared area and in adjacent areas. Vegetation clearing on treed peatlands with thick ground ice will generally lead to permafrost melting, followed by collapse of the soil surface to form craters, and then by the development of very wet peatland habitat and/or open water in the craters (Figure 3-4 illustrates this pathway of effects). In this situation, the direct effect on habitat is vegetation clearing in the Project Footprint, an initial indirect effect is soil warming which leads to the secondary indirect effect, permafrost melting within the cleared area initially and then in surrounding areas, followed by the tertiary indirect effect, peatland surface collapse, and finally the ultimate indirect habitat effect which is conversion to very wet peatland habitat and/or open water.

The size and nature of the indirect zone of influence will be determined by how the particular Project impact interacts with the ecosystem component of interest and local conditions. For example, tree clearing in dense forest on permafrost soils will have a much larger habitat zone of influence than tree clearing on a sparsely treed bedrock outcrop. In this example comparison, the nature and spatial extent of indirect habitat effects will range from conversion to aquatic areas to barely measurable. In general, indirect Project effects on vegetation, soils, animals and key ecological flows are expected to decline with distance from the Project impacts.

As described in Section 3.1, this report compiles the modelling used to predict potential indirect Project effects on terrestrial habitat arising from the Project-related clearing, excavation, flooding and upstream water regime changes.

As discussed in Section 3.2, the main potential indirect effects from these impacts into surrounding areas are:

- Edge effects on vegetation and soils around new or expanded openings;
- Changes to soil drainage, moisture and structure (*e.g.*, from increased evaporation, altered surface water drainage or elevated groundwater); and
- Soil warming and permafrost melting.

The primary pathways for these potential Project effects are the same as those shown in the pathway and linkage diagrams provided in Section 3.2.

The spatial extent of these indirect effects on terrestrial habitat is referred to as the Project's terrestrial habitat zone of influence. The predicted size and locations of the terrestrial habitat zone of influence feeds into many components of ecosystem dynamics and the environmental assessment.

Due to the size and complexity of the Project, the initial intent was to develop multivariate statistical models to predict the magnitude and nature of Project effects on terrestrial habitat. Once habitat relationships were confirmed and expected residual Project effects became fairly well understood, it was determined that empirical models would be adequate for effects predictions (an empirical model uses observed patterns under comparable conditions rather than constructing a model of processes between state factors). That is, the effort required to produce the additional rigor provided by a process or simulation model was not warranted when it became clear that likely Project effects on terrestrial habitat using overestimates of expected effects were within the regionally acceptable range once mitigation measures and modifications to Project design were adopted.

Empirical models were used to predict terrestrial habitat effects. That is, the extent and nature of indirect effects observed at northern Manitoba locations previously exposed to similar impacts under similar ecological conditions were used as the model for the Project's expected terrestrial habitat zone of influence.

The EIS used the overall maximum and typical maximum potential distances of indirect effects to delineate the terrestrial habitat Local Study Area and the predicted terrestrial habitat zone of influence. It was assumed that the overall maximum distance that potential indirect Project effects on terrestrial habitat could extend from the Project Footprint and reservoir is 150 m with a few localized exceptions (*e.g.*, hydrological changes affecting long, linear wetlands). Based on professional judgment and information available at the time, this 150 m overall maximum width was thought to be three times wider than the expected typical maximum width of 50 m.

This report provides evidence to confirm the:

- generalizations regarding the most influential driving factors for Manitoba boreal habitat dynamics (Section 3.2.4) hold for the Regional Study Area; and,
- assumed size of the Project's terrestrial habitat zone of influence arising from:
    - vegetation clearing;
    - reservoir creation and water regulation.

3.3.2 STUDY AREAS

The Regional and Local Study Areas for terrestrial habitat were Study Zones 5 and 2 in Map 2-1, respectively. ECOSTEM (2012b) describes the methodology used to delineate topic-specific regional and local study areas.

3.3.3 INFORMATION SOURCES

3.3.3.1 EXISTING INFORMATION

Section 3.2 summarized the literature regarding the key drivers and pathways for terrestrial habitat and ecosystem patterns and dynamics.

The effects of clearing on vegetation adjacent to northern Manitoba transmission line rights-of-way are documented in a study conducted along more than 900 km of transmission line rights-of-way, some of which overlap the Regional Study Area (Ehnes and ECOSTEM 2006).

There was no existing information on reservoir-related effects on terrestrial habitat from studies conducted in the Regional Study Area when Project studies commenced.

3.3.3.2 PROJECT STUDIES

Field studies to develop a better understanding of local terrestrial ecosystems and to help predict potential Project effects were conducted from 2001 to 2012. These studies were essential because little data for terrestrial ecosystem components were available for the Regional Study Area when the studies commenced. The purposes of these studies were to confirm the broad relationships reported in the literature, to identify important local variations on or exceptions to literature generalizations and to document terrestrial ecosystem and habitat responses to hydroelectric development in northern Manitoba as examples of how Project area ecosystems would likely be affected.

Project studies collected vegetation, soils and environmental data at over 500 habitat plots, along over 540 km of habitat transects and at over 4,000 soil profile sample points in the Regional Study Area over the years 2003 to 2011. Additional data, including photo-interpreted features from large-scale historical stereo air photos, were collected as needed for the vegetation clearing and reservoir effects studies.

3.3.4 METHODS

The Project EIS and technical reports provided the evidence to support the generalizations regarding the key influences on terrestrial habitat patterns and the predicted extent of the Project's terrestrial habitat zone of influence, with one exception. Rather than duplicating all of that information, this report summarizes the key findings contained in those reports. The exception referred to in the first sentence is a study conducted to confirm the expected width of terrestrial habitat edge effects from vegetation clearing. For ease of reference, the background, methods and results for the vegetation clearing study area are all provided in Section 3.4.2.

3.4 RESULTS

3.4.1 MOST INFLUENTIAL DRIVERS FOR HABITAT PATTERNS

3.4.1.1 UPLANDS AND INLAND PEATLANDS

Large-scale terrestrial habitat mapping and plot data from the Regional Study Area confirmed associations between environmental drivers and habitat components. Large-scale terrestrial habitat mapping implicitly showed the strong relationship between vegetation type and ecosite type in that some vegetation types were either completely or largely confined to a subset of the ecosite types in the habitat type combinations (Table 3-1). For example, the balsam poplar dominant vegetation type (*i.e.*, BA Pure in Table 3-1) was confined to the mineral coarse ecosite type and the Shrub/Low Veg Mixture vegetation type was confined to very wet ecosite types and ice scoured areas.

Reflecting the important role of topography in ecosite development, virtually all of the mineral and thin peatland ecosites in the large-scale habitat mapping area (*i.e.*, Study Zone 4) occurred on crests or the upper portions of slopes (see Table 2C-4 in the Terrestrial Environment Supporting Volume). Most low-lying areas contained either ground ice peatlands or wet peatlands (88% of the area; see Table 2C-5 in the Terrestrial Environment Supporting Volume). Wet peatlands and riparian peatlands were generally associated with areas where water collects and/or drains such as depressions, runnels and flat topography. Peat thickness in runnels tended to decrease with increasing runnel slope.

The largest differences in vegetation types were associated with differences in ecosite type. These relative degrees of influence are demonstrated by the labelled photo in Photo 3-4, which was taken in the Study Zone 4. The habitats at the top of the hill are relatively dry. In contrast, the collapse scar bog in the lowest topographic location has no trees because there was too much water for trees to survive to maturity.

Results that show how the habitat mapping demonstrates other associations between environmental drivers and habitat components are provided in Appendix 2C of the TE SV.

Table 3-1: Percentage Distribution of Broad Vegetation Types Across Coarse Ecosite Types

Broad Vegetation Type	Mineral	Thin peatland	Shallow peatland	Ground ice peatland	Permafrost peatland-other	Deep peatland	Wet deep peatland	Riparian Peatland	Ice Scoured Upland	Shoreline Wetland	Shoreline Wetland-regulated	Total area in type (ha)
BA Mixedwood	-	41.2	58.8	-	-	-	-	-	-	-	-	*1*
BA Mixture	56.8	2.4	40.8	-	-	-	-	-	-	-	-	*1*
BA Pure	100.0	-	-	-	-	-	-	-	-	-	-	*1*
TA Mixedwood	78.1	11.9	7.2	2.8	-	-	-	-	-	-	-	*404*
TA Mixedwood/ Tall Shrub	16.9	73.6	9.5	-	-	-	-	-	-	-	-	*347*
TA Mixture	74.7	14.1	8.8	2.3	-	-	-	-	-	-	-	*275*
TA Mixture/ Tall Shrub	60.8	16.0	23.2	-	-	-	-	-	-	-	-	*16*
TA Pure	62.9	24.6	12.5	-	-	-	-	-	-	-	-	*70*
TA Pure/ Tall Shrub	37.1	50.4	12.5	-	-	-	-	-	-	-	-	*544*
WB Mixedwood	66.2	10.6	15.3	7.9	-	-	-	-	-	-	-	*52*
WB Mixedwood/ Tall Shrub	-	1.7	98.3	-	-	-	-	-	-	-	-	*5*
WB Mixture	72.4	12.5	-	11.0	-	-	-	4.0	-	-	-	*36*
WB Pure	-	-	-	93.2	-	-	-	6.8	-	-	-	*13*
WB Pure/ Tall Shrub	-	-	-	92.0	-	8.0	-	-	-	-	-	*21*
JP Mixedwood	71.6	23.1	5.2	-	-	-	-	-	-	-	-	*253*
JP Mixedwood/ Tall Shrub	43.9	36.9	19.2	-	-	-	-	-	-	-	-	*219*
JP Mixture	70.9	27.4	1.7	0.0	-	-	-	-	-	-	-	*1,481*
JP Mixture/ Tall Shrub	68.8	26.9	4.3	-	-	-	-	-	-	-	-	*992*
JP Pure	72.2	24.7	3.1	-	-	-	-	-	-	-	-	*336*
JP Pure/ Tall Shrub	17.1	76.6	6.3	-	-	-	-	-	-	-	-	*113*

Table 3-1: Percentage Distribution of Broad Vegetation Types Across Coarse Ecosite Types

Broad Vegetation Type	Mineral	Thin peatland	Shallow peatland	Ground ice peatland	Permafrost peatland-other	Deep peatland	Wet deep peatland	Riparian Peatland	Ice Scoured Upland	Shoreline Wetland	Shoreline Wetland-regulated	Total area in type (ha)
BS Mixedwood	85.0	10.9	4.1	-	-	-	-	-	-	-	-	*445*
BS Mixedwood/ Tall Shrub	17.8	63.7	18.5	-	-	-	-	-	-	-	-	*102*
BS Mixture	35.2	29.3	21.4	7.0	0.2	6.5	-	0.5	-	-	-	*3,377*
BS Mixture/ Tall Shrub	47.1	38.7	11.6	-	-	0.1	-	2.5	-	-	-	*136*
BS Pure	10.2	43.2	27.1	15.9	0.2	2.5	0.0	0.8	-	-	-	*122,399*
BS Pure/ Tall Shrub	4.2	17.6	37.1	9.4	0.4	16.2	-	15.1	-	-	-	*507*
TL Mixedwood	-	98.8	1.2	-	-	-	-	-	-	-	-	*7*
TL Mixture	5.6	15.9	18.3	8.1	0.5	50.1	-	1.5	-	-	-	*2,436*
TL Mixture/ Tall Shrub	-	16.8	43.0	-	-	33.5	-	6.7	-	-	-	*4*
TL Pure	9.4	5.7	12.1	8.5	0.3	61.5	-	2.5	-	-	-	*417*
TL Pure/ Tall Shrub	-	2.8	53.0	-	-	43.1	-	1.1	-	-	-	*11*
Tall Shrub	2.4	9.6	16.3	5.1	0.1	8.0	-	33.7	-	-	24.8	*2,625*
Shrub/Low Veg Mixture	-	-	-	-	-	-	-	15.5	21.2	-	63.4	*577*
Low Vegetation	2.6	27.6	21.6	24.6	1.1	9.2	0.0	12.2	-	-	1.0	*24,687*
Emergent	-	-	-	-	-	-	-	-	-	87.9	12.1	*127*
Emergent Island	-	-	-	-	-	-	-	-	-	100.0	-	*81*

* Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

** BA= balsam poplar; TA=trembling aspen; WB=white birch; JP=jack pine; BS=black spruce; TL=tamarack.

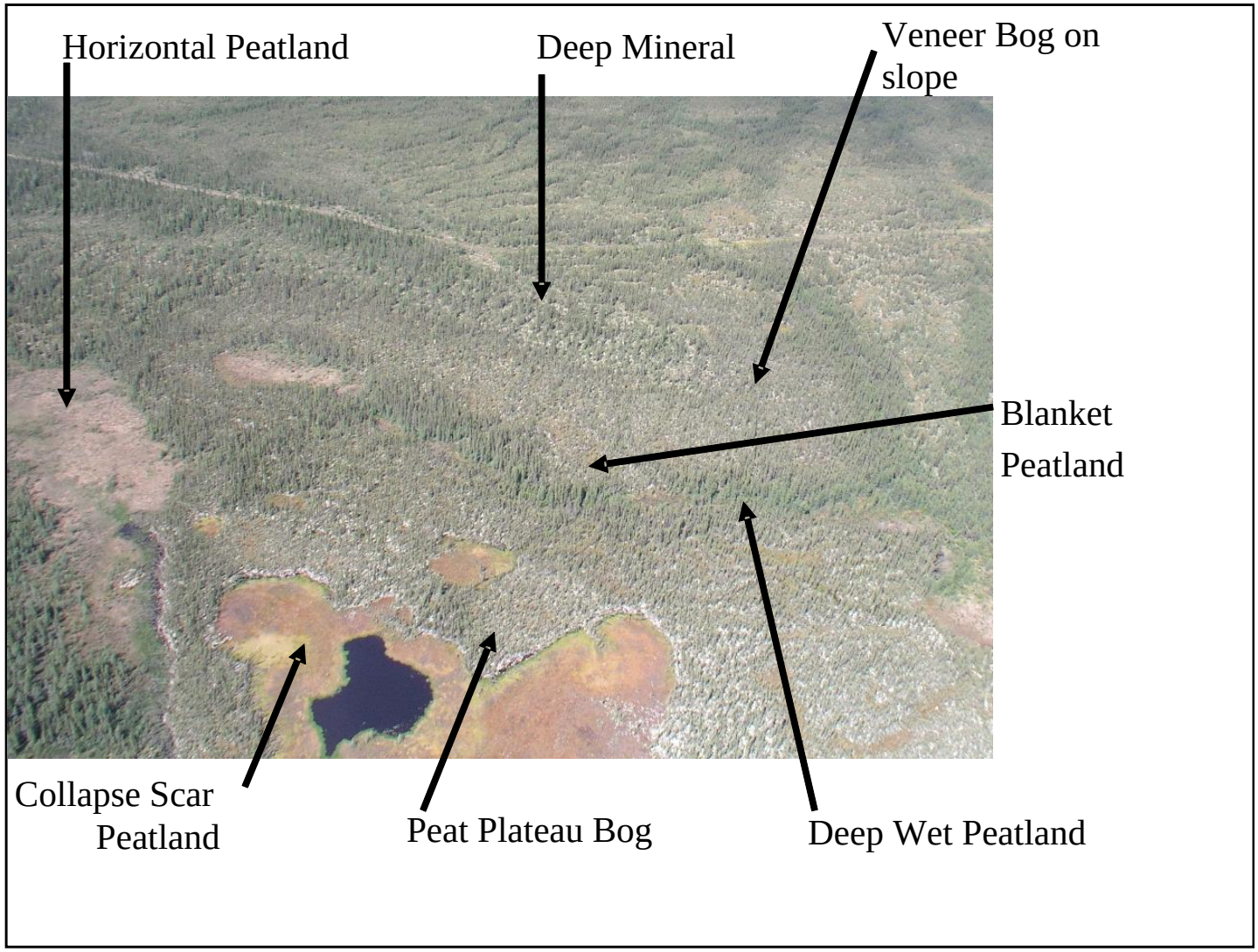


Photo 3-4: A Common Toposequence in the Regional Study Area, Showing the Sequence of Ecosite Types that Occur when Moving from a Hilltop (Deep Mineral in the Photo) to the Lowest Nearby Elevation (Forefront)

Multivariate analysis of plot data from lower Nelson River region studies also confirmed that the inland vegetation types were associated with differences in site conditions, particularly soil moisture, depth to groundwater and soil type (soil type is strongly influenced by moisture regime). A Ward's clustering (Sorensen distance measure) of 698 inland habitat plots produced the following three, very broad groupings of the plots in terms of very coarse site conditions groups: uplands (*i.e.*, mineral soil or thin feathermoss peatland); shallow peatlands; and wet peatlands (Figure 3-7). The upland group included thin feathermoss peatland because vegetation on these site conditions was more similar to mineral sites than to other peatland types. The subsequent subdivisions of the very broad upland group related to overstorey tree leaf type (*i.e.*, broadleaf versus needleleaf) and to whether or not the plot was recently burned. The very broad wet peatland group strongly separated into three sub-groups based on vegetation structure.

The 22 group Ward's clustering solution was comparable to the mapped coarse habitat types in both characteristics and number of groups. The 60 group solution was chosen as a third level of classification detail, primarily used to describe the variation in habitat within the groups of the 22 group solution, particularly with respect to mineral and wet peatland habitat types. Multi-response permutation procedures analysis in PC-ORD (Sorensen distance measure) indicated that the groups, and all pairwise comparisons between groups, were significantly different from one another. Within-group agreement increased up to the 60 group solution level.

Ordinations corroborated and elucidated the Ward's cluster analysis results. Nonmetric multidimensional scaling (NMS) of species in the 698 inland habitat plots resulted in a two-dimensional ordination solution (final stress and instability for the solution after 97 iterations was 16.27 and 0.00047, respectively). The first two extracted ordination axes were significantly stronger than expected by chance ($P = 0.0278$). Of the total variation in the dataset, 81.1% was explained by the first two ordination axes, including 42.7% explained by Axis 2.

The six coarsest plot habitat types separated into relatively distinctive clusters on the ordination scattergram, with some degree of overlap (Figure 3-8). Group separation occurred along Axis 1 and 2, with the largest gradient occurring from the upper-right to lower-left of the ordination diagram.

Environmental variables with the highest Kendall tau-b with Axis 1 in the NMS ordination were total and fibric organic substrate thickness, moisture regime, drainage regime, canopy closure and canopy height (Table 3-2). Organic substrate thickness increased in plots toward the left of the ordination scattergram (Figure 3-8), as did the moisture regime, along with the abundance of *Sphagnum* spp, small bog cranberry and leather-leaf. Plots toward the right of the ordination scattergram were drier, and better drained with thinner organic substrates, and tended to have greater canopy cover and height, and more abundant prickly rose, twinflower and bunchberry.

Environmental variables most highly correlated with Axis 2 were depth to water table, canopy height and total organic substrate thickness (Table 3-2). Although these variables were also correlated with Axis 1, the first two variables were more highly correlated with Axis 2. As a reflection of this, plots at the bottom of the ordination scattergram (Figure 3-8) had the deepest water tables (>1.2m deep) and highest vegetation canopies, as well as higher abundances of big red stem moss and rock cranberry. Those at the

top of the ordination scattergram tended to have water tables closer to the surface and shorter canopies, along with more abundant sedges, bog rosemary, three-leaved Solomon's-seal and bogbean.

Plant species separated into groups along both ordination axes. Plots containing broadleaf tree species, including balsam poplar and trembling aspen grouped toward the lower right of the scattergram (Figure 3-8), and white spruce, white birch and jack pine grouped toward the lower center side of the scattergram. Conversely, leather-leaf and wetland herbs such as sedges, round-leaved sundew, cotton-grass and bogbean were grouped with plots at the upper-left side of the ordination. The plexus diagram for this ordination indicated a few strong species associations.

See ECOSTEM (2013) for details regarding methods and additional results.

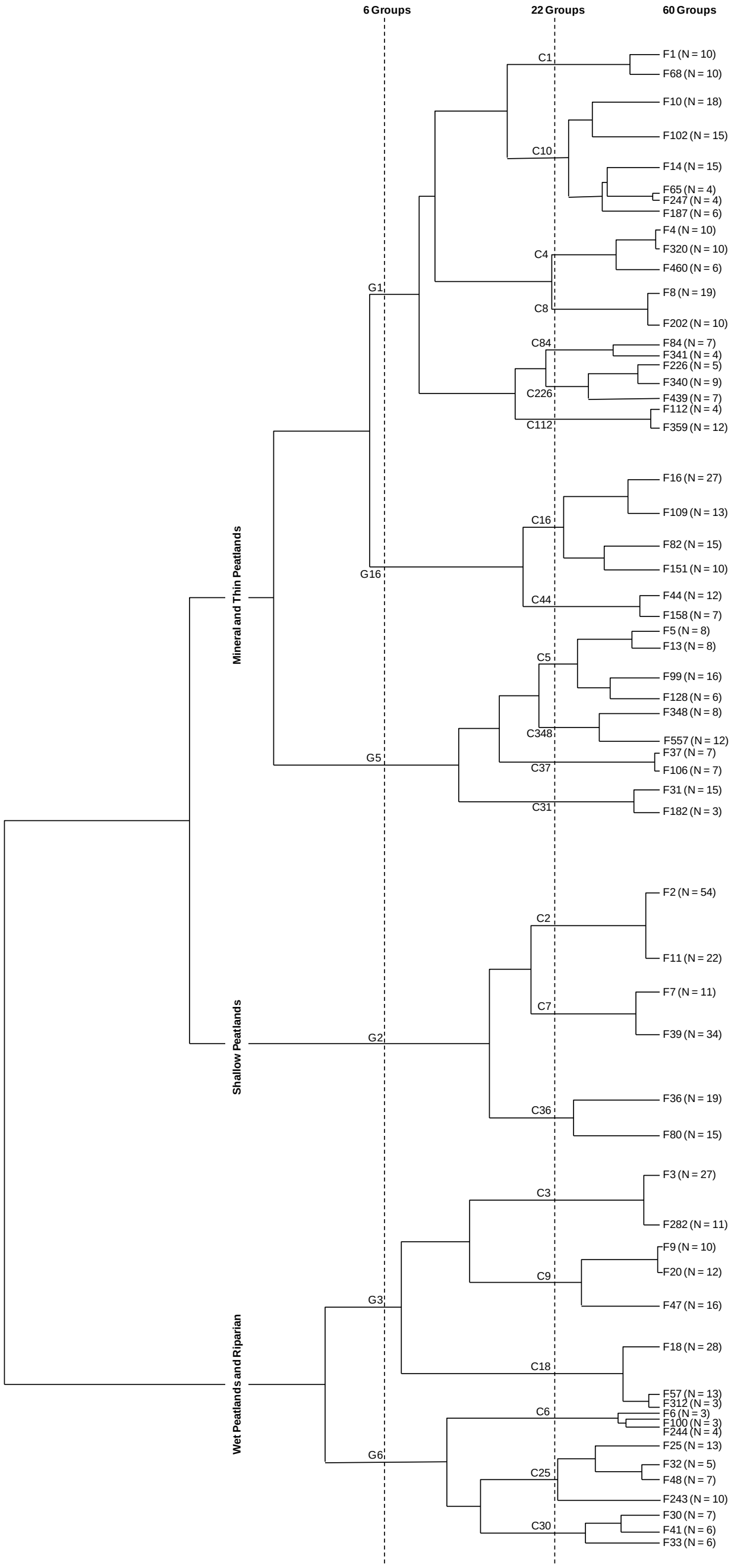


Figure 3-7: Dendrogram illustrating plot grouping from the Ward's cluster analysis to the 60 group solution. Dashed lines represent the group levels chosen to represent general (G), coarse (C), and fine (F) plot habitat types

Numbers in parentheses are the number of plots in each fine group.

Figure 3-8: Scattergram from a nonmetric multidimensional scaling species ordination of 698 inland habitat plots[1], shaded by general plot habitat type

[1] Only species with Kendall tau *b* correlation coefficients of 0.3 or higher are shown in ordination. Species names displayed are abbreviations. Percentages following the axis labels are percent species variability explained by the axis.

Table 3-2: Kendall tau *b* correlation coefficients for species and environmental variables with Axes 1 and 2 of the NMS ordination of the 698 inland habitat plots

Species	tau *b*	Environment	tau *b*
Axis 1			
Sphagnum spp	-0.65	Peat depth class	-0.64
Vaccinium oxycoccos	-0.65	Fibric OM thickness	-0.60
Chamaedaphne calyculata	-0.53	OM thickness	-0.58
Kalmia polifolia	-0.49	Drainage regime	-0.51
Drosera rotundifolia	-0.47	Moisture regime	-0.50
Rubus chamaemorus	-0.46	% cover <0.1m strata	-0.41
Maianthemum trifolia	-0.42	Mesic OM thickness	-0.39
Andromeda polifolia	-0.37	Slope position	-0.26
Eriophorum spp	-0.36	Depth to mottling	-0.21
TA > 15-20cm	0.31	% cover 0.5-1.3m strata	0.22
Rubus pubescens	0.32	% slope	0.26
Viola spp	0.33	Dom. mineral particle size	0.30
Fragaria virginiana	0.35	C-horizon particle size	0.31
Mertensia paniculata	0.35	LFH thickness	0.38
Petasites frigidus var. *palmatus*	0.35	Depth to water table	0.38
Orthillia secunda	0.35	Canopy height	0.40
Mitella nuda	0.40	Canopy closure	0.42
Hylocomium splendens	0.42	Mineral thickness in pit	0.46
Viburnum edule	0.42		
Alnus viridis ssp. *crispa*	0.46		
Chamerion angustifolium	0.49		
Cornus canadensis	0.50		
Linnaea borealis	0.55		
Rosa acicularis	0.58		
Axis 2			
Pleurozium schreberi	-0.55	Depth to water table	-0.53
Vaccinium vitis-idaea	-0.52	Canopy height	-0.50
Hylocomium splendens	-0.39	Canopy closure	-0.42
BS > 9-15 cm	-0.38	Depth to gleying	-0.25
Cladina mitis	-0.36	% slope	-0.24
Cladina rangiferina	-0.33	LFH thickness	-0.20
Cladina stellaris	-0.33	Humic OM thickness	0.23

Species	**tau *b***	**Environment**	**tau *b***
BS 0-9 cm	-0.30	Fibric OM thickness	0.31
Larix laricina seed	0.31	Mesic OM thickness	0.33
Drosera rotundifolia	0.33	Slope position	0.34
Eriophorum spp	0.35	Drainage regime	0.40
Salix pedicellaris	0.35	Moisture regime	0.40
Vaccinium oxycoccos	0.36	OM thickness	0.42
Betula pumila	0.36	Peat depth class	0.45
Chamaedaphne calyculata	0.37		
Sphagnum spp	0.38		
Equisetum fluviatile	0.40		
Potentilla palustris	0.40		
Menyanthes trifoliata	0.41		
Maianthemum trifolia	0.41		
Andromeda polifolia	0.42		
Carex spp	0.59		

Notes: Only species and environmental variables with a minimum tau *b* of 0.3 and 0.2, respectively, are shown. Nomenclature for some species may have changed since these results were produced.

3.4.1.2 SHORE ZONE

Photos from the Regional Study Area illustrate the high importance of water depth and water regime on shore zone habitat zonation (see Photo 3-5 for a Nelson River example and Photo 3-3 for an off-system lake example). Both photos exhibit a sequence of distinct vegetation bands that coincide with median water depth ranges.

Large scale habitat mapping indicated that the nature of shore zone habitats in the Nelson River and off-system waterbodies were considerably different, presumably due to the substantial differences in water and ice regimes (see Section 6.3.2.2.1 in ECOSTEM 2012b), which was confirmed by the results of the cluster analyses presented below. Some examples of differences observed in the habitat mapping were as follows (Terrestrial Environment Supporting Volume, Section 2.3.4.1.3). On the Nelson River, shrub and/or low vegetation on upper beach was the most abundant of the shore zone coarse habitat types. Nelson River marsh was virtually absent. In contrast, shoreline wetlands in off-system waterbodies were predominantly marshes occurring within shallow lacustrine environments and along the sunken margins of floating peatlands.

Separate multivariate analyses of Nelson River and off-system waterbody datasets were completed. The considerable differences in the nature of shore zone habitats in the Nelson River and off-system waterbodies were expected to dominate the multivariate results and hide the more interesting patterns related to other environmental factors if data from these water regulation systems were pooled for the analyses.

Ward's clustering (using the Sorensen distance measure) of 7,337 quadrats sampled along transects at 134 Nelson River shore zone locations produced a 15 group Nelson River shore zone habitat type classification. Dendrogram branching for the shore zone cluster analyses (Figure 3–9, Figure 3–10) was not as strongly organized by environmental factors as for inland habitat plots because the entire shore zone water depth gradient was contiguously sampled whereas the ecotones between stand types were avoided for the inland habitat sampling. The entire shore zone is an ecotone in that the vegetation composition and environmental conditions change substantially over short distances.

The first branch in the Nelson River shore zone habitat dendrogram (Figure 3-9) separated two low slope, organic substrate beach habitat types located within a similar water depth range from the other quadrats (Table 3–3). These were the only shore zone habitat types to be largely confined to the Keeyask reach compared with the downstream reaches. The second main branch separated three vegetation types with species that can tolerate root submergence for extended periods and occur on low slope, organic substrate in a similar water depth range. Two of these three vegetation types predominantly occurred in the downstream reaches while the third (N860) had similar proportions of locations in the Keeyask versus the downstream reaches. The final distinct branch, which included the N1 and N10 vegetation types (Table 3–3), represented inland edge types with woody vegetation occurring almost exclusively in the downstream reaches. Water Horsetail was the only habitat type confined to mineral substrates.

Ward's clustering (using the Sorensen distance measure) of the 4,839 quadrats sampled along transects at 53 off-system locations produced a 13-group shore zone habitat type classification (multi-response permutation procedures analysis). Sorensen distance measure indicated that the groups, and all pairwise

comparisons between groups, were significantly different from one another. The first branching produced a group of two creeping spike rush shallow water habitat types (Figure 3–10) occurring at different water depth ranges, with different mean slope and substrate type (Table 3-4). The second main branch separated three of the four remaining shallow water habitat types, which were characterized by water horsetail and/or floating-leaved aquatic species, including small yellow pond-lily and bur-reed on low slopes and different depth ranges. The third main branch generally separated three lower to upper beach sedge habitat types. In the final main branch, viscid great-bulrush (the only habitat type found predominantly on mineral substrates) was strongly separated from the remaining groups.

Ordinations corroborated and elucidated the Ward's cluster analysis results. Nonmetric multidimensional scaling (NMS) of species in 4,505 off-system quadrats resulted in a two-dimensional ordination solution (final stress and instability for the solution after 73 iterations was 7.27 and 0.0005, respectively). Of the total variation in the dataset, 60.1% was explained by the first two ordination axes, including 27.5% explained by Axis 2.

The three broad dendrogram branches separated into relatively distinctive clusters on the ordination scattergram, with some degree of overlap (Figure 3-11). Environmental variables with the highest significant Kendall tau-b correlations with Axis 1 in the NMS ordination were substrate composition (Table 3-5). Percentages of sand, cobbles, and gravel substrates increased in quadrats toward the left of the ordination scattergram (Figure 3-11), along with the abundance of creeping spike rush, spiked water milfoil and bottle sedge. Quadrats toward the right of the ordination scattergram had lower percentages of these coarse substrates, and tended to have more abundant small yellow pond-lily and water horsetail.

Environmental variables most highly correlated with Axis 2 were relative water depth, percent water cover, and percentage of organic and clay substrates (Table 3-5). Quadrats at the bottom of the ordination scattergram (Figure 3-11) had the deepest water, highest water cover and the highest percentage of clay substrates. They also had higher abundances of small yellow pond-lily. Those at the top of the ordination scattergram tended to have higher organic substrate cover, along with more abundant bottle sedge, marsh reed grass and water sedge.

Since measuring water depth from the inland edge or water level on the day of sampling has limitations, the habitat types produced by Ward's clustering were grouped into water depth duration zones based on a combination of measured water depths and the locations of the dominant plant for a habitat type relative to the remainder of the transect. Shallow water, lower beach and upper beach/inland edge were the water depth duration zones for the analysis. Within each water depth duration zone, habitat types from the two clusterings with the same characteristic species were treated as the same habitat type (see Table 7-38 in ECOSTEM 2012b). On this basis, only one of the shallow water and one of the lower beach habitat types was found in both the Nelson River and off-system water regulation zones (Table 3-6).

Water Horsetail was the only shallow water habitat type found in the Nelson River (Table 3-7), and most of these occurrences were in the Keeyask reach. Yellow pond-lily, the two water horsetail types and creeping spike-rush were the most common shallow water habitat types in off-system waterbodies. These were emergent and floating-leaved, or marsh, habitat types. The Water Horsetail habitat type usually occurred on mineral substrates with bottle sedge and water smartweed in the Nelson River, and the two

off-system types on organic, or a mixture of mineral and organic substrates with narrow-leaved bur-reed and small yellow pond-lily (Table 3-7). The Viscid Great Bulrush habitat type, which included viscid great bulrush as its sole species, was associated with fine mineral substrates. Generally, off-system marsh tended to be more species-rich (Table 3-7) and floating-leaved species were more abundant.

Off-system shore zone wetlands had higher habitat diversity than Nelson River wetland within the shallow water and the lower beach water depth duration zones, by a ratio of six types to one over both zones (Table 3-6). This was generally supported by the large-scale habitat mapping, which showed true emergent vegetation being much more widely distributed in off-system lakes than on the Nelson River, where it was rare and confined to more sheltered bays and inlets.

The higher habitat diversity in the lower beach and shallow water zones in off-system waterbodies was attributed to a lower degree of water level fluctuations and the low frequency of winter drawdowns compared to the Nelson River. This would create higher potential to develop marshes with a variety of emergent wetland species establishing in the lower beach and shallow water zone.

The higher number of Nelson River upper beach/inland edge zone habitat types compared with off-system waterbodies (10 versus 7; Table 3-6), was likely due to the variety of water regime and bank conditions represented by the four Nelson River reaches included in the data and because off-system transects did not extend across wide riparian peatlands into the inland edge (*i.e.*, fewer upland ecosite types were captured by the off-system transects).

See ECOSTEM (2012b) for methods and additional results.

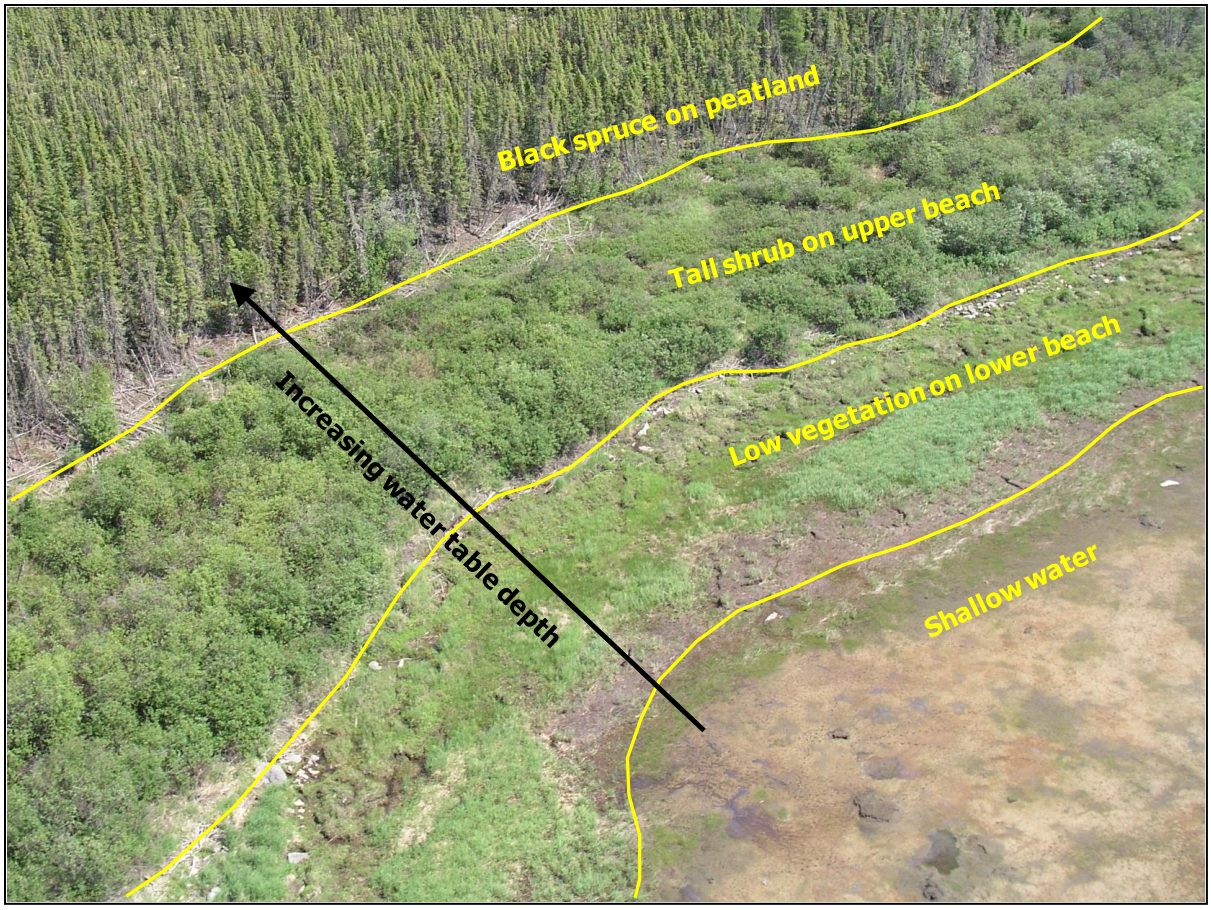


Photo 3-5: Photo illustrating vegetation bands that reflect a water depth gradient in a back bay on the Nelson River during very low water

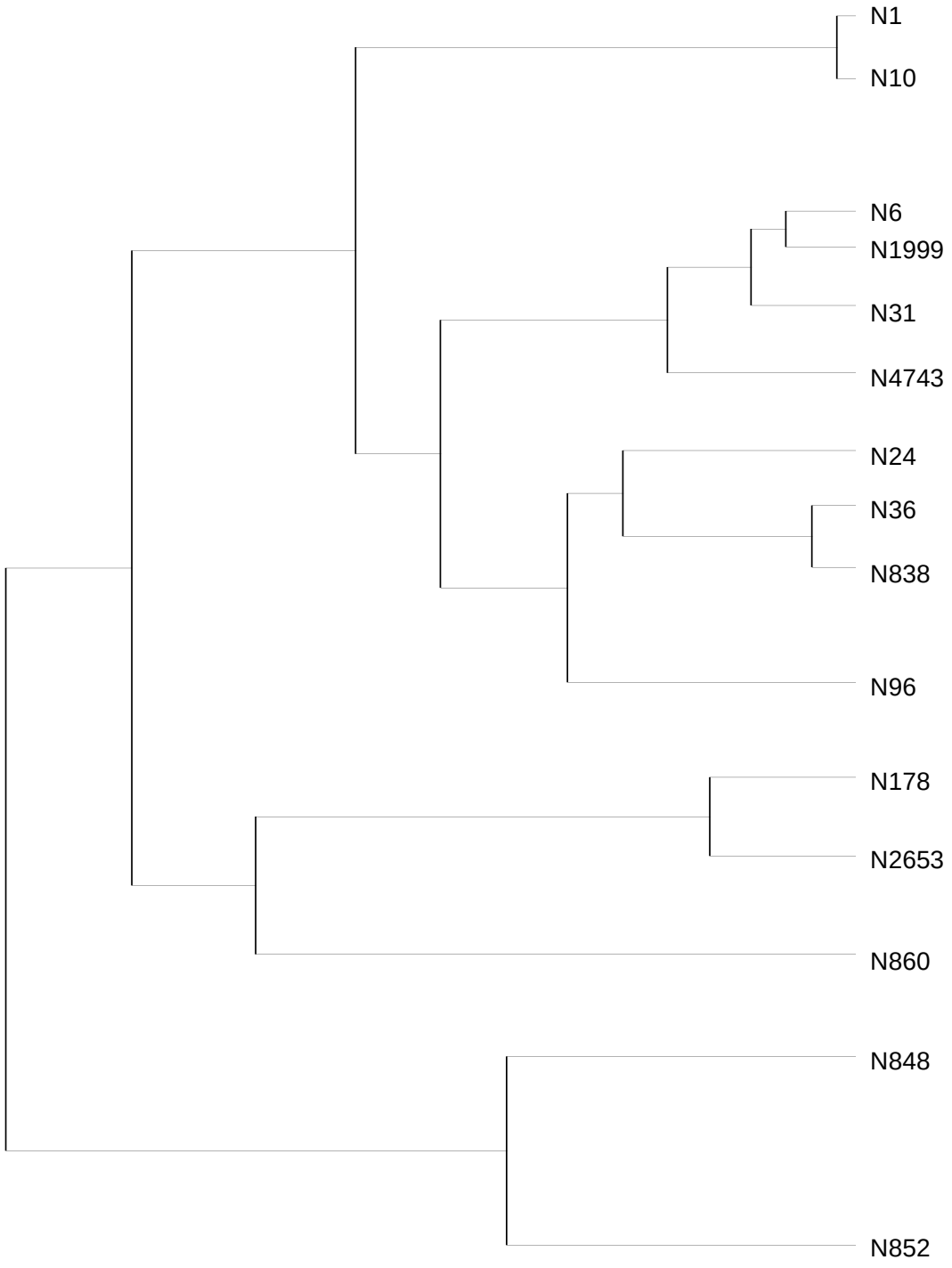


Figure 3-9: Ward's cluster dendrogram of species from the 134 Nelson River shore zone locations

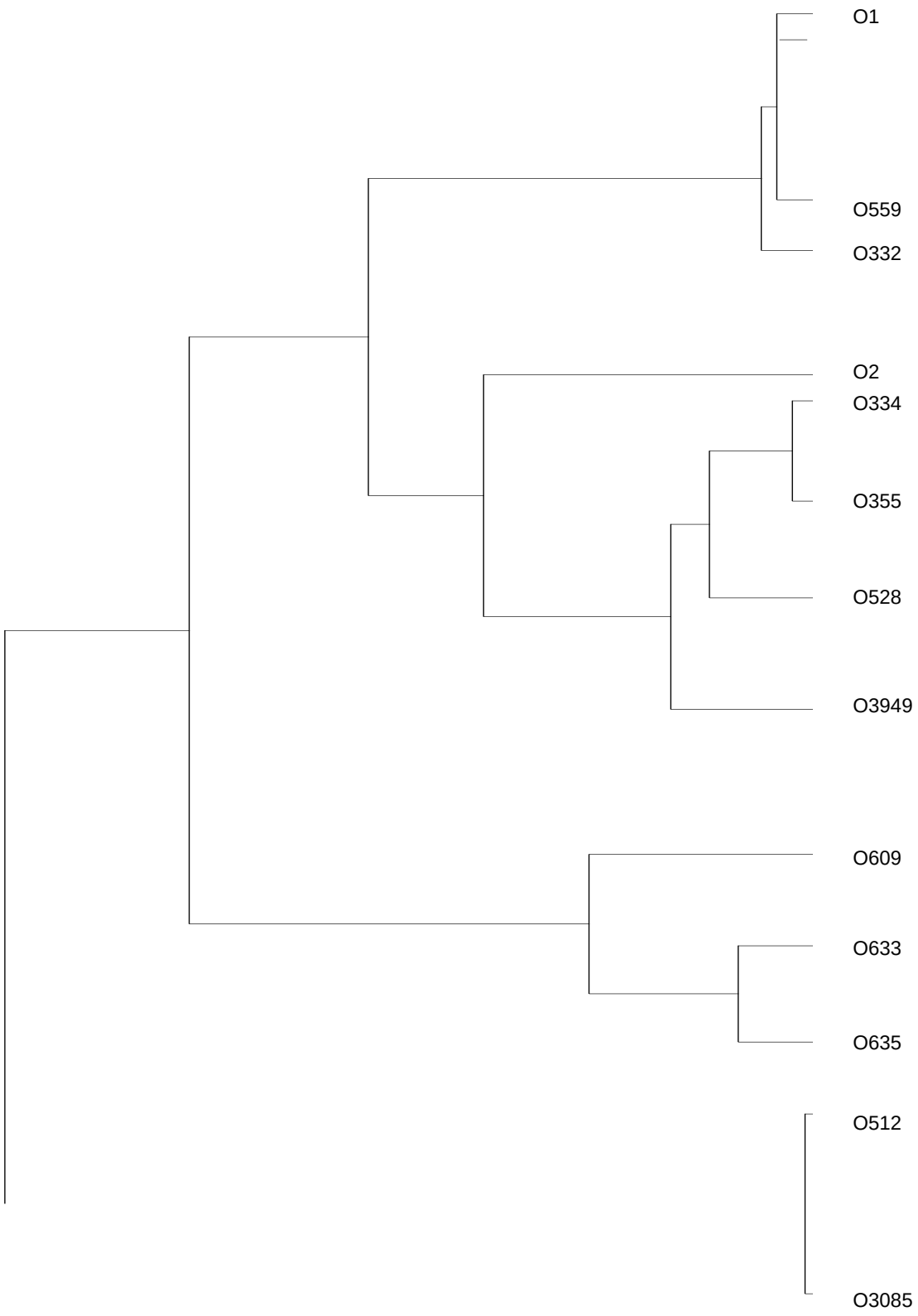


Figure 3-10: Ward's cluster dendrogram of species from the 127 off-system shore zone locations

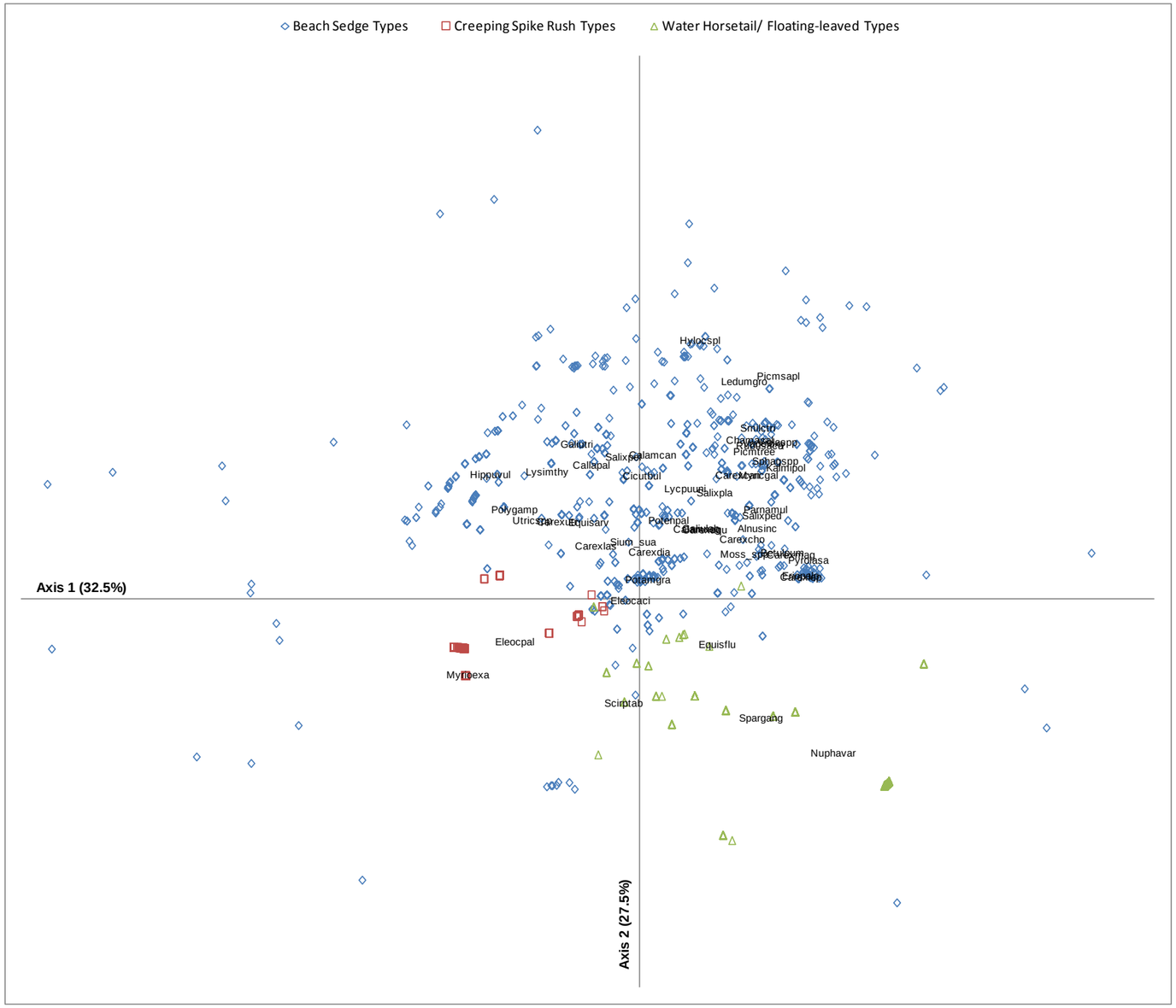


Figure 3-11: Scattergram from a nonmetric multidimensional scaling species ordination of 4,505 off-system quadrats[1], shaded by major dendrogram branches

[1] Species names displayed are abbreviations. Percentages following the axis labels are percent species variability explained by the axis.

Table 3-3: Characteristics of the 15 Nelson River shore zone habitat types

Shore Zone Habitat Type	GroupID	Indicator Species	Composition	Depth Range (inland edge; Nelson R.)		% Slope Nelson R.		*Number of Quadrats*	Number of Locations		
				Range	Median	Mean (St. dev.)	Substrate		Keeyask	Stephens/ Long Spruce/ Limestone	All
Silverweed/ Narrow reed-grass	N852	*Argentina anserina, Calamgrostis stricta, Epilobium ciliatum, Persicaria lapathifolia, Ranunculus flammula, Galium trifidum*	*Argentina anserina* (80%), *Calamgrostis stricta, Galium trifidum, Epilobium ciliatum, Persicaria amphibian, Persicaria lapathifolium, Eleocharis acicularis,* Grass spp, *Ranunculus flammula, Eleocharis palustris, Agrostis scabra, Mentha arvensis*	11 to 55 cm	27	1 (4)	Organic	893	*31*	*7*	*38*
Water Sedge/ Marsh Reed Grass	N178	*Carex aquatilis*	*Carex aquatilis* (98%), Moss species, *Carex diandra*, *Carex magellanica*	5 to 28 cm	18	3 (5.8)	Organic	*633*	*2*	*19*	*21*
Water Horsetail/ Bottle Sedge	N1999	*Equisetum fluviatile, Carex utriculata*	*Equisetum fluviatile* (98%), *Carex utriculata*, *Polygonum amphibium*	7 to 26 cm	16	0 (1.3)	Fine mineral	*108*	*5*	*1*	*6*
Small Bedstraw/ Creeping Spike-Rush/ Water Smartweed	N848	*Eleocharis palustris, Galium trifidum, Bidens cernua, Persicaria amphibian, Sium suave, Eleocharis spp*	*Galium trifidum* (48%), *Eleocharis palustris, Persicaria amphibian, Carex aquatilis, Sium suave, Bidens cernua, Eleocharis* spp	8 to 39 cm	15	0 (3.4)	Organic	877	*24*	*12*	*36*
Marsh-Five-Finger/ Sedge	N2653	*Potentilla palustris*	*Potentialla palustris* (100%), *Carex aquatilis,* Moss species, *Salix planifolia Calamagrostis canadensis*	2 to 21 cm	7	3 (4.2)	Organic	*273*	*3*	*16*	*19*
Bog Bilberry/ Sweet Gale	N838	*Myrica gale, Vaccinium uliginosum*	*Vaccinium uliginosum* (70%), *Carex aquatilis, Myrica gale, Salix planifolia*	-1 to 29 cm	7	2 (5.7)	Fine to coarse mineral, organic	362	*1*	*20*	*21*
Flat-Leaved Willow/ Sedge	N860	*Salix planifolia*	*Salix planifolia* (100%), *Carex aquatilis*	-12 to 25 cm	0	4 (11.1)	Organic	*501*	*15*	*20*	*35*
Common Horsetail	N24	*Equisetum arvense*	*Equisetum arvense* (93%), *Carex aquatilis, Vaccinium uliginosum, Salix planifolia, Argentina anserina, Salix myrtillifolia, Rhododendron groenlandicum, Myrica gale*	-12 to 17 cm	0	11 (28.7)	Organic	396	*18*	*29*	*47*
Flat-Leaved Willow/ Marsh Reed Grass	N96	*Calamagrostis canadensis, Rubus pubescens*	*Calamagrostis canadensis* (85%) *Salix planifolia*, *Vaccinium uliginosum*, *Salix myrtillifolia*, *Rubus pubescens*, *Equisetum arvense*	-55 to -2 cm	-14	4 (12.9)	Organic	*581*	*20*	*28*	*48*

Shore Zone Habitat Type	GroupID	Indicator Species	Composition	Depth Range (inland edge; Nelson R.)		% Slope Nelson R.		*Number of Quadrats*	Number of Locations		
				Range	Median	Mean (St. dev.)	Substrate		Keeyask	Stephens/ Long Spruce/ Limestone	All
Labrador Tea/ Black Spruce	N36	*Rhododendron groenlandicum*, *Carex gynocrates*, *Vaccinium uliginosum*	*Rhododendron groenlandicum* (78%), *Vaccinium uliginosum, Carex gynocrates, Calamagrostis canadensis, Salix myrtillifolia, Moss* spp, *Epilobium angustifolium, Carex aquatilis, Picea mariana* tree	-52 to -1 cm	-19	19 (28.9)	Organic	*289*	*4*	*45*	*49*
Black spruce/ Willow	N6		*Picea mariana* tree (25%), *Salix bebbiana, Rosa acicularis, Cornus Canadensis, Alnus viridis* ssp. *crispa, Salix arbusculoides, Chamerion angustifolium, Salix pellita*	-124 to 3 cm	-48	30 (43)	Organic or fine mineral	790	*21*	*68*	*89*
Green Alder/ Stair-step moss	N10	*Alnus viridis* ssp. *crispa, Hylocomium splendens* (16)	*Alnus viridis* ssp. *crispa* (99%), *Hylocomium splendens, Vaccinium vitis-idaea, Rhododendron groenlandicum*	-159 to 8 cm	-49	42 (29.8)	Organic, fine mineral	129	*2*	*18*	*20*
Fireweed	N31	*Chamerion angustifolium*, Moss_spp *Rubus idaeus*	*Chamerion angustifolium* (63%) Moss_spp *Equisetum arvense, Alnus viridis* ssp. *crispa, Rubus idaeus*, *Linnaea borealis*	-298 to -42 cm	-108	46 (37.4)	Organic, fine mineral	469	*3*	*48*	*51*
Black spruce/ Rock Cranberry/ Feathermoss	N1	*Vaccinium vitis-idaea, Hylocomium splendens* (32), *Rhododendron groenlandicum, Pleurozium schreberi, Cladina mitis, Cladina rangiferina, Geocaulon lividum, Picea mariana* tree	*Vaccinium vitis-idaea* (74%), *Rhododendron groenlandicum, Hylocomium splendens, Picea mariana* tree, *Pleurozium schreberi, Cladina mitis, Geocaulon lividum,* Moss spp, *Picea mariana* sapling, *Alnus viridis* ssp. *crispa, Cladina rangiferina, Picea mariana* seedling, *Cornus canadensis*	-272 to -60 cm	-149	41 (39.1)	Organic, fine mineral	782	2	*71*	*73*
Sphagnum/ Leather-leaf	N4743	*Chamaedaphne calyculata*, *Sphagnum* spp, Moss spp	*Chamaedaphne calyculata* (93%), Moss spp, *Sphagnum* spp, *Salix planifolia*, *Carex aquatilis*	-242 to 35 cm	-162	12 (44.7)	Organic	*254*		*6*	*6*

Table 3-4: Characteristics of the 13 off-system shore zone habitat types

Shore Zone Habitat Type	GroupID	Indicator Species	Composition	Depth Range (waterline; off-system)		% Slope	Substrate	*Number of Quadrats*	Number of Locations
				Range	Median	Mean (St. dev.)			
Small Yellow Pond-Lily	O609	*Nuphar variegata*	*Nuphar variegata* (100%)	27 to 88 cm	69	2 (1.7)	Organic, fine mineral	*443*	*15*
Viscid Great-Bulrush	O2	*Schoenoplectus tabernaemontani*	*Schoenoplectus tabernaemontani* (100%)	61 to 74 cm	67	1 (2.3)	Fine mineral	*330*	*2*
Water Horsetail/ bur-reed/ Pond-Lily	O635	*Sparganium angustifolium, Nuphar variegata*	*Equisetum fluviatile* (93%), *Sparganium angustifolium* (85%), *Nuphar variegata* (83%)	45 to 73 cm	58	2 (2.2)	Organic, fine mineral and mixtures	*414*	*9*
Creeping Spike-Rush/ Spiked water-milfoil	O3085	*Myriophyllum sibiricum*, *Eleocharis palustris*	*Eleocharis palustris* (100%), *Myriophyllum sibiricum* (100%)	26 to 59 cm	44	1 (0.2)	Fine mineral, occasional organic	*588*	*1*
Water Horsetail	O633	*Equisetum fluviatile*	*Equisetum fluviatile* (100%)	15 to 51 cm	32	2 (3.0)	Organic	*353*	*9*
Creeping Spike-Rush	O512	*Eleocharis palustris*	*Eleocharis palustris* (100%), *Carex utriculata* (42%), *Carex aquatilis* (18%)	7 to 47 cm	24	8 (11.4)	Organic, fine to coarse mineral and mixtures	*275*	*10*
Sedge/ Alpine Cotton-Grass/ Water Horsetail	O3949	*Carex leptalea, Trichophorum alpinum, Carex magellanica* ; Moss spp, *Carex aquatilis; Equisetum fluviatile,*	*Carex aquatilis* (100%), *Carex leptalea* (100%), *Equisetum fluviatile* (100%), *Trichophorum alpinum* (100%) Moss spp (100%), *Carex magellanica* (99%), *Betula pumila* (10%)	69 to -29 cm	40	2 (4.0)	Organic	*269*	*1*
Marsh-Five-Finger/ Sedge	O528	*Comarum palustre, Carex diandra*	*Comarum palustre* (98%), *Carex utriculata* (98%), *Carex aquatilis* (85%), *Equisetum fluviatile* (56%), *Eleocharis palustris* (48%), *Carex diandra* (45%), Moss spp (14%)	3 to -3 cm	-1	1 (7.6)	Organic	*463*	*8*
Bottle Sedge	O559	*Carex utriculata*	*Carex utriculata* (100%), *Equisetum fluviatile* (14%)	21 to -15 cm	-1	5 (7.6)	Organic	*622*	*22*
Bottle Sedge/ Bladderwort	O1	*Utricularia* spp, *Lysimachia thyrsiflora*	*Carex utriculata* (93%), *Utricularia* spp (91%), *Lysimachia thyrsiflora* (29%), *Calla palustris* (22%), *Equisetum fluviatile* (12%), *Hippuris vulgaris* (12%)	-3 to -18 cm	-15	7 (69.4)	Organic	*228*	*10*
Bottle Sedge/ Marsh Reed Grass	O332	*Persicaria amphibia, Calamagrostis canadensis*	*Carex utriculata* (80%), *Calamagrostis canadensis* (65%), *Persicaria amphibia* (29%), *Salix pellita* (22%), *Comarum palustre* (21%), *Carex pellita* (17%)	-9 to -48 cm	-20	6 (13.7)	Organic	*249*	*20*
Water Sedge/ Marsh Reed Grass	O355	*Calamagrostis canadensis*	*Carex aquatilis* (77%) *Calamagrostis canadensis* (73%), Moss spp (37%), *Potentilla palustris* (32%), *Chamaedaphne calyculata* (23%), *Carex utriculata* (23%), *Calla palustris* (12%), *Equisetum fluviatile* (11%), *Cicuta bulbifera* (11%)	-3 to -53 cm	-22	6 (20.6)	Organic	*409*	*27*

Shore Zone Habitat Type	GroupID	Indicator Species	Composition	Depth Range (waterline; off-system)		% Slope	Substrate	*Number of Quadrats*	Number of Locations
				Range	Median	Mean (St. dev.)			
Water Sedge/ Sphagnum	O334	*Sphagnum* spp, *Chamaedaphne calyculata*	*Carex aquatilis* (94%), *Sphagnum* spp (82%), *Comarum palustre* (72%), *Carex magellanica* (47%), *Chamaedaphne calyculata* (46%), *Calamagrostis canadensis* (24%), *Carex canescens* (22%), *Salix pedicellaris* (15%), *Salix planifolia* (13%), *Vaccinium oxycoccos* (11%)	-19 to -44 cm	-23	3 (6.8%)	Organic	*196*	*12*

Table 3-5: Kendall tau *b* correlation coefficients for species and environmental variables with Axes 1 and 2 of the NMS ordination of the 4,505 off-system quadrats

Species	tau *b*	Environment	tau *b*
Axis 1			
Nuphar varigata	0.477	% Organic	0.200
Eleocharis palustris	-0.470	% Sand	-0.413
Myriophyllum sibiricum	-0.437	% Gravel	-0.265
Equisetum fluviatile	0.328	% Cobble	-0.359
Carex utriculata	-0.319		
Axis 2			
Nuphar varigata	-0.528	Relative Water Depth	-0.528
Carex utriculata	0.459	% Water	-0.576
Calamagrostis canadensis	0.400	% Organic	0.357
Carex aquatilis	0.312	% Clay	-0.324

Table 3-6: Number of habitat types occurring in Nelson River and off-system, Nelson River only and off-system only

Water Depth Duration Zone	Nelson River and Off-system	Nelson River Only	Off-system Only
Shallow Water	0	1	6
Lower Beach	1	1	5
Upper Beach and Inland Edge	1	9	0

Table 3-7: Typical species composition of off-system and Nelson River shallow water (marsh) habitat

Off-System Marsh	Nelson River Marsh
Habitat Types	
Water horsetail Water Horsetail/ bur-reed/ Pond-Lily Viscid great bulrush Small yellow pond-lily Creeping Spike-Rush/ Spiked water-milfoil Creeping spike-rush	Water horsetail/ bottle sedge
Typical Plant Species	
Mineral substrates: Various-leaved pondweed (*Potamogeton gramineus*), Viscid great-bulrush (*Schoenoplectus tabernaemontani*), creeping spike-rush (*Eleocharis palustris*), water horsetail (*Equisetum fluviatile*), Spiked water-milfoil (*Myriophyllum sibiricum*) Organic substrates: Richardson's pondweed (*Potamogeton richardsonii*), narrow-leaved bur-reed (*Sparganium angustifolium*), needle spike-rush (*Eleocharis acicularis*), small yellow pond-lily (*Nuphar variegata*)	Mineral substrates: Water horsetail (*Equisetum fluviatile*), bottle sedge (*Carex utriculata*), water smartweed (*Persicaria amphibia*)

3.4.2 VEGETATION CLEARING AND ROAD EDGE EFFECTS

3.4.2.1 INTRODUCTION

The effects of clearing on vegetation adjacent to transmission line rights-of-way in northern Manitoba is documented in a study conducted along more than 900 km of transmission line rights-of-way, some of which overlap the Regional Study Area (Ehnes and ECOSTEM 2006). That study found that effects of clearing on adjacent overstorey vegetation extended less than 10 m from the clearing edge. This narrow zone of overstorey edge effects was attributed to the low proportion of area that is dense forest. Consequently, habitat attributes are more strongly influenced by factors other than those related to canopy closure.

3.4.2.2 METHODS

Edge effects resulting from vegetation clearing were documented from aerial surveys conducted along PR 280 and from available low-altitude helicopter-based still photography collected along cutlines in the Regional Study Area. The basic strategy for identifying clearing-related edge effects was to examine homogeneous habitat patches extending at least 75 m from the clearing edge. These patches were visually scanned along an imaginary perpendicular line, searching for any changes in vegetation structure, vegetation composition or ecosite type that occurred with proximity to the cleared edge. While the focus was on a change of any width, quantification was limited to identifying locations where changes extended more than 15 m from the cleared edge.

For the PR 280 study, vegetation clearing edge effects aerial surveys were conducted by one observer in a Bell Jet Ranger helicopter during July 11, 2004, September, 2004 (date not recorded) and June 25, 2005. The observer was in the front left seat of the helicopter (stated position is relative to the direction of helicopter forward motion). The helicopter generally flew over the habitat along the right side of the road so the observer had the first 10 m of habitat edge passing directly below while looking ahead over a much wider band along the edge. Suitable photos acquired during other studies were also examined for edge effects.

For the cutline study, low-altitude helicopter-based photos acquired for other studies (primarily cutline regeneration) were searched for edge effects. Photos were acquired by the same methods as the PR 280 study; however in most cases the main focus was to photograph vegetation in the cutline. Consequently, not all photos along the cutline extended far enough from the clearing edge to be suitable for the edge effects analysis. Photos along the searched cutlines were not included in the analysis where: they did not cover sufficient area on either side of the clearing; the cutline had regenerated to the degree that edge effects could be masked; the habitat had recently burned; or where the adjacent habitat was heterogeneous.

3.4.2.3 RESULTS

3.4.2.3.1 ROAD EFFECTS

Approximately 103 km of PR 280 between Split Lake and the eastern limit of the Regional Study Area were searched for edge effects extending more than 15 m from the clearing edge. Much of this stretch of PR 280 was not suitable for this study due to recent burns. The suitable segments that were searched are shown in Map 3-2.

Edge effects extending more than 15 m from the clearing edge were not observed. Effects extending five to ten meters from the edge were common. The typical effect was better tree growth within 10 m of the edge, especially where it appeared that the roadside ditch had improved drainage of an adjacent peatland. The photos in Figure 3-122 provide some examples of typical edge effects along PR 280.

3.4.2.3.2 VEGETATION CLEARING EFFECTS

A total of 35.5 km of cutlines in 16 geographic areas within the Regional Study Area was searched for clearing-related edge effects (Map 3-3). Nearly 540 photos were available along the searched cutlines, with 375 photos being suitable for edge effects analysis.

None of the cutlines searched in the Regional Study Area exhibited evidence of edge effects extending more than 15 meters inland from the clearing edge. In some places, trees growing along the edge were taller and had higher canopy closure than those immediately inland from the edge, but this effect generally only extended between one and a few trees in width. Patches of tree blow-down were not observed. The photos in Figure 3-123 provide some examples of these typical edge effects along cutlines in the Regional Study Area.

3.4.2.4 CONCLUSIONS

Results from studies of clearing-related edge effects indicated that the expected typical width of edge effects from vegetation clearing for roads and cutlines was expected to be less than 15 m. This conclusion was consistent with observations gathered from a considerable amount of low altitude flying throughout the area.

A limitation of this study was that plant community changes relating to understorey plants, plant growth forms shorter than tall shrubs, and possibly some canopy and ecosite effects could not be detected by overhead data. Results from other studies (ECOSTEM 2012b; ECOSTEM upubl.) and field observations indicated that changes not observable from above were typically subtle beyond approximately 5 m from the inland edge.

In terms of Project effects predictions, results from this study supported the assumption that the typical maximum width of effects would be less than 50 m. Also, the EIS assumption is a substantial overestimate of the expected width of edge effects arising from road and cutline clearing.

Figure 3-12: Example photos of typical width and nature of edge effects along PR 280 between Split Lake and Long Spruce

Figure 3-13: Example photos of typical width and nature of edge effects along cutlines in the Regional Study Area

3.4.3 RESERVOIR ZONE OF INFLUENCE ON TERRESTRIAL HABITAT

3.4.3.1 INTRODUCTION

ECOSTEM (2013) presents results from studies conducted to document reservoir flooding and water regulation effects on terrestrial habitat. The predominant pathways for these effects is expected to be related to flooding, larger openings adjacent to terrestrial habitat, new edges, water regime changes and an elevated groundwater table along the shoreline. Another potential pathway for effects that was examined was localized occurrences of elevated groundwater in areas distant from the reservoir shoreline resulting from deep groundwater layer connections.

Since it was not possible to conduct large-scale experiments to determine likely Project effects, existing reservoirs and/or regulated rivers in northern Manitoba, referred to as proxy areas, were studied as examples for how key Keeyask terrestrial ecosystem components were expected to respond to flooding and water regulation. Data were developed from historical air photos, recent air photos and/or aerial surveys (depending on the particular study) for four Nelson River reaches previously exposed to hydroelectric development (the proxy areas). Results from two additional proxy areas on the Burntwood River provided additional evidence or corroboration for observed patterns.

This section summarizes findings presented in ECOSTEM (2013) that relate to the typical width of the terrestrial habitat zone of influence resulting from past flooding and/or water regulation.

3.4.3.2 RESULTS

Two studies were conducted to measure potential terrestrial habitat effects on the inland side of the proxy area shorelines (*i.e.*, the inland edge zone) that extended more than 10 m inland of the initial flooding shoreline (ECOSTEM 2013). The primary data source was large-scale stereo photos taken in various years extending from prior to flooding to 2011. Portions of proxy area shorelines lacking suitable historical air photos were excluded from the searches, as were segments that included conditions that would confound the detection of reservoir-related effects (*i.e.*, had burned, were cleared or were peat plateau bogs at initial flooding (peat plateau bogs typically do not experience groundwater effects because their surface is usually elevated above reservoir water)). The second data source was recent low-altitude photos acquired from a helicopter, which was another method for obtaining data to document the extent of inland edge habitat effects.

Of the shorelines searched in large-scale stereo air photos, inland edge habitat effects that extended more than 10 m inland of the initial flooding shoreline were detected on approximately 3% of the Kelsey shoreline, 41% of the Kettle shoreline, and less than 1% of the Long Spruce shoreline after approximately 31 years of project operation (Section 6.4 in ECOSTEM 2013). Identical results were obtained from recent low altitude photos acquired from a helicopter (Section 7.4 in ECOSTEM 2013).

Where present, potential shore zone effects (*e.g.*, tree mortality, vegetation composition change) that were not attributable to peat plateau bog disintegration or to natural changes such as age-related tree mortality, vegetation succession, permafrost melting or soil development, typically extended less than 25 meters inland from the initial flooding shoreline in the Kelsey, Kettle and Long Spruce proxy areas, with the vast majority extending less than 50 meters. The effects width was less than 10 m for at least 65% of the searched shoreline in all three proxy areas, and was as high as 97% for Kelsey. There were localized areas where confirmed effects extended more than 75 m, but these locations comprised less than 1.5% and 0.6% of the Kelsey and Kettle shorelines, respectively.

After weighting for shoreline length, the overall mean width of potential effects over the entire searched shoreline length was approximately 6 m and 14 m for Kelsey and Kettle, respectively, assuming an average 5 m effect even where no effects were observed. Using the recent helicopter-based photos increased the detectability of some effects, which increased mean effects width in Kettle to 17 m but had no effect for Kelsey. Effects width was not measured for Long Spruce but is expected to be less than that observed for Kelsey given that only 1% of the shoreline had observable potential effects.

Photo 3-6 to Photo 3-11 demonstrate a range of conditions in the Kelsey and Kettle reservoirs. Photo 3-6 and Photo 3-7 show a common condition in Kelsey, a combination of no visible terrestrial habitat zone of influence extending beyond 10 m from the initial flooding shoreline and moderate to high local relief. Photo 3-8 and Photo 3-9 show examples of the many disintegrating peatlands in the Kettle reservoir, as well as some of the shore zones that have developed since flooding. Photo 3-10 and Photo 3-11 illustrate the range of effects in Kettle, with no visible effects extending beyond 10 m inland along high-relief shoreline in the former, and the formation of a wide shore zone with tall shrubs along lower-relief shoreline in the latter.

Local relief (degree of slope change from shoreline) and ecosite type were key factors contributing to differences in the inland edge effects observed both between and within proxy areas. Kelsey and Long Spruce had less than 2% of their mapped shoreline length exhibiting inland edge effects not related to ice scouring after 30 years of flooding (approximately half of the total observed effects at Kelsey were likely related to ice scouring) and water regulation whereas approximately 41% of mapped Kettle shorelines had inland edge habitat effects. Kelsey and Long Spruce were dominated by high shoreline relief while Kettle had a mixture of low and high shoreline relief. Additionally, within each proxy area, inland edge habitat effects extending at least 10 m from the initial flooding shoreline predominantly occurred in low relief shore segments. A similar pattern was observed for Wuskwatim Lake where, with a few minor exceptions, dead trees in the forest edge were confined to shoreline segments that had low to medium sloped substrates.

Ecosite type and local inland relief were also important factors associated with the width of inland edge habitat effects. In the Kelsey and Kettle proxy areas, the widest inland edge effects tended to be in shore segments with deep wet peatlands (*i.e.*, horizontal fen, basin bog, flat bog) on the inland edge, while the narrower width classes were associated with mineral, thin peatland and shallow peatland ecosite types. A qualitative evaluation of the Long Spruce photos found similar patterns. As noted above, there was a strong correspondence between ecosite type and surface slope. Level ecosite types were expected to demonstrate inland edge habitat effects further inland than a sloped ecosite type. Deep wet peatlands

typically had level surfaces whereas the underlying mineral/bedrock layer in thin or shallow peatlands, or the substrate surface in mineral ecosites, typically rose gradually to rapidly from the shoreline. Raising the water table in deep wet peatlands would move the groundwater into the plant rooting zone if it wasn't already there prior to reservoir flooding.

In Kelsey, the widest shore zone effects tended to be associated with deep wet peatlands while the narrower width classes were associated with mineral and thin to shallow peatlands, Kettle differed in that most of the shoreline with effects greater than 50 meters (which occurred on less than 2% of the searched shoreline) were associated with mineral and veneer bog on slope (although, where deep wet peatlands were affected, the effects tended to be wide). In Kettle, the mineral and veneer bog on slope shore segments with wide effects had relatively low surface slopes. The extent of effects on deep wet and riparian peatlands are overstated in the results because the entire polygon was classified as having a reservoir-related effect even if effects were only observed near the water's edge.

A limitation of the inland edge effects studies was that plant community changes relating to understorey plants, plant growth forms shorter than tall shrubs, and possibly some canopy and ecosite effects could not be detected from the photos. Results from other studies (ECOSTEM 2012b; ECOSTEM upubl.) and field observations indicated that changes not observable in the air photos were typically subtle beyond approximately 5 m from the inland edge.

Peat plateau bog shore segments were not included in the shoreline proportions presented in ECOSTEM (2013). Including these segments would reduce the reported proxy area shoreline proportions with inland edge habitat effects extending at least 10 m from the initial flooding shoreline because such effects were not observed in these shore segments. In peat plateau bog shore segments, pre- and post-flood soil conditions were unchanged except in locations where Nelson River water levels were raised to close to the surface of the peat plateau bog. Under natural conditions, peat plateau bogs are elevated above the surrounding areas and their banks undergo recession due to ground ice melting (ECOSTEM 2011c). Consequently, the inland edge habitat simply collapses or subsides into the reservoir before groundwater-related habitat effects can occur (ECOSTEM 2012a). Peatland disintegration dynamics, and associated shoreline dynamics, are detailed in ECOSTEM (2012a).

In summary, the percentage of shoreline with a terrestrial habitat zone of influence extending more than 10 m ranged from 1% to 41% in the three proxy areas. The mean the zone of influence width was less than 20 m for all three proxy areas, which was considerably less than the 50 m assumed for the terrestrial habitat effects assessment. The zone of influence disappeared quickly in shore segments with moderate to high slopes. In flatter shore segments, particularly those with peat ecosite types, the zone of influence width was as large as 75 m for as much as approximately 5% of the shoreline, depending on the proxy area. Shore segments with potential effects extending more than 75 m comprised less than 2% of proxy area shorelines. In all cases these potential effects consisted of tree mortality, and other than in the flat fens, this mortality likely was due to factors other than reservoir creation.

Photo 3-6: Kelsey reservoir – shoreline looking east along the north side of the eastern arm in 2011

Photo 3-7: Kelsey reservoir – shoreline along the main Nelson River channel (looking north from the south end of the photo coverage area)

Photo 3-8: Kettle reservoir – overview of some of the central islands that were analyzed for potential shore zone effects between 1971 and 2003/2006. The large foreground island is mineral while the islands immediately behind it are disintegrating peatlands (photo taken in 2007 looking west)

Photo 3-9: Kettle reservoir – overview of south portion of Ferris Bay that was analyzed for potential shore zone effects between 1971 and 2003/2006 (photo taken in 2007 looking west). Most of the shorelines in the right two-thirds of the photo are disintegrating peatlands.

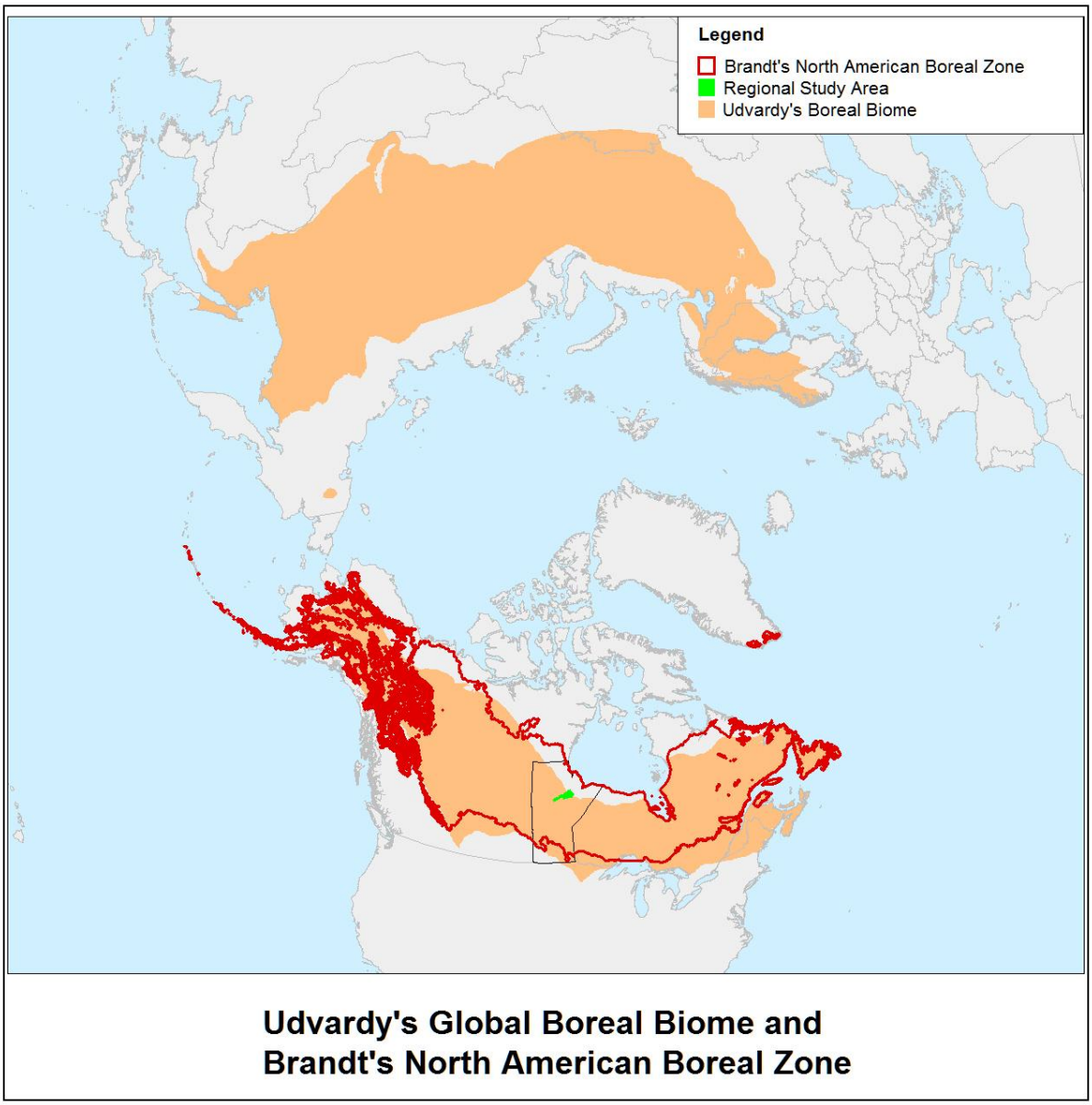
Photo 3-10: Kettle reservoir – high-slope mineral bank along a portion of the shoreline with no visible shore zone effects between 1971 and 2003/2006 (photo taken in 2011, looking northeast)

Photo 3-11: Kettle reservoir – low slope organic bank showing tree mortality and tall shrub development in the shore zone between 1971 and 2003/2006. Note scattered dead trees amongst the tall shrubs which are replacing what was a treed area immediately after flooding (photo taken in 2011, looking north)

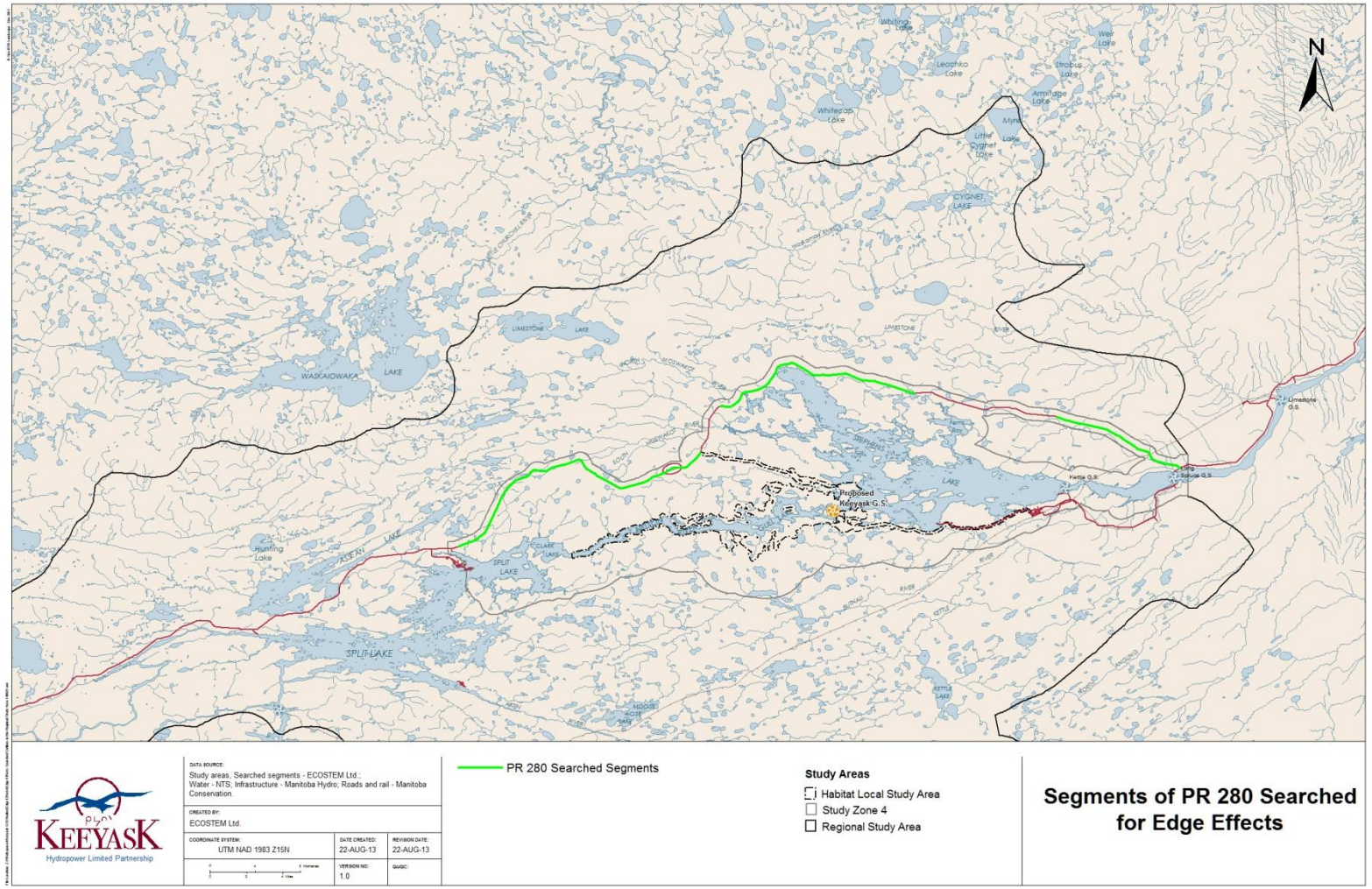
3.4.3.3 CONCLUSIONS

Results from data collected for Project studies confirmed generalizations regarding the most influential driving factors for Manitoba boreal habitat patterns and dynamics as well as the key assumptions used to predict potential Project effects on terrestrial habitat. While the EIS assumed that the typical maximum width of indirect effects on terrestrial habitat was 50 m, results demonstrated that this width was typically less than 15 m for vegetation clearing and less than 20 m for reservoir creation and water regulation. For reservoir-related effects, the terrestrial habitat zone of influence could be wider at shore segments with low relief and/or flat peatland ecosite types, but this rarely extended as much as 75 m inland.

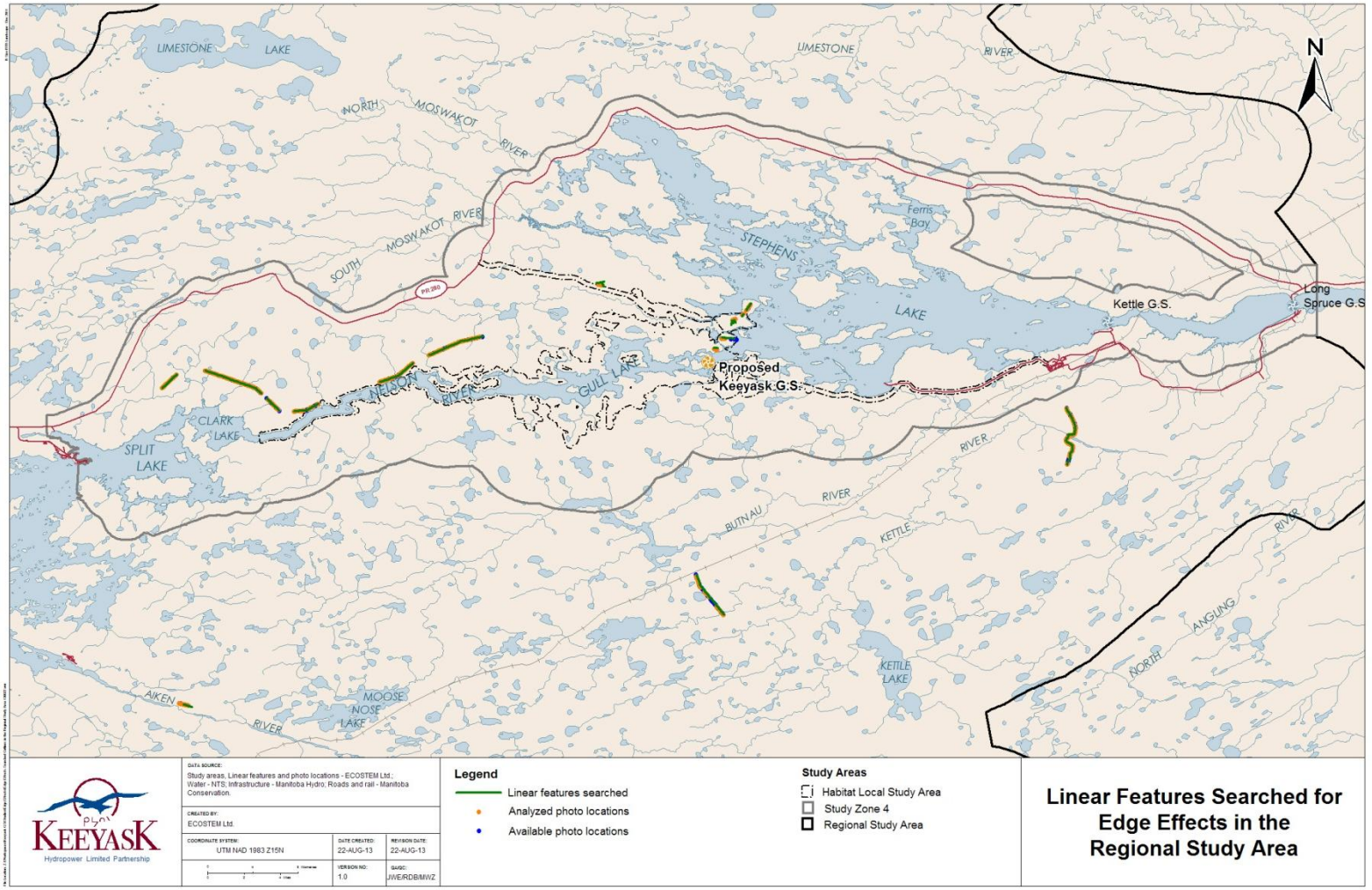
3.5 MAPS



Map 3-1: Udvardy's global boreal biome and Brandt's North American boreal zone



Map 3-2: Portions of PR 280 searched for edge effects from vegetation clearing



Map 3-3: Portions of cutlines searched for edge effects from vegetation clearing

4.0 MOOSE MODEL

4.1 SPECIES OVERVIEW FROM LITERATURE

4.1.1 GENERAL LIFE HISTORY

The moose (*Alces alces*) is the largest member of the Cervidae family and second only to the bison (*Bison bison*) in weight for terrestrial species in North America. Its appearance is characterized by a massive body, long legs, high humped shoulders, extended muzzle, large nose, noticeable dewlap, and short tail (Peterson 1974).

Moose are permanent residents of the boreal forest, and are well adapted to northern climates (Karns 2007). Moose are found only in the northern hemisphere, where their distribution is limited in the north by suitable habitat and by climate in the south (Kelsall and Telfer 1974; Renecker and Hudson 1986; Karns 2007).

Moose mate in September and October. Male moose are polygamous and will search for several females to breed with which may lead to competition with other males, which can sometimes be fatal (Bubenik 2007). The gestation period is approximately eight months and females will usually bear one calf in May or June (Schwartz 2007), however, when food is plentiful, twinning may occur (Gasaway *et al.* 1992) and the occasional triplet may be observed (Franzmann and Schwartz 1985). Bull moose rarely live past 15 years, and the longevity record for cows is 25 years (Wilson and Ruff 1990).

Home range varies by sex and can be affected by season and habitat quality amongst other factors. The home range of males may be larger than that of females with the home range of females doubling in summer as compared to winter home range (Cederlund and Sand 1994). During the autumn rut season, mature bulls range more extensively than immature bulls, and compared to typical movements the remainder of the year (Ballard *et al.* 1991). Winter home ranges can be strongly influenced by snow depth, as moose migrate from areas with deep snow conditions to areas with less snow and restrict their movements to these areas (Hundertmark 2007). Home range may also vary with habitat quality, although confounding factors can complicate analysis of habitat effects on home range (Greenwood and Swingland 1983). Some studies have suggested home ranges in less productive habitats are smaller than those in more productive habitats (Leptich and Gilbert 1989, Ritchie 1978, Taylor and Ballard 1979).

4.1.2 DISTRIBUTION AND ABUNDANCE

4.1.2.1 CONTINENTAL

In North America, moose range extends from Alaska to the east coast of Canada, and south into Washington and Idaho, including the northernmost reaches of Minnesota and New England, USA (Karns 2007). A few individuals have dispersed down the Rocky Mountains, and established in Oregon (Karns 2007).

In the mid-1990s, there was an estimated 500,000 to 1 million moose in Canada (Canadian Wildlife Service 1997). Canadian distributions have varied over the past century. Over several decades the eastern population has grown due to numerous re-introduction efforts and natural immigration into northern Quebec and Ontario (Banfield 1974). Moose have been re-establishing themselves in historic ranges, and are colonizing new areas (Karns 2007). The western distribution of moose expanded into portions of the North West Territories, and into the coastal and southern ranges of British Columbia (Banfield 1974). Moose have been expanding their range southward in Saskatchewan, where the population has been increasing over the last three decades (Government of Saskatchewan 2012).

4.1.2.2 PROVINCIAL

Moose are generally widespread and abundant, throughout Manitoba (NatureServe 2012). After1992, the provincial population was estimated at 32,000 individuals (Manitoba Conservation and Water Stewardship no date). Moose range in the province extends from the agricultural transition zone in southern Manitoba to the Hudson Bay (Map 4-1).

In the 1980s, population declines were observed throughout Manitoba in response to timber harvests (Coady 1982). In southern Manitoba, low populations have resulted in partial or full GHA closures. Since 2011, significant declines in moose populations have been identified and moose harvest has been suspended in many Game Hunting Areas (GHAs) due to low populations (Manitoba Conservation and Water Stewardship 2012). Manitoba Conservation and Water Stewardship is concerned about rapidly declining moose populations in certain areas and management actions, in addition to closures, have included research initiatives, wolf management, disease and parasite management, access control, moose population assessments, consultation with rights-based communities, moose management strategies including the establishment of moose advisory committees, and the addition of wildlife biologists.

4.1.2.3 REGIONAL STUDY AREA

Moose are widely distributed in the region. Historic evidence of moose suggests that their northern limit was once in the southern part of the Moose Regional Study Area (Study Zone 5) (Kelsall 1972), and that they were mostly absent from the Oxford House area (Preble 1902; Lister 1996). However, surveys in the mid-1900s indicated their range extended as far north as Hudson Bay (Kelsall 1972). In northeastern Manitoba, moose are at the fringe of their range. As the niche moose inhabit is limited

on the tundra, moose cannot persist in this biome, and moose density is generally low (B. Knudsen, pers. comm.).

A moose census conducted between 1983 and 1987 in Northern Flood Agreement areas found variable moose densities among habitats sampled. Average moose density was highest in young mixed-wood habitat (6-30 years post-fire; 0.205 moose/km^2), followed in descending order by burnt areas (0-5 years post-fire; 0.076 moose/km^2), open coniferous (0.053 moose/km^2), closed coniferous (0.037 moose/km^2), and mature mixed-wood (0.028 moose/km^2) (Elliott 1988). In 1994, the moose population in the Split Lake Resource Management Area (SLRMA) was estimated at 1,639 individuals (Split Lake Resource Management Board 1994). Over half of the cows observed were accompanied by calves, the number of calves increased significantly from the previous year, and there was a surplus of bulls (Split Lake Resource Management Board 1994). Photo 4-1 depicts a moose cow and calf in the Keeyask region.

Photo 4-1: Moose Cow and Calf in the Keeyask Region

The region lies within portions of GHAs 1, 2, 3, 3a, 9 and 9a. The province of Manitoba has not conducted moose population surveys in GHAs 1 or 2 (D. Hedman, pers. comm.). The estimated moose density for GHA 9 is approximately 10 moose per 100 km^2, approximately 9 moose per 100 km^2 in GHA 9a, and approximately 1 moose per 100 km ^{2} in GHA 3 (Manitoba Conservation, unpublished data).

4.1.2.4 LOCAL STUDY AREA

Scientific data are not available at this level, but abundance and distribution are expected to be similar to that for the region.

4.1.3 FACTORS THAT INFLUENCE DISTRIBUTION AND ABUNDANCE

4.1.3.1 SEASONAL FORAGE AND WATER

Limiting factors for moose consider density-dependent and density-independent relationships. Habitat quality and food requirements have been cited as potentially important limiting factors for moose (Peek *et al.* 1976). Moose are browsers, feeding on a variety trees and shrubs in winter and on herbaceous plants, leaves, and new growth in summer. Although moose may have local food preferences, these are primarily determined by availability.

In spring, summer and fall, a large variety of leaves and new growth of plants (*i.e.*, especially shrubs and trees) such as willow (*Salix* spp.), beaked hazelnut (*Corylus cornuta*), red-osier dogwood (*Cornus stolonifera*), speckled alder (*Alnus rugosa*), white birch (*Betula papyrifera*), and trembling aspen (*Populus tremuloides*), are most often consumed by moose. Their diet also includes a wide variety of aquatic vegetation, such as yellow pond lily (*Nupahr variegatum*), wild rice (*Zizania aquatica*), bur-reed (*Sparganium angustifolium*), horsetail (*Equisetum* spp.), and pondweeds (*Potamogeton* spp.; LeResche *et al.* 1973; Brassard *et al.* 1974; Dodds 1974; Crête and Bédard 1975; Coady 1982; Peek 2007). Occasionally, other forbs and grasses are also consumer.

In winter, the diet shifts to mainly browse species, including willow, white birch, trembling aspen, and balsam fir (*Abies balsamea*; LeResche *et al.* 1973; Brassard *et al.* 1974; Dodds 1974; Peek 1974; Crête and Bédard 1975; Peek 2007). Numerous other species of terrestrial plants have been reported to be fed on by moose in Manitoba and their use depends on local availability; these may include: mountain maple (*Acer spicatum*), western snowberry (*Symphoricarpos occidentalis*), European cranberry (*Viburnum trilobum*), nannyberry (*Viburnum lentago*), red-osier dogwood, speckled alder, beaked hazelnut, russet buffaloberry (*Sheperdia canadensis*), menziesia (*Menziesia ferruginea*), Saskatoon serviceberry (*Amelancier alnifolia*), common chokecherry (*Prunus virginiana*), pincherry (*Prunus pensylvanica*), and balsam poplar (*Populus balsamifera*); Renecker and Schwartz 2007).

Depending on natural succession, habitat may change over time, resulting in alternative forage preferences. Forest fires provide excellent moose browse across North America. Fires help to remove the overstory of larger, unpalatable trees, and promote the growth of deciduous shrubs, such as willow and aspen, which are preferred moose browse. Studies have shown that moose densities in an area increase 5-10 years after a fire as browse becomes established, and moose reach their highest densities 11-30 years after a fire, as browse production peaks (Schwartz and Franzmann 1989; Loranger *et al.* 1991; Maier *et al.* 2005). Fires also create a patchy habitat mosaic, important for providing a variety of browse species, as well as feeding and cover areas in close proximity (Maier *et al.* 2005).

The presence of cutblocks can increase habitat quality for moose through the creation of early seral-stage vegetative communities. Moose favor areas of high forest productivity, in regenerating stands where vegetation reaches heights of 3 m (Telfer 1974; Bowman *et al.* 2010).

4.1.3.2 SECURITY

Protection from predators is a consideration in habitat selection by moose, particularly females with calves (Dussault *et al.* 2005). Females with calves select habitat with high food availability and protection from predators (see Section 4.1.3.5), while males seek habitat with moderate food abundance, cover from predators, and areas with deep snow (Dussault *et al.* 2005).

4.1.3.3 THERMAL COVER

In late winter, habitat that provides the best cover may be selected, and can range from tall shrubs to dense conifer forest (Peek 2007). In severe winter conditions, dense conifer forest is most commonly selected, while aspen-dominated stands are preferred in more moderate winter conditions (Peek *et al.* 1976). In summer, moose experience stress at temperatures greater than 14°C (Karns 2007), and will seek out mature stands with coniferous trees for cooling while selecting against sites where the temperature exceeds 30°C (Schwab and Pitt 1991). Riparian and wetland areas may also provide respite from hot weather (Lankester and Samuel 2007). Upland areas, particularly jack pine stands, may also be used for shelter from the weather (Coady 1982).

4.1.3.4 BREEDING

Mating typically occurs during a three-week period (Bubenik 2007) in September and October (Leblond *et al.* 2010). The length of gestation appears to vary by location, and is roughly 231 days (Schwartz 2007). In Manitoba, the average day of breeding was September 29, with almost all females bred by October 12 (Crichton 1992). During the rut, foraging is a low priority for bulls (Miquelle 1990). Competition between bulls usually involves displays, charges, and fighting, which can sometimes be fatal (Bubenik 2007). Oestrus in females may be delayed or reoccur if breeding does not occur during the initial period (Schwartz 2007).

4.1.3.5 CALVING AND REARING

Conception during late oestrous is not advantageous as calves will be born later in the summer and will have a reduced growing period prior to the strenuous winter season. Late conceptions may be due to a variety of factors, such as low bull/cow ratios, young females breeding, poor nutritional conditions for cows, and avoidance of large rut groups by cows with calves (Coady 1982). A single calf is typical; twin calves are common when nutritional conditions are exceptional (Franzmann and Schwartz 1985; Gasaway *et al.* 1992), and on rare occasion, triplets are observed (Franzmann and Schwartz 1985).

Moose select calving habitat based on site characteristics, not broad habitat types (Bowyer *et al.* 1999). General requirements of moose calving sites are seclusion, shelter, and nearby browse and

water used to escape predators (Bubenik 2007). Islands are frequently used, presumably to avoid predators (Bubenik 2007). Peninsulas and shorelines are used by moose as calving habitats due to the high density of forage such as willow (Bowyer *et al.* 1999). Mainland calving sites include islands in open bog (Cederlund *et al.* 1987). Calving moose may select high-density forage areas as a result of the high energy costs of lactation (Bowyer *et al.* 1999).

4.1.3.6 DISPERSAL AND MIGRATION

Dispersal begins at approximately one year of age, in June, as calves distance themselves from their mothers (Labonté *et al.* 1998). Most young do not disperse, staying relatively near their mothers' home ranges (Cederlund *et al.* 1987; Labonté et *al.* 1998). Young males are more likely to disperse than females to prevent inbreeding and reduce competition for resources (Hundertmark 2007). Dispersing young tend to wander randomly, which contrasts with migration, where moose make predictable movements between seasonal ranges, generally a common winter range and discrete summer ranges (Hundertmark 2007). The same route is typically used every year (Hundertmark 2007).

4.1.3.7 FACTORS THAT REDUCE EFFECTIVE HABITAT

Anthropogenic developments can increase or decrease habitat quality for moose (Laurian *et al.* 2008; Bowman *et al.* 2010). Moose tend to avoid proximity to humans (Neumann 2009), however, habituation may decrease adverse responses to roads (Burson *et al.* 2000). Roads, particularly highways, may reduce the extent of habitat use in areas located up to 500 m from each side of a roadway (Laurian *et al.* 2008, but also see Burson III *et al.* 2000). Roadways are not avoided altogether, however, where certain features of roads, such as the availability of salt in winter, may benefit moose (Laurian *et al.* 2008). The creation of early seral-stage vegetative communities, such as those maintained along roadsides, are also often attractive to moose as sources of forage and where increased road density has been linked with increased moose occurrences (Bowman *et al.* 2010).

Insect pests such as flies may reduce effective habitat for moose by driving them from preferred habitat (Lankester and Samuel 2007). Insects can harass moose to the point where individuals may suffer weight loss by trying to avoid them, and may distract moose from other hazards (Lankester and Samuel 2007).

4.1.3.8 MORTALITY

4.1.3.8.1 PREDATION

Predation, particularly by wolves and bears (Van Ballenberghe and Peek 1971; Ballard and Van Ballenberghe 2007) is a major source of moose mortality. Gray wolves (*Canis lupus*) are the primary natural predators of moose across North America, providing temporary regulation to population levels (Frenzel 1974; Wolfe 1974; Peterson 1977). Wolves prey selectively on young calves and older adults (Pimlott 1967; Peterson and Allen 1974; Peterson 1977). As such, wolves can prevent moose population growth, reducing the number of yearlings below the mortality rate of adults. However,

several hypotheses have been proposed as to whether predators such as wolves can actually limit moose density or not (Ballard and Van Ballenberghe 2007).

Black (*Ursus americanus*), brown (*Ursus arctos*) and grizzly (*Ursus arctos horribilis*) bears are natural predators of moose in North America (Boutin 1992; Gasaway *et al.* 1992; Boertje *et al.* 2010). Bears typically prey on calves, although they can and do kill adult moose (LeResche 1968; Van Ballenberghe and Ballard 2007). Predation by bears can affect local moose populations. However, across North America, the effect is generally not as significant as the influence of wolf predation (Coady 1982). Little is known about the relative contribution of bears to moose calf mortality in Manitoba, and of these species, only black bear is present in the Moose Regional Study Area. Opportunistic encounters may allow wolverine (*Gulo gulo*), coyote (*Canis latrans*), and lynx (*Lynx canadensis*) to prey upon moose, but these species have relatively little predatory influence (Coady 1982).

Other species such as white-tailed deer may act as an alternative prey source for both hunters and predators, reducing moose mortality. Although this pathway is considered important in multiple predator and prey systems (*e.g.*, southeastern Manitoba), this is not considered as most influential factor at Keeyask due to the absence of white-tailed deer.

Based on the ungulate biomass available in the area (see Appendix A), it was estimated that 10 packs of 6 wolves occupy the area year-round, with an additional 50 wolves (16 packs) moving into the area in winter with migratory caribou herds. The density of wolves in the SLRMA is approximately 1.4 individuals/1,000 km² in summer and 2.6 individuals/1,000 km² in winter.

4.1.3.8.2 HUNTING

Hunting is an effective tool in managing moose numbers (Timmerman and Buss 2007). Models of moose populations suggest that selective harvest of moose, where bulls and cows are harvested in limited numbers while calves are hunted without restriction, balances benefits to hunters with long-term moose population growth (Timmerman and Buss 2007). Conversely, moose populations in Maine, New Hampshire, and Vermont previously extended south into Pennsylvania (Dodds 1974). Moose had disappeared from Wisconsin as of the early 1960s (De Vos 1964), and are now found only in the Upper Peninsula of Michigan (Michigan Department of Natural Resources 2012). Excessive hunting and habitat loss have been identified as key reasons for the extirpation of moose in these specific regions (Coady 1982). Manitoba currently allows harvest of bulls, and in some GHAs, calves (Manitoba Conservation and Water Stewardship 2012). Domestic harvests may include all sexes and age classes.

In northeastern Manitoba, the sale of moose harvest licenses is ongoing and includes the sale of resident and non-resident licenses in GHAs 1, 2, 3a, 3, 9 and 9a which overlap the Moose Regional Study Area (Section 1.7.3.2 of the Resource Use Supporting Volume). Alternately, in southern Manitoba moose harvesting licenses are not available for GHAs including 13, 13a, 14, 14a, 18, 18a, 18b, 18c and 26 where rights based harvest in these areas has also been restricted (Manitoba Conservation and Water Stewardship 2012). Declines in moose population in the south are thought to have been precipitated by a number of factors, including hunting, where the temporary suspension

of moose harvesting licenses in southern GHAs will be ongoing until the moose populations in these areas recover (Manitoba Conservation and Water Stewardship 2012).

4.1.3.8.3 ACCIDENTAL MORTALITY

Child (2007) described sources of accidental moose mortality. Cumulatively, accidental deaths can be a significant cause of moose mortality. Accidental deaths such as entrapment by vegetation and drowning claim more moose calves than adults. Adult moose typically perish in falls and in collisions with vehicles. Traffic along linear features is often linked with an increase in collisions with vehicles and result in a corresponding increase in mortality. In Manitoba, it is estimated that 12 moose fatalities by vehicles and 12 by trains occur annually, representing 0.5% of the allowable annual harvest of moose. From 2008-2012, out of 52 wildlife-vehicle collisions, a single moose-vehicle collision was reported (Manitoba Public Insurance unpubl. data).

Other causes of accidental death are breaking through ice and drowning, becoming stuck in deep mud or snow, and becoming trapped in a fast-moving forest fire. Bulls die from wounds resulting from fighting and sparring during the rutting season. Entanglement in discarded wires, cables, ropes, and snares can also lead to death (Child 2007).

4.1.3.9 OTHER FACTORS THAT INFLUENCE SURVIVAL AND HABITAT USE

4.1.3.9.1 DISEASES AND PARASITES

Brucellosis and anthrax are the two primary diseases that affect moose in North America. Brucellosis, a zoonosis usually acquired from livestock, is caused by bacteria transfer and affects the reproductive tract, potentially causing abortions (Anderson and Lankester 1974; Coady 1982). While the disease is chronic, it is rarely fatal (Lankester and Samuel 2007).

Anthrax is caused by bacterial spores, which can be ingested, inhaled, or transferred through the skin while eating low-lying vegetation (Dixon *et al.* 1999). Most hoofed mammals are susceptible to this fatal disease (Lankester and Samuel 2007). Anthrax in moose has only been observed as "spill over" from large bison epizootics (Dragon *et al.* 1999). While anthrax occurs in Manitoba, it has generally been found in the southeastern, south central, and Interlake regions (Manitoba Agriculture, Food and Rural Initiatives no date).

Moose contract the majority of parasites when their range overlaps with white-tailed deer (*Odocoileus virginianus*), including a meningeal nematode, a liver fluke, and a winter tick. Linear features may facilitate the movement of white-tailed deer, bringing disease and parasites that may decrease individual fitness or may result in an increase in deaths.

"Moose disease" (also called "brainworm") is caused by *Parelaphostrongylus tenuis*, a meningeal nematode. This parasite uses snails as an intermediate host and is ingested by moose. "Moose disease" may cause paraplegia and/or death. This parasite appears to be moving west across North America with the expansion of the white-tailed deer range (Coady 1982).

The liver fluke (*Fascioloides magna*) encapsulates in pairs in the liver. Immature parasites travel through the liver tissue until another parasite is located, causing extensive damage in some species. Moose are particularly sensitive to the liver fluke, with infection causing direct or indirect mortality (Olsen and Fenstermacher 1942; Karns 1972; Wobeser *et al.* 1985).

The winter tick (*Dermacentar albipictus*) infests the outer hide moose (Anderson and Lankester 1974) and causes excessive grooming and hair loss (Lankester and Samuel 2007). Winter ticks are one of the few parasites with the potential to limit moose numbers, as they can cause appreciable late-winter deaths (Lankester and Samuel 2007).

4.1.3.9.2 MALNUTRITION

Malnutrition is a serious issue that mainly affects moose in winter. Malnutrition occurs due to the inability to digest low quality browse or from a lack of specific nutrients (Coady 1982). In winter, environmental factors increase the energy requirements for survival. As moose already exist in a negative energy balance throughout the winter any factors that increase the required energy expenditure may have severe consequences.

Calves are the first age group to succumb to malnutrition because they have the least amount of fat and protein stores, but require the greatest amount of energy to travel through deep snow (Houston 1968; LeResche and Davis 1973; Peterson 1977). Calves may also die from malnutrition due to their mothers' inadequate milk production or from abandonment and starvation due to insufficient nutrients available to the cow. Older adults may also succumb to the increased energy requirements of the winter environment, and it has been noted that older males make up a greater proportion of malnutrition fatalities of adults (Peterson 1977). Malnutrition in older males may be proportionally more severe due to the weight lost during the rut and the inability to replace these reserves prior to the winter season (Lent 1974).

4.1.3.9.3 SEVERE WEATHER

Moose are well adapted to withstand the effects of climate (Schwartz and Renecker 2007). In particular, the fat reserves and lower metabolism of adults enable them to endure extreme cold (Schwartz and Renecker 2007). Calves are less suited to withstand cold temperatures (Schwartz and Renecker 2007).

The low surface area to volume ratio of adult moose, which is an advantage in cold weather due to the retention of heat, can also exacerbate the effects of heat loading (Schwartz and Renecker 2007). Heat stress can begin at a seemingly moderate temperature of 14°C (Schwartz and Renecker 2007), and may contribute to body condition deterioration, malnutrition, and energy loss, potentially resulting in death (Murray *et al.* 2006). Continued exposure to upper temperature limits may have a detrimental cumulative effect on moose (Lenarz *et al.* 2009).

In northern Minnesota, moose populations have declined drastically from the 1980s to early 2000s. The cause of this decline is not fully understood, but may be a result of climate change (Minnesota Department of Natural Resources 2011).

4.1.3.9.4 SNOW DEPTH

Winter range use differs throughout winter, when the accumulation of snow affects moose movements and their ability to find food (Mech *et al.* 1987; Dussault *et al.* 2005). Mech *et al.* (1987) concluded that offspring of adult moose are affected by three consecutive winters of deep snow. Deep snow hinders mobility and can result in mortality due to an inability to reach forage (Renecker and Schwartz 2007). The cumulative effect of increased energetic costs of foraging and travelling in deep snow could render moose more vulnerable to predation (Mech *et al.* 1987).

4.1.3.10 HABITAT SELECTION

Moose inhabit the boreal forest of North America and they commonly range to near the limit of trees. In northeastern Manitoba, moose are at the fringe of their range, and moose density is low (Knudsen *et al.* 2010; Cree Nation Partners 2013). As the niche moose inhabit is limited on the tundra, moose cannot persist in this biome. As one moves from core boreal forest, with its patches of higher quality moose habitat, towards the tree line, some of the life requisites (food quality, winter thermal shelter) become less abundant, and the habitat capability to support moose declines (Feldhamer *et al.* 2003, Karns 2007). This pattern is common as one moves from the centre of a species' range toward the edge. Food availability has been shown to be a strong predictor of the general distribution patterns of animal's (McArthur and Pianka 1966, Morris 1988) and herbivores such as moose (Danell and Lundberg 1991, Edenius *et al.* 2002). The SLRMA is located sufficiently close to the range limit of moose in Manitoba that even the higher quality habitat in the SLRMA may show a reduced capability to support moose.

Winter ranges are smaller than summer ranges and are influenced by food availability, thermal cover, and predator avoidance (Phillips *et al.* 1973; Dussault *et al.* 2005). Moose occupy habitat in a wide range of seral stages, riparian and forested areas, and the periphery of burns (Irwin 1975; Coady 1982). Areas composed of a mosaic of deciduous or mixed regenerating stands, interspersed with mature coniferous stands, are preferred habitats as these areas offer both a dense shrub layer for browse and dense cover from the environment and predators (Dussault *et al.* 2006). In Manitoba, black spruce (*Picea mariana*) stands are often used for cover in winter, while willow communities are also used for cover and browse (Palidwor *et al.* 1995). Snow depth also plays a role in habitat use in winter. Both upland and lowland habitats are used throughout the winter, but winters with deep snow may cause moose to shift to lowland riparian areas where snow depths are less (Coady 1982).

In summer, moose home ranges expand (Stevens 1970; Phillips *et al.* 1973; Crête and Courtois 1997; van Beest *et al.* 2011). Forest stands dominated by broadleaf trees, jack pine, tall shrubs, riparian and aquatic habitat, and recently burned areas are commonly inhabited (Irwin 1975; Coady 1982; Peek 2007).

Riparian areas provide moose with an abundance of food items, including aquatic vegetation and may offer respite from hot weather and insects (Lankester and Samuel 2007). Upland areas, particularly jack pine, are used for shelter from the weather and predators (Coady 1982). Moose may also inhabit areas where coniferous trees create edges near shrub stands, which allow moose to browse on new growth while using protective cover from the nearby canopy. Burned areas are also used in summer due to the abundance of high-quality browse. Deciduous burn stands are preferred but conifer burn

stands may also be used (Irwin 1975). A large burn will result in a short-term loss of both food and cover. However, shrubs and young regrowth are important food sources as the area begins to regenerate. As a result of regeneration, moose density tends to peak between 11-30 years after a fire as browse species growth peaks (Maier *et al.* 2005). Fires also, create a patchy habitat mosaic, important for providing a variety of browse species, as well as feeding and cover areas in close proximity (Maier *et al.* 2005). Fire can increase the extent or quality of habitat and may result in more successful births and twinning as cows have improved food resources and access to nutrition However, if fires are too frequent in an area, a decline in moose habitat quality may result as browse species lack a sufficient amount of time to develop into high-quality browse.

4.1.3.11 HOME RANGE SIZE

The size of moose home ranges depends on a variety of factors, including season, habitat quality, weather, sex, and age of the individual Hundertmark 2007). Moose show strong fidelity to their home ranges and movements between foraging habitats within their home ranges (Hundertmark 2007). Winter home ranges can be strongly influenced by severe winter factors such as snow depth, as moose migrate from areas with deep snow conditions to areas with less snow and restrict their movements to these areas (Hundertmark 2007). The environmental conditions experienced by moose throughout the year such as weather, habitat quality, predatory pressures, and disturbances are strongly associated with movements of moose within their home ranges (Hundertmark 2007).

The sizes of moose home ranges depend on whether individuals are migratory or reside in the same range year-round. In a study of home range and habitat usage by moose in Minnesota, Phillips *et al.* (1973) observed that moose used a distinctly different habitat in spring than during the rest of the year. Moose in Alaska showed strong fidelity to their summer and winter ranges (MacCracken *et al.* 1997). The timing of migration to winter home ranges is dependent on snow depth; an early heavy snow fall results in early movement of moose and a more gradual accumulation of snow results in movement to wintering grounds later in the winter (Ballard *et al.* 1991). The distance between summer and winter home ranges may vary; ranging from 16-93 km for moose in south-central Alaska (Ballard *et al.* 1991).

In Sweden, annual home ranges of males (25.9 km^2) were larger than those of females (13.7 km^2; Cederlund and Sand 1994). Summer home ranges of female moose in south-central Sweden were twice the size of winter home ranges (Cederlund and Okarma 1988). In Alberta, mean home ranges for males and females of varying ages ranged from 31.2 to 59.6 km^2 in winter and from 4.9 to 59.7 km^2 in summer (Hundertmark 2007).The home ranges of females may overlap with those of other females in the same region; however, individuals are rarely in the same place at the same time (Cederlund and Okarma 1988). Mature bulls exhibit more extensive and varied movement during the fall rut compared to immature bulls, and compared to typical movements the remainder of the year (Ballard *et al.* 1991). In Alaska, seasonal home ranges were estimated at a minimum of 92 km^2, and when migration was included exceeded 259 km^2 (Hundertmark 2007). In Minnesota, annual home ranges were no larger than 3.9 km^2 and in Maine, mean winter home range size averaged 25.8 km^2 (Hundertmark 2007).

Home range sizes for moose in Manitoba are largely unknown (Palidwor *et al.* 1995), and may be highly variable.

4.1.3.12 FRAGMENTATION AND CUMULATIVE EFFECTS

Fragmentation of habitat, such as the development of linear features, may result in an increase of predation on moose by wolves and humans as a result of better access to moose habitat (James and Stuart-Smith 2000; Latham *et al.* 2011). Humans will use new linear features to move into areas that were previously less accessible. Human access generally leads to additional mortality due to hunting, poaching, and management actions (Jalkotzy *et al.* 1997). Alternatively, fragmentation such as the development of cutlines, seismic lines and transmission lines may increase moose habitat by creating edge-type habitat that promote the growth of preferred moose browse such as willow (McNicol and Gilbert 1980; Jalkotzy *et al.*1997; Potvin *et al.* 2005).

The fragmentation of moose habitat through the construction of roads can lead to effective habitat loss through factors associated with sensory disturbance (Laurian *et al.* 2008; Jiang *et al.* 2009; Bowman *et al.* 2010). This is despite the potential for newly available preferred forage items and saltlicks to be available following road construction. The extent to which moose avoid roads and roadside is variable with moose proximity to these areas increasing at low-traffic times (Neumann *et al.* 2013), indicating the link between traffic levels and sensory disturbance resulting in effective habitat loss for moose. Research conducted by Laurian *et al.* (2012) indicated that moose avoided highways and forest roads by 100 to 250 m with males avoiding these roads more than females. Conversely, other studies suspected that moose did not move in close proximity to roads due to the lack of forage and salt pools as opposed to vehicle disturbances (Yost and Wright, 2001; Laurian *et al.*, 2008; Laurian *et al.*, 2012). Many studies have demonstrated that roadsides are readily used as sources of forage and do not serve to impede gene flow (Finnegan *et al.* 2012).

4.1.3.13 MOST INFLUENTIAL FACTORS

The factors having the greatest influence on moose population size can vary by region and can occur at different spatial scales within moose ranges. In descending order of importance for example, Dussault *et al.* 2005 (based on Ballenberghe and Ballard 1998), selected predation, availability of food, climate, parasites and disease as factors potentially limiting to moose populations throughout their range. These natural factors, in combination with the degree of other influential factors (*e.g.*, hunting, human disturbance) are thought to determine the size of a moose population. Table 4-1 summarizes moose life requisites, and ranks these factors in order of importance based on literature and expert opinion.

Figure 4-1 identifies all pathways considered, which link the potential effects of the Project to the moose population. This linkage diagram includes all potential pathways regardless of their likelihood of occurrence. The relative degree of influence among connections along these pathways is then weighted relative to each other as these apply to the Project.

Figure 4-2 demonstrates only the most influential factors for the moose population in the Keeyask region as a simplified pathway diagram. The final selection includes predation, habitat quality, fire

and harvest. Habitat quality may be limited by the availability of food or cover, and it is largely influenced by fire. These are the factors thought to influence moose population size the most at Keeyask. Hunting, predation and other less influential factors are modelled in detail elsewhere (see Technical Appendix, Moose Harvest Sustainability Plan 2013).

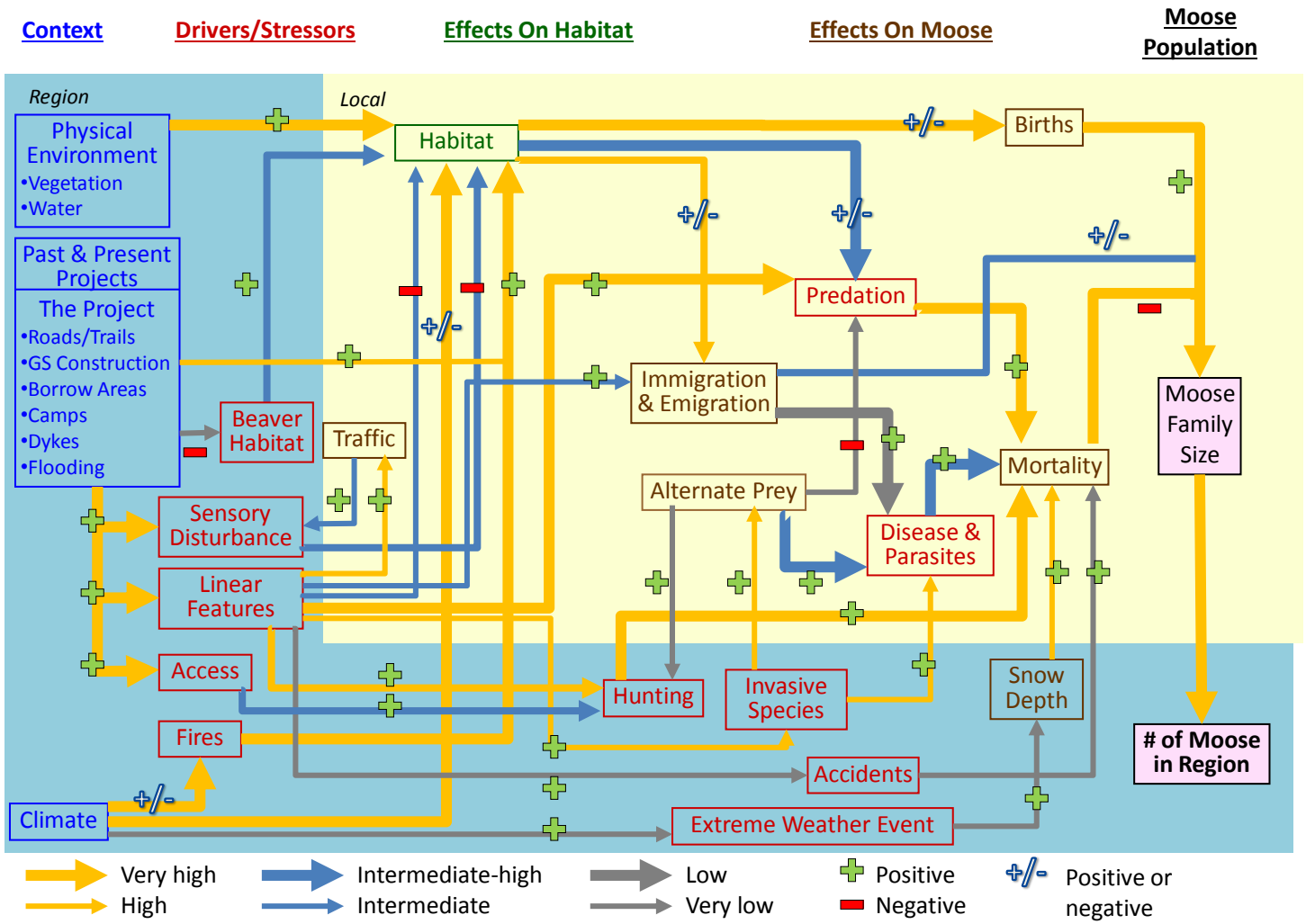


Figure 4-1: Linkage Diagram of All the Potential Effects of the Keeyask Generating Project on the Moose Population

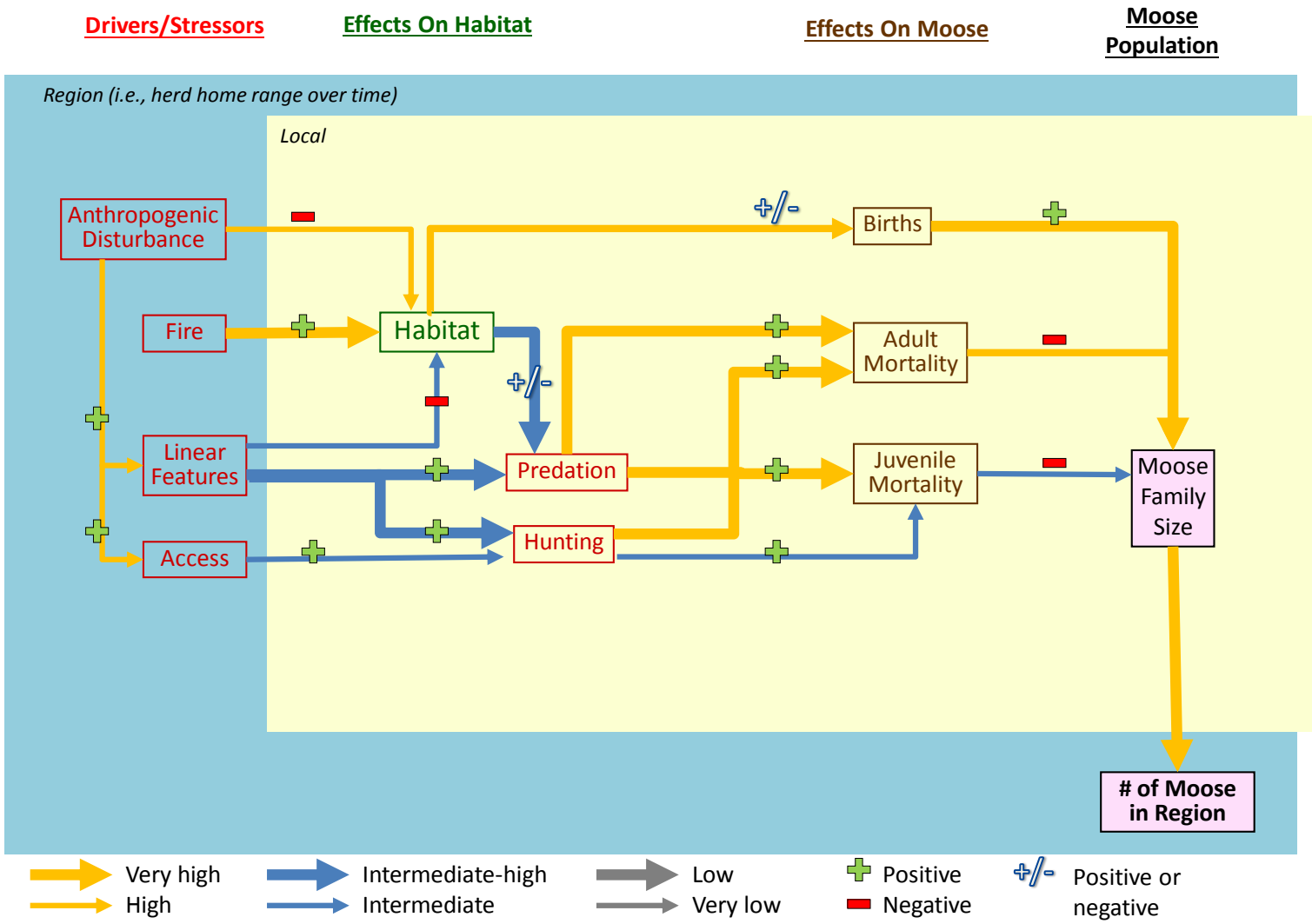


Figure 4-2: Most Influential Factors Linkage Diagram for Moose in the Keeyask Region

Table 4-1: Moose Life Requisites and Factors That Can Substantially Influence Survival, Reproduction, and Habitat Use

Requisite/Factor	Rank	Period	Preference	Location	Context	Area	Canada/North America	Manitoba
Habitat	1	Winter	Seral and mature communities[8] Riparian areas[8] Restricted habitat use[8] Periphery of burns and unburned forest areas[16]	Upland and lowland seral habitat shift[8] Lowland riparian areas are selected if snow depth increases significantly[8]	Balsam fir (in mature stands), white birch, quaking aspen (in seral stands), willows, other foods[9, 11, 12, 25]	Home range: 0.78 – 7.5 km^2 Averaging 3.6 km^2 for cows and 3.1 km^2 for bulls[29]	Coniferous, mixedwood and deciduous boreal forest	Coniferous, mixedwood and deciduous boreal forest, from southern to northern Manitoba. Moose habitat capability declines from the core boreal forest, with its patches of higher quality moose habitat, towards the tree line, and some of the requirements for life requisites (*e.g.*, food quality, winter thermal shelter) may become less abundant.
	3	Calving May to June[4]	Lowland and upland mature stands[8] Aquatic areas[8] Secluded areas[23] Top of a hill[6]	Islands, isolated muskegs, riparian areas, or isolated patches of forest. Return to the same general area every year[4, 14, 23] On hills with <10% slopes[6] Greater distance from the nearest river[6]		Females stay at or near parturition sites (*i.e.*, within 100 m) for several weeks after having giving birth[1] Lactating cows spend more time in safer areas with protective cover than non-lactating cows Variable; some return within <2 km every year for calving	Various; Coniferous or deciduous island, isolated muskegs, riparian areas, or isolated patches of forest[4, 14, 23]	Mid May to Mid June[39]
	4	Breeding (rut) Mid-September to late November[4]	Lowland and upland mature stand shrubs; often near water[18]	Often near water[18]		Home range		
	2	Summer	Extensive habitat use[8] Lowland and upland mature stand shrubs[8] Aquatic areas (May-June)[8] Deciduous (primarily) and conifer (secondary) stands in burn areas[16]	Coniferous trees near shrub stands "edge effect" - seral habitats may be created by fire, clear-cutting and glacial or fluvial action[10] Lowland and upland mature stand shift[8] Aquatic areas[8]	Willows, balsam fir (in mature stands), white birch, quaking aspen (in seral stands), marsh/muskeg [8, 9, 11, 12,25]	Home range: 2.6 – 38 km^2 Averaging 17 km^2 for cows and 14.5 km^2 for bulls[29]	The number of core areas per moose ranged from 1 to 7 (mean 2.4 km^2) with an average core area size of 10.2 km^2	Summer home ranges larger than winter range[36] Home ranges may contain 2 core areas with "migratory" movements between them Some animals or populations are migratory between distinct seasonal ranges to optimize environmental conditions in support of their needs

Table 4-1: Moose Life Requisites and Factors That Can Substantially Influence Survival, Reproduction, and Habitat Use

Requisite/Factor	Rank	Period	Preference	Location	Context	Area	Canada/North America	Manitoba
Food	1	Winter	Woody browse, shrubs and trees[8, 25] Tall shrub and deciduous sapling cover[33] Food in proximity to shelter from predators and snow[41]	Woody browse, shrubs and trees that extend above the snow cover[8] Moose population peaks at 11 to 30 years post fire[20]	Balsam fir, white birch, quaking aspen, willows, red-osier dogwood, mountain ash, beaked hazel, poplar, pin cherry, and maple[4, 9, 11, 12, 25] Shrub cover of species $\geq$1m in height and deciduous sapling cover[3] Winter browse intake rate 9.8-14 g/min. Ingest 4.5-5.5 kg of dry weight 5.3-9.3 hours of browsing required Areas with less snow depth If movements become restricted (snow), moose may exert heavier impacts on local food sources	Site to patch layout (shelter in proximity to food most important) in winter home range	In Western North America willows are the most important winter food[25, 31] In Central and Eastern North America balsam fir, quaking aspen and paper birch are the most important winter food[25]	In the Moose Regional Study Area, a number of preferred moose forage species of nutritional value are limited in extent (*i.e.,* aspen) or rare/absent (*i.e.,* red-osier dogwood, mountain ash, beaked hazel, maple and balsam fir).
	2	Summer	Emergent and herbaceous plants[8] Leaves and succulent leaders Shrubs, woody browse[8] Salt licks[5]	In northern MB, very little willow or birch in first 3 years after. After 5 years plants grow rapidly, moose production increases and lasts for 20 years after fire; moose declines to 35 years post-fire to pre-fire levels	Summer foods required to build reserves for winter survival. Ingest 10-12 kg of dry weight Summer browse intake rate 18-23 g/min. 7.2-11.1 hours of browsing required Leaves, aquatic plants, forbs, and grasses; new growth on many of the species eaten in winter[4]	Site to summer home range (larger than winter)		Summer foods important and needed for building fat reserves to last the winter[8]
Cover	3	Winter	Dense coniferous forest and tall shrubs[37]		Dense conifers in severe winters Aspen-dominated stands in moderate winter conditions[39]	Site to home range		
	3	Summer	Near water, shaded areas[38]	Aquatic areas[37] Upland areas (jack pine stands)[7]	Seek out shaded sites, select against sites >30°C[38]	Site to home range		
	5	Fall – breeding peaks between late Sept. and early Oct.	Form rutting groups – ranging in size from pairs to 30+ adults	Often near water	Increased vulnerability to harvest	Home range		
	3	Calving Late May to early	Diverse range of plant material[14]	Islands[14]	Lower quality food selection as restricted to	Patch - mosaic		

Table 4-1: Moose Life Requisites and Factors That Can Substantially Influence Survival, Reproduction, and Habitat Use

Requisite/Factor	Rank	Period	Preference	Location	Context	Area	Canada/North America	Manitoba
		June[4]			island vegetation[14]			
Predators and avoidance	1	Year-round	Gray wolf[8]	Kill sites were located at lower elevation (less snow), near high moose density, close to edge class polygons, farther from small size class patch edges, near low road density, closer to trails and streams, and in areas of high wolf usage[17]	Calves and adults[27] Majority killed are young calves and adults over eight years of age [27, 28]	Patch to home range		
	2	Spring to fall	Black and brown bears[26]		Primarily calves[3, 8]	Home range		
	6	Year-round	Wolverine, coyote, lynx, and domestic dogs[8]	Opportunistic[8]		Home range		
Other Mortality Sources - Hunting	1	Late summer (August) through early winter (December) Occasionally, at other times of the year (opportunistic, poaching)		Roads, trails, waterways	Different types of management systems stressing bulls only and/or calves. Cow harvest can lead to population decline. Cow harvest can change with education[35]	Hunting seasons vary for specific Game Hunting Areas/Wildlife Management Units and types of hunting archery or rifle	Alberta moose hunting season: September 5 through December 15[2] Saskatchewan moose hunting season: September 17 through December [34] Ontario moose hunting season: September 15 through December 15[24]	Depending on license type and game hunting area –hunting season is generally open from August 27 – December 23[21] Game Hunting Areas (specifically areas for moose hunting): 1, 2,2A,3,3A,4,5,6,6A, 7,7A,8,9,9A,10,11,12,13,13A,14,14A,15,15A,17,17A,18-18C,20,21,21A, 26,27,28,29,29A,31,31A,34,34C, 36[21] Moose hunting currently closed to licensed harvest in GHAs: 13, 13a, 14, 14a, 18, 18a, 18b, 18c, and 26[21]
Malnutrition	5	Usually during winter	Exist in negative energy balance throughout winter – factors increasing energy expenditure are severe	Deep snow can result an inability to reach forage[32] Deep snow is the main contributing factor; >70 cm can impede movement[7] >90 cm may fatally restrict movement[7]	Calves are the first age group to surrender to malnutrition – they have the least amount of fat and protein stores and require the greatest amount of energy to travel through deep snow[19, 27] Older adults may also succumb to malnutrition – specifically older males that lose weight before winter due to the rut[18] Malnourished moose susceptible to increase predation rates[8]	Home range		
Disease	4	When moose and white-tailed deer overlap in the same range[1]	"Moose disease" or "brainworm" caused by *Parelaphostrongylus tenuis* a meningeal nematode[1] Liver fluke (Fascioloides	Overlap areas with white-tailed deer range[1,8]	Ingested by moose - snails are the intermediate host. Neurological disorder – resulting in paraplegia and death[8]	Home range	Overlap areas with white-tailed deer range[1,8] Disease appears to be moving west with the white-tailed deer	Winter tick and brainworm range may be limited if white-tailed deer are absent

Table 4-1: Moose Life Requisites and Factors That Can Substantially Influence Survival, Reproduction, and Habitat Use

Requisite/Factor	Rank	Period	Preference	Location	Context	Area	Canada/North America	Manitoba
			magna)[1] Winter tick (Dermacentar albipictus)[1]		Liver fluke: can be fatal[30] Winter tick: Initial hair loss at neck, shoulders, withers, and perianal regions[22] Corresponding with reduced weight gain and decreased fat stores[22]		range expansion[8]	
Accidents	6	Varies seasonally	Motor vehicles[8] Drowning (primarily calves) [8] Falls[8] Combat injuries during rut[8]	Vehicular fatalities: most important accidental death source – any age or sex[8] Drowning: calves following cows across swift water or unable to exit steep banks[8] Falls: No relation to age or sex[8] Rut injuries: Bulls in rut compete often causing fatal injuries [8,]	Vehicles: primarily in winters with deep snow where ploughed highways and railroads provide efficient corridors for movement Rut injuries: Combat injuries often include locked antlers, body punctures, head and ear lacerations, and eye injuries, all can be fatal	Home range		
Climate	3	Varies seasonally	Wet areas and shade in summer for cooling thermoregulation Dense coniferous forest near tall shrub in winter[37]	Deep snow is the main contributing factor; >70 cm can impede movement[7]	Deep snow increases energy requirements, restricts range, can result an inability to reach forage[32]	Home range	Highly variable across continent	

4.2 METHODS

The moose habitat quality model was developed through the following steps:

1. Summarize moose-habitat relationships from relevant literature, existing information for the Regional Study Area and professional judgment (Figure 4-2 and Table 4-1 summarize these relationships). Producing this summarization is an iterative process in which preliminary generalizations are progressively refined as studies are conducted in the Regional Study Area;
2. Verify the relationships for the Regional Study Area by conducting field studies within it;
3. Use available information and professional judgment to assign each mapped habitat type (ECOSTEM 2011) into either primary, secondary or non-habitat for moose; and
4. Use data and other information from the Regional Study Area to verify and refine the predicted categorization of mapped habitat types into primary, secondary and non-habitat for moose.

The resulting moose habitat quality classes were used to quantify the total amount of moose habitat in the Regional Study Area and produce an effects assessment on habitat lost as a result of the Project.

Section 4.1 provides the information for Step 1. The verifications for Step 2 are based on conducted sampling activities in the Moose Local and Regional Study Areas. The following sections provide an overview of the Project studies that contributed information to model development and verification. Section 4.3.2 then presents the moose habitat quality model developed at Step 3. The subsequent sections describe the data and analysis methods used to verify and refine the preliminary moose habitat quality model.

4.2.1 STUDY AREAS

As noted in Section 4.1.2, the Regional and Local Study Areas for moose were Study Zones 4 and 5, respectively, in Map 2-1.

4.2.2 INFORMATION SOURCES

4.2.2.1 EXISTING INFORMATION FOR THE STUDY AREA

Section 4.1 summarized the literature regarding the key drivers and pathways for moose habitat.

Existing information for moose in the study area includes harvest data from Manitoba Conservation and Water Stewardship, population data from Game Hunting Area surveys, population survey from the Split Lake Resource Management Area and information from published literature (see Section 4.1.2).

Information sources for habitat in the study area include the ECOSTEM habitat dataset, including fire history.

There was no existing information on reservoir-related effects on moose from studies conducted in the Regional Study Area when Project studies commenced.

4.2.2.2 DATA COLLECTION

The moose habitat quality model was used to derive the amount of primary and secondary moose habitat available in the Regional Study Area. These were informed based on a literature review and through field studies where information on habitat use by moose was collected alongside information on species distribution and abundance in the Local and Regional Study Areas.

Field studies conducted to support the evaluation of moose habitat included:

- Mammal sign surveys on calving islands in 2003;
- Mammal sign surveys 2001-2004, 2009;
- Mammal sign surveys and trail camera studies 2010-2011; and
- Winter aerial surveys 2002-2006, 2009-2010, 2012.

During mammal sign surveys, moose sign, as well as that from other species, was recorded along each sampling transect. The types of sign recorded included scat, tracks, trails, browse, feeding sites, and shelters. First Nations field assistants were often consulted to confirm mammal sign as to the correct species and animal age. Often, tracking transects were traversed multiple times within each field season (Manitoba Hydro 2005).

Mammal sign surveys conducted in the Keeyask region 2001-2004, were based on the use of habitat mosaics to evaluate moose presence in these areas. Each habitat mosaic was made up of multiple habitat types (Table 4-2).

Table 4-2: Habitat Codes Used in the Sampling of Mammal Tracking Transects in the Keeyask Local Study Area 2001–2004

Habitat Code	Coarse Habitat Type or Habitat Mosaic	Rarity	Coarse Habitat Types Included
H01	Black spruce treed on uplands	Common	Black spruce treed on uplands
H02	Black spruce treed and young regeneration on uplands	Common	Black spruce treed on uplands Young regeneration on uplands
H03	Black spruce treed on uplands or shallow peatland	Common	Black spruce treed on shallow peatland Black spruce treed on uplands
H04	Black spruce treed on shallow peatland	Common	Black spruce treed on shallow peatland
H05	Black spruce treed and young regeneration on shallow peatland	Common	Black spruce treed on shallow peatland Black spruce treed on uplands Young regeneration on uplands Low vegetation on uplands

Habitat Code	Coarse Habitat Type or Habitat Mosaic	Rarity	Coarse Habitat Types Included
			Low vegetation on wet peatland
H06	Jack pine treed on uplands	Rare	Jack pine treed on uplands Jack pine mixedwood on uplands
H07	Jack pine treed on uplands and young regeneration	Common	Jack pine treed on uplands Young regeneration on uplands Low vegetation on uplands
H08	Jack pine mixedwood on uplands	Rare	Jack pine mixedwood on uplands
H09	Young regeneration on uplands	Common	Young regeneration on uplands
H10	Young regeneration on uplands or shallow peatland	Common	Young regeneration on shallow peatland Black spruce treed on shallow peatland Young regeneration on uplands Low vegetation on wet peatland Tall shrub on shallow peatland Tall shrub on wet peatland
H11	Young regeneration on shallow peatland	Common	Young regeneration on shallow peatland Young regeneration on wet peatland
H12	Black spruce mixedwood on uplands	Rare	Black spruce mixedwood on uplands Black spruce treed on uplands
H13	Broadleaf mixedwood on uplands	Rare	Broadleaf mixedwood on peatlands Black spruce treed on uplands Black spruce treed on shallow peatland
H14	Broadleaf treed on uplands	Rare	Broadleaf treed on uplands
H15	Low vegetation or tall shrub on wet or shallow peatlands	Common	Low vegetation on wet peatland Tall shrub on wet peatland
H16	Black spruce treed on wet peatland	Common	Black spruce treed on wet peatland Black spruce-tamarack mixture on wet peatland

To determine the importance of coarse habitat mosaics, winter and summer sampling activities were conducted. In 2003, islands in Stephens and Gull lakes were also surveyed to determine the presence of moose, as well as other species, on these islands.

Additional mammal sign surveys were conducted 2010-2012. These surveys were conducted based on the alternate classification of sampling locations as coarse habitat types and based on efforts to more exhaustively sample islands in lakes and peatland complexes in the Keeyask region. In conducting these mammal sign surveys, trail cameras were often used to supplement and further assess species presence and age.

Aerial surveys of moose in the Keeyask region were conducted based on surveys conducted between 2002-2006 (Manitoba Hydro 2004), and in the Split Lake Resource Management Area (SLRMA) in 2009 and 2010 (Knudsen *et al.* 2010). Alternate aerial surveys were conducted in 2011-2012 over three survey

occasions. Surveys were done using a fixed-wing aircraft and were conducted over an area approximately 8,500 km^2.

4.2.3 ANALYSIS METHODS

The initial classification of moose habitat was informed, and in some cases, quantified, by statistical analysis of data collected in the Local and Regional Study Areas.

Model validation procedures were based on winter and summer surveys. Based on locations where moose were observed, information on habitat at these locations was assessed and used to determine if the moose habitat quality model, derived based on above analysis with literature support, was sufficient in characterizing moose habitat use in the Local and Regional Study Areas.

4.2.3.1 DESCRIPTIVE STATISTICS

4.2.3.1.1 HABITAT-BASED MAMMAL SIGN SURVEYS

The exploration of habitat mosaic use by moose was conducted based on the frequency with which moose sign was found on transects replicated in particular broad habitat mosaics. Based on mammal sign surveys conducted 2001-2004, 16 habitat mosaic types were used and included 5 habitat mosaics identified as "rare" and 11 identified as "common" (Table 4-2). Rare habitat mosaics (habitats) were identified as those that comprise less than or equal to 1% of the available habitat in Zone 4; all other habitats comprising more than 1% of habitat in Zone 4 were characterized as common habitat mosaics (Table 4-2).

In total, 55 broad habitat mosaic transects were sampled in eight habitat mosaics winter 2001 (Table 4B-1), 103 transects were sampled in 12 habitat mosaics in summer 2001 (Table 4B-2), 71 transects sampled were sampled on nine habitat mosaics in winter 2002 (Table 4B-3), 195 transects sampled on 12 habitat mosaics in summer 2002 (Table 4B-4), 262 transects were sampled on all 12 identified habitat mosaics in summer 2003 (Table 4B-5), and 21 transects sampled in summer 2004 were all in a single type of habitat mosaic (Table 4B-6).

Mammal sign survey data from riparian areas in 2002 and 2003 were compared to identify the importance of riparian areas to moose. These data were also examined to identify differences of use of riparian areas by moose between the reservoir (Stephens Lake), off-system lakes (small lakes and ponds in Zone 4), and Gull Lake. Mann-Whitney U tests were used to determine if differences in moose sign frequency (sign/m) occurred between riparian areas of Gull Lake, reservoir (Stephens Lake), and off-system lakes during 2002-2003. Sign frequency observed in 2002 and 2003 along each riparian, coarse habitat mosaic transect (Gull Lake and Stephens Lake), and lake perimeter transect (small lakes) was averaged. A broad habitat mosaic transect was considered riparian if its start point was located within 100 m of a waterbody. Only data collected in summer in common habitat types were used; data from islands were excluded. From 2002-2003 a total of 56 transects, covering 27,420 m were surveyed along Gull Lake riparian

transects; 35 transects, covering 16,795 m, were surveyed along Stephens Lake riparian transects; and 20 transects, covering 43,260 m, were surveyed along off-system lake perimeters.

4.2.3.1.2 ISLAND USE

Islands in Stephens Lake were surveyed for adult and calf moose. In total, 67 islands on Stephens Lake in Zone 3 were surveyed for moose activity during the summer of 2003. Moose presence was recorded, and variables such as the size of islands and nearest distance to the mainland were measured using GIS.

4.2.3.1.3 MOOSE BROWSE COMPARISONS

Moose browsing data from the Keeyask Transmission Project and south access road area was used to explore the frequency and intensity of browsing among habitat types. These data were also used to examine the importance of "tall shrub" habitat to moose browse presence and intensity.

Data from the 2009 moose browse transects were used to compare the presence and browse intensity between primary and secondary moose habitat as delineated in the moose habitat quality model. Not all transects were included in the analyses. Only transects dominated by a single coarse habitat type (>50% proportion) were included in the comparison. Fire data was also used to help determine if the transect was located in either primary or secondary habitat. A total of 14 transects were designated as primary moose habitat, with 10 containing the presence of moose browse and 4 with none. A total of 29 transects were designated as secondary moose habitat, with 16 containing the presence of moose browse and 13 with none. The number of primary and secondary habitat transects with moose browse present and absent was compared using a chi-square test of independence. For each transect, the category value of moose browse intensity was averaged and compared between primary and secondary moose habitat using a Mann-Whitney U test.

Due to the potential importance of "tall shrub" habitat to moose, a comparison of moose browse presence and browse intensity between transects containing tall shrub to those not containing tall shrub was performed. Tall shrub of all types was found on 31 transects, with 24 of these containing moose browse and 7 with none. Tall shrub was absent on 141 transects, with 85 of these containing moose browse and 56 with none. The number of transects with and without tall shrub with moose browse present was compared using a chi-square test of independence. For each transect the categorical value of moose browse intensity was averaged and compared between transects with and without tall shrub using a Mann-Whitney U test.

4.2.3.1.4 FIRE INFLUENCE

To examine the influence of fire on moose densities, moose density within the 2010 Split Lake RMA aerial survey grids was compared to historical fire information. Fire has been shown to strongly influence moose habitat by improving browse availability and moose densities have been shown to peak 11-30 years after a fire (Maier *et al.* 2005).

Historical fire data in Manitoba from 1929-2011 (Manitoba Conservation and Water Stewardship 2013) was intersected with the moose density grids from the SLRMA (Map 4-2) to determine the burned proportion and dominant fire class within each grid. Fires were assigned to a burn age class based on the

year of occurrence (Table 4-3). Due to some grids containing overlapping fire boundaries from numerous past fires, the fire with the largest proportional area within the grid was assumed to have the greatest influence. Grids containing a past fire that covered less than 10% of the grid were assumed to have a negligible effect and were designated as burn age class 1.

Table 4-3: Burn Age Classes Used in Examination of Moose Coarse Habitat Type Selection

Burn Age Class	Burn Age Range (years)	Recorded Fire Events
1	50+	1960
2	40-49	1967, 1972
3	30-39	1975, 1976, 1977, 1980, 1981
4	20-29	1983, 1984, 1989, 1990, 1992
5	10-19	1993, 1994, 1995, 1996, 1998, 1999, 2001, 2002
6	0-9	2003, 2005, 2010, 2011

A Mann-Whitney U test was used to determine if average moose densities were higher on grids dominated by fire greater than 30 years old (burn age classes 1-3) compared to grids dominated by fire less than 30 years old (fire class 4-6) as it has been shown that moose densities peak 11-30 years after a fire (Maier *et al.* 2005).

4.2.4 MODEL VALIDATION

Validation of moose habitat quality models took place through an evaluation of coarse habitat types occurring proximal to locations where moose were observed. Winter sampling locations were based on aerial surveys performed from 2009 to 2012. Summer sampling locations were based on the 2010 and 2011 placement of trail cameras on islands around Stephens Lake as well as on peatland complexes in areas surrounding Stephens Lake.

In addition, the influence of fires affecting moose selection of coarse habitat types was modelled as an additional explanatory variable. Each coarse habitat type was identified as having an affiliated burn age class as per Table 4-3. The coarse habitat types identified as having not been affected by recorded fire events were assigned a default burn age of 1. Based on the combination of the 35 available coarse habitat types, with the six available burn age classes, 151 variations of coarse habitat types with associated burn age classes were tested.

For moose, winter habitat data was collected through aerial surveys performed from 2009 to 2012 in the Keeyask region. In total, 43 locations were identified where moose were observed during aerial surveys. Four locations were documented during 2009 aerial surveys in the Keeyask region, 16 locations were documented based on 2010 stratification and sampling, and 23 locations were documented based on a

series of three aerial surveys performed in the winter of 2011-2012. A minimum of one moose was observed at each location where geographic coordinates were recorded.

Identification of summer moose peatland complex habitat was collected based on trail camera locations set up in the Keeyask region in 2010-2011. Each trail camera had a set of corresponding geographic coordinates that were subsequently used to identify coarse habitat types occurring in locations where moose were successfully photographed. In total, 100 trail cameras had moose recorded on them from May to October in 2010 and 2011.

Analysis of coarse habitat type used by moose in the summer was assessed based on sampling locations that occurred on islands in lakes (n = 70) and those occurring in proximity to sampled peatland complexes (n = 30). This was done to account for potential differences in moose selection for coarse habitat types based on variation in island in lake/peatland complex use.

The identification of habitat information at multiple spatial scales was done through a buffering of UTM coordinates where moose were identified. Buffers used in the identification of habitat information included 100-m, 250-m, 500-m and 1,000-m buffers. The quantities of coarse habitat type within a buffered UTM coordinate were averaged to indicate the extent of each coarse habitat type occurring for each particular group of sampling locations.

To indicate the coarse habitat types occurring most commonly in locations where moose were sampled, each coarse habitat type was ranked based on its overall proportion. The coarse habitat types appearing most frequently, and cumulatively making up 80% of the habitat area for a buffer level, were treated as coarse habitat types potentially selected for and used by moose. In addition, coarse habitat types were weighed based on their relative proportions in Study Zone 4 as a whole to indicate if they were seen with greater frequency inside buffered sampling areas.

4.3 RESULTS

4.3.1 DESCRIPTIVE STATISTICS

4.3.1.1 POPULATION SURVEYS

Aerial surveys conducted in 2009 and 2010[1] indicated that the moose population was 2,600 +/- 21.4% (95% confidence interval = 2,044 to 3,155) in the SLRMA (6 moose/100 km^2). Of these 2,600, an estimated 1,035 were bulls, 876 were cows and 313 were calves (Knudsen *et al.* 2010). The lowest moose densities were observed in the northeastern portion of the SLRMA and the highest were observed primarily near major rivers or water bodies and younger burns (Knudsen *et al.* 2010) (Map 4-3).

[1] A three-stage aerial survey for moose was conducted between March 2009 and January-February 2010. During the final stage, stratified random sampling was used to estimate the moose population over the entire Split Lake Resource Management Area.

4.3.1.1.1 REGIONAL STUDY AREA

Aerial surveys in the Regional Study Area indicated that overall average moose density remained about the same from 2002 to 2006 (Table 4-4). Moose density ranged from 0.02 individuals/km² in 2002 to 0.06 individuals/km² in 2004.

Table 4-4: Moose Density in Study Zone 6, 2002 to 2006

Study Year	Area Surveyed (km^2)	Number Observed	Density (individuals/km^2)	Density Range (min, max individuals/km^2)
2002	771	12	0.02	(0.00, 0.09)
2003	1462	63	0.04	(0.00, 0.26)
2004	559	32	0.06	(0.00, 0.38)
2005	513	22	0.04	(0.00, 0.77)
2006	336	18	0.05	(0.00, 0.62)
Total/Mean	3641	147	0.04	(0.00, 0.77)

Data extrapolated from the 2010 SLRMA aerial survey indicate that the moose population is approximately 950 individuals in the Moose Regional Study Area. Aerial surveys for moose (and caribou) were conducted during winter on nine other occasions between 2002–2003 and 2006–2007. A total of 212 moose were observed in a 2,338 km² survey area. Moose density averaged 0.09 moose/km² (min = 0; max = 0.77) over the study periods. Moose densities were greater north of the Nelson River, with the greatest densities occurring in a burn west of Stephens Lake and near Orr Lake (Knudsen *et al.* 2010). Moose were also observed in the Regional Study Area during aerial surveys for caribou in December 2011, January 2012, March 2012, and incidental observations during caribou surveys in February 2013.

Overall, calculated moose densities based on surveys flown in Study Zone 6 agree with that in Knudsen *et al.* 2010), which indicate a low overall average density of moose of approximately 0.06 moose/km² in the Moose Regional Study Area. There are variations however, and high moose densities tend to be clustered.

4.3.1.1.2 LOCAL STUDY AREA

Aerial surveys in the Moose Local Study Area Study (Zone 4) conducted from 2002 to 2006 indicated densities ranging from 0.02 km² to 0.27 km² (Table 4-5). The highest in-year sampling density recorded was 0.38 individuals per km². None of the blocks surveyed in 2006 were in the Local Study Area. Resource users from Fox Lake Cree Nation (FLCN) indicate that the Butnau River, Kettle River, and

Cache Lake are important areas for moose hunting, and that food for moose is abundant in these areas (FLCN 2010 Draft).

Table 4-5: Moose Density in the Local Study Area, 2002 to 2006

Study Year	Area Surveyed (km^2)	Number Observed	Density (individuals/km^2)	Density range (min, max individuals/km^2)
2002	447	9	0.02	(0.00, 0.09)
2003	207	12	0.06	(0.00, 0.13)
2004	73	20	0.27	(0.00, 0.38)
2005	57	10	0.18	(0.00, 0.15)
2006	-	-	-	-
Total/Mean	784	51	0.07	(0.00, 0.38)

Moose densities were very low (less than 0.05 individuals/km^2) to low (0.06 to 0.15 individuals/km^2) in the Local Study Area as observed during the 2010 SLRMA aerial survey. High densities (0.26 to 0.35 individuals/km^2) were observed in a large burn west of the northern arm of Stephens Lake to Provincial Road (PR) 280 just outside the Local Study Area (Knudsen *et al.* 2010).

4.3.1.2 HABITAT-BASED MAMMAL SIGN SURVEYS

The sampling of transects in the Local Study Area occurred for coarse habitat mosaics sampled in the summer and winter. Lake perimeters and riparian shorelines were only surveyed in summer. Based on the sampling of these areas, the area with the highest density of moose sign was identified as riparian shorelines during the summer period (Table 4-6). Moose signs were abundant (0.35 sign/100 m^2) and found on all lake perimeter transects. Mean frequency of moose signs were greater at lakes south of Gull Lake (0.40 signs/100 m^2) than north (0.31 signs/100 m^2). Signs of moose activity were very abundant on small and medium-sized lakes (0.39 signs/100 m and 0.35 signs/100 m^2, respectively), and abundant on large lakes (0.23 signs/100 m^2). Moose signs were abundant on transects north and south of Gull and Stephens lakes, and on islands.

Moose sign was very abundant and very widespread on riparian shoreline transects on Gull Lake (Table 4-6). Signs were also very abundant on the north and south shores of the lake and on islands. Mean sign frequency was greatest on the south shore (1.16 signs/100 m^2). Moose signs were very abundant in riparian zones of all widths and slopes, with one exception; signs of moose activity were abundant on shorelines with the greatest slopes (0.48 signs/100 m^2). Moose signs were observed in all seven habitats

surveyed. Mean sign frequency ranged from 0.33 signs/100 m² in low vegetation or tall shrub on wet peatland to 1.17 signs/100 m² in black spruce treed on shallow peatland and in broadleaf mixedwood on mineral and thin peatland.

Moose were widely distributed and often found near water (*e.g.*, Looking-back Creek). Signs of activity were found in all habitats in the Local Study Area, although they were found in fewer habitats and were less widely distributed in winter. Highly variable moose densities (none [0] to medium [0.16 to 0.25 individuals/km²]) can be expected in the Regional Study Area. The greatest moose densities were observed north of PR 280, outside of the Local Study Area.

Table 4-6: Abundance and Distribution of Moose Signs (signs/100 m²) in the Local Study Area

Transect Type	Mean	S.E.	Abundance	Proportion of Transects	Distribution	Species Rarity
Lake perimeters	0.35	0.05	abundant	1.00	very widespread	very common
Coarse habitat mosaics (summer)	0.32	0.02	abundant	0.98	very widespread	very common
Coarse habitat mosaics (winter)	0.27	0.01	abundant	0.28	widespread	very common
Riparian shorelines	0.98	0.14	very abundant	0.85	very widespread	very common

A comparison of moose sign frequency along riparian transects indicated that moose sign frequency was significantly higher on smaller, off-system lake riparian areas compared to Gull Lake or Stephens Lake riparian areas. Sign frequencies were similar between Gull and Stephens Lake riparian areas (Table 4-7).

Table 4-7: Probability (P) Values of Comparisons of Average Moose Sign Frequency (sign/m) From Gull Lake and Stephens Lake and Off-system Lake Riparian Areas in 2002 and 2003; α = 0.05

	Gull Lake	Stephens Lake	Off-system Lakes	Average Sign Frequency (sign/m)
Gull Lake	1	--	--	0.20
Stephens Lake	0.69	1	--	0.16
Off-system	<0.01	<0.01	1	0.35

To assess the importance of habitat mosaics in identifying locations preferred by moose, mammal sign surveys conducted in winter 2001-2002 indicated the presence of moose on 23 of 126 sampled transects (Table 4-8). Nine of 16 habitat mosaics were sampled with moose sign observed on six of these. The habitat mosaics where moose sign was most common included black spruce treed on shallow peatland and young regeneration on uplands or shallow peatland (Table 4-8). These are both considered potential

habitat mosaics used by moose with the former being considered potential secondary habitat and the latter being potential primary habitat. Only a single rare habitat mosaic type was sampled, broadleaf mixedwood on uplands, which demonstrated some use by moose.

Table 4-8: Habitat Class Information for Sampled Mammal Tracking Transects in the Keeyask Region Where Moose Signs Were Observed Winter 2001–2002

Habitat Mosaic	Habitat Class Code	# Sampled Transects	# Transects with Moose	% Transects with Moose	1° or 2° Habitat
Black spruce treed on uplands	H01	64	9	14.06	2°
Black spruce treed and young regeneration on uplands	H02	3	0	0.00	2°
Black spruce treed on uplands or shallow peatland	H03	22	3	13.64	2°
Black spruce treed on shallow peatland	H04	16	6	37.50	2°
Black spruce treed and young regeneration on shallow peatland	H05	0	0	N/A	2°
Jack pine treed on uplands[1]	H06	0	0	N/A	1°
Jack pine treed on uplands and young regeneration	H07	0	0	N/A	1°
Jack pine mixedwood on uplands[1]	H08	0	0	N/A	1°
Young regeneration on uplands	H09	8	3	37.50	1°
Young regeneration on uplands or shallow peatland	H10	3	1	33.33	1°
Young regeneration on shallow peatland	H11	0	0	N/A	1°
Black spruce mixedwood on uplands[1]	H12	0	0	N/A	2°
Broadleaf mixedwood on uplands*	H13	6	1	16.67	1°
Broadleaf treed on uplands[1]	H14	0	0	N/A	1°
Low vegetation or tall shrub on wet or shallow peatlands	H15	1	0	0.00	1°
Black spruce treed on wet peatland	H16	3	0	0.00	2°
TOTAL		126	23	18.25	

[1.] Considered rare habitat mosaics.

Mammal sign surveys conducted summer 2001-2004 indicated the presence of moose on 480 of 581 sampled transects (Table 4-6). All 16 habitat mosaics were sampled with moose sign observed to varying extents on all of them. Six habitat mosaics had moose sign on 100% of sampled transects including black spruce treed on uplands or shallow peatland, black spruce treed and young regeneration on shallow peatland, jack pine treed on uplands and young regeneration, jack pine mixedwood on uplands, young regeneration on uplands or shallow peatland, and young regeneration on shallow peatland. The lowest occurrence of moose sign occurred on the low vegetation or tall shrub on wet or shallow peatlands habitat mosaic. Of the five rare habitat mosaics sampled, the portion of moose sign observed ranged from 75% to 100%.

Table 4-9: Habitat Class Information for Sampled Mammal Tracking Transects in the Keeyask Region Where Moose Signs Were Observed Summer 2001–2004

Habitat Mosaic	Habitat Class Code	# Sampled Transects	# Transects with Moose	% Transects with Moose	1° or 2° Habitat
Black spruce treed on uplands	H01	297	225	75.76	2°
Black spruce treed and young regeneration on uplands	H02	7	6	85.71	2°
Black spruce treed on uplands or shallow peatland	H03	54	54	100.00	2°
Black spruce treed on shallow peatland	H04	80	70	87.50	2°
Black spruce treed and young regeneration on shallow peatland	H05	6	6	100.00	2°
Jack pine treed on uplands[1]	H06	4	3	75.00	1°
Jack pine treed on uplands and young regeneration	H07	2	2	100.00	1°
Jack pine mixedwood on uplands[1]	H08	7	7	100.00	1°
Young regeneration on uplands	H09	42	41	97.62	1°
Young regeneration on uplands or shallow peatland	H10	10	10	100.00	1°
Young regeneration on shallow peatland	H11	5	5	100.00	1°
Black spruce mixedwood on uplands[1]	H12	11	10	90.91	2°
Broadleaf mixedwood on uplands[1]	H13	20	15	75.00	1°
Broadleaf treed on uplands[1]	H14	7	6	85.71	1°
Low vegetation or tall shrub on wet or shallow	H15	22	13	59.09	1°

Habitat Mosaic	Habitat Class Code	# Sampled Transects	# Transects with Moose	% Transects with Moose	1° or 2° Habitat
peatlands					
Black spruce treed on wet peatland	H16	7	7	100.00	2°
TOTAL		581	480	82.62	

[1.] Considered rare habitat mosaics

4.3.1.3 ISLAND USE

Moose (including, cows, calves, and bulls) were present on 57% of islands surveyed in 2003. Moose cows and calves were present on 19% of islands. Calf frequency on islands may be related to island size, with higher frequencies of calves recorded on larger islands (Figure 4-3). This relationship does not appear to be consistent with adult moose (Figure 4-4).

Broad, coarse, and fine habitat types on islands were dominated by black spruce types. Of the 67 islands surveyed in 2003, all broad and fine habitat types were dominated by black spruce and 65 (97%) of coarse habitat types were dominated by black spruce.

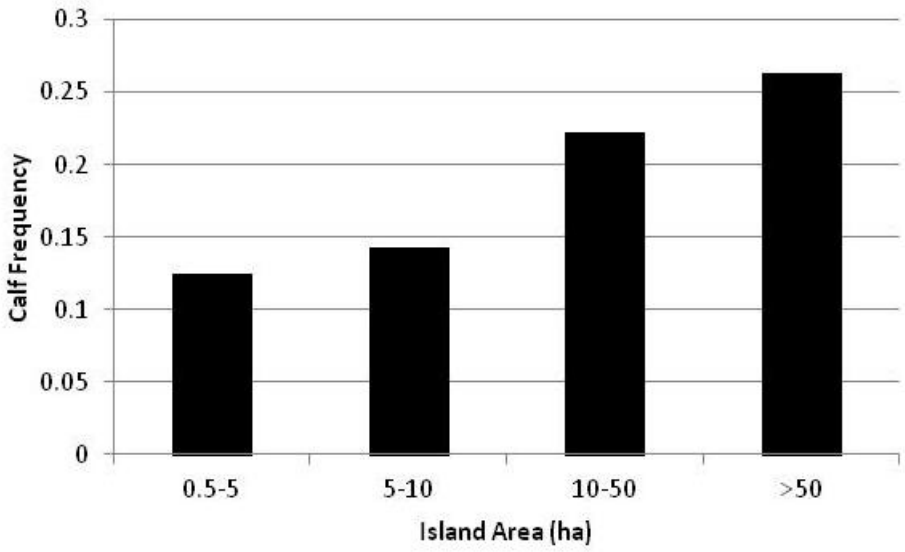


Figure 4-3: Moose Calf Frequency on Various Sized Islands Surveyed in 2003

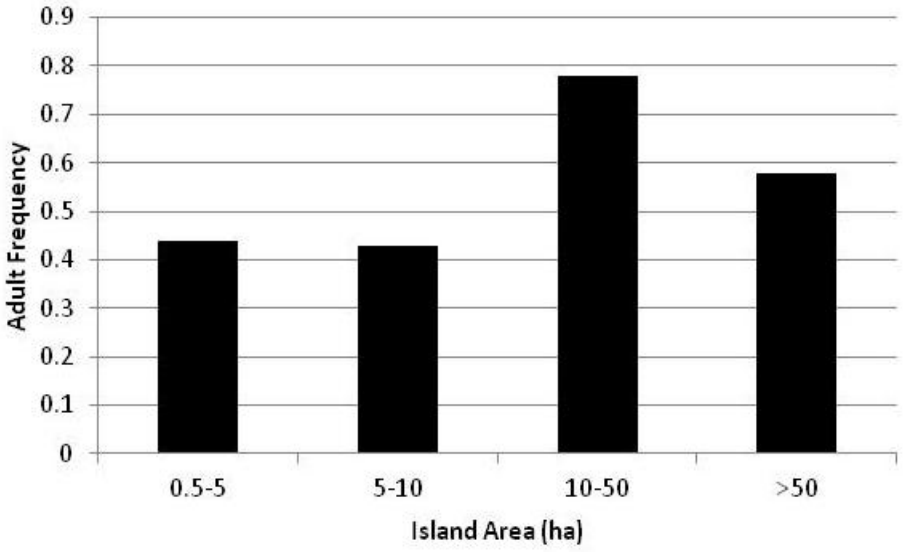


Figure 4-4: Adult Moose Frequency on Various Sized Islands Surveyed in 2003

4.3.1.4 MOOSE BROWSE

The number of primary habitat transects with the presence of moose browse was not significantly different from the number of secondary transects with the presence of moose browse (chi-square = 1.04, df = 1, P = 0.31). Browsing intensity was also not significantly different between primary habitat transects and secondary habitat transects (Mann-Whitney U test statistic = 239.50, P = 0.33).

The presence of tall shrub on transects did not have a significant influence on the presence of moose browse compared to transects without tall shrub (chi-square = 3.21, df = 1, P = 0.07). The intensity of browsing was also not significantly different between transects with tall shrub compared to those without (Mann-Whitney U test statistic = 1878.50, P = 0.21).

4.3.1.5 FIRE INFLUENCE

Extra low and low moose densities were most often found on grids dominated by burn age class 1. Medium moose densities were most often located on grids dominated by burn age class 4. However, medium moose densities were also found relatively frequently on grids dominated by burn age classes 1 and 5. High moose densities were most often found on grids dominated by burn age class 4 (Table 4-10).

Table 4-10: Number and Percent of Grids in Each Fire Class With Different Moose Densities

Moose Density (moose/100 km^2)	Burn Age Class No. Grids (% of grids for moose density) 1	2	3	4	5	6	Total
Extra low (≤2)	611 (62)	32 (3)	12 (1)	135 (14)	100 (10)	98 (10)	988
Low (2.1-4.7)	385 (41)	44 (5)	25 (3)	197 (21)	159 (17)	128 (14)	938
Medium (4.8-9.9)	152 (27)	39 (7)	28 (5)	170 (31)	119 (22)	45 (8)	553
High (10-34.1)	12 (12)	5 (5)	3 (3)	51 (51)	28 (28)	2 (2)	101

Grids dominated by fire greater than 30 years old had significantly lower moose densities (4.67 moose/100 km^2 , n = 1348) compared to grids dominated by fire less than 30 years old (7.31 moose/100 km^2, n= 1232; Mann-Whitney U test statistic= 609,433.50, P= <0.001).

4.3.2 MOOSE HABITAT QUALITY MODEL

Deciduous browse is considered the most important component of moose habitat, both in summer and winter. Plant species including willow, alder, poplar and white birch are assumed to be the important forage species in northern forests. In spring, summer and fall, deciduous leaves and emergent vegetation are important forage types, and these are associated with the tall shrub layer. Forage plants associated with water is an important feature of moose habitat quality; however, in the study area, water is not thought to be limiting.

The initial identification of coarse habitat types important to moose is based on moose selection for dietary items important in meeting various life-history requirements (for more information see Sections 4.1.3.1 and 4.1.3.10). Moose forage plants present in the Keeyask region are described in Appendix H. An overall qualitative importance value was assigned to plants of potential importance, which was based on seasonal availability and preference. In a separate step, qualitative importance was assigned to each coarse habitat type by described occurrences of the deciduous browse species identified above. See Section 2.3.4 of the TE SV for a description and photos of habitat types.

Moose are generalists, and occupy a wide range of forest types. Cover used by moose often consists of dense forest, often dominated by conifers, with specific tree species use dependent on availability within the daily range of moose. Within the northern boreal forest, a range of cover types may be used, including mature conifers to tall shrub. This model assumes that nearby cover is always provided within each coarse habitat type, regardless of season, and that it is contained within its daily range of movements.

Summer and winter moose sign data or moose browse data that did not detect significant differences among habitat types were not informative for potential weighting purposes, other than indicating that a large number of habitat types should be considered. Field data analysis did indicate however, that forest age should be incorporated into the model as a habitat modifier because there was a strong association between increased moose density and younger age-class forest types, particularly in winter. This agrees with the literature where fire is identified as an important driver that can influence the availability of moose browse and cover.

In the first iteration of the model, primary moose habitat consists of a habitat types capable of providing moose high quality and preferred forage plants, regardless of season. These elements are described by coarse habitat type. Tall shrubs are the primary forage group of moose in the winter, with species use dependent upon availability. Other coarse habitat types were selected as they can provide an abundance of food items throughout the year. Marsh, vegetated riparian peatland, and vegetated upper beach are important food sources, recognizing that nutrient-rich marsh plants are only available in summer. Secondary coarse habitat types were selected as they provide additional sources of browse, particularly in winter when other food sources are less available, and a larger availability of some leaf forage in summer. Burns provide increased browse quality over time as the forest regenerates over about 30 years.

Isolation from predators, particularly when calving, can be important factor in the life requisites for moose. Islands are often used for calving. Field data indicated that if a detailed model were to be developed, island size could be used as a descriptive variable in its development.

Table 4-11: Primary and Secondary Moose Habitat Types in the Moose Regional Study Area

	Coarse Habitat Type
Primary Habitat	Broadleaf mixedwood on all ecosites
	Broadleaf treed on all ecosites
	Jack pine mixedwood on mineral and thin peatland
	Jack pine treed on mineral and thin peatland
	Jack pine treed on shallow peatland
	Low vegetation on mineral and thin peatland
	Marsh
	Tall shrub on mineral and thin peatland
	Tall shrub on shallow peatland
	Tall shrub on wet peatland[1]
	Vegetated riparian peatland[2]
	Vegetated upper beach[3]
	Burn[4]
Secondary Habitat	Black spruce mixedwood on mineral and thin peatland
	Black spruce mixedwood on shallow peatland
	Black spruce treed on mineral soil
	Black spruce treed on shallow peatland
	Black spruce treed on wet peatland[5]
	Black spruce treed on thin peatland
	Low vegetation on shallow peatland
	Low vegetation on wet peatland[6]
	Tamarack-black spruce mixture on wet peatland[7]
	Tamarack treed on shallow peatland
	Tamarack treed on wet peatland[8]
Non-Habitat	Human infrastructure
	Vegetated ice scour[9]
	Marsh Island[10]

1. Consists of Tall shrub on wet peatland and Tall shrub on riparian peatland coarse habitat types
2. Consists of Nelson River shrub and/or low vegetation on sunken peat coarse habitat type
3. Consists of Nelson River shrub and/or low vegetation on upper beach coarse habitat type
4. Consists of select coarse habitat types affected by fire s 1975 as well as Young regeneration coarse habitat types
5. Consists of Black spruce treed on wet peatland and Black spruce treed on riparian peatland coarse habitat types
6. Consists of Low vegetation on wet peatland and Low vegetation on riparian peatland coarse habitat types
7. Consists of Tamarack-black spruce mixture on wet peatland and Tamarack-black spruce mixture on riparian peatland coarse habitat types
8. Consists of Tamarack treed on wet peatland and Tamarack treed on riparian peatland coarse habitat types
9. Consists of Nelson River shrub and/or low vegetation on ice scoured upland coarse habitat type
10. Consists of Nelson River marsh coarse habitat type

4.3.3 MODEL VALIDATION

Various coarse habitat types were identified based on the geographic buffering of locations where moose were observed during winter sampling activities. The coarse habitat types observed most frequently, and based on the application of four different buffer levels, included: black spruce treed on shallow peatland, black spruce treed on thin peatland, and black spruce treed on shallow peatland (Table 4-12). It should be noted that the burn age classes associated with these coarse habitat types varied but predominately consisted of forest greater than 50 years old; indicating low levels of burn in locations where moose were observed. Moose observations were also common by the "shallow water "habitat designations indicating these landscape features may be important to local moose. Data tables indicating quantities of coarse habitat types for each buffer level where moose were observed can be found in Tables 4B-7 to 4B-10.

Table 4-12: Rankings of Coarse Habitat Types Based on Abundance With 100, 250, 500 and 1000 m Buffers Applied to Winter Moose Sampling Locations

Coarse Habitat Type	Burn Age Class	100 m	250 m	500 m	1000 m
Black spruce treed on shallow peatland	1	1	1	1	1
Black spruce treed on thin peatland	1	2	2	2	2
Black spruce treed on shallow peatland	6	3	3	3	3
Shallow water	NA	4	4	4	6
Low vegetation on mineral or thin peatland	4	5	5	6	7
Low vegetation on shallow peatland	4	6	7	7	10
Low vegetation on shallow peatland	3	7	9	11	-
Black spruce treed on thin peatland	6	8	6	5	5
Low vegetation on shallow peatland	1	9	10	14	13
Low vegetation on mineral or thin peatland	3	10	11	13	-
Low vegetation on wet peatland	1	11	15	-	-
Black spruce treed on mineral soil	1	12	13	8	8
Human infrastructure	1	13	8	12	12
Black spruce treed on shallow peatland	3	14	16	15	14
Low vegetation on shallow peatland	5	15	14	10	9
Nelson River	NA	16	12	9	4
Black spruce treed on shallow peatland	4	17	-	-	-
Black spruce treed on thin peatland	3	-	-	16	11
Low vegetation on mineral or thin peatland	5	-	-	17	15
Black spruce treed on thin peatland	4	-	-	-	16

Defining the importance of coarse habitat types to moose in winter was based on the presence of coarse habitat types found inside and outside of buffered moose observations (Table 4-13). Ranking of coarse habitat types, based on being identified as more common in buffered areas relative to Study Zone 4, indicated moose selection of coarse habitat alternate to those listed above (Table 4-12). Notably, those coarse habitat types indicating portions of jack pine and tamarack may have been used by moose. There is also some indication of moose selection for coarse habitat types having been affected by fire in the last 30 years, including areas identified as having quantities of black spruce present. Four of seven top ranked coarse habitat types support the existing model. Data tables indicating amounts of coarse habitat types based on their proportions inside and outside of buffer areas can be found in Tables 4B-11 to 4B-14.

Table 4-13: Ranking of Coarse Habitat Types Based on Relative Use With 100, 250, 500 and 1000 m Buffers Applied to Winter Moose Sampling Locations

Coarse Habitat Type	Burn Age Class	100 m	250 m	500 m	1000 m
Tamarack treed on wet peatland	6	1	1	3	4
Black spruce treed on wet peatland	4	5	6	9	12
Jack pine treed on mineral or thin peatland	4	16	12	6	9
Nelson River shrub and/or low vegetation on ice scoured upland	1	13	15	15	7
Black spruce treed on wet peatland	6	14	9	14	17
Black spruce treed on mineral soil	4	9	8	22	19
Black spruce treed on shallow peatland	4	11	16	20	16
Low vegetation on mineral or thin peatland	4	10	10	13	31
Human infrastructure	6	21	19	18	14
Low vegetation on shallow peatland	4	12	14	16	33
Black spruce treed on riparian peatland	6	6	17	21	32
Black spruce treed on riparian peatland	4	7	13	19	38
Black spruce treed on shallow peatland	3	23	25	32	29
Low vegetation on mineral or thin peatland	3	18	23	27	46
Tamarack treed on shallow peatland	6	42	22	36	15

Summer moose sampling locations were treated separately based on being sampled on islands in lakes or in proximity to peatland complexes. Based on the sampling of islands in lakes, moose use of limited number of coarse habitat types (Table 4-14); primarily black spruce treed on mineral soil, and black spruce treed on shallow peatland areas which have not been affected by fire. As expected in the sampling of islands in lakes, a high proportion of habitat within each buffer level consists of "Nelson River." Data tables indicating amounts of coarse habitat types based on their proportions inside buffered areas can be found in Tables 4B-15 to 4B-18.

Table 4-14: Ranking of Coarse Habitat Types Based on Abundance With 100, 250, 500 and 1000 m Buffers Applied to Summer Moose Sampling Locations on Islands in Lakes

Coarse Habitat Type	Burn Age Class	100 m	250 m	500 m	1000 m
Black spruce treed on mineral soil	1	1	2	2	2
Nelson River	NA	2	1	1	1
Black spruce treed on shallow peatland	1	3	3	-	-
Nelson River shrub and/or low vegetation on sunken peat	1	4	-	-	-

Summer moose sampling locations on peatland complexes had varying coarse habitat types present (Table 4-15). These included black spruce treed on shallow peatland low vegetation on riparian peatland, and low vegetation on shallow peatland. Similar to the results described for islands in lakes, above, sampled coarse habitat types did not appear to have been affected by recorded fire events in the Keeyask region. Based on the sampling of habitat amounts there was an indication of shallow water as being often found in locations where moose were sampled, indicating this habitat feature may be important to moose. Data tables indicating amounts of coarse habitat types based on their proportions inside buffered areas can be found in Tables 4B-19 to 4B-22.

Table 4-15: Ranking of Coarse Habitat Types Based on Abundance With 100, 250, 500 and 1000 m Buffers Applied to Summer Moose Sampling Locations on or Near Peatland Complexes

Coarse Habitat Type	Burn Age Class	100 m	250 m	500 m	1000 m
Black spruce treed on shallow peatland	1	1	1	1	1
Low vegetation on riparian peatland	1	2	3	5	5
Low vegetation on shallow peatland	1	3	2	4	4
Low vegetation on wet peatland	1	4	6	-	-
Shallow water	NA	5	4	3	3
Black spruce treed on thin peatland	1	-	5	2	2
Black spruce treed on mineral soil	1	-	-	-	6

An evaluation of coarse habitat types based on their proportions inside buffered habitat areas and Study Zone 4 indicate the addition of some coarse habitat types as being potentially selected for by moose encountered on islands in lakes (Table 4-16). Of note, Nelson River shrub and/or low vegetation on sunken peat and black spruce mixedwood on mineral or thin peatland were both highly preferred. The

selection of these habitat types is alternate to those coarse habitat types which indicate high amounts of black spruce. Only a single coarse habitat type indicated the presence of recent fires, indicating that burnt areas are not selected for or are present in substantial quantities. Data tables indicating amounts of coarse habitat types based on their proportions inside and outside of buffer areas for islands in lakes can be found in Tables 4B-23 to 4B-26.

Table 4-16: Ranking of Coarse Habitat Types Based on Relative Use With 100, 250, 500 and 1000 m Buffers Applied to Summer Moose Sampling Locations on Islands in Lakes

Coarse Habitat Type	Burn age Class	100 m	250 m	500 m	1000 m
Nelson River shrub and/or low vegetation on sunken peat	1	1	1	1	1
Black spruce mixedwood on mineral or thin peatland	1	2	2	3	5
Black spruce treed on mineral soil	1	3	3	5	7
Black spruce treed on mineral soil	4	6	4	2	6
Nelson River	NA	9	5	6	3
Nelson River shrub and/or low vegetation on upper beach	1	5	6	10	12
Broadleaf mixedwood on all ecosites	1	4	7	13	13
Tall shrub on riparian peatland	1	8	8	11	14
Low vegetation on mineral or thin peatland	1	10	9	19	32
Black spruce treed on shallow peatland	1	12	10	16	27
Nelson River shrub and/or low vegetation on ice scoured upland	1		11	18	50
Low vegetation on wet peatland	1	7	12	14	30
Black spruce treed on wet peatland	1	11	13	20	31
Black spruce treed on thin peatland	1	14	14	25	22
Low vegetation on shallow peatland	1	13	15	23	35

Through a comparison of the quantities of coarse habitat type inside Study Zone 4 with buffered peatland complex sampling areas, alternate habitat types used by moose were identified (Table 4-17). For example, broadleaf mixedwood on all ecosites and young regeneration on shallow peatland are coarse habitat types selected for by moose which were not identified in the previous analysis. Also few of the coarse habitat types selected by moose on peatland complexes have been affected by recorded fire events. Data tables indicating amounts of coarse habitat types based on their proportions for each buffer level in the sampling of peatland complexes can be found in Tables 4B-27 to 4B-30.

Table 4-17: Ranking of Coarse Habitat Types Based on Relative Use With 100, 250, 500 and 1000 m Buffers Applied to Summer Moose Sampling Locations on or Near Peatland Complexes

Coarse Habitat Type	Burn Age Class	100 m	250 m	500 m	1000 m
Low vegetation on riparian peatland	1	1	2	3	7
Low vegetation on shallow peatland	1	2	6	6	10
Broadleaf mixedwood on all ecosites	1	3	9	21	19
Tall shrub on shallow peatland	1	4	13	11	28
Young regeneration on shallow peatland	5	5	7	17	12
Low vegetation on wet peatland	1	6	10	8	18
Broadleaf treed on all ecosites	1	7	14	26	34
Tall shrub on wet peatland	1	8	28	27	23
Off-system marsh	1	9	16	12	11
Tamarack treed on shallow peatland	1	10	3	7	14
Low vegetation on shallow peatland	6	11	24	34	42
Black spruce treed on riparian peatland	1	12	15	15	20
Black spruce treed on wet peatland	1	13	23	25	32
Tamarack- black spruce mixture on wet peatland	1	14	11	18	36
Black spruce treed on shallow peatland	4	15	19	10	29

4.3.3.1 APPLICATION OF THE MOOSE HABITAT QUALITY MODEL

The moose habitat quality model was constructed based on a review of most influential factors important for moose and the association of these factors with habitat types found in the Keeyask landscape. Habitat types were sampled during field studies to assess moose habitat use and patterns of occurrence, and were used in the validation of the model.

Validation of the moose habitat quality model further demonstrated patterns of moose habitat use in the Moose Local Study Area. This was done through an evaluation of locations where moose were surveyed through winter aerial surveys and summer trail-camera locations. Based on a review of coarse habitat types present in locations where moose were observed, varying moose habitat use patterns were identified. In particular, based on summer sampling location, moose were not found to commonly be within proximity to young forest age classes, which was found to generally be the case based on winter sampling locations. The alternate selection of non-burned habitat areas by moose in summer may be due to limitations in study design as trail-camera placement primarily took place in potential calving and rearing areas including peatland complexes and islands in lakes. However, that considerable numbers of moose were observed on sampled peatland complexes and lakes indicates their potential alternate use of these areas compared to those that are burnt.

Based on the results of field studies and validation measures used to explore moose habitat use in the Keeyask region, Table 4-18 presents the model used to identify the potential extent of habitat suitability for moose in the Keeyask region. No differentiation occurred based on the summer and winter seasons although alternate consideration was given to potential primary and secondary habitat types as described above.

The amounts of primary and secondary moose habitat as predicted by the moose habitat quality model are detailed in Table 4-19 for Zone 2, the Local Study Area (Zone 4) and the Regional Study Area (Zone 5) using two different iterations of the coarse habitat classification (versions 12 and 14) . The amount of habitat in Zone 2 was used to calculate the percentage of physical habitat affected by the Project. The quantification of primary, secondary and total habitat available based on identified primary and secondary habitat types is presented as Table 4-19 and is depicted in Map 4-4.

Table 4-18: Primary and Secondary Moose Habitat Types in the Regional Study Area

	Coarse Habitat Type	Burn Age Limits
Primary habitat	Broadleaf mixedwood on all ecosites	no restrictions
	Broadleaf treed on all ecosites	no restrictions
	Jack pine mixedwood on mineral and thin peatland	no restrictions
	Jack pine treed on mineral and thin peatland	no restrictions
	Jack pine treed on shallow peatland	no restrictions
	Low vegetation on mineral and thin peatland	no restrictions
	Off-system marsh	no restrictions
	Tall shrub on mineral and thin peatland	no restrictions
	Tall shrub on riparian peatland	no restrictions
	Tall shrub on shallow peatland	no restrictions
	Tall shrub on wet peatland	no restrictions
	Nelson River shrub and/or low vegetation on sunken peat	no restrictions
	Nelson River shrub and/or low vegetation on upper beach	no restrictions
	Black spruce mixedwood on mineral and thin peatland	≥ 1975 ≤ 2010
	Black spruce mixedwood on shallow peatland	≥ 1975 ≤ 2010
	Black spruce treed on mineral soil	≥ 1975 ≤ 2010
	Black spruce treed on riparian peatland	≥ 1975 ≤ 2010
	Black spruce treed on shallow peatland	≥ 1975 ≤ 2010
	Black spruce treed on thin peatland	≥ 1975 ≤ 2010
	Black spruce treed on wet peatland	≥ 1975 ≤ 2010
	Tamarack- black spruce mixture on riparian peatland	≥ 1975 ≤ 2010
	Tamarack- black spruce mixture on wet peatland	≥ 1975 ≤ 2010
	Tamarack treed on riparian peatland	≥ 1975 ≤ 2010
	Tamarack treed on shallow peatland	≥ 1975 ≤ 2010
	Tamarack treed on wet peatland	≥ 1975 ≤ 2010
	Young regeneration on mineral or thin peatland	no restrictions
	Young regeneration on riparian peatland	no restrictions
	Young regeneration on shallow peatland	no restrictions

Table 4-18: Primary and Secondary Moose Habitat Types in the Regional Study Area

	Coarse Habitat Type	Burn Age Limits
	Young regeneration on wet peatland	no restrictions
Secondary habitat	Black spruce mixedwood on mineral and thin peatland	<1975
	Black spruce mixedwood on shallow peatland	<1975
	Black spruce treed on mineral soil	<1975
	Black spruce treed on riparian peatland	<1975
	Black spruce treed on shallow peatland	<1975
	Black spruce treed on thin peatland	<1975
	Black spruce treed on wet peatland	<1975
	Low vegetation on wet peatland	no restrictions
	Low vegetation on riparian peatland	no restrictions
	Low vegetation on shallow peatland	no restrictions
	Tamarack- black spruce mixture on riparian peatland	<1975
	Tamarack- black spruce mixture on wet peatland	<1975
	Tamarack treed on riparian peatland	<1975
	Tamarack treed on wet peatland	<1975
	Tamarack treed on shallow peatland	<1975

Table 4-19: Results of the Moose Habitat Quality Model

	V12 Coarse Habitat	V14 Coarse Habitat	Zone 2 Area (ha)	Local Study Area Existing Area (ha)	Regional Study Area Existing Area (ha)
Primary Habitat	Broadleaf mixedwood on all ecosites	Broadleaf mixedwood on all ecosites	155.69	810.10	6,123.25
	Broadleaf treed on all ecosites	Broadleaf treed on all ecosites	180.47	978.80	7,398.32
	Jack pine mixedwood on mineral and thin peatland	Jack pine mixedwood on mineral and thin peatland[1]	14.00	189.42	1431.75
	Jack pine treed on mineral and thin peatland	Jack pine treed on mineral and thin peatland[1]	126.69	1,227.69	9,279.59
	Jack pine treed on shallow peatland	Jack pine treed on shallow peatland[1]	0.02	22.27	168.36
	Low vegetation on mineral and thin peatland	Low vegetation on mineral and thin peatland	466.61	7,461.60	56,399.22

V12 Coarse Habitat	V14 Coarse Habitat	Zone 2 Area (ha)	Local Study Area Existing Area (ha)	Regional Study Area Existing Area (ha)
Marsh	Off-system marsh	11.86	193.21	534.08
Tall shrub on mineral and thin peatland	Tall shrub on mineral and thin peatland	77.24	315.81	2,387.09
Tall shrub on shallow peatland	Tall shrub on shallow peatland	33.87	561.63	4,245.12
Tall shrub on wet peatland	Tall shrub on riparian peatland	230.16	973.51	7,358.37
	Tall shrub on wet peatland	34.44	212.55	1,606.58
Vegetated Riparian Peatland	Nelson River shrub and/or low vegetation on sunken peat	79.32	236.54	236.54
Vegetated Upper Beach	Nelson River shrub and/or low vegetation on upper beach	186.15	1,018.02	1,018.31
Burn	Black spruce mixedwood on mineral or thin peatland[2]	1.50	120.48	910.65

V12 Coarse Habitat	V14 Coarse Habitat	Zone 2 Area (ha)	Local Study Area Existing Area (ha)	Regional Study Area Existing Area (ha)
	Black spruce mixedwood on shallow peatland[2]	2.89	25.23	190.70
	Black spruce treed on shallow peatland[2]	933.07	6,957.40	52,588.17
	Black spruce treed on mineral soil[2]	246.87	1,404.62	10,616.98
	Black spruce treed on thin peatland[2]	1,242.95	9,081.80	68,645.62
	Black spruce treed on riparian peatland[2]	5.88	95.52	721.99
	Black spruce treed on wet peatland[2]	15.54	204.87	1,548.55
	Jack pine mixedwood on mineral or thin peatland[2]	53.64	268.92	2,032.66
	Jack pine treed on mineral or thin peatland[2]	284.10	1,784.96	1,3491.82
	Jack pine treed on shallow peatland[2]	22.74	62.61	473.28
	Tamarack- black spruce mixture on riparian peatland[2]	1.31	6.08	45.97
	Tamarack- black spruce mixture on wet peatland[2]	2.28	42.66	322.43
	Tamarack treed on riparian peatland[2]	0.00	1.17	8.86
	Tamarack treed on shallow peatland[2]	26.33	71.92	543.62
	Tamarack treed on wet peatland[2]	0.44	6.15	46.47
	Young regeneration on mineral and thin peatland	0.12	467.89	3,536.57

	V12 Coarse Habitat	V14 Coarse Habitat	Zone 2 Area (ha)	Local Study Area Existing Area (ha)	Regional Study Area Existing Area (ha)
		Young regeneration on riparian peatland	0.02	3.45	26.04
		Young regeneration on shallow peatland	1.09	268.45	2,029.13
		Young regeneration on wet peatland	0.13	19.20	145.15
	Total Primary Habitat		4,437.41	35,094.55	256,111.24
Secondary Habitat	Black spruce mixedwood on mineral or thin peatland	Black spruce mixedwood on mineral or thin peatland[1]	35.04	389.40	2943.33
	Black spruce mixedwood on shallow peatland	Black spruce mixedwood on shallow peatland[1]	2.34	25.29	191.13
	Black spruce treed on mineral soil	Black spruce treed on mineral soil[1]	1,318.52	12,374.50	93,533.85
	Black spruce treed on shallow peatland	Black spruce treed on shallow peatland[1]	2,147.21	46,880.94	354,354.06
	Black spruce treed on thin peatland	Black spruce treed on thin peatland[1]	2,845.54	45,373.26	342,958.08
	Black spruce treed on wet peatland	Black spruce treed on wet peatland[1]	105.07	3,225.66	24,381.45
		Black spruce treed on riparian peatland[1]	42.83	995.30	7,523.05
	Low vegetation on shallow peatland	Low vegetation on shallow peatland	710.42	11,416.80	86,295.01
	Low vegetation on wet peatland	Low vegetation on wet peatland	145.70	2,563.17	19,373.98
		Low vegetation on riparian peatland	225.58	3,007.28	22,730.83
	Tamarack- black spruce mixture on wet peatland	Tamarack- black spruce mixture on riparian peatland	0.70	49.56	374.62
		Tamarack- black spruce mixture on wet peatland	30.81	1,417.41	10,713.62

	V12 Coarse Habitat	V14 Coarse Habitat	Zone 2 Area (ha)	Local Study Area Existing Area (ha)	Regional Study Area Existing Area (ha)
	Tamarack treed on wet peatland	Tamarack treed on riparian peatland	0.00	9.28	70.14
	Tamarack treed on shallow peatland	Tamarack treed on wet peatland	2.89	256.04	1,935.31
		Tamarack treed on shallow peatland	65.82	663.50	5,015.10
Total Secondary Habitat			7,678.46	128,647.39	972,393.56
Total Primary and Secondary Habitat			12,115.89	163,741.92	1,228,504.80

[1.] Coarse habitat type quantities limited based on age (< 1975)

[2.] Coarse habitat type quantities limited based on age (≥ 1975 ≤ 2010)

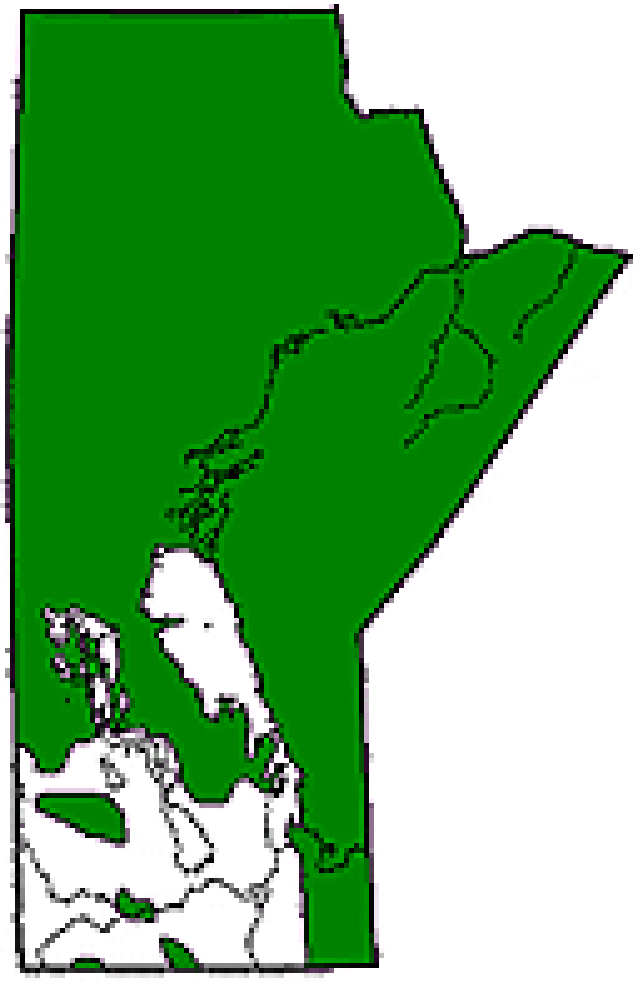
4.4 CONCLUSIONS

The moose habitat model performed reasonably well, but only based on a limited number of confirmed high-ranking coarse habitat classes. Moose presence on the landscape was generally widespread, and was not restricted to certain habitat areas or habitat types as the existing model indicates. The use of mature versus younger age class forest types had limited success for validating the local study area. Aerial survey data from the region however, strongly suggested that there should be an association with a preference for young age class forest types. The model as is, appears to under-estimate the importance of mature forest types. Additional data would be required to test, modify and strengthen the existing model.

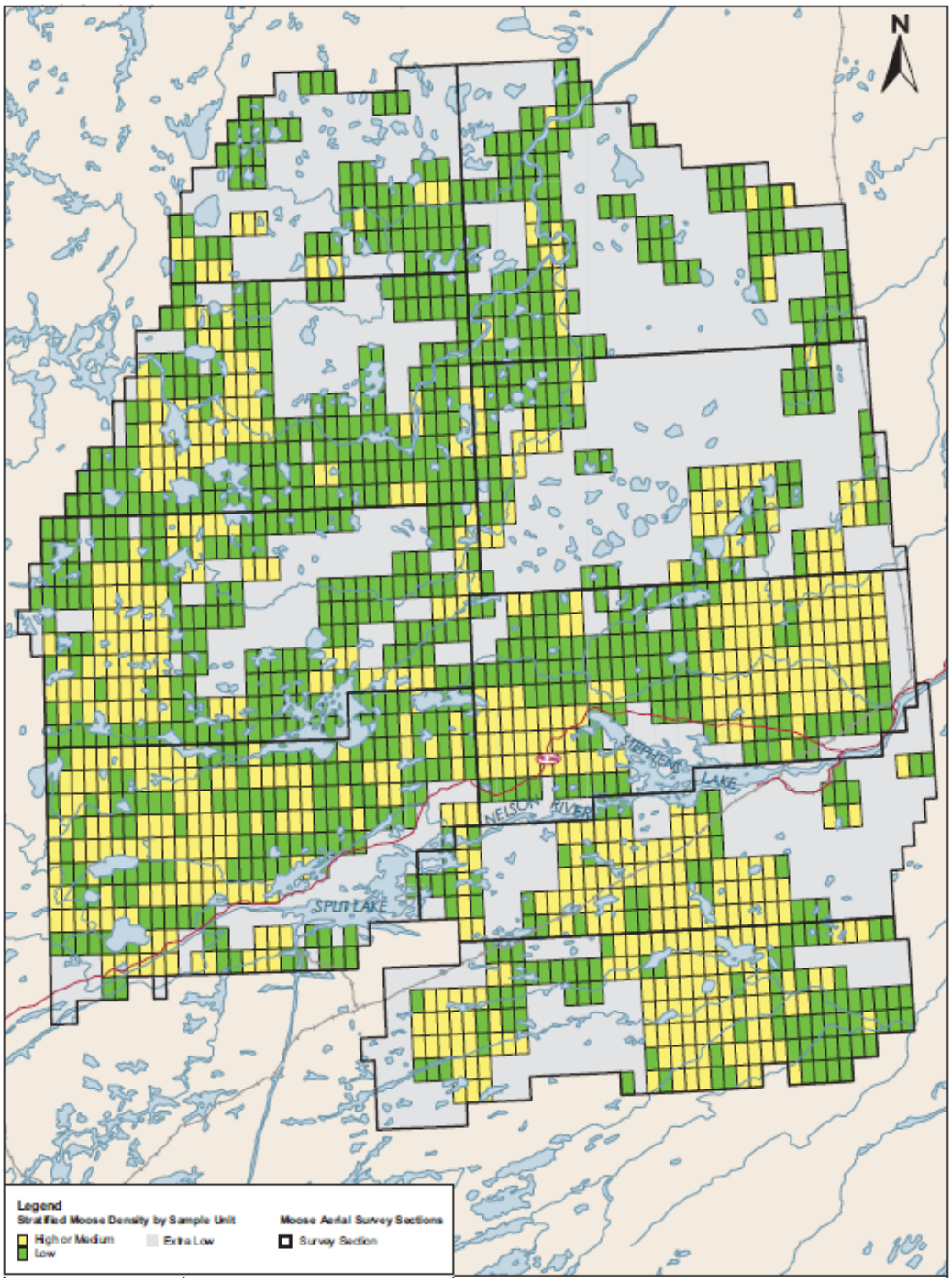
Isolation from predators, particularly when calving, can be important factor in the life requisites for moose. Islands are often used for calving. Field data indicated that if a detailed model were to be developed, island size could be used as a variable in its development. While the existing model explores islands and peatland complexes use in general, separation of these features into specific sub-models for these types of habitat could improve overall model performance.

As indicated by the field data, many moose locations were identified as close to bodies of water, including lakes and ponds, as well as the Nelson River. It is therefore likely that the coarse habitat types located closer to bodies of water are used by moose at higher levels than coarse habitat types further away from these features. The application of a spatial buffer to the existing model that includes water courses and waterbodies, and additional testing to validate distance to water, would likely improve the model and increase the amount of primary habitat in the Keeyask region for moose.

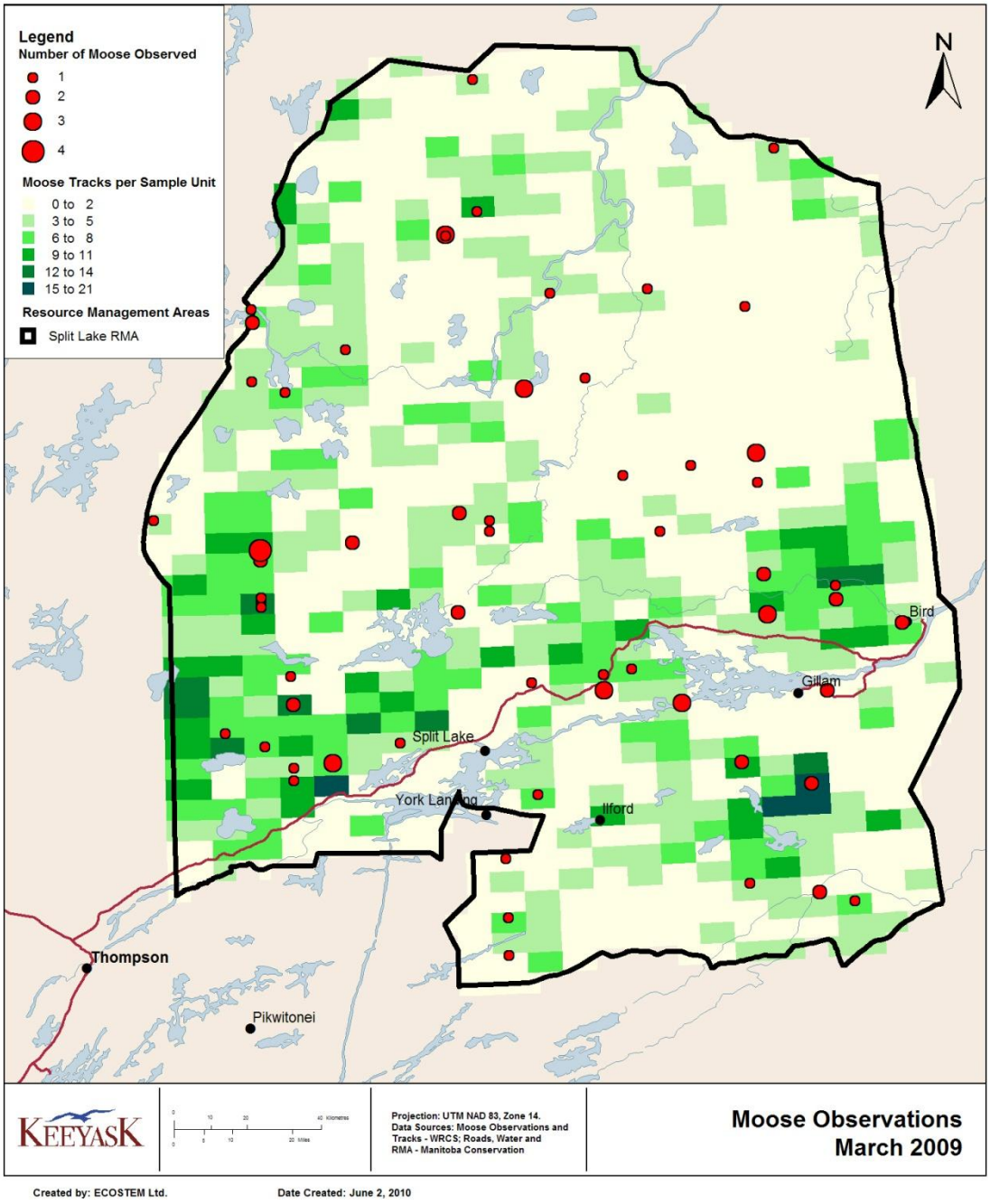
4.5 MAPS



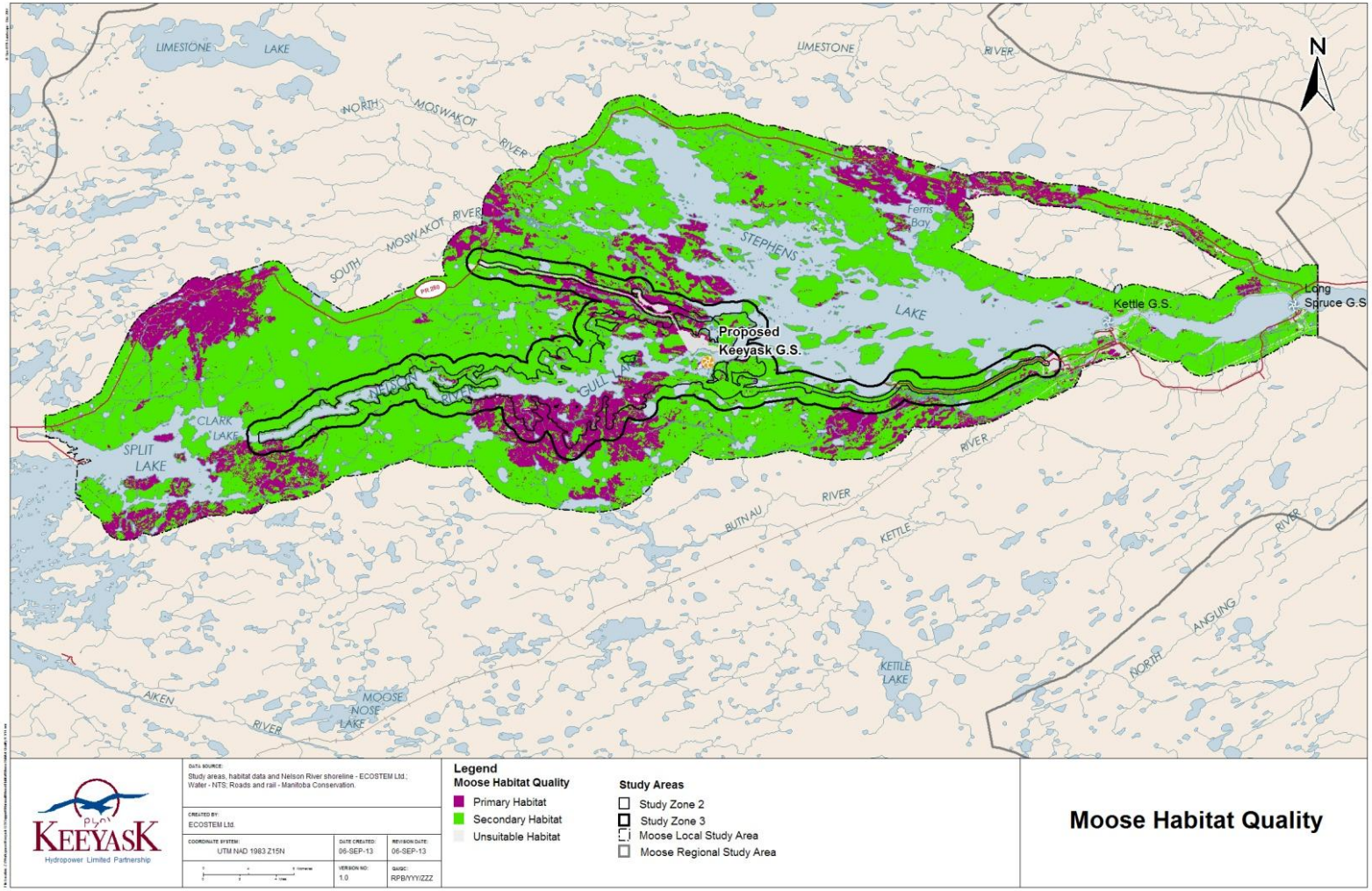
Map 4-1: Manitoba Moose Range (Manitoba Conservation and Water Stewardship)



Map 4-2: Moose Density in Split Lake Resource Management Area Based on 2010 Aerial Survey



Map 4-3: Moose Observations Recorded During the 2009 Split Lake Resource Management Area Moose Survey



Map 4-4: Moose Habitat Quality

5.0 CARIBOU

5.1 SPECIES OVERVIEW FROM LITERATURE

5.1.1 GENERAL LIFE HISTORY

All caribou are of the genus *Rangifer tarandus*. However, there is some debate regarding further classification of the species. Banfield (1961) historically classified caribou based craniometry, or skull characteristics (Courtois *et al.* 2003; Hummel and Ray 2008). Currently, caribou are classified based on morphological characteristics, habitat use, behaviour, and genetics, among other factors (*e.g.*, Bergerud 1994; Mallory and Hillis 1996; Thomas and Gray 2002; Courtois *et al.* 2003; Cronin *et al.* 2005; Hummel and Ray 2008; Environment Canada 2012).

Caribou are highly adapted to cold northern climates (Campbell 1994). Notable adaptations include large hooves, circular in shape that act similarly to snowshoes, paddles, and shovels for foraging in the snow (Miller 2003). Caribou bodies are compact, with thick fur containing an over-layer of guard hairs to prevent heat loss through convection and to minimize the effects of cold climatic conditions; including frigid river crossings (Banfield 1987; Hummel and Ray 2008). Caribou are the only members of the deer family whose sexes both grow antlers (DeCesare *et al.* 2011); those of females are generally smaller than those of males (Miller 2003). Notable behavioural adaptations include seasonal migrations based on the availability of lichens, an important food source for caribou, and reducing exposure to parasites and predators (Gunn 2008). The extent of seasonal movements varies by population, from long-distance migrations to short movements within a home range (Brown *et al.* 2001).

5.1.2 DISTRIBUTION AND ABUNDANCE

5.1.2.1 CONTINENTAL AND GLOBAL

Reindeer and caribou distribution is circumpolar. With the exception of some polar oceans, range is latitudinal from about 46 to 80^{o} North (Giest 1998). The distribution of caribou in Canada ranges from Newfoundland in Atlantic Canada to the Yukon and Nunavut in the north (Banfield 1987). There are generally four recognized subspecies in Canada: Alaska or Grant's caribou (*R. t. granti*), found in and near Alaska; Peary caribou (*R. t. pearyi*) found in the high arctic; barren-ground caribou (*R. t. groenlandicus*), found in Nunavut and the Northwest Territories; and woodland caribou (*R. t. caribou*), found across Canada (Røed *et al.* 1991; Mallory and Hillis 1996; Courtois *et al.* 2003; Cronin *et al.* 2005; Environment Canada 2012). A fifth subspecies, known as Dawson caribou (*R. t. dawsoni*), from the island of Haida Gwaii in British Columbia, is extinct (Thomas and Gray 2002; British Columbia (B.C.) Ministry of Forests, Mines and Lands 2010; Environment Canada 2012). Other

subspecies of caribou occur in northern Europe and Asia, where they are more commonly referred to as reindeer (Hummel and Ray 2008).

Woodland caribou are further divided into forest-dwelling and forest-tundra migratory types (Thomas and Gray 2002; Schaefer 2003; Ontario Ministry of Natural Resources 2009; Abraham *et al.* 2012) in eastern and central Canada. The forest-dwelling type is commonly referred to as boreal woodland caribou, and the forest-tundra migratory type is called coastal caribou in Manitoba (Manitoba Conservation 2005; Manitoba Conservation and Water Stewardship no date). Coastal caribou are not listed by the federal *Species at Risk Act* (SARA) or *The Endangered Species Act* of Manitoba (MESA). In western Canada, northern and mountain woodland caribou are found in addition to boreal woodland caribou (B.C. Ministry of Environment, Lands and Parks 2000; B.C. Ministry of Forests, Lands, and Mines 2010).

5.1.2.2 PROVINCIAL

Three varieties of caribou are identified in Manitoba: barren-ground, coastal woodland, and boreal woodland. Hummel and Ray (2008) indicate that barren-ground and coastal caribou populations are the migratory tundra ecotype whose appearance may vary by region. Barren-ground caribou are the *R. t. groenlandicus* subspecies and coastal and boreal woodland caribou are the *R. t. caribou* subspecies. Boreal woodland caribou populations in Manitoba are listed as threatened under SARA and MESA. These varieties of caribou are discussed in further detail in Section 5.1.2.3.

5.1.2.2.1 BARREN-GROUND CARIBOU

Barren-ground caribou from the Qamanirjuaq herd migrate from Nunavut in autumn to overwinter in Manitoba's northern forests. They return to the northern extent of their range to calve, forming large herds, and calve *en masse* (Kelsall 1968). They form large congregations during the fall breeding season before moving south for the winter (Thompson and Abraham 1994; Hummel and Ray 2008). A substantial decline in barren-ground caribou numbers began in the 1950s (FLCN 2010 Draft) and population was estimated at less than 50,000 individuals in the 1970s (Beverly and Qamanirjuaq Caribou Management Board 2002). However, hunters indicated that the population was not declining but was increasing; and it is believed that the herd was larger than surveys indicated (Beverly and Qamanirjuaq Caribou Management Board 2002). The discrepancy is thought to be due in part to changes in the herd's distribution (Beverly and Qamanirjuaq Caribou Management Board 2002). The population was estimated at 496,000 individuals in 1994 (Beverly and Qamanirjuaq Caribou Management Board 2002) and at 348,000 individuals in 2008, with an estimated overall decline of 2% annually (Campbell *et al.* 2010). Few were observed in Manitoba in 2011, and the herd may be in decline (Beverly and Qamanirjuaq Caribou Management Board 2011). Range use and movement patterns continue to be variable and unpredictable (Beverly and Qamanirjuaq Caribou Management Board 2002). Portions of large calving and winter ranges continue to be used each year, but the herd does not return to the same area annually (Beverly and Qamanirjuaq Caribou Management Board 2002). Movements and range use vary with weather, snowmelt, predator avoidance, and the availability of food (Beverly and Qamanirjuaq Caribou Management Board 2012). Although the herd may be shrinking and/or has been redistributed, recent reports indicate that Qamanirjuaq caribou are still plentiful (Beverly and Qamanirjuaq Caribou Management Board 2011).

5.1.2.2.2 COASTAL CARIBOU

Coastal caribou behaviour is similar to that of barren-ground caribou, particularly during calving and migration (Thomas and Gray 2002). Coastal caribou from the Cape Churchill and Pen Islands herds migrate from northern Manitoba and northern Ontario, respectively, into the Keeyask region in winter and leave the area in spring to calve.

Coastal caribou have occupied the southern Hudson Bay coast since the 1700s (Lister 1996; Abraham *et al.* 2012). These animals were observed migrating from the Hudson Bay coast to what is now known as York Factory and Fort Severn, and were rarely seen near the coast in winter (Lister 1996; Abraham and Thompson 1998). Surveys in the 1950s, 1960s, and 1980s confirmed that the group of caribou was absent from the coast in winter, and movement inland in winter was documented (Abraham and Thompson 1998). Large numbers of caribou were observed at the coast near the Manitoba-Ontario border in 1979 (Abraham and Thompson 1998). This group was documented in the area during the calving period when studies were conducted in the 1980s and 1990s and this group was named the Pen Islands herd (Thompson and Abraham 1994). Migratory caribou, possibly from the Pen Islands herd, were observed and harvested in the Shamattawa area in the 1980s. Hunters indicated the animals moved west toward Oxford House in the fall, returning to the coast in spring (Abraham and Thompson 1998). In the mid-1990s, the herd size was estimated at 10,800 individuals (Abraham and Thompson 1998; Abraham *et al.* 2012), and its range was documented in 1995 (Map 5-1, Map 5-2), and is currently thought to number approximately 16,600 animals (G. Racey *pers. comm.* 2012).

The Cape Churchill herd of coastal caribou is thought to have increased rapidly in size beginning in the 1960s (Gunn *et al.* 2011). The herd was estimated at 58 individuals in 1965 (Campbell 1994; Gunn *et al.* 2011), in the hundreds in the 1970s (Manitoba Hydro 2012), at a minimum of 2,300 individuals in 1979 (Abraham and Thompson 1998), 1,700 animals in the mid-1980s (Elliott 1986), and at least 3,013 in the mid-1990s (Gunn *et al.* 2011). The population was estimated to be from 1,800 to 2,200 individuals in 1998 (Campbell 1994; Gunn *et al.* 2011). Coastal caribou generally move from the coastal tundra in northern Manitoba to the taiga in early winter, then back again in late winter (Kearney and Thorleifson 1987). In the 1970s most of the herd remained in the vicinity of what is now the Churchill Wildlife Management Area and Wapusk National Park, with some moving farther west (Manitoba Hydro 2012). The Cape Churchill herd is estimated at 3,500 - 5,000 individuals (Hedman in Manitoba Hydro 2012).

5.1.2.2.3 BOREAL WOODLAND CARIBOU

High numbers or densities of boreal woodland caribou do not occur across the boreal landscape (Manitoba Hydro 2012, Environment Canada 2011). These caribou congregate in traditional wintering areas, disperse in spring, and are solitary during the calving and calf-rearing season likely as a strategy to avoid predators (Environment Canada 2011). Predator avoidance drives boreal woodland caribou to use islands in lakes and 'bog islands' for calving (Bergerud *et al.* 1990). Typically they inhabit large, unfragmented, mature coniferous dominated boreal forests characterized by low ecological diversity and predator densities (Bradshaw *et al.*, 1995; Stuart-*Smith et al.*, 1997; Rettie and Messier, 2000).

The most recent population estimate of boreal woodland caribou in Manitoba is 1,060 to 1,545 individuals on 10 identified ranges (Environment Canada 2012). A previous population estimate indicated that there were approximately 1,820 to 3,130 woodland caribou on the 10 identified ranges (Manitoba Conservation 2005). Population size and conservation concern vary by range; all populations in Manitoba appear stable (Environment Canada 2012).

Manitoba's boreal woodland caribou herds were also considered by Environment Canada (2012) based on the extent their ranges consist of disturbed and undisturbed habitat (Table 5-1). The portion of intact/undisturbed habitat in a boreal woodland caribou range is considered, based on Environment Canada (2012) models, to be attributable to the likelihood of population growth (lambda). If the quantity of disturbed habitat exceeds 35%, an identified "disturbance management threshold," has been surpassed. Levels of disturbance over 35% are not immediately attributable to a caribou population not being considered stable as population size and other demographic factors must also be taken into account.

Based on Table 5-1, the extent to which Manitoba woodland caribou ranges have been affected by anthropogenic development and quantities of burned habitat (*i.e.,* the portion of each range that has been affected by fires in the past 40 years) varies based on the caribou range being considered. Of note, those woodland caribou ranges which exceed the disturbance management threshold of 35% disturbed habitat also tend to have been affected by fires affecting a minimum of 20% of each particular range. Manitoba Conservation (2005) has indicated the importance of monitoring fire events as they occur in Manitoba woodland caribou ranges as part of habitat planning and management actions aimed at conserving this species. Comparable estimates of the quantity of disturbed and undisturbed habitat in the Caribou Local and Regional Study Areas are available in Appendix E.

Table 5-1: Habitat Condition for Manitoba Boreal Woodland Caribou Ranges based on Environment Canada Woodland Caribou Recovery Strategy (2012)

Range	Intact Habitat (%)	Total Disturbed Habitat (%)	Burned Habitat (%)	Anthropogenic Development (%)
The Bog	84	16	4	12
Kississing	49	51	39	13
Naosap	50	50	28	26
Reed	74	26	7	20
North Interlake	83	17	4	14
William Lake	69	31	24	10
Wabowden	72	28	10	19
Wapisu	76	24	10	14
Manitoba North	63	37	23	16
Manitoba South	83	17	4	13
Manitoba East	71	29	26	3
Atikaki-Berens	65	35	31	6
Owl-Flintstone	61	39	25	18

5.1.2.3 REGIONAL STUDY AREA

Three groupings of caribou are described for the Caribou Regional Study Area (Zone 6): barren-ground caribou (*Rangifer tarandus groenlandicus*); coastal caribou (*R.t. caribou*), which is a forest-tundra migratory woodland caribou ecotype; and summer resident caribou (summer residents), a type of woodland caribou whose exact range and herd association is uncertain.

5.1.2.3.1 BARREN-GROUND CARIBOU

Barren-ground caribou spend much of the summer in the tundra, beyond the tree line, and overwinter in the boreal forest (Kelsall 1968), where they select mature spruce stands with an abundance of lichens to consume (Rupp *et al.* 2006), as do all caribou in the Regional Study Area. Barren-ground caribou form large herds during the calving season and tend to calve *en masse*, forming nursery groups (Kelsall 1968). The rut is in late October, and occurs in Nunavut (Beverly and Qamanirjuaq Caribou Management Board 1999).

In the Keeyask region, barren-ground caribou migrate to the area north of the Nelson River (FLCN Evaluation Report Draft; Map 5-3). Barren-ground caribou from the Qamanirjuaq herd ranged as far south as Split Lake and as far east as the Hudson Bay railway track running between Ilford and Churchill (Miller and Robertson 1967; Split Lake Cree 1996a). Caribou migration began to diminish in the 1950s (Split Lake Cree 1996a). A substantial decline in barren-ground caribou numbers began in the 1950s, and after construction of the Kettle GS there were virtually none south of the Nelson River (FLCN Evaluation Report Draft). In the 1990s, there was a limited return of caribou (Split Lake Cree 1996a) while more recently, in the winter of 2004–2005, a large number of barren-ground caribou returned to the Keeyask region (FLCN Evaluation Report Draft). Current range data for the herd support this distributional extent, where the southeastern limit is now near Stephens Lake. The Nelson River generally serves as an extralimital boundary for Qamanirjuaq barren-ground caribou in the Keeyask region. About 10,000 Qamanirjuaq caribou have been estimated to reach the Regional Study Area, although this type of occurrence is infrequent.

5.1.2.3.2 COASTAL CARIBOU

Coastal caribou from the Pen Islands and Cape Churchill herds occur near or within the Regional Study Area in winter and leave in spring to calve near the Hudson Bay coast. The Pen Islands coastal caribou herd migrates from Ontario to the area south of the Nelson River (FLCN Evaluation Report Draft), through Shamattawa to the Atkinson Lake area (WLFN 2002), as far west as the Nelson River at York Landing and as far south as Oxford House. Animals from the Pen Islands herd were first reported in the Keeyask region in the 1990s (Thompson 1994; Thompson and Abraham 1994; Abraham and Thompson 1998; Abraham *et al.* 2012). Although larger migrations into the Regional Study Area were observed in the winters between 2001 and 2005, less than 300 animals believed to be Pen Islands caribou are typically observed in most winters. In the winter of 2011–2012, less than 30 caribou were observed during field studies. Based on surveys flown in 2013, in excess of 10 000 animals were estimated to have been in the Caribou Regional Study Area (LaPorte *et al.* 2013).

The rutting period of Pen Islands caribou is from mid-September to mid-October, when most of the herd is near the Hudson Bay coast (Abraham and Thompson 1998). A large migration of Cape

Churchill caribou near or into the Regional Study Area was observed in winter 2010 (Manitoba Hydro 2012); however, there are generally fewer than 50 animals in most winters.

Aerial surveys of known calving grounds for Pen Islands caribou along Manitoba's Hudson Bay coastline indicate that summer residency has declined in the province, and some animals may have moved inland (Abraham *et al.* 2012). Possible causes of the shift in distribution from the Hudson Bay coast in Manitoba east to Cape Henrietta Maria in Ontario include habitat change, disturbance, nutritional stress due to range deterioration, and increased mortality due to differences in hunting and predation pressure across the range (Abraham *et al.* 2012). Summer use of the Keeyask region is described below, including cases where Pen Islands caribou appeared to be calving in the Stephens Lake area.

The movement of Pen Islands caribou into the Caribou Regional Study Area has been demonstrated through the movements of radio-collared Pen Islands caribou commencing in 2010 (Manitoba Hydro 2012; Map 5-4). For these studies, 25 radio-collared female caribou had their movements tracked where instances of caribou calving were identified based on limited movement of these animals during the calving and rearing season. Based on this, some radio-collared female caribou were identified as potentially calving on islands in Stephens and Gull Lakes as well as peatland complexes in or near the Caribou Regional Study Area. Appendix 5C-1 indicates the overall movements of these radio-collared Pen Islands Caribou in the study zones in the Keeyask region, including the Caribou Local Study Area (Study Zone 4) and Regional Study Area (Study Zone 6). Caribou calving most frequently occurs in May or June. Recent data (2012) were added to Appendix 5C-1 as they became available.

Manitoba Hydro (2012) indicted the presence of "Gillam-area" Pen Islands caribou typified by having movements restricted to the Gillam area for all or part of the year. Based on the summer range of these caribou, eight of which were radio-collared which allowed the extent of individual animal movements to be evaluated, with an average range size of 4,426 km^2. The annual range of these caribou was 41,000 km^2 (Map 5-5, Map 5-6, Map 5-7, Map 5-8). Based on radio collaring of Pen Islands caribou it was indicated that the movements of these animals intersect that of the Caribou Local and Regional Study Areas used in assessing the Project. Data from 2010-2012 indicate that at least six animals were found in Zone 3, three used Zone 4, one used Zone 5 and one caribou used Zone 6 among years during the May to July calving period (Appendix C)

While the Nelson River generally serves as a physical boundary for both Pen Islands and Cape Churchill coastal caribou in the Keeyask region, river crossing locations have been reported in the Regional Study Area and on the lower Nelson River (FLCN 2010 Draft). Genetic studies indicated that coastal caribou genotypes were found north and south of the Nelson River between 2004-2006 (Ball and Wilson 2007).

Recent radio-collaring data (Map 5-9) indicate that most of the Cape Churchill coastal caribou activity is north of the Nelson River while Pen Islands coastal caribou activity is south of the river (Manitoba Conservation unpubl. data; Manitoba Hydro 2011b). Slightly more Pen Islands coastal caribou use habitat north of the Nelson River than Cape Churchill coastal caribou (Manitoba Conservation unpubl. data; Manitoba Hydro 2011b). Winter and summer core use areas of coastal caribou are depicted in (Map 5-10). In addition to barren-ground and coastal caribou, some KCNs

Members have identified a third variety of caribou common to the Keeyask region: woodland caribou, which are present year-round and can be distinguished from migratory caribou based on their appearance (FLCN Evaluation Report Draft; FLCN 2012 Draft; YFFN Evaluation Report (*Kipekiskwaywinan*)). This group of caribou has recently been described as migratory woodland caribou (Mammals Working Group 2012, January 24; FLCN 2012 Draft). The exact core range, long-term calving frequency, and herd association of the caribou that remain in the Keeyask region year-round cannot be clearly determined. This group could be coastal caribou, boreal woodland caribou, or a mixture of both, and are referred to as summer resident caribou.

5.1.2.3.3 BOREAL WOODLAND CARIBOU

The current range of boreal woodland caribou extends into the southwest corner of the Regional Study Area near Thompson, but threatened boreal woodland caribou are not recognized by Manitoba Conservation (Map 5-11) or Environment Canada (Map 5-12) as occurring in the Gull and Stephens lakes area (Manitoba Conservation 2005; Environment Canada 2012). The Nelson-Hayes boreal woodland caribou herd that once was indicated to have occurred within the Keeyask region was indicated to have blended with the coastal Pen Islands herd and no longer exist as a discrete population (Manitoba Conservation 2005a).

Although there is some uncertainty as to whether or not the SARA or MESA-listed boreal woodland caribou type is present in the Regional Study Area, calving behaviour, general morphology, and possibly genetic evidence suggests that the small subgroup of summer resident caribou are more similar to woodland caribou than to any other ecotype found in the region. However, recent data collected by Manitoba Conservation showed that eight radio-collared Pen Islands caribou cows occupied summer habitat in the Keeyask region over two years. At least one animal that remained in the Keeyask region for the summer migrated long distances into Ontario the following spring. (Manitoba Conservation unpubl. data; Manitoba Hydro 2012). Winter migration distances for several collared caribou were in the order of hundreds of kilometers, separating winter range from summer range, which is uncharacteristic of forest-dwelling boreal woodland caribou in Manitoba and elsewhere (Manitoba Conservation unpubl. data; Manitoba Hydro 2011b). During the winter, the summer residents most likely interact with migrating coastal caribou, which could make it difficult to differentiate among the mixed populations (Mammals Working Group 2012, January 24).

It is unclear whether summer residents are coastal caribou that periodically do not return to traditional calving areas in Ontario or northern Manitoba, boreal woodland caribou beyond their current recognized range, or a mixture of both. For the purposes of the assessment of potential effects of the Keeyask Project, the group of summer resident caribou was treated as an independent population that uses a smaller range than migratory groups and is more likely to use calving and rearing habitat that occurs in the Keeyask region. For the purposes of this habitat modelling exercise, the summer seasonal occurrences of this subgroup of animals and their respective habitats are treated most similarly to a boreal woodland caribou ecotype. Photo 5-1 depicts a summer resident cow and calf.

Photo 5-1: Summer Resident Caribou Cow and Calf in the Keeyask Region

5.1.2.4 LOCAL STUDY AREA

Until the Pen Islands and Cape Churchill radio-collaring studies, scientific data were not available at this level. Abundance and distribution were expected to be similar to the region.

5.1.3 FACTORS THAT INFLUENCE DISTRIBUTION AND ABUNDANCE

5.1.3.1 HABITAT

Habitat loss, alteration, and degradation have been identified as primary factors limiting or threatening caribou populations and may be caused by natural and anthropogenic factors (Thomas and Gray 2002; Environment Canada 2012). Important factors affecting caribou, including fire and clear-cutting, result in the disturbance of lichen, which caribou depend on as a food source (Fisher and Wilkinson 2005). Wildfires are a natural part of forest succession; however, their short-term effect on caribou can be detrimental if there is no suitable adjacent habitat (Klein 1982; Rupp *et al.* 2006). Clear-cutting also removes mature forests from the landscape, decreasing habitat for boreal woodland caribou. Hydroelectric development disturbs caribou habitat via flooding (Harrington

1996); linear features alter and reduce caribou habitat and can cause increased predation by gray wolves (Latham *et al.* 2011) and harvesting by hunters (Environment Canada 2011), as they facilitate travel.

Barren-ground caribou spend much of the summer in Nunavut, on the tundra beyond the tree line, and overwinter in the boreal forest (Kelsall 1968), where they select mature spruce stands with an abundance of lichens to consume (Rupp *et al.* 2006), as do all caribou in the Regional Study Area. While crossing snow-covered tundra in the spring, female barren-ground caribou feed on high points of land where snow depth is shallow (Beverly and Qamanirjuaq Caribou Management Board 1999). Calving tends to begin in hilly areas where a patch work of snow and open ground transform into meadows with new plant growth in late June (Beverly and Qamanirjuaq Caribou Management Board 1999). Post-calving, windy upland areas with minimal vegetation that provide respite from mosquitoes are occupied (Beverly and Qamanirjuaq Caribou Management Board 1999).

Coastal caribou occupy tundra habitats in the summer and forested habitats in the winter (Abraham and Thompson 1998, Kearney and Thorleifson 1987). During the peak in calving for the Pen Islands herd, the sexes segregate with females occupying coastal tundra areas and males occupying forest-tundra and forest areas to the south while both sexes aggregate in forest-tundra areas in the summer (Abraham and Thompson 1998). At this time of year, spruce-lichen ridges may be preferred (Abraham and Thompson 1998).

In central Manitoba, boreal woodland caribou occupy peatlands surrounded by upland forest communities and smaller peatlands in summer and winter (Brown *et al.* 2000). Winter range tends to be larger than summer range (Brown *et al.* 2000). In the Wabowden, Manitoba area, boreal woodland caribou occupied closed black spruce-dominated stands, often isolated in muskeg (Hirai 1998). During the spring calving season, female caribou select lowland black spruce-muskeg or muskeg-open bog habitat (Hirai 1998). Nearby water and open bogs provide important escape habitat during calving and post-calving periods (Brown *et al.* 2000).

Boreal woodland caribou select habitat for a variety of reasons, particularly food availability and predator avoidance (Rettie and Messier 2000). Fine-scale habitat selection is in areas with abundant lichen (Terry *et al.* 2000; Johnson *et al.* 2001; Thomas and Gray 2002; Mosnier *et al.* 2003). Coarse-scale habitat selection is in areas with preferred lichen species and heavy lichen loads (Darby and Pruitt 1984; Chubbs *et al.* 1993; Bradshaw *et al.* 1995). Boreal woodland caribou exhibit a clear preference for old-growth coniferous forest and wetland complexes (Thomas and Gray 2002). Additional considerations include the size and configuration of habitat patches (O'Brien *et al.* 2006) and the connectivity of habitat areas (Fall *et al.* 2007). The matrix, or area surrounding habitat patches, is also important for movement and for avoiding humans and predators while foraging (O'Brien *et al.* 2006).

The construction of linear features can result in range retraction and can increase predation rates by creating corridors for movement by wolves and other predator species (James and Stuart-Smith 2000; Dyer *et al.* 2001). Human development often creates disturbance habitat preferred by other species such as moose and deer (Thomas and Gray 2002). Vegetation types generally avoided by caribou include young coniferous stands and recent burns (Rettie and Messier 2000). Woodland caribou can co-exist with fire if suitable habitat is available in adjacent areas (Schaefer 1988; Schaefer and Pruitt

1991), as burned areas are avoided for 50 years or more following a fire (Schaefer and Pruitt 1991; Thomas and Gray 2002).

5.1.3.1.1 SEASONAL FORAGE AND WATER

Green forage such as horsetails, graminoids, and forbs are commonly consumed by caribou in spring (Rettie *et al.* 1997, Rettie and Messier 2000; Drucker *et al.* 2010). Summer and autumn forage consists of horsetails, graminoids, forbs, sedges, deciduous shrubs, and fungi (Rettie *et al.* 1997; Drucker *et al.* 2010). Beginning in autumn, the diet shifts to lichens, which are important foods in winter (Rettie *et al.* 1997; Proceviat *et al.* 2003).

Caribou are highly selective of winter habitat, preferring areas with abundant terrestrial lichens (Rettie and Messier 2000). Where snow pack is dense and deep, caribou may rely on arboreal rather than terrestrial lichens (Schaefer and Pruitt 1991; Johnson *et al.* 2001; Thomas and Gray 2002).The suitability and amount of winter habitat is often considered a limiting factor for caribou, and in the case of migratory types, the timing of migration to new areas. Winter habitat in the Keeyask region is in black spruce-, jack pine-, or tamarack-dominated peatland and is not divided into primary or secondary types. Habitat is selected at multiple spatial scales and based on its level of disturbance, as human-caused or natural alteration and fragmentation could attract moose, which in turn attract gray wolves, increasing the predation risk for caribou (Rettie and Messier 2000).

5.1.3.1.2 SECURITY

For caribou, security is associated with calving and rearing (see Section 5.1.3.1.5).

5.1.3.1.3 THERMAL COVER

References to winter thermal cover are sparse in the literature. Summer thermal cover is not referenced in the literature. Caribou are physiologically adapted to living in extremely harsh northern climates (Kendall 1968) and forested winter habitat selection appears to be based mainly on the availability of forage such as lichens (Thomas and Gray 2002; Sharma *et al.* 2009). However, extreme windchill factors will cause caribou to seek out forested areas for shelter (Kensall 1968).

5.1.3.1.4 BREEDING

The rut, or breeding period, occurs in fall for all types of caribou that can be found in the Keeyask region. Barren-ground caribou from the Qamanirjuaq herd rut in late October in Nunavut (Beverly and Qamanirjuaq Caribou Management Board 1999). Pen Islands coastal caribou rut from mid-September to mid-October, generally within 30 km of the Hudson Bay coast (Abraham and Thompson 1998). The Cape Churchill coastal caribou rut begins in late October, in the Northwest Territories (Campbell 1994).

Woodland caribou are polygamous; bulls defend harems of up to 15 cows (Banfield 1987; Campbell 1994). Breeding and pregnancy in females typically occurs at one or more years of age (Rettie and Messier 1998). The rut occurs from early October to early November (Banfield 1987), when days grow shorter (Ropstad 2000). Estrus in reproductive females can continue for an extended period

and pregnancy rates among animals are generally high (>90%; Bubenik *et al.* 1997, Stuart-Smith *et al.* 1997; Rettie and Messier 1998). Gestation lasts seven and a half to eight months (Banfield 1987).

Little is known about the rutting behaviour of summer resident caribou. Signs of the fall rut were limited during field studies. Potential indications included observations of bulls in pursuit of single cows in peatland complexes and a harem collected on a large island in Stephens Lake photographed by trail cameras. Rutting habitat usually consists of unobstructed areas, including open and semi-open bogs (Darby and Pruitt 1984), which are habitats similar to calving and rearing complexes in the Keeyask region. It is unlikely that caribou rut in the Local Study Area, which is composed mainly of secondary peatland complexes that are unsuitable for mating due to their relatively small size.

5.1.3.1.5 CALVING AND REARING

Fidelity to calving sites varies among herds. Barren-ground caribou exhibit strong fidelity to the same general area year after year, rather than to a specific site (Gunn *et al.* 2007; Gunn *et al.* 2012). Pen Islands coastal caribou have well-defined calving areas (Abraham and Thompson 1998); however, a recent study suggests a shift in the distribution of animals during the calving season in the last decade, with the possible abandonment of former coastal calving areas (Abraham *et al.* 2012). Shifts in calving areas have also been reported for barren-ground caribou (Beverley and Qamanirjuaq Caribou Resource Management Board 2012). In central Manitoba, Brown *et al.* (2000) report that female woodland caribou revisited calving sites annually. No calving site fidelity was detected in Saskatchewan; possibly due to an abundance of suitable sites (Rettie and Messier 2001). Cows in the Wabowden, Manitoba area exhibited range overlap from one year to the next, but did not choose the same specific calving areas (Hirai 1998).

Calving occurs from mid-May to early July (Banfield 1987) and calving areas are selected largely based on forage availability (Lantin *et al.* 2003) and predator avoidance (Bergerud *et al.* 1990). The availability of forage species allows for the replacement of energy and nutrients lost through lactation (Post *et al.* 2003).

Caribou cows incorporate a number of strategies to increase calf survival. Barren-ground caribou calve in large groups (Kelsall 1968; Gunn *et al.* 2012) and pregnant cows migrate to the calving grounds ahead of non-pregnant cows and bulls to reduce predation by wolves (Beverly and Qamanirjuaq Caribou Management Board 2011). Coastal caribou demonstrate similar behaviour (Thomas and Gray 2002). In contrast, boreal woodland caribou disperse when calving in order to decrease the risk of predation (Rettie and Messier 2001; Schaefer 2008). Their preference for islands in lakes or peatlands and avoidance of moose habitat also reduces the likelihood of predation by wolves (Rettie and Messier 2000). Summer resident caribou in the Keeyask area calve in isolated island habitat, which is characteristic of boreal woodland caribou in Manitoba and elsewhere (Shoesmith and Storey 1977; Hirai 1998; Rettie and Messier 2000).

5.1.3.2 DISPERSAL AND MIGRATION

Caribou herds have particular migration patterns, but do not necessarily follow the same route each year (Miller 2003). The use of multiple migration routes, rather than a single route, is common in ungulates such as caribou (Sawyer *et al.* 2009). The route between summer and winter ranges depends

mainly on the availability of forage, which is affected by ice conditions and snow cover (Miller 2003). Because caribou are gregarious (Miller 2003), young do not disperse to establish independent home ranges.

The Beverly and Qamanirjuaq Caribou Management Board (1999) described the range and migration seasons of Qamanirjuaq barren-ground caribou. These animals spend the winter in the forests of northern Manitoba and some may range into Saskatchewan, the western Northwest Territories, and along the coast of Hudson Bay. The spring migration begins in mid-March, with pregnant females and yearlings departing for calving grounds first, followed by males and non-pregnant females. Traditional calving grounds are in Nunavut, south of Baker Lake and east of Rankin Inlet, overlapping Banks Lake and Kaminuriak Lake. Southward migration begins in late July, and caribou generally reach the forest by November or December (Beverly and Qamanirjuaq Caribou Management Board 1999). In late December and early January 2010, the Qamanirjuaq herd was observed as far south as the Limestone Lake area, however most of the herd was seen just south of the Churchill River. In December 2004 and January 2005, barren-ground caribou were observed crossing Provincial Road (PR) 280 between the north arm of Stephens Lake and the PR 290 junction, some of which also crossed the Nelson River. Presently, barren-ground caribou are rarely observed that far south.

Coastal caribou from the Pen Islands and Cape Churchill herds migrate from northern Ontario and northern Manitoba, respectively, into parts of the Regional Study Area in winter and leave the area in spring to calve. The Pen Islands coastal caribou herd migrates from the Hudson Bay coast in Ontario to the forests of northeastern Manitoba and northwestern Manitoba (Magoun *et al.* 2005). In spring, females calve near the Hudson Bay coast (Abraham *et al.* 2012) then aggregate with other sex and age classes in June and July (Abraham and Thompson 1998). In September they begin a southward migration, not on a narrow migration route but over a large area (Abraham and Thompson 1998). Different routes are used each year (Abraham and Thompson 1998). Based on aerial reconnaissance surveys between 2003 and 2008, Pen Islands caribou appear to move west into the Regional Study Area in late December and early January, with the greatest number of caribou occurring in late January and early February. By March, Pen Islands caribou move east of the Regional Study Area and make their way back into Ontario.

There is little documentation of the migratory patterns of Cape Churchill coastal caribou. The herd generally occupies the coastal Hudson Bay area of Manitoba spring and summer (Kearney and Thorleifson 1987), and its southward migration is generally bounded by the CN rail line to the west and the Nelson River to the south (Campbell 1994).

Recent data (2010-2011) showed that a few radio-collared Pen Islands caribou cows occupied summer habitat in the Keeyask region over two years. At least one animal occupied summer habitat in the Keeyask region, but migrated long distances into Ontario the following spring (Manitoba Conservation unpubl. data; Manitoba Hydro 2011). Winter migration distances for several collared caribou were in the order of hundreds of kilometres, separating winter range from summer range.

5.1.3.3 FACTORS THAT REDUCE EFFECTIVE HABITAT

Disturbance from human activities can reduce effective habitat for caribou without reducing the amount of physical habitat available. Sensory disturbance from construction, aircraft, and the use of recreational vehicles, for example, can cause habitat avoidance or temporary abandonment and can interrupt foraging (*e.g.*, Luick *et al.* 1996; Frid and Dill 2002; Thomas and Gray 2002). While caribou can be found near infrastructure such as roads, studies indicate that use of the area within 5 km of developments declines between 50 and 90% (Vistnes and Nellemann 2008) and decreases within 4 km of mining activities (Weir *et al.* 2007). While sensory disturbance from human activity is generally associated with noise, lights and vibrations may also reduce effective habitat for caribou. Little information specific to these types of disturbance is available.

5.1.3.4 MORTALITY

5.1.3.4.1 PREDATION

While golden eagle, lynx, wolverine, and bears are all predators of caribou, particularly calves (Banfield 1987), gray wolves are major predators of adult caribou (Klein 1991; Latham *et al.* 2011). Bergerud and Ballard (1988) concluded that predation of caribou calves was the most consistent natural limiting factor in the dynamics of the Nelchina herd in Alaska from 1950 to 1984. Caribou, particularly calves, are easier for wolves to kill than other ungulates, especially in deep snow (Miller *et al.* 1985; Kuzyk 2002). It should be noted however, that little is known about the relative contribution of other predators to caribou mortality, especially in Manitoba

The areas in which wolves hunt can be influenced by human activities (James and Stuart-Smith 2000; Kuzyk 2002; Latham *et al.* 2011). Predation risk and mortality increases near linear corridors such as roads and seismic lines, particularly in summer (James and Stuart-Smith 2000; Latham *et al.* 2011; Whittington *et al.* 2011). Consequently, caribou tend to avoid such corridors (Dyer *et al.* 2001; Latham *et al.* 2011), reducing the amount of effective habitat available (Latham *et al.* 2011). Linear corridors and openings created by disturbances such as clear-cutting may also attract alternative prey such as moose (Rettie and Messier 2000; Kuzyk 2002). Habitat alteration can increase predation on caribou by creating habitat for moose, whose increased population can support a higher density of gray wolves (Cumming 1992; Rettie and Messier 2000).

Wolves that are permanent residents in the Split Lake Resource Management Area (SLRMA) prey primarily on moose. Summer resident caribou are relatively rare, and migratory caribou, while abundant in some areas, are not a sufficiently reliable year-round food source to allow resident packs to establish and defend adequately productive hunting territories around them. Based on the SLRMA Ungulate Biomass Index, this area can support 60 wolves. For the entire SLRMA, that is a density of 1.4 wolves per 1,000 km^2, which is low compared to elsewhere in North America. It is estimated further that an additional 50 wolves (16 packs) move into the area in winter with migratory caribou herds.

The average number of wolves in a pack when deer and/or moose are the main prey is 6, therefore the SLRMA would be expected to have around 10 packs of resident wolves. These packs would not

be distributed uniformly or randomly around the RMA. Wolves cannot persist in areas where the density of moose is below 3 per 100 km^2, and almost 40% of the SLRMA has a moose density of 2 per 100 km^2. The packs would occupy territories centered on areas of higher moose density. Given the arrangement of areas of high moose densities observed during 2010 aerial surveys, the territories of the 10 resident packs would be primarily in the southern and western portions of the SLRMA, and would probably each have a core area of approximately 2,000 km^2. This expectation has been confirmed by maps of wolf pack locations provided by local First Nations residents. These areas with wolf densities are expected to change over time along with the distribution of high moose clustered.

5.1.3.4.2 HUNTING

Hunting of caribou is permitted in Manitoba by First Nations, Métis, and licensed hunters. However, no hunters may harvest boreal woodland caribou. Hunting is thought to be a significant source of female caribou mortality, and illegal hunting is a concern in some areas for boreal woodland caribou (Environment Canada 2012).

For barren-ground caribou and coastal caribou, Manitoba Conservation has established a licensed caribou hunt in Game Hunting Areas 1, 2, 3, in the extreme north of the province, where a limited number of licenses are available annually for the fall and winter hunting seasons (Manitoba Conservation and Water Stewardship 2012). In northern Manitoba, the majority of license sales are associated with barren-ground caribou. License sales for Pen Islands caribou are currently limited to only 75 tags with an estimated success rate of about 50%.

First Nations hunters are not restricted to hunting seasons or bags limits, but may hunt for subsistence only. While hunting is an important source of mortality for caribou (Thomas and Gray 2002; Environment Canada 2012), caribou are harvested to a lesser extent than moose by KCNs Members in the Regional Study Area (Keeyask Hydropower Limited Partnership 2012). Domestic harvest coincides with the movements of migratory caribou into northeastern Manitoba from Ontario, mainly during late fall and winter (Abraham and Thompson 1998). The proportion of the Pen Islands Caribou Herd collectively harvested by Shamattawa, Gods Lake and Fort Severn was estimated at approximately 2-5% of the 1987 summer population count. In 1991-92 caribou migrated further southwest and reached beyond Gillam resulting in an exceptional harvest estimated to be 650 from northeastern Manitoba (C. Elliott, pers. comm.). An estimate harvest of 234 in Ft. Severn that year yielded a total harvest of 884 (or 11.9% of the herd based on the 1987 population) (Thompson and Abraham 1994). In 2010, the harvest of 100 Cape Churchill animals was recorded, much of which occurred in proximity to the Conawapa Access Road (Hedman in Manitoba Hydro 2012).

5.1.3.4.3 ACCIDENTAL MORTALITY

Accidental mortality includes occasional collisions with vehicles on roads, trains, drowning when crossing water and other factors (Thomas and Gray 2002). Drowning is a common hazard during annual migrations (Banfield 1954; Miler and Gunn 1986; Ruttan 2012), as caribou regularly cross frozen rivers and lakes. Observations of barren-ground caribou sniffing the edge of thin ice and returning into the forest after attempting to cross thin ice on lakes in the Northwest Territories, and the tendency of caribou to detour around individuals that have broken through the ice (Miller and Gunn 1986), indicate that caribou can react to dangerous ice conditions and will seek out safer

routes. Furthermore, historical caribou drownings have been identified in the FLCN Evaluation Report (FLCN 2012). Collisions with vehicles are not a significant threat to caribou populations (Environment Canada 2012). Occurrences of intra-specific competition between males during the breeding season can also be source of mortality or a factor leading to increased mortality rates due to biased sex ratios in caribou populations (Stuart-Smith *et al.* 1997).

5.1.3.5 OTHER FACTORS THAT INFLUENCE SURVIVAL AND HABITAT USE

5.1.3.5.1 DISEASES AND PARASITES

Disease is generally not a significant factor in caribou mortality (Klein 1991; Environment Canada 2012). *Trypanosoma* species, previously known to infect many vertebrate species (Lefebvre *et al.* 1997), were detected in caribou in 1975 (Kingston *et al.* 1982). These single-celled organisms are not known to cause a pathogenic response in caribou (Kingston *et al.* 1982).

Parelaphostrongylus tenuis, a meningeal brainworm that is harmless to white-tailed deer that transmit it, is fatal to caribou (Trainer 1973; Cumming 1992). Larvae from deer droppings infect terrestrial gastropods found on forage plants. The gastropods are ingested when forage plants are consumed by caribou and other cervids, infecting the host (Anderson 1972).

Insect harassment can affect the physical condition of caribou by decreasing the amount of time spent feeding (Russell and Nixon 1990). Avoidance of warble flies (*Hypoderma tarandi*) and nose bot flies (*Cephenemyia trompe*) can significantly decrease foraging time and increase the amount of energy expended running (Vors and Boyce 2009). The severity of insect harassment is related to the weather (Thomas and Gray 2002), with warmer temperatures generally increasing the abundance of insects (Vors and Boyce 2009).

5.1.3.5.2 MALNUTRITION

Malnutrition is linked to the availability of forage and the ability to forage. Habitat alteration and degradation, snow depth, and insect harassment all affect the availability of foods such as lichens (Thomas and Gray 2002). Feeding time decreases with increased insect harassment (Russell and Nixon 1990; Thomas and Gray 2002; Vors and Boyce 2009). Malnutrition can result in decreased body condition, reduced calf production, and in extreme cases, mortality (Klein 1991).

5.1.3.5.3 SEVERE WEATHER

Adverse weather can affect caribou reproduction and survival (Thomas and Gray 2002; Vors and Boyce 2009). Severe storms can result in caribou mortality, particularly of calves (Dau 2005). Severe weather events are expected to increase with climate change, resulting in small, indirect effects on caribou, such as a decline in pregnancy rates, reduced calf survival, increased risk of predation by wolves (Environment Canada 2012), and changes in the composition of forage species (Vors and Boyce 2009). The earlier emergence and increased abundance of harassing insects associated with increased temperatures could lead to decreased body condition (Vors and Boyce 2009).

5.1.3.5.4 SNOW DEPTH

Snow depth plays an important role in the ability of caribou to forage, as deep snow limits access to terrestrial lichens (Vors and Boyce 2009). Compaction of snow due to high winds may have more of an effect on the accessibility of terrestrial vegetation (Dau 2005). Snow depth has an important influence on movements (Miller 2003). Movement rates are negatively correlated with snow depth (Stuart-Smith *et al.* 1997), and boreal woodland caribou select areas with less snow to facilitate movement and to access forage (Johnson *et al.* 2001; Sharma *et al.* 2009).

5.1.3.6 HOME RANGE SIZE

Home range size and the extent of movements within home ranges vary among types of caribou. Barren-ground caribou from the Qamanirjuaq herd migrate more than 1,000 km from Nunavut to Manitoba (Wakelyn 1999) and Beverly-Qamanirjuaq range covers approximately 700,000 km² (Klein *et al.* 1999). While boreal woodland caribou are not long-distance migrants, their range use shifts seasonally for predator avoidance and location of forage (Ferguson and Elkie 2004b). The distance between boreal woodland caribou winter and summer ranges can exceed 20 km (Ferguson and Elkie 2004a). Females in particular occupy relatively small ranges in summer (Stuart-Smith 1997; Rettie and Messier 2001), which is also a predator avoidance strategy (Rettie and Messier 2001; Ferguson and Elkie 2004b). During calving season, a marked decline in home-range use occurs; collared cows from the Smoothstone-Wappeweka herd in Saskatchewan used, on average, 0.16 km² (Dyke 2008). In some cases, there is little overlap between boreal woodland caribou summer and winter range areas (Ferguson and Elkie 2004b) but not on all ranges (Stuart-Smith *et al.* 1997; Dyke 2008), where habitat availability and landscape composition could be considered limiting factors in animal dispersal.

Caribou range in Manitoba also varies with the type of caribou. The Qamanirjuaq barren-ground caribou herd typically winters northwest of the Regional Study Area. Pen Islands coastal caribou occupy the northeastern portion of the province in winter, from the Nelson River estuary at Hudson Bay and west to the communities of Bird and Gillam, and occasionally as far as Ilford and York Landing. Cape Churchill coastal caribou generally occur north of Bird in winter.

While studying boreal woodland caribou in central Manitoba, Brown *et al.* (2000) calculated an overall population range of 4,600 km², and an average individual home range of 581 ± 74 km². Seasonal ranges varied in size, with an autumn and winter range of 3,200 km², summer range of 2,500 km², and spring range of 1,770 km² (Brown *et al.* 2000). For caribou in the Kississing-Naosap range in Manitoba, home ranges were somewhat similar where, for collared females, a range of 555 km² was calculated (Dyke 2008). Berger *et al.* (2000) calculated the Owl Lake home range size of collared females to be in the order of 1,150 km². Brown *et al.* (2000) indicated the movements of collared females in summer were limited to a 83 km² area that was used over multiple years, and these ranges frequently overlapped with those of other (presumably calving) females. In winter, boreal woodland caribou are somewhat more gregarious than during the calving and rearing season (Cumming and Beange 1987; Brown *et al.* 2000).

Recent radio-collaring efforts from 2010-2011 indicate that Pen Islands caribou (Gillam-area summer residents) summer range occupies approximately 4,426 km² (Manitoba Hydro 2012). Furthermore, the summer range of Pen Islands caribou in the Gillam area was significantly greater than annual

ranges of the Wabowden, Wimapedi-Wapisu, and Harding Lake boreal woodland caribou herds (Manitoba Hydro 2012).

5.1.3.7 FRAGMENTATION AND CUMULATIVE EFFECTS

The fragmentation of caribou habitat through the alteration or development of existing habitat plays an important role in reducing overall habitat effectiveness beyond the loss of habitat alone. Because of this, fragmentation is often considered as a measure of cumulative landscape-level effects. The most common example of fragmentation is based on the effects of anthropogenic linear features including the construction of roads, pipelines, etc.., but can also be associated with the linear clearing of tracts of habitat, usually forests, in the creation of trails, seismic lines, and other linear features. Most importantly, caribou have evolved to live on a landscape with high levels of natural disturbance, which is driven by the fire cycle. This coupled with the need to separate themselves from predators requires that caribou populations have very large tracts of undisturbed habitat. Habitat disturbance and fragmentation considers the effects of fire in addition to human features.

As a species, caribou are niche specialists that use habitat areas not readily used by other large mammal species. This allows for the separation of caribou from predator species as well as other ungulate species that may in turn attract predators (Cumming *et al.* 1996), contributing to mortality from predation and hunting access, and reducing core area size (Dyer *et al.* 2002). In addition, for caribou, fragmentation can be associated with sensory disturbances caused by machinery, people, smells, sounds, etc., which serves to limit their movements to otherwise valuable habitat areas.

While there is some resilience in the ability of caribou to adapt to fragmentation, based on access to alternate habitat areas, caribou are prone to landscape-level effects. The extent to which caribou are affected through landscape fragmentation varies based on a variety of factors, namely their behavioural patterns that constitute the consideration of caribou as belonging to alternate groupings. Sedentary forest-dwelling woodland caribou are particularly susceptible to cumulative landscape-level effects based on reduced range movements and distribution, in many ways matching that of the Canadian boreal forest, which has undergone a substantial transformation based on ongoing anthropogenic activities (Cumming *et al.* 1996, McLoughlin *et al.* 2003).

While the loss of habitat, either directly or indirectly, is of concern in conserving non-migratory forest-dwelling woodland caribou, predation of caribou by wolves and bears is considered a key limiting factor (Wittmer *et al.* 2005). Increased predation of caribou can be associated with fragmentation effects through the creation of linear corridors accessed by wolves which increase their hunting efficacy relative to an undisturbed landscape (James and Stuart-Smith 2000; Dyer *et al.* 2001). Fragmentation occurring through anthropogenic development has also been identified as creating isolated caribou sub-populations which, due to lower population sizes, have a reduced likelihood of population persistence (Wittmer *et al.* 2007).

Loss of habitat effectiveness for migratory caribou based on fragmentation effects has also been recorded for barren-ground caribou. Nellemann and Cameron (1998) identified reduced habitat use as occurring in proximity to areas with high road densities within an existing oil-field complex. This was most apparent for adult female caribou and caribou calves, indicating the relative sensitivity of caribou during the spring-summer calving and rearing season. Other factors attributed to

development included heightened competition for forage, increased risk of predation and lower productivity of the herd (Nellemann and Cameron 1998). Boulanger *et al.* (2012) indicated the avoidance of migratory barren-ground caribou by 11-14 km from a diamond mine in the Canadian Arctic, demonstrating reduced caribou movements within a former habitat range.

5.1.3.8 MOST INFLUENTIAL FACTORS

Caribou require large tracts of undisturbed landscapes to maintain populations. The factors that have the greatest influence on caribou population size and habitat relationships vary by region and occur at different spatial scales within a region. Overall, the spatial arrangement of disturbances (*i.e.*, especially fire), the number of alternate prey (*e.g.*, moose, deer), and the density and types predators, affect the degree to which recruitment and adult mortality (*i.e.*, especially cows) contribute to the long-term viability of a caribou population. Current disturbance across radio-collared Pen Islands summer resident caribou summer range are depicted inMap 5-13, Map 5-14, and Map 5-15).

All caribou require secure habitat for maintaining separation from predators such as wolves, and especially during the calving and calf-rearing periods. These natural factors, in combination with the degree of other influential factors (*i.e.*, human disturbance) are thought to determine the size of caribou populations. If cumulative factors result in sufficient habitat deficiencies at the landscape-level, reduced fecundity and increased mortality can lead to declines.

Table 5-2 summarizes caribou life requisites, and ranks these factors in order of importance based on literature and expert opinion.

Figure 5-1 identifies all pathways considered, which link the potential effects of the Keeyask Project to the caribou populations occurring in the region. This linkage diagram includes all potential pathways regardless of their likelihood of occurrence. The relative degree of influence among connections along these pathways is then weighted relative to each other as these apply to the Keeyask Project.

Figure 5-2 demonstrates only the most influential factors for the caribou populations in the Keeyask region as a simplified pathway diagram. The final selection includes fire, habitat fragmentation and intactness, predation, and calving and rearing habitat quality. Habitat quality may be limited by the availability of food, and it is largely influenced by fire. These are the factors thought to influence caribou population size the most at Keeyask.

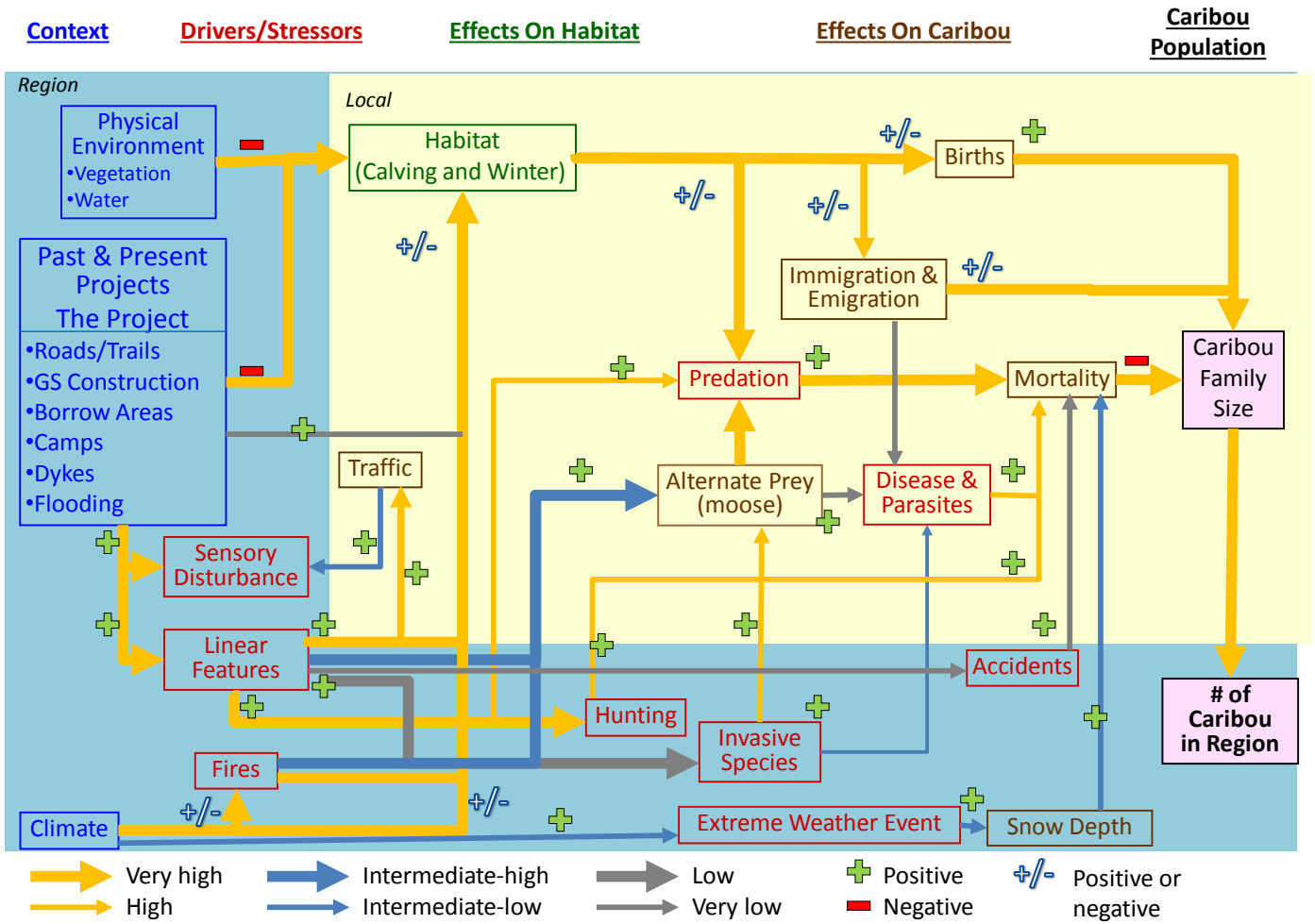


Figure 5-1: Linkage Diagram of All the Potential Effects of the Keeyask Generating Project on the Caribou Population

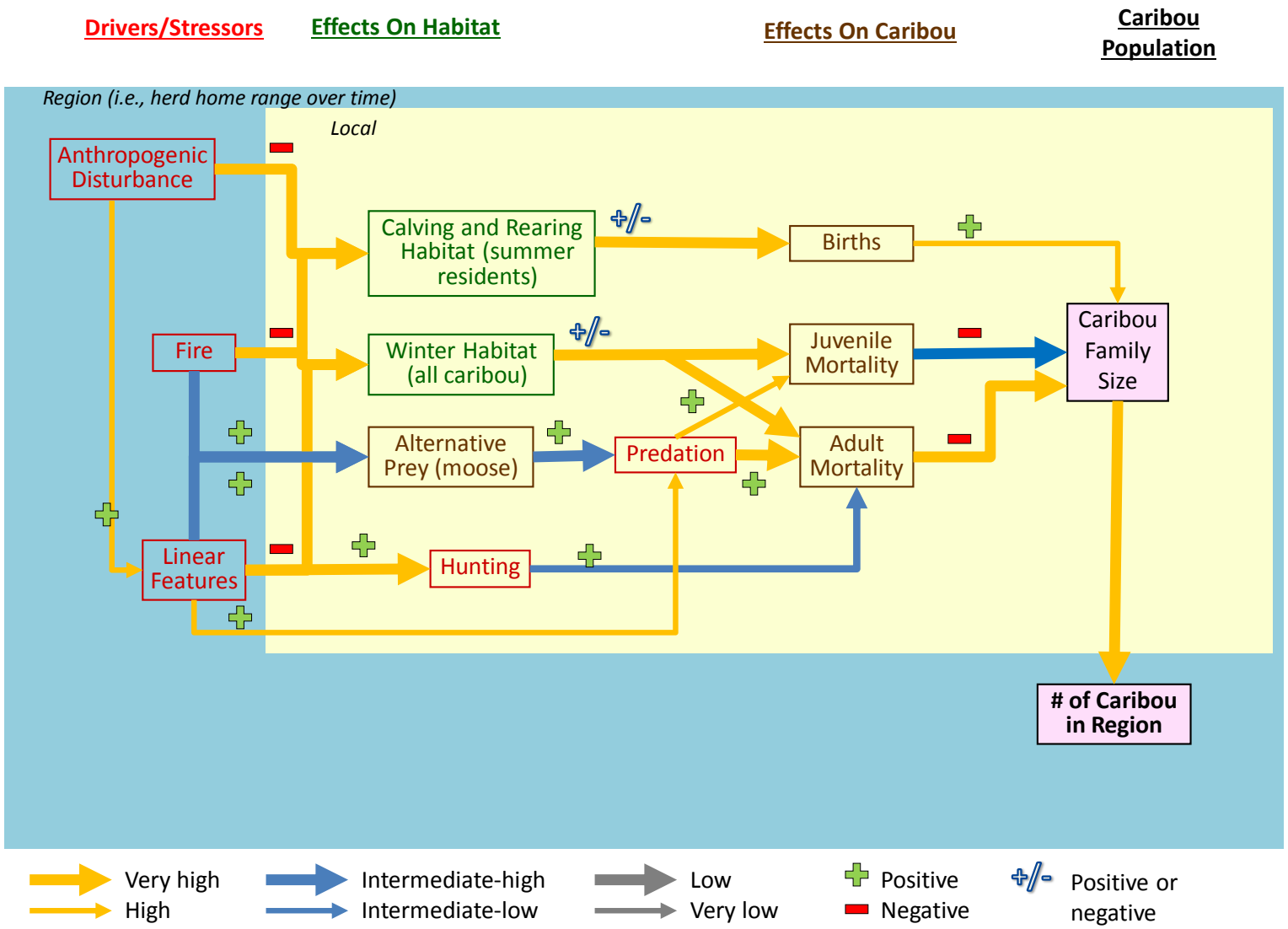


Figure 5-2: Most Influential Factors Linkage Diagram for Caribou in the Keeyask Region

Table 5-2: Caribou Life Requisites and Factors That Can Substantially Influence Survival, Reproduction, and Habitat Use

Requisite/Factor	Rank	Period	Preference	Location	Context	Area	Canada/North America	Manitoba
Habitat - Winter	1	Winter	Mature conifer forest[9] Strong avoidance or burned areas[9]	Winter range	Mature forest provides cover and forage such as lichens[9]	Landscape	Stands 151-250 years after fire used more than other age classes[20]	Jack pine communities; habitat selection may be influenced by snow depth[20]
Summer	1	Mid-May to early July[1]	Females tend to disperse to avoid predators[2] String bogs and large muskegs[7,12]	Summer range	Rarely more than one calf produced per cow in a season[3,4] Caribou spread out over large tracts of undisturbed forest to reduce predation[7]	Isolated islands or peatland complexes Mosaic to landscape	Isolated areas used for calving[22]	Large peatland systems[21]
Food - Winter	1	Winter	Lichens, horsetails and sedges, willow and birch twigs[1]	Winter range	As snow depth increases, arboreal lichens may be selected due to ease of access[5,9] Fire substantially reduces winter food. Produces moose habitat and associated predators	Site to patch	Lichens are important forage for caribou in winter[18]	Arboreal lichens important in winter[23]
Summer	4	Summer	Lichens, mushrooms, grasses, sedges, forbs, leaves of willow and birch, berries[1]	Summer range	High-quality forage consumed in summer is required for survival, growth, and reproduction[9]	Site to patch	Ericaceans and terrestrial lichens[24]	Bog shrubs, graminoids, horsetails[21]
Predators and avoidance	1	Summer higher than winter	Wolves, bears, wolverines, lynx, golden eagles[1,9]	Home range	Predation of adult female caribou drives lambda and subsequently population stability. Prey on the young[1] Thought to be the most important source of caribou mortality[11,13,15]	Mosaic to landscape	Gray wolf predation limits many North American caribou populations[13], particularly when wolf densities are high[26]	Black bears prey on calves[21] Caribou important summer prey for gray wolves in northern Manitoba[25]
Relationship with other ungulates	3	Yearly	Separation from moose and predator association Avoid sources of competition	Home range	Mature forest provides cover and forage such as lichens in winter. Avoids younger successional stages of plant growth	Mosaic to landscape	Wolf selection for areas used by white-tailed deer maintain strong spatial separation between wolves and caribou[27]	Select peatland systems to space away from alternate prey[21]
Other mortality sources – Disease/Parasites	5	Summer – Warble flies, nasal bot flies[2]	Flies harass caribou, which can interfere with feeding; they lay eggs on caribou legs and lower body, or in the nose and throat[10]	Larvae found under skin and in nasal passages of caribou[10]	Wounds caused by burrowing larvae can become infected[9]	Summer range	Less common in caribou in the high arctic[6] Unknown distribution	
		Yearly - Brain worm[2]	Caused by a parasitic nematode that invades the	Acquired by the consumption of snails and slugs	Transferred to caribou by deer; fatal in caribou[2]	Overlap with white-tailed deer rang	Wide distribution in eastern and central North America[16]	

Table 5-2: Caribou Life Requisites and Factors That Can Substantially Influence Survival, Reproduction, and Habitat Use

Requisite/Factor	Rank	Period	Preference	Location	Context	Area	Canada/North America	Manitoba
			central nervous system[16]	on browsed vegetation[16]				
Hunting	4	Fall and winter		Home range	Limited number of licenses available for resident and non-resident hunters; First Nations persons may hunt for subsistence and are not restricted to hunting seasons[8]	Home range	Most provinces and territories with caribou populations have a caribou season, with the exception of Alberta, where hunting of caribou is prohibited, and Ontario, where no season is listed	Game Hunting Areas 1, 2, and 3. An average of 538 licenses per year issued from 1999 to 2002 for barren-ground caribou; 75 tags available for Pen Islands caribou
Accidents	6	Year round	Includes collisions with vehicles on roads[2], drowning when crossing large bodies of water	Home range	Vehicular collisions do not appear to have more effect on caribou mortality than disease and parasites[2] Drowning do not contribute substantially to overall mortality[9]	Home range	Eight caribou killed by collisions with vehicles from 1984 to 2010 in a study of mountain caribou in British Columbia[29]	Three or four areas on PTH 60 near The Pas identified as locations for caribou-vehicle collisions; most people interviewed for Environment Canada's Aboriginal Traditional Knowledge Report on boreal caribou had not heard of such incidents[28]
Mating	5	Early October to early November[1]		Rutting often occurs in bogs or fens[2]	A single male accumulates and defends a harem of up to 15 females[1]	Fall range	Near coastal areas Bogs	
Invasive Species	5	Year round		Areas affected through anthropogenic development or climate change	The movement of potential alternate prey species such as white-tailed deer in to areas used by caribou	Home range		
Climate	3	Varies seasonally	Wet areas and shade in summer for cooling thermoregulation Dense coniferous forest near tall shrub in winter[37]	Deep snow is the main contributing factor; >70 cm can impede movement[7]	Deep snow increases energy requirements, restricts range, can result in inability to reach forage[32]	Home range	Highly variable across continent	

5.2 METHODS

Caribou habitat models, including a winter habitat model and calving/rearing habitat model were developed through the following steps:

1. Summarize caribou-habitat relationships from relevant literature, existing information for the Regional Study Area and professional judgment (Figure 5-2, Table 5-3). Producing the summary was an iterative process in which preliminary generalizations were progressively refined as studies were conducted in the Regional Study Area;
2. Verify the relationships for the Regional Study Area by conducting field studies within it. Habitat-based mammal sign surveys, trail camera surveys, and aerial surveys were used to perform different analyses for verification, including: comparison of reservoir, proxy, and off-system riparian areas and use of calving/rearing islands;
3. Use available information and professional judgment to assign each mapped habitat type (ECOSTEM 2011) into either primary, secondary or non-habitat for caribou; and recalculate habitat intactness using exact methods as possible outlined by Environment Canada (2012);
4. Use data and other information from the Regional Study Area to verify and refine the predicted categorization of mapped habitat types into primary, secondary, and non-habitat for caribou.

The resulting caribou habitat quality models were used to quantify the total amount of caribou winter and calving and rearing habitat in the Regional Study Area and produce an effects assessment on habitat lost as a result of the Project.

5.2.1 STUDY AREAS

The Local and Regional Study Areas for caribou were Study Zones 4 and 6, respectively, in in Map 2-1. The area that addressed intactness for a hypothetical boreal woodland caribou population was Study Zone 5.

5.2.2 INFORMATION SOURCES

5.2.2.1 EXISTING INFORMATION FOR THE STUDY AREA

Section 5.2 4.2 summarized the literature regarding the key drivers and pathways for caribou habitat.

Existing information for caribou in the study area includes Aboriginal traditional knowledge, reports from Environment Canada and Manitoba Conservation and Water Stewardship, and general information from published literature (see Section 5.1). Bipole III radio-collaring data (2010-2011) were used to provide context, but were not incorporated into the model. Information sources for habitat in the study area include the ECOSTEM habitat dataset, which also includes fire history.

There was no existing information on reservoir-related effects on caribou from studies conducted in the Regional Study Area when Project studies commenced.

5.2.2.2 DATA COLLECTION

Data collection for the interpretation of caribou habitat use was done differently for calving and rearing habitat areas than for winter habitat areas. Habitat use for calving and rearing was based on data from summer field studies using tracking and trail camera studies from 2003, 2005, 2010 and 2011, data from studies examining the use of islands in Stephens Lake in 2009 and 2011, and data from studies examining the use of peatland complexes in the Local and Regional Study Areas.

Field studies informing the construction and validation of the caribou habitat quality model included:

- Mammal sign surveys 2001-2004
- Winter aerial surveys 2009-2010, 2012
- Mammal sign surveys and trail camera studies 2010-2012

Coarse habitat classifications were used to assess habitat use by caribou based on mammal tracking studies completed 2001-2004. Tracking transects involved the laying of thread over sampling areas identified as coarse or rare habitat mosaics (Table 5-3). For mammal sign surveys, mammal signs were recorded along the length of each transect and included scat, tracks, trails, browse and feeding sites, and beds.

Table 5-3: Habitat Codes Used in the Sampling of Mammal Tracking Transects in the Keeyask Local Study Area 2001–2004

Habitat Code	Coarse Habitat Type or Habitat Mosaic	Rarity	Coarse Habitat Types Included
H01	Black spruce treed on uplands	Common	Black spruce treed on uplands
H02	Black spruce treed and young regeneration on uplands	Common	Black spruce treed on uplands Young regeneration on uplands
H03	Black spruce treed on uplands or shallow peatland	Common	Black spruce treed on shallow peatland Black spruce treed on uplands
H04	Black spruce treed on shallow peatland	Common	Black spruce treed on shallow peatland
H05	Black spruce treed and young regeneration on shallow peatland	Common	Black spruce treed on shallow peatland Black spruce treed on uplands Young regeneration on uplands Low vegetation on uplands Low vegetation on wet peatland
H06	Jack pine treed on uplands	Rare	Jack pine treed on uplands Jack pine mixedwood on uplands
H07	Jack pine treed on uplands and young regeneration	Common	Jack pine treed on uplands Young regeneration on uplands

Habitat Code	Coarse Habitat Type or Habitat Mosaic	Rarity	Coarse Habitat Types Included
			Low vegetation on uplands
H08	Jack pine mixedwood on uplands	Rare	Jack pine mixedwood on uplands
H09	Young regeneration on uplands	Common	Young regeneration on uplands
H10	Young regeneration on uplands or shallow peatland	Common	Young regeneration on shallow peatland Black spruce treed on shallow peatland Young regeneration on uplands Low vegetation on wet peatland Tall shrub on shallow peatland Tall shrub on wet peatland
H11	Young regeneration on shallow peatland	Common	Young regeneration on shallow peatland Young regeneration on wet peatland
H12	Black spruce mixedwood on uplands	Rare	Black spruce mixedwood on uplands Black spruce treed on uplands
H13	Broadleaf mixedwood on uplands	Rare	Broadleaf mixedwood on peatlands Black spruce treed on uplands Black spruce treed on shallow peatland
H14	Broadleaf treed on uplands	Rare	Broadleaf treed on uplands
H15	Low vegetation or tall shrub on wet or shallow peatlands	Common	Low vegetation on wet peatland Tall shrub on wet peatland
H16	Black spruce treed on wet peatland	Common	Black spruce treed on wet peatland Black spruce-tamarack mixture on wet peatland

5.2.3 ANALYSIS METHODS

The preliminary classification of primary, secondary and non-habitat for caribou – for winter and for calving and rearing - was confirmed, and in some cases, quantified, by statistical analysis of data collected in the Local and Regional Study Areas.

Winter habitat use by caribou was defined as a most important factor and was assessed using a variety of analytical techniques. These included habitat mosaics analysis and model validation to identify habitat types containing forage materials (*i.e.*, lichen) of importance to caribou. To model the extent of habitat where caribou forage requirements are met, habitat modelling aimed to identify the extent of mature black spruce on the landscape while limiting those habitat areas of little forage value, including recently burnt areas (*i.e.*, "young regeneration" habitat).

Caribou calving and rearing areas were analyzed based on the use of islands by caribou in summer. Islands were assessed as being of primary or secondary importance based on the observation history of caribou adults and calves. Island size and habitat composition were considered as variables,

potentially influencing use. Sampled peatland complexes were similarly considered where observations from these complexes were used to model available alternate caribou calving and rearing areas in the Caribou Regional Study Area.

Model validation added variables to the expert evaluation model, modifying the extent of potential habitat availability and loss compared to the originally calculated estimates. Mammal sign survey and trail camera data from 2012 were used to determine the accuracy of derived primary and secondary islands in lake and peatland complex size classifications. Observations of caribou and caribou tracks during aerial surveys performed from 2003 to 2011 in the Keeyask region were used to validate the winter habitat quality model.

5.2.4 DESCRIPTIVE STATISTICS

5.2.4.1 POPULATION SURVEYS

5.2.4.1.1 REGIONAL STUDY AREA

Aerial surveys of the Regional Study Area indicated a mean density of 0.12 individuals/km² over a five-year period (Table 5-4). Caribou density reached a maximum of 0.26 individuals/km² in 2004. Caribou density was lowest in 2005, the same year no caribou were observed in the Nelson River area downstream of the Long Spruce Generating Station (GS).

Table 5-4: Caribou Density in the Regional Study Area, 2002 to 2006

Study Year	Area Surveyed (km²)	Number Observed	Density (individuals/km²)	Density (min., max. individuals/km²)	95% Confidence Interval
2002	771	24	0.03	(0.00, 0.14)	(0.00, 0.06)
2003	1,462	347	0.24	(0.00, 2.24)	(0.12, 0.36)
2004	559	146	0.26	(0.00, 1.72)	(0.07, 0.45)
2005	513	8	0.02	(0.00, 0.30)	(0.00, 0.04)
2006	336	16	0.05	(0.00, 0.44)	(0.00, 0.10)
Total/Mean	3,641	541	0.12	(0.00, 2.24)	(0.06, 0.18)

The greatest number of caribou observed in winter occurred between December 2004 and January 2005 and included Qamanirjuaq, Pen Islands, and Cape Churchill caribou. About 10,000 animals were observed moving in larger groups between the north arm of Stephens Lake and the Fox Lake Cree Nation community of Bird (Manitoba Conservation, unpubl. data).

During the January and March 2009 aerial survey for moose that systematically covered a large portion of the SLRMA, 526 Qamanirjuaq, Pen Islands, and Cape Churchill caribou were recorded incidentally. In January 2010, a similar but more intensive aerial survey for moose was conducted in

the same geographic region. High densities of caribou tracks were recorded in some areas, but no caribou were observed.

Before 2013, the greatest number of Pen Islands caribou counted on a single occasion was on December 12, 2006 from a comparison area near the Limestone GS. The number of animals was estimated at 900 to 1,200. The animals were loosely separated into two herds and were observed moving towards the Regional Study Area. In December 2009 during a survey conducted by FLCN, 400 to 500 Pen Islands caribou were observed in an area northeast of Fox River near Naismith Camp (FLCN Evaluation Report Draft). Tracks indicated the caribou were moving west. Additional groups of 10 to 20 caribou, as well as solitary caribou, were observed along the flight path (FLCN Evaluation Report Draft). Caribou signs were observed in the Atkinson Lake area in December 2011 and 27 caribou were observed on the eastern edge of Split Lake in January 2010. In March, 26 caribou were observed midway between the December and January observations. These were likely Pen Islands caribou leaving their winter grounds and making their way east.

A total of 4,169 caribou were observed in the Local and Regional Study Areas in February 2013. It was estimated that 13,985 (95% LCI 9,810; 95% UCI 19,933) caribou were in the area (LaPorte *et al.* 2013). They were travelling in a predominantly north-easterly to easterly direction. Most were observed south of the Nelson River, but many groups were observed north of the river and Gull and Stephens lakes (Map 5-16). Some moved north of the KIP construction zone, and fewer still crossed PR 280.

5.2.4.1.2 LOCAL STUDY AREA

Few of the caribou observed during winter aerial surveys from 2002 to 2006 were observed in the Caribou Local Study Area (Study Zone 4). Observations were only made in 2002, where density was 0.05 individuals/km² based on the observation of 21 animals (Table 5-5). A subsequent 2011–2012 winter aerial survey also did not observe any caribou in the Local Study Area, although did establish the presence of fresh tracks in the area. No survey blocks were flown in the Local Study Area in 2006. Based on an aerial survey flown in February 2013, thousands of animals, assumed to be Pen Islands caribou were seen in the Local Study Area (LaPorte *et al.* 2013).

Caribou were also observed based in spring to fall trail camera studies conducted 2010-2012 in the Caribou Local Study Area. A conservative estimate for the group of animals residing in the Local Study Area in summer is 20 to 50 individuals. This is based on ongoing surveys (including trail camera studies conducted on Stephens and Gull lakes, as well as on peatland complexes elsewhere in the Local Study Area)„which have demonstrated use of caribou calving and rearing areas (see Appendix D for more information detailing how the estimate of 20-50 animals in the Caribou Local Study Area was calculated). This is despite low quantities of caribou observed during winter aerial surveys.

Table 5-5: Caribou Density in the Local Study Area, 2002 to 2006

Study Year	Area Surveyed (km²)	Number Observed	Density (individuals/km²)	Density (min., max. individuals/km²)
2002	447	21	0.05	(0.00, 0.14)

2003	207	0	0.00	(0.00, 0.00)
2004	73	0	0.00	(0.00, 0.00)
2005	57	0	0.00	(0.00, 0.00)
2006	-	-	-	-
Total/Mean	784	21	0.01	(0.00, 0.14)

5.2.4.1.3 HABITAT-BASED MAMMAL SIGN SURVEYS

From sign surveys conducted 2001-2004, the presence of caribou sign was assessed based on their frequency within sampled habitat mosaics. In total, 16 habitat mosaic types were used and included five habitat mosaics identified as "rare" and 11 identified as "common" (see Table 5-3). In considering the potential for caribou to be located along sampled transects, habitat types designated as potential primary habitat areas included H01 (black spruce treed on uplands), H03 (black spruce treed on uplands or shallow peatland), H04 (black spruce treed on shallow peatland), H06 (jack pine treed on uplands) and H16 (black spruce treed on wet peatland) with the other habitat types not considered as caribou habitat.

The number of habitat mosaics where sign surveys were conducted varied based on yearly sampling activities. Varying amounts of habitat mosaics were sampled each year, with 55 transects sampled in winter 2001 (Table 4B-1), 103 transects in summer 2001 (Table 4B-2), 71 transects in winter 2002 (Table 4B-3), 195 transects in summer 2002 (Table 4B-4), 262 transects in summer 2003 (Table 4B-5), and 21 transects in summer 2004 (Table 4B-6).

In an attempt to inform study design, sign surveys from calving and rearing islands in lakes in 2003 were analyzed to determine habitat preferences of calving caribou. The presence/absence of caribou on islands was modeled using binary, logistic regression as a function of island area (ha) and the nearest distance to mainland (m). Models were run on caribou presence, including cows, calves, and bulls, and calving caribou presence, including cows and calves only.

In total, 67 islands were surveyed for caribou activity in Zone 3 during the summer of 2003. Caribou presence was recorded, and variables such as the size of islands and nearest distance to the mainland were measured. Where possible, the age and sex of individuals was identified.

5.2.4.1.4 TRAIL CAMERA STUDIES OF CALVING AND REARING AREAS

In an attempt to inform study design, sign surveys from calving and rearing islands in lakes were analyzed to determine habitat preferences of calving and calf-rearing locations for caribou.

Gull Lake and Stephens Lake contained a total of 347 islands of various sizes. Island sampling selection was informed on an exploratory basis. As islands were explored, very many small islands (<0.5 ha) did not appear to be suitable for calving habitat because they consisted of bare rock or ice-scoured willow. As a result, only a small number of islands that had forest cover, which were heavily dominated by black spruce, could be sampled. From these data, an attempt was made to sample as wide a range of sizes distributed throughout Gull and Stephens lakes, and as many of the islands as logistically possible. In total, 108 islands were surveyed for caribou activity on these lakes during the summers of 2003, 2005, 2010, 2011, and 2012. Caribou presence was recorded, and variables such as

the size of islands and nearest distance to the mainland were measured. Where possible, the age and sex of individuals was identified.

Trail cameras were used on islands in an attempt to identify unique adult animals based on distinguishing characteristics, namely the presence of body scarring and unique antler morphology. Because cow caribou in particular tend to shed antlers and hair in June and begin to grow new antlers shortly after calving, individual identification carried through from one period to the next was problematic. As such, data were grouped and reviewed for individual identification by two periods: Period 1, the pre-calving/calving period from mid-May to early July and Period 2, the post-calving period from early July to mid-September. Caribou identified as unique individuals during the review of photos from one sampling period were then compared with those from other sampling periods (*i.e.*, unique individuals identified from May/July photos were compared with unique individuals identified in July/September photos). The separation of data into these two periods allowed for minimum and maximum counts of unique caribou.

For islands in lakes, the indication of secondary calving and rearing complexes was based on habitat areas which support adult caribou approximately 65% of the time, and calves less than 45% of the time (when considering peatland complexes) or less than 25% of the time (when considering islands in lakes). Indications of primary habitat were based on the presence of adults approximately 90% of the time, and calves more than 45% of the time (when considering peatland complexes) or more than 25% of the time (when considering islands in lakes).

The influence of fire events on the potential for islands in lakes and for peatland complexes to be used as calving and rearing habitat was evaluated through a comparison of islands in lakes and peatland complexes where fire events have been recorded with islands in lakes and peatland complexes where no fire events have been recorded. The presence of cows and calves was compared between those areas affected by fire and those where no fire events had been recorded.

5.2.5 MODEL VALIDATION

5.2.5.1 VALIDATION OF THE WINTER CARIBOU HABITAT QUALITY MODEL

Validation of the winter caribou habitat quality model was done by identifying coarse habitat types present where caribou were observed. In addition, the influence of fires on caribou selection of coarse habitat types was modelled as an additional factor. This was done by assigning each coarse habitat type with a burn age class (Table 5-6). Coarse habitat types not affected by recorded fire events were assigned a default burn age class of 1.

Table 5-6: Burn Age Classes Used in Examination of Caribou Coarse Habitat Type Selection

Burn Age Class	Burn Age (years)	Recorded Fire Events
1	50+	1960

Burn Age Class	Burn Age (years)	Recorded Fire Events
2	40-49	1967, 1972
3	30-39	1975, 1976, 1977, 1980, 1981
4	20-29	1983, 1984, 1989, 1990, 1992
5	10-19	1993, 1994, 1995, 1996, 1998, 1999, 2001, 2002
6	0-9	2003, 2005, 2010, 2011

Based on the association of burn age information with coarse habitat types, a total of 151 coarse habitat types with associated burn age classes were considered as present in Study Zone 4; the area for which coarse habitat type information was available. In addition, amounts of shallow water, indicating the presence of lakes and streams and the Nelson River, were considered based on their proximity to sampling locations in evaluating coarse habitat types and habitat information.

For habitat analysis, a total of 42 sets of geographic coordinates were used. Of the 42 locations, 8 were locations of caribou observations from aerial surveys preformed in 2003 and 2007. The remaining 34 locations were caribou tracks identified in February 2002, March 2002, December 2003, February 2003, January 2004, and January 2006. For habitat analysis, only areas with fresh tracks indicating the likely presence of a minimum of five caribou were considered. An additional habitat analysis was preformed based on an aerial survey conducted in February 2013 using an additional 141 sampling locations where caribou were observed. These sampling locations were only based on locations where actual caribou were observed and where track information was not considered. Typically, more than one animal was observed at each location and all observations occurred within the Local Study Area.

The identification of habitat information at multiple spatial scales was done by buffering the UTM coordinates of caribou locations. Buffers used in the identification of habitat information included 100-m, 250-m, 500-m and 1,000-m levels. The proportion of each coarse habitat type for all sets of UTM coordinates at each buffer level was averaged to compare differences in the selection of coarse habitat types across buffer levels.

To indicate the most common coarse habitat types of caribou observations, each coarse habitat type was ranked based on its proportion. The coarse habitat types appearing most frequently, and cumulatively making up 80% of the habitat area for a buffer level, were treated as coarse habitat types potentially selected for and used by caribou. In addition, coarse habitat types were weighted based on their relative proportions in Study Zone 4 as a whole to indicate if they occurred with greater frequency inside of buffered sampling areas.

5.2.5.2 VALIDATION OF THE CARIBOU CALVING AND REARING HABITAT QUALITY MODEL

Validation of the caribou calving and rearing models used the 2012 sign surveys and trail camera photo data. The 2012 sign survey and trail camera data, included presence/absence data on caribou calves and adults from 57 islands in Stephens Lake and 49 peatland complexes in the Keeyask region.

After tabulating the number of calves and adults on islands and in peatland complexes, these areas were categorized as primary and secondary habitat areas based on predefined size classes (see Section 5.1.3.1.5). The proportions of adults and calves on islands in lakes and in peatland complexes were then compared to the anticipated results based on the original modelling exercise.

5.3 RESULTS

5.3.1 DESCRIPTIVE STATISTICS

5.3.1.1 HABITAT-BASED MAMMAL SIGN SURVEYS

Caribou signs were very common along lake perimeter transects in the Local and Regional Study Areas in summer (Table 5-7). No lake perimeters were surveyed in winter. Signs were abundant at lakes north of Gull Lake and sporadic at lakes south of Gull Lake. Mean frequency of caribou signs was similar inside (0.20 signs/100 m²) and outside (0.21 signs/100 m²) Study Zone 1. Signs of caribou activity were observed in all six habitats surveyed. Mean frequency of caribou signs ranged from 0.07 signs/100 m² in black spruce treed on mineral and thin peatland or shallow peatland to 0.29 signs/100 m² in low vegetation or tall shrub on wet peatland habitat. Signs were also abundant in young regeneration on mineral and thin peatland or shallow peatland (0.28 signs/100 m²) and black spruce treed on shallow peatland (0.25 signs/100 m²).

Signs of caribou activity were very common on coarse habitat mosaic transects in summer. Signs were abundant (Table 5-7) and observed on all transects. Caribou signs were very abundant on islands over the three-year study period. Signs were abundant on transects north (0.33 signs/100 m²) and south (0.37 signs/100 m²) of Gull and Stephens lakes. Mean frequency of caribou signs was similar in riparian (0.35 signs/100 m²) and terrestrial (0.37 signs/100 m²) areas, and inside (0.38 signs/100 m²) and outside (0.34 signs/100 m²) Study Zone 1. Signs of caribou activity were observed in all 13 habitats surveyed. Mean sign frequency ranged from 0.04 signs/100 m² in black spruce mixedwood on mineral and thin peatland to 0.50 signs/100 m² in black spruce treed on mineral and thin peatland or shallow peatland.

Table 5-7: Abundance and Distribution of Caribou Signs (signs/100 m²) in the Local Study Area

Transect Type	Mean	S.E.	Abundance	Proportion of Transects	Distribution	Species Rarity
Lake perimeters	0.21	0.03	abundant	1.00	very widespread	very common
Coarse habitat mosaics	0.36	0.07	abundant	0.84	very widespread	very common
Coarse habitat mosaics (winter)	0.08	0.05	scarce	0.11	scattered	sparse
Riparian	0.72	0.21	very	0.72	very	very common

shorelines	abundant	widespread

Signs of caribou activity were sparse on coarse habitat mosaic transects in winter. Sign abundance was scarce and distribution was scattered (Table 5-7). Signs were scarce (0.03 signs/100 m²) on transects north of Gull and Stephens lakes and sporadic on transects south of the lakes (0.12 signs/100 m²). Mean frequency of caribou signs was greater on transects inside Study Zone 1 (0.21 signs/100 m²) than outside (0.16 signs/100 m²). Caribou signs were observed in four of the nine habitats surveyed. No signs were observed in black spruce treed on mineral and thin peatland or shallow peatland, young regeneration on mineral and thin peatland, young regeneration on mineral and thin peatland or shallow peatland, low vegetation or tall shrub on wetland, or on black spruce treed on wet peatland habitat. Where signs were observed, they ranged from 0.07 signs/100 m² in black spruce treed and young regeneration on mineral and thin peatland and in black spruce treed on shallow peatland, to 0.13 signs/100 m² on black spruce treed on mineral and thin peatland and in broadleaf mixedwood on mineral and thin peatland.

Caribou signs were very common along riparian transects in the Local Study Area in summer. Signs were very abundant and very widespread (Table 5-7). No riparian transects were surveyed in winter. Caribou signs were very abundant on the north and south shores of Gull Lake and on island shorelines over the three-year study period. Mean sign frequency was greatest on the south shore of the lake (1.06 signs/100 m²). Caribou signs were very abundant on transects in all widths of riparian zones, and on all slopes. Signs were observed in all but one of the seven habitats surveyed. None were found in broadleaf treed on all ecosites habitat. Where signs were observed, mean frequency ranged from 0.25 signs/100 m² in black spruce mixedwood on mineral and thin peatland to 2.83 signs/100 m² broadleaf mixedwood on mineral and thin peatland.

Caribou were active in the Local Study Area in summer, and were scarce in winter. Caribou density was greater in the Regional Study Area than the Local Study Area in winter. Seasonal variation in caribou density was expected, as several caribou populations migrate through the Keeyask region. The timing of movements and the habitats used may vary among caribou types and from year to year for each type of caribou. Variations in caribou densities are further explained by habitat quality, habitat availability, and the spatial distribution of habitats in the study areas (Thompson and Abraham 1994; Abraham and Thompson 1998).

Based on sampling of islands in lakes in 2003, adult caribou were present on 63% of the islands. Sign from caribou cows and calves were present on 49% of islands.

The identification of caribou through trail camera surveys conducted from 2010 to 2012 aided in the estimation of the number identified as summer resident caribou in the Keeyask region. Between 2010 and 2012, the trail camera data collection period ranged mainly from mid-May to mid-September of each year. The number of trail cameras set ranged from a low of 81 in 2010, to a high of 111 cameras in 2012. Trail cameras were set in caribou calving and rearing habitats on islands in lakes and islands in peatland complexes located mainly in the Local Study Area. A few camera sets extended into Study Zone 5.

The evaluation of habitat mosaics as representing potential winter habitat areas for caribou in the Local Study Area in 2001-2002 indicated the presence of caribou on 9 of 126 transects (Table 5-8). Transects were located on 9 of 16 modelled habitat mosaics with caribou sign observed on four of these. The habitat mosaics where caribou sign were most common were black spruce treed and young regeneration on uplands habitat mosaic. Despite a relatively large amount of transects being sampled in the black spruce treed on uplands or shallow peatland habitat mosaic (n = 22), and this habitat mosaic designated as potential primary caribou habitat, no caribou sign were observed in this area. Only a single rare habitat mosaic type was surveyed: broadleaf mixedwood on uplands, which demonstrated substantial use by caribou.

Table 5-8: Habitat Class Information for Sampled Mammal Tracking Transects in the Keeyask Region Where Caribou Signs Were Observed Winter 2001–2002

Habitat Mosaic	Habitat Class Code	Sampled Transects	Transects with Caribou	% Transects with Caribou	1° or 2° Habitat
Black spruce treed on uplands	H01	64	4	6.25	1°
Black spruce treed and young regeneration on uplands	H02	3	1	33.33	
Black spruce treed on uplands or shallow peatland	H03	22	0	0.00	1°
Black spruce treed on shallow peatland	H04	16	3	18.75	1°
Black spruce treed and young regeneration on shallow peatland	H05	0	0	N/A	
Jack pine treed on uplands[1]	H06	0	0	N/A	1°
Jack pine treed on uplands and young regeneration	H07	0	0	N/A	
Jack pine mixedwood on uplands[1]	H08	0	0	N/A	
Young regeneration on uplands	H09	8	0	0.00	
Young regeneration on uplands or shallow peatland	H10	3	0	0.00	
Young regeneration on shallow peatland	H11	0	0	N/A	
Black spruce mixedwood on uplands[1]	H12	0	0	N/A	
Broadleaf mixedwood on uplands[1]	H13	6	1	16.67	
Broadleaf treed on uplands[1]	H14	0	0	N/A	
Low vegetation or tall shrub on wet or shallow	H15	1	0	0.00	

Habitat Mosaic	Habitat Class Code	Sampled Transects	Transects with Caribou	% Transects with Caribou	1° or 2° Habitat
peatlands					
Black spruce treed on wet peatland	H16	3	0	0.00	1°
TOTAL		126	9	7.14	

1. Considered rare habitat mosaics

5.3.2 CARIBOU HABITAT QUALITY MODEL

5.3.2.1 CARIBOU WINTER HABITAT QUALITY MODEL

The selection of coarse habitat types of importance to all caribou (*i.e.*, barren-ground, coastal and woodland) during the winter was based on a review of coarse habitat type descriptions, presented in Section 2.3.4.2 of the Terrestrial Environment Supporting Volume, as plant communities with specific plant species potentially valuable as caribou forage (Appendix H).

The caribou winter habitat quality model was based on the identification of coarse habitat types of importance to caribou during the winter months. This model accounts for the presence of preferred winter dietary items for caribou (terrestrial and arboreal lichen species), which grow in mature coniferous forests. For this reason, those coarse habitat types associated with quantities of coniferous forest (particularly black spruce), which makes up a large portion of the Local and Regional Study Areas (Section 2.3.4.2 of the Terrestrial Environment Supporting Volume), were selected as habitat types for use in the caribou winter habitat quality model. No coarse habitat types of secondary importance to caribou were identified in the caribou winter habitat model development (Table 5-9).

Table 5-9: Winter Habitat Types in the Caribou Regional Study Area

	Coarse Habitat Type
Selected habitat types	Black spruce treed on mineral soil
	Black spruce treed on shallow peatland
	Black spruce treed on wet peatland[1]
	Black spruce treed on thin peatland
	Jack pine treed on mineral and thin peatland
	Jack pine treed on shallow peatland
	Tamarack-black spruce mixture on wet peatland[2]
	Tamarack treed on shallow peatland
	Tamarack treed on wet peatland[3]
Non-selected habitat types	Broadleaf mixedwood on all ecosites
	Broadleaf treed on all ecosites
	Human
	Jack pine mixedwood on mineral and thin peatland
	Low vegetation on mineral and thin peatland
	Low vegetation on shallow peatland

Coarse Habitat Type
Low vegetation on wet peatland[4]
Marsh
Tall shrub on mineral and thin peatland
Tall shrub on shallow peatland
Tall shrub on wet peatland[5]
Vegetated riparian peatland[6]
Vegetated upper beach[7]
Vegetated ice scour[8]
Marsh Island[9]
Young regeneration on mineral and thin peatland
Young regeneration on shallow peatland
Young regeneration on wet peatland[10]

1. Consists of black spruce treed on wet peatland and black spruce treed on riparian peatland coarse habitat types
2. Consists of tamarack-black spruce mixture on wet peatland and tamarack-black spruce mixture on riparian peatland coarse habitat types
3. Consists of tamarack treed on wet peatland and tamarack treed on riparian peatland coarse habitat types
4. Consists of low vegetation on wet peatland and low vegetation on riparian peatland coarse habitat types
5. Consists of tall shrub on wet peatland and tall shrub on riparian peatland coarse habitat types
6. Consists of Nelson River shrub and/or low vegetation on sunken peat coarse habitat type
7. Consists of Nelson River shrub and/or low vegetation on upper beach coarse habitat type
8. Consists of Nelson River shrub and/or low vegetation on ice scoured upland
9. Consists of Nelson River marsh coarse habitat type
10. Consists of young regeneration on wet peatland and young regeneration on riparian peatland coarse habitat types

5.3.2.2 CARIBOU CALVING AND REARING HABITAT MODEL

When calving, to avoid predators summer resident woodland caribou inhabit calving and rearing complexes, which are clusters of islands in lakes or islands of black spruce surrounded by expansive wetlands or treeless areas (called peatland complexes).

The development of this model was directly informed by field data. Size classes for primary and secondary calving and rearing habitat on islands in lakes and in peatland complexes were calculated based on sampling information collected over multiple years. In verifying the size classes of primary and secondary calving and rearing habitat areas, 107 islands in lakes and 48 peatland complexes were sampled on 200 and 65 occasions, respectively. A breakdown of these habitat areas based on the primary and secondary calving and rearing size classes for islands in lakes is presented in Table 5-12 and Figure 5-3 and for peatland complexes is presented in Table 5-13 and Figure 5-4.

Broad, coarse, and fine habitat types on islands were dominated by black spruce types. Of the 108 islands surveyed in 2003, 2005, 2010, and 2011, all broad and fine habitat types were dominated by black spruce and 106 (98%) of coarse habitat types were dominated by black spruce. As a result, tree cover types on islands was not explored further in the models.

Island area was a significant factor determining use of islands by caribou, but distance to mainland was not. The coefficient of area is large relative to its standard error (t-ratio = 2.233), and the confidence intervals do not cross 1, indicating significance. According to the estimate the presence of caribou is increased by a factor of 1.028 as island size increases by 1 ha. The relatively high value of the McFadden's Rho-squared, indicates a satisfactory model fit (Table 5-10).

For calving caribou neither area nor distance to mainland appeared to be reliable indicators of island use. The confidence limits for both variables overlapped 1, indicating a lack of significance and model fit was relatively poor as indicated by the relatively low McFadden's Rho-square value (Table 5-11).

Table 5-10: Results of the Binary Logistic Regression for the Presence/absence of Caribou on Islands

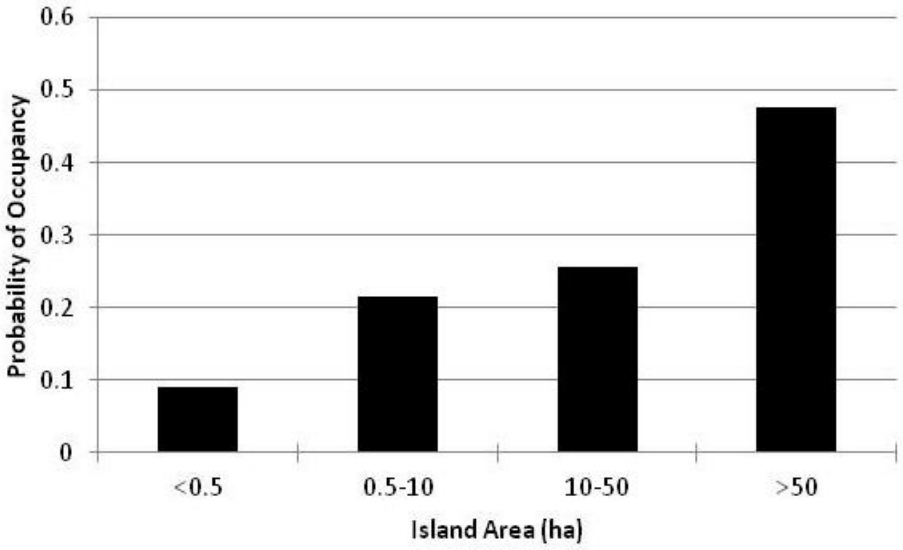
Parameter	Estimate	S.E.	t-ratio	p	Odds Ratio	Upper (95%)	Lower (95%)
Constant	0.403	0.468	0.861	0.389	..	..	..
Area (ha)	0.028	0.012	2.233	0.026	1.028	1.053	1.003
Distance to Mainland (m)	-0.001	0	-1.756	0.079	0.999	1.000	0.998
McFadden's Rho-squared = 0.175							

Table 5-11: Results of the Binary Logistic Regression for the Presence/absence of Calving caribou on Islands

Parameter	Estimate	S.E.	t-ratio	p	Odds Ratio	Upper (95%)	Lower (95%)
Constant	-0.038	0.430	-0.088	0.930	..	..	..
Area (ha)	0.007	0.004	1.704	0.088	1.007	1.015	0.999
Distance to Mainland (m)	0	0	-1.054	0.292	1	1	0.999
McFadden's Rho-squared = 0.078							

Table 5-12: Results of the Caribou Calving and Rearing Habitat Model for Islands in Lakes for Tracking and Trail Camera Surveys Conducted in 2003, 2005, 2010 and 2011

Island Size	Times Sampled	Calves Observed	Adults Observed
<0.5 ha	11	1 (9%)	7 (64%)
0.5 – 10 ha	102	22 (22%)	74 (73%)
>10 ha	87	32 (37%)	72 (83%)



Note: An additional size category was included for illustrative purposes.

Figure 5-3: Probability of Occupancy for Caribou Calves on Various Sized Islands Surveyed 2003, 2005, 2010, and 2011

Table 5-13: Results of the Caribou Calving and Rearing Habitat Model for Peatland Complexes for Tracking and Trail Camera Surveys Conducted 2010 and 2011

Complex Size	Times Sampled	Calves Observed	Adults Observed
<30 ha	9	2 (22%)	2 (22%)
30 – 200 ha	38	16 (42%)	27 (71%)
>200 ha	18	11 (61%)	17 (94%)

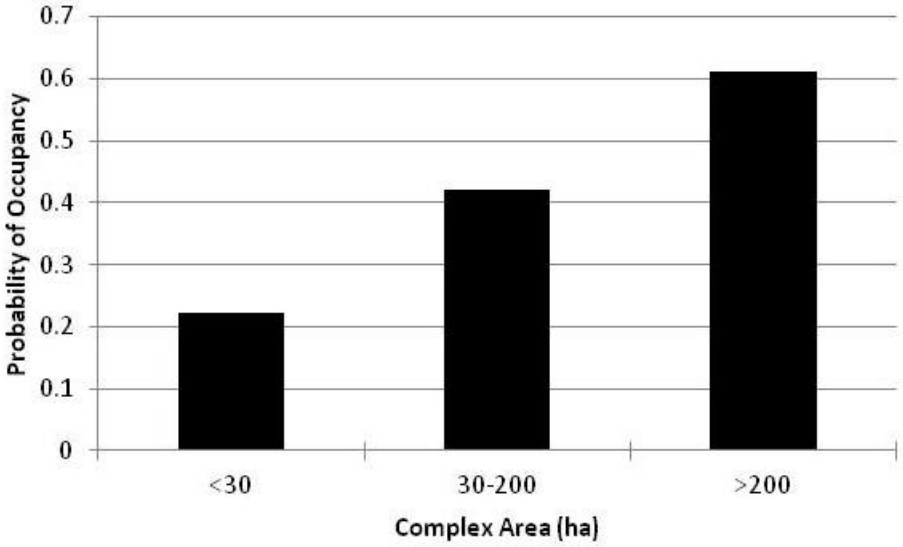


Figure 5-4: Probability of Occupancy for Caribou Calves on Various Sized Peatland Complexes Surveyed 2010 and 2011

The results of this analysis indicate the increased use of islands in lakes and peatland complexes for caribou calving and rearing with increasing island in lake or peatland complex size. Many islands in lakes and peatland complexes identified as calving and rearing areas and surveyed in multiple years were determined to often be used for calving and rearing year after year. Based on the surveys of caribou calving and rearing complexes, caribou calf and adult occupancy rates for primary and secondary habitat areas were established and serve as a baseline for considering use rates in subsequent survey years.

In the final analysis, primary calving and rearing habitat is defined as islands greater than 10 ha in lakes or peatland complexes greater than 200 ha. Secondary calving and rearing habitat is defined as islands between 0.5 and 10 ha in lakes or as peatland complexes between 30 and 200 ha.

5.3.3 MODEL VALIDATION

5.3.3.1 CARIBOU WINTER HABITAT QUALITY MODEL

5.3.3.1.1 VALIDATION OF THE CARIBOU WINTER HABITAT QUALITY MODEL

An evaluation of coarse habitat types selected by caribou based on spatial scale indicates some differences in the selection of habitat types (Table 5-14). Consistently high-ranked coarse habitat types indicate not-burned habitat including black spruce treed on shallow peatland and black spruce treed on thin peatland. In addition, high amounts of "Nelson River" habitat indicate caribou selection of habitat areas that are near the river. Other coarse habitat types selected by caribou included those with the presence of low vegetation (*i.e.,* low vegetation on mineral or thin peatland, and low vegetation on riparian peatland). The association with low vegetation likely has to do with movements through the area rather than the potential availability of browse. Data tables indicating

amounts of coarse habitat types for locations of caribou events recorded during winter surveys can be found as Tables 5B-1 to 5B-4.

Table 5-14: Rankings of Coarse Habitat Types based on Abundance With 100, 250, 500 and 1000 m Buffers Applied to Winter Caribou Observation Locations

Coarse Habitat Type	Burn Age Class	100 m	250 m	500 m	1000 m
Nelson River	NA	1	2	3	4
Black spruce treed on shallow peatland	1	2	1	1	2
Black spruce treed on thin peatland	1	3	3	2	1
Low vegetation on mineral or thin peatland	5	4	5	6	-
Low vegetation on riparian peatland	1	5	6	7	6
Low vegetation on shallow peatland	1	6	9	8	8
Low vegetation on wet peatland	1	7	7	9	-
Black spruce treed on wet peatland	1	8	10	-	10
Shallow water	NA	9	8	5	5
Black spruce treed on mineral soil	1	10	4	4	3
Low vegetation on mineral or thin peatland	3	-	-	-	7
Low vegetation on shallow peatland	6	-	-	-	9

A comparison of the proportions of coarse habitat types inside buffered habitat areas to Study Zone 4 indicated alternate coarse habitat types used by caribou (Table 5-15). This included mature black spruce mixedwood on shallow peatland and black spruce treed on riparian peatland, both supporting the model. Compared to the previous analysis, related solely to the abundance of coarse habitat types, selected coarse habitat indicated the presence of habitat types affected by fire which did not, however, include quantities of black spruce. Data tables indicating amounts of coarse habitat types at caribou event locations, compared with those proportions existing in Study Zone 4 as a whole, can be found in Tables 5B-5 to 5B-8.

Additional evaluation of coarse habitat types sampled in proximity to caribou observations occurred based on the February 2013 survey of Pen Islands caribou in the Keeyask region. The most common coarse habitat types occurring in proximity to caribou observations included black spruce treed on shallow peatland, black spruce treed on thin peatland and black spruce treed on mineral soil (Table 5-16). All three top-ranked habitats supported the model. Other abundant coarse habitat types in proximity to sampled caribou locations included quantities of low vegetation on riparian peatland and low vegetation on shallow peatland, indicating the potential importance of these habitat types. Only a single habitat type indicated as abundant was affected by fire. Data tables indicating amounts of coarse habitat types for caribou observations recorded during the February 2013 aerial survey can be found as Tables 5B-9 to 5B-12.

Table 5-15: Ranking of Coarse Habitat Types Based on Relative Use With 100, 250, 500 and 1000 m Buffers Applied to Winter Caribou Observation Locations

Coarse Habitat Type	Burn Age Class	100 m	250 m	500 m	1000 m
Black spruce mixedwood on shallow peatland	1	1	1	4	33
Black spruce treed on riparian peatland	2	2	2	1	20
Low vegetation on mineral or thin peatland	2	3	6	7	5
Tall shrub on riparian peatland	5	4	27	45	64
Tamarack treed on shallow peatland	3	5	28	26	16
Tall shrub on shallow peatland	1	6	9	21	73
Low vegetation on mineral or thin peatland	5	7	11	12	65
Low vegetation on riparian peatland	5	8	7	30	19
Black spruce mixedwood on mineral or thin peatland	1	9	16	15	45
Tall shrub on mineral or thin peatland	1	10	5	3	84
Low vegetation on riparian peatland	1	11	22	18	22
Low vegetation on shallow peatland	4	12	15	39	83
Low vegetation on mineral or thin peatland	4	13	13	46	70
Low vegetation on wet peatland	1	14	20	25	49
Broadleaf mixedwood on all ecosites	3	15	48	32	7

Table 5-16: Rankings of Coarse Habitat Types Based on Abundance With 100, 250, 500 and 1000 m Buffers Applied to Winter Caribou Observation Locations Based on Aerial Survey Flown February 2013

Coarse Habitat Type	Burn Age Class	100 m	250 m	500 m	1000 m
Black spruce treed on shallow peatland	1	1	1	1	1
Black spruce treed on thin peatland	1	2	2	2	2
Nelson River	NA	3	3	3	3
Black spruce treed on mineral soil	1	4	4	4	4
Shallow water	NA	5	5	5	5
Low vegetation on riparian peatland	1	6	7	-	-
Low vegetation on shallow peatland	1	7	6	6	6
Low vegetation on shallow peatland	3	8	-	-	-

A review of coarse habitat types occurring in proximity to caribou observations during the February 2013 aerial survey, based on the relative occurrence of coarse habitat types occurring elsewhere in the

Caribou Local Study Area, indicated the presence of varied habitat types (Table 5-17). Three of the top five ranked habitat types provided support for the model, including suitable burn age categories. Data tables indicating amounts of coarse habitat types at caribou observations, compared with those proportions existing in Study Zone 4 as a whole, can be found as Tables 5B-13 to 5B-16.

Table 5-17: Ranking of Coarse Habitat Types based on Relative Use With 100, 250, 500 and 1000 m Buffers Applied to Winter Caribou Observation Locations Based on Aerial Survey Flown February 2013

Coarse Habitat Type	Burn Age Class	100 m	250 m	500 m	1000 m
Tall shrub on shallow peatland	3	2	1	8	-
Jack pine treed on mineral or thin peatland	2	1	2	4	8
Low vegetation on riparian peatland	2	12	5	12	7
Jack pine mixedwood on mineral or thin peatland	1	6	7	17	10
Black spruce treed on shallow peatland	2	13	10	16	12
Broadleaf mixedwood on all ecosites	1	7	8	14	30
Human infrastructure	6	9	14	24	13
Black spruce mixedwood on mineral or thin peatland	1	4	6	26	26
Black spruce treed on mineral soil	3	14	21	15	16
Tamarack treed on shallow peatland	1	5	9	29	24
Low vegetation on shallow peatland	2	15	12	21	20
Black spruce treed on riparian peatland	2	30	31	7	5
Black spruce treed on wet peatland	2	20	16	30	15
Black spruce treed on shallow peatland	1	22	19	25	18
Low vegetation on riparian peatland	1	19	18	28	25

5.3.3.1.2 APPLICATION OF THE CARIBOU WINTER HABITAT QUALITY MODEL

Research and the results of field studies were jointly used to assess and validate winter habitat areas used by caribou. It is expected that caribou winter needs are similar for migratory and non-migratory caribou. To this extent, the winter caribou habitat quality represents portions of habitat available for calculations of available habitat caribou with the model presented here being useful in the evaluation of habitat availability, in the winter, for all groups considered. Based on the results of winter habitat quality modelling, where the impact of recorded fire events on caribou habitat selection was also examined, portions of the Local Study Area and Regional Study Area consist of usable caribou habitat.

For caribou calving and rearing habitat modelling, size classes were developed based on the presence of caribou calves and adults on sampled islands in lakes and peatland complexes. Some existing primary and secondary calving and rearing areas are expected to change due to Project-related

shoreline erosion. Based on the results of caribou habitat modelling, caribou in the Keeyask region are regularly sampled and appear to show habitat selection trends consistent with the literature.

As discussed in Section 5.1.3.1, primary caribou winter habitat consists of areas that provide ample food items, particularly arboreal lichens, and include black spruce-, jack pine-, and tamarack-dominated stands. Coarse habitat types selected for the caribou winter habitat model can be found in Table 5-18. Intactness calculations are provided separately. Please see Appendix E for further details.

The results of the caribou winter habitat quality model are detailed in Table 5-19 for Study Zone 2, the Local Study Area (Study Zone 4), and Study Zone 5 (using two different iterations of the coarse habitat classification [versions 12 and 14]), and are depicted in Map 5-17. Habitat for the Regional Study Area was not calculated as habitat was not quantified at this scale. The amount of habitat in Study Zone 2 was used to calculate the percentage of physical and effective habitat affected by the Project. See Appendix G for further calculations of the amount of winter caribou habitat available in the Caribou Local Study Area and Study Zone 5.

Table 5-18: Caribou Winter Habitat Types in the Regional Study Area

Coarse Habitat Type	Burn Age
Black spruce treed on mineral soil	<1971
Black spruce treed on riparian peatland	<1971
Black spruce treed on shallow peatland	<1971
Black spruce treed on thin peatland	<1971
Black spruce treed on wet peatland	<1971
Jack pine treed on mineral and thin peatland	<1971
Jack pine treed on shallow peatland	<1971
Tamarack-black spruce mixture on riparian peatland	<1971
Tamarack-black spruce mixture on wet peatland	<1971
Tamarack treed on riparian peatland	<1971
Tamarack treed on shallow peatland	<1971
Tamarack treed on wet peatland	<1971

Table 5-19: Results of the Caribou Winter Habitat Model

	V12 Coarse Habitat	V14 Coarse Habitat[1]	Zone of Effect (ha)	Local Study Area Existing Area (ha)	Study Zone 5 Existing Area (ha)
Winter Caribou Habitat (Physical Habitat Loss)[2]	Black spruce treed on mineral soil	Black spruce treed on mineral soil	1,318.52	12,374.63	93,534.84
	Black spruce treed on shallow peatland	Black spruce treed on shallow peatland	2,147.21	46,928.84	354,716.12
	Black spruce treed on thin peatland	Black spruce treed on thin peatland	2,845.54	45,414.54	343,270.10
	Black spruce treed on wet peatland	Black spruce treed on wet peatland	105.07	3,228.63	24,403.94
		Black spruce treed on riparian peatland	42.83	995.32	7,523.26
	Jack pine treed on mineral and thin peatland	Jack pine treed on mineral and thin peatland	126.69	1,230.00	9,297.05
	Jack pine treed on shallow peatland	Jack pine treed on shallow peatland	0.02	22.27	168.36
	Tamarack- black spruce mixture on wet peatland	Tamarack- black spruce mixture on riparian peatland	0.70	49.56	374.62
		Tamarack- black spruce mixture on wet peatland	30.81	1,417.41	10,713.62

	V12 Coarse Habitat	V14 Coarse Habitat[1]	Zone of Effect (ha)	Local Study Area Existing Area (ha)	Study Zone 5 Existing Area (ha)
	Tamarack treed on shallow peatland	Tamarack treed on shallow peatland	65.82	664.59	5,023.40
	Tamarack treed on wet peatland	Tamarack treed on riparian peatland	0.00	9.28	70.14
		Tamarack treed on wet peatland	2.89	256.04	1935.31
	Total Primary Habitat		6,686.10	112,591.13	851,030.76
Winter Caribou Habitat (Effective Habitat Loss)[3]	Black spruce treed on mineral soil	Black spruce treed on mineral soil	1,029.88	12,374.63	93,534.84
	Black spruce treed on shallow peatland	Black spruce treed on shallow peatland	6,290.05	46,928.84	354,716.12
	Black spruce treed on thin peatland	Black spruce treed on thin peatland	5,015.68	45,414.54	343,270.10
	Black spruce treed on wet peatland	Black spruce treed on wet peatland	360.52	3,228.63	24,403.94
		Black spruce treed on riparian peatland	117.40	995.32	7,523.26
	Jack pine treed on mineral and thin peatland	Jack pine treed on mineral and thin peatland	200.47	1,230.00	9,297.05
	Jack pine treed on shallow peatland	Jack pine treed on shallow peatland	0.36	22.27	168.36
	Tamarack- black spruce mixture on wet peatland	Tamarack- black spruce mixture on riparian peatland	10.15	49.56	374.62
		Tamarack- black spruce mixture on wet peatland	101.01	1,417.41	10,713.62
	Tamarack treed on shallow peatland	Tamarack treed on shallow peatland	128.12	664.59	5,023.40
	Tamarack treed on wet peatland	Tamarack treed on riparian peatland	0.94	9.28	70.14
		Tamarack treed on wet peatland	23.03	256.04	1,935.31
	Total Primary Habitat		13,227.61	112,591.13	851,031
Winter Caribou Habitat (Total Habitat	Black spruce treed on mineral soil	Black spruce treed on mineral soil	2,348.41	12,374.63	93,534.84
	Black spruce treed on shallow peatland	Black spruce treed on shallow peatland	8,437.26	46,928.84	354,716.12
	Black spruce treed	Black spruce treed	7,861.22	45,414.54	343,270.10

	V12 Coarse Habitat	V14 Coarse Habitat[1]	Zone of Effect (ha)	Local Study Area Existing Area (ha)	Study Zone 5 Existing Area (ha)
Loss)[4]	on thin peatland	on thin peatland			
	Black spruce treed on wet peatland	Black spruce treed on wet peatland	465.59	3,228.63	24,403.94
		Black spruce treed on riparian peatland	160.23	995.32	7,523.26
	Jack pine treed on mineral and thin peatland	Jack pine treed on mineral and thin peatland	327.17	1,230.00	9,297.05
	Jack pine treed on shallow peatland	Jack pine treed on shallow peatland	0.38	22.27	168.36
	Tamarack- black spruce mixture on wet peatland	Tamarack- black spruce mixture on riparian peatland	10.84	49.56	374.62
		Tamarack- black spruce mixture on wet peatland	131.82	1,417.41	10,713.62
	Tamarack treed on shallow peatland	Tamarack treed on shallow peatland	193.94	664.59	5,023.40
	Tamarack treed on wet peatland	Tamarack treed on riparian peatland	0.94	9.28	70.14
		Tamarack treed on wet peatland	25.92	256.04	1,935.31
	Total Primary Habitat		19,963.71	112,591.13	851,030.76

1. Coarse habitat type quantities limited based on age (< 1975)
2. Physical Habitat Loss: Zone 2
3. Effective Habitat Loss: Portion of Zone 3 not containing Zone 2
4. Total Habitat Loss: Zone 3

5.3.3.2 CARIBOU CALVING AND REARING HABITAT MODEL

5.3.3.2.1 VALIDATION OF THE CARIBOU CALVING AND REARING HABITAT QUALITY MODEL

Tracking and trail camera studies (2012) were used to test the modelled island in lake and peatland complex size classes. This was done to demonstrate if the presence of caribou calves and adults occurred at the expected rates based on island and peatland complex size classes identified from sampling data from previous years.

In 2012, 57 islands in lakes were sampled on multiple occasions. Of these, 25 were determined to be between 0.5 and 10 ha (*i.e.*, fitting the description of secondary calving and rearing habitat) and 31 were identified as being over 10 ha in size (primary calving and rearing habitat). A breakdown of the results for on how many islands caribou calves and adults were encountered is presented as Table 5-20.

Table 5-20: Caribou Calf and Adult Occupancy Rates for Islands in Lakes Surveyed on Stephens Lake in 2012

	Primary Calving and Rearing Habitat (>10 ha)	Secondary Calving and Rearing Habitat (0.5 – 10 ha)
Calves	20/31 (65%)	11/25 (44%)
Adults	29/31 (94%)	20/25 (80%)

Table 5-21 compares rates of island in lake occupancy, by caribou calves and adults, based on the 2012 data, with those rates derived using data from field studies in previous years. While there was some variation in the use of islands in lakes occupied by caribou calves and adults in 2012, compared to expected rates, values were similar; particularly as initial classes were not meant to be exhaustive in their predictive capabilities but only to serve as a useful modelling guideline.

Table 5-21: Island in Lake Use by Caribou Calves and Adults in 2012 Compared to Expected Rates

	Primary Calving and Rearing Habitat (>10 ha)		Secondary Calving and Rearing Habitat (0.5 – 10 ha)	
	Observed	Expected	Observed	Expected
Calves	65%	>25%	44%	<25%
Adults	94%	~90%	80%	~65%

During 2012 field studies of peatland complexes in Study Zone 5, 49 different complexes were surveyed. Of the 49 complexes surveyed, 27 were determined to be 30 to 200 ha in size (secondary caribou calving and rearing habitat) and 16 were over 200 ha (primary calving and rearing habitat). The portion of peatland complexes occupied by caribou calves and adults, based on the results of 2012 field studies, are presented in Table 5-22.

Table 5-22: Caribou Calf and Adult Occupancy Rates for Peatland Complexes in Zone 5 in 2012

	Primary Calving and Rearing Habitat (>200 ha)	Secondary Calving and Rearing Habitat (30 – 200 ha)
Calves	11/16 (69%)	11/27 (41%)
Adults	15/16 (94%)	16/27 (59%)

Peatland complex use in 2012, based on expected rates of use for primary and secondary caribou calving and rearing habitat, is provided in Table 5-23. Based on observations of caribou in 2012, there was high use of peatland complexes identified as primary calving and rearing habitat as 69% of these sampled areas had signs of caribou calves present. Alternately, 41% of surveyed peatland complexes identified as potential secondary calving and rearing habitat indicated the presence of

caribou calves. The rate of adult caribou observations on primary and secondary calving and rearing complexes were close to expected levels at 94 and 59%, respectively.

Table 5-23: Peatland Complex Use by Caribou Calves and Adults in 2012 Compared to Expected Rates

	Primary Calving and Rearing Habitat (>200 ha)		Secondary Calving and Rearing Habitat (30 – 200 ha)	
	Observed	Expected	Observed	Expected
Calves	69%	>45%	41%	<45%
Adults	94%	~90%	59%	~65%

Primary and secondary calving and rearing habitat use by caribou in 2012 indicated levels comparable with those expected from the model. Size classes for primary and secondary calving and rearing habitats were established to indicate the relative use of islands in lakes and surrounding peatland complexes. These standards, applied to the 2012 data, indicated some similarity in measured levels. Differences in observed rates of adult and calf caribou use compared to expected levels are within those limits acceptable in examining variation in natural habitat use patterns by caribou. Factors that may alter the yearly use of habitat areas by caribou include density dependence, where increased island in lake use by some may lead to the alternate use of peatland complexes by others. Other factors may include disturbances, or changes in predator numbers, where the needs for islands in lakes as refuges from predators become more or less important on a year-to-year basis.

5.3.3.2.2 APPLICATION OF THE CARIBOU CALVING AND REARING HABITAT QUALITY MODEL

Field surveys indicated the use of specialized areas as caribou calving and rearing areas in the Keeyask region. The size of sampled islands in lakes and peatland complexes was found to be an important variable for describing caribou use. This was based on sampling information that spanned multiple years. The area-based results of the application are described in Table 5-24.

Modelling islands in lakes and peatland complex size for calving and rearing indicated that islands over 10 ha in lakes were preferred by caribou calving and rearing activities as were peatland complexes greater than 200 ha. Islands between 0.5 – 10 ha in lakes were identified as potentially used for calving and rearing; although to limited extent, as were peatland complexes between 30 – 200 ha. While these size classes are useful indicators of islands in lakes and peatland complex use for calving and rearing activities, it should be noted that there is variation in the yearly use of these areas. In consideration of future monitoring, a power analysis was conducted to identify the statistical power available for determining the importance of islands in lakes and islands in peatland complexes and can be found in Appendix F.

The results for the caribou calving and rearing habitat models are detailed in Table 5-25 for Zone 2 plus the area of sensory disturbance (Zone 3 minus Zone 2), the Local Study Area and Regional Study Area, and are depicted in Map 5-18. See Appendix G for further calculations of the amount of calving and rearing habitat available in the Caribou Local and Regional Study Areas.

Table 5-24: Application of a Caribou Calving and Rearing Model for Islands in Gull and Stephens Lake

	Habitat Quality	Existing Environment (ha)
Study Zone 2	Primary	509.49
	Secondary	37.60
	Non	0.84
	Total	547.93
Local Study Area	Primary	5,664.63
	Secondary	316.95
	Non	236.66
	Total	6,218.24
Study Zone 5	Primary	13,107.54
	Secondary	1,164.40
	Non	937.63
	Total	15,209.29

Table 5-25: Habitat Quality Changes Following the Development of the Keeyask Generation Project Based on the Application of a Caribou Calving and Rearing Model for Peatland Complexes in the Keeyask region

	Habitat Quality	Zone of Effect Existing Area (ha)	Study Zone 4 Existing Area (ha)	Study Zone 5 Existing Area (ha)[1]
Physical habitat loss (Study Zone 2)	Primary	0	5,675.95	19,086.00
	Secondary	69.03	2,596.44	4,914.47
	Non	0	253.12	498.04
	Total	69.03	8,525.51	24,498.52
Effective habitat loss (Study Zone 3 without Study Zone 2)	Primary	0	5,675.95	19,086.00
	Secondary	674.40	2,596.44	4914.47
	Non	0	253.12	498.04
	Total	674.40	8,525.51	24,498.52
Total habitat loss (Study Zone 3)	Primary	0	5,675.95	19,086.00
	Secondary	743.43	2,596.44	4,914.47
	Non	0	253.12	498.04
	Total	743.43	8,525.51	24,498.52

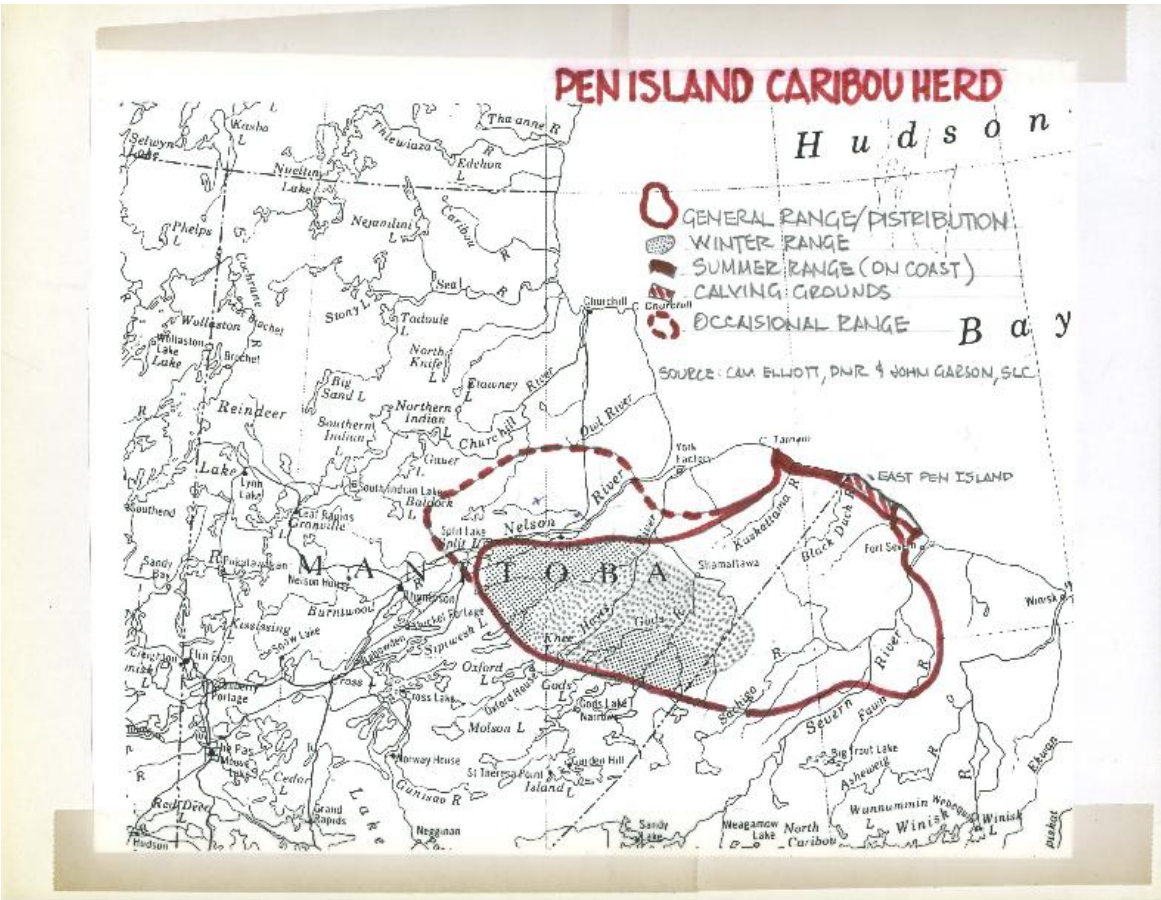
1. Only 69% of Regional Study Area mapped with peatland complex areas identified

5.4 CONCLUSIONS

The caribou winter habitat model performed reasonably well, based on the relatively high use of mature black spruce dominated coarse habitat types as predicted. The model, as is, appears to slightly over-estimate habitat availability, especially with respect to the use of tamarack. Additional data would be required to strengthen and test the existing model.

The caribou calving and rearing habitat model performed reasonably well. Based on the validation, it underestimated the importance of the smaller island size group. The peatland complex grouping was more accurate. Based on annual variation in the use of islands in lakes and peatland complexes, it was only possible to predict an average rate of use without associated confidence intervals. More years of sampling information would allow a model with improved predictive capabilities to be built. It should be understood, however, that there are a variety of factors which can influence caribou habitat use during the calving and rearing period (*e.g.*, inter-species and intra-species density dependence responses, environmental factors) that can be explored. While models can be built to accommodate such changes, additional sampling data would be needed to accommodate for these sources of variability and to identify those seasons which can be properly assessed as outliers and alternately considered for analysis purposes.

5.5 MAPS



Map 5-1: Range of the Pen Islands Herd in 1995 (W. Kennedy *pers. comm.* 2013)

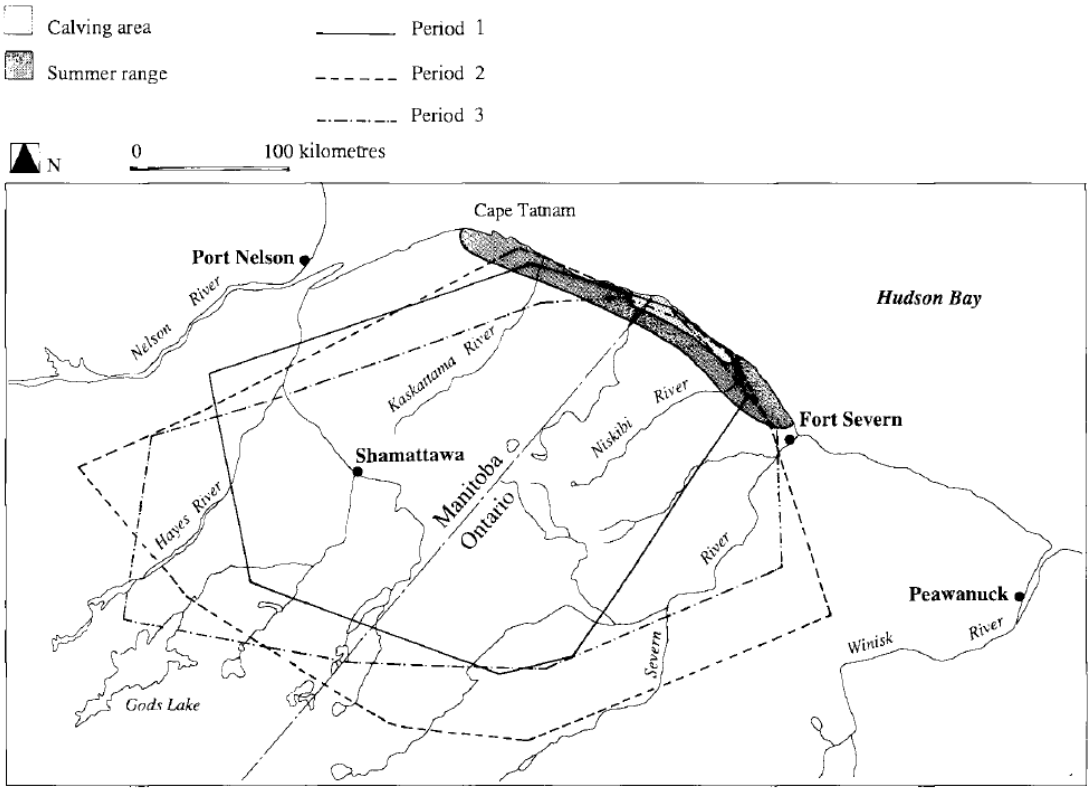
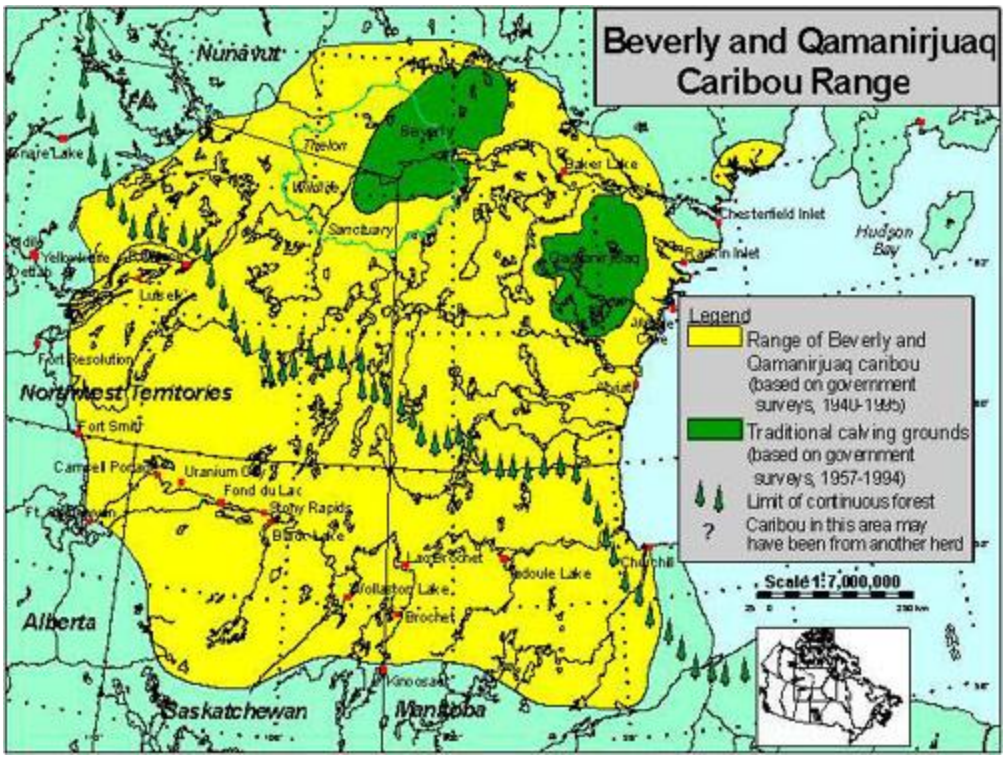
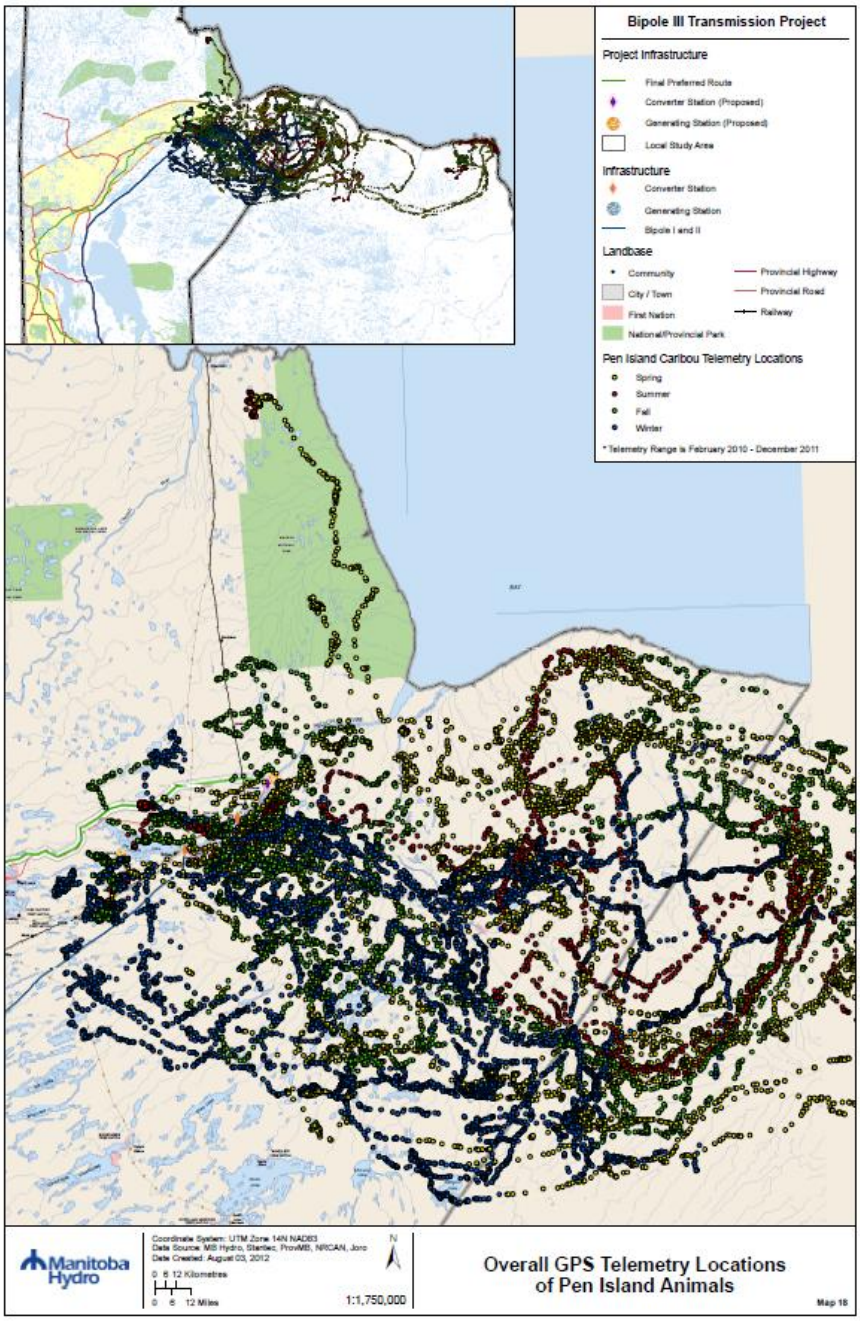


Fig. 2. Annual range of Pen Islands caribou herd showing calving area and summer areas and outer convex polygon of all fall-winter radio telemetry locations in each year (Period 1= Sept.1987- June 1988; Period 2 = Sept. 1988 - July 1989; Period 3 = Sept. 1989 - March1990).

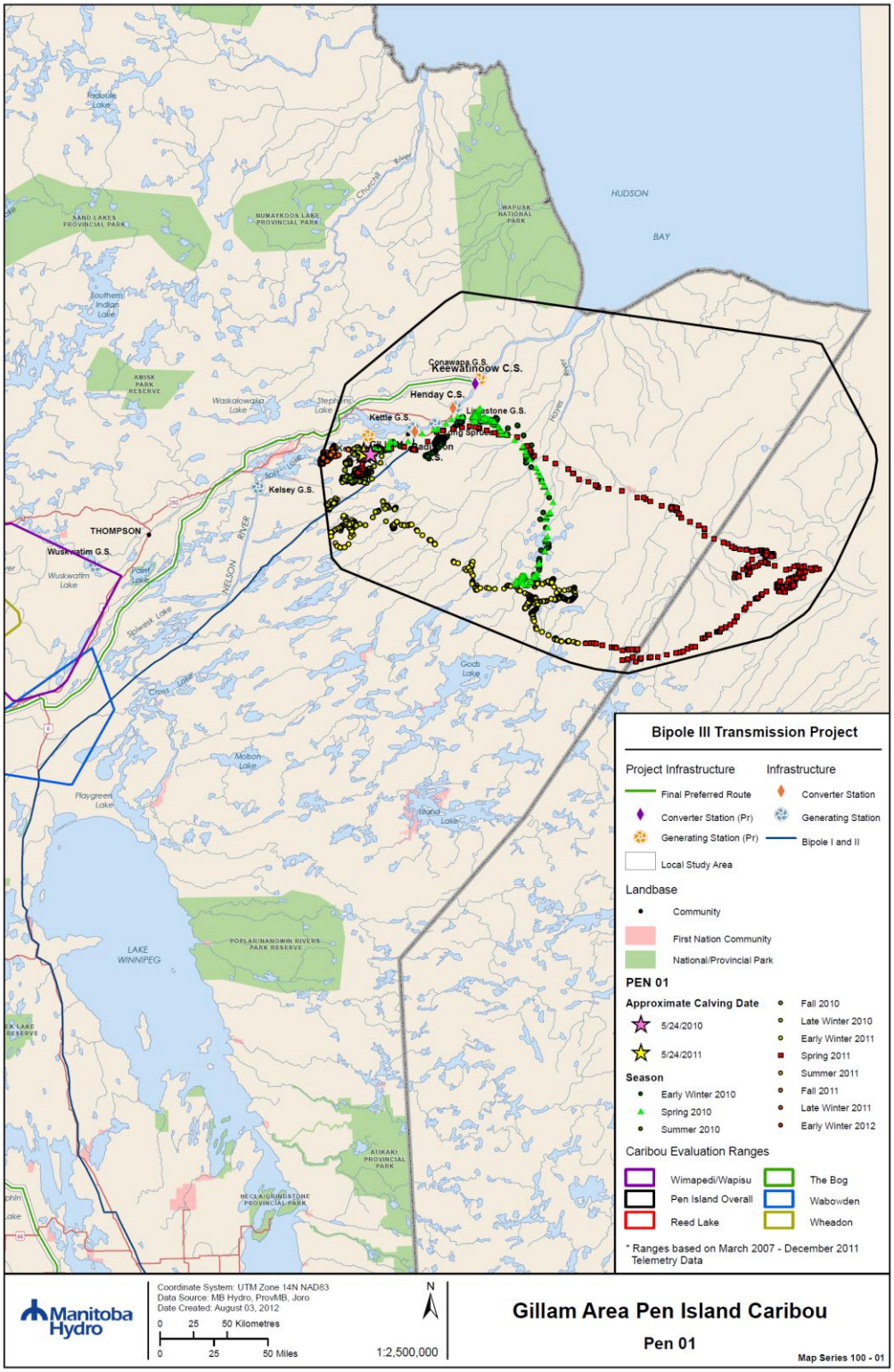
Map 5-2: Pen Islands Caribou Range (Abraham and Thompson 1998)



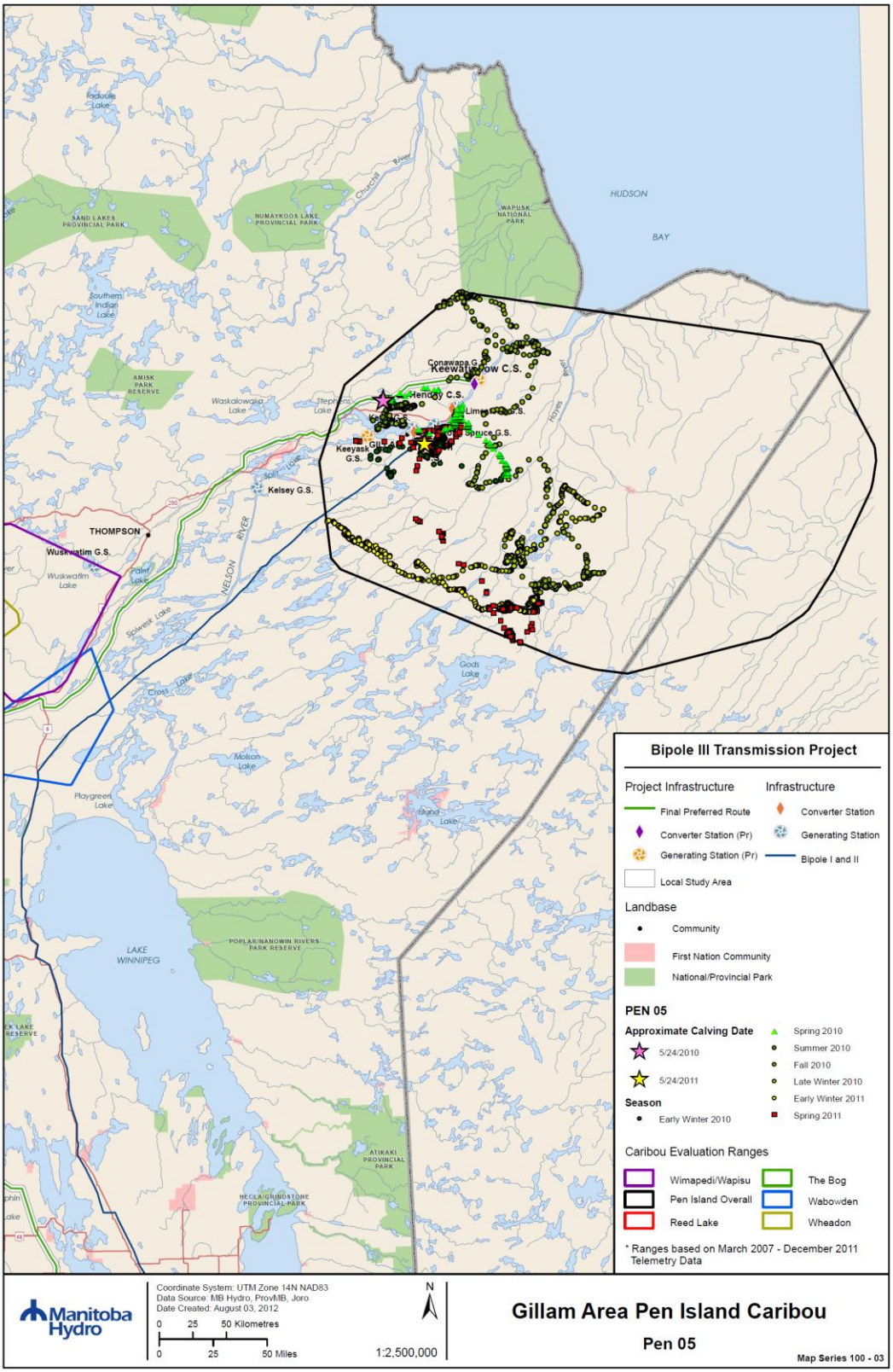
Map 5-3: Annual Range of Beverly and Qamanirjuaq Caribou Herds (Beverly and Qamanirjuaq Management Board 2013)



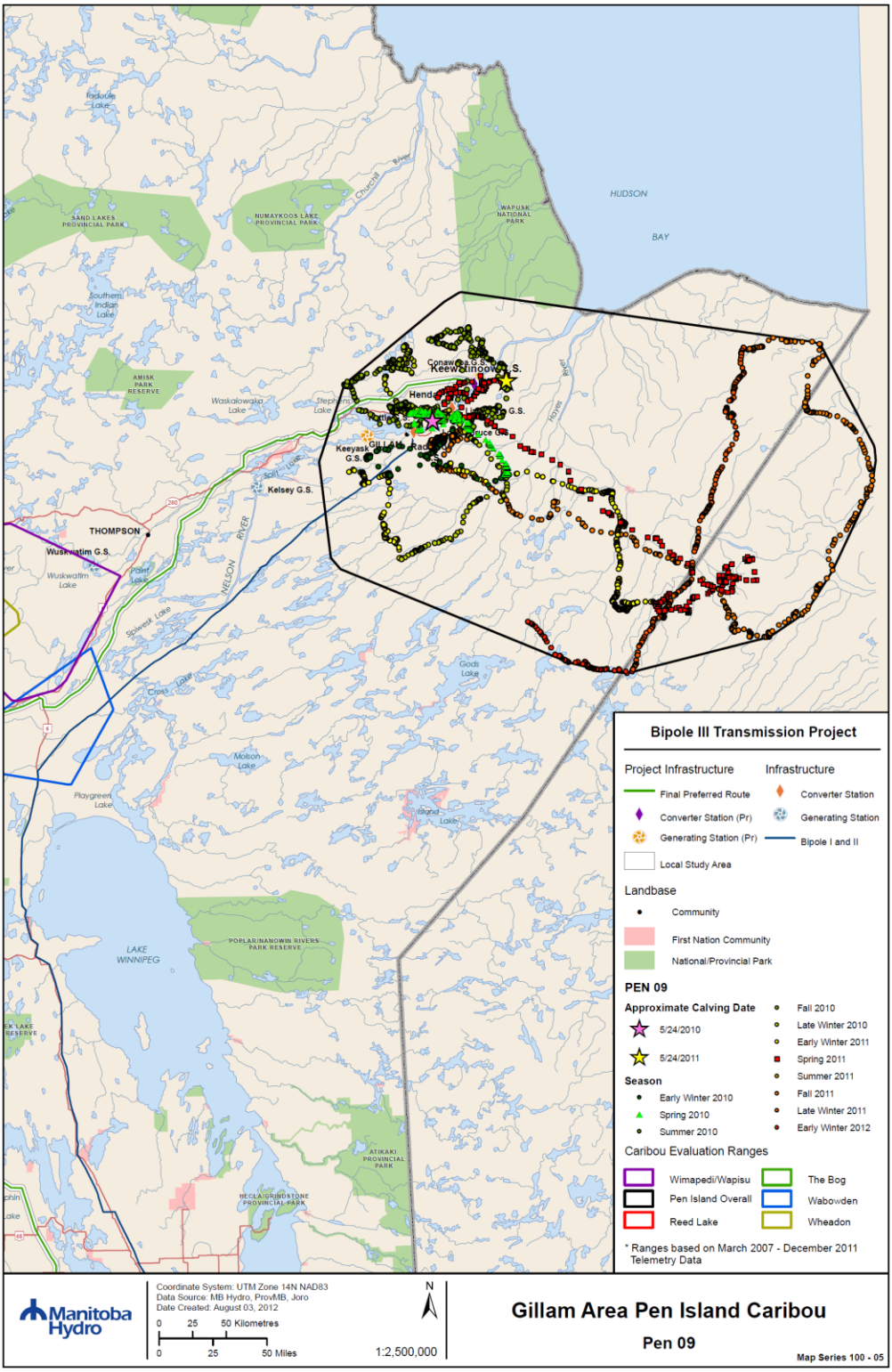
Map 5-4: Telemetry Locations of Pen Islands Caribou In and Near the Regional Study Area (Manitoba Hydro 2012)



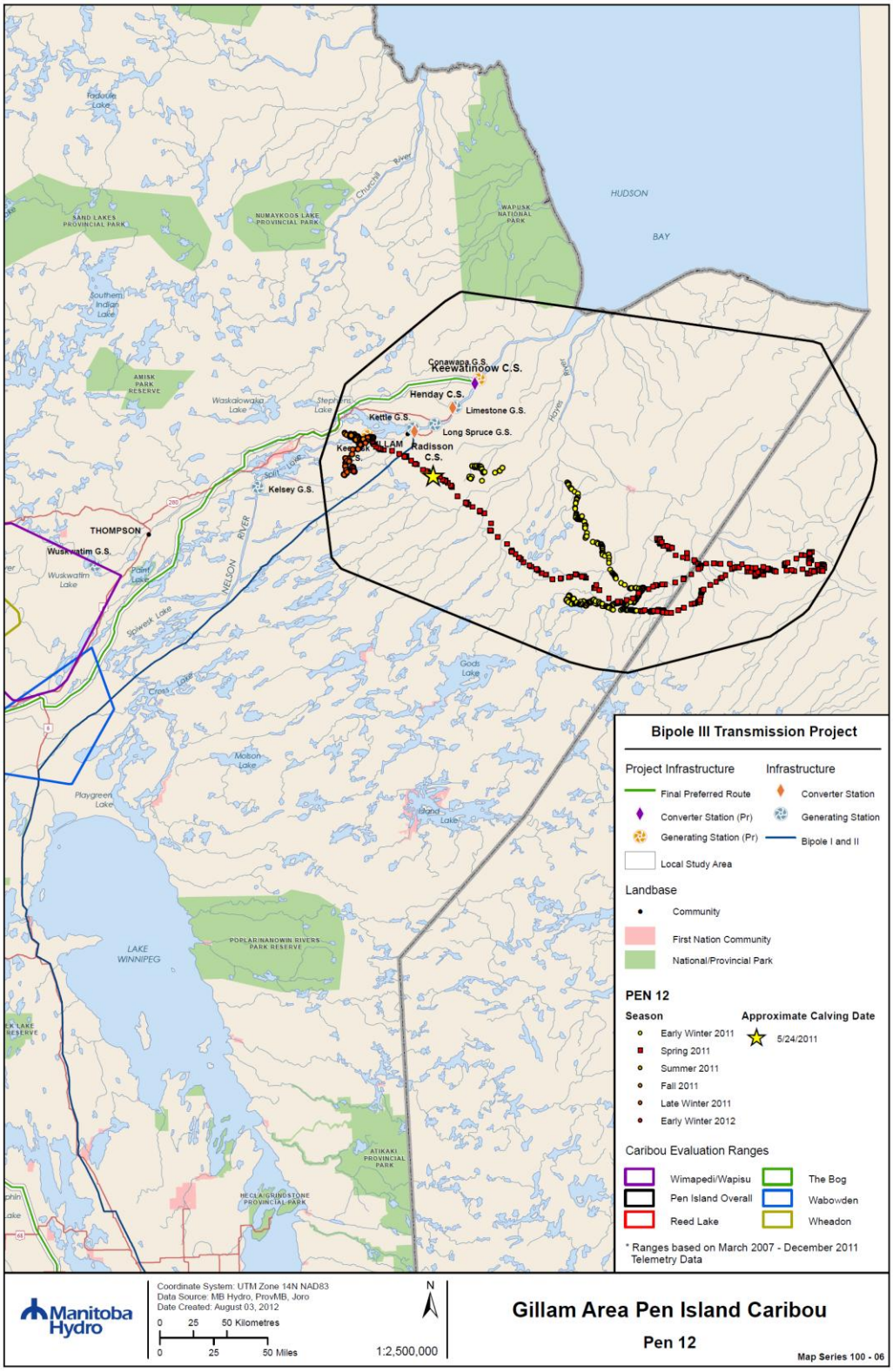
Map 5-5: Movements of Radio-collared Pen Islands Caribou – Pen 01 (from Manitoba Hydro 2012)



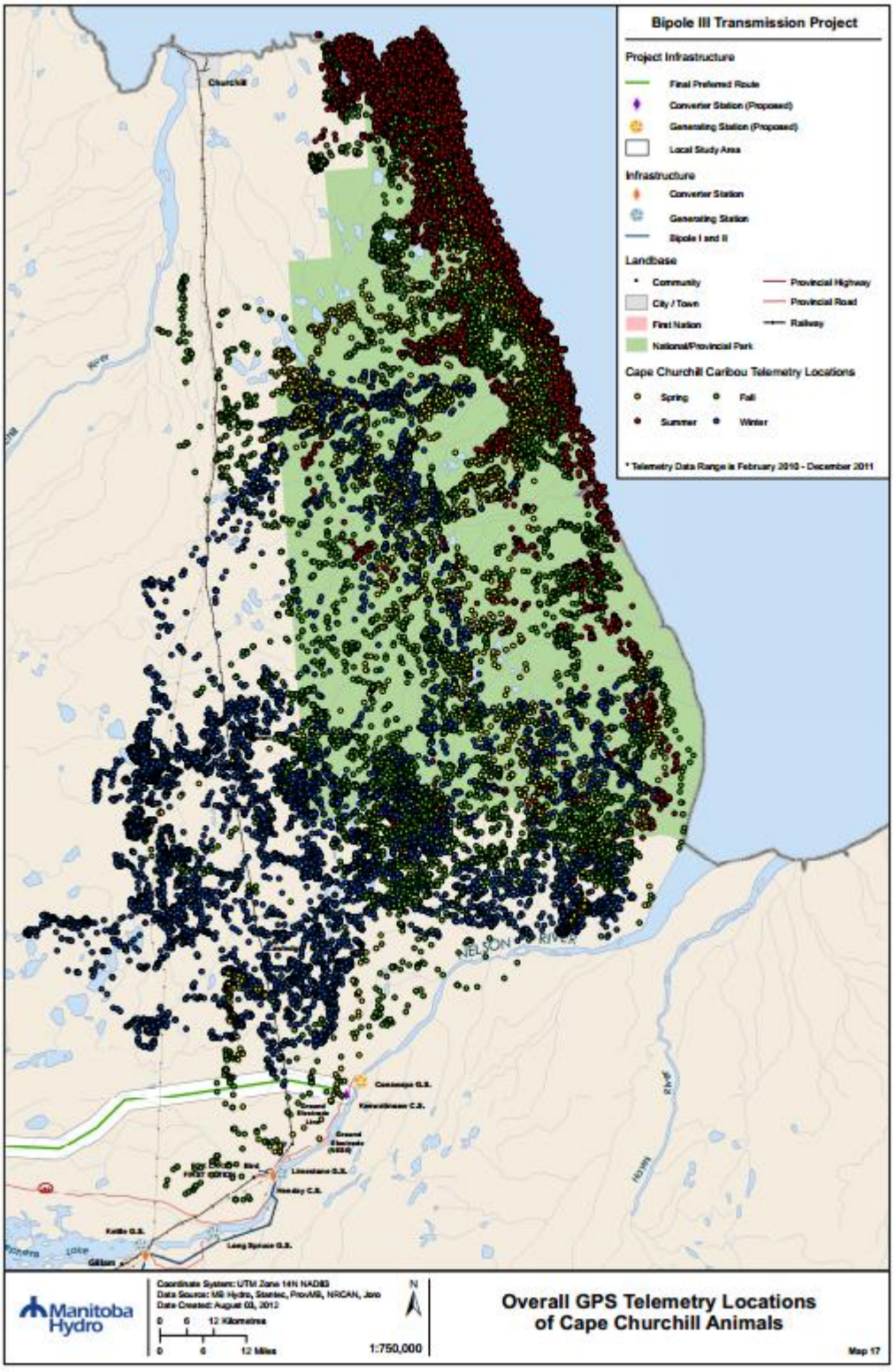
Map 5-6: Movements of Radio-collared Pen Islands Caribou – Pen 05 (from Manitoba Hydro 2012)



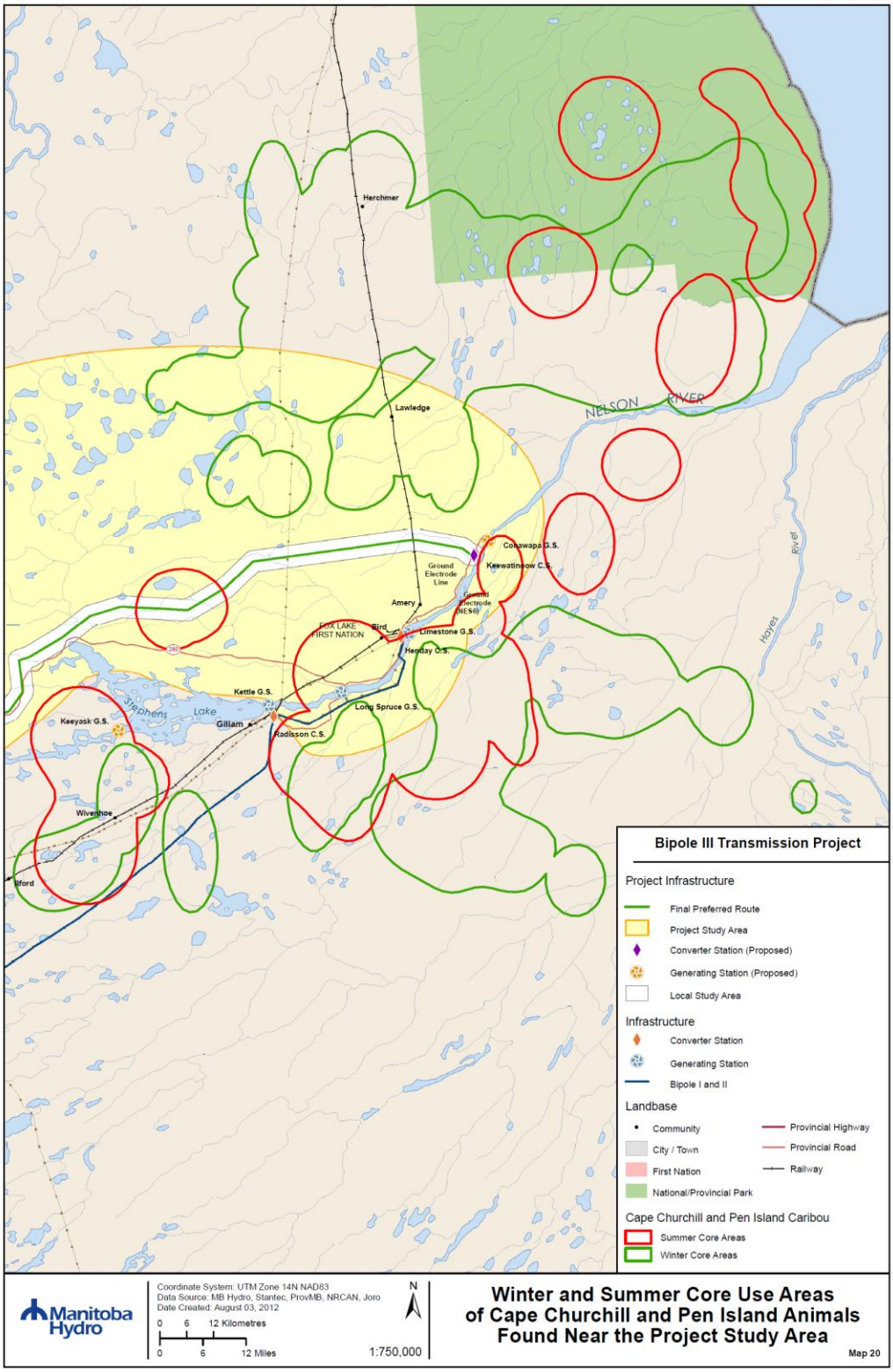
Map 5-7: Movements of Radio-collared Pen Islands Caribou – Pen 09 (from Manitoba Hydro 2012)



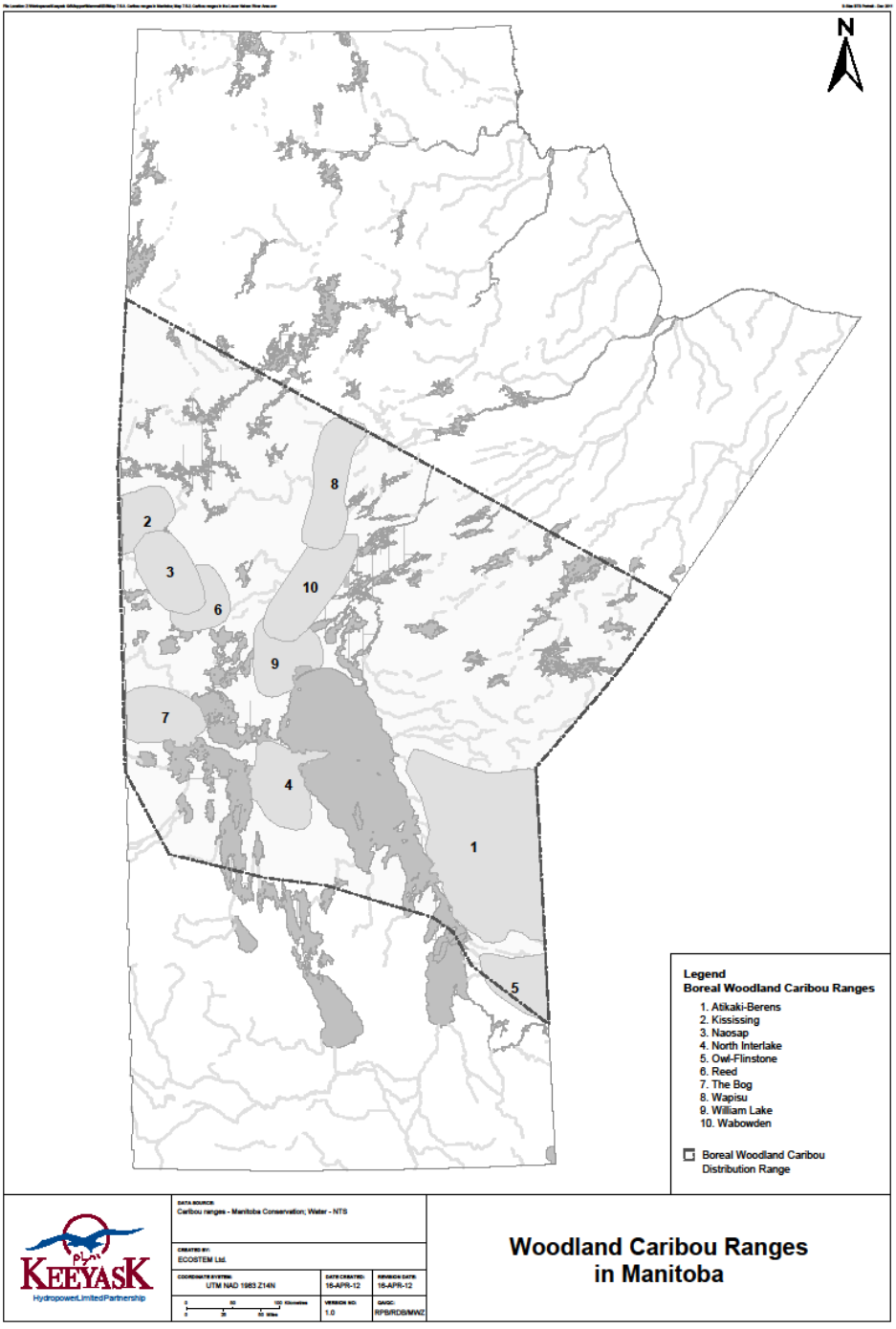
Map 5-8: Movements of Radio-collared Pen Islands Caribou – Pen 12 (from Manitoba Hydro 2012)



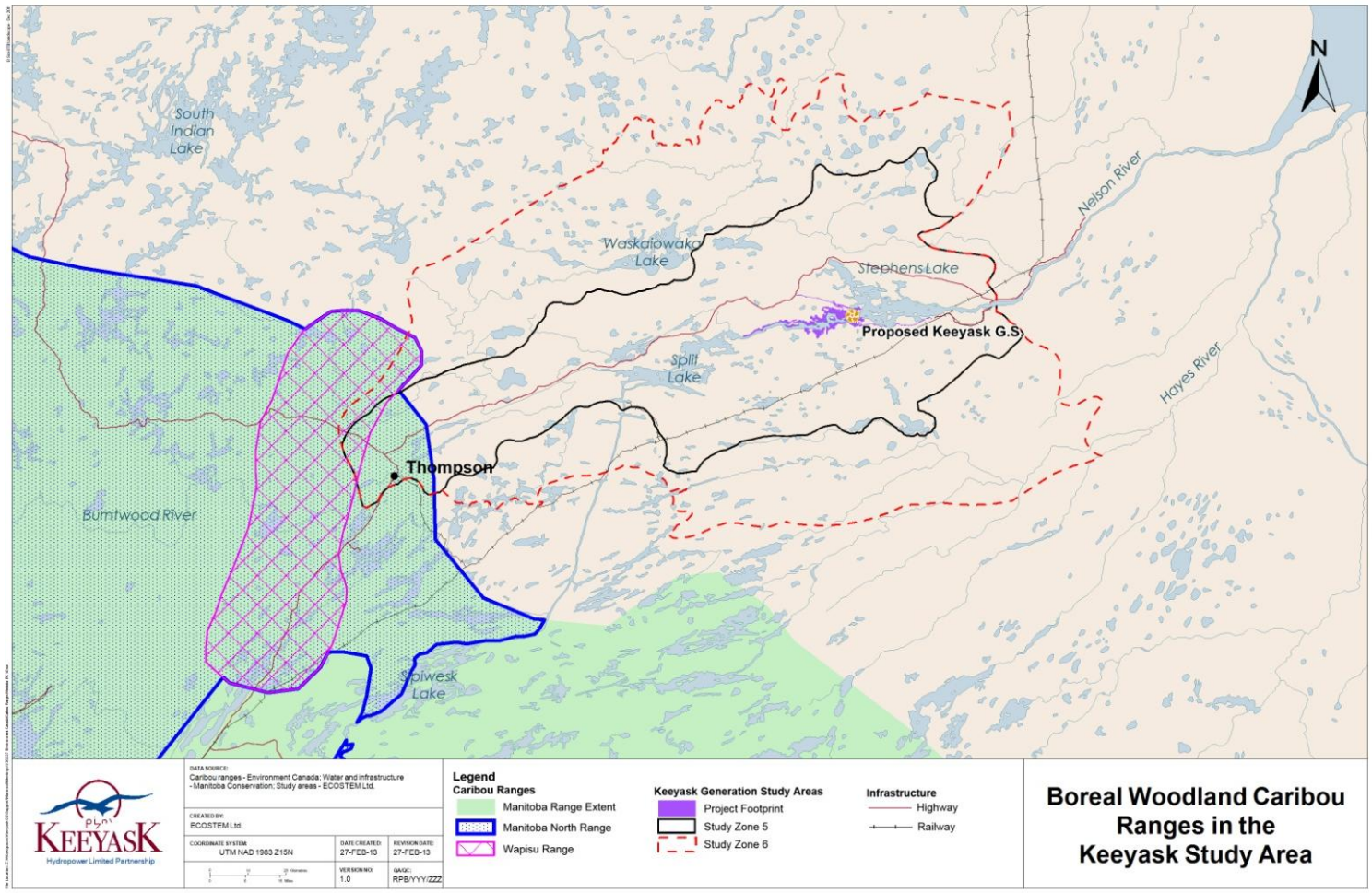
Map 5-9: Telemetry Locations of Cape Churchill Caribou In and Near the Regional Study Area (from Manitoba Hydro 2012)



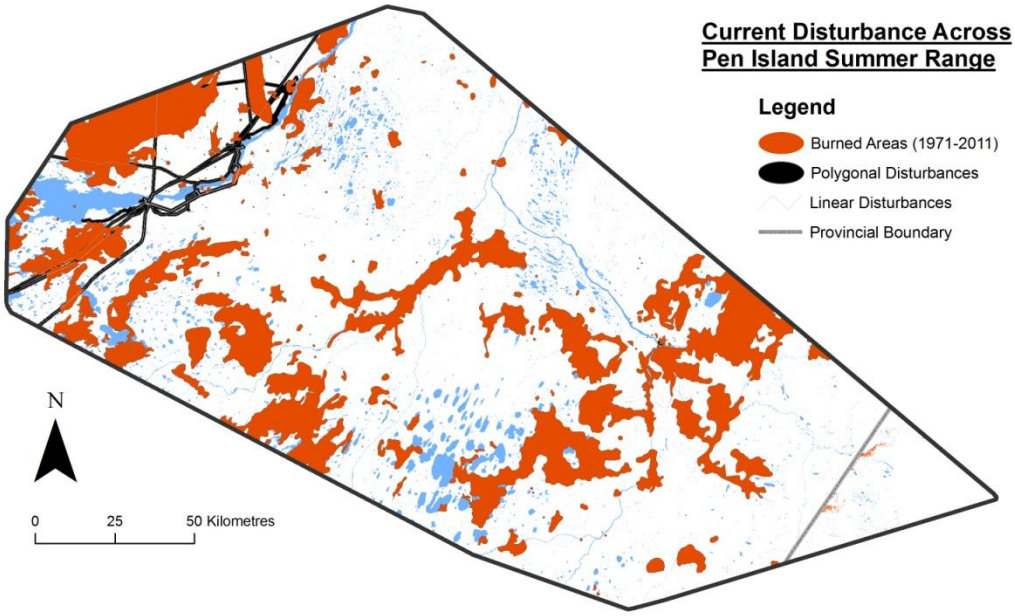
Map 5-10: Winter and Summer Core Use Areas of Cape Churchill and Pen Islands Caribou Found Near the Project Study Area (from Manitoba Hydro 2012)



Map 5-11: Boreal Woodland Caribou Ranges in Manitoba



Map 5-12: Boreal Woodland Caribou Ranges in the Keeyask Region



Pen Island (Combined)		
Evaluation Range Attributes	Pen Island Range Area Total*	29,808 km2
	Pen Island Range Manitoba Portion Area* *(96% of total evaluation range)*	28,514 km2
	Pen Island Range Ontario Portion Area*	1,294 km2
	Population Size**	N/A
Determination of Habitat Amount	Range Area	29,808 km2 (100%)
	Pen Island Range Manitoba Portion Disturbance	6592 km2 (22%)
	Pen Island Range Ontario Portion Disturbance	14 km2 (0.1%)
	Total Current Habitat Disturbance	6606 km2 (22%)
	Total Available Undisturbed Habitat	23202 km2 (78%)

*Range Area excludes water

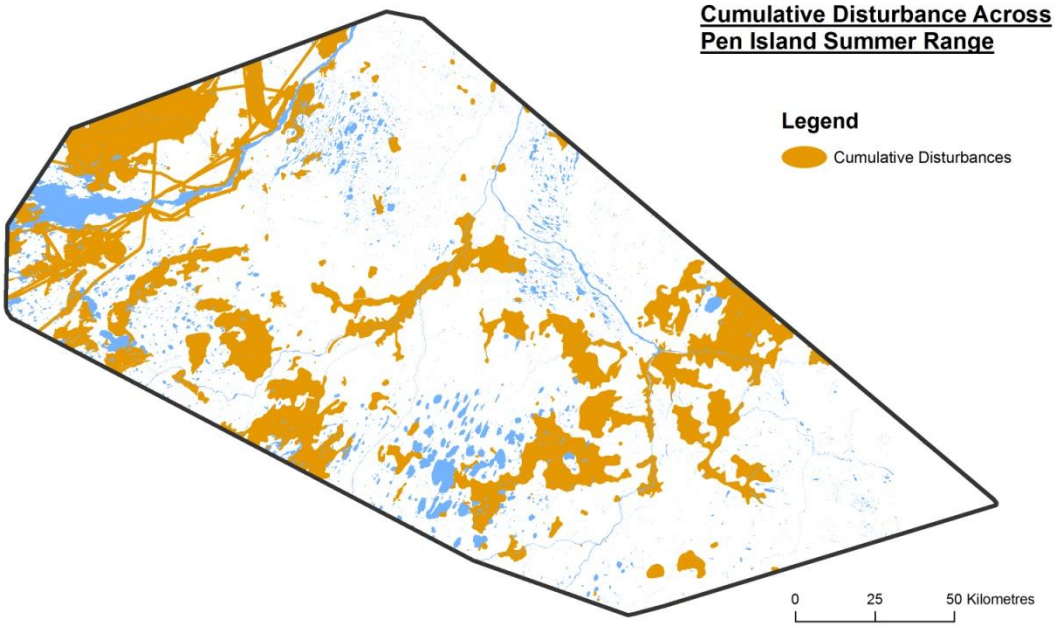
**Population size is not currently available within the evaluation range

Pen Island (Manitoba Portion)		
Evaluation Range Attributes	Range Area Total*	28,514 km2
	Natural Disturbance	5959 km2
	Anthropogenic Disturbance	561 km2
	FPR Disturbance	15 km2
	Total Disturbance	6535 km2
	Population Size**	N/A
Determination of Habitat Amount	Range Area	28,514 km2 (100%)
	Natural Disturbance	5959 km2 (21%)
	Anthropogenic Disturbance	561 km2 (2%)
	FPR Disturbance	15 km2 (0.1%)
	Total Current Habitat Disturbance	6535 km2 (23%)
	Available Undisturbed Habitat	21,979 km2 (77%)

*Range Area excludes water

**Population size is not currently available within the evaluation range

Map 5-13: Disturbance Across Pen Islands Summer Range (from Manitoba Hydro 2012)

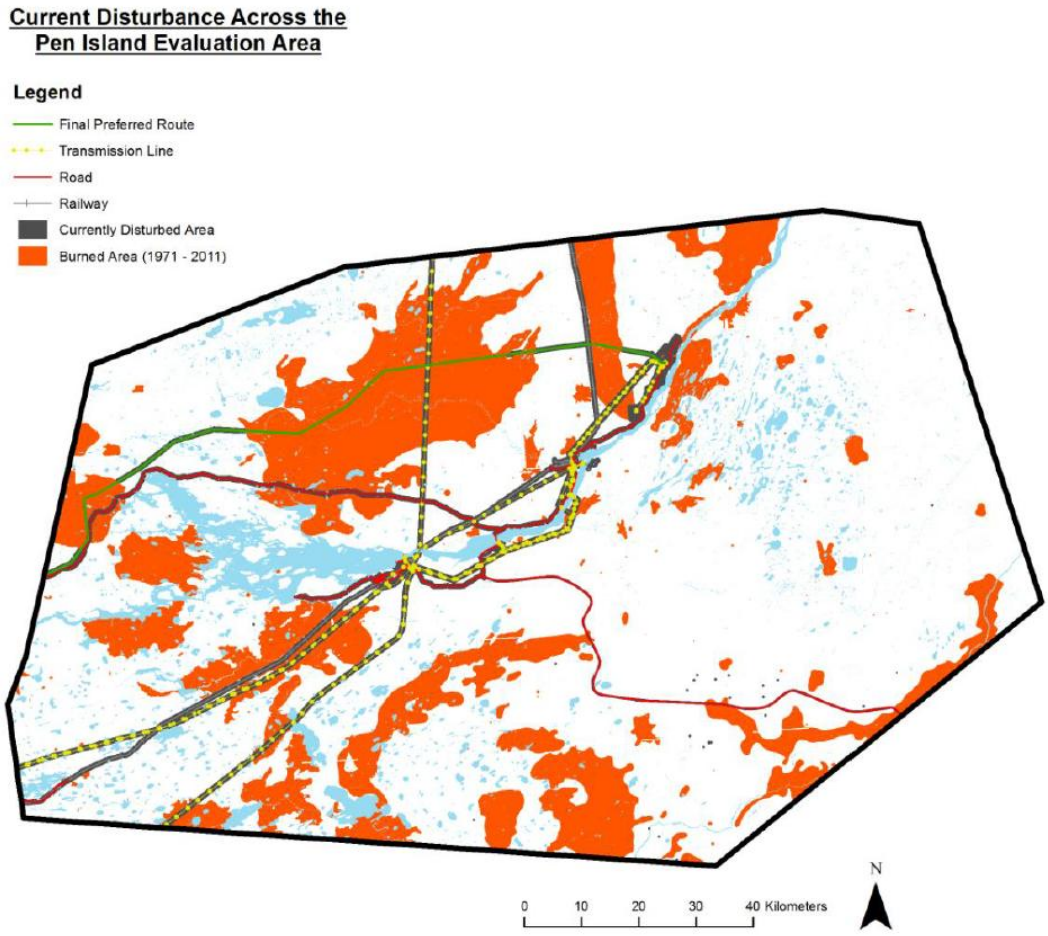


Pen Island (Manitoba Portion)		
Evaluation Range Attributes	Range Area Total*	28,514 km2
	Current Disturbance	1364 km2
	Future Disturbance	116 km2
	FPR Disturbance	15 km2
	Total Cumulative Disturbance	1495 km2
	Population Size**	N/A
Determination of Habitat Amount	Range Area	28,514 km2 (100%)
	Current Disturbance	1364 km2 (5%)
	Future Disturbance	116 km2 (0.4%)
	FPR Disturbance	15 km2 (0.1%)
	Total Cumulative Disturbance	1495 km2 (5%)
	Available Undisturbed Habitat	27,019 km2 (95%)

*Range Area excludes water

**Population size is not currently available within the evaluation range

Map 5-14: Cumulative Disturbance Across Pen Islands Summer Range (from Manitoba Hydro 2012)

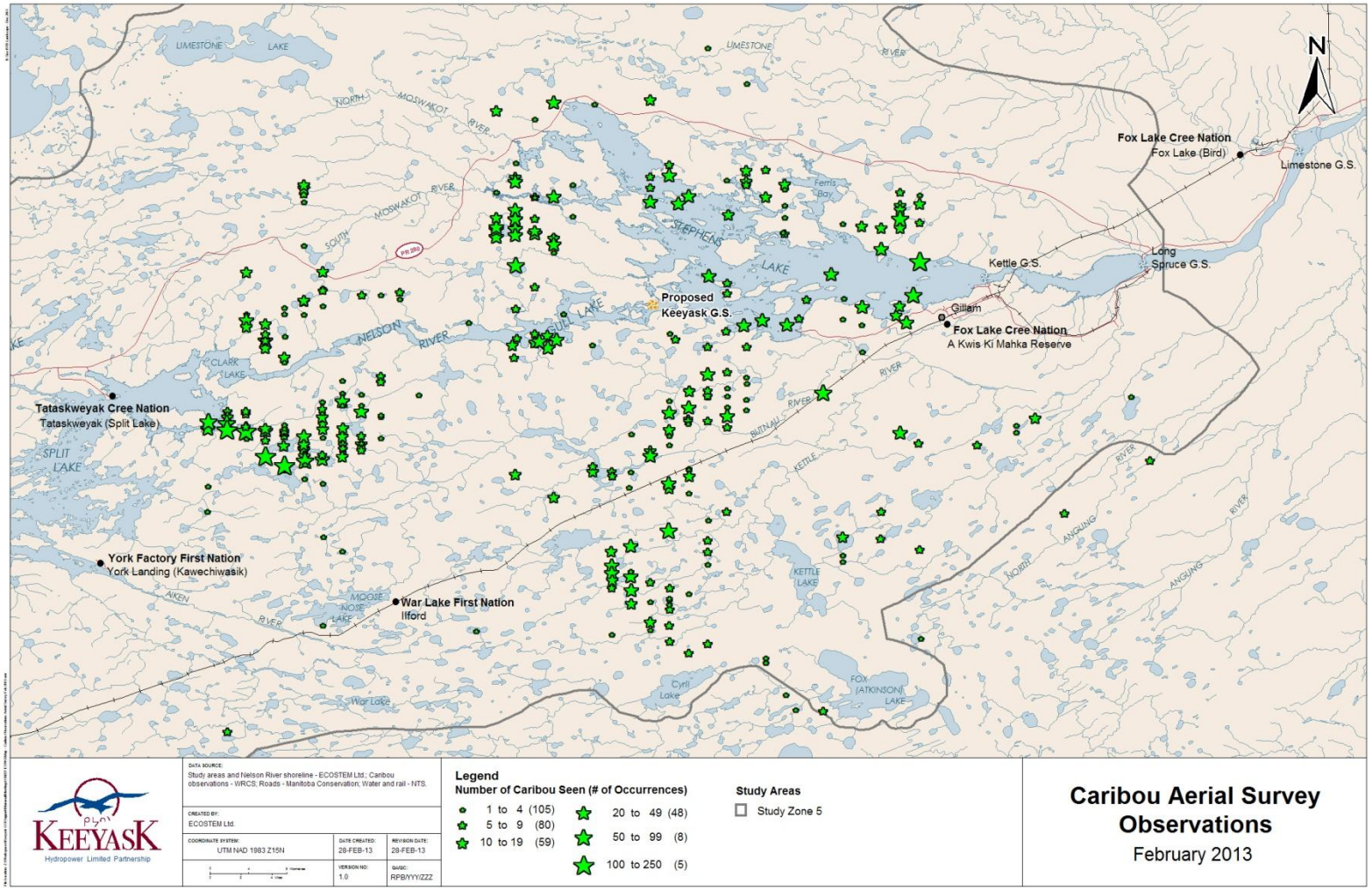


Pen Island		
Evaluation Area Attributes	Evaluation Area Size*	14,695 km^2
	Population Size**	N/A
	Current Habitat Disturbance	4,043 km^2
Determination of Habitat Amount	Evaluation Area Size*	14,695 km^2 (100%)
	Current Habitat Disturbance	4,043 km^2 (28%)
	Total Available Undisturbed Habitat	10,652 km^2 (72%)

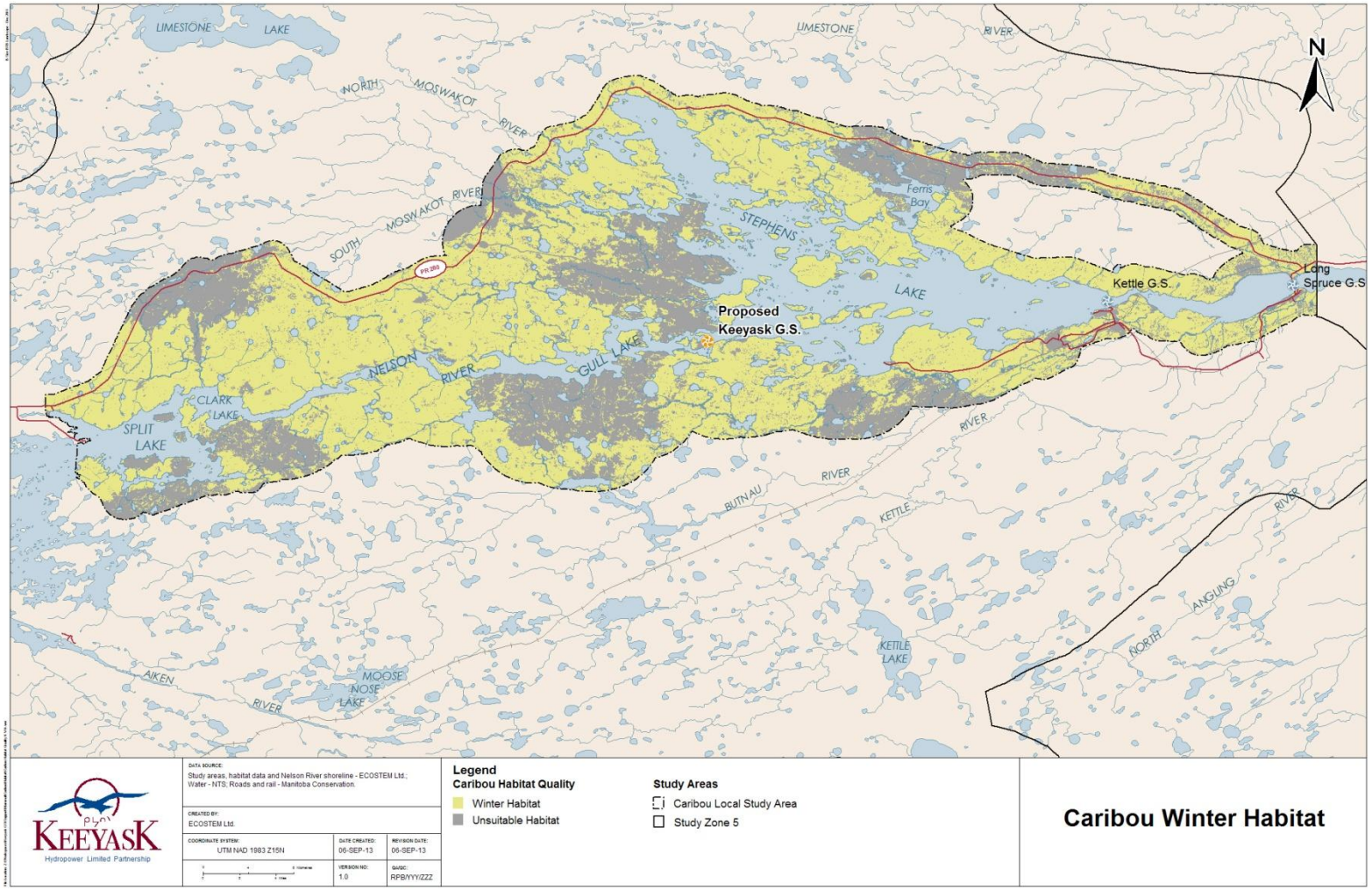
**Range Area excludes water*

***Population size is not currently available within current evaluation range*

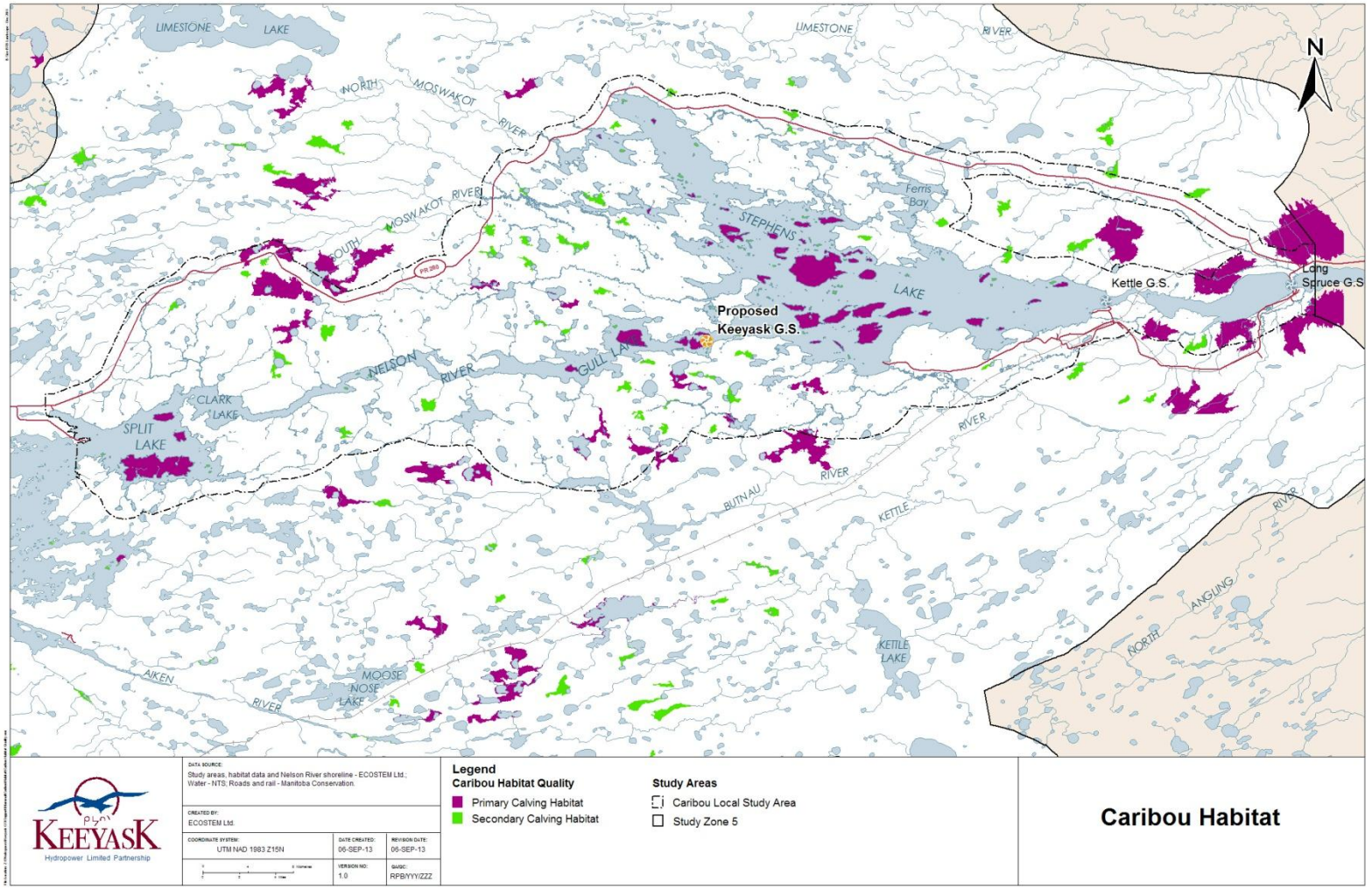
Map 5-15: Current Disturbance Within the Pen Islands Core Use Summer Area (from Manitoba Hydro 2012)



Map 5-16: Locations of Pen Islands Caribou in the Keeyask Region Based on February 2013 Aerial Survey



Map 5-17: Caribou Winter Habitat



Map 5-18: Caribou Calving and Rearing Habitat

6.0 BEAVER

6.1 SPECIES OVERVIEW FROM LITERATURE

6.1.1 GENERAL LIFE HISTORY

The beaver (*Castor canadensis*) is capable of creating aquatic habitats and altering terrestrial habitats for many wildlife species. The beaver is the largest rodent in North America (Müller-Schwarze and Sun 2003). Due to the placement of the eyes, ears, and nostrils; the size of fore and hind limbs; and a large flattened tail, the beaver is highly adapted for life in aquatic environments (Baker and Hill 2003). Although strong and efficient swimmers, beaver are awkward on land. However, they manage to harvest a sufficient number of trees to maintain their energy requirements.

Beaver is a keystone species that have been documented impacting both the physical and biological environment in which they live (Naiman *et al.* 1986), and create habitat for insects, birds and other mammals. Found primarily in forested areas with nearby water bodies, beaver are most active from dusk to dawn (Allen 1982). Beaver modify their natural environment to maximize their foraging potential and to increase survival. They gain access to additional food sources in the summer and stored caches in the winter by building dams, canals, and lodges (Müller-Schwarze and Sun 2003). Waterways are dammed and flooded to ensure depth is sufficient so as not to freeze to the bottom, which would reduce beaver mobility and disconnect them from their food caches in the winter (Butler 1991). Lodges are built above the water line in the fall and typically have a feeding den, a resting den, fresh air source and multiple exit tunnels to escape from predators (Jenkins and Busher 1979; Allen 1982; Collen and Gibson 2001; Müller-Schwarze and Sun 2003).

6.1.2 DISTRIBUTION AND ABUNDANCE

6.1.2.1 CONTINENTAL AND GLOBAL

Baker and Hill (2003) describe beaver as widely distributed throughout North America, across the majority of the United States and Canada and into northern Mexico. The beaver's continental range excludes the arctic tundra, possibly due to the lack of woody vegetation for food and the formation of thick winter ice on water bodies, which limits access to the surface (Baker and Hill 2003).

After the settlement of North America by Europeans, beaver populations were heavily trapped, resulting in severely decreased populations and extirpation from areas of their natural range (Baker and Hill 2003). These declines were reversed with the implementation of hunting and trapping regulations, designation of hunting and trapping seasons, and reintroduction to former ranges (Baker and Hill 2003). These efforts resulted in the

re-establishment of beaver populations in much of their natural North American range (Baker and Hill 2003). In the 1980s the North American population was estimated at 6 to 12 million individuals (Naiman *et al.* 1986; Naiman *et al.* 1988), compared with 40-60 million individuals prior to European settlement (Seton 1929). Beaver populations in many areas are now at healthy levels and management priorities have shifted from conservation to limiting damage to human infrastructure (Canadian Wildlife Service 2011).

6.1.2.2 PROVINCIAL

Beaver are widespread, abundant, and secure throughout Manitoba and are considered a problem wildlife species by the Wildlife Branch of Manitoba Conservation and Water Stewardship (Manitoba Conservation and Water Stewardship no date; NatureServe 2012). In an effort to manage problem beaver Manitoba Conservation implemented a subsidy to trappers of $20 per beaver in 1993 to reduce problem beaver incidents (Manitoba Conservation and Water Stewardship no date). Beaver problems are especially prevalent in western Manitoba around the Riding Mountain National Park and Duck Mountain areas (Manitoba Conservation and Water Stewardship no date).

6.1.2.3 REGIONAL STUDY AREA

Scientific data reflecting the specific abundance and distribution of beaver are not available in the region. Beaver have been heavily trapped in the past for their fur. They were the most commonly trapped furbearers in the 1930s, but were scarce in areas other than the vicinity of the Churchill River (Split Lake Cree 1996a). Prices for fur, particularly beaver, began to decline in the early 1950s (Split Lake Cree 1996a). A recovery in the mid-1970s and early 1980s is reflected in the Split Lake harvesting data (Split Lake Cree 1996a).

Beaver are widely distributed and commonly trapped in the Split Lake Resource Management Area (SLRMA), the Fox Lake Resource Management Area, and York Factory First Nation's Trapline 13 in the York Factory Resource Management Area. Beaver harvest from 1996 to 2009 comprised 13% of total fur production in the Regional Study Area (Manitoba Conservation and Water Stewardship unpubl. data).

In the SLRMA, beaver comprised 32% of total fur production from 1960 to 1996 (Split Lake Resource Management Board unpubl. data). On average, 500 beaver have been harvested annually in the Regional Study Area between 1996 and 2008 (Manitoba Conservation and Water Stewardship unpubl. data). The number of beaver harvested from the Resource Use Regional Area between 1996 and 2008 averaged five beaver per trapline per year (SE SV).

6.1.2.4 LOCAL STUDY AREA

Scientific data are not available at this level, but abundance and distribution are expected to be similar to the region.

6.1.3 FACTORS THAT INFLUENCE DISTRIBUTION AND ABUNDANCE

6.1.3.1 SEASONAL FORAGE AND WATER

Beavers are herbivores that feed mainly on herbaceous and woody plants (Baker and Hill 2003). Beavers tend to shift from a woody diet in winter to an herbaceous diet in spring and summer (Jenkins and Busher 1979; Clements 1991). Preferred forage species vary by region; however, the leaves and growing tips of willow, poplar, and alder (Baker and Hill 2003) and some aquatic plants (Jenkins 1980) are generally consumed. Although feeding varies annually, geographically, and seasonally, it appears that beaver maximize their protein intake and minimize their potassium to sodium ratio and their energy output (Jenkins and Busher 1979). Beaver have also been observed using alder as structural material instead of food (Slough 1978).

Deciduous woody plants are usually the most important component of beaver diet and the primary limiting factor in winter (Novak 1998). Winter food caches are piled in deep water near the lodge to ensure underwater access to them throughout winter (Lancia *et al.* 1982). Winter food preferences include bark from trembling aspen, poplar, willow, birch, cottonwood, and alder; additional summer food sources include sedges, grasses, as well as water lily and cattail roots and stems.

As beaver deplete their surrounding food supply, they must forage further from their lodge, which increases their susceptibility to terrestrial predators (Baker and Hill 2003). One acre of aspen produces enough food to sustain 10 beaver for 1 year (Brenner 1962). Beaver often over-consume surrounding woody species and must migrate to a new location (Clements 1991). With increasing distance from the shore, beaver actively select smaller trees (Jenkins 1980). Beaver cut more trees in fall, when alternate food sources become scarce, to fulfill current and upcoming winter food requirements (Jenkins 1980; Allen 1982). Abandonment of sites is often attributed to floods on larger streams or depletion of food resources on smaller streams (Rutherford 1953).

Beavers prefer a seasonably stable water level. Water depth and stability is controlled on small streams and ponds, but larger rivers and lakes water depth or fluctuation cannot be controlled, and may not be suitable as beaver habitat (Slough and Sadleir 1977). Large lakes that are circular or without bays are not suitable habitat (Allen 1983). In streams, gradient is important in determining suitability of habitat for beavers; steep profiles in excess of 12% slope are rarely used (Slough and Sadleir 1977).

6.1.3.2 SECURITY

The lodge is the major source of escape, resting, thermal, and reproductive cover (Jenkins and Busher 1979; Photo 6-1). Lodges and burrows are constructed in part for protection from predators (Baker and Hill 2003). There may be several active or inactive lodges in a beaver territory (Baker and Hill 2003).

Photo 6-1: Beaver Lodge in Northern Manitoba

6.1.3.3 THERMAL COVER

Lodges and burrows are used for protection from the weather (Baker and Hill 2003).

6.1.3.4 BREEDING

Beaver are monogamous and live in family units commonly referred to as colonies (Baker and Hill 2003). Colonies typically consist of an adult breeding pair, yearlings, young of the year, and kits (Baker and Hill 2003). The density of colonies depends mainly on the quality of surrounding habitat (Collen and Gibson 2001). Females have their first litter at the age of one and a half or two years (Baker and Hill 2003; Müller-Schwarze and Sun 2003). Breeding occurs once a year in winter, generally from January to March (Novak 1998).

6.1.3.5 LITTERS AND REARING

After a gestation period of approximately 100 days the kits are born in spring (Baker and Hill 2003). An average of three or four kits is born per litter in North America (Novak 1998). Beavers in northern areas tend to have larger litters (Baker and Hill 2003).

6.1.3.6 DISPERSAL

At approximately two years of age, beaver migrate from their family group in search of a mate and suitable habitat to start a colony of their own (Allen 1982; Clements 1991; Müller-Schwarze and Sun 2003**)**. Subadults may remain in the colony if resources are scarce (Baker and Hill 2003). Entire colonies can also move between ponds in a territory (Baker and Hill 2003). Dispersal distances can vary between sexes and direction. In New York, the majority (74%) of dispersing beavers initiated dispersal in a downstream direction after ice-out, and females dispersed significantly farther away than males (Sun *et al.* 2000). In Idaho, Leege (1968) found that the average dispersal distance was 8 km, with a maximum of 18 km. In Manitoba, Wheatley (1989) measured dispersal the distances of two beaver at 24 and 36 km respectively, including at least 1 km overland in the latter case.

6.1.3.7 FACTORS THAT REDUCE EFFECTIVE HABITAT

6.1.3.8 MORTALITY

6.1.3.8.1 PREDATION

Aquatic habitat provides beaver with protection from predators (Naiman *et al.* 1988), which can be a major driver of beaver populations. Beaver are exposed to many natural predators when foraging on shore or migrating. Gray wolf, coyote, cougar, lynx, bears, wolverine, mink, (Baker and Hill 2003), and river otter prey on beaver to various extents (Novak 1998). Gray wolf is the most frequent predator of the beaver, particularly when larger game (*e.g.*, deer, moose) are in decline (Baker and Hill 2003; Müller-Schwarze and Sun 2003). The addition of linear features on the landscape creates corridors that gray wolf and other predators readily move along, providing access into areas that were previously less accessible, increasing predation. Sudden changes in water level may also result in increased predation as it can force beaver out of their protective lodges (Baker and Hill 2003).

6.1.3.8.2 TRAPPING

Unmanaged trapping has the potential to substantially depress beaver populations. Historically, high harvests of beavers occurred in the 1700's (Obbard *et al.* 1987) and by1900 beaver were nearly extirpated from North America. In Ontario, Novak (1998) demonstrated the substantial decline in beaver harvests from about 1920 to the mid-1930s, as a result of overharvesting and trapping seasons were closed. High fur prices were thought to be the driver of excessive harvest. Management, including licensing trappers, establishing seasons, setting quotas, and restricting trappers to traplines have allowed for the recovery of beaver populations (Novak 1998).

6.1.3.8.3 ACCIDENTAL MORTALITY

Of the different types of accidental mortality, road kills are a common cause of accidental death, specifically when beaver are dispersing in the spring (Müller-Schwarze and Sun 2003). An increase in linear features and

traffic is often linked with an increase in collisions with vehicles and results in a corresponding increase in mortality.

Flooding in mid-winter and spring can destroy lodges and result in beaver drowning (Baker and Hill 2003). On rare occasions beaver are found dead under a fallen tree (Hitchcock 1954), possibly due to misjudging where a tree will fall while cutting (Scotter and Scotter 1989).

6.1.3.9 OTHER FACTORS THAT INFLUENCE SURVIVAL AND HABITAT USE

6.1.3.9.1 DISEASES AND PARASITES

Tularemia, *Giardia*, and rabies are diseases that can affect beaver (Clements 1991). Tularemia infects the liver, spleen, lungs, and lymph nodes; is often fatal (Novak 1998); and can cause widespread mortality during outbreaks (Baker and Hill 2003). Infected beaver carcasses can contaminate water (Jellison *et al.* 1942), and ticks and mosquitoes can also transmit the disease (Petersen *et al.* 2009). Beaver can be infected with the *Giardia* cyst, which causes an infection in humans more commonly termed "beaver fever" (Daly *et al.* 2010). While rabies has been documented in beaver, few details are available (Baker and Hill 2003)

Other parasites of beaver include helminths, beetles, and mites. Beaver serve as hosts for up to 11 species of helminths, which are not fatal (Müller-Schwarze and Sun 2003). Beaver serve as hosts for at least two species of beetles as well as approximately 15 species of mites. One large beaver may carry up to 10 species and a total of 133,000 mites (J. Whitaker, personal communication in Müller-Schwarze and Sun 2003). Species form groups on different parts of beavers' bodies, such as the head and neck, back, and belly (Müller-Schwarze and Sun 2003).

6.1.3.9.2 MALNUTRITION

In northern areas, starvation can be an important source of mortality if beaver cannot construct a cache large enough to last the winter (Baker and Hill 2003). Energy deficits require energy conservation methods such as reduced activity and periods of dormancy (Novakowski 1966). Older animals appear to use fat reserves to survive the winter (Novakowski 1967).

6.1.3.9.3 SEVERE WEATHER

Winter temperatures restrict beaver movement to below-ice activity (Muëller-Schwarze 2011). This voluntary restriction in movement may be due to the large amount of energy individuals require to be active above ice in low temperatures (Lancia *et al.* 1982; Baker and Hill 2003). The temperature inside the lodge hovers near 0°C, even in severe winter weather (Baker and Hill 2003). Above-ice activity occurs when daily air temperatures are above –10°C (Lancia *et al.* 1982).

6.1.3.9.4 SNOW DEPTH

As beaver spend much of the winter in their lodges to avoid the cold (Baker and Hill 2003) and cache food near the lodge, snow depth does not appear have a direct effect on beaver.

6.1.3.10 HABITAT SELECTION

As beaver can modify their surroundings to create suitable habitat, they are able to occupy a variety of habitats (Baker and Hill 2003). Water and a surrounding food source are necessities (Novakowski 1965), with water being the more important of the two requirements (Novak 1998). Beavers build dams to hold back the flow of water in order to create a pond deep enough to allow swimming under winter ice (generally 2 to 3 m deep), which provides access to their food caches (Banfield 1987). As a result, ponds, small lakes, and streams with low water velocity are preferred, while fast-moving or seasonally fluctuating water is avoided (Novak 1998). Beaver may also inhabit suitable human-constructed waterbodies (Novak 1998; Baker and Hill 2003).

Beaver typically do not use uplands areas far from water, and prefer riparian habitats that provide an ample supply of tall shrubs and trees 1.5-4.4 cm in diameter, which provide beavers with a sufficient food supply, as well as lodge and dam-building materials (Jenkins and Busher 1979; Banfield 1987; Pattie and Hoffmann 1990; Clements 1991; Barnes and Mallik 1997). Beaver may also construct burrows along the banks of a waterbody. Additionally, beaver rarely forage far from shore. In Ohio, beaver ventured as far as 30 m from shorelines (Raffel *et al.* 2009) and in Massachusetts, beaver rarely wandered further than 100 m from ponds (Jenkins 1980).

In winter, beavers spend most of their time in their lodges (Figure 6-1) or burrows. Lodges and burrows help create a microenvironment that maintain a temperature of approximately 0^{o}C, allowing beaver to live in extreme northern climates (Lancia *et al.* 1982). In addition to shelter from the elements, lodges and burrows provide beaver with protection from predators (Müller-Schwarze and Sun 2003).

Fire may have important influence on beaver habitat. A large burn may result in a short-term loss of food and cover as tall shrubs and trees are burned. As the area regenerates, young regrowth can become important food source (Bartos and Muegller1981). However, if fires occur too frequently it may reduce the amount of suitable beaver habitat (Hood *et al.* 2007).

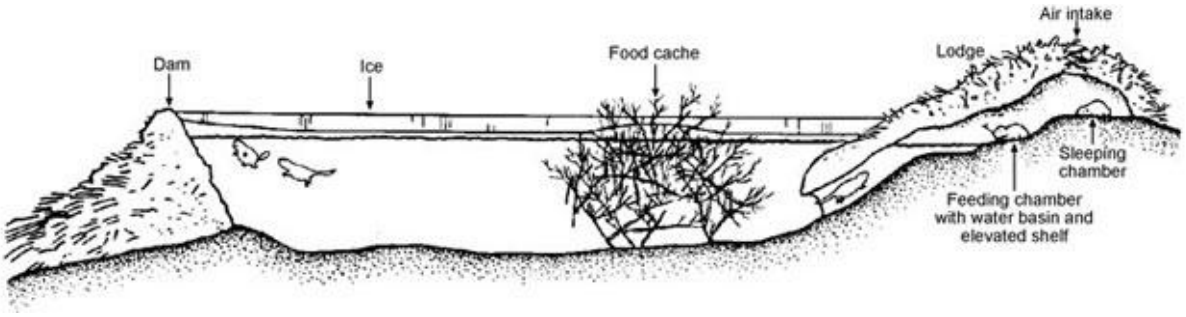


Figure 6-1: Beaver dam, winter cache, and lodge (Canadian Wildlife Service 2005)

6.1.3.11 HOME RANGE SIZE

The size and shape of beaver home ranges depends on the waterbody they inhabit (Novak 1998) and the structure of the family unit (Muëller-Schwarze and Sun 2003). The sizes of beaver home ranges are not well defined in the literature. In southern Ontario, home ranges from 0.04 to 22 ha were reported (Gillespie 1977).

The distance between beaver colonies varies with habitat quality. In central Sierra Nevada Busher *et al. (*1983) reported distances between colonies ranging from 0.76 km to 1.55 km. The distance between colonies may affect the dispersal distance of young beaver from natal areas. In two areas densely populated by beaver, McNew and Woolf (2005) reported an average dispersal distance of 2.3 km for females and 0.89 km for males at one site and 6.8 km for females and 5.2 km for males at another site. Sun *et al.* (2000) also found female dispersal distances to be greater than those of males, thought to reduce the risk of potential inbreeding. Beaver movements and dispersal have been associated with streams and rivers swelling over their banks following heavy rains or snowmelt (Svendsen 1980), with the majority of beaver dispersing downstream (Sun *et al.* 2000).

Beaver home ranges generally follow the shorelines of the waterbodies they encompass and vary in size and shape (Wheatley 1997a). Most activity (75%) is concentrated in approximately 25% of a beaver's home range (Wheatley 1997b). In southeastern Manitoba, beaver home ranges are smaller in winter than in summer (Wheatley 1997b). Summer home ranges are 2.25 to 42.75 ha in size, with an average of 10.34 ha (Wheatley 1997b). In winter, beaver tend not to travel beyond their food cache; home ranges are generally 0.25 ha in size (Wheatley 1997b).

6.1.3.12 FRAGMENTATION AND CUMULATIVE EFFECTS

Fragmentation of habitat, such as the development of linear features, may result in an increase of predation on beaver by wolves and humans as a result of better access to beaver habitat (James and Stuart-Smith 2000; Latham *et al.* 2011). Beavers can live in close proximity to man, but railways, roads, and land clearing next to water may be limiting factors affecting beaver habitat suitability (Slough and Sadleir 1977).

Developments of hydro-electric reservoirs that fluctuate water levels more than 150 cm, or overwinter drawdowns more than 50 cm, make beaver habitat unsuitable (Smith and Peterson 1991). Beaver were present on the Nelson River prior to hydroelectric development; however, fluctuating water levels and habitat loss

from flooding diminished their presence considerably (FLCN 2010 Draft, YLFN Evaluation Report *(Kipekiskwayiwinan)* 2012). The extent of the local beaver population that was affected is unknown.

6.1.3.13 MOST INFLUENTIAL FACTORS

The factors having the greatest influence on beaver population size can vary by region and can occur at different spatial scales within the range of beaver. In descending order of importance availability of food (as influenced by climate), physiographic and hydrologic factors, predation, malnutrition, accidents, parasites and disease are factors potentially limiting to beaver populations throughout their range. These natural factors, in combination with the degree of other influential factors (*e.g.*, trapping, human disturbance) are thought to determine the size of beaver populations. Table 6-1 summarizes beaver life requisites, and ranks these factors in order of importance based on literature and expert opinion.

Figure 6-2 identifies all pathways considered, which link the potential effects of the Project to the beaver population. This linkage diagram includes all potential pathways regardless of their likelihood of occurrence. The relative degree of influence among connections along these pathways is then weighted relative to each other as these apply to the Keeyask Project.

Figure 6-3 demonstrates only the most influential factors for the beaver population in the Keeyask region as a simplified pathway diagram. The final selection includes habitat quality as may be limited by food, and influenced by fire, and water. These are the factors thought to influence beaver population size the most at Keeyask.

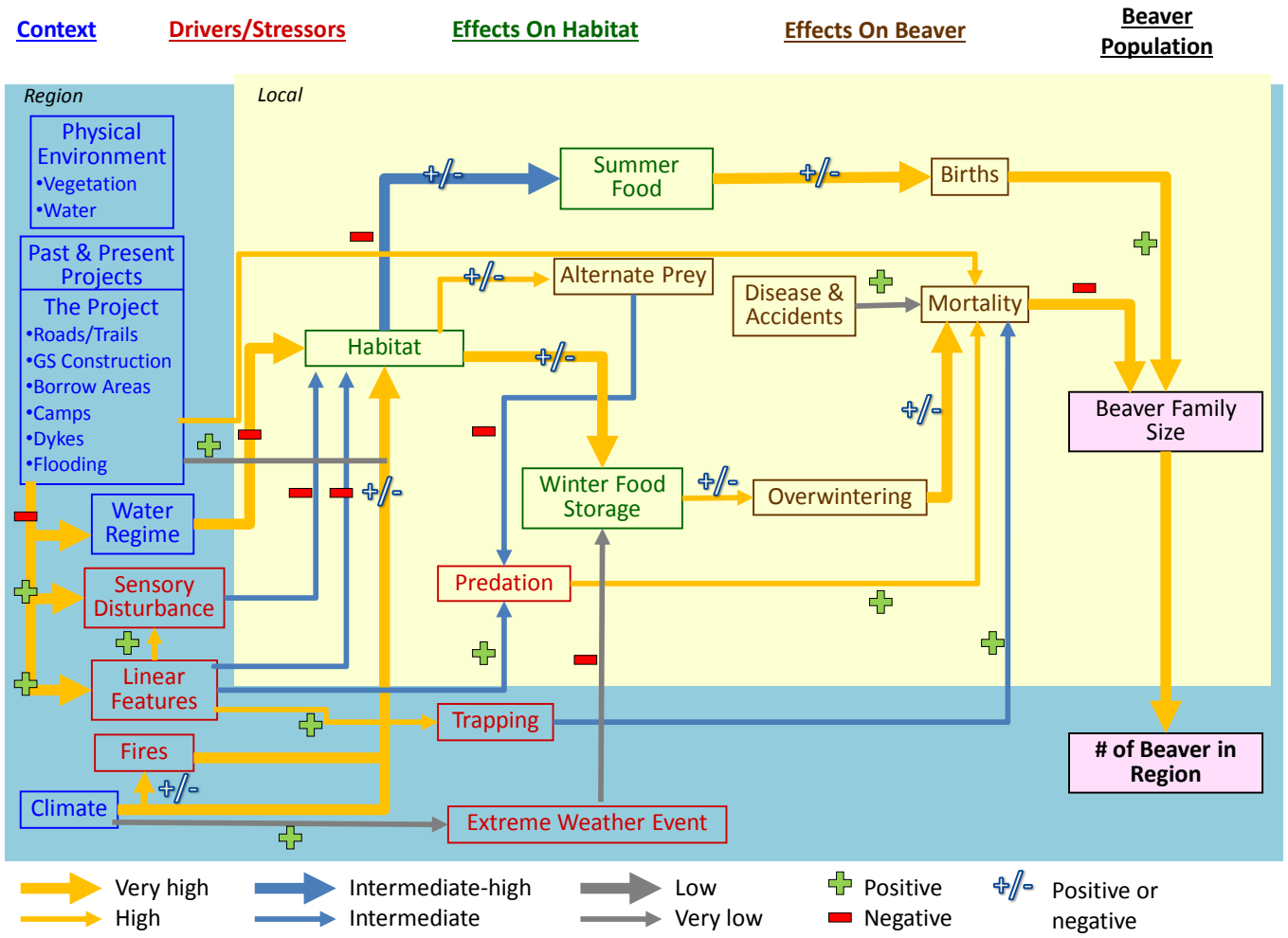


Figure 6-2: Linkage Diagram of All Potential Effects of the Keeyask Generating Project on the Beaver Population

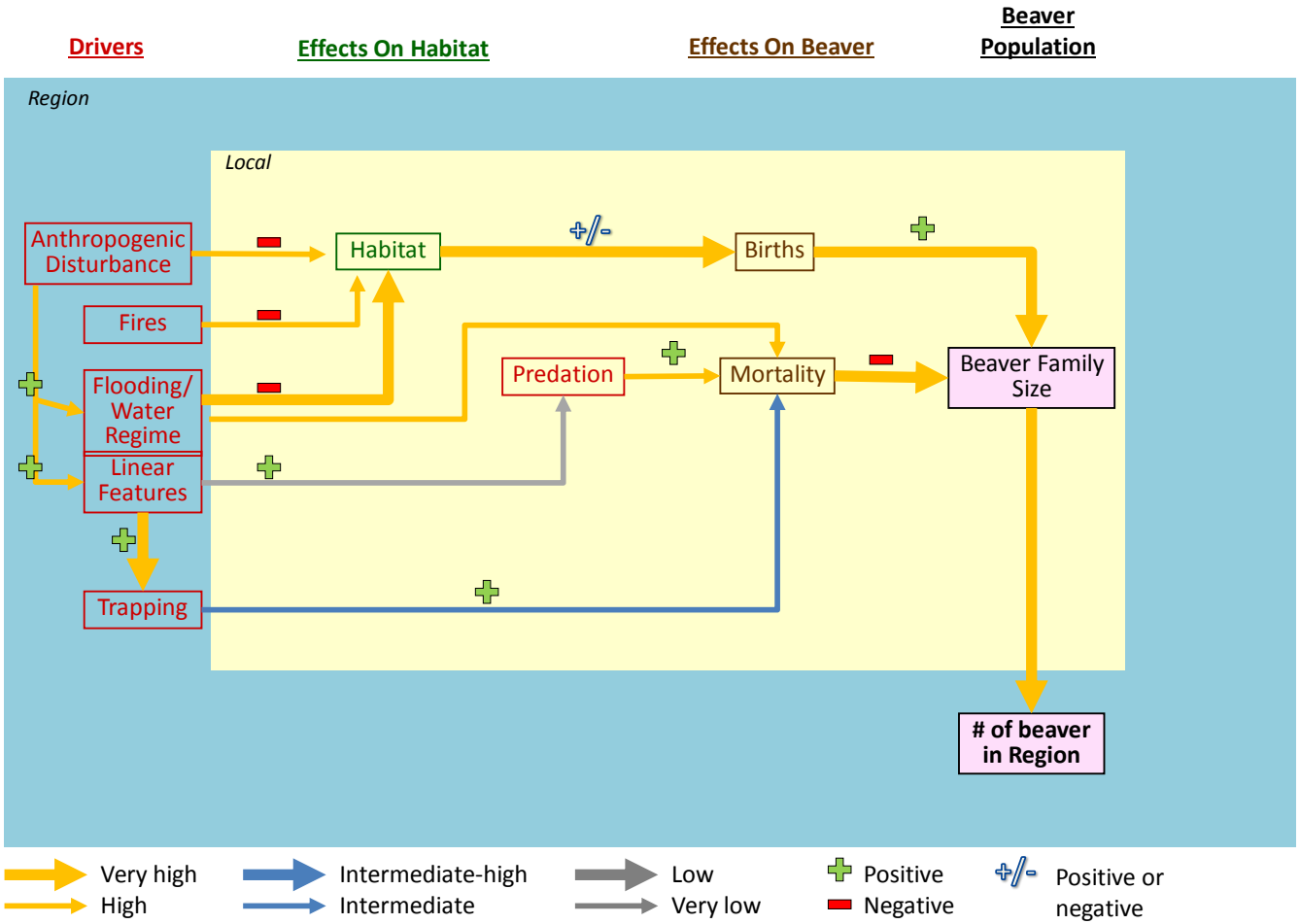


Figure 6-3: Most Influential Factors Linkage Diagram for Beaver in the Keeyask Region

Table 6-1: Beaver Life Requisites and Factors That Can Substantially Influence Survival, Reproduction, and Habitat Use

Rank	Period	Preference	Location	Context		Area	Canada/North America	Manitoba
Habitat	1	Winter	Lodge and reduced home range[14]	Slow streams surrounded by aspen or lakes with shallow bays with deciduous trees and shrubs[9,21, 25]	Sticks, branches, bark and mud [20,24]	Less than 0.25 ha[32]	Stable water levels (<0.7 m variation) Less than 15% stream gradient – prefer <6% gradient[23] Lakes <8 ha –optimal Lakes >8 ha require irregular shorelines[23]	
	2	Summer to fall	Foraging on land or water[20,24]	Water bodies with deciduous trees on shoreline [3,10,20,24]	Prefer aspen, willow [20,24] Prefer to remain near trembling aspen, poplar, willow, birch, cottonwood, and alder as well as grasses, sedges, cat tails and water lilies[7,9]	~10 ha[32]	Stable water levels (<1.7 m/yr variation) Less than 15% stream gradient – prefer <6% gradient [22] Lakes < 8 ha –optimal[22,17] Lakes >8 ha require irregular/complex shorelines[22]	Summer home range size ranged between 2.25 to 42.75 ha Fall home range – between 1.0 to 8.0 ha[32]
Habitat	3	Breeding	Water	Water environment in home range[24]	Water	Home range		
Lodge	1	Winter –in climates with extreme winter temperatures[24,32]	Either on shoreline (bank) or surrounded by water in middle of pond (island)[6,24,32]	Built with wood material and mud[13, 22,24, 32] Bank lodges – under large uprooted tree or shrub[6,,7,22] Slope of bank is usually greater at lodge site (average 40.7^{O}) – greater water depth 1 m from shore (for winter access) with increased canopy closure and ground cover[11]	If preferred food is limited, less preferred tree species will be used for building material[6]	Dependent on family size, years occupied, and water level – typically 6 m in diameter by 2 m high[24]		Wuskwatim Lake area 0.35 to 0.49 beaver lodges/km
Food	1	Winter	Woody diet –bark[2,3, 6,8,13,24]	Deciduous trees stored in underwater/under ice cache near lodge[3,6,24,29]	Alder raft/cap freezes into ice with primarily aspen and willow stored under- may include birch, fir,	Typically less than 0.25 ha around lodge[11] Require 1.5 lbs of food (bark/twigs) daily[1,8]		

Table 6-1: Beaver Life Requisites and Factors That Can Substantially Influence Survival, Reproduction, and Habitat Use

Rank	Period	Preference	Location	Context		Area	Canada/North America	Manitoba
				Water must be at least 2 m deep to allow under ice movement yet 3 m or less to allow food cache to be anchored[22]	white spruce, and jack pine[13,25,29,32]			
Food	3	Summer through fall	Herbaceous diet- leaves and growing tips[3,3,6,8,24] Young deciduous vegetation – leaves[22] Tree stands of intermediate density[22]	On shore or in water[6,20]	Prefer immature (20-35 yrs) trembling aspen -stands with a crown closure of 50 to 70% - leaves, bark, and twigs[5,7,8,12,22,25,30,32] Willow (leaves and growing tips) secondary choice[4,5,7,8,22,31] Alder, birch, jack pine growing tips[1,5,20,25,26,32] Primarily 1, 2 and 3 inch diameter class trees[7,12,30]	Usually <30 m from shore but maximum range is 2-3 km[7,13,15,22] Will cut smaller trees and be more species-selective at increased distances[3,18,23,27]		Typically ≤100 m away from water; >100 m food decreases in suitability by 40%[22]
			Aquatic vegetation[7,13,23]	Water and land	Grasses, herbs, leaves, fruits, and aquatic plants- water lilies[2,6,7,24,25,31]	May travel up to 3 km from lodge to forage[22]		
	3	Spring	Herbaceous diet[6,24]	On shore or in water[6,24]	Willow, poplar and alder bark[2] Grasses, herbs, leaves, fruits, and aquatic plants (roots and stems)[6,7,22,24]	May travel up to 3 km from lodge to forage[22]		
Water	1	Winter	Home range is located in stable, slow moving freshwater sources that may satisfy their water	Rivers, lakes, and ponds[6,20,24]	Under ice freshwater source Must be a minimum of 2 m deep for winter movement[22]	0.25 ha[32]	Lakes >8 ha require irregular/complex shorelines[22] Stable water levels (<0.7 m variation) Less than 15% stream gradient – prefer <6%	

Table 6-1: Beaver Life Requisites and Factors That Can Substantially Influence Survival, Reproduction, and Habitat Use

Rank	Period	Preference	Location	Context		Area	Canada/North America	Manitoba
			requirement – accessible under ice throughout winter[6,22,24]				gradient[22]	
	1	Summer	Home range is located in stable, slow moving freshwater sources that may satisfy their water requirement[6,24,22]	Rivers, lakes, and ponds[6,24,20] Lakes >8 ha require irregular/complex shorelines[22]	Freshwater rivers, lakes, and ponds[6,24]	~10 ha[32]		
Predators and avoidance	2	Year round	Humans, wolves, coyotes, bears, lynx, and wolverines[6,20,24]	Terrestrial portion of habitat	Shoreline and surrounding terrestrial habitat	<125 m in from shore line[9]	Wolves increase predation on beaver when ungulate populations are low	
Other mortality sources – Disease/Parasites	6	May and October	Tularemia[9,6,24]	Blood, organs, body fluids, excreta[24]	Bacterial zoonosis[6,20,24]	Home range	Ticks are hosts and vectors[6,24]	Tick or deerfly bite, direct contact with infected tissue, inhalation, ingestion of contaminated water[9,6,24]
		Year round	Helminths[24]	Caecum, liver, large intestine, stomach, small intestine[24]	Primarily infected from water sources[24]			
		NA	Giardia				Beaver are vectors for this infection [24]	
		NA	Rabies[6,24]	N/A			Few actual reports	
Accidents	5	Summer	Crushed by falling trees[16,24,28]	Terrestrial portion of habitat		Home range		
		Winter	Starvation, raising water levels[6]	Lodge and underwater cache		Winter range is 0.25 ha[32]	Increased water depth from snow melts or spring melts or cut off from winter cache due to complete freeze of water body or inadequate winter food storage	
	5	Spring	Roadkill [6,24]	Juvenile (2 years of age) spring dispersal	Crossing over drainage culverts	Home range to dispersal distances up to 18 km[14,21]		
Trapping	2	Year round	Entire home range area –terrestrial and aquatic	Trapping or shooting[16]		Home range		
Mating	5	Mid-late January[16] February[22]		Water habitat under ice[20]	Evening or night[24]		Mean litter size between 3 or 4 kits[20] Weaned at about 2 months	

Table 6-1: Beaver Life Requisites and Factors That Can Substantially Influence Survival, Reproduction, and Habitat Use

Rank	Period	Preference	Location	Context	Area	Canada/North America	Manitoba
						and forage outside the lodge[9] 2 yr old beaver disperse in spring via water or land[32] Mean dispersal distance 8.5 km with max 18 km[21] Extreme dispersal distances of over 200 km have been recorded[14]	
	5	November – March [6]		Water, bank dens or lodges[6]			

6.2 METHODS

6.2.1 STUDY AREAS

The Local and Regional Study Areas for beaver were Study Zones 3 and 4, respectively, in Map 2-1.

6.2.2 INFORMATION SOURCES

6.2.2.1 EXISTING INFORMATION FOR THE STUDY AREA

Section 6.1 summarized the literature regarding the key drivers and pathways for beaver habitat.

Existing information for beaver in the study area includes Aboriginal Traditional Knowledge, information from Manitoba Conservation and Water Stewardship, and general information from published literature (see Section 6.1). Information sources for habitat in the study area include the ECOSTEM habitat dataset.

There was no existing information on reservoir-related effects on beaver from studies conducted in the Regional Study Area when Project studies commenced.

6.2.2.2 DATA COLLECTION

Aerial surveys for beaver were conducted by helicopter along watercourses and waterbodies in fall 2001 and 2003. Only lodges from the fall 2001 were used to validate the Beaver Habitat Models to avoid the use of double-counted lodges from 2003. The number of beaver lodges along waterbodies was counted and their positions were marked using a GPS. Beaver lodges were classified as active or inactive based on the presence of food caches and evidence of recent maintenance on the lodge. The linear distance surveyed was used to calculate the density of beaver lodges per km of transect. Waterbodies greater than 0.5 km^2 in area were considered lakes while those less than 0.5 km^2 were considered ponds. Named lakes and rivers were classified separately.

Sign survey transects were conducted from 2002-2003 along riparian, coarse habitat mosaics, on large rivers, large lakes, and small lakes. Mammal signs were recorded along the length of each transect and included scat, tracks, trails, browse and feeding sites, and shelters. Riparian, coarse habitat mosaic transects were 500 m long, with a start point within 100 m of a waterbody, extending into the uplands. Riparian, coarse habitat transects were conducted on large rivers (*i.e.*, Nelson River and Gull Lake) and large lakes (Stephens Lake). Riparian transects were also conducted on Gull and Stephens Lake and consisted of 100-m long transects, parallel to the shore. Lake perimeter transects encompassed the entire perimeter of lakes and ponds. Lake perimeter transects were conducted in small, off-system lakes. From 2002-2003 a total of 56 transects, covering 27,420 m were surveyed along Gull Lake riparian transects; 35

transects, covering 16,795 m, were surveyed along Stephens Lake riparian transects; and 20 transects, covering 43,260 m were surveyed along off-system lake perimeters.

6.2.3 ANALYSIS METHODS

The beaver habitat quality model was used to derive the amount of primary and secondary beaver habitat available in the Regional Study Area. These were informed based on a literature review and through field studies where information on habitat use by beaver was collected alongside information on species distribution and abundance in the local and regional study areas.

Model validation procedures were based on fall aerial furbearer surveys. Based on locations where beaver lodges were observed, habitat types at these locations were assessed to determine model performance.

6.2.4 DESCRIPTIVE STATISTICS

6.2.4.1 POPULATION SURVEYS

6.2.4.1.1 REGIONAL STUDY AREA

Beaver are abundant in the Beaver Regional Study Area (Study Zone 4). Aerial surveys indicated streams and ponds could be the preferred habitats of beaver, based on the density of active lodges (Table 6-2). Beaver also inhabited small lakes and rivers and appeared to avoid islands in lakes, islands in ponds, and islands in rivers. The total number of lodges observed was 341 and 182 in fall 2001 and 2003 respectively. These totals include areas located outside the Beaver Regional Study Area, and are excluded from the results reported.

The mean density of active beaver lodges from 2001 and 2003 was very low at Gull and Stephens lakes while small unnamed lakes were more productive. The estimated linear density of active beaver lodges was 0.09 lodges/km. Mean active lodge densities among ponds, creeks, streams and small lakes was not significantly different (Appendix I). Based on an extrapolation of only the active number of lodges observed in the area flown and adjusted by density to the linear length of ponds, streams and lakes sampled in the region, the beaver population in the Beaver Regional Study Area is estimated at 250 active colonies (Appendix I).

Outside the Beaver Regional Study Area, some context for beaver habitat can be provided by large lakes. Assean Lake, which was sampled in 2003, is a large lake unaffected by hydro-electric development, where the active beaver lodge density was 0.02 lodges/km. Similar context for beaver habitat for large rivers is problematic. The nearest such river is the Hayes River, and it may not be directly comparable in size and water velocity of the historic Nelson River. It should also be noted, that the Hayes River region falls into another ecoregion, and as such, the overall quality of beaver habitat based on the availability of food and cover (*e.g.*, the presence of aspen) may not be the same as Keeyask. In the Hayes River region the density of active beaver lodges was greatest in French Creek (0.35 lodges/km), Kapaseetik Lake

(0.33 lodges/km), and streams (0.27 lodges/km). The mean stream density here is very similar to the stream density at Keeyask. Overall beaver density on the Hayes River itself was 0.07 lodges/km.

Table 6-2: Density of Active Beaver Lodges on Waterbodies in the Regional Study Area, Fall 2001 and 2003

Water Type	Name	2001 Number	2001 Density[1]	2003 Number	2003 Density	Mean Density
Island lake	Stephens	-	-	0	0	-
Island pond	Clark	0	0	0	0	0
	Stephens	0	0	0	0	0
	Unnamed	0	0	0	0	0
Island river	Nelson central[2]	1	0.13	0	0	0.07
	Nelson downstream	0	0	0	0	0
	Unnamed	0	0	0	0	0
Lake	Clark	0	0	0	0	0
	Stephens	6	0.04	0	0	0.02
	Unnamed	12	0.10	7	0.06	0.08
Ponds		16	0.10	12	0.10	0.10
Rivers	Nelson central[2]	2	0.01	1	0.03	0.02
	Nelson downstream	1	0.03	0	0	0.02
	Unnamed	2	0.07	2	0.08	0.08
Streams		57	0.27	30	0.22	0.25
Total		97	0.11	52	0.08	0.10

1. Lodges/km

2. Includes Gull Lake

Inactive lodges can indicate habitat that is no longer suitable because of existing food limitations, or potentially suitable future beaver habitat when the vegetation recovers. When active and inactive lodges are considered, mean lodge density was also greatest in streams and ponds (Table 6-3).

Table 6-3: Density of All Active and Inactive Beaver Lodges on Waterbodies in the Regional Study Area, Fall 2001 and 2003

Water Type	Name	2001 Number	2001 Density[1]	2003 Number	2003 Density	Mean Density
Island lake	Stephens	-	-	0	0	-
Island pond	Clark	0	0	0	0	0
	Stephens	0	0	0	0	0
	Unnamed	0	0	1	0.17	0.09
Island river	Nelson central[2]	1	0.13	0	0	0.07
	Nelson downstream	0	0	0	0	0
	Unnamed	0	0	0	0	0
Lake	Clark	0	0	1	0.04	0.02

Water Type	Name	2001 Number	2001 Density[1]	2003 Number	2003 Density	Mean Density
	Stephens	**7**	**0.04**	**1**	**0.01**	**0.03**
	Unnamed	**21**	**0.18**	**13**	**0.12**	**0.15**
Ponds		**33**	**0.21**	**26**	**0.19**	**0.20**
Rivers	Nelson central[2]	**3**	**0.02**	**2**	**0.02**	**0.02**
	Nelson downstream	**1**	**0.03**	**0**	**0**	**0.02**
	Unnamed	**4**	**0.03**	**2**	**0.02**	**0.03**
Streams		**112**	**0.52**	**44**	**0.36**	**0.44**
Total		**182**	**0.20**	**90**	**0.13**	**0.17**

1. Lodges/km
2. Includes Gull Lake

6.2.4.1.2 LOCAL STUDY AREA

The density of active beaver lodges was greatest in small rivers in the Beaver Local Study Area (Study Zone 3) in 2001 and in ponds in 2003 (Table 6-4). Mean density for the two-year study period was not significantly different among small rivers, streams, and lakes (Appendix I).

Table 6-4: Density of Active Beaver Lodges on Waterbodies in the Local Study Area, Fall 2001 and 2003

Water Type	Name	2001 Number	2001 Density[1]	2003 Number	2003 Density	Mean Density
Island pond	Stephens	**0**	**0**	**0**	**0**	**0**
	Unnamed	**0**	**0**	**0**	**0**	**0**
Island river	Nelson central[2]	**1**	**0.13**	**0**	**0**	**0.07**
	Unnamed	**-**	**-**	**0**	**0**	**0**
Lake	Unnamed	**7**	**0.21**	**4**	**0.12**	**0.17**
Ponds		**6**	**0.11**	**7**	**0.15**	**0.13**
Rivers	Nelson central[2]	**2**	**0.01**	**0**	**0**	**0.01**
	Unnamed	**1**	**0.50**	**0**	**0**	**0.25**
Streams		**22**	**0.28**	**5**	**0.10**	**0.19**
Total		**39**	**0.12**	**16**	**0.08**	**0.10**

1. Lodges/km
2. Includes Gull Lake

6.2.4.2 HABITAT-BASED MAMMAL SIGN SURVEYS

Sign survey transects were conducted from 2002-2003 along riparian shorelines and lake perimeters. Mammal sign recorded along the length of each transect included scat, tracks, trails, browse and feeding sites, scent posts, shelters, lodges and dams.

Validation of the beaver habitat quality model was done by assessing the habitat characteristics of active and inactive beaver lodge locations during aerial furbearer surveys in the Keeyask region conducted during the fall 2001. In total, the geographic coordinates from 139 identified beaver lodges were used for the validation of the beaver habitat quality model.

The influence of recorded fire events on coarse habitat types in Study Zone 4 was treated as an additional factor to explain potential habitat selection by beaver in the Keeyask region. The impact of fire events on the selection of coarse habitat types by beaver was tested by associating coarse habitat types with the locations of recorded fire events (Table 6-5). Beaver locations were then associated to sampled coarse habitat classes, which also have an associated burn age class. Those coarse habitat types in areas not affected by recorded fire events were assigned a default burn age class of 1. In total, 151 coarse habitat types with associated burn age classes were considered as present in Study Zone 4. In addition, the amount of shallow water, indicating the presence of lakes and streams, and the Nelson River, was considered based on their proximity to survey locations and in being potentially selected for by this species.

Table 6-5: Burn Age Classes Used in Examination of Beaver Coarse Habitat Type Selection

Burn Age Class	Fire Age (years)	Recorded Fire Events
1	50+	1960
2	40-49	1967, 1972
3	30-39	1975, 1976, 1977, 1980, 1981
4	20-29	1983, 1984, 1989, 1990, 1992
5	10-19	1993, 1994, 1995, 1996, 1998, 1999, 2001, 2002
6	0-9	2003, 2005, 2010, 2011

The potential for the selection of coarse habitat types at multiple spatial scales by beaver was done by buffering UTM coordinates of each lodge. Buffers used in the identification of habitat information included 100 m, 250 m, 500 m and 1,000 m levels. The results of habitat analysis for each set of coordinates were then averaged for each applied buffer level to compare averaged values between the four buffer levels.

For analysis purposes, coarse habitat types occurring with the greatest abundance at each buffer level were ranked. According to rank, coarse habitat types cumulatively making up 80% of a buffered habitat area were treated as selected for by beaver.

An evaluation of the beaver habitat quality model was done through an evaluation of beaver lodge locations based on the presence of primary or secondary habitat areas. This was done by assessing the location of recorded beaver lodges based on locations where amounts of primary and secondary habitat were identified using the beaver habitat quality model.

6.3 RESULTS

6.3.1 DESCRIPTIVE STATISTICS

6.3.1.1 HABITAT-BASED MAMMAL SIGN SURVEYS

Beaver signs were very common on lake perimeter transects in the Local and Regional Study Areas (Table 6-6) and observed in all three study years. Signs were abundant and observed on all small lakes surveyed, but were sparse on riparian shoreline transects at Gull Lake, where abundance was scarce and distribution was localized. Signs of beaver activity were observed on the north and south shores of Gull Lake, and in riparian zones of all widths. Comparison of beaver signs among riparian types were not significantly different (Appendix I).

Table 6-6: Abundance and Distribution of Beaver Signs (signs/100 m²) in the Local Study Area

Transect Type	Mean	S.E.	Abundance	Proportion of Transects	Distribution	Species Rarity
Lake perimeters	0.27	0.08	abundant	1.00	very widespread	very common
Riparian shorelines	0.03	0.01	scarce	0.07	localized	sparse

6.3.2 BEAVER HABITAT QUALITY MODEL

As described in Section 6.1, the availability of beaver food is one of the most influential factors affecting the size of the beaver population. Beaver require suitable amounts of poplar, alder, and willow of certain sizes in order to provide a sufficient food supply and as building materials. These food sources must also be located near water in order to provide security for beavers against predators.

The initial identification of coarse habitat types important to beaver was based on the selection of dietary items important in meeting various life-history requirements. Beaver forage species present in the Keeyask region are described in Appendix H. All plant species potentially suitable as beaver food in the Keeyask area were reviewed and cross-checked against food plant preferences in the literature. Coarse habitat types were assigned importance as meeting either meeting all food requirements, or valued as less suitable where there appeared to be some deficiency (*i.e.*, missing plant species, containing less preferable plant species, or limited abundance).

The water regime is an essential factor for beaver. In most cases, beaver control their own water depth in creeks, small streams and ponds. A waterbody must be sufficiently deep to provide under-ice movement for access to food caches, or beavers may face starvation. The water cannot be too deep, fast-flowing or

have highly variable water level fluctuations. Based on the data collected during field studies, both the Nelson River (including Gull Lake), and the main body of Stephens Lake were excluded as beaver habitat.

The first iteration model defines primary (preferred) habitat for beaver as being near shorelines and water. Primary riparian environments have low exposure or low water velocity with aspen nearby, such as broadleaf mixedwood or broadleaf treed habitat, and willow, such as habitats dominated by tall shrubs (Table 6-7). The likelihood of beaver using water and vegetation located farther than 200 m surrounding a creek, or upland habitats located farther than 100 m from a lake or pond shoreline is assumed low, thus potential and desirable plant foods outside this boundary were not considered as beaver habitat. Secondary coarse habitat types were selected if they provided additional sources of less desirable and potentially less abundant browse, or as a secondary source of lodge building materials.

Table 6-7: Primary and Secondary Beaver Habitat Types in the Beaver Regional Study Area

	Coarse Habitat Type
Primary Habitat	Broadleaf mixedwood on all ecosites
	Broadleaf treed on all ecosites
	Tall shrub on mineral and thin peatland
	Tall shrub on shallow peatland
	Tall shrub on wet peatland[1]
	Vegetated riparian peatland[2]
	Marsh
Secondary Habitat	Black spruce mixedwood on mineral and thin peatland
	Black spruce mixedwood on shallow peatland
	Black spruce treed on mineral and thin peatland
	Black spruce treed on shallow peatland
	Black spruce treed on wet peatland[3]
	Jack pine mixedwood on mineral and thin peatland
	Jack pine treed on mineral and thin peatland
	Jack pine treed on shallow peatland
	Low vegetation on mineral and thin peatland
	Low vegetation on shallow peatland
	Low vegetation on wet peatland[4]
	Tamarack-black spruce mixture on wet peatland[5]
	Tamarack treed on shallow peatland
	Tamarack treed on wet peatland[6]
	Young regeneration on mineral and thin peatland
	Young regeneration on shallow peatland
	Young regeneration on wet peatland[7]
Non-habitat	Vegetated upper beach[8]
	Vegetated ice scour[9]
	Marsh Island[10]

Coarse Habitat Type
Human infrastructure

1. Consists of tall shrub on wet peatland and tall shrub on riparian peatland coarse habitat types
2. Consists of Nelson River shrub and/or low vegetation on sunken peat coarse habitat type
3. Consists of black spruce treed on wet peatland and black spruce treed on riparian peatland coarse habitat types
4. Consists of low vegetation on wet peatland and low vegetation on riparian peatland coarse habitat types
5. Consists of tamarack-black spruce mixture on wet peatland and tamarack-black spruce mixture on riparian peatland coarse habitat types
6. Consists of tamarack treed on wet peatland and tamarack treed on riparian peatland coarse habitat types
7. Consists of young regeneration on wet peatland and young regeneration on riparian peatland coarse habitat types
8. Consists of Nelson River shrub and/or low vegetation on sunken peat coarse habitat type
9. Consists of Nelson River shrub and/or low vegetation on upper beach coarse habitat type
10. Consists of Nelson River shrub and/or low vegetation on ice scoured upland coarse habitat type
11. Consists of Nelson River marsh coarse habitat type

6.3.2.1 VALIDATION OF THE BEAVER HABITAT MODEL

Coarse habitat types occurring in proximity to observed active and inactive beaver lodges indicated a variety of coarse habitat types as selected for by this species (Table 6-8). Notably, portions of the coarse habitat types black spruce treed on shallow peatland, and black spruce treed on thin peatland were abundant in areas where beaver lodges were sampled. Of the 139 beaver lodges examined, only 28 (20%) were directly on areas identified as primary habitat. This is not surprising as the most-preferred habitat (*i.e.*, broad-leafed forest) is relatively rare in distribution and extent compared to all other forest types. A second type of primary habitat consisting of off-system marsh is also rare. Tall shrub on riparian peatland was predicted correctly, and ranked fifth.

In ranking habitat types occurring in proximity to surveyed beaver lodge locations, portions of the shallow water and Nelson River habitat classes were common. This is understandable given that this species is an aquatic furbearer. It also confirms that beaver habitat is located near the Nelson River, where lodges are observed in connecting creeks or streams.

All top-ranked coarse habitat types indicated not having been affected by recorded fires in the Beaver Regional Study Area.

Data tables indicating amounts of coarse habitat types for beaver lodge locations can be found in Appendix B Tables 6B-1 to 6B-4.

Table 6-8: Rankings of Coarse Habitat Types Based on Abundance With 100, 250, 500 and 1000 m Buffers Applied to Observed Beaver Lodge Locations

Coarse Habitat Type	Burn Age Class	100 m	250 m	500 m	1000 m
Black spruce treed on shallow peatland	1	1	1	1	1
Black spruce treed on thin peatland	1	2	2	2	2

Coarse Habitat Type	Burn Age Class	100 m	250 m	500 m	1000 m
Shallow water	1	3	3	3	3
Low vegetation on riparian peatland	1	4	4	4	7
Tall shrub on riparian peatland	1	5	6	9	-
Nelson River	1	6	5	6	6
Black spruce treed on riparian peatland	1	7	8	10	-
Black spruce treed on shallow peatland	6	8	10	-	8
Black spruce treed on wet peatland	1	9	-	11	10
Low vegetation on shallow peatland	1	10	-	8	9
Black spruce treed on mineral soil	1	-	7	5	5
Black spruce treed on thin peatland	6	-	9	7	4

6.3.3 APPLICATION OF THE BEAVER HABITAT QUALITY MODEL

Adjustments to the model were not made, primary beaver habitat consists of habitats that have low exposure or low water velocity with aspen nearby, such as marshes, broadleaf mixedwood or broadleaf treed habitat, and willow, such as habitats dominated by tall shrubs. Secondary coarse habitat types were selected as they provide additional sources of less desirable or potentially less abundant browse. Coarse habitat types selected for the primary and secondary beaver models can be found in Table 6-9. Additionally, the likelihood of beaver using water and vegetation farther than 100 m from shorelines, or upland habitats farther than 100 m from shorelines is assumed low and these habitats beyond the buffer were not used in the model.

Table 6-9: Beaver Primary and Secondary Habitat Types in the Regional Study Area

	Coarse Habitat Type
Primary habitat	Broadleaf mixedwood on all ecosites
	Broadleaf treed on all ecosites
	Off-system marsh
	Tall shrub on mineral and thin peatland
	Tall shrub on riparian peatland
	Tall shrub on shallow peatland
	Tall shrub on wet peatland
	Nelson River shrub and/or low vegetation on sunken peat
Secondary habitat	Black spruce mixedwood on mineral and thin peatland
	Black spruce mixedwood on shallow peatland
	Black spruce treed on mineral soil
	Black spruce treed on shallow peatland

	Coarse Habitat Type
	Black spruce treed on riparian peatland
	Black spruce treed on thin peatland
	Black spruce treed on wet peatland
	Jack pine mixedwood on mineral and thin peatland
	Jack pine treed on mineral and thin peatland
	Jack pine treed on shallow peatland
	Low vegetation on mineral and thin peatland
	Low vegetation on riparian peatland
	Low vegetation on shallow peatland
	Low vegetation on wet peatland
	Tamarack-black spruce mixture on riparian peatland
	Tamarack-black spruce mixture on wet peatland
	Tamarack treed on riparian peatland
	Tamarack treed on shallow peatland
	Tamarack treed on wet peatland
	Young regeneration on mineral and thin peatland
	Young regeneration on shallow peatland
	Young regeneration on wet peatland

The results of the beaver habitat quality model are detailed in Table 6-10 for Study Zone 2, the Local Study Area (Study Zone 3), and the Regional Study Area (Study Zone 4), and are depicted in Map 6-1. The amount of habitat in Study Zone 2 was used to calculate the percentage of habitat affected by the Project. See Appendix G for further calculations of the amount of beaver habitat available in the Local and Regional Study Areas.

Table 6-10: Results of the Beaver Habitat Quality Model

	V12 Coarse Habitat	V14 Coarse Habitat	Study Zone 2 Area (ha)	Local Study Area Existing Area (ha)	Regional Study Area Existing Area (ha)
Primary Habitat	Broadleaf mixedwood on all ecosites	Broadleaf mixedwood on all ecosites	4.17	9.61	36.11
	Broadleaf treed on all ecosites	Broadleaf treed on all ecosites	20.65	46.11	90.74
	Tall shrub on mineral and thin peatland	Tall shrub on mineral and thin peatland	5.80	17.36	83.99
	Tall shrub on shallow peatland	Tall shrub on shallow peatland	8.20	61.90	192.72

	V12 Coarse Habitat	V14 Coarse Habitat	Study Zone 2 Area (ha)	Local Study Area Existing Area (ha)	Regional Study Area Existing Area (ha)
	Tall shrub on wet peatland	Tall shrub on riparian peatland	97.56	197.83	547.31
		Tall shrub on wet peatland	11.10	38.65	132.25
	Vegetated riparian peatland	Nelson River shrub and/or low vegetation on sunken peat	12.37	14.02	24.99
	Marsh	Off-system Marsh	11.86	30.67	193.21
	Total Primary Habitat		171.71	416.15	1301.33
Secondary Habitat	Black spruce mixedwood on mineral or thin peatland	Black spruce mixedwood on mineral or thin peatland	1.60	2.89	13.19
	Black spruce mixedwood on shallow peatland	Black spruce mixedwood on shallow peatland	0.98	1.85	2.03
	Black spruce treed on mineral soil and thin peatland	Black spruce treed on mineral soil	72.23	103.54	918.45
		Black spruce treed on thin peatland	260.02	674.91	5628.26
	Black spruce treed on wet peatland	Black spruce treed on wet peatland	19.04	92.26	580.57
		Black spruce treed on riparian peatland	35.66	142.89	896.71
	Black spruce treed on shallow peatland	Black spruce treed on shallow peatland	283.51	976.95	5377.93
	Jack pine mixedwood on mineral and thin peatland	Jack pine mixedwood on mineral and thin peatland	5.20	10.19	14.49
	Jack pine mixedwood on mineral and thin peatland	Jack pine mixedwood on mineral and thin peatland	5.20	10.19	14.49
	Jack pine treed on	Jack pine treed on	-	0.56	3.80

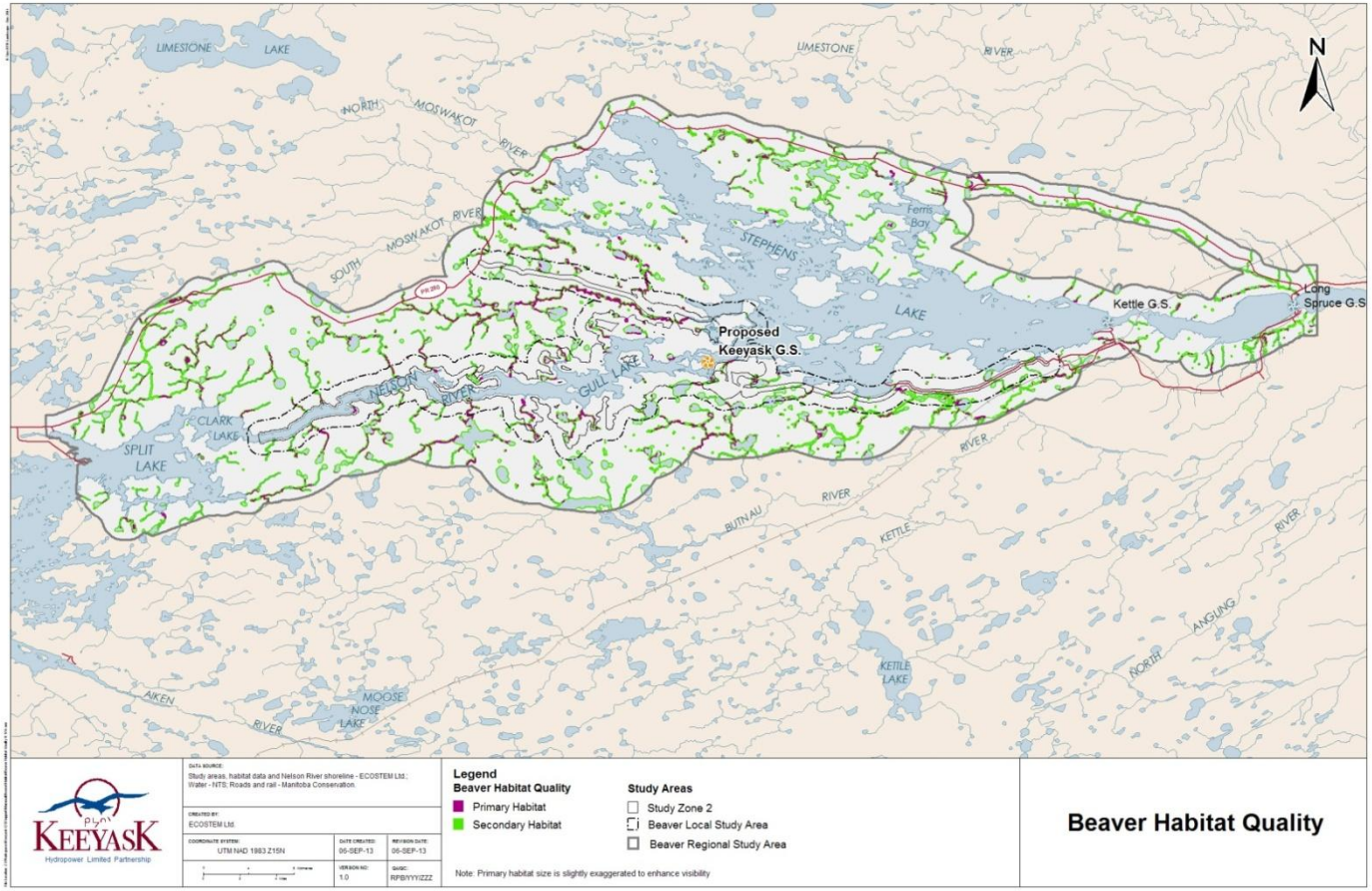
V12 Coarse Habitat	V14 Coarse Habitat	Study Zone 2 Area (ha)	Local Study Area Existing Area (ha)	Regional Study Area Existing Area (ha)
shallow peatland	shallow peatland			
Low vegetation on mineral and thin peatland	Low vegetation on mineral and thin peatland	16.28	130.14	883.89
Low vegetation on shallow peatland	Low vegetation on shallow peatland	44.19	264.45	1,532.37
Low vegetation on wet peatland	Low vegetation on wet peatland	25.83	72.39	503.83
	Low vegetation on riparian peatland	148.86	438.53	2,392.52
Tamarack- black spruce mixture on wet peatland	Tamarack- black spruce mixture on riparian peatland	0.54	2.92	33.63
	Tamarack- black spruce mixture on wet peatland	3.81	12.66	180.28
Tamarack treed on shallow peatland	Tamarack treed on shallow peatland	9.15	28.21	107.43
Tamarack treed on wet peatland	Tamarack treed on riparian peatland		1.66	6.95
	Tamarack treed on wet peatland	0.13	3.64	32.45
Young regeneration on mineral and thin peatland	Young regeneration on mineral and thin peatland		1.25	65.62
Young regeneration on shallow peatland	Young regeneration on shallow peatland	0.94	2.64	31.29
Young regeneration on wet peatland	Young regeneration on wet peatland	0.12	0.12	1.92
	Young regeneration on riparian peatland	0.02	0.31	3.13
Total Secondary Habitat		929.88	2993.96	19354.63
Total Habitat		1101.59	3410.11	20655.96

6.4 CONCLUSIONS

Assessment of beaver habitat use was done based on the sampling of riparian areas to determine their extent of use. Model validation was performed to identify primary and secondary habitat types used by beaver. Potential habitat for use by beaver was modelled based on habitat types occurring within proximity to streams and ponds. The quantification of beaver habitat through model validation allowed for the consideration of habitat used by beaver from those levels indicated by the preliminary habitat quality model alone.

The strongest association was the presence of shallow water as expected. The presence of a "tall shrub" habitat type was discerned as a top-ranking primary habitat where high-quality beaver forage materials are likely present. Model performance could have improved slightly by considering adjustments between primary and secondary habitat types, or potentially, by limiting habitat to mature forest age classes. It is suspected however, that a fine scale habitat assessment would be required to substantially increase performance of the existing model.

6.5 MAPS



Map 6-1: Beaver Habitat Quality

7.0 OLIVE-SIDED FLYCATCHER

7.1 INTRODUCTION

Olive-sided flycatcher is a medium sized songbird which inhabits mature coniferous forests in North America. It is a stocky flycatcher with a stout bill. Olive sided-flycatchers are often seen perching high atop dead snags while foraging for food. They have been observed in the Keeyask Regional and Local Study Areas. The olive-sided flycatcher is a neo-tropical migratory species which has been assessed by COSEWIC and is listed as threatened under SARA (Schedule 1). This species has experienced widespread declines throughout its range.

7.2 SPECIES OVERVIEW FROM LITERATURE

7.2.1 GENERAL LIFE HISTORY

This insect-eating bird is generally associated with open woodland, in habitat along forest edges and is frequently found in burned forests (Altman and Sallabanks 2012). Olive-sided flycatchers inhabit mature forest stands with complex canopy structure. They prefer to nest near forest edges close to bogs or in burned sites. Adults like to perch on tall trees near forest openings where insect prey may be more abundant (Altman and Sallabanks 2012). The female normally lays a clutch of three eggs and exhibits strong breeding and wintering site fidelity (Altman and Sallabanks 2012).

7.2.2 DISTRIBUTION AND ABUNDANCE

7.2.2.1 CONTINENTAL AND GLOBAL

Olive-sided flycatchers are summer residents of North American boreal and coniferous-deciduous forests from Alaska to Newfoundland and in mountainous regions of the western United States (Koonz and Taylor 2003). This species, which has the longest migration route of any other North American breeding flycatcher (BAMP 2012), overwinters primarily in Panama and the Andes Mountains of South America (Altman and Sallabanks 2012).

Over the past 30 years, this species has experienced significant declines in population throughout its range (Altman and Sallabanks 2000). Olive-sided flycatcher populations in Canada have declined by 3.8% per year since 1970 (Collins and Downes 2009), with total population declines of 79% in the 38-year period between 1968 and 2006 and 29% in the 10-year period between 1996 and 2006 (COSEWIC 2007A). In the United

States, populations have declined 2.6% per year since 1966 (Sauer *et al.* 2011). The North American population estimate for the 1990s is 1.2 million olive-sided flycatchers (Rich *et al.* 2004). Population declines may be attributed to deforestation on their wintering grounds in the Andes and possibly forest-management practices on their breeding grounds (Koonz and Taylor 2003).

7.2.2.2 PROVINCIAL

In Manitoba, olive-sided flycatcher is sparsely distributed in lowland coniferous forests of southern, central and northern parts (extreme north-east excluded) of the province (Koonz and Taylor 2003). There have been very few recorded observations of olive-sided flycatcher nests in Manitoba, which likely reflects both the low population densities and inaccessibility to breeding areas by human observers (Koonz and Taylor 2003).

Populations in Manitoba have decreased by 3.9% per year since 1989 (Collins and Downes 2009). Although population density data are very limited for olive-sided flycatcher in Manitoba, the Boreal Avian Modelling Project (BAMP) suggests that densities in the province are relatively low compared with densities of this species in other parts of its range (BAMP 2012). The population estimate of olive-sided flycatcher in Manitoba is 50,000 individuals (Rich *et al.* 2004).

7.2.2.3 REGIONAL STUDY AREA

The olive-sided flycatcher uses the Bird Regional Study Area (Zone 4; Map 2-1) for breeding. Primary and secondary breeding habitat for olive-sided flycatcher is widespread, occurring in areas where coniferous forest edge occurs. The majority of olive-sided flycatchers observed during field studies occurred in areas supporting mature black spruce forest adjacent to beaver floods, creeks, lakes and regenerating forest (*i.e.,* burns). Although rare, this species was observed in its primary and secondary habitat located throughout the study area.

7.2.3 FACTORS THAT INFLUENCE DISTRIBUTION AND ABUNDANCE

7.2.3.1 HABITAT

Suitable breeding habitat is essential for the survival of olive-sided flycatcher. Breeding habitat must provide suitable sites for nesting, as well as availability of food and shelter. Olive-sided flycatcher prefer older coniferous or mixedwood (spruce dominated) forests adjacent to open areas such as regenerating burns (5 to 15 years old), wetlands, ponds, beaver floods, lakes, marshes, muskegs, fens and swamps. Although they prefer older forests, they will also use younger forests that are adjacent to open areas. Stands with semi-open canopy are preferred.

7.2.3.1.1 SEASONAL FORAGE AND WATER

Olive-sided flycatchers need unobstructed air space within forest clearings where they can perch on top of tall trees, snags or dead branches at the top of trees (Altman and Sallabanks 2012). They tend to perch at a higher height than the canopy. Olive-sided flycatcher forage at the edge of forest stands or in areas where the canopy is open so that there is maximum light and insect prey can easily be spotted (Altman and Sallabanks 2012). During the breeding season, olive-sided flycatcher eat primarily insects from the order Hymenoptera (*e.g.*, bees, wasps, flying ants), but also eat flies, moths, grasshoppers and dragonflies (Altman and Sallabanks 2012).

7.2.3.1.2 BREEDING

The female picks the nest site, often out towards the tip of a horizontal branch where another overhanging branch provides protection from weather conditions (Altman and Sallabanks 2012). Nests are shallow, small, open-cup structures constructed of twigs, rootlets and arboreal lichen. Nests are often placed well out from the trunk of the tree in clusters of needles or twigs (Altman and Sallabanks 2012).

7.2.3.1.3 BROOD REARING

Breeding pairs of olive-sided flycatcher are monogamous, with both parents helping to raise the young. Olive-sided flycatchers lay a clutch of 3-4 eggs. Incubation of the eggs takes 14 days and is done only by the female bird. The male will bring food to the female on the nest. When hatched, young are altricial (featherless and helpless). The female stays with the young on the nest, but both parents feed the young. Nestlings will fledge after 21-23 days (Ehrlich *et al.* 1988).

7.2.3.1.4 DISPERSAL AND MIGRATION

After rearing of their young, birds need to fatten up for the purpose of moulting and in preparation for fall migration. Information on their dispersal after rearing is limited, but they may disperse locally to find areas with greater or different food supply. Olive-sided flycatchers start their fall migration to South America between mid-August and early September (Koonz and Taylor 2003).

7.2.3.2 FACTORS THAT REDUCE EFFECTIVE HABITAT

Construction-related noise from heavy equipment, blasting and other human activities may cause olive-sided flycatchers to avoid nesting within and adjacent to infrastructure zones. While land clearing activities may create some foraging habitat for olive-sided flycatchers, the use of equipment in those areas may render it unsuitable in the near term, due to noise and human activity.

Changes in forest structure from land clearing can also reduce the availability of effective habitat. Although olive-sided flycatcher have shown higher abundance in mid-successional stands derived from commercial timber harvest, evidence from the United States suggests that nest success is lower than in regenerating burns (COSEWIC 2007A). Changes to forest structure, hydrology or wetlands may also impact insect prey populations, thereby reducing effective breeding habitat.

7.2.3.3 MORTALITY

7.2.3.3.1 PREDATION

Olive-sided flycatcher nests may be predated by other birds such as gray jay or mammals such as red squirrel (Altman and Sallabanks 2012). No published literature on predation of adult birds could be found, but their behaviour of foraging in open clear spaces makes them vulnerable to birds of prey.

7.2.3.3.2 ACCIDENTAL MORTALITY

Accidental mortality of olive-sided flycatcher may occur as a result of vehicle traffic. As olive-sided flycatchers generally forage at heights between 5 to 15-m, the danger of accidental mortality from vehicle strikes is low (McCracken 2008).

7.2.3.4 OTHER FACTORS THAT INFLUENCE SURVIVAL AND HABITAT USE

7.2.3.4.1 DISEASES AND PARASITES

No information is available on whether disease or parasites are threats to olive-sided flycatcher (Altman and Sallabanks 2012).

7.2.3.4.2 MALNUTRITION

As an insectivore, the olive-sided flycatcher is vulnerable to a predator-prey mismatch (Post *et al.* 2008), a situation whereby the availability of food is altered due to climate change (Ruckstuhl *et al.* 2008; Achard *et al.* 2008). Insects in the boreal forest are hatching progressively earlier each year; birds dependent upon insects must respond by laying eggs earlier in order to catch peak insect abundance (Crick 2004). Unfortunately for long-distance migrants, seasonal changes in photoperiod rather than climatic cues are used to prompt migrations northward (Wormworth 2006). As a result, birds may arrive on the breeding grounds too late to provide adequate food for their young (Crick 2004).

7.2.3.4.3 SEVERE WEATHER

Climatic conditions play a very important role in the distribution of birds breeding in the boreal forest. Spring and summer temperature and precipitation impact species abundances and survival during the breeding season (DesGranges and LeBlanc 2012). In inclement weather, aerial insect prey is less available, which may increase the risk of starvation. In poor weather conditions, olive-sided flycatcher will forage from lower perches and fly towards the ground, rather than higher up in the air (Altman and Sallabanks 2012). This behavior may make them more susceptible to collisions with vehicles or infrastructure.

7.2.3.5 FRAGMENTATION AND CUMULATIVE EFFECTS

Fragmentation of habitat may be caused by associated developments such as roads, transmission lines and possible future development of exploration lines (*i.e.*, cutlines). This habitat fragmentation creates more edge habitat, which may be used by olive-sided flycatcher.

7.2.3.6 MOST INFLUENTIAL FACTORS

The most influential factors affecting olive-sided flycatcher distribution and abundance in the Bird Regional Study Area are related to the availability of suitable breeding and foraging habitat. Such habitat includes:

- old and mature spruce dominated coniferous or mixedwood forests with open or semi-open canopies;
- areas within 50 m of the edge of an open area such as regenerating burn (5 to 15 years old), beaver pond with snags, water body, bogs, muskeg, open area with snags and lakes with dead standing trees;
- areas within 50 m of poor or rich wooded fen and wooded swamp; and
- areas with tall trees (including dead standing trees) where they can perch to forage.

While there are a number of factors that influence olive-sided flycatcher populations in the Bird Regional Study Area, fire and beaver activity (*i.e.*, flooding) are key drivers in the creation of olive-sided flycatcher breeding habitat (Figure 7–1).

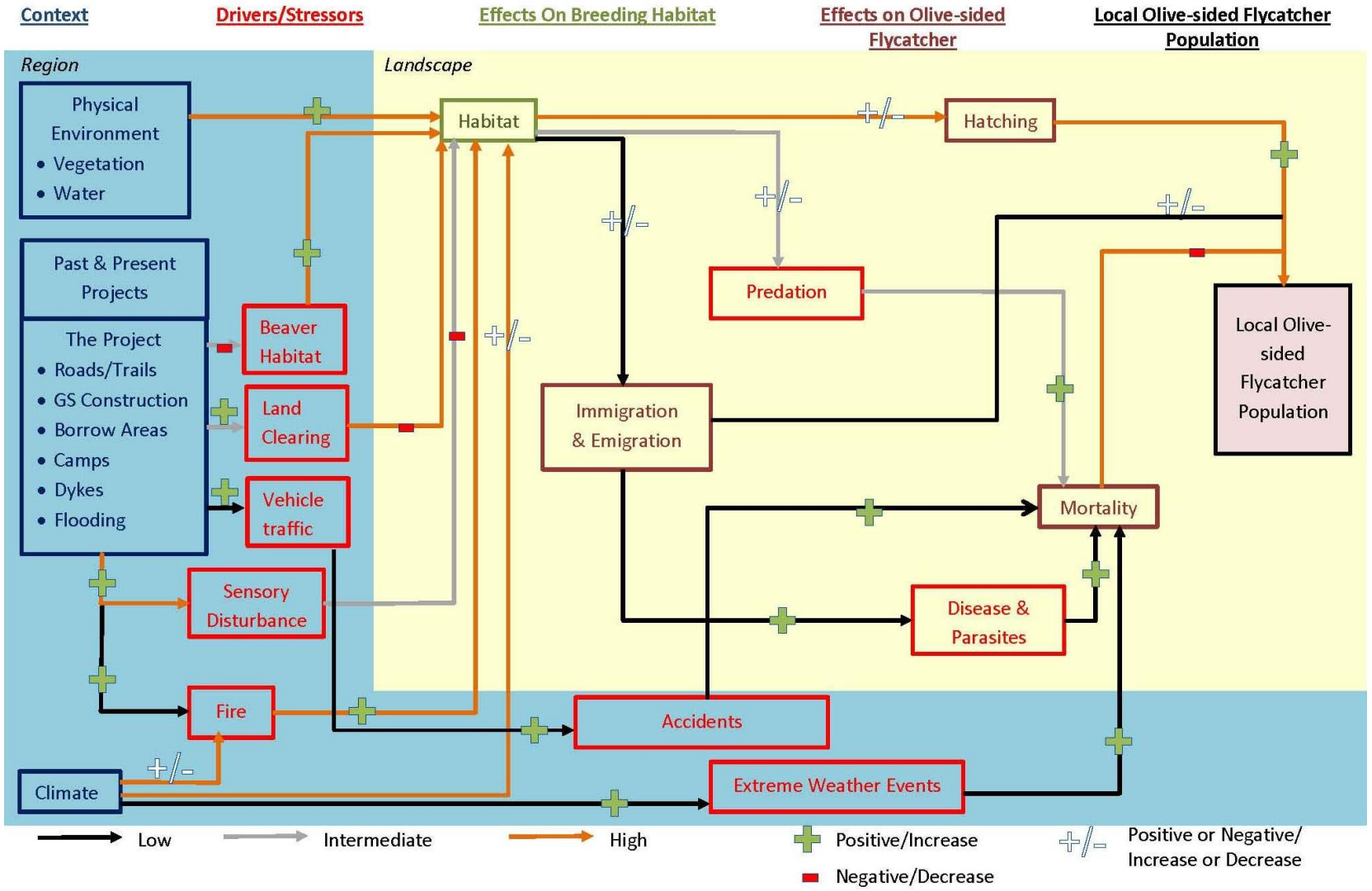


Figure 7–1 **Factors influencing local population of olive-sided flycatcher breeding in the Keeyask Bird Regional Study Area**

7.2.4 HABITAT IN THE STUDY AREA

7.2.4.1 REGIONAL STUDY AREA

Within the Bird Regional Study Area, olive-sided flycatcher have been observed inhabiting areas with mature forests that are in close proximity to open areas such as regenerating burn, beaver floods, water bodies, or muskeg. Primary and secondary breeding habitat for this species is distributed evenly throughout the Bird Regional Study Area (Map 7–1).

7.2.4.2 LOCAL STUDY AREA

Primary and secondary breeding habitat for this olive-sided flycatcher is distributed evenly throughout the Local Study Area, occurring along regenerating burns, rivers, creeks and other water bodies. Olive-sided flycatcher occupies large breeding territories that range in size from about 10 to 26-ha. Their foraging range is up to 1 km from the nest.

7.3 METHODS

The olive-sided flycatcher habitat quality model was developed through the following steps:

1. Summarize habitat relationships from relevant literature, existing information for the Bird Regional Study Area and professional judgment. Producing this summarization was an iterative process in which preliminary generalizations were progressively refined as studies were conducted in the Bird Regional Study Area;
2. Verify the relationships for the Bird Regional Study Area by conducting field studies within the Bird Regional Study Area;
3. Use available information and professional judgment to assign mapped habitat types (ECOSTEM 2011) into primary and secondary habitat categories for olive-sided flycatcher; and,
4. Use data and other information from the Bird Regional Study Area to verify and refine the predicted categorization of mapped habitat types into primary and secondary habitat for olive-sided flycatcher.

The resulting olive-sided flycatcher habitat quality class was used to quantify the total amount of olive-sided flycatcher habitat in the Bird Regional Study Area at various points in time.

7.3.1 STUDY AREAS

Study sites are located in the Bird Regional (Zone 4) and Local Study Areas and the Project Footprint, shown in Map 2-1. Surveys were performed in a variety of habitat types that were representative of the entire study

area. A greater proportion of surveys were completed in the Project Footprint to gain a better understanding of the use of habitat that would be lost due to flooding from the project.

7.3.2 INFORMATION SOURCES

A variety of information sources were used in developing study design, data collection method and data modelling. For study design, spatial information such as aerial photographs, forest resource inventory and topographical mapping was used for choosing sampling locations. As well, a preliminary spatial stand level habitat dataset (ECOSTEM 2008) for the project was used for choosing sample locations in later years of the study. For data collection, standard data collection protocols for point-count sampling (Ralph *et al.* 1993, Welsh 1993) were employed. A revised stand level habitat dataset for the project (ECOSTEM 2011), as well as peer reviewed literature on habitat preferences were used to develop habitat quality models.

7.3.2.1 EXISTING INFORMATION FOR THE STUDY AREA

Information sources used for the study area include the provincial Forest Resource Inventory data, topographical mapping (NTS), aerial photography and the ECOSTEM habitat dataset.

7.3.2.2 DATA COLLECTION

Data collected on the breeding bird community, including the olive-sided flycatcher, was initiated in 2001, with samples collected in 2001-2007 and in 2009-2012. During this time, 1036 point-count plots along 156 transects were surveyed, with variable numbers of transects being surveyed every year. Some of these transects were surveyed over multiple years, while others were only sampled once. Sampling was conducted in a variety of habitat types within the Bird Local and Regional Study Areas. Sample locations were chosen within representative habitat types (Table 7–1). For the most part, common habitat types had the most samples, while less common habitat types had fewer samples. However, some rarer habitat types (*e.g.*, those with jack pine, tamarack, trembling aspen and white birch) had proportionally more sampling, in order to identify any rare, uncommon or unique bird species and/or species assemblages (Table 7–1).

In early years of the study, points were chosen based on aerial photography and ground reconnaissance. Points were placed along transects within fairly homogenous habitat. In later years of the study, transect locations were selected to capture multiple points within individual stands at the broad habitat level (as characterized by the ECOSTEM habitat dataset) and to identify habitat preferences of the bird VECs, (including primary and secondary quality habitat for species at risk) as identified in the habitat models. Transect configuration, direction and length were dependant on specific site characteristics.

Areas where sampling efforts were focused included the south access road right-of-way, the Gull Rapids site, and low lying riparian areas that would be inundated by the Project (*e.g.*, north and south shores of Gull Lake, islands). Eighty-seven percent of all plots surveyed over the years fell within the Bird Local Study Area, while thirteen percent fell within outside of the Bird Local Study Area. Of the points within the Bird Local Study Area, 46% of all plots were surveyed in the area that will be flooded (Project Footprint - Zone 1), 19% of

within 150-m of the area to be flooded (Zone 2) and 21% greater than 150 m away from areas to be flooded (Local Study Area, Zone 3).

Survey effort for breeding birds increased over the three-year sampling period (2001-2003). In 2001, surveys were conducted at 197 survey stops located along 32 pre-selected transects. In 2002, 226 stops along 35 transects were surveyed. As information on locations of potential borrow areas became available in 2003, sampling effort increased to include 337 stops along 59 transects. The majority of transect stops surveyed in 2001 were resurveyed in 2002 and 2003.

In 2004, survey effort was focused in the area of the potential routing for the north access road. In mid-June, 58 stops located along 11 transects were surveyed for breeding birds using the esker (original site of the proposed north access road). In 2005, survey efforts expanded to include both the proposed north and south access road areas. Transects established along the esker in 2004 were replicated in 2005. In June 2005, a total of 62 survey stops located along six transects were surveyed in the proposed south access road area.

In 2006, surveys occurred at 69 stops located along six transects situated in the proposed south access road area and at 49 stops located along two transects situated near the shore of the north arm of Stephens Lake. If the Project proceeds, the new or altered shorelines at Gull Lake may, over time, resemble existing shorelines within a few bays located along the northwestern portion of Stephens Lake. For comparative purposes, 2006 surveys at Stephens Lake occurred in riparian habitats similar to those found in the Gull Lake riparian area (*e.g.*, sparsely treed muskeg and black spruce forest). By 2007, survey effort along the north arm of Stephens Lake expanded to include 61 stops along four transects and 65 stops along 11 transects located in comparative areas adjacent to Gull Lake and the Nelson River (at transects surveyed previously in 2003). In June 2010 breeding bird surveys occurred in regenerating forest and mixed-wood forest types throughout the Bird Local Study Area. In 2011, 171 stops along 29 transects were completed. In 2012 regenerating forests and mature forests were surveyed at 38 stops located along 11 transects.

Table 7-1 Broad Habitats Represented by Breeding Bird Survey Program in Keeyask Bird Regional Study Area, 2001-2012

Broad Habitat	Bird Regional Study Area Totals		Bird Regional Study Area Sampled		Percent Represented by Samples
	Area (ha)	Percent	Area (ha)	Percent	
Black spruce dominant on thin peatland	52995.62	31.69	422.46	23.56	0.80
Black spruce dominant on shallow peatland	33333.01	19.93	250.76	13.99	0.75
Black spruce dominant on ground ice peatland	19531.32	11.68	82.26	4.59	0.42
Black spruce dominant on mineral	12525.15	7.49	195.74	10.92	1.56
Low Vegetation on thin peatland	6815.34	4.07	53.46	2.98	0.78
Low vegetation on ground ice peatland	6072.58	3.63	28.07	1.57	0.46
Low vegetation on shallow peatland	5344.22	3.20	43.48	2.42	0.81
Black spruce dominant on wet peatland	3430.53	2.05	12.35	0.69	0.36
Human infrastructure	3375.75	2.02	86.84	4.84	2.57
Low vegetation on riparian peatland	3007.28	1.80	18.35	1.02	0.61
Low vegetation on wet peatland	2563.17	1.53	4.80	0.27	0.19
Jack pine dominant on mineral	1994.71	1.19	131.20	7.32	6.58
Black spruce mixture on mineral	1253.97	0.75	93.10	5.19	7.42
Tamarack mixture on wet peatland	1234.94	0.74	3.45	0.19	0.28
Black spruce dominant on riparian peatland	1090.82	0.65	4.20	0.23	0.39
Black spruce mixture on thin peatland	1040.91	0.62	31.08	1.73	2.99
Tall shrub on riparian peatland	973.51	0.58	13.42	0.75	1.38
Trembling aspen dominant on all ecosites	905.35	0.54	32.48	1.81	3.59
Trembling aspen mixedwood on all ecosites	751.54	0.45	51.59	2.88	6.86
Black spruce mixture on shallow peatland	736.85	0.44	11.27	0.63	1.53
Jack pine mixture on thin peatland	672.66	0.40	31.87	1.78	4.74

Broad Habitat	Bird Regional Study Area Totals		Bird Regional Study Area Sampled		Percent Represented by Samples
	Area (ha)	Percent	Area (ha)	Percent	
Tall Shrub on upper beach- regulated	650.45	0.39	4.33	0.24	0.67
Low vegetation on mineral	646.26	0.39	7.45	0.42	1.15
Tamarack mixture on shallow peatland	447.24	0.27	3.17	0.18	0.71
Young regeneration on thin peatland	433.30	0.26	0.01	0.00	0.00
Tall shrub on shallow peatland	428.97	0.26	3.82	0.21	0.89
Black spruce mixedwood on mineral	396.60	0.24	28.04	1.56	7.07
Tamarack mixture on thin peatland	387.70	0.23	6.89	0.38	1.78
Jack pine mixedwood on mineral	277.19	0.17	53.07	2.96	19.14
Tamarack dominant on wet peatland	262.19	0.16	3.14	0.17	1.20
Tall shrub on thin peatland	253.12	0.15	6.52	0.36	2.57
Black spruce mixture on ground ice peatland	237.16	0.14	3.56	0.20	1.50
Black spruce mixture on wet peatland	225.13	0.13	1.32	0.07	0.59
Tall shrub on wet peatland	212.55	0.13	3.36	0.19	1.58
Shrub/Low Veg Mixture on Upper beach- regulated	205.22	0.12	3.49	0.19	1.70
Tamarack mixture on ground ice peatland	196.34	0.12	0.50	0.03	0.26
Jack pine mixedwood on thin peatland	181.15	0.11	5.51	0.31	3.04
Jack pine dominant on thin peatland	169.40	0.10	3.45	0.19	2.04
Low vegetation on upper beach- regulated	162.35	0.10	1.17	0.07	0.72
Shrub/Low Veg Mixture on Sunken Peat- regulated	160.65	0.10	2.69	0.15	1.68
Young regeneration on ground ice peatland	150.24	0.09	0.00	0.00	0.00
Tamarack mixture on mineral	136.60	0.08	16.00	0.89	11.72
Tall shrub on ground ice peatland	132.66	0.08	1.42	0.08	1.07
Shrub/Low veg mixture on ice scoured upland	122.09	0.07	2.80	0.16	2.30
Young regeneration on shallow peatland	118.22	0.07	0.00	0.00	0.00
Black spruce mixedwood on thin peatland	113.28	0.07	0.98	0.05	0.87

Broad Habitat	Bird Regional Study Area Totals		Bird Regional Study Area Sampled		Percent Represented by Samples
	Area (ha)	Percent	Area (ha)	Percent	
Emergent on upper beach	94.12	0.06	0.38	0.02	0.40
Emergent island in littoral	81.32	0.05	0.01	0.00	0.02
Low vegetation on sunken peat- regulated	75.89	0.05	0.00	0.00	0.00
White birch dominant on all ecosites	70.79	0.04	2.37	0.13	3.34
Jack pine mixture on shallow peatland	67.37	0.04	1.94	0.11	2.87
Tall shrub on mineral	62.69	0.04	2.45	0.14	3.90
White birch mixedwood on all ecosites	57.09	0.03	6.99	0.39	12.24
Tamarack dominant on shallow peatland	56.33	0.03	0.11	0.01	0.19
Tamarack- black spruce mixture on riparian peatland	55.64	0.03	1.67	0.09	3.01
Tamarack dominant on mineral	39.28	0.02	1.32	0.07	3.36
Black spruce mixedwood on shallow peatland	37.32	0.02	0.00	0.00	0.00
Tamarack dominant on ground ice peatland	35.51	0.02	0.00	0.00	0.00
Young regeneration on mineral	34.59	0.02	0.00	0.00	0.00
Tamarack dominant on thin peatland	30.82	0.02	0.00	0.00	0.00
Young regeneration on wet peatland	19.20	0.01	0.00	0.00	0.00
Emergent on lower beach	17.77	0.01	0.16	0.01	0.92
Jack pine dominant on shallow peatland	17.50	0.01	0.05	0.00	0.30
Jack pine mixedwood on shallow peatland	13.20	0.01	0.08	0.00	0.60
Emergent on lower beach- regulated	11.11	0.01	0.00	0.00	0.00
Tamarack dominant on riparian peatland	10.45	0.01	0.00	0.00	0.00
Emergent on sunken peat- regulated	4.26	0.00	0.00	0.00	0.00
Young regeneration on riparian peatland	3.45	0.00	0.00	0.00	0.00
Balsam poplar dominant on all ecosites	2.66	0.00	0.00	0.00	0.00
Balsam poplar mixedwood on all ecosites	1.48	0.00	0.00	0.00	0.00
Totals	**167255.13**		**1782.41**		

Methods used for conducting breeding bird surveys were consistent with standard procedures and included using the point-count method for sampling breeding bird communities (Ralph *et al.* 1993, Welsh 1993). Breeding bird surveys coincided with peak songbird breeding activity, between late May and early July (USGS 2007). While this method primarily targeted passerines, other forest birds were also recorded when encountered (*e.g.*, woodpeckers, upland game birds, raptors, and shorebirds). The standard point-count method procedures (Ralph *et al.* 1993, Welsh 1993) used for all breeding bird surveys were as follows:

- Surveys were conducted during peak bird singing hours, between sunrise (approximately 5:00am) and 10:30 a.m.
- Point-count stops were generally located at 150-m intervals along transects of variable length; transect length was dependent on habitat availability.
- Two biologists recorded all birds and other wildlife heard or seen within and just outside of a 75-m radius (1.77 ha) point-count plot for a period of three minutes.
- Data on habitat, vegetation types and time were recorded at each stop and representative photographs of surveyed habitat types were also taken. Surveys were not conducted in moderate to high winds (>20 km/h) or in rain/snow.

Some breeding bird surveys were targeted towards areas known to provide habitat for olive-sided flycatcher. Selection of transect locations was based on known habitat preferences, and in later years of the study, based on the olive-sided flycatcher model. In total, 253 point count plots in areas identified as primary or secondary habitat for olive-sided flycatcher in the Bird Regional Study Area were sampled. Sampling for olive sided flycatcher was fairly representative of the amount of different broad habitat types identified in the model (Table 7–2). Some less common habitat types, such as those with young regenerating trees had proportionally higher sampling effort, as it is important to capture unique habitat types that may be important to olive-sided flycatcher.

Table 7-2 Field Samples of olive-sided flycatcher habitat from 2001-2012 by Broad Habitat Type

Broad Habitat Type*	Percent of Primary and Secondary habitat	Percent of Samples
Black spruce dominant on thin peatland	23.97%	19.21%
Black spruce dominant on ground ice peatland	19.48%	4.37%
Black spruce dominant on shallow peatland	15.34%	23.14%
Shallow water	6.78%	-
Black spruce dominant on wet peatland	5.95%	0.87%
Black spruce dominant on mineral	4.10%	9.17%
Low vegetation on wet peatland	2.67%	0.87%
Black spruce dominant on riparian peatland	2.63%	-
Low vegetation on ground ice peatland	2.59%	1.75%
Low vegetation on riparian peatland	1.72%	2.62%
Black spruce mixture on shallow peatland	1.36%	0.87%
Tamarack mixture on wet peatland	1.30%	-

Low Vegetation on thin peatland	1.28%	-
Low vegetation on shallow peatland	1.09%	1.75%
Black spruce mixture on thin peatland	1.09%	4.80%
Black spruce mixture on mineral	0.90%	3.06%
Human infrastructure	0.89%	1.31%
Black spruce mixture on wet peatland	0.63%	-
Jack pine dominant on mineral	0.60%	3.93%
Tamarack mixture on shallow peatland	0.55%	-
Tall shrub on riparian peatland	0.52%	-
Tall Shrub on upper beach- regulated	0.50%	-
Black spruce mixture on ground ice peatland	0.38%	0.44%
Trembling aspen dominant on all ecosites	0.37%	1.75%
Black spruce mixedwood on thin peatland	0.30%	0.44%
Young regeneration on thin peatland	0.30%	1.31%
Tall shrub on shallow peatland	0.28%	-
Black spruce mixedwood on mineral	0.26%	-
Trembling aspen mixedwood on all ecosites	0.23%	2.18%
Low vegetation on mineral	0.23%	1.31%
Jack pine mixture on thin peatland	0.22%	0.44%
Tamarack- black spruce mixture on riparian peatland	0.22%	-
Tamarack dominant on wet peatland	0.17%	-
Tall shrub on thin peatland	0.15%	-
Young regeneration on shallow peatland	0.15%	1.31%
Young regeneration on ground ice peatland	0.14%	0.44%
Jack pine mixedwood on mineral	0.12%	-
Tamarack mixture on thin peatland	0.12%	0.44%
Black spruce mixedwood on shallow peatland	0.11%	-
Tamarack mixture on ground ice peatland	0.10%	-
Tall shrub on wet peatland	0.08%	0.44%
Tall shrub on ground ice peatland	0.06%	-
Tall shrub on mineral	0.06%	0.44%
Emergent on upper beach	0.06%	-
Tamarack dominant on shallow peatland	0.05%	-
Young regeneration on mineral	0.05%	4.80%
Jack pine mixedwood on thin peatland	0.05%	0.44%
White birch dominant on all ecosites	0.04%	0.44%
Tamarack mixture on mineral	0.04%	0.44%
Low vegetation on upper beach- regulated	0.03%	-
Jack pine dominant on thin peatland	0.03%	-
Emergent island in littoral	0.03%	-
Tamarack dominant on riparian peatland	0.02%	-
Shrub/Low Veg Mixture on Upper beach- regulated	0.02%	-
Shrub/Low veg mixture on ice scoured upland	0.02%	-
Jack pine mixture on shallow peatland	0.01%	0.44%
Tamarack dominant on ground ice peatland	0.01%	-
Emergent on lower beach	0.01%	-
Young regeneration on riparian peatland	0.01%	-
Low vegetation on sunken peat- regulated	0.01%	-
Tamarack dominant on thin peatland	0.01%	-

Young regeneration on wet peatland	0.00%	-
White birch mixedwood on all ecosites	0.00%	-

*Broad habitat types assigned to each point-count stop were based on the stand level-attributes. In cases where several broad habitat types occurred within a point count, the broad habitat type of the stand that covered the majority of the 75-m point-count radius was used.

7.3.3 EXPERT INFORMATION MODEL

A preliminary classification of primary and secondary habitat for olive-sided flycatcher was developed based on the relevant literature, existing information from the Bird Regional Study Area and professional judgment developed from conducting studies in the Bird Regional Study Area and elsewhere. Table 7–3 lists the mapped habitat types classified as primary and secondary habitat, including any spatial relationships (*e.g.*, within 50 m of a recent burn).

There were several stages in the operation of the model. Firstly, to identify open areas that may be used by olive-sided flycatcher, the following queries and geospatial analyses were run in MapInfo Version 9.5 on the stand level habitat data (ECOSTEM 2011):

- Polygons where the vegetation structure was water (*i.e.*, all areas of open water) were identified.
- Polygons where the age of the stand (in 2010) was greater than 4 and less than 16 were selected, identifying all regenerating burns between 5 and 15 years old.
- Polygons where the wetland class was a bog, fine ecosite type was a wet peatland, a shore zone peatland or a shore zone and where vegetation structure was either low vegetation or tall shrubland were selected, identifying all open bogs.
- Polygons where the wetland class was a fen and vegetation structure was classified as either forest or woodland were selected, identifying all wooded fens.
- A buffer of 50 m was created around all open areas.

For primary habitat, a query was used to identify mature coniferous forest:

- Polygons which were not recently burned and where the broad vegetation type was black spruce and the vegetative structure was forest or woodland were selected, identifying mature black spruce stands

For secondary habitat, a query was used to identify young spruce dominated needle forest/woodland and late successional or semi-open coniferous and mixedwood forests:

- Polygons where the vegetation structure was forest or woodland, the broad vegetation type was black spruce pure or black spruce mixture and the age was more than 4 and less that 16 years old were selected, identifying younger, black spruce dominated woodland/forests
- Polygons where the broad vegetation type was black spruce mixture, black spruce mixedwood, jack pine mixedwood or jack pine mixture, the canopy closure was between 10% and 50% and the age was mature were selected, identifying late successional open and semi-open coniferous and or mixedwood forests

The final step involved selecting the forests (identified by the queries) which fell within the 50-m buffer of open areas to identify potential olive-sided flycatcher nesting habitat (*i.e.*, forested edges). As well, a 50-m buffer was created for the identified primary and secondary forest stands in order to include up to 50 m of the open areas adjacent to the primary and secondary habitat.

Table 7-3 Mapped habitat types for olive-sided flycatcher in Bird Regional Study Area

	Habitat Description	Modelled Habitat Attributes	Additional Factors (*e.g.*, proximity to water or edge)	Most common Broad Habitat types in Model
Primary Habitat	Old and mature needle forest/woodland (spruce dominated) or late successional open and semi-open coniferous and mixedwood forests within 50 m of open edge	● Broad vegetation type is Black Spruce, ● Age in 2010 is mature and ● Broad vegetation structure is forested or woodland	● Within 50 m of Open Bog, Wooded Fen, Water or Burn	Black spruce dominant on thin peatland, Black spruce dominant on shallow peatland, Black spruce dominant on ground ice peatland, Black spruce dominant on wet peatland, Black spruce dominant on riparian peatland, Low vegetation on ground ice peatland, Low vegetation on wet peatland, Black spruce dominant on mineral, Shallow water, Low vegetation on riparian peatland, Low Vegetation on thin peatland, Low vegetation on shallow peatland
	Edge habitat (*e.g.,* burn that is between 5 and 15 years, Beaver ponds with snags; water; bogs; muskeg; open areas with snags and lakes with standing dead trees) that falls within 50 m of Mature Black Spruce forest/woodland	● Vegetation structure is water (*i.e.*, all open water areas) ● Age in 2010 is between 5 and 15 years old (*i.e.*, burn) ● Wetland class is a bog, fine ecosite type is a wet peatland, a shore zone peatland or a shore zone and vegetation structure was either low vegetation or tall shrubland were selected, (*i.e.*, open bogs)	● Within 50 m of mature black spruce forest/woodland identified as primary habitat	
	Poor wooded fen, rich wooded fen and wooded swamp that falls within 50 m of Mature Black Spruce forest/woodland	● Wetland class is a fen and vegetation structure is classified as either forest or woodland (*i.e.,* wooded fens)	● Within 50 m of mature black spruce forest/woodland identified as primary habitat	
Secondary Habitat	Young needle forest/woodland (spruce dominated) within 50 m of an edge	● Vegetation structure is forest or woodland, ● Broad vegetation type is Black Spruce Pure or Black Spruce Mixture and ● Age in 2010 is between 5 and 15 years old	● Within 50 m of Open Bog, Wooded Fen, Water or Burn	Black spruce dominant on thin peatland, Black spruce dominant on shallow peatland, Black spruce dominant on ground ice peatland, Black spruce dominant on mineral, Black spruce dominant on wet peatland, Low Vegetation on thin peatland, Black spruce dominant on riparian peatland, Low vegetation on shallow peatland, Low vegetation on wet peatland, Black spruce mixture on thin peatland, Low vegetation on riparian peatland, Black spruce mixture on shallow peatland, Low vegetation on mineral, Shallow water, Black spruce mixture on mineral
	Late successional open and semi-open coniferous and or mixedwood forests within 50 m of an edge	● Broad vegetation type is Black Spruce Mixture, Black Spruce Mixedwood, Jack Pine Mixedwood or Jack Pine Mixture, ● Canopy closure is between 10% and 50% and ● Age in 2010 is mature	● Within 50 m of Open Bog, Wooded Fen, Water or Burn	
	Edge habitat (*e.g.,* burn that is between 5 and 15 years, Beaver ponds with snags; water; bogs; muskeg; open areas with snags and lakes with standing dead trees) that falls within 50 m of young needle forest/woodland open/semi-open late successional coniferous/mixedwood forest	● Vegetation structure is water (i.e,. all open water areas) ● Age in 2010 is between 5 and 15 years old (*i.e.*, burn) ● Wetland class is a bog, fine ecosite type is a wet peatland, a shore zone peatland or a shore zone and vegetation structure was either low vegetation or tall shrubland were selected, (*i.e.,* open bogs)	● Within 50 m of young needle forest/woodland or open/semi-open late successional coniferous mixed-wood identified as secondary habitat	
	Poor wooded fen, rich wooded fen and wooded swamp that falls within 50 m of young needle forest/woodland or open/semi-open late successional coniferous/mixedwood forest	● Wetland class is a fen and vegetation structure is classified as either forest or woodland (*i.e.*, wooded fens)	● Within 50 m of young needle forest/woodland or open/semi-open late successional coniferous mixed-wood identified as secondary habitat	

7.3.4 ANALYSIS METHODS

The preliminary classification of primary and secondary habitat for olive-sided flycatcher was confirmed, and in some cases, quantified, by analysis of data collected in the Bird Regional Study Area.

Queries and geospatial analyses were run in MapInfo Version 9.5 on the spatial ECOSTEM habitat data to identify suitable habitat for olive-sided flycatcher. Models selected for mature forested coniferous areas that were within 50 m of water, open bog, wooded fen or young regeneration that was between 5 and 15 years old. Primary and secondary habitat for olive-sided flycatcher was identified.

Area of suitable habitat polygons were summed to calculate how much habitat was available, while suitable habitat that fell within the project footprint was summed to calculate how much habitat would be lost or impacted with project development.

Several assumptions must be noted with respect to model verification:

- Models are based on peer-reviewed literature as well as professional opinion.
- True model validation is not always possible for rare species (due to their low abundance); however, field observations can be used to verify and support habitat quality model predictions.
- As birds are highly mobile and move throughout their territories, observations in areas that are not identified as suitable habitat can occur.

7.4 RESULTS

7.4.1 DESCRIPTIVE STATISTICS

The expert information model identified 9,513 ha (5.7% of total land area) of primary breeding habitat for olive-sided flycatcher in all study areas. Of this habitat, 7,867 ha (82% of available habitat) falls within the Bird Regional Study Area (*i.e.*, Zone 4), 1,084 ha (11.3% of available habitat) falls within the Local Study Area (*i.e.*, Zone 3), 244 ha (2.6% of available habitat) falls within the 150-m buffer of Project Footprint (*i.e.*, Zone 2) and 352 ha (3.7% of available habitat) falls within the Project Footprint (*i.e.*, Zone 1).

The model identified 8,039 ha (4.8% of total land area) of secondary breeding habitat for olive-sided flycatcher. Of this habitat, 5,226 ha (65% of available habitat) falls within the Bird Regional Study Area (*i.e.*, Zone 4), 1,276 ha (15.8% of available habitat) falls within the Local Study Area (*i.e.*, Zone 3), 354 ha (4.4% of available habitat) falls within the 150-m buffer of Project Footprint (*i.e.*, Zone 2) and 1,172 ha (14.6% of available habitat) falls within the Project Footprint (*i.e.*, Zone 1).

Based on field observations, the broad habitats with the highest recorded densities of olive-sided flycatcher include; 1) black spruce dominant on ground ice peatland, 2) low vegetation on ground ice peatland and 3) low vegetation on shallow peatland (Table 7-4). These broad habitats also made up higher percentage of the primary and secondary habitat identified in the expert information model (see Table 7–2). In summary, the field observations showed that olive-sided flycatchers use mature forest, open bogs (*i.e.*, low vegetation) and young regenerating areas, which fits with the model predictions for this species.

Table 7-4 Territories (# of singling males) per hectare of Olive-sided flycatcher in Keeyask Bird Regional Study Area, 2001-2012

Broad Habitat type	Density (Singing males/ha)										
	2001	2002	2003	2004	2005	2006	2007	2009	2010	2011	2012
Black spruce dominant on ground ice peatland	0.09 ± 0.22	0.03 ± 0.12	0.13 ± 0.24	-	-	0	0	0	0	0	0.07 ± 0.2
Black spruce dominant on mineral	0.03 ± 0.13	0.045 ± 0.16	0	0	0	0.04 ± 0.15	0	0	0	0	0
Black spruce dominant on riparian peatland	-	-	-	-	-	-	-	-	-	-	0.14 ± 0.38
Black spruce dominant on shallow peatland	0	0	0.04 ± 0.14	-	0	0	0	0	0	0	0
Black spruce dominant on thin peatland	0	0.02 ± 0.11	0	0	0	0	0	0.02 ± 0.11	0	0	0
Black spruce dominant on wet peatland	0	0	0	-	0	0.56 ± 0	-	0	0	0	0
Black spruce mixture on ground ice peatland	0	0.28 ± 0.4	0	-	-	-	-	-	-	-	-
Black spruce mixture on thin peatland	0	0	0	-	-	-	-	0.06 ± 0.18	0	0	0
Human infrastructure	0	0	0	-	0	0	-	0.56 ± 0	0	0	0
Low vegetation on ground ice peatland	0.28 ± 0.4	0	0	0	0	0	0	0	0	0.19 ± 0.33	0
Low vegetation on riparian peatland	0	0	0.28 ± 0.4	-	-	-	0	0	0	0	0
Low vegetation on shallow peatland	0	0	0	-	0.03 ± 0.12	0.06 ± 0.18	0	0	0.04 ± 0.16	0	0
Low vegetation on thin peatland	0	0	0	-	0.05 ± 0.16	0	0	0	0	0	0
Trembling aspen dominant on all ecosites	0	0.28 ± 0.4	0	0	0	0	-	0	0	0	-
Young regeneration on shallow peatland	0	0	0.56 ± 0	-	-	-	0	-	-	-	-

Note: Only broad habitat types where olive-sided flycatcher was present are listed in the table. Broad habitats where they are absent are not listed, as rare species absence data is considered ambiguous due to low number of observations, activity patterns, elusive behaviors and/or inaccessible habitats (Ottaviani *et al.* 2004).

In total, there were 39 observations of olive-sided flycatcher that fell within the 75-m radius point-count stops between 2001 and 2012. Of these observations, 23 (59%) were within areas identified as either primary or secondary habitat for olive-sided flycatcher. Five (13%) of the observations were within 100 m of primary or secondary habitat, while 6 (15%) were between 100 m and 500 m from the identified primary or secondary habitat. Five observations (13%) were between 500 m and 1100 m from either primary or secondary habitat.

Several assumptions underline the interpretation of these results:

- The point count method does not pinpoint the exact location of individuals.
- Olive-sided flycatcher has large territories for breeding and foraging. As the model only identifies breeding habitat, some of the observations that were further away from the predicted primary or secondary habitat may have been within foraging habitat, or while travelling within their larger territory.

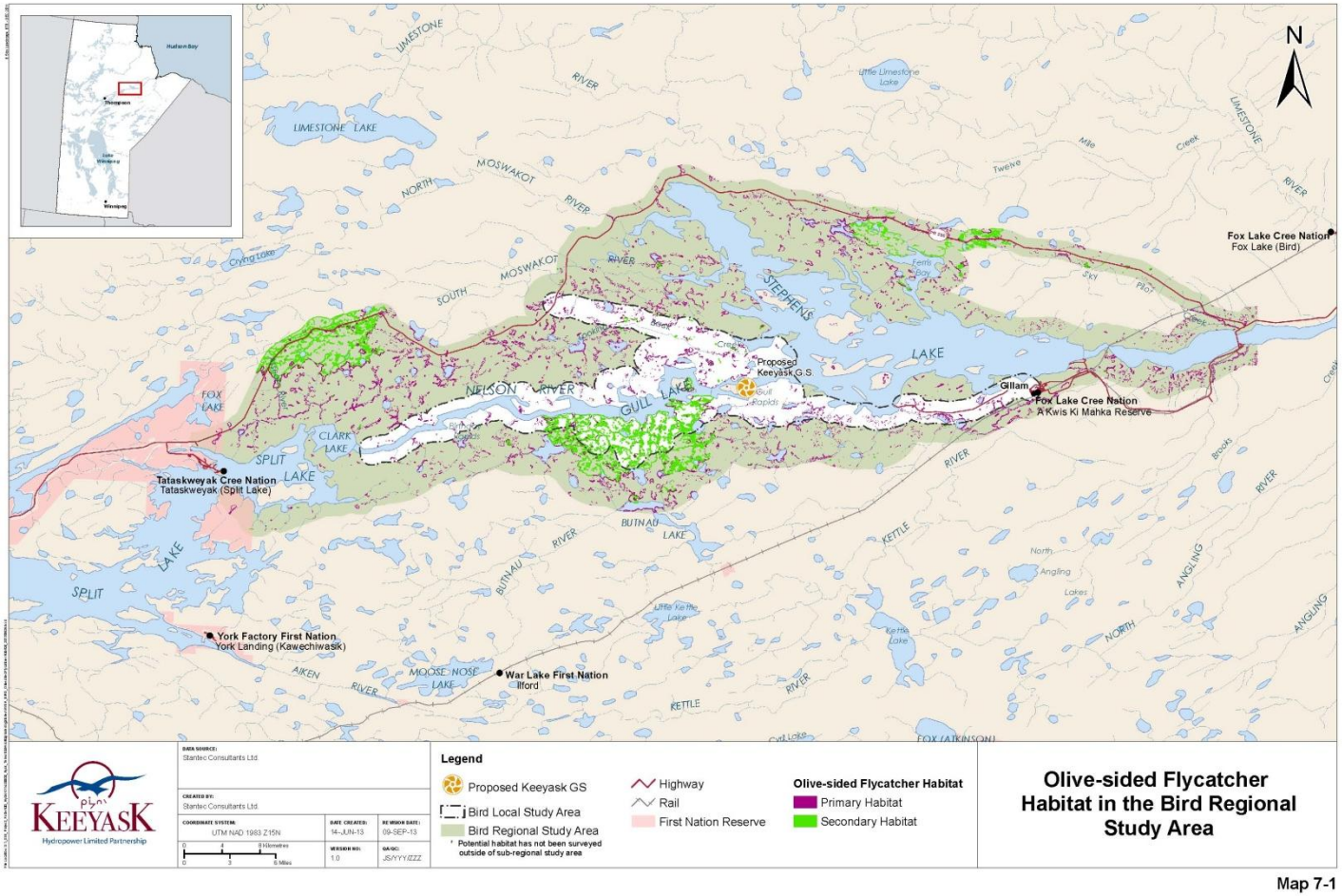
7.5 CONCLUSIONS

Field observations indicated that the highest densities of olive-sided flycatcher were in mature forest (*i.e.*, black spruce dominant) and areas with open bogs (*i.e.*, low vegetation communities). The habitat characteristics of areas where olive-sided flycatcher were observed in the field are consistent with the predictions from the expert information model.

The broad habitats where olive-sided flycatcher was observed were also identified as important habitat types in the expert information model. As the majority of field observations fell within habitat identified as primary or secondary habitat, the model appears to perform well.

A number of limitations exist for this analysis. The point-count method estimates populations within a 75-m radius, but does not necessarily give the ability to pinpoint the exact location (and exact habitat type) that each bird falls within. Olive-sided flycatcher is a rare species and field observations were sparse. Olive-sided flycatchers have very large territories for foraging, making their habitat preferences diverse. Information on rare species like this one is often challenging to obtain. As most birds respond to local, patch and landscape level habitat attributes, a model including vegetation structure (*e.g.*, structure, tree height, presence of snags, vegetative composition) could provide a more refined estimate of suitable habitat. However, with a rare species such as olive-sided flycatcher, it would be difficult to collect sufficient field data to refine the attributes.

7.6 MAPS



Map 7–1: Olive-sided Flycatcher Habitat in the Bird Regional Study Area

8.0 RUSTY BLACKBIRD

8.1 INTRODUCTION

Rusty blackbird is a medium-sized songbird with pale yellow eyes and a slightly curved bill. During the breeding season, the male rusty blackbird is totally black with greenish gloss to its body and violet gloss to its head and neck, while the female is brownish grey. This species is named for the rust-colored edging on their non-breeding plumage. Rusty blackbird is found throughout the Bird Regional and Local Study Areas.

8.2 SPECIES OVERVIEW FROM LITERATURE

8.2.1 GENERAL LIFE HISTORY

Rusty blackbird has been assessed by COSEWIC and is listed as a species of special concern under SARA (Schedule 1). Rusty blackbird has experienced widespread decline throughout its range. Due to its low population density, rusty blackbird is not well studied like other North American blackbirds. This species nests along bogs, muskeg, swamp, beaver ponds, creeks and other waterways in wet coniferous forests.

8.2.2 DISTRIBUTION AND ABUNDANCE

8.2.2.1 CONTINENTAL AND GLOBAL

Rusty blackbirds breed in the coniferous forests from Alaska to the Maritime Provinces, to south-eastern Canada and north-eastern United States and overwinter in the south-eastern United States from South Dakota to the Gulf coast (Avery 1995). They migrate in large flocks, often with different species of blackbirds. In the United States, rusty blackbird populations have declined, but this decline is not deemed statistically significant (Sauer *et al.* 2011). In Canada, rusty blackbird has declined an average of 8.7% per year since 1970 (Collins and Downes 2009) with overall population declines of 85% since the 1960's and 18.3% from 1997 to 2007 (COSEWIC 2006).

There is much uncertainty regarding the population of rusty blackbird in Canada, estimated to be between 110,000 and 1.4 million individuals (COSEWIC 2006). Partners in Flight estimates the population of rusty blackbird to be 1.9 million across its breeding range (Rich *et al.* 2004). The declines are possibly related to habitat loss from activities such as clear -cut logging and the associated invasion of competitive species such as common grackle and red-winged blackbird. On their wintering range, conversion of wetlands for agriculture and urban development are the primary cause of habitat loss (COSEWIC 2006).

8.2.2.2 PROVINCIAL

Rusty blackbird range in Manitoba is in the treed muskeg north of the 55th parallel, which is further north that other blackbird species in the province (Nero and Taylor 2003). They pass through southern Manitoba between late March and mid-April and arrive on their northern breeding grounds by the second week of May to early June (Nero and Taylor 2003). The Canadian Breeding Bird Survey does not report specific trends for Manitoba, but does show an average population decline of 16.3% per year in the boreal softwood shield since 1970 (Collins and Downes 2009). In Manitoba the population estimate for rusty blackbird is 140,000 individuals (Rich *et al.* 2004).

8.2.2.3 REGIONAL STUDY AREA

Rusty blackbirds return to their breeding grounds in the study area from their wintering grounds in the Mississippi Valley Area in the central United States. Rusty blackbird primary and secondary breeding habitat includes wet peatlands (*e.g.*, bogs) and wooded swamps that are widely available throughout the Bird Regional Study Area. Within these habitats, rusty blackbirds will nest in young conifers located adjacent to wetlands or areas that pool water. In the Bird Regional Study Area, rusty blackbirds were observed using riparian habitat associated with inland lakes, creeks, the Nelson River and Gull Lake. This species was detected throughout the Bird Regional Study Area and was most often associated with creeks, inland lakes, Nelson River shorelines, and wet peatland located in inland areas. During the breeding bird surveys, detection of this species was relatively uncommon, although some were observed during boat and helicopter surveys.

8.2.3 FACTORS THAT INFLUENCE DISTRIBUTION AND ABUNDANCE

8.2.3.1 HABITAT

Breeding habitat is a critical requirement in the life cycle of rusty blackbird. They inhabit wet coniferous and mixedwood forests from the northern edge of the tundra to the beginning of the deciduous forests and grasslands. Rusty blackbirds most frequently nest close to forest openings with bogs, muskeg, swamps, and beaver ponds or near the wetlands adjacent to rivers, streams and lakes (Flood 1987, Semenchuk 1992).

8.2.3.1.1 SEASONAL FORAGE AND WATER

Rusty blackbirds are opportunistic feeders that eat plants, insects and other animal food. They forage on the ground for aquatic insects and small fish in riparian areas adjacent to wetlands, ponds, creeks, rivers and lakes (Avery 1995). They wade in shallow water and will plunge their whole head into the water to catch prey. Rusty blackbird have been observed finding prey in moss or under leaf litter or even attacking, killing and eating other bird prey (Avery 1995, Nero and Taylor 2003).

8.2.3.1.2 BREEDING

Nests are built near the edges of water, often a few metres up a coniferous tree or on a willow (Nero and Taylor 2003). The female builds a bulky nest, with the outer layer constructed of dried twigs, grasses and lichen with an inner bowl of wet, decaying vegetation (Avery 1995). The nest is often against the trunk of a tree amid a thick layer of small branches that provide cover. No information is available on the size of breeding territories for rusty blackbird.

8.2.3.1.3 BROOD REARING

Rusty blackbirds produce a clutch of three to six eggs, which are incubated solely by the female. The incubation period lasts approximately 14 days (Ehrlich *et al.* 1988). The male brings food to the incubating female, who joins him to feed on a perch close to the nest. Young are altricial (featherless and helpless) at birth. Both parents feed the young, and the nestlings remain in the nest for a period of 11 to 13 days before fledging.

8.2.3.1.4 DISPERSAL AND MIGRATION

After rearing of their young, birds need to fatten up for the purpose of moulting and in preparation for fall migration. Information on the dispersal of rusty blackbirds after rearing is limited, but they may disperse locally to find areas with greater or different food supply.

Rusty blackbirds start their southern migration in early to mid-September and reach southern Manitoba by October (Nero and Taylor 2003). From there, they continue on to their wintering grounds in the United States.

8.2.3.2 FACTORS THAT REDUCE EFFECTIVE HABITAT

Construction-related noise from heavy equipment may reduce effective habitat due to avoidance. Although construction noise may reduce acoustical quality of bird song communication, reproductive success of rusty blackbirds is not expected to be adversely effected (Brumm 2004, Habib *et al.* 2007).

Clearing and flooding from the project may cause habitat alteration, which in turn, may reduce effective habitat. Changes to predator and prey densities from habitat alteration may also impact rusty blackbird habitat use. Mercury contamination of boreal wetlands due to construction of hydro reservoirs may also reduce available habitat for rusty blackbird (COSEWIC 2006).

8.2.3.3 MORTALITY

8.2.3.3.1 PREDATION

Hawks, owls and falcons are the main predators of adult rusty blackbird and grey jay (*Perisoreus canadensis*) may act as a nest predator (Avery 1995). The observed aggressive behavior of adult rusty blackbirds towards

American marten (*Martes americana*), Northern harrier (*Circus cyaneus*) and sharp-shinned hawk (*Accipiter striatus*) indicates that these species may also be predators (COSEWIC 2006).

8.2.3.3.2 ACCIDENTAL MORTALITY

Accidental mortality of rusty blackbird may occur as a result of vehicle traffic along roads/highways. Accidental rusty blackbird mortality is associated with nuisance blackbird control programs. However, these control programs normally occur in urban or agricultural areas and are unlikely to be a factor within the Bird Regional Study Area.

8.2.3.4 OTHER FACTORS THAT INFLUENCE SURVIVAL AND HABITAT USE

8.2.3.4.1 DISEASES AND PARASITES

Although West-Nile Virus is known to have an impact on corvids, rusty blackbird has not been impacted (Mengak 2009). Rusty Blackbird can be hosts to lice, nasal mites or blood parasites (Avery 1995).

8.2.3.4.2 MALNUTRITION

In times when the main food supply of insects and small fish is not available, rusty blackbirds have been known to predate upon other birds. They are opportunistic feeders who will eat a variety of other foods when supplies are low (Avery 1995).

8.2.3.4.3 SEVERE WEATHER

Climatic conditions play a very important role in the distribution of birds breeding in the boreal forest. Both the spring/summer temperature and precipitation impact species abundances and survival during the breeding season (DesGranges and LeBlanc 2012). As rusty blackbirds forage along wetland areas, heavy rain will reduce the amount of suitable foraging substrate, which may cause mortality from starvation or nest failure (Savard *et al.* 2011).

8.2.3.5 FRAGMENTATION AND CUMULATIVE EFFECTS

Fragmentation of habitat may be caused by associated developments such as roads, transmission lines and possible future development of exploration lines (*i.e.*, cutlines). As rusty blackbird is dependent on wetlands/riparian habitats, changes to the water regime may have a negative impact on their populations.

8.2.3.6 MOST INFLUENTIAL FACTORS

Availability of suitable breeding habitat is the most influential factor for the survival of rusty blackbird. Suitable breeding habitat must provide areas for nest sites and resources for other life requisites such as foraging, shelter and security. Rusty blackbird primary breeding habitat includes:

- needleleaf tree or tall shrub on deep wet peatland ;

- black spruce and tamarack larch are dominant tree species; and
- wet or deep peatland associated with horizontal or riparian fens

Secondary habitat includes:

- mixedwood and needleleaf on shallow peatland;
- needleleaf dominant with some bog birch;
- ground ice present in peatland; and
- habitat associated with a collapse scar or peat plateau bog

While there are a number of factors that influence rusty blackbird populations in the Bird Regional Study Area, availability of wetlands and riparian habitats is the key driver in the availability of rusty blackbird breeding habitat (Figure 8–1).

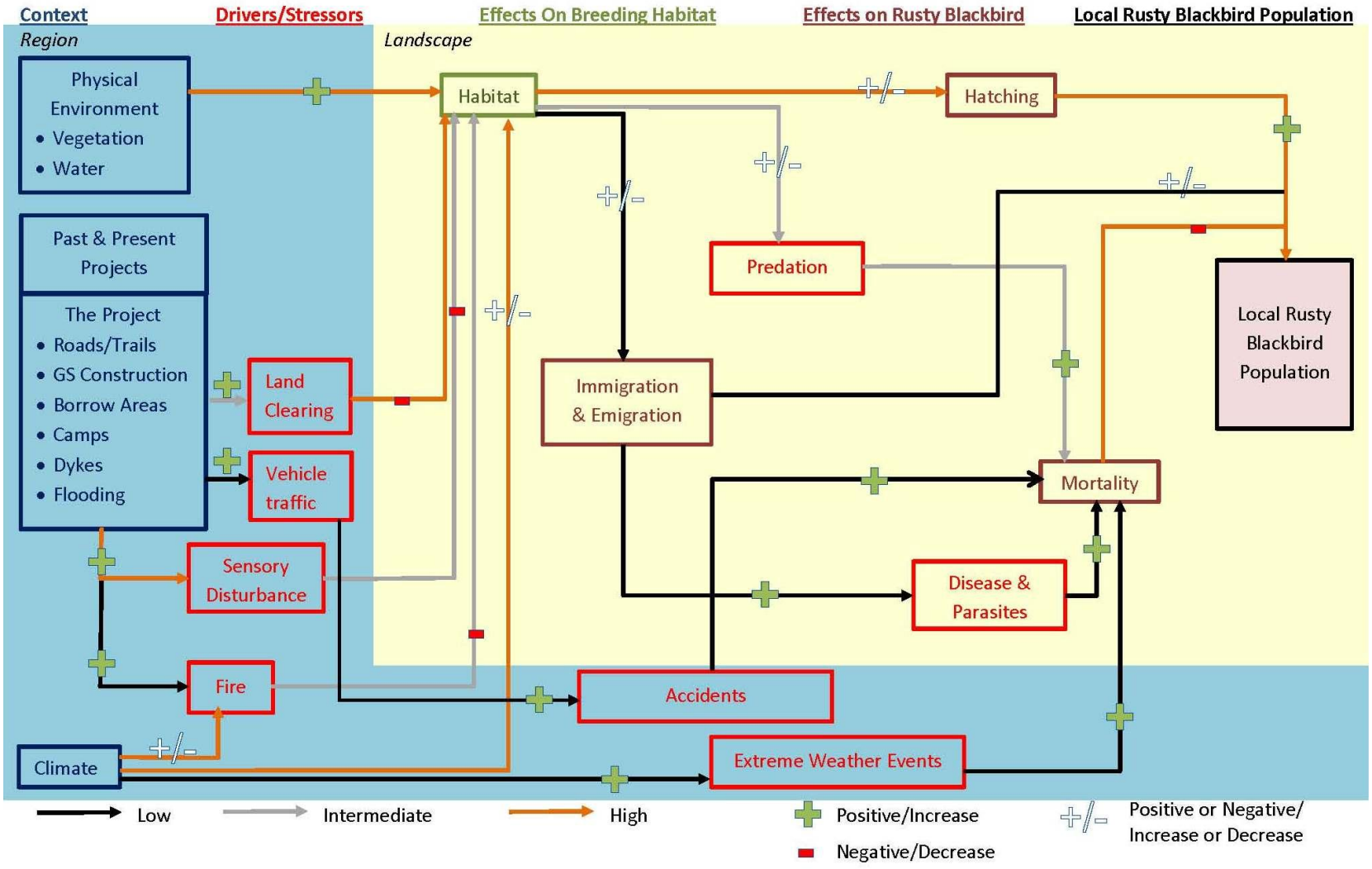


Figure 8–1 Factors influencing local population of rusty breeding in the Keeyask Bird Regional Study Area

8.2.4 HABITAT IN THE STUDY AREA

8.2.4.1 REGIONAL STUDY AREA

Primary and secondary breeding habitat includes wet peatlands (*e.g.,* bogs) and wooded swamps that are widely available throughout the Bird Regional Study Area. Although rusty blackbird habitat is spread throughout the Bird Regional Study Area, there are several areas with larger patches of breeding habitat. Coniferous forests on deep peatlands and ground ice peatlands, which provide primary and secondary breeding habitat for rusty blackbird, are abundant adjacent to Long Spruce GS forebay (*i.e.*, Kettle GS tailrace). Another large patch of primary breeding habitat occurs south of PR280, about 10 km north of Clark Lake. Primary breeding habitat also occurs along creeks throughout the Bird Regional Study Area.

8.2.4.2 LOCAL STUDY AREA

Most of the primary habitat within the local study area is along the creeks and rivers that flow into Gull Lake. The secondary breeding habitat is spread throughout the Local Study Area.

8.3 METHODS

The rusty blackbird habitat quality model was developed through the following steps:

1. Summarize habitat relationships from relevant literature, existing information for the Bird Regional Study Area and professional judgment. Producing this summarization was an iterative process in which preliminary generalizations were progressively refined as studies were conducted in the Bird Regional Study Area;
2. Verify the relationships for the Bird Regional Study Area by conducting field studies within the Bird Regional Study Area;
3. Use available information and professional judgment to assign mapped habitat types (ECOSTEM 2011) into either primary or secondary habitat categories for rusty blackbird; and,
4. Use data and other information from the Bird Regional Study Area to verify and refine the predicted categorization of mapped habitat types into primary and secondary-habitat for rusty blackbird.

The resulting rusty blackbird habitat quality classes were used to quantify the total amount rusty blackbird habitat in the Bird Regional Study Area at various points in time.

8.3.1 STUDY AREAS

Study sites are located in the Bird Regional and Local Study Areas and the Project Footprint, which are shown in Map 2-1. Surveys were performed in a variety of habitat types that were representative of the entire study area. A greater proportion of surveys were completed in Project Footprint to gain a better understanding of populations in habitat that would be lost due to flooding from the project.

8.3.2 INFORMATION SOURCES

8.3.2.1 EXISTING INFORMATION FOR THE STUDY AREA

A variety of information sources were used in developing study design, data collection method and data modelling. For study design, spatial information such as aerial photographs, forest resource inventory and topographical mapping was used for choosing sampling locations. As well, a preliminary spatial stand level habitat dataset (ECOSTEM 2008) for the project was used for choosing sample locations in later years of the study. For data collection, standard data collection protocols for point-count sampling (Ralph *et al.* 1993, Welsh 1993) were employed. A revised stand level habitat dataset for the project (ECOSTEM 2011), as well as peer reviewed literature on habitat preferences were used to develop habitat quality models.

8.3.2.2 DATA COLLECTION

See section 7.3.2.2 for a detailed description of data collection for the whole breeding bird sampling programs.

Some breeding bird surveys were targeted towards areas known to provide habitat for rusty blackbird. Transect location selection was based on known habitat preferences, and in later years of the study, based on the rusty blackbird model. In total, 171 point count plots in areas with primary or secondary habitat for rusty blackbird in the Bird Regional Study Area were sampled. Sampling in rusty blackbird habitat was fairly representative of the amount of different broad habitat types identified in the model (Table 8-1). Some habitats types which are not as common in the study area, such as those with low vegetation, had proportionally higher sampling effort, as these areas are known to provide good quality habitat for rusty blackbird.

Table 8-1 Field Samples of rusty blackbird habitat from 2001-2012 by Broad Habitat Type

Broad Habitat Type*	Percent in primary and secondary habitat	Percent of samples
Black spruce dominant on ground ice peatland	69.96%	20.00%
Black spruce dominant on wet peatland	12.77%	4.12%
Tamarack mixture on wet peatland	4.64%	1.18%
Black spruce dominant on riparian peatland	3.90%	2.94%
Tall shrub on riparian peatland	1.88%	1.18%
Tamarack dominant on wet peatland	1.00%	1.18%
Black spruce mixture on wet peatland	0.83%	0.59%
Low vegetation on ground ice peatland	0.82%	11.18%
Black spruce mixture on ground ice peatland	0.82%	1.76%
Tamarack mixture on ground ice peatland	0.74%	-
Low vegetation on wet peatland	0.73%	1.76%
Tall shrub on wet peatland	0.72%	0.59%
Tall shrub on ground ice peatland	0.23%	0.59%
Low vegetation on riparian peatland	0.22%	3.53%
Black spruce dominant on shallow peatland	0.17%	11.76%
Tamarack- black spruce mixture on riparian peatland	0.16%	0.59%
Tamarack dominant on ground ice peatland	0.13%	-
Human infrastructure	0.05%	-
Trembling aspen mixedwood on all ecosites	0.04%	0.59%
Tamarack dominant on riparian peatland	0.03%	-
Black spruce dominant on thin peatland	0.03%	17.06%
Tall shrub on shallow peatland	0.02%	-
White birch mixedwood on all ecosites	0.02%	-
Trembling aspen dominant on all ecosites	0.01%	1.18%
White birch dominant on all ecosites	0.01%	-
Black spruce mixture on shallow peatland	0.01%	1.18%
Tall Shrub on upper beach- regulated	0.01%	-
Tamarack mixture on shallow peatland	0.01%	0.59%
Shrub/Low Veg Mixture on Sunken Peat- regulated	0.00%	0.59%
Black spruce mixedwood on shallow peatland	0.00%	-
Emergent on lower beach	0.00%	-
Low vegetation on shallow peatland	0.00%	2.35%
Emergent on upper beach	0.00%	-
Black spruce mixedwood on mineral	0.00%	-

Shrub/Low veg mixture on ice scoured upland	0.00%	-
Jack pine mixture on thin peatland	0.00%	-
Low vegetation on upper beach- regulated	0.00%	-
Young regeneration on ground ice peatland	0.00%	-
Jack pine dominant on mineral	0.00%	1.18%
Jack pine mixedwood on thin peatland	0.00%	1.18%
Black spruce dominant on mineral	0.00%	1.18%
Shallow water	0.00%	0.59%
Black spruce mixture on mineral	0.00%	1.76%
Black spruce mixedwood on thin peatland	0.00%	-
Jack pine mixture on ground ice peatland	0.00%	-
Black spruce mixture on thin peatland	0.00%	0.59%
Low Vegetation on thin peatland	0.00%	4.71%
Tall shrub on thin peatland	0.00%	-
Young regeneration on wet peatland	0.00%	-

*Broad habitat types assigned to each point-count stop were based on the stand level-attributes. Although several broad habitat types may fall within the same point count, the broad habitat type of the stand that covered the majority of the 75-m point-count radius was used in all analyses.

8.3.3 EXPERT INFORMATION MODEL

A preliminary classification of primary and secondary habitat for rusty blackbird was developed based on the relevant literature, existing information from for the Bird Regional Study Area and professional judgment developed from conducting studies in the Bird Regional Study Area and elsewhere. Table 8-2 lists the mapped habitat types classified as primary and secondary habitat, including any spatial relationships.

The model was used to identify suitable breeding habitat within the Study Areas in order to quantify the amount that would be lost from project development. To determine primary habitat for rusty blackbird, the following queries were run:

- Polygons where the broad vegetation type was black spruce and/or tamarack needleleaf forests and tall shrubs in wet (*i.e.*, deep or riparian) peatlands were selected.
- Polygons where the land cover was riparian habitats with shrubs or low vegetation on the shore zone were selected.

For secondary habitat, all polygons with a coarse habitat type of ground ice peatland were identified.

Table 8-2 Mapped habitat types for rusty blackbird in Bird Regional Study Area

	Habitat Description	Modelled Habitat Attributes	Additional Factors (*e.g.*, proximity to water or edge)	Most common Broad Habitat Types in Model
Primary Habitat	Needleleaf treed or tall shrub on deep wet peatland ● Dominant species include Black Spruce and Tamarack Larch	● Broad vegetation type is black spruce or ● Broad vegetation type is tamarack needleleaf forest		Black spruce dominant on wet peatland, Black spruce dominant on ground ice peatland, Black spruce dominant on riparian peatland, Black spruce dominant on shallow peatland, Black spruce dominant on thin peatland, Low vegetation on wet peatland, Low vegetation on riparian peatland, Low vegetation on ground ice peatland, Shallow water, Low Vegetation on thin peatland, Tamarack mixture on wet peatland
	● Wet or deep peatland associated with horizontal or riparian fens	● Broad habitat type is tall shrub on wet peatland and ● Landcover is riparian habitats with broad vegetation type of shrubs or low vegetation	● Riparian areas occurred along shorelines of inland lakes, creeks, and wetlands ● Most of the riparian area associated with the Nelson River is considered sub-optimal rusty blackbird breeding habitat. Areas that were included in the model as primary habitat were associated with some of the creek mouths and inlets.	
Secondary Habitat	Mixedwood and needleleaf on shallow peatland ● Needleleaf dominant with some bog birch ● Ground ice present in peatland Associated with a collapse scar or peat plateau bog	● Ground ice peatland	Most of the riparian area associated with the Nelson River is considered sub-optimal rusty blackbird breeding habitat. Areas that were included in the model as secondary habitat were associated with some of the creek mouths and inlets.	Black spruce dominant on ground ice peatland, Low vegetation on ground ice peatland, Black spruce dominant on shallow peatland, Black spruce dominant on thin peatland, Black spruce dominant on wet peatland, Low vegetation on wet peatland, Black spruce dominant on riparian peatland

8.3.4 ANALYSIS METHODS

The preliminary classification of primary and secondary habitat for rusty blackbird was confirmed, and in some cases, quantified, by analysis of data collected in the Bird Regional Study Area.

Queries and geospatial analyses were run in MapInfo Version 9.5 on the large-scale habitat mapping dataset (ECOSTEM 2011) to identify suitable habitat for rusty blackbird. Models selected for mature forested coniferous areas and shrubby areas in wet peatlands.

Area of suitable habitat polygons were summed to calculate how much habitat was available, while suitable habitat that fell within the project footprint was summed to calculate how much habitat would be lost or affected with project development.

Several assumptions must be noted with respect to model verification:

- Models are based on peer-reviewed literature as well as professional opinion.
- True model validation is not always possible for rare species (due to their low abundance); however, field observations made during the breeding period can be used to verify and support habitat quality model predictions.
- As birds are highly mobile and move throughout their territories, observations in areas that are not identified as suitable habitat can occur.

8.4 RESULTS

8.4.1 DESCRIPTIVE STATISTICS

The expert information model for rusty blackbird identified 15,905 ha (7.2% of total land area) of primary breeding habitat for rusty blackbird. Of this habitat, 12,472 ha (78% of available habitat) falls within the Bird Regional Study Area (*i.e.*, Zone 4), 2,137 ha (13.4% of available habitat) falls within the Local Study Area (*i.e.*, Zone 3), 748 ha (4.7% of available habitat) falls within the 150-m buffer of Project Footprint (*i.e.*, Zone 2) and 547 ha (3.4% of available habitat) falls within the Project Footprint (*i.e.*, Zone 1).

Secondary habitat is also widely available throughout the study area, there is a total of 17,536 ha (7.9% of total land area) of secondary breeding and foraging habitat for rusty blackbird. Of this habitat, 15,052 ha (86% of available habitat) falls within the Bird Regional Study Area (*i.e.*, Zone 4), 1,857 ha (10.6% of available habitat) falls within the Local Study Area (*i.e.*, Zone 3), 92 ha (0.5% of available habitat) falls within the 150-m buffer of Project Footprint (*i.e.*, Zone 2) and 535 ha (3% of available habitat) falls within the Project Footprint (*i.e.*, Zone 1).

The broad habitats with the highest recorded densities of rusty blackbird include 1) tall shrub on ground ice peatland, 2) low vegetation on riparian peatland and 3) low vegetation on ground ice peatland (Table 8-3). All of these habitat types were well represented in the expert information model for rusty blackbird (see Table 8-1). In summary, the highest densities on rusty blackbird were in areas with low vegetation, tall shrubs and black spruce dominated sites on wet/riparian or ground ice peatlands, which is consistent with the predictions of the modelled primary and secondary quality habitat for rusty blackbird.

Many rusty blackbirds were also observed during spring, summer and fall helicopter flights near shorelines and riparian areas. The field observations showed that rusty blackbirds are using riparian areas with low vegetation or needleleaf forests, which is consistent with the model for this species.

Table 8-3 Density (# of singing males) per hectare of Rusty Blackbird in Keeyask Bird Regional Study Area, 2001-2012

	Density (Singing males/ha)										
Broad Habitat type	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2009**	**2010**	**2011**	**2012**
Black spruce dominant on ground ice peatland	0	0	0.03 ± 0.12	-	-	0	0	0	0	0	0
Black spruce dominant on mineral	0	0	0	0	0	0	0	0	0.02 ± 0.11	0	0.28 ± 0.56
Black spruce dominant on riparian peatland	-	-	-	-	-	-	-	-	-	-	0.42 ± 0.54
Black spruce dominant on shallow peatland	0.02 ± 0.1	0	0.02 ± 0.1	-	0	0	0	0	0.03 ± 0.12	0	0
Black spruce dominant on thin peatland	0	0	0.007 ± 0.06	0	0	0	0	0	0.01 ± 0.09	0	0
Black spruce dominant on wet peatland	0	0	0	-	0	0	-	0.56 ± 0	0	0	0
Black spruce mixedwood on mineral	-	-	-	-	-	-	-	0	0.04 ± 0.14	-	-
Black spruce mixture on shallow peatland	-	-	-	-	-	-	-	0	0.19 ± 0.33	0	0
Black spruce mixture on thin peatland	0	0	0	-	-	-	-	0	0.03 ± 0.13	0	0
Jack pine dominant on mineral	-	-	-	0	0	-	-	0	0	0.02 ± 0.12	0
Jack pine mixture on thin peatland	-	-	-	0	0	0	0	-	0	0	0.19 ± 0.33
Low vegetation on ground ice peatland	0	0	0	0	0	0	0	0	0	0.19 ± 0.33	0.28 ± 0.56
Low vegetation on mineral	0	0	0	0	0	0.06 ± 0.18	0	0	0	-	0
Low vegetation on riparian peatland	0	0	0.28 ± 0.4	-	-	-	0	0	0.28 ± 0.4	0.28 ± 0.4	0.28 ± 0.33
Low vegetation on shallow peatland	0	0	0.08 ± 0.21	-	0.03 ± 0.13	0.03 ± 0.13	0	0	0	0	0
Low vegetation on thin peatland	0.04 ± 0.16	0	0	-	0	0	0	0.04 ± 0.15	0	0	0
Tall shrub on ground ice peatland	0	0	0	-	-	-	-	-	0.56 ± 0	1.13 ± 0	0
Tamarack mixture on thin peatland	-	-	-	-	-	-	-	0	0.11 ± 0.25	0	-

Note: Only broad habitat types where rusty blackbird was present are listed in the table. Broad habitats where they are absent are not listed, as rare species absence data is considered ambiguous due to low number of observations, activity patters, elusive behaviors and/or inaccessible habitats (Ottaviani et al, 2004).

In total, there were 36 observations of rusty blackbird that fell within the 75-m radius point-count stops. Of these observations, 16 (44%) were within areas identified as either primary or secondary habitat for rusty blackbird. Seven (19%) of the observations were within 100 m of primary or secondary habitat, while nine (25%) were between 100 m and 500 m from the identified primary or secondary habitat. Four observations (11%) were between 500 m and 1500 m from either primary or secondary habitat.

Several assumptions underline the interpretation of these results:

- The point count method does not pinpoint the exact location of individuals.
- Rusty blackbirds have large territories for breeding and foraging. Some individuals may be been travelling within their territory, but not within primary or secondary habitat, when observed.

8.5 CONCLUSIONS

Field observations during breeding bird surveys indicated that the highest densities of rusty blackbird were found in bogs (*i.e.*, low vegetation), areas with tall shrubs, riparian areas and other wet peatlands. These habitat characteristics are consistent with the predictions from the expert information model.

The broad habitats where rusty blackbird was observed were also identified as important habitat types in the expert information model. As the majority of field observations fell within habitat identified as primary or secondary habitat, the model appears to perform well.

A number of limitations exist for this analysis. The point-count method estimates populations within a 75-m radius, but does not necessarily give the ability to pinpoint the exact location (and exact habitat type) that each bird falls within. Although rusty blackbirds are noted during helicopter surveys, they are always observed flying and are not necessarily nesting in the immediate area. Rusty blackbird is a rare species and field observations were limited. Information on rare species like this one is often challenging to obtain. As most birds respond to local, patch and landscape level habitat attributes, a model including vegetation structure (*e.g.*, structure, tree height, presence of snags, vegetative composition) could provide a more refined estimate of suitable habitat. However, with a rare species such as rusty blackbird, it would be difficult to collect sufficient field data to refine the attributes.

9.0 COMMON NIGHTHAWK

9.1 INTRODUCTION

Common nighthawk is a medium-sized bird with dark brown mottled plumage, a large flattened head, large eyes, a large mouth, and a small bill. It has long slender pointed wings, a slightly notched tail and a white patch on its primaries. Common nighthawk breeds in open, dry sites within the Bird Regional Study Area. Common nighthawk has been assessed by COSEWIC and listed as threatened by SARA (Schedule 1) due to population declines throughout its range.

9.2 SPECIES OVERVIEW FROM LITERATURE

9.2.1 GENERAL LIFE HISTORY

Common nighthawk forages for flying insects at dusk and dawn near marshes, rivers and lakeshores (Taylor 2003). It arrives on the breeding ground later than most (late May to early June) and is among the first to leave (starting mid-July) (Brigham *et al.* 2011). Common nighthawks are known to inhabit both urban and rural areas. The primary natural breeding habitat is in forested regions with clearings and rock outcrops, or in burned sites (Taylor 2003).

9.2.2 DISTRIBUTION AND ABUNDANCE

9.2.2.1 CONTINENTAL AND GLOBAL

Common nighthawk winter throughout South America. During their fall migration, they travel over land through the centre of North America and pass through central portions of the northern part of South America east of the Andes (Brigham *et al.* 2011). In Canada, common nighthawk numbers have declined 4.7% per year since 1970 (Collins and Downes 2009), with an overall population decline of 49.5% since the late 1960s (COSEWIC 2007B). In the United States, there has been a 1.7% decline per year since 1966 (Sauer *et al.* 2011).

The population estimate of common nighthawk is 10 million individuals across North America (Rick *et al.* 2004). Population estimates in Canada range from 400,000 individuals (COSEWIC 2007A) to 1 million individuals (Rick *et al.* 2004). Possible reasons for declines include use of insecticides on wintering grounds and along migration routes (Brigham *et al.* 2011), loss of forest openings due to fire suppression and reforestation, and intensive use of agricultural land (COSEWIC 2007B).

9.2.2.2 PROVINCIAL

Common nighthawks breed throughout the province of Manitoba up to the treeline. They are normally found in forested areas with extensive clearings or rock outcrops. Common nighthawk populations in Manitoba are in decline, but results from surveys are not considered statistically significant (Collins and Downes 2009). The population of common nighthawk in Manitoba has been estimated at 100,000 birds (Rich et al 2004).

9.2.2.3 REGIONAL STUDY AREA

Common nighthawk habitats are in high, dry areas of the Bird Regional Study Area. Rock outcrops, ridges, high banks, and eskers with bare ground (*e.g.*, recent burns) make up primary and secondary breeding habitat for this species. Within the Bird Regional Study Area, common nighthawks have been observed nesting and foraging in regenerating forests (burns) and in areas along the south access road route. Foraging activity has been detected in open habitats including at wetlands, inland lakes, along the Nelson River and inland creeks.

Within the Bird Regional Study Area, common nighthawks have been observed in regenerating forests (old burns), along the south access road route and in fens associated with creeks and inland lakes. Habitat is not considered to be a factor limiting common nighthawk populations within the Bird Regional Study Area, as primary and secondary breeding habitat is widespread and abundant throughout the region.

9.2.3 FACTORS THAT INFLUENCE DISTRIBUTION AND ABUNDANCE

9.2.3.1 HABITAT

Breeding habitat is a critical requirement in the life cycle of common nighthawk. Breeding habitats must provide suitable sites for nesting and other life requisites such as foraging, shelter and security. Common nighthawks require open areas with sparse vegetation to build their nest. They will inhabit dry outcrops, open shrubland or non-vegetated sites. Human activities such as deforestation, urbanization, clearing for linear features (e.g, roads, transmission lines, cutlines) can increase available habitat and influence distribution. Climatic fluctuations on the breeding grounds or during migrations can impact both distribution and abundance of common nighthawk (COSEWIC 2007B).

9.2.3.1.1 SEASONAL FORAGE AND WATER

Common nighthawk forage primarily on flying insects such as queen ants, beetles, caddisfly and moths (Brigham *et al.* 2011). They forage while in flight in low light conditions of dawn and dusk. Occasionally, common nighthawk will forage in large groups. A general decline in insect populations due to large-scale insecticide use also reduces the abundance of common nighthawk (COSEWIC 2007B).

9.2.3.1.2 BREEDING

In forested areas, common nighthawks have territory sizes estimated to be about 22.3 hectares (COSEWIC 2007B). The female chooses the nest site in an open area near a log, rock, clump of vegetation, shrubs or small gravel patches (Brigham *et al.* 2011). They lay their eggs on open ground on rocks, near logs, clumps of vegetation or on sandy gravel (Brigham *et al.* 2011). No nest is built, but a small depression is created in the ground where the female lays her clutch of two eggs (Ehrlich *et al.* 1988). If nest sites are situated along gravel or dirt roads, there is an increased chance of vehicles (including ATVs) colliding with adults or destroying nests (COSEWIC 7B).

9.2.3.1.3 BROOD REARING

Incubation is done primarily by the female, with assistance from the male. Eggs take 19 days to hatch and the young fledge within 21 days. Young are semi-precocial (open eyes, down on body, ability to leave the nest) when born (Ehrlich *et al.* 1988). The nestlings are dependent on their parents for 45 to 52 days (COSEWIC 2007B).

9.2.3.1.4 DISPERSAL AND MIGRATION

After rearing of their young, birds need to fatten up for the purpose of moulting and in preparation for fall migration. Information regarding the dispersal of common nighthawk after rearing is limited, but they may disperse locally to find areas with greater or different food supply. Fall migration for common nighthawk in Manitoba commences in mid-July, peaks in mid-August and is normally complete by the second week of September (Taylor 2003). Common nighthawk may migrate in large flocks to their South American wintering grounds.

9.2.3.2 FACTORS THAT REDUCE EFFECTIVE HABITAT

Construction-related noise from heavy equipment, blasting and other human activities may cause common nighthawk to avoid using areas within or adjacent to the Project Footprint. In these areas, avoidance of breeding habitats will likely persist until disturbances have ceased. Birds displaced from breeding habitat will likely relocate to alternate available habitats not affected by construction disturbance, providing the disturbance occurs early enough in the breeding season that nesting can be re-initiated.

As common nighthawk prefer open, post-disturbance habitat, land clearing associated with road construction, development of infrastructure, and extraction of granular material in borrow areas can increase the availability of effective habitat following the cessation of disturbance.

9.2.3.3 MORTALITY

9.2.3.3.1 PREDATION

Predators of common nighthawk adults, young and eggs include common raven, American crow, gulls, owls, falcons, skunks, foxes, coyotes and snakes (Brigham *et al.* 2011). All of these predators may be attracted to the

open areas due to increased availability of prey and ease of catching prey in an area with low or no vegetation cover. As common nighthawks forage in open habitats and breed on bare ground, they are susceptible to predation. Lighting near infrastructure will attract a high density of insect prey, in turn, attracting common nighthawk to developed areas that may host a higher density of predators.

9.2.3.3.2 ACCIDENTAL MORTALITY

Although vehicle traffic may be a factor in accidental mortality, nighthawks forage at heights well above vehicles (McCraken 2008), thus this risk is low.

9.2.3.4 OTHER FACTORS THAT INFLUENCE SURVIVAL AND HABITAT USE

9.2.3.4.1 DISEASES AND PARASITES

Blood parasites have been found in common nighthawk (Brigham *et al.* 2011). However, there is no information available on whether disease or parasites are threats to this species. No information exists on the occurrence of blood parasites in the Regional Study Area.

9.2.3.4.2 MALNUTRITION

The general decline in insect prey populations due to large-scale insecticide use in areas away from the Project may contribute to overall population declines observed in common nighthawk (COSEWIC 2007B).

As an insectivore, common nighthawk is vulnerable to a predator-prey mismatch (Post *et al.* 2008), a situation whereby the availability of food is altered due to climate change (Ruckstuhl *et al.* 2008; Achard *et al.* 2008). Insects in the boreal forest are hatching progressively earlier each year; birds dependent upon insects must respond by laying eggs earlier in order to catch peak insect abundance (Crick 2004). Unfortunately for long-distance migrants, seasonal changes in photoperiod rather than climatic cues are used to prompt migrations northward (Wormworth 2006). As a result, birds may arrive on the breeding grounds too late to provide adequate food for their young (Crick 2004).

9.2.3.4.3 SEVERE WEATHER

Climatic conditions play an important role in the distribution of birds breeding in the boreal forest. Spring and summer temperature and precipitation impact species abundances and survival during the breeding season (DesGranges and LeBlanc 2012). Rainy, cold weather during the nesting season can cause common nighthawk mortality or nest failure due to starvation from lack of insect prey (COSEWIC 2007B).

9.2.3.5 FRAGMENTATION AND CUMULATIVE EFFECTS

As common nighthawk is dependent open areas, fragmentation has a positive effect on their preferred habitat quality.

9.2.3.6 MOST INFLUENTIAL FACTORS

The most influential factor affecting local common nighthawk populations is the presence of suitable breeding habitat. Wildfire is a key driver in creating suitable breeding habitat for common nighthawk.

Primary breeding habitat for common nighthawk is outcrop sites with open and semi-open vegetation types, including:

- Dry post-disturbance stages <20 years since burn with sparse vegetation cover for nesting (total shrub cover <20%, total tree cover <10%)
- Open, dry coniferous forest, forest clearings, forests with sparse ground cover on mineral soil.

Secondary breeding habitat includes:

- Early successional stage or shrub communities maintained by fire or clearing (cutlines) or flooding (fen/marsh/wet meadow);
- Areas where seedlings and advance regeneration may be abundant;
- Areas where tree cover is less than10%;
- Areas where shrub cover is less than 20%, herb layer cover is greater than 20%;
- Coniferous forest (Jack Pine dominant; mature to old forest).

While there are a number of factors that influence common nighthawk populations in the Bird Regional Study Area, wildfire and open post-disturbance areas are key drivers in the availability of common nighthawk habitat (Figure 9–1).

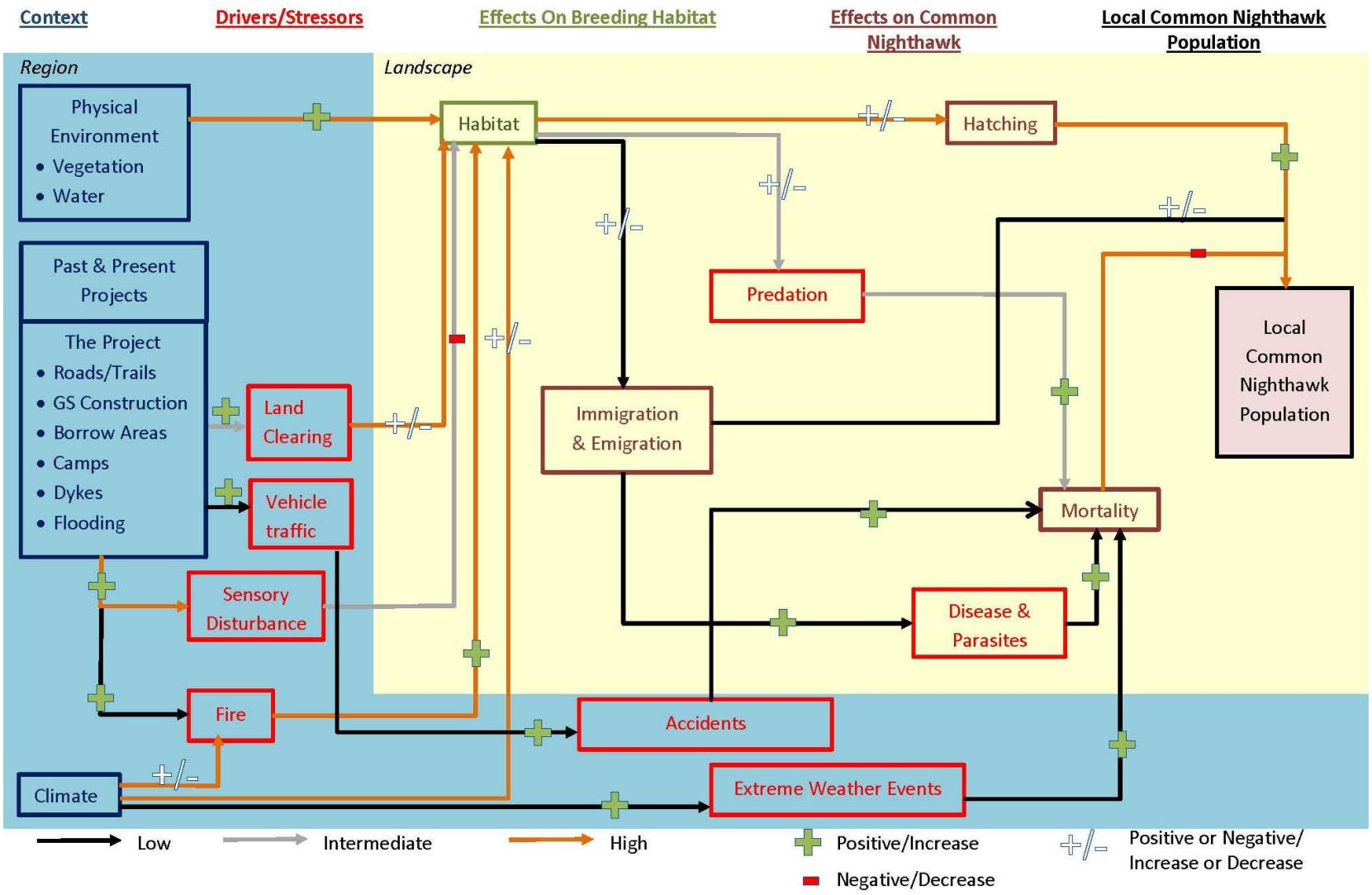


Figure 9–1 **Factors influencing local population of common nighthawk breeding in the Keeyask Bird Regional Study Area**

9.2.4 HABITAT IN THE STUDY AREA

9.2.4.1 REGIONAL STUDY AREA

Common nighthawk is distributed throughout the Bird Regional Study Area within suitable habitat types, where they have been observed in regenerating burn areas which are open and dry with sparse ground cover. Young burns along PR280 and on both sides of the North Access Road near Stephens Lake provide large patches of high and moderate quality habitat within the Bird Regional Study Area.

9.2.4.2 LOCAL STUDY AREA

Moderate quality habitat in young burn areas along the North Access Road is abundant within the Local Study Area. Some periodically flooded areas with sparse vegetation on the shores and islands of Gull Lake also provide moderate quality habitat. High quality habitat within the local study area is found in dry open areas, with larger patches occurring along the South Access Road close to the proposed Keeyask Generating Station.

9.3 METHODS

The common nighthawk habitat quality model was developed through the following steps:

1. Summarize habitat relationships from relevant literature, existing information for the Bird Regional Study Area and professional judgment. Producing this summarization was an iterative process in which preliminary generalizations were progressively refined as studies were conducted in the Bird Regional Study Area;
2. Verify the relationships for the Bird Regional Study Area by conducting field studies within the Bird Regional Study Area;
3. Use available information and professional judgment to assign mapped habitat types (ECOSTEM 2011) into primary or secondary habitat categories for common nighthawk; and,
4. Use data and other information from the Bird Regional Study Area to verify and refine the predicted categorization of mapped habitat types into primary and secondary-habitat for common nighthawk.

The resulting common nighthawk habitat quality class was used to quantify the total amount common nighthawk habitat in the Bird Regional Study Area at various points in time.

9.3.1 STUDY AREAS

Study sites are located in the Bird Regional and Local Study Areas and the Project Footprint, which are shown in Map 2-1. Surveys were performed in a variety of habitat types that were representative of the entire study

area. A greater proportion of surveys were completed in Project Footprint to gain a better understanding of populations in habitat that would be lost due to flooding from the project.

9.3.2 INFORMATION SOURCES

A variety of information sources were used in developing study design, data collection method and data modelling. For study design, spatial information such as aerial photographs, forest resource inventory and topographical mapping was used for choosing sampling locations. As well, a preliminary spatial stand level habitat dataset (ECOSTEM 2008) for the project was used for choosing sample locations in later years of the study. For data collection, standard data collection protocols for point-count sampling (Ralph *et al.* 1993, Welsh 1993) were employed. A revised stand level habitat dataset for the project (ECOSTEM 2011) as well as peer reviewed literature on habitat preferences were used to develop habitat quality models.

9.3.2.1 EXISTING INFORMATION FOR THE STUDY AREA

Information sources used for the study area include the provincial Forest Resource Inventory data, topographical mapping (NTS), aerial photography and the ECOSTEM habitat dataset.

9.3.2.2 DATA COLLECTION

See section 7.3.2.2 for a detailed description of data collection for the entire breeding bird sampling program.

In June 2010, 2011 and 2012, site-specific investigations for nocturnally active species at risk (including common nighthawk) occurred in suitable habitats throughout the Regional Study Area. Remote recording units were deployed in areas that had the highest potential of detecting common nighthawk (*e.g.*, wetlands, regenerating forest). Common nighthawk are most vocal and therefore detectable, in foraging habitat (*e.g.*, forest openings). Units were programed to monitor morning, early evening and night-time bird activity.

9.3.3 EXPERT INFORMATION MODEL

A preliminary classification of primary habitat for common nighthawk was developed based on the relevant literature, existing information from for the Bird Regional Study Area and professional judgment developed from conducting studies in the Bird Regional Study Area and elsewhere. Table 9-1 lists the mapped habitat types classified as primary habitat, including any spatial relationships.

The model was used to identify suitable breeding habitat within the Bird Regional Study Area in order to quantify the amount that would be lost from project development. Both primary and secondary habitat for common nighthawk was identified. The following steps were taken to identify primary habitat:

- Polygons where the fine ecosite was an outcrop were selected to identify all outcrops.

- Polygons where the fine ecosite was shallow thin mineral or deep dry mineral, the stand age in 2010 was between 0 and 20 years old and the vegetation structure is low shrub and/or graminoid and/or bryoid were selected to identify dry post-burn sites.
- Polygons where the fine ecosite is a mineral soil (*i.e.*, shallow thin, deep dry or deep wet mineral), a thin peatland type (i.e,. veneer bog on slope) an organic or mineral type (*i.e.*, swamp), or a shallow peatland (*i.e.*, veneer bog of blanket bog), the stand has not been recently burned, and the vegetation structure is low shrub and/or graminoid and/or bryoid were selected to identify all areas of open dry habitats with low vegetation.
- Polygons where the fine ecosite is a mineral soil (*i.e.*, shallow thin, deep dry or deep wet mineral), a thin peatland type (*i.e.*, veneer bog on slope) an organic or mineral type (*i.e.*, swamp), or a shallow peatland (*i.e.*, veneer bog of blanket bog), the stand has not been recently burned and the vegetation structure is sparsely treed were selected to identify all areas of open dry treed habitat.
- All identified primary common nighthawk habitat polygons that were less than 10ha in size were removed, as stands this size are too small to provide appropriate nesting habitat.

The following steps were taken to identify secondary habitat for common nighthawk:

- All cutlines were identified from a linear features shapefile and a 5-m buffer was created around them. Habitat the fell within the 5-m corridor was considered to be cutline habitat.
- Polygons where the fine ecosite is an outcrop or shallow/thin mineral, the age is between 0 and 20 years old and the vegetative structure is low shrub and/or graminoid and/or bryoid were selected to identify young burn habitat.
- Polygons where the broad vegetation type is jackpine and the stand has not been recently burned were selected to identify jack pine stands.
- Polygons where the fine ecosite type is a shore zone type of upper beach (regulated) were selected to identify areas along the Nelson River that are regularly flooded.
- All polygons that were less than 10ha is size were removed from the identified secondary habitat polygons.

Table 9-1 Mapped habitat types for common nighthawk in Bird Regional Study Area

	Habitat Description	Modelled Habitat Attributes	Additional Factors	Most common Broad Habitat Types in Model
Primary Habitat	Any outcrop	● Fine Ecosite is an outcrop	● Stands had to be larger than 10ha in size	Black spruce dominant on thin peatland, Black spruce dominant on shallow peatland, Low Vegetation on thin peatland, Low vegetation on shallow peatland, Black spruce dominant on mineral, Black spruce dominant on ground ice peatland, Low vegetation on mineral, Human infrastructure, Low vegetation on ground ice peatland
	Dry Post-disturbance stages <20 years since burn with sparse vegetation for nesting (total shrub cover <20%, total tree cover <10%)	● Fine Ecosite is shallow thin mineral or deep dry mineral, ● Stand age is less than 20 years old and ● Vegetation structure is low shrub and/or graminoid and/or bryoid	● Stands had to be larger than 10ha in size	
	Open, dry coniferous forest, forest clearings, forests with sparse ground cover on mineral	● Fine Ecosite is a mineral soil, thin peatland type, organic or shallow peatland, ● Age is mature and ● Vegetation structure is low shrub and/or graminoid and/or bryoid or ● Vegetation structure is sparsely treed	● Stands had to be larger than 10ha in size	
Secondary Habitat	Early successional stage or shrub communities maintained by fire or clearing (cut-lines) or flooding (fen/marsh/wet meadow); seedlings and advanced regeneration may be abundant; tree cover <10%; shrub cover <20%	● Cutlines/linear features identified	● 5-m buffer around cutline was considered habitat	Black spruce dominant on thin peatland, Black spruce dominant on shallow peatland, Black spruce dominant on ground ice peatland, Low vegetation on ground ice peatland, Black spruce dominant on mineral, Low Vegetation on thin peatland, Low vegetation on shallow peatland, Tall Shrub on upper beach- regulated, Low vegetation on riparian peatland, Low vegetation on wet peatland, Jack pine dominant on mineral, Human infrastructure, Jack pine mixture on thin peatland, Tall shrub on riparian peatland
		● Fine Ecosite is an outcrop or shallow/thin mineral, stand age is less than 20 years old and ● Vegetation structure is low shrub and/or graminoid and/or bryoid	● Stands had to be larger than 10 ha in size	
		● Fine Ecosite is regulated upper beach shore zone	● Stands had to be larger than 10 ha in size	
	Coniferous forest (Jack Pine dominant - mature to old forest)	● Vegetation type is Jack Pine and ● Stand has not been recently burned	● Stands had to be larger than 10 ha in size	

9.3.4 ANALYSIS METHODS

The preliminary classification of primary habitat for common nighthawk was confirmed, and in some cases, quantified, by analysis of data collected in the Bird Regional Study Area.

Queries and geospatial analyses were run in MapInfo Version 9.5 on the large-scale habitat mapping dataset (ECOSTEM 2011) to identify suitable habitat for common nighthawk. Models selected for open, dry coniferous forest, outcrops and areas with sparse vegetation.

The model output was mapped to show areas of suitable breeding habitat for common nighthawk. Area of suitable habitat polygons were summed to calculate how much habitat was available, while suitable habitat that fell within the project footprint was summed to calculate how much habitat would be lost with project development. As clearing for the project will create habitat, calculations were also done to estimate increases in habitat amount.

Several assumptions must be noted with respect to model verification:

- Models are based on peer-reviewed literature as well as professional opinion.
- True model validation is not always possible for rare species (due to their low abundance); however, field observations can be used to verify and support habitat quality model predictions.
- As birds are highly mobile and move throughout their territories, observations in areas that are not identified as suitable habitat can occur.

9.4 RESULTS

9.4.1 DESCRIPTIVE STATISTICS

In all study areas, there is a total of 10,188 ha (4.6% of total land area) of primary breeding and foraging habitat for common nighthawk. Of this habitat, 7,503 ha (74% of available habitat) falls within the Bird Regional Study Area (i.e,. Zone 4), 1,506 ha (14.8% of available habitat) falls within the Local Study Area (*i.e.*, Zone 3), 428 ha (4.2% of available habitat) falls within the 150-m buffer of Project Footprint (*i.e.*, Zone 2) and 750 ha (7.4% of available habitat) falls within the Project Footprint (*i.e.*, Zone 1).

Secondary habitat is also widely available throughout the study area, where there is a total of 8,984-ha (4% of total land area) of secondary breeding and foraging habitat for common nighthawk. Of this habitat, 5,957 ha (66% of available habitat) falls within Zone 4 (*i.e.*, the Bird Regional Study Area), 1,789 ha (20% of available habitat) falls within the Zone 3 (*i.e.*, the Local Study Area), 536 ha (6% of available

habitat) falls within Zone 2 (*i.e.*, 150-m buffer of Project Footprint) and 702 ha (8% of available habitat) falls within Zone 1 (*i.e.*, the Project Footprint).

As breeding bird surveys are not designed to capture nocturnally active species such as common nighthawk, very few were detected during these surveys. No observations of common nighthawk were made inside point-survey plots; there were only incidental observations between or outside of plots. Habitats where they were detected include mostly open areas with low vegetation.

Recording units were deployed in forty different locations during the breeding bird survey periods from 2010-2012. Twenty-five of the recording units were within or in close proximity (100 m) to the modelled primary or secondary common nighthawk habitat, while the other fifteen were greater than 100 m away. Common nighthawk were present at twenty out of the twenty-five recording units (80%) placed within 100 m of their primary or secondary habitat, while they were recorded at only six out of the fifteen (40%) recording units placed greater than 100 m away. Recorders where common nighthawks were observed were in open areas with young regeneration, low vegetation and tall shrubs (Table 9-2).

Several assumptions underpin the interpretation of these results. First, the recording units do not pinpoint the exact location of individuals. Second, common nighthawk have large territories for breeding and for foraging. The model only identified breeding habitats; observations made outside of primary or secondary habitat may have been within foraging habitat.

Table 9-2 Broad Habitat types of recorder locations with observations of common nighthawk 2010-2012.

Broad Habitat Type
Low vegetation on wet peatland
Tall shrub on shallow peatland
Young regeneration on shallow peatland
Young regeneration on uplands
Young regeneration on wet peatland

Habitat attributes at recording unit locations along with known habitat preferences from expert knowledge in the literature helped in choosing primary and secondary habitat for the common nighthawk habitat model. As predicted by the model, common nighthawk were mainly observed in areas with low vegetation, early successional stage communities, areas with human infrastructure (*i.e.*, areas that are cleared), and drier areas.

9.5 CONCLUSIONS

As there were no observations of common nighthawk within point-survey plots and uncertainty about the distance of observations to recording units, no statistical verification can be provided for this model. As discussed in the assumptions, field data for rare species and species at risk are often not sufficient to provide validation for habitat quality models.

Incidental observations (including nest detections) and recording unit data suggest that common nighthawks inhabit open areas supporting low vegetation, early successional stage communities, areas with human infrastructure (*i.e.*, areas that are cleared) and drier areas (*e.g.*, mineral sites associated with eskers) within the Bird Regional Study Area. As the majority of field observations fell within habitat identified as primary or secondary habitat, the model appears to perform well. The model is also supported by the fact that the great majority of recording units in or near primary or secondary common nighthawk habitat recorded the presence of common nighthawk at a frequency twice that of the other, more distant recording units.

10.0 GLOSSARY

Altricial: Helpless at birth and dependant on parents for nourishment.

Aquatic: Living or found in water.

Attribute: A readily definable and inherent characteristic of a plant, animal, or habitat.

Bedrock: A general term for any solid rock, not exhibiting soil-like properties, that underlies soil or other surficial materials.

Benchmark: A reference or target condition or range of conditions that is used to evaluate the state or trend of an attribute of interest.

Biomass: Total mass of living matter, within a given unit of area or volume.

Bog: A type of peatland that receives nutrient inputs from precipitation and dryfall (particles deposited from the atmosphere) only. Sphagnum mosses are the dominant peat forming plants. Commonly acidic and nutrient poor.

Boreal: Of or relating to the cold, northern, circumpolar area just south of the tundra, dominated by coniferous trees such as spruce, fir, or pine. Also called taiga.

Borrow area: An area where earth material (clay, gravel or sand) is excavated for use at another location (also referred to as 'borrow sites' or 'borrow pits').

Broad habitat type: The third coarsest level in the hierarchical habitat classification used for the terrestrial assessment. From coarsest to finest, the levels in the habitat classification system are land cover, coarse habitat type, broad habitat type and fine habitat type used for the terrestrial assessment.

Buffer: An area surrounding a defined geographic area, usually created by locating a line a fixed distance around the area of interest.

Camp: A temporary residence for employees working on a construction project at a remote location, consisting of bunkhouse dormitories, a kitchen and other facilities.

Churchill River Diversion: The diversion of water from the Churchill River to the Nelson River and the impoundment of water on the Rat River and Southern Indian Lake as authorized by the CRD Licence.

Coarse habitat type: The second coarsest level in the hierarchical habitat classification used for the terrestrial assessment. From coarsest to finest, the levels in the habitat classification system are land cover, coarse habitat type, broad habitat type and fine habitat type used for the terrestrial assessment.

Construction: Includes activities anticipated to occur during Project development.

Core area: A natural area that meets a minimum size criteria after applying an edge buffer on human features. Two minimum sizes (200 ha, 1,000 ha) after applying a 500 m buffer on human features were used in the intactness effects assessment.

Crest: The top surface of a dam or roadway, or the high point of the spillway overflow section, or the highpoint of a landform.

Cumulative effect (impact): The effect on the environment, which results when the effects of a project combine with those of the past, existing, and future projects and; the incremental effects of an action on the environment when the effects are combined with those from other past, existing and future actions.

Drainage regime: A classification of the typical speed at which water inputs drain from the soil.

Driver: Any natural or human-induced factor that directly or indirectly causes a change in the environment.

Driving factor: Any natural or human-induced factor that directly or indirectly causes a change in the environment.

Duration: the period of time in which an effect may exist or remain detectable (*i.e.*, the recovery time for a resource, species or human use).

Ecosite type: A classification of site conditions that have important influences on ecosystem patterns and processes. Site attributes that were directly or indirectly used for terrestrial habitat classification included moisture regime, drainage regime, nutrient regime, surface organic layer thickness, organic deposit type, mineral soil conditions and permafrost conditions.

Ecosystem: A dynamic complex of plant, animal and micro-organism communities and their non-living components of the environment interacting as a functional unit (Canadian Environmental Assessment Agency).

Ecosystem function: The outcomes of ecosystem patterns and processes viewed in terms of ecosystem services or benefits. Examples include producing oxygen to breathe, habitat for animals, purifying water and storing carbon.

Ecozone: A classification system that defines different parts of the environment with similar land features (geology and geography), climate (precipitation, temperature, and latitude), and organisms.

Edge effect: The effect of an abrupt transition between two different adjoining ecological communities on the numbers and kinds of organisms in the transition between communities as well as the effects on organisms and environmental conditions adjacent to the abrupt transition.

Effect: Any change that the Project may cause in the environment. More specifically, a direct or indirect consequence of a particular Project impact [ref]. The impact-effect terminology is a statement of a cause-effect relationship (see **Cause-effect linkage**). A terrestrial habitat example would be 10 ha of vegetation clearing (*i.e.*, the impact) leads to habitat loss, permafrost melting, soil conversion, edge effects*, etc.* (*i.e.*, the direct and indirect effects).

Effective habitat: An estimate of the percentage of habitat available to support individuals within a wildlife population after subtracting habitat alienated by human influences (*e.g.*, sensory disturbances). Human influences do not include physical habitat losses.

Emergent: A plant rooted in shallow water and having most of its vegetative growth above water.

Environmental assessment: Process for identifying project and environment interactions, predicting environmental effects, identifying mitigation measures, evaluating significance, reporting and following-up to verify accuracy and effectiveness leading to the production of an Environmental Assessment report. EA is used as a planning tool to help guide decision-making, as well as project design and implementation (Canadian Environmental Assessment Agency).

Evapotranspiration: The process by which water is transferred to the atmosphere through evaporation, such as plants emitting water vapour from their leaves.

Existing environment: The present condition of a particular area; generally included in the assessment of a project or activity prior to the construction of a proposed project or activity.

Fen: Peatland in which the plants receive nutrients from mineral enriched ground and/or surface water. Water chemistry is neutral to alkaline. Sedges, brown mosses and/or Sphagnum mosses are usually the dominant peat forming vegetation.

Fire regime: The frequency, size, intensity, severity, patchiness, seasonality and type (*e.g.*, ground versus canopy) of fires in the Fire Regime Area.

Fledge: A stage of development or process (fledging) for birds where a juvenile leaves the nest and attempts to fly.

Flooding: The rising of a body of water so that it overflows its natural or artificial boundaries and covers adjoining land that is not usually underwater.

Fragmentation: Refers to the extent to which an area is broken up into smaller areas by human features and how easy it is for animals, plant propagules and other ecological flows such as surface water to move from one area to another. Fragmentation can isolate habitat and create edges, which reduces habitat for interior species and may reduce habitat effectiveness for other species. *OR* The breaking up of contiguous blocks of habitat into increasingly smaller blocks as a result of direct loss and/or sensory disturbance (*i.e.*, habitat alienation). Eventually, remaining blocks may be too small to provide usable or effective habitat for a species.

Generating station: A complex of structures used in the production of electricity, including a powerhouse, spillway, dam(s), transition structures and dykes.

Glaciofluvial: Pertaining to streams fed by melting glaciers, or to the deposits and landforms produced by such streams.

Glaciolacustrine: Pertaining to lakes fed by melting glaciers, or to the deposits forming therein

Gleying: A soil condition that develops under long-term anaerobic, reducing conditions. These soils are generally grayish, bluish, or greenish in color and are characteristic of many water-logged soils.

Global change: Large-scale changes in environmental attributes such as climate, ground level ultra-violet radiation and ozone layer thickness.

Gradient: The rate at which a water level increases or decreases over a specific distance.

Graminoid: Grasses and grasslike plants such as sedges and rushes.

Granular: Composed of granules or grains of sand or gravel.

Groundwater: The portion of sub-surface water that is below the water table, in the zone of saturation.

Habitat: The place where a plant or animal lives; often related to a function such as breeding, spawning, feeding, etc.

Habitat alteration: Regarding terrestrial habitat, occurs when changes in one or more habitat attributes are large enough to convert a habitat patch to a different fine habitat type.

Habitat attribute: A readily definable and inherent characteristic of a habitat patch.

Habitat effect: Regarding terrestrial habitat, any change in a habitat attribute that results from the Project.

Habitat loss: Conversion of terrestrial habitat into human features or aquatic areas.

Habitat patch: A defined geographic area where habitat attributes are relatively homogenous (*e.g.*, a map polygon).

Habitat zone of influence: Spatial extent of direct and indirect Project effects on terrestrial habitat.

Herbaceous: A plant that has leaves and stems that die down to the soil level at the end of the growing season and does not develop persistent woody tissue. Can also refer to the parts of a plant that die and are shed at the end of a growing season.

Humic: Partially decomposed organic material that occurs on the soil surface (also **humus**) or has been incorporated into the soil profile by physical and biological processes.

Hydroelectric: Electricity produced by converting the energy of falling water into electrical energy (*i.e.*, at a hydro generating station).

Ice regime: A description of ice on a water body (*i.e.*, lake or river) with respect to formation, movement, scouring, melting, daily fluctuations, seasonal variations, *etc.*

Impact: Essentially, a statement of what the Project is in terms of the ecosystem component of interest while a project effect is a direct or indirect consequence of that impact (*i.e.*, a statement of the cause-effect relationship). A terrestrial habitat example would be 10 ha of vegetation clearing (*i.e.*, the impact) leads to habitat loss, permafrost melting, soil conversion, edge effects, etc. (*i.e.*, the direct and indirect effects). Note that while *Canadian Environmental Assessment Act* requires the proponent to assess project effects, Manitoba legislation uses the terms impact and effect interchangeably. See also Effect.

Impact area: The geographic area encompassed by a particular Project impact.

Indicator species: A species that is closely correlated with a particular environmental condition or habitat type such that its presence, absence, or state of well-being can be used as indicator of environmental conditions. A species whose population size and trend is assumed to reflect the population size and trend of other species associated with the same geographic area and habitats.

Infrastructure: Permanent or temporary structures or features required for the construction of the principal structures, including access roads, construction camps, construction power, batch plant and cofferdams.

Inland peatland: A peatland that is beyond the direct influence of a water body's water regime and ice regime.

Inland wetland: A wetland that is beyond the direct influence of a water body's water regime and ice regime.

Invasive plant: A plant species that is growing outside of its country or region of origin and is out-competing or even replacing native organisms.

Keeyask Cree Nations: As a convenience to readers, all four communities are referred to in this document as the Keeyask Cree Nations (KCNs).

Key topic: A topic selected to focus the terrestrial effects assessment. Includes valued environmental components and key supporting topics.

Lacustrine: Of or having to do with lakes, and also used in reference to soils deposited as sediments in a lake.

Landscape: The ecological landscape as consisting of a mosaic of natural communities; associations of plants and animals and their related processes and interactions.

Landscape configuration: The arrangement of landforms, waterbodies and vegetation types in a defined geographic area.

Landscape element: A particular sequence of broad habitat types that repeats itself throughout an area. Landscape elements are a reflection of strong environmental gradients that repeat themselves in the area. Toposequences and hydrosequences are examples of landscape elements.

Landscape level: The level in the mappable ecosystem hierarchy that is between the stand and the sub-region.

LFH: A surface organic soil horizon primarily developed from the accumulation and decomposition of leaves, twigs and woody materials. LFH refers to the progressive stages of decomposition that typically increase from surface to depth, with the L layer being the least decomposed and the H layer being highly decomposed.

Local study area: The spatial area within which potential Project effects on individual organisms, or individual elements in the case of ecosystem attributes, may occur. Effects on the populations to which the individual organisms belong to, or the broader entity in the case of ecosystem attributes, were assessed using a larger regional study area; the spatial area in which local effects are assessed (*i.e.*, within close proximity to the action where direct effects are anticipated.

Magnitude: A measure of the size of an effect. *Alternatively,* a measure of how adverse or beneficial an effect may be.

Marsh: A class in the Canadian Wetland Classification System which includes non-peat wetlands having at least 25% emergent vegetation cover in the water fluctuation zone.

Mesic: Characterized by, relating to, or requiring a moderate amount of moisture.

Mineral soil: Naturally occurring, unconsolidated material that has undergone some form of soil development as evidenced by the presence of one or more horizons and is at least 10 cm thick. If a surface organic layer (*i.e.*, contains more than 30% organic material or 17% organic carbon by weight) is present, it is less than 20 cm thick.

Mitigation: A means of reducing adverse Project effects. Under the *Canadian Environmental Assessment Act*, and in relation to a project, mitigation is "the elimination, reduction or control of the adverse environmental effects of the project, and includes restitution for any damage to the environment caused by such effects through replacement, restoration, compensation or any other means."

Model: A description or analogy used to help visualize something that cannot be directly observed. Model types range from a simple set of linkage statements or a conceptual diagram to complex mathematical and/or computer model.

Moisture regime: The usual amount of water available for plant growth during the growing season.

Monitoring: Measurement or collection of data to determine whether change is occurring in something of interest. The primary goal of long term monitoring of lakes and rivers is to understand how aquatic communities and habitats respond to natural processes and to be able to distinguish differences between human-induced disturbance effects to aquatic ecosystems and those caused by natural processes; a continuing assessment of conditions at and surrounding the action. This determines if effects occur as predicted or if operations remain within acceptable limits, and if mitigation measures are as effective as predicted.

Multivariate techniques: Statistical or modelling techniques that capture the interrelationships between two or more factors.

Network linkage diagram: A schematic diagram that shows the states, driving factors, relationships and direction of flows in a complex system such as an ecosystem; a simple diagrammatic representation of a cause-effect relationship between two related states or actions that illustrates an impact model.

Non-native species: Species that are present in a specified region only as a direct or indirect result of human activity.

Off-system: Water body or waterway outside of the Nelson River hydraulic zone of influence.

Organic: The compounds formed by living organisms.

Organism: An individual living thing.

Paludification: Process beginning on mineral soils whereby vegetation (primarily sphagnum mosses) progressively creates a wetter moisture regime that eventually leads to the formation of a surface organic layer that expands laterally and vertically over time. It is the process whereby peatlands form on mineral uplands.

Parameter: Characteristics or factor; aspect; element; a variable given a specific value.

Parasites: An organism that lives in association with, and at the expense of, another organism, the host, from which it obtains organic nutrition.

Parent material: The unconsolidated mineral or organic material from which the soil develops.

Peatland: A type of wetland where organic material has accumulated at the surface.

Peat plateau bog: Ice-cored bog with a relatively flat surface that is elevated from the surroundings and has distinct banks.

Plant functional type: Genotypic limitations on the transformation of resources into growth and reproduction. Since these limitations change over long periods, the practical manifestation for the assessment was the species pool.

Polygon: An area fully encompassed by a series of connected lines.

Population: A group of interbreeding organisms of the same species that occupy a particular area or space.

Post-project: The actual or anticipated environmental conditions that exist once the construction of a project has commenced.

Precocial: Covered with down and capable of moving about when hatched.

Project footprint: The maximum potential spatial extent of clearing, flooding and physical disturbances due to construction activities and operation of the Project, including areas unlikely to be used.

Project linkage: A causal linkage where a Project feature is the event. See also **causal linkage**.

Proxy area: Ecologically comparable areas previously exposed to impacts similar to those expected for the Keeyask Generating Station.

Rapids: A section of shallow, fast moving water in a stream made turbulent by totally or partially submerged rocks.

Regime: The frequency, size, intensity, severity, patchiness, seasonality and sub-type of a periodic event or continual fluctuation.

Reservoir: A body of water impounded by a dam and in which water can be stored for later use. The reservoir includes the forebay.

Resident: With respect to wildlife, resident refers to a dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating (Canadian Environmental Assessment Agency).

Riparian: Along the banks of rivers and streams.

Riparian peatland: Peatland that borders a water body or waterway. The portion adjacent to the water is usually floating.

Runnel: A narrow channel found where two slopes meet.

Shallow water: A class in the Canadian Wetland Classification System which includes open water areas that are typically less than 2 m deep, that may be periodically dewatered, and having less than 25% emergent vegetation cover.

Shallow peatland: A broad ecosite type which includes peatlands that typically have peat that is at least 100 cm thick, lack continuous or extensive discontinuous ground ice and have a water table that is typically more than 20 cm below the surface.

Shoreline wetland: A wetland where surface water level fluctuations, water flows and ice scouring are the dominant driving factors.

Shore zone: Areas along the shoreline of a waterbody including the shallow water, beach, bank and immediately adjacent inland area that is affected by the water body.

Site type: A plot or smaller area classification of site conditions that have important influences on ecosystem patterns and processes. Site attributes that were directly or indirectly used for habitat classification included moisture regime, drainage regime, nutrient regime, surface organic layer thickness, organic deposit type, mineral soil conditions and permafrost conditions.

Stand: A relatively uniform area in terms of vegetation, vegetation age, soils and topography that ranges from approximately one to one hundred hectares in size

Study area: The geographic limits within which effects on a VEC (valued environmental component) or supporting topic is assessed.

Substrate: the material forming the streambed; also solid material upon which an organism lives or to which it is attached. See also bed material.

Terrestrial: Belonging to, or inhabiting the land or ground.

Terrestrial habitat: Terrestrial habitats include forests and grasslands (among others). They are typically defined by factors such as plant structure (trees and grasses), leaf types (*e.g.*. broadleaf and needleleaf), plant spacing (forest, woodland, savannah) and climate.

Terrestrial plant: Any plant adapted to grow on the land or areas with water that is typically shallower than 2 m.

Terrestrialization: The process whereby all or portions of a waterbody or waterway are filled in by organic sediment deposition and the horizontal expansion of peat from the shore towards the center of the waterbody or waterway.

Thin peatland: A fine type in the hierarchical ecosite classification that includes veneer bogs that occur on slopes or crests.

Till: An unstratified, unconsolidated mass of boulders, pebbles, sand and mud deposited by the movement or melting of a glacier.

Topography: General configuration of a land surface, including its relief and the position of its natural and manmade features.

Toposequence: A series of adjacent habitat types that have developed in response to strong differences in moisture regime, site type and disturbance regime that are created by slope position.

Transect: A line located between points and then used to investigate changes in attributes along that line.

Transmission line: A conductor or series of conductors used to transmit electricity from the generating station to a substation or between substations.

Tundra: Treeless plain characteristic of arctic and subarctic regions, with permanently frozen subsoil and dominant vegetation of mosses, lichens, herbs, and dwarf shrubs.

Upland: A land ecosystem where water saturation at or near the soil surface is not sufficiently prolonged to promote the development of wetland soils and vegetation.

Valued environmental component: Any part of the environment that is considered important by the proponent, public, scientists and government involved in the assessment process. Importance may be determined on the basis of cultural values or scientific concern.

Vascular plant: Any plant which has specialized tissues for transporting sugar, water and minerals within the plant.

Veneer bog: Bogs with thin peats (*i.e.*, generally less than 1.5 m thick) that generally occurs on gentle slopes and contain discontinuous permafrost.).

Waterbody: An area with permanent surface water.

Wetland: A land ecosystem where periodic or prolonged water saturation at or near the soil surface is the dominant driving factor shaping soil attributes and vegetation composition and distribution. **Peatland**s are a type of wetland.

Zone Of Influence: The spatial areas outside of the Project Footprint where direct and indirect effects occur. The location and size of the zone of influence varies for each ecosystem component of interest.

11.0 REFERENCES

11.1 LITERATURE CITED

Aboriginal Traditional Knowledge summary reports on woodland caribou (*Rangifer tarandus caribou*), Boreal population. Manitoba. Compiled by Environment Canada 2011 [online]. Available from http://www.sararegistry.gc.ca/document/default_e.cfm?documentID=2306 [accessed September 3, 2013].

Abraham, K. F. and Thompson, J. E. 1998. Defining the Pen Islands caribou herd of southern Hudson Bay. Rangifer 10: 33-40.

Abraham, K. F., Pond, B. A., Tully, S. M., Trim, V., Hedman, D., Chenier, C., and Racey, G. D. 2012. Recent changes in summer distribution and numbers of migratory caribou on the southern Hudson Bay coast. Rangifer Special Issue No. 20: 269–276.

Achard, F., Eva, H. D., Mollicone, D., and Beuchle, R. 2008. The effect of climate anomalies and human ignition factor on wildfires in Russian boreal forests. Phil. Trans. R. Soc. B. 363, 2331–2339.

Alberta Government. 2012. 2012 Alberta Hunting Draws. Available at http://www.albertaregulations.ca/hunting-draws.html [accessed 27 July, 2012].

Aldous, S. E. 1938. Beaver food utilization studies. Journal of Wildlife Management 2: 215-222.

Aleksiuk, M. 1970. The seasonal food regime of arctic beavers. Ecology 51: 264-270.

Aleksiuk, M. and Cowan, I. M. 1969. Aspects of seasonal energy expenditure in the beaver (*Castor canadensis* Kuhl) at the northern limits of its distribution. Canadian Journal of Zoology 47: 471-481.

Allen, A. W. 1982. Habitat suitability index models: beaver. U.S. Department of the Interior, Fish and Wildlife Service. FWS/OBS-W10.30 Revised. 20 pp. Available from http://breb.ro/Publicatii/hab_suitability_index_models_beaver.pdf [accessed 10 August, 2012].

Allen, T. F. H. and Starr, T. B. 1982. Hierarchy: perspectives for ecological complexity. University of Chicago Press, Chicago.

Allen, T. F., O'Neill, R. V., and Hoekstra, T. W. 1987. Interlevel relations in ecological research and management: some working principles from hierarchy theory. Journal of Applied Systems Analysis, 14:63-79.

Altman, B. and Sallabanks, R. 2012. Olive-sided Flycatcher (Contopus cooperi), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/502

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

Anderson, R. C. and Lankester, M. W. 1974. Infectious and parasitic diseases and arthropod pests of moose in North America. Naturaliste canadien 101: 23-50.

Athabasca Landscape Team. 2009. Athabasca Caribou Landscape Management Options Report. Alberta Caribou Committee. Edmonton, AB. 107 pp.

Atwood, E. L. Jr. 1938. Some observations on adaptability of Michigan beavers released in Missouri. Journal of Wildlife Management 2: 165-166.

Avery, M. L. 1995. Rusty Blackbird (Euphagus carolinus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/200

B. C. (British Columbia) Ministry of Environment, Lands and Parks. 2000. Caribou in British Columbia: ecology, conservation and management . Province of British Columbia. Available from http://www.env.gov.bc.ca/wld/documents/caribou_fs.pdf [accessed 13 October, 2011].

B.C. Ministry of Forests, Mines and Lands. 2010. The state of British Columbia's forests, 3rd edition. Forest Practices and Investment Branch, Victoria, BC. Available from www.for.gov.bc.ca/hfp/sof/index.htm#2010_report [accessed 13 October, 2011].

Bailey, R. G. 2009. Ecosystem Geography: From Ecoregions to Sites. Springer, New York. 251 pp.

Baker, B. W. and Hill, E. P. 2003. Beaver (*Castor canadensis*). In Wild mammals of North America: biology, management, economics. Edited by J. A. Chapman and G. A. Feldhamer. John Hopkins University Press, Baltimore, Maryland. pp. 288-310.

Ball, M. and Wilson, P. 2007. Analysis of woodland caribou fecal samples collected from northern Manitoba in 2006. Natural Resources DNA Profiling and Forensic Centre Final Report, Trent University Biology Department, Peterborough, Ontario. Prepared for Wildlife Resource Consulting Services MB Inc. 11 pp.

Ballard, W. B., Franzmann, A. W., Taylor, K. P., Spraker, T., Schwartz, C. C. and Peterson, R. O. 1979. Comparison of techniques utilized to determine moose calf mortality in Alaska. Proceedings of the North American Moose Conference and Workshop 15: 362-387.

Ballard, W. B. and Van Ballenberghe, V. 2007. Predator/prey relationships. In Ecology and Management of the North American Moose. Edited by A. W. Franzmann and C. C. Schwartz. Wildlife Management Institute, Boulder, Colorado. pp. 247-273.

Ballard, W. B., Whitman, J. S., and Reed, D. J. 1991. Population dynamics of moose in south-central Alaska. Wildlife Monographs 114: 3-49.

BAMP. 2012. Boreal Avian Monitoring Project. Online at: http://www.borealbirds.ca/ Accessed On November 28, 2012.

Banfield, A. W. F. 1961. A revision of the reindeer and caribou, genus *Rangifer*. National Museum of Canada Bulletin No. 177. 137 pp.

Banfield, A. W. F. 1974. The mammals of Canada. University of Toronto Press, Toronto, Ontario.

Banfield, A. W. F. 1987. The mammals of Canada, University of Toronto Press, Toronto, Ontario.

Barnes, D.M. and Mallik, A. U. 1997. Habitat factors influencing beaver dam establishment in northern Ontario watershed. Journal of Wildlife Management 61(4): 1371-1377.

Bartos, D. L. and Mueggler, W. F.1981. Early succession in aspen communities following fire in western Wyoming. J. Range Manage. 43: 212–215.

Berger, R. P., Martinez-Welgan, I., and Wisener, M. 2000. Analysis of global positioning system (GPS) relocation data (1995-1999) for the Owl Lake woodland caribou, Part A - Synopsis of technical reports and Part B - Technical Reports. Prepared for Manitoba Hydro, Manitoba Conservation, Pine Falls Paper Company, Manitoba Model Forest and TREE by Wildlife Resource Consulting Services MB Inc., I. Martinez-Welgan and Dimark Communications Group Inc., Winnipeg, Manitoba.

Bergerund, A. T. 1972. Food habits of Newfoundland caribou. Journal of Wildlife Management 36(3): 913-923.

Bergerud, A. T. 1977. Diets of caribou. In M. Recheigl, Jr. ed. Diets of mammals. V1. CRC Press, Cleveland, Ohio.

Bergerud, A. T. 1985. Antipredator strategies of caribou: dispersion along shorelines. Canadian Journal of Zoology 63: 1324-1329.

Bergerud, A. T. 1994. Evolving perspectives on caribou population dynamics, have we got it right yet? Rangifer Special Issue No. 9: 95-116.

Bergerud, A. T. 1996. Evolving perspectives on caribou population dynamics, have we got it right yet? Rangifer Special Issue No. 9: 95-116.

Bergerud, A. T. and Ballard, W. B. 1988. Wolf predation on caribou: the Nelchina herd case history, a different interpretation. Journal of Wildlife Management. 52: 344-357.

Bergerud, A. T., Ferguson, R., and Butler, H. 1990. Spring migration and dispersion of woodland caribou at calving. Animal Behaviour 39: 360-368.

Betcher, R., Grove, G. and Pupp, C. 1995. Groundwater in Manitoba: Hydrogeology, Quality Concerns, Management. Environmental Sciences Division, National Hydrology Research Institute, Environment Canada. NHRI Contribution No. CS-93017. 47 pp.

Beverly and Qamanirjuaq Caribou Management Board. 1999. Protecting Beverly and Qamanirjuaq caribou and caribou range. Beverly and Qamanirjuaq Caribou Resource Management Board, Stonewall, Manitoba. Available from http://www.arctic-caribou.com/bevreport.html [accessed 24 July, 2012].

Beverly and Qamanirjuaq Caribou Management Board. 2002. 20th anniversary report 1982-2002. Beverly and Qamanirjuaq Caribou Management Board, Stonewall, MB. Available from http://www.arctic-caribou.com/PDF/20th-annualreport.pdf [accessed May 3, 2013].

Beverly and Qamanirjuaq Caribou Management Board. 2011. 29th annual report for the year ending March 31, 2011. Beverly and Qamanirjuaq Caribou Management Board, Stonewall, Manitoba. Available from http://www.arctic-caribou.com/PDF/BQCMB_2010_2011_Annual_Report.pdf [accessed 9 March, 2012].

Beverly and Qamanirjuaq Caribou Management Board. 2012. 30th annual report for the year ending March 31, 2012. Beverly and Qamanirjuaq Caribou Management Board, Stonewall, MB. Available from http://www.arctic-caribou.com/BQCMB_report_2012_v3_lo.indd_annualreport.pdf [accessed May 3, 2013].

Beverly and Qamanirjuaq Caribou Management Board. 2013. Beverly and Qamanirjuaq range [online]. Available from http://www.arctic-caribou.com/parttwo/mapatlas.html [accessed August 22, 2013.

Boertje, R. D., Keech, M. A., and Paragi, T. F. 2010. Science and values influencing predator control for Alaska moose management. Journal of Wildlife Management 74(5): 917-928.

Boulanger, J., Poole, K. G., Gunn, A., and Wierzchowski, J. 2012. Estimating the zone of influence of industrial development on wildlife: a migratory caribou *Rangifer tarandus groenlandicus* and diamond mine case study. Wildlife Biology (18): 164-179.

Boulet, M., Couturier, S., Cote, S. D., Otto, R. D. & Bernatchez, L. 2007. Integrative use of spatial, genetic, and demographic analyses for investigating genetic connectivity between migratory, montane, and sedentary caribou herds. Molecular Ecology 16: 4223-4240.

Boutin, S. 1992. Predation and moose population dynamics: a critique. Journal of Wildlife Management 56(1): 116-127.

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

Bowyer, R. T., van Ballenberghe, V., Kie, J. G., and Maier, J. A. K. 1999. Birth-site selection by Alaskan moose: maternal strategies for coping with a risky environment. Journal of Mammalogy 80: 1070-1083.

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

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

Bradt, G. W. 1938. A study of beaver colonies in Michigan. Journal of Mammalogy 19(2): 139-162.

Brady, N. C. 1974. The Nature and Properties of Soils. 8th Edition. Macmillan Publishing Co. New York. 639 pp.

Brandt, J. P. 2009. The extent of the North American boreal zone. Environ. Rev. 17: 101–161.

Brassard, J. M., Audy, E. Crête, M., and Greiner, P. 1974. Distribution and winter habitat of moose in Quebec. Naturaliste canadien 101: 67-80.

Brenner, F. J. 1962. Foods consumed by beavers in Crawford County, Pennsylvania. Journal of Wildlife Management 26: 104-107.

Brigham, R. M., Ng, J., Poulin, R. G., and Grindal, S. D. 2011. Common Nighthawk (Chordeiles minor), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/213

Brown, K. G., Elliott, C., and Messier, F. 2000. Seasonal distribution and population parameters of woodland caribou in central Manitoba: implications for forestry practices. Rangifer 12: 85-94.

Brown, G. S., Mallory, F. F., and Rettie, W. J. 2001. Range size and seasonal movement for female woodland caribou in the boreal forest of northeastern Ontario. Rangifer Special Issue No. 14: 227-233.

Brumm, H. 2004. The impact of environmental noise on song amplitude in a territorial bird. Journal of Animal Ecology 73(3). pp434-440.

Bubenik, A. B. 2007. Behaviour. In Ecology and Management of the North American Moose. Edited by A. W. Franzmann and C. C. Schwartz. Wildlife Management Institute, Boulder, Colorado. pp. 173-221.

Bubenik, G. A., Schams, D., White, R. J., Rowell, J., Blake, J., and Bartos, L. 1997. Seasonal levels of reproductive hormones and their relationship to the antler cycle of male and female reindeer (*Rangifer tarandus*). Comparative Biochemical Physiology 116B: 269-277.

Burson, S. L. III, Belant, J. L., Fortier, K. A., and Tomkiewicz, W. C. III. 2000. The effect of vehicle traffic on wildlife in Denali National Park. Arctic 53: 146-151.

Busher, P. E. 1996. Food caching behaviour of beavers (*Castor canadensis*): selection and use of woody species. American Midland Naturalist 135: 343-348.

Busher, P. E., Warner, R. J., and Jenkins, S. H. 1983. Population density, colony composition, and local movements in two Sierra Nevada beaver populations. Journal of Mammalogy 64: 314-318.

Butler, D. R. 1991. Beavers as agents of biogeomorphic change: a review and suggestions for teaching exercises. Journal of Geography 90(5): 210-217.

Campbell, M. W. 1994. The winter ecology of Cape Churchill caribou (*Rangifer tarandus* spp). M.S. Thesis, University of Manitoba, Winnipeg, Manitoba. 216 pp.

Canadian Forest Service. 2013. *http://cfs.nrcan.gc.ca/pages/251*

Canadian Wildlife Service. 1997. Mammal fact sheets: moose [online]. Available at www.hww.ca/hww2.asp?id=93 [accessed 17 February, 2010].

Canadian Wildlife Service. 2005. Hinterland who's who: beaver [online]. Available from http://www.hww.ca/en/species/mammals/beaver.html [accessed 14 August, 2012].

Canadian Wildlife Service. 2011. Mammal fact sheets: beaver [online]. Available from: http://www.hww.ca/hww2.asp?id=82 [Accessed 1 April, 2011].

Canfield, R. H. 1941. Application of the line interception method in sampling range vegetation. Journal of Forestry 39(9): 388-394.

Cederlund, G. and Sand. H. 1994. Home-range size in relation to age and sex in moose. Journal of Mammalogy 75: 1005-1012.

Cederlund, G. N. and Okarma, H. 1988. Home range and habitat use of adult female moose. Journal of Wildlife Management 52: 336-343.

Cederlund, G., Sandegren, F., and Larsson, K. 1987. Summer movements of female moose and dispersal of their offspring. Journal of Wildlife Management 51(23): 342-352.

Chekchak T., Courtois, R., Ouellet, J.-P., Breton, L. and St-Onge, S. 1998. Caractéristiques des sites de mise bas de l'orignal (*Alces alces*). Canadian Journal of Zoology 76: 1663-1670.

Child, K. N. 2007. Incidental mortality. In Ecology and Management of the North Journal of American Moose. Edited by A. W. Franzmann and C. C. Schwartz. Wildlife Management Institute, Boulder, Colorado. pp. 275-301.

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

Clements, C. 1991. Beavers and riparian ecosystems. Rangelands. 13(6): 277-279.

Coady, J. W. 1974. Influence of snow on behaviour of moose. Naturaliste canadien 101: 417-436.

Coady, J. W. 1982. Moose (*Alces alces*). In Wild Mammals of North America- Biology, Management, and Economics. Edited by J. A. Chapman and G. A. Feldhamer. Johns Hopkins University Press, Baltimore, Maryland. pp. 902-922.

Collen, P. and Gibson, R. J. 2001. The general ecology of beavers (*Castor* spp.), as related to their influence on stream ecosystems and riparian habitats, and the subsequent effects on fish – a review. Reviews in Fish Biology and Fisheries 10: 439-461.

Collins, B. T. and Downes, C. M. 2009. Canadian Bird Trends Web site Version 2.3. Canadian Wildlife Service, Environment Canada, Gatineau, Quebec, K1A 0H3

Cook, T. D. and Campbell, D. T. 1979. Quasi-experimentation: design and analysis issues for field settings. Rand McNally College Publishing Company, Chicago.

COSEWIC 2006. COSEWIC assessment and status report on the rusty blackbird (Euphagus carolinus) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 28 pp.

COSEWIC. 2007A. COSEWIC assessment and status report on the olive-sided flycatcher (Contopus cooperi) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 25 pp.

COSEWIC. 2007B. COSEWIC assessment and status report on the common nighthawk (Chordeiles minor) in Canda. Committee on the Status of Endangered Wildlife in Canada. Chelsea, Quebec. Carl Savignac

Courtois, R., Bernatchez, L., Ouellet, J.-P., and Breton, L. 2003. Significance of caribou (*Rangifer tarandus*) ecotypes from a molecular genetics viewpoint. Conservation Genetics 4: 393-404.

Cree Nation Partners. 2013. Moose Harvest Sustainability Plan. Draft version. 41 pp + appendices.

Crête, M. and Bédard, J. 1975. Daily browse consumption by moose in the Gaspé Peninsula, Québec. Journal of Wildlife Management 39: 368-373.

Crête, M. and Courtois, R. 1997. Limiting factors might obscure population regulation of moose (Cervidae: *Alces alces*) in unproductive boreal forests. Journal of Zoology 242: 765-781.

Crête, M. and Gauthier, L. 1990. Food selection during early lactation by caribou calving on the tundra in Quebec. Arctic 46:60-65.

Crichton, V. 1992. Six year (1986/87-1991/92) summary of in utero productivity of moose in Manitoba, Canada. Alces 28: 203-214.

Crick, H.Q.P. 2004. The Impact of Climate Change on Birds. Ibis 146: 48-56.

Cronin, M. A., MacNeil, M. D., and Patton, J. C. 2005. Variation in mitochondrial DNA and microsatellite DNA in caribou (Rangifer tarandus) in North America. Journal of Mammalogy 86(3): 495-505.

Cronk, J. K. and Fennessy, M. S. 2001. Wetland Plants: Biology and Ecology. CRC Press. 482 pp.

Cumming, H. G. 1992. Woodland caribou: facts for forest managers. The Forestry Chronicle 68: 481-491.

Cumming, H. G. and Beange, D. B. 1987. Dispersion and movements of woodland caribou near Lake Nipigon, Ontario. Journal of Wildlife Management 51(1): 69-79.

Cumming, H.G., Beange, D.B., and Lavoi, G. 1996. Habitat partitioning between woodland caribou and moose in Ontario: the potential role of shared predation risk. Rangifer Special Issue No. 9: 81-94.

Curatolo, J. A. and Murphy, S. M. 1986. The effects of pipelines, roads, and traffic on movements of caribou, *Rangifer tarandus*. Canadian Field-Naturalist 100:218-224.

Daly, E. R., Roy, S. J., Blaney, D. D., Manning, J. S., Hill, V. R., Xiao, L., and Stull, J. W. 2010. Outbreak of giardiasis associated with a community drinking-water source. Epidemiology and Infection 138: 491-500.

Danell K, Edenius, L., and Lundberg, P. 1991. Herbivory and tree stand composition: Moose patch use in winter. Ecology 72:1350–1357

Darby, W. R., and Pruitt Jr., W. O. 1984. Habitat use, movements, and grouping behaviour of woodland caribou, *Rangifer tarandus caribou*, in southeastern Manitoba. Canadian Field-Naturalist 98(2): 184-190.

Dau, J. 2005. Two caribou mortality events in Northwest Alaska: possible causes and management implications. Rangifer Special Issue No. 16: 37-50.

Davis, J. L. and Franzmann, A. W. 1979. Fire-moose-caribou interrelationships: a review and assessment. Proceedings of the North American Moose Conference and Workshop 15: 80-118.

De Vos, A. 1964. Range changes of mammals in the Great Lakes region. American Midland Naturalist 71(1): 210-231.

DeCesare, N. J., Hebblewhite, M., Bradley, M., Smith, K. G., Hervieux, D., and Neufeld, L. 2011. Estimating ungulate recruitment and growth rates using age rations. Journal of Wildlife Management 76(1): 144-153.

Demarchi, M. W. 2003. Migratory patterns and home range size of moose in the Central Nass Valley, British Columbia. Northwestern Naturalist 84: 135-141.

DesGranges, J. and LeBlanc, M. 2012. The influence of summer climate on avian community composition in the eastern boreal forest of Canada. Avian Conservation and Ecology 7(1): 2.

DesMeules, P.1962. Intensive study of an early spring habitat of moose (*Alces alces* americana Cl.) in Laurentides Park, Quebec. Paper. Presented at Northeastern Section. Wildlife. Conference., Monticello, New York. 12 pp.

DeStefano, S., Koenen, K. K. G., Henner, C. M., and Strules, J. 2006. Transition to independence by subadult beavers (*Castor canadensis*) in an unexploited, exponentially growing population. Journal of Zoology 269: 434-441.

Dieter, C. D. and McCabe, T. R. 1989. Factors influencing beaver lodge site selection on a prairie river. American Midland Naturalist 122: 408-411.

Dixon, T. C., Meselson, M., Guillemin, J., and Hanna, P. C. 1999. Anthrax. New England Journal of Medicine 341: 815-826.

Dodds, D. G. 1974. Distribution, habitat, and status of moose in the Atlantic provinces of Canada and northeastern United States. Naturaliste canadien 101: 51-65.

Donkor, N. T. and Fryxell., J. M. 1999. Impact of beaver foraging on structure of lowland boreal forests of Algonquin Provincial Park, Ontario. Forest Ecology and Management 118: 83-92.

Dragon, D. C., Elkin, B. T., Nishi, J. S., and Ellsworth, T. R. 1999. A review of anthrax in Canada and implications for research on the disease in northern bison. Journal of Applied Microbiology 87: 208-213.

Drucker, D. G., Hobson, K. A., Ouellet, J.-P., and Courtois, R. 2010. Influence of forage preferences and habitat use on ^{13}C and ^{15}N abundance in wild caribou (*Rangifer tarandus caribou)* and moose (*Alces alces*) from Canada. Isotopes in Environmental and Health Studies 46(1): 107-121.

Dussault, C., Courtois, R., and Ouellet, J-P. 2006. A habitat suitability index model to assess moose habitat selection at multiple spatial scales. Canadian Journal of Forest Research 36: 1097-1107.

Dussault, C., Ouellet, J.-P., Courtois, R., Huot, J., Breton, L., and Jolicoeur, H. 2005. Linking moose habitat selection to limiting factors. Ecography 28: 619-628.

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

Dyer, S. J., O'Neill, J. P., Wasel, S. M., and Boutin, S. 2002. Quantifying barrier effects of roads and seismic lines on movements of female woodland caribou in northeastern Alberta. Canadian Journal of Zoology 80: 839-845.

Dyke, C. 2008. Characterization of woodland caribou (*Rangifer tarandus caribou*) calving habitat in the boreal plains and boreal shield ecozones of Manitoba and Saskatchewan. M.N.R.M. Thesis. University of Manitoba, Winnipeg, Manitoba.

Dzus, E., Ray, J., Thompson, I., and Wedeles, C. 2010. Caribou and the National Boreal Standard: Report of the FSC Canada Science Panel. FSC Canada. 71 pp.

ECOSTEM Ltd. (ECOSTEM) 2011c. Composition and Distribution of Shoreline and Inland Peatlands in the Keeyask Reservoir Area and Historical Trends in Peatland Disintegration. Report GN 9.2.1 prepared for Manitoba Hydro.

ECOSTEM Ltd. 2012. Keeyask Project Generating Station: Terrestrial Habitats and Ecosystems in the Lower Nelson River Region: Keeyask Regional Study Area. Report prepared for Manitoba Hydro. 503 pp.

ECOSTEM Ltd. (ECOSTEM) 2012a. Peatland Disintegration in the Proposed Keeyask Reservoir Area: Model Development and Post-Project Predictions. Report GN 9.2.7 prepared for Manitoba Hydro.

ECOSTEM Ltd. (ECOSTEM) 2012b. Terrestrial Habitats and Ecosystems in the Lower Nelson River Region: Keeyask Regional Study Area. Technical report prepared for Manitoba Hydro.

ECOSTEM Ltd. (ECOSTEM) 2013. Responses of Terrestrial Habitats to Reservoir Flooding and Water Regulation in Northern Manitoba. Technical report prepared for Manitoba Hydro.

Edenius L., G. Ericsson, and P. Näslund. 2002. Selectivity by moose vs. the spatial distribution of aspen: a natural experiment. Ecography 25:289–294.

Edwards, J. 1983. Diet shifts in moose due to predator avoidance. Oecologia 60: 185-189.

Ehnes, J. W. 1998. The influences of site conditions, age and disturbance by wildfire or winter logging on the species composition of naturally regenerating boreal plant communities and some

implications for community resilience. Ph. D. thesis, Department of Botany, University of Manitoba, Winnipeg, Manitoba.

Ehnes, J. W. 2011. Evaluation of Pimachiowin Aki as an outstanding representation of healthy multi-level boreal ecosystems. Prepared for Pimachiowin Aki Nomination for Inscription on the World Heritage List. 215 pp.

Ehnes, J. W. and ECOSTEM Ltd. 2006. Indirect Terrestrial Habitat Loss And Conversion Adjacent To Existing Transmission Line Rights-Of-Way In North-Western Manitoba. Prepared for ND LEA Engineers & Planners Inc. and Manitoba Hydro.

Ehrlich, P.R., Dobkin, D.S., and Wheye, D. 1988. The Birders's Handbook. A fieldguide to the Natural History of North American Birds. Simon and Schuster Inc. New York , New York.

Elliott, D.C. 1986. Moose and woodland caribou management program relative to the Limestone Hydro Electric Development 1986 Moose Census. Manitoba Department of Natural Resources. Thompson, MB. 18 pp. In Manitoba Hydro. 2012. Bipole III Transmission Project supplemental caribou technical report. Prepared for Manitoba Hydro by Joro Consultants Inc., Winnipeg, MB. August 2012. 108 pp.

Elliott, D.C.M. 1988. Large area moose census in Northern Manitoba. Alces 24:48-55.

Environment Canada. 2008. Scientific review for the identification of critical habitat for woodland caribou (*Rangifer tarandus caribou*), boreal population, in Canada. Environment Canada, Ottawa, Ontario. 238 pp.

Environment Canada. 2012. Recovery strategy for the woodland caribou, boreal population (*Rangifer tarandus caribou*) in Canada. *Species at Risk Act* Recovery Strategy Series. Environment Canada, Ottawa, Ontario. 55 pp + appendices.

Erikson, A. B. 1944. Parasites of beavers, with a note on Paramphistomum castori Kofoid and Park, 1937 a Synonym of Stichorchis subtriquetrus. American Midland Naturalist 31(3): 625-630.
Fryxell, J. M. and Doucet, C. M. 1993. Diet choice and the functional response of beavers. Ecology 74: 1297-1306.

Fall, A., Fortin, M.-J., Manseau, M., and O'Brien, D. 2007. Spatial graphs: principles and applications for habitat connectivity. Ecosystems 10: 448-461.

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

Ferguson, S. H. and Elkie, P. C. 2004b. Seasonal movement patterns of woodland caribou (*Rangifer tarandus caribou*). Journal of Zoology 262: 125-134.

Finnegan, L.A., Wilson, P.W., Price, G.N., Lowe, S.J., Patterson, B.R., Fortin M-J., and Murray, D.L. 2012. The complimentary role of genetic and ecological data in understanding population structure: a case study using moose (*Alces alces*). European Journal of Wildlife Research 58(2): 415-423.

Fisher, J. T. and Wilkinson, L. 2005. The response of mammals to forest fire and timber harvest in the North American boreal forest. Mammal Review 35: 51-81.

FLCN (Fox Lake Cree Nation). 2010. Keeyask Traditional Knowledge Report. Draft. Fox Lake Cree Nation, Manitoba

FLCN. 2012. Fox Lake Aski Keskentamowin Keeyask Powistik 2012 (Draft). Submitted March 29, 2012.

Flood, N. 1978. Rusty Blackbird, p. 476–477. In M. D. Cadman, P. F. J. Eagles and F. M. Helleiner [EDS.], Atlas of the breeding birds of Ontario. University of Waterloo Press, Waterloo, ON.

Ford, A. 2009. Modeling the Environment, Second Edition. Island Press. 400 pp.

Forman, R. T. T. and Deglinger, R. D. 2000. The ecological road-effect zone of a Massachusetts (U.S.A.) suburban highway. Conservation Biology 14: 36-46.

Franzmann, A. W. and Schwartz, C. C. 1985. Moose twinning rates: a possible population condition assessment. Journal of Wildlife Management 49(2): 394-396.

Fraser, D., Chavez, E.R., and Paloheimo, J. E. 1984. Aquatic feeding by moose: selection of plant species and feeding areas in relation to plant chemical composition and characteristics of lakes. Canadian Journal of Zoology 62: 80-87.

Frenzel, L. D. 1974. Occurrence of moose in food of wolves as revealed by scat analysis: a review of North American studies. Naturalist canadien 101: 467-479.

Frid, A. and Dill, L. 2002. Human-caused disturbance stimuli as a form of predation risk. Conservation Ecology 6(1): 11.

Gallant, D., Bérubé, C. H., Tremblay,E., and Vasseur, L. 2004. An extensive study of the foraging ecology of beavers (*Castor canadensis*) in relation to habitat quality. Canadian Journal of Zoology 82: 922-933.

Gasaway, W. C., Boertje, R. D., Grangaard, D. V., Kelleyhouse, D. G., Stephenson, R. O., and Larsen, D. G. 1992. The role of predation in limiting moose at low densities in Alaska and Yukon and implications for conservation. Wildlife Monographs 120: 3-59.

Gese, E. C. and Shadle, A. R., 1943. Reforestation of aspen after complete cutting by beavers. Journal of Wildlife Management 7: 223-228.

Giest, V. 1998. Deer of the world. Their evolution, behavior, and ecology. Stackpole Books, Mechanicsburg, PA. 421pp.

Gillespie, P. S. 1977. Summer activities, home range and habitat use of beaver. M.Sc thesis, University of Toronto, Toronto, Ontario. 149 pp. in Wheatley, M. 1997. Beaver, *Castor canadensis*, home range size and patterns of use in the taiga of southeastern Manitoba: I. Seasonal variation. Canadian Field-Naturalist 111(2): 204-210.

Goddard, J. 1970. Movement of moose in a heavily hunted area of Ontario. Journal of Wildlife Management 34: 436-445.

Godkin, G. F. 1986. Fertility and twinning in Canadian reindeer. Proceedings of the 4th international reindeer/caribou symposium, Whitehorse, Yukon, Canada. Nordic Council for Reindeer Research, Harstad, Norway. pp. 145-158.

Government of Canada 2002. *Species at Risk Act*. S.C. 2002, c.29. Available from http://laws-lois.justice.gc.ca/eng/acts/S-15.3/page-1.html [accessed 18 June 2012].

Government of Saskatchewan. 2012. Moose population increasing in southern Saskatchewan. News Release June 8, 2012 [online]. Available from http://www.gov.sk.ca/news?newsId=e94c4341-c0a4-44e1-ace6-844defc5721b [accessed March 5, 2013].

Green, H. U. 1936. The beaver of the Riding Mountain, Manitoba: an ecological study and commentary. Canadian Field-Naturalist 50: 1-8.

Gunn, A. 2008. Migratory tundra caribou. In Caribou and the north: a shared future. By M. Hummel and J. C. Ray. Dundurn Press, Toronto, Ontario. pp. 200-222.

Gunn, A., Poole, K. G., and Nishi, J. S. 2012. A conceptual model for migratory tundra caribou to explain and predict why shifts in spatial fidelity of breeding cows to their calving grounds are infrequent. Rangifer Special Issue No. 20: 259-267.

Gunn, A., Poole, K. G., Wierzchowski, J., and Campbell, M. 2007. Assessment of caribou protection measures. Indian and Northern Affairs Canada, Gatineau, Quebec. 41 pp.

Gunn, A., Russell, D., and Earner, J. 2011. Northern caribou population trends in Canada. Canadian Biodiversity: Ecosystem Status and Trends 2010, Technical Thematic Report No. 10. Canadian Councils of Resource Ministers, Ottawa, ON. 71 pp.

Gustine, D. D., Parker, K. L., Lay, R. J., Gillingham, M. P., and Heard, D. C. 2006. Calf survival of woodland caribou in a multi-predator ecosystem. Wildlife Monographs 165: 1-32.

Habib, L.E., M. Bayne and S.Boutin. 2007. Chronic industrial noise affects pairing success adn age structure of Ovenbirds Seiurus aurocapilla. Journal of Applied Ecology 44: 176-184.

Harrington, F. H. 1996. Human impacts on George River caribou: an overview. Rangifer Special Issue No. 9: 277-278.

Hellsten, S. 2000. Environmental factors and aquatic macrophytes in the littoral zone of regulated lakes: Causes, consequences and possibilities to alleviate harmful effects. Ph. D. thesis, University of Oulu, Finland.

Hibbard, E. A. 1958. Movements of beaver transplanted in North Dakota. Journal of Wildlife Management 22(2): 209-211.

Hiner, L. E. 1938. Observations of the foraging habits of beaver. Journal of Mammalogy 19: 317-319.

Hirai, T. 1998. An evaluation of woodland caribou (*Rangifer tarandus caribou*) calving habitat in the Wabowden area, Manitoba. M.S. Thesis, University of Manitoba, Winnipeg, Manitoba.

Hitchcock, H. B. 1954. Felled tree kills beaver (*Castor canadensis*). Journal of Mammalogy 35: 452.

Hood, G.A., Bayley, S.E., and Olson, W. 2007. Effects of prescribed fire on habitat of beaver (*Castor Canadensis*) in Elk Island National Park, Canada. Forest Ecology and Management 239: 200-209.

Hoskins, L. W. and Dalke, P. D. 1955. Winter browse on the Pocatello big game range in southern Idaho. Journal of Wildlife Management 19: 215-225.

Houston, D. B. 1968. The Shiras moose in Jackson Hole, Wyoming. Grand Teton Natural History Association Technical Bulletin No. 1. 110 pp.

Howard, R. J. and Larson, J. S. 1985. A stream habitat classification system for beaver. Journal of Wildlife Management 49(1): 19-25.

Hummel, M. and Ray, J. C. 2008. Caribou and the north: a shared future. Dundern Press, Toronto, Ontario. 288 pp.

Hundertmark, K. J. 2007. Home range, dispersal and migration. In Ecology and Management of the North American Moose. Edited by A. W. Franzmann, and C. C. Schwartz. Wildlife Management Institute, Boulder, Colorado. pp 303-335.

Irwin, L. J. 1975. Deer-moose relationships on a burn in northeastern Minnesota. Journal of Wildlife Management 39: 653-662.

J.D. Mollard and Associates Limited (JDMA). 2012. Keeyask Generation Project Stage IV Studies - Physical Environment: Existing Environment Mineral Erosion. Deliverable GN 9.2.2. Prepared For Hydro Power Planning Department Power Projects Development Division Power Supply. 34 pp + figures and maps.

Jalkotzy, M.G., Ross, P.I., and Nasserden, M.D. 1997. The Effects of Linear Developments on Wildlife: A Review of Selected Scientific Literature. Prep. For Canadian Association of Petroleum Producers. Arc Wildlife Services Ltd., Calgary. 115pp.

James, A. R. C. and Stuart-Smith, A. K. 2000. Distribution of caribou and wolves in relation to linear corridors. Journal of Wildlife Management 36: 154-159.

Jellison, W. L., Kohls, G. M., Butler, W. J., and Weaver, J. A. 1942. Epizootic tularaemia in the beaver, *Castor canadensis*, and the contamination of stream water with *Pasteurella tularensis*. American Journal of Epidemiology 36(2): 168-182.

Jenkins, S. H. 1980. A size-distance relation in food selection by beavers. Ecology 61(4): 740-746.

Jenkins, S. H. 1981. Problems, progress and prospects in studies of food selection by beavers. Proceedings of the Worldwide Furbearer Conference 1: 559-579.

Jenkins, S. H., and Busher, P.E. 1979. *Castor canadensis*. Am. Sot. Mammal, New York. Mammalian Species 120:1-8.

Jiang, G., Ma, J., Zhang, M., and Stott, P. 2009. Multiple spatial-scale resource selection function models in relation to human disturbance for moose in northeastern China. Ecological Research 24: 423-440.

Johnson, C. J., Parker, K. L., and Heard, D. C. 2001. Foraging across a variable landscape: behavioral decisions made by woodland caribou at multiple spatial scales. Oecologia 127: 590-602.

Johnson, C. J., Parker, K. L., Heard, D. C., and Seip, D. R. 2004. Movements, foraging habits, and habitat use strategies of northern woodland caribou during winter: implications for forest practices in British Columbia. B.C. Journal of Ecosystems and Management 5: 22-35.

Joly, K., Chapin, F. S. III, and Klein, D. R. 2010. Winter habitat selection by caribou in relation to lichen abundance, wildfires, grazing, and landscape characteristics in northwest Alaska. Ecoscience 17(3): 321-333.

Jung, T. S. and Staniforth, J. A. 2010. Unusual beaver, *Castor canadensis*, dams in central Yukon. Canadian Field-Naturalist 124(3): 274-275.

Karns, P. D. 1972. Minnesota's 1971 moose hunt: a preliminary report on the biological collections. Proceedings of the North American Moose Conference and Workshop 8: 115-123.

Karns, P. D. 2007. Population distribution, density and trends. In Ecology and Management of the North American Moose. Edited by A. W. Franzmann, and C. C. Schwartz. Wildlife Management Institute, Boulder, Colorado. pp. 125-139.

KBM Forestry Consultants Inc. 2006. A pilot moose habitat model for the mid boreal uplands ecoregion of the Manitoba model forest [online]. Manitoba Model Forest Network. Available at http://www.manitobamodelforest.net/publications/Habitat%20Suitability%20index%20Model%20-%20Moose%202006.pdf [accessed 4 April, 2011].

Kearney, S. and Thorleifson, I. 1987. The Cape Churchill caribou herd: its status and management. Manitoba Department of Natural Resources unpublished report. 40 pp. In Campbell, M. W., 1994. The winter ecology of Cape Churchill caribou (*Rangifer tarandus* spp.). M. Sc. Thesis, Department of Zoology, The University of Manitoba, Winnipeg, MB. 216 pp.

Keddy, P. 2010. Wetland ecology principles and conservation. Second Edition. Cambridge University Press, Cambridge, United Kingdom. 497 pp.

Keeyask Generation Proejct. 2012a. Environmental Impact Statement – Supporting Volume – Habitat and Ecosystems. 358 pp.

Keeyask Generation Proejct. 2012b. Environmental Impact Statement – Supporting Volume – Terrestrial Environment. 319 pp.

Keeyask Hydropower Limited Partnership. 2012. Domestic Resource Use. In Keeyask Generation Project environmental impact statement response to EIS guidelines Chapter 6 environmental effects assessment. pp. 171-175. Available from http://keeyask.com/wp/wp-content/uploads/2012/07/Response-to-EIS-Guidelines-part-5a-of-7.pdf [Accessed 24 July, 2012].

Kelsall, J. P. 1968. The migratory barren-ground caribou of Canada. Queen's Printer and Controller of Stationary. Ottawa, Ontario. 340 pp.

Kelsall, J. P. 1972. The northern limits of moose (*Alces alces*) in western Canada. Journal of Mammalogy 53(1): 129-138.

Kelsall, J. P. and Telfer, E. S. 1974. Biogeography of moose with particular reference to western North America. Naturaliste canadien 101: 117-130. Cited in Karns, P. D. 2007. Population distribution, density and trends. In Ecology and Management of the North American Moose. Edited by A. W. Franzmann, and C. C. Schwartz. Wildlife Management Institute, Boulder, Colorado. pp. 125-139.

King, A. W. 1993. Considerations of scale and hierarchy. In S. Woodley, J. Kay, G. Francis (eds.) Ecological Integrity and the Management of Ecosystems. St. Lucie Press.

Kingston, N., Morton, J. K., and Deiterich, R. 1982. *Trypanosoma cervi* from Alaskan reindeer, *Rangifer tarandus*. Journal of Eukaryotic Microbiology 29: 588-591.

Klein, D. R. 1980. Conflicts between domestic reindeer and their wild counterparts: a review of Eurasian and North American experience. Arctic 33 (4): 739-756.

Klein, D. R. 1982. Fire, lichens and caribou. Journal of Range Management. 35: 390-395.

Klein, D. R. 1991. Limiting factors in caribou population ecology. Rangifer Special Issue No. 7: 30-35.

Klein, D. R., Moorehead, L., Kruse, J., and Braund, S. R. 1999. Contrasts in use and perceptions of biological data for caribou management. Wildlife Society Bulletin 27(2): 488-498.

Knudsen, B., Berger, R., Johnstone, S., Kiss, B., Paille, J. and Kelly, J. 2010. Keeyask Project environmental studies program: Split Lake Resource Management Area moose survey 2009-2010. A report for Manitoba Hydro prepared by Wildlife Resource Consulting Services MB Inc. 145 pp.

Knudsen, B., Berger, R., Johnstone, S., Kiss, B., Paille, J., and Kelly, J. 2010. Split Lake Resource Management Area moose survey 2009 and 2010. Keeyask Generation Project Environmental Studies Program Report #10-01. Prepared for Manitoba Hydro by Wildlife Resource Consulting Services MB Inc., Winnipeg. 144pp.

Kunkel, K. E. and Pletscher, D. H. 2000. Habitat factors affecting vulnerability of moose to predation by wolves in southeastern British Columbia. Canadian Journal of Zoology 78(1): 150-157.

Koonz W. H and Taylor, P. 2003. Olive-sided Flycatcher. In:The Birds of Manitoba. Manitoba Avian Research Committee. Manitoba Naturalists Society, Winnipeg, Manitoba.

Kuzyk, G. W. 2002. Wolf distribution and movements on caribou ranges in west-central Alberta. M.S. Thesis, University of Alberta, Edmonton, Alberta.

Labonté, J., Ouellet, J.-P., Courtois, R., and Bélisle, F. 1998. Moose dispersal and its role in the maintenance of harvested populations. Journal of Wildlife Management 62(1): 225-235.

Lancia, R.A., Dodge, W.E., and Larson, J.S. 1982. Winter activity patterns of two radio-marked beaver colonies. Journal of Mammalogy 63: 598-606.

Lankester, M. W. and Samuel, W. M. 2007. Pests, parasites and diseases. In Ecology and Management of the North American Moose. Edited by A. W. Franzmann and C. C. Schwartz. Wildlife Management Institute, Boulder, Colorado. pp. 479-517.

Lantham,. A. D. M., Latham, M. C., Knopff, K. H., Hebblewhite, M. and Boutin, S. 2013. Wolves, white-tailed deer, and beaver: implications of seasonal prey switching for woodland caribou declines. Ecography 36: 1-15.

Lantin, E., Drapeau, P., Paré, M., and Bergeron, Y. 2003. Preliminary assessment of habitat characteristics of woodland caribou calving areas in the Claybelt region of Québec and Ontario, Canada. Rangifer Special Issue No. 14: 247-254.

Latham. A. D. M., Latham, M. C., Boyce, M. S., and Boutin, S. 2011. Movement responses by wolves to industrial linear features and their effect on woodland caribou in northeastern Alberta. Ecological Applications 21(8): 2854-2865.

Laurian, C., Dussault, C., Ouellet, J.-P., Courtois, R., Poulin, M., and Breton, L. 2008. Behavior of moose relative to a road network. Journal of Wildlife Management 72: 1550-1557.

Leblond, M., Dussault, C., and Ouellet, J.-P. 2010. What drives fine-scale movements of large herbivores? A case study using moose. Ecography 33: 1102-1112.

Leege, T. A. 1968. Natural movements of beavers in southeastern Idaho. Journal of Wildlife Management 32: 973-976.

Lefebvre, M. F., Semalulu, S .S., Oatway, A. E., and Nolan, J. W. 1997. Trypanosomiasis in woodland caribou of northern Alberta. Journal of Wildlife Diseases 33: 271-277.

Lenarz, M. S., Nelson, M. E., Schrage, M. W., and Edwards, A. J. 2009. Temperature mediated moose survival in northeastern Minnesota. Journal of Wildlife Management 73: 503-510.

Lent, P. C. 1974. A review of rutting behaviour in moose. Naturaliste canadien 101: 307-323.

Leptich, D. J. and Gilbert, J. R. 1989. Summer home range and habitat use by moose in northern Maine. Journal of Wildlife Management 53:880-884.

LeResche, R. E. 1968. Spring-fall calf mortality in an Alaskan moose population. Journal of Wildlife Management 32: 953-956.

LeResche, R. E. 1974. Moose migrations in North America. Naturaliste canadien 101:393-415.

LeResche, R. E. and Davis, J. L. 1973. Importance of nonbrowse foods to moose on the Kenai Peninsula, Alaska. Journal of Wildlife Management 37: 279-287.

Lister, K. 1996. Fishing stations and the low country: a contribution to Hudson Bay Lowland ethnohistory. Open Access Dissertations and Theses. Paper 6956. 438 pp.

Loranger, A. J., Bailey, T. N., and Larned, W. W. 1991. Effects of forest succession after fire in moose wintering habitats on the Kenai Peninsula, Alaska. Alces, 27: 100-109.

Luick, B. R., Kitchens, J. A., White, R. G., and Murphy, S. M. 1996. Modelling energy and reproductive costs in caribou exposed to low flying military jet aircraft. Rangifer Special Issue No. 9: 209-212.

MacArthur R. H. and Pianka, E. R. 1966. On optimal use of a patchy environment. American Naturalist 100:603–609.

MacCracken, J. G., Ballenberghe, V. V., and Peek, J. M. 1993. Use of aquatic plants by moose: sodium hunger or foraging efficiency? Canadian Journal of Zoology 71: 2345-2351.

MacCracken, J. G., Ballenberghe, V. V., and Peek, J. M. 1997. Habitat relationships of moose on the Copper River Delta in coastal south-central Alaska. Wildlife Monographs 136: 3-52.

Magoun, A. J., Abraham, K. F., Thompson, J. E., Ray, J. C., Gauthier, M. E., Brown, G. S., Woolmer, G., Chenier, C. J., and Dawson, F. N. 2005. Distribution and relative abundance of caribou in the Hudson Plains Ecozone of Ontario. Ragnifer Special Issue No. 16: 105-121.

Maier, J. A. K., Ver Hoef, J. M., McGuire, A. D., Bowyer, R. T., Sapterstein, L., and Maier, H. A. 2005. Distribution and density of moose in relation to landscape characteristics: effects of scale. Canadian Journal of Forest Research 35: 2233-2243.

Mallory, F. F. and Hillis, T. L. 1996. Demographic characteristics of circumpolar caribou populations: ecotypes, ecological constraints, releases, and population dynamics. Rangifer Special Issue No. 10: 49-60.

Manitoba Agriculture, Food and Rural Initiatives. No date. Anthrax FAQ [online]. Available at http://www.gov.mb.ca/agriculture/livestock/anhealth/jaa02s00.html [accessed 27 July, 2012].

Manitoba Breeding Bird Atlas. 2012. Regional Data Summaries from 2010-2012: Hudson Bay Coast and Gillam/Shamattawa Regions. [online]. Available from http://www.birdatlas.mb.ca/mbdata/datasummaries.jsp?lang=en [accessed 30 January 2013].

Manitoba Conservation. 2005. Manitoba's conservation and recovery strategy for boreal woodland caribou (*Rangifer tarandus caribou*). Manitoba Wildlife and Ecosystem Branch, Winnipeg. Available from http://www.gov.mb.ca/conservation/wildlife/sar/pdf/bw_caribou_strategy.pdf [accessed 24 July, 2012].

Manitoba Conservation and Water Stewardship. 2012. 2012 Manitoba Hunting Guide. Available at www.gov.mb.ca/conservation/wildlife/hunting/ [accessed 26 July, 2012].

Manitoba Conservation and Water Stewardship 2013. Manitoba Land Initiative – Forest Inventory Maps. Available at http://mli2.gov.mb.ca/forestry/index.html [accessed 29 July, 2013].

Manitoba Conservation and Water Stewardship. Moose fact sheet [online]. Available at http://www.gov.mb.ca/conservation/wildlife/mbsp/fs/moose.html [accessed 26 July, 2012].

Manitoba Conservation and Water Stewardship. Moose range map [online]. Available at http://www.gov.mb.ca/conservation/wildlife/mbsp/fs/moose.html [accessed Aug 22, 2013].

Manitoba Conservation and Water Stewardship. No date. Problem wildlife: beaver [online]. Available from http://www.gov.mb.ca/conservation/wildlife/problem_wildlife/furbearing.html [accessed 13 August, 2012].

Manitoba Conservation and Water Stewardship. No date. Species at risk boreal woodland caribou fact sheet. Wildlife and Ecosystem Protection Branch [online]. Available from http://www.gov.mb.ca/conservation/wildlife/sar/fs/wlcaribou.html [accessed 24 July, 2012].

Manitoba Forestry Wildlife Management Project. 1994. Habitat suitability index model for the beaver (*Castor canadensis*). The Manitoba Forestry/Wildlife Management Project, Winnipeg, Manitoba.

Manitoba Hydro. 2004. Keeyask Project – Environmental Studies Program: Results of mammal investigations in the Keeyask Study Area, 2004. Prepared for Manitoba Hydro by Wildlife Resource Consulting Services, Manitoba Inc. 64 pp.

Manitoba Hydro. 2011. Bipole III Transmission Project caribou technical report (draft). Prepared for Manitoba Hydro by Joro Consultants Inc., Winnipeg, MB. November 2011. 205 pp.

Manitoba Hydro. 2012. Bipole III Transmission Project supplemental caribou technical report. Prepared for Manitoba Hydro by Joro Consultants Inc., Winnipeg, MB. August 2012. 108 pp.

Manitoba Hydro. 2012. Keeyask Project Generating Station: Terrestrial Habitats and Ecosystems in the Lower Nelson River Region: Keeyask Regional Study Area. Prepared for Manitoba Hydro by ECOSTEM Ltd. 503 pp.

McCracken. 2008. Are Aerial Insectivores Being Bugged out?. Bird Watch Canada Issues 42. January 2008.

McDevitt, A. D., Mariani, S., Hebblewhite, M., Decesare, N. J., Morgantini, L., Seip, D., Weckworth, B. V., and Musiani, M. 2009. Survival in the Rockies of an endangered hybrid swam from diverged caribou (*Rangifer tarandus*) lineages. Molecular Ecology 18: 665-679.

McGinley, M. A. and Whitham, T. G. 1985. Central place foraging by beavers (*Castor canadensis*): a test of foraging predictions and the impact of selective feeding on the growth form of cottonwoods (*Populus fremontii*). Oecologia 66(4): 558-562.

McLaughlin, R. F. and Addison, E. M. 1986. Tick (*Dermacentor albipictus*)-induced winter hair-loss in captive moose (*Alces alces*). Journal of Wildlife Diseases 22(4): 502-510.

McLellan, M. L., Serrouya, R., McLellan, B. N., Furk, K., Heard, D. C., and Wittmer, H. U. 2012. Implications of body condition on the unsustainable predation rates of endangered mountain caribou. Oecologia 169: 853-860.

McLoughlin, P. D., Dzus, E., Wynes, B., and Boutin, S. 2003. Declines in populations of woodland caribou. Journal of Wildlife Management 67(4): 755-761.

McNew L. B. Jr. and Woolf, A. 2005. Dispersal and survival of juvenile beavers (*Castor canadensis*) in southern Illinois. American Midland Naturalist 154: 217-228.

McNicol, J. G. and Gilbert, F. F. 1980. Late winter use of upland cutovers by moose. Journal of Wildlife Management 44(2): 363-371.

Mech, L. D., McRoberts, R. E., Peterson, R. O., and Page, R. E. 1987. Relationship of deer and moose populations to previous winters' snow. Journal of Animal Ecology 56: 615-627.

Mengak, M. T. 2009. Rusty Blackbird (Euphagus carolinus). Natural History Publication Serries. NHS-09-08. Warnell School of Forestry and Natural Resources, The University of Georgia.

Metsaranta, J. M., Mallory, F. F., and Cross, D. W. 2003. Vegetation characteristics of forest stands used by woodland caribou and those disturbed by fire or logging in Manitoba. Rangifer Special Issue No. 14: 255-266.

Michigan Department of Natural Resources. 2012. History of moose in Michigan [online]. Michigan Department of Natural Resources. Available at http://www.michigan.gov/dnr/0,4570,7-153-10370_12145_58476-256178--,00.html [accessed 9 August, 2012].

Millennium Ecosystem Assessment. 2005. Ecosystems and human well-being: a framework for assessment. Washington, D.C., Island Press.

Miller, F. L. 2003. Caribou (*Rangifer tarandus*) In Wild Mammals of North America. Edited by J. A. Chapman and G. A. Feldhamer. The Johns Hopkins University Press, Baltimore and London. pp. 965-997.

Miller, M. J., Dawson, R. D., and Schwantje, H. 2003. Manual of common diseases and parasites of wildlife in northern British Columbia. University of Northern British Columbia, Prince George, British Columbia.

Miller, P. and Ehnes, J. 2000. Canadian approaches to sustainable forest management maintain ecological integrity? In Ecological integrity: Integrating Environment, Conservation and Health. Edited by D. Pimentel, L. Westra. and R. F. Noss. Island Press, Washington, D.C. pp. 157-176.

Miller, F. L., Gunn, A., and Broughton, E. 1985. Surplus killing as exemplified by wolf predation on newborn calves. Canadian Journal of Zoology 63: 295-300.

Miller, D. R. and Robertson, D. R. 1967. Results of tagging caribou at Little Duck Lake, Manitoba. Journal of Wildlife Management 31: 150-159.

Minnesota Department of Natural Resources. 2011. Minnesota Research and Moose Management Plan. Accessed August 2013. Available at http://files.dnr.state.mn.us/fish_wildlife/wildlife/moose/management/mooseplan-final.pdf

Miquelle, D. G. 1990. Why don't bull moose eat during the rut? Behavioral Ecology and Sociobiology 27(2): 145-151.

Moayeri, M. 2013. Reconstructing the summer diet of wolves in a complex multi-ungulate system in northern Manitoba, Canada. M.Sc. Thesis, University of Manitoba, Winnipeg, Manitoba. 109 pp.

Moose Harvest Sustainability Plan. 2012. Sustainable Moose Harvesting in the Split Lake Resource Management Area. Draft report prepared for Manitoba Hydro. 49 pp. plus appendices.

Morris D. W. 1988. Habitat-Dependent Population Regulation and Community Structure. Evolutionary Ecology 2:253–269.

Mosnier, A., Ouellet, J., Sirois, L., and Fornier, N. 2003. Habitat selection and home range dynamics of the Gaspé caribou: a hierarchical analysis. Canadian Journal of Zoology 81: 1174-1184.

Muëller-Schwarze, D. 2011. The beaver: its life and impact. Cornell University Press, Ithaca, New York. 228 pp. Available from http://books.google.ca/books?hl=en&lr=&id=HZ5WjXB5Pr8C&oi=fnd&pg=PA64&dq=beaver+activity+winter+temperature&ots=WYtSjSl6BL&sig=gOwlhsMhiBSVVirfscBde-DwDSw#v=onepage&q=beaver%20activity%20winter%20temperature&f=false [accessed 14 August, 2012].

Müller-Schwarze, D. and Sun, L. 2003. The beaver: natural history of a wetlands engineer. Comstock Publishing Associates, Ithaca, N.Y. 190 pp. Available from http://books.google.ca/books?id=eqIenKko3lAC&printsec=frontcover#v=onepage&q&f=false [accessed 13 August, 2012].

Murray, D. L., Cox, E. W., Ballard, W. B., Whitlaw, H. A., Lenarz, M. S., Custer, T. W., Barnett, T., and Fuller, T. K. 2006. Pathogens, nutritional deficiency, and climate influences on a declining moose population. Wildlife Monographs 166: 1-30.

Mytton, W. R. and Keith, L. B. 1981. Dynamics of moose populations near Rochester, Alberta, 1975-1978. Canadian Field-Naturalist. 95(1): 39-49.

Naiman, R. J., Johnston, C. A., and Kelley, J. C. 1988. Alteration of North American streams by beaver. BioScience 38(11), How Animals Shape Their Ecosystems: 753-762.

Naiman, R. J., Melillo, J. M., and Hobbie, J. E. 1986. Ecosystem alteration of boreal forest streams by beaver (*Castor canadensis*). Ecology 67: 1254-1269.

National Wetlands Working Group. 1997. The Canadian Wetland Classification System. 2nd Ed. Edited by B.G. Warner and C.D.A. Rubec. Wetlands Research Centre, University of Waterloo, Waterloo, Ontario. 68 pp.

NatureServe, 2012. NatureServe Explorer: an online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available at www.natureserve.org/explorer/ [accessed 26 July, 2012].

NatureServe. 2012. NatureServe Explorer: an online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available from ttp://www.natureserve.org/explorer [accessed 13 August, 2012].

Nellemann, C. and Cameron, R. D. 1998. Cumulative impacts of an evolving oil-field complex on the distribution of calving caribou. Canadian Journal of Zoology 76(8): 1425-1430.

Nellemann, C., Vistnes, I., Jordhøy, P., and Strand, O. 2001. Winter distribution of wild reindeer in relation to power lines, roads and resorts. Biological Conservation 101: 351-360.

Nero and Taylor. 2003. Rusty Blackbird - in The Birds of Manitoba.

Neumann, W. 2009. Moose *Alces alces* behavior related to human activity. Doctoral Thesis. Swedish University of Agricultural Sciences, Umea. 56 pp.

Neumann, W., Ericsson, W., Dettki, H., and Radeloff, V. C. 2013. Behavioural response to infrastructure of wildlife adapted to natural disturbances. Landscape and Urban Planning 114: 9-27.

Northcott, T. H. 1971. Feeding habits of beaver in Newfoundland. Oikos 22: 407-410.

Novak, M. 1998. Beaver. In Wild furbearer management and conservation in North America. Edited by M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch. Ontario Ministry of Natural Resources, Peterborough, Ontario. pp. 282-312.

Novakowski, N. 1965. Population dynamics of a beaver population in northern latitudes. Ph.D. Thesis, University of Saskatchewan, Saskatoon, Saskatchewan. 154 pp.

Novakowski, N. S. 1967. The winter bioenergetics of a beaver population in northern latitudes. Canadian Journal of Zoology 45: 1107-1118.

O'Brien, D., Manseau, M., Fall, A., and Fortin, M.-J. 2006. Testing the importance of spatial configuration of winter habitat for woodland caribou: An application of graph theory. Biological Conservation 130 (1): 70-83.

Obbard, M. E. 1987. Beaver. In M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, eds. Wild furbearer management and conservation in North America. Ontario Trappers Assoc., North Bay.

Oechel, W. C. and Lawrence, W. T. 1985. Taiga. In B. F. Chabot and H. A. Mooney. Physiological ecological of North American plant communities. Chapman and Hall, New York. pp. 66-94.

Olsen, O. W. and Fenstemacher, R. 1942. Parasites of moose in northern Minnesota. American Journal of Veterinary Research 3: 403-408.

Ontario Ministry of Natural Resources. 2009. Ontario's woodland caribou conservation plan. Ontario Ministry of Natural Resources, Peterborough, Ontario. Available from http://www.mnr.gov.on.ca/stdprodconsume/groups/lr/@mnr/@species/documents/document/277783.pdf [accessed 24 July, 2012]. 24 pp.

Ontario Ministry of Natural Resources. 2012. Ontario Hunting Regulations Summary – Fall 2012 to Spring 2013. Ontario Ministry of Natural Resources, Peterborough, Ontario. Available at http://www.mnr.gov.on.ca/en/Business/FW/Publication/MNR_E001275P.html [accessed 27 July, 2012].

Ottaviani, D., Lasinio, G. J., and Boitani, L. 2004. Two statistical methods to validate habitat suitability models using presence-only data, Ecological Modelling, Volume 179, Issue 4, Pages 417-443

Palidwor, K. L., Schindler, D. W., and Hagglund, B. R. 1995. Habitat suitability index models within the Manitoba Model Forest Region: Moose (*Alces alces*) Version 2.0. Manitoba Model Forest Network. Available at http://www.manitobamodelforest.net/publications/Habitat%20Suitability%20Index%20Model%20-%20Moose%20Ver%202.0.pdf [accessed 4 April, 2011].

Parovshchikov, V. Y. 1961. Foods of beaver near Archangelsk [in Russian with English summary]. Zoologicheski Zhurnal XL: 623-624.

Pattie, D. L. and Hoffmann, R. S. 1990. Mammals of the North American parks and prairies. Donald L. Pattie, Edmonton, Alberta. 579 pp.

Payette, S. 1992. Fire as a controlling process in the North American boreal forest. In A systems analysis of the global boreal forest. Edited by H. H. Shugart, R. Leemans and G. Bonan. Cambridge University Press, Cambridge, pp. 144-169.

Peek, J. M. 1974. On the nature of winter habitats of Shiras moose. Naturaliste canadien 101: 131-141.

Peek, J. M. 2007. Habitat relationships. In Ecology and Management of the North American Moose. Edited by A. W. Franzmann, and C. C. Schwartz. Wildlife Management Institute, Boulder, Colorado. pp. 351-375.

Peek, J. M., Urich, D. L., and Mackie, R. J. 1976. Moose habitat selection and relationships to forest management in northeastern Minnesota. Wildlife Monographs 48: 3-65.

Peterson, R. L. 1974. A review of the general life history of moose. Naturaliste canadien 101: 9-21.

Peterson, R. O. 1977. Wolf ecology and prey relationships on Isle Royale. National Park Service Scientific Monographs Series No. 11. Available from http://www.nps.gov/history/history/online_books/science/11/contents.htm [accessed 9 August, 2012].

Peterson, R. O. and Allen, D. L. 1974. Snow conditions as a parameter in moose-wolf relationships. Naturaliste canadien 101: 481-492.

Petersen, J. M., Mead, P. S., and Schriefer, M. E. 2009. *Francisella tularensis*: an arthropod-borne pathogen. Veterinary Research 40(7).

Phillips, R. L., Berg, W. E., Siniff, D. B. 1973. Moose movement patterns and range use in northwestern Minnesota. Journal of Wildlife Management 37: 266-278.

Pierce, D. J. and Peek, D. B. 1984. Moose habitat use and selection patterns in north-central Idaho. Journal of Wildlife Management 48: 1335-1343.

Pimlott, D. H. 1967. Wolf predation and ungulate populations. American Zoologist 7: 267-278.

Pinkowski, B. 1983. Foraging behaviour of beavers (*Castor canadensis*) in North Dakota. Journal of Mammalogy 64: 312-314.

Post, E., and Forchhammer, M. C. 2008. Climate change reduces reproductive success of an Arctic herbivore through trophic mismatch. Phil. Trans. R. Soc. B. 363, 2369–2375.

Post, E., Bøving, S., Pedersen, C., and MacArthur, M. 2003. Synchrony between caribou calving and plant phenology in depredated and non-depredated populations. Canadian Journal of Zoology 81: 1709-1714.

Potvin, F., Breton, L. and R. Courtois. 2005. Response of beaver, moose, and snowshoe hare to clear-cutting in a Quebec boreal forest: a reassessment 10 years after cut. Canadian Journal of Forest Research 35: 151-160.

Proceviat, S. K., Mallory, F. F., and Rettie, W. J. 2003. Estimation of arboreal lichen biomass available to woodland caribou in Hudson Bay lowland black spruce sites. Rangifer Special Issue No. 14: 95-99.

Pybus, M. J. 1990. Survey of hepatic and pulmonary helminths of wild cervids in Alberta, Canada. Journal of Wildlife Diseases 26(4): 453-459.

Raffel, T. R., Smith, N., Cortright, C, and Gatz, A. J. 2009. Central place foraging by beavers (*Castor canadensis*) in a complex lake habitat. American Midland Naturalist 162: 62-73.

Ralph, C. J., Guepel, G. R., Pyle, P., Martin, T E., and Desante, P. F. 1993. Handbook of field methods for monitoring landbirds. Pacific Southwest Research Station. Albany, California.

Reisenhoover, K. L. Composition and quality of moose winter diets in interior Alaska. Journal of Wildlife Management 53(3): 568-577.

Rempel, R. S., Elkie, P. C., Rodgers, A. R., and Gluck, M. J. 1997. Timber-management and natural-disturbance effects on moose habitat: Landscape evaluation. Journal of Wildlife Management 61: 517-524.

Renecker, L. A., and Hudson, R. J. 1986. Seasonal energy expenditures and thermoregulatory responses of moose. Canadian Journal of Zoology 64(2): 322-327.

Renecker, L. A. and Schwartz, C.C. 2007. Food habits and feeding behaviour. In Ecology and Management of the North American Moose. Edited by A. W. Franzmann and C. C. Schwartz. Wildlife Management Institute, Boulder, Colorado. pp. 403-439.

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

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

Rettie, W. J. and Messier, F. 2001. Range use and movement rates of woodland caribou in Saskatchewan. Canadian Journal of Zoology 79: 1933-1940.

Rettie W. J., Sheard, J. W., and Messier, F. 1997. Identification and description of forested vegetation communities available to woodland caribou: relating wildlife habitat to forest cover data. Forest Ecology and Management 93: 245-260.

Rich, T. D., Beardmore, C. J., Berlanga, H., Blancher, P. J., Bradstreet, M. S. W., Butcher, G. S., Demarest, D. W., Dunn, E. H., Hunter, W. C., Iñigo-Elias, E. E., Kennedy, J. A., Martell, A. M., Panjabi, A. O., Pashley, D. N., Rosenberg, K. V., Rustay, C. M., Wendt, J. S., and Will, T. C. 2004. Partners in Flight North American Landbird Conservation Plan. Cornell Lab of Ornithology. Ithaca, NY. Partners in Flight website. http://www.partnersinflight.org/cont_plan/ (VERSION: March 2005).

Ritchie, B. W. 1972. Ecology of moose in Feremont County, Idaho. Wildlife Bulletin 7. Idaho Department of Fish and Game, Boise. 33 pp.

Røed, K. H., Ferguson, M. A. D., Crête, M., and Bergerud, T. A. 1991. Genetic variation in transferring as a predictor for differentiation and evolution of caribou from eastern Canada. Rangifer 11(2): 65-74.

Romito, T., Smith, K., Beck, B., Todd, M., Bonar, R., and Quinlan, R. 1999. Moose winter habitat: habitat suitability index model version 5. Foothills Model Forest, Hinton, Alberta. Available at http://foothillsresearchinstitute.ca/Content_Files/Files/HS/HS_report27.pdf [accessed 9 August, 2012].

Ropstad, E. 2000. Reproduction in female reindeer. Animal Reproduction Science 60-61: 561-570.

Rowe, J. S., 1961. The level-of-integration concept and ecology. Ecol. 42(2): 420-427.

Ruckstuhl, K.E, Johnson, E. A., and Miyanishi, K. 2008. The Boreal Forest and Climate Change Philosophical Transactions of the Royal Society; Biological Sciences, Volume 363, Issue 1501, Pages 2243-2247, July 2008.

Rupp, S., Olson, M., Adams, L. G., Dale, B. W., Joly, K., Henkelman, J., Collins, W. B., and Starfield, A. M. 2006. Simulating the influences of various fire regimes on caribou winter habitat. Ecological Applications 16(5): 1730-1743.

Russell, D. E. and Nixon, W. A. 1990. Activity budgets, food habits and habitat selection of the Porcupine Caribou Herd during the summer insect season. Rangifer Special Issue No. 3: 255.

Rutherford, W. H. 1953. Effects of a summer flash flood upon a beaver population. Journal of Mammalogy 34:261-262.

Salmo Consulting Inc. Diversified Environmental Services. GAIA Consultants Inc. Forem Technologies Ltd. and AXYS Environmental Consulting Ltd. 2003. CEAMF Study: Volume 2. Cumulative Effects Indicators, Thresholds and Case Studies. The BC Oil and Gas Commission and The Muskwa Kechika Advisory Board. 83 pp.

Saris, W. E. and Stronkhorst, L. H. 1984. Causal modeling in non-experimental research: an introduction to the LISREL approach. Sociometric Research Foundation, Amsterdam.

Saskatchewan Ministry of Environment. 2011. 2011 Saskatchewan Hunters' and Trappers' Guide. Saskatchewan Ministry of Environment, Regina, Saskatchewan. Available at http://www.environment.gov.sk.ca/adx/aspx/adxGetMedia.aspx?DocID=3222bfc9-1f52-4a80-be7f-e8066cf9f09e [accessed 27 July, 2012].

Sauer, J. R., Hines, J. E., Fallon, J. E., Pardieck, K. L., Ziolkowski, Jr. D. J., and Link, W. A. 2011. The North American Breeding Bird Survey, Results and Analysis 1966 - 2010. Version 12.07.2011 USGS Patuxent Wildlife Research Center, Laurel, MD.

Savard, J-P. L, Cousineau, M., and Drolet, B. 2011. Exploratory analysis of correlates of the abundance of rusty blackbirds (Euphagus carolinus) during fall migration. Ecoscience 18(4): 402-408.

Sawyer, H., Kauffman, M. J., Nielson, R. M., and Horne, J. S. 2009. Identifying and prioritizing ungulate migration routes for landscape-level conservation. Ecological Applications 19(8): 2016-2025.

Schaefer, J. A. 1988. Fire and woodland caribou (*Rangifer tarandus caribou*): an evaluation of range in southeastern Manitoba. M.S. thesis. University of Manitoba, Winnipeg, Manitoba.

Schaefer, J.A. 1996. Canopy, snow, and lichens on woodland caribou range in southeastern Manitoba. Rangifer Special Issue No. 9: 239-244.

Schaefer, J. A. 2003. Long-term range recession and the persistence of caribou in the taiga. Conservation Biology 17(5): 1435-1439.

Schaefer, J. A. 2008. Boreal forest caribou. In Caribou and the north: a shared future. By M. Hummel and J. C., Ray. Dundurn Press, Toronto, Ontario. pp.223-239.

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

Schmelzer, I. 2004. Recovery strategy for three woodland caribou herds (*Rangifer tarandus caribou*; boreal population) in Labrador. Inland Fish and Wildlife Division, Department of Environment and Conservation, Government of Newfoundland and Labrador, St. John's, Newfoundland. 51 pp. Available from http://www.env.gov.nl.ca/env/wildlife/endangeredspecies/recovery_strategy_feb2005_corrections.pdf [accessed 24 July, 2012].

Schneider, R. R. and Wasel. S. 2000. The effect of human settlement on the density of moose in northern Alberta. Journal of Wildlife Management 64: 513-520.

Schwab, F.E. and Pitt, M. D. 1991. Moose selection of canopy cover types related to operative temperature, forage, and snow depth. Canadian Journal of Zoology 69:3071-3077.

Schwartz, C. C. 2007. Reproduction, natality and growth. In Ecology and Management of the North American Moose. Edited by A. W. Franzmann and C. C. Schwartz. Wildlife Management Institute, Boulder, Colorado. pp. 141-171.

Schwartz, C.C. and Renecker, L. A. 2007. Nutrition and energetics. In Ecology and Management of the North American Moose. Edited by A. W. Franzmann and C. C. Schwartz. Wildlife Management Institute, Boulder, Colorado. pp. 441-478.

Schwartz, C.C. and Franzmann, A. W. 1989. Bears, wolves, moose and forest succession, some management considerations on the Kenai Peninsula, Alaska. Alces, 25: 1-10.

Scotter G. W. and Scotter, E. 1989. Beaver, *Castor canadensis*, mortality caused by felled trees. Canadian Field-Naturalist 103: 400-401.

Seip, D. R. 1991. Predation and caribou populations. Rangifer Special Issue No. 7: 46-52.

Semenchuk, G.P., 1992. The atlas of breeding birds of Alberta. Federation of Alberta Naturalists, Edmonton, AB.

Seton, E. T. 1929. Lives of game animals, Volume 4 Part 2, Rodents, etc. Doubleday, Doran, Garden City, New York. In Baker, B. W. and Hill, E. P. 2003. Beaver (*Castor canadensis*); In Wild mammals of North America: biology, management, economics. Edited by J. A. Chapman, and G. A. Feldhamer. John Hopkins University Press, Baltimore, Maryland. pp. 288-310.

Sharma, S., Couturier, S., and Côté, S. D. 2009. Impacts of climate change on the seasonal distribution of migratory caribou. Global Change Biology 15: 2549-2562.

Shoesmith, M. W. and Storey, D R. 1977. Movements and associated behaviour of woodland caribou in central Manitoba. Manitoba Department of Renewable Resources and Transportation Services, Research MS Rep. No. 77-15.

Slough, B. G. 1978. Beaver food cache structure and utilization. Journal of Wildlife Management 42: 644-646.

Slough, B.G. and Sadleir, R.M.F.S. 1977. A land capability classification system for beaver (*Castor canadensis*). Canadian Journal of Zoology 55(8): 1324-1335.

Smith, D. W. and Peterson, R. O. 1991. Behavior of beaver in lakes with varying water levels in Northern Minnesota. Environmental Management 15(1):395-401.

Smith, R.E., Veldhuis, H., Mills, G. F., Eilers, R. G., Fraser, W. R., and Lelyk, G. W. 1998. Terrestrial Ecozones, Ecoregions, and Ecodistricts of Manitoba: An Ecological Stratification of Manitoba's Natural Landscapes. Land Resource Unit, Brandon Research Centre, Research Branch, Agriculture and Agri-Food Canada. Research Branch. Technical Bulletin 1998-9E.

Sorensen, T., McLoughlin, P.D., Hervieux, D., Dzus, E., Nolan, J., Wynes, B. And Boutin, S. 2008. Determining sustainable levels of cumulative effects for boreal caribou. The Journal of Wildlife Management. 72(4): 900 – 905.

Split Lake Cree. 1996a. Analysis of change: Split Lake Cree post project environmental review. Split Lake Cree - Manitoba Hydro Joint Study Group; vol. 2 of 5.

Split Lake Resource Management Board. 1994. Moose Conservation Plan 1993/94. Split Lake, Manitoba. 22 pp.

Stegeman, L. C. 1954. The production of aspen and its utilization. Journal of Wildlife Management 18: 348-358.

Stephens, P. W. and Peterson, R. O. 1984. Wolf-avoidance strategies of moose. Holarctic Ecology 7: 239-244.

Stevens, D. R. 1970. Winter ecology of moose in the Gallatin Mountains, Montana. Journal of Wildlife Ecology 34(1): 37-46.

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

Sun, L., Müller-Schwarze, D., and Schulte, B. A. 2000. Dispersal pattern and effective population size of the beaver. Canadian Journal of Zoology 78: 393-398.

Svendsen, G. E. 1980. Population parameters and colony composition of beaver (*Castor canadensis*) in southeast Ohio. American Midland Naturalist 104: 47-56.

Swannack, T. M., Fischenich, J. C. and Tazik, D. J. 2012. Ecological Modeling Guide for Ecosystem Restoration and Management. Prepared for the U.S. Army Corps of Engineers, Washington, D.C. 61 pp.

TAEM Consultants 1997. Cooperative moose management in the Manitoba Model Forest. Manitoba Model Forest Network, Pine Falls, Manitoba. Available at: http://www.manitobamodelforest.net/publications/Cooperative%20Moose%20Management%201997%20Report.pdf [accessed April 4, 2011].

Taylor, K.P. and Ballard, W. B. 1979. Moose movements and habitat use along the Susitna River near Devil's Canyon. Proceeding of the North American Moose Conference Workshop 15:169-186.

Taylor. P. 2003. Common Nighthawk In: The Birds of Manitoba. Manitoba Avian Research Committee. Manitoba Naturalists Society, Winnipeg, Manitoba.

Telfer, E. S. 1974. Logging as a factor in wildlife ecology in the boreal forest. Forestry Chronicle 50: 186-189.

Terry, E. L., McLellan, B.N., and Watts, G. S. 2000. Winter habitat ecology of mountain caribou in relation to forest management. Journal of Applied Ecology 37: 589-602.

Thomas, D. C., Barry, S. J., and Alaie, G. 1996. Fire – caribou - winter range relationships in northern Canada. Rangifer 16(2): 57-67.

Thomas, D. C. and Gray, D. R. 2002. Update COSEWIC status report on the woodland caribou *Rangifer tarandus* in Canada. Committee on the Status of Endangered Species in Canada, Ottawa, Ontario.

Thompson, J. E. and Abraham, K. F. 1994. Range, seasonal distribution and population dynamics of the Pen Islands caribou herd of southern Hudson Bay: final report. Ontario Ministry of Natural Resources, Moosonee, Ontario. 144 pp.

Thompson, R. C. 1994. Ground-breaking co-management in the Split Lake Resource Management Area of Manitoba, Canada. Rangifer Special Issue No. 9: 259-262.

Timmerman, H. R. and Buss, M. E. 2007. Population and harvest management. In Ecology and Management of the North American Moose. Edited by A. W. Franzmann and C. C. Schwartz. Wildlife Management Institute, Boulder, Colorado. pp. 559-615.

Townsend, J. E. 1952. Beaver ecology in western Montana with special reference to movements. Journal of Mammalogy 34: 459-479.

Trainer, D. O. 1973. Caribou mortality due to the meningeal worm. Journal of Wildlife Diseases 9: 376-378.

Turetsky, M.R., Weider, R. K., Williams, C. J., and Vitt, D. H. 2000. Organic matter accumulation, peat chemistry, and permafrost melting in peatlands of boreal Alberta. Ecoscience 7:379-392.

Udvardy, M. D. 1975. A classification of the biogeographical provinces of the world. IUCN Occasional Paper no. 18. Morges, Switzerland: IUCN.

USGS. 2007. Effects of Global Climate Change on Shorebird Migration. Fort Collins Science Centre. US Department of teh Interior. Retrieved from http://www.fort.usgs.gov.

Van Ballenberghe, V. and Peek, J. M. 1971. Radio-telemetry studies of moose in northeastern Minnesota. Journal of Wildlife Management 35: 63-71.

van Beest, F. M., Rivrud, I. M., Loe, L. E., Milner, J. M., and Mysterud, A. 2011. What determines variation in home range size across spatiotemporal scales in a large browsing herbivore? Journal of Animal Ecology 80: 771-785.

Vistnes, I. and Nellemann, C. 2008. The matter of spatial and temporal scales: a review of reindeer and caribou response to human activity. Polar Biology 31: 399-407.

Vitt, D.H., Halsey, L. A., and Zoltai, S. C. 1994. The bog landforms of continental western Canada in relation to climate and permafrost patterns. Arctic and Alpine Research 26:1-13.

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

Wakelyn, J. 1999. The Qamanirjuaq herd- an arctic enigma. Beverly and Qamanirjuaq Caribou Management Board, Stonewall, Manitoba. Available from http://www.arctic-caribou.com/PDF/qcs.pdf [accessed 20 July, 2012].

Waltner-Toews, D., Kay, J. J., and Lister, N. E. (eds.). 2008. The Ecosystem Approach: Complexity, Uncertainty, and Managing for Sustainability. Columbia University Press. 383 pp.

Weber, M. G. and Flannigan, M. D. 1997. Canadian boreal forest ecosystem structure and function in a changing climate: impact on fire regimes. Environ. Rev. 5: 145–166.

Weir, J., Mahoney, J., McLaren, B., and Ferguson, S. H. 2007. Effects of mine development on woodland caribou *Rangifer tarandus* distribution. Wildlife Biology 13: 66-74.

Welsh, D. A. 1993. An Overview of the Ontario Forest Bird Monitoring Program. Canadian Wildlife Service Report. Nepean, Ontario.

Wheatley, M.1989. Ecology of beaver (Castor canadensis) in the taiga of southeastern Manitoba. MSc. Thesis, University of Manitoba, Winnipeg, Manitoba, 167 pp

Wheatley, M. 1994. Boreal beaver (*Castor canadensis*): home range, territoriality, food habits and genetics of a mid-continent population. Ph.D. Thesis, University of Manitoba, Winnipeg, Manitoba, 506 pp.

Wheatley, M. 1997a. Beaver, *Castor canadensis*, home range size and patterns of use in the taiga of southeastern Manitoba: III. Habitat variation. Canadian Field-Naturalist 111(2): 217-222.

Wheatley, M. 1997b. Beaver, *Castor canadensis*, home range size and patterns of use in the taiga of southeastern Manitoba: I. Seasonal variation. Canadian Field-Naturalist 111(2): 204-210.

Whitney, H. 2004. Parasites of caribou (2): fly larvae infestations. Newfoundland and Labrador Wildlife Diseases Factsheet. Department of Natural Resources, St. John's, Newfoundland Publication AP010. 2 pp.

Whittington, J., Hebblewhite, M., DeCesare, N. J., Neufeld, L., Bradley, M., Wilmshurst, J., and Musiani, M. 2011. Caribou encounters with wolves increase near roads and trails: a time-to-event approach. Journal of Applied Ecology 48: 1535-1542.

Wilson, D. E. and Ruff, S. The Smithsonian Book of North American Mammals.2nd Edition. University Press of Colorado, Colorado, U.S.A.733 pp.

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

Wittmer, H. U., McLellan, B. N., Serrouya, R., and C. D. Apps. 2007. Changes in landscape composition influence the decline of a threatened woodland caribou population. Journal of Animal Ecology 76(3): 568-579.

WLFN (War Lake First Nation). 2002. War Lake OWL process: Keeyask Project, July 2002. War Lake First Nation, Manitoba.

Wobeser, G. A., Gajadhar, A., and Hunt, H. M. 1985. *Fascioloides magna*: occurrence in Saskatchewan and distribution in Canada. Canadian Veterinary Journal 26: 241-244.

Wolfe, M. M. 1974. An overview of moose coactions with other animals. Naturaliste canadien 101: 437-456.

Wormworth, J. 2006. Bird species and climate change; a Global Status Report. A Climate Risk Report to the World Wildlife Fund for Nature.

YFFN (York Factory First Nation) Evaluation Report (*Kipekiskwaywinan*): Our voices. 2012. Support from Hilderman, Thomas, Frank, and Cram and Northern Light Heritage Services. York Landing, Manitoba. June 2012.

York Factory First Nation (YFFN). 2012. Kipekiskwayiwinan - Our voices, Part 5. [online] Available at http://keeyask.com/wp/wp-content/uploads/2012/07/Kipekiskwaywinan_Our-Voices_June_2012_Part-5.pdf. [Accessed Aug 23, 2013]

Zumpt, F. 1965. Myiasis in man and animals in the Old World. Butterworths, London. In Karter, A. J., Folstad, I., and Anderson, J. R. 1922. Abiotic factors influencing embryonic development, egg hatching, and larval orientation in the reindeer warble fly, Hypoderma tarandi. 1992. Medical and Veterinary Entomology 6: 355-362.

11.2 PERSONAL COMMUNICATIONS

Kennedy, W. 2013. Hobbs and Associates, Winnipeg, MB, February 1, 2013.

Monkman, R. 2009. Manager of Community Relations, Aboriginal Relations Division, Manitoba Hydro, Winnipeg, MB. August 17, 2009.

Racey, G. 2012. Ontario Ministry of Natural Resources, October 17, 2012.

Whitcher, J. 2010. Pilot, Custom Helicopters, St. Andrews, MB. October 6, 2010.

Appendix A
Predator Benchmark

GRAY WOLF DENSITY

Ungulate biomass was used to calculate the density of wolves in the Keeyask region. Because wolves are highly mobile, scarce on the landscape, and relatively small in comparison to ungulates, the usual aerial survey techniques used to estimate ungulate populations are impractical for wolves (Moose Harvest Sustainability Plan 2013). However, wolf numbers and ungulate biomass are closely related, and by estimating the total biomass of ungulate prey (moose and caribou) in the Split Lake Resource Management Area (SLRMA) the number of wolves that can be supported by the prey base can be estimated (Moose Harvest Sustainability Plan 2013). Moose abundance in the SLRMA has been known since 2010, but caribou abundance needs to be estimated, the details of which are outlined in the Moose Harvest Sustainability Plan (2013).

Ungulate abundance is converted to ungulate biomass following Fuller *et al.* (2003) to obtain ungulate biomass index (UBI) units. The UBIs for moose and caribou are relative to the UBI of 1 for white-tailed deer, with a UBI of 6 for moose and a UBI of 2 for caribou. Total UBI in the sample units of the SLRMA was calculated by summing the estimated number of moose multiplied by 6 and the estimated number of caribou multiplied by 2. By dividing the total UBI by the mean UBI per wolf of 271 (Fuller *et al.* 2003), the number can be estimated.

Based on the ungulate biomass available in the area, it was estimated that 10 packs of 6 wolves occupy the area year-round, with an additional 50 wolves (16 packs) moving into the area in winter with migratory caribou herds. The density of wolves in the SLRMA is approximately 1.4 individuals/1,000 km² in summer and 2.6 individuals/1,000 km² in winter.

Wolves that are permanent residents in the SLRMA prey primarily on moose. Resident woodland caribou are relatively rare, and migratory caribou, while abundant in the winter in some areas, are not a sufficiently reliable year-round food source to allow resident packs to establish and defend adequately productive hunting territories around them. The SLRMA moose population of 2,600 moose provides a prey base of approximately 15,600 Ungulate Biomass Index units (UBI units[1]) for wolves (Fuller *et al.* 2003). Fuller *et al.* (op. cit.) used 32 studies of wolves and their ungulate prey in North America to calculate that the average number of UBI units needed to support one wolf is approximately 270. Using these data, the SLRMA would be expected to support a resident population of approximately 60 wolves. For the entire RMA, would represent a density of 1.4 wolves/1000 km².

While that would be an appropriate number to use for overall wolf density in the SLRMA, it is not useful in establishing boundaries between low, medium and high densities of wolves, however, for the following reasons. The average number of wolves in a pack when deer and/or moose are the main prey is 6 Fuller *et al.* op. cit.). Therefore, the SLRMA would be expected to have 10 packs of resident wolves. These packs would not be distributed uniformly or randomly around the RMA.

- [1] UBI units are a tool for indicating the food available to wolves. White-tailed deer are 1 unit, caribou are 2 units, and moose are 6 units.

Wolves cannot persist in areas where the density of moose is below 3/100 km² (Messier 1994), and almost 40% of the SLRMA has a moose density of 2/100 km². Packs would occupy territories centered on areas of higher moose density. Given the arrangement of areas of high moose densities, the territories of the 10 resident packs would be primarily in the southern and western portions of the SLRMA, and would probably each have a core area of approximately 2,000 km². This area could be represented schematically by a circle of 25-km radius, centered on a patch of high moose density. The pack would probably search, explore and defend a total area of approximately 4,000 km², because of the overall moose density and the irregular distribution of areas of low, medium and high densities of moose (Keith 1983). This expectation has been confirmed by maps of wolf pack locations provided by local First Nations residents.

The above arrangement, which yields a wolf density of approximately 3/1000 km² in the core of the pack's territory, requires the assumption that neither wolves nor moose in the SLRMA are experiencing a dramatic population increase or decrease. This wolf density also matches the lowest wolf densities in the literature, where wolf densities range from approximately 3 (Singer and Dalle-Molle 1985) to 42 (Van Ballenberghe *et al.* 1975) per 1,000 km². This would be appropriate for the area's extremely low moose density (lower than any of the 32 studies cited earlier).

Including other literature (Salmo Consulting Inc *et al.* 2003), the Moose Harvest Sustainability Plan (2013) indicates that the following benchmarks are most likely to be appropriate for this area. The benchmark values used for gray wolf density indicated a low magnitude adverse effect on ungulates where gray wolf density is below 4 wolves/1,000 km², a moderate magnitude adverse effect where gray wolf density is between 4 and 6 wolves/1,000 km² and a high magnitude adverse effect where gray wolf density is more than 6 wolves/1,000 km² (Moose Harvest Sustainability Plan). Current gray wolf densities in the SLRMA are far enough below 4/1,000 km² that increases to this level should be detectable. This benchmark was used in the assessment of caribou and moose.

Table A- 1: Predation by Resident Packs of Wolves in the Split Lake Resource Management Area

Unit Number	Unit Name	2010 Moose Population	Resident Packs	Resident Wolves	Area (km²)	Number of Wolves/1,000 km²	Moose per Wolf
1	Manteosippi	410	0.7	4.2	8,961	0.5	98
2	Oopawaha	235	2	12	5,152	2.3	20
3	Numaykoosani	190	0.2	1.2	5,919	0.2	158
4	Kakwasaneesi	502	2.7	16.2	5,820	2.8	31
5	Wasekanoosees	369	1.4	8.4	4,270	2.0	44
6	Askekosani	557	1.8	10.8	7,580	1.4	52
7	Kitchesippi	337	1.2	7.2	6,208	1.2	47
	Total	2,600	10	60	43,910	1.4	43

Appendix B
Habitat Quality Model Data for Mammal VECs

Table 4B-1: Mammal Tracking Transects Sampled in Keeyask Region in Winter 2001

Habitat Code	# Transects Sampled	# Transects with Caribou	# Transects with Moose
H01	26	1	6
H02	1	1	0
H03	11	0	1
H04	8	2	3
H09	4	0	0
H10	1	0	0
H13	3	1	0
H16	1	0	0
Total	55	5	10

Table 4B-2: Mammal Tracking Transects Sampled in Keeyask Region in Summer 2001

Habitat Code	# Transects Sampled	# Transects with Caribou	# Transects with Moose
H01	62	14	29
H02	1	0	1
H03	10	6	10
H04	12	2	6
H09	4	1	4
H10	1	0	1
H12	1	0	1
H13	5	2	2
H14	1	0	1
H15	5	0	0
H16	1	0	1
Total	103	25	56

Table 4B-3: Mammal Tracking Transects Sampled in Keeyask Region in Winter 2002

Habitat Code	# Transects Sampled	# Transects with Caribou	# Transects with Moose
H01	38	3	3
H02	2	0	0
H03	11	0	2
H04	8	1	3
H09	4	0	3
H10	2	0	1
H13	3	0	1
H15	1	0	0
H16	2	0	0
Total	71	4	13

Table 4B-4: Mammal tracking transects sampled in Keeyask Region in Summer 2002

Habitat Code	# Transects Sampled	# Transects with Caribou	# Transects with Moose
H01	109	52	91
H02	3	2	3
H03	18	11	18
H04	29	21	25
H05	3	3	3
H09	5	2	5
H10	5	3	5
H12	4	0	3
H13	6	4	5
H14	2	0	2
H15	8	4	5
H16	3	3	3
Total	195	105	168

Table 4B-5: Mammal Tracking Transects Sampled in Keeyask Region in Summer 2003

Habitat Code	# Transects Sampled	# Transects with Caribou	# Transects with Moose
H01	126	90	105
H02	3	3	2
H03	26	20	26
H04	39	32	39
H05	3	3	3
H06	4	1	3
H07	2	1	2
H08	7	2	7
H09	12	10	12
H10	4	4	4
H11	5	4	5
H12	6	6	6
H13	9	5	8
H14	4	1	3
H15	9	5	8
H16	3	3	3
Total	262	190	236

Table 4B-6: Mammal Tracking Transects Sampled in Keeyask Region in Summer 2004

Habitat Code	# Transects Sampled	# Transects with Caribou	# Transects with Moose
H09	21	9	20

Table 4B-7: Ranking of Coarse Habitat Types Based on Quantity Within a 100 m Buffer of Moose Sampling Locations in Winter 2009 and 2010

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Average Area (ha)
Black spruce treed on shallow peatland	1	1	20.12	20.12	0.62
Black spruce treed on thin peatland	1	2	11.04	31.15	0.34
Black spruce treed on shallow peatland	6	3	7.36	38.51	0.23
Shallow water	1	4	6.07	44.58	0.19
Low vegetation on mineral or thin peatland	4	5	5.67	50.25	0.17
Low vegetation on shallow peatland	4	6	4.75	54.99	0.15
Low vegetation on shallow peatland	3	7	3.25	58.24	0.10
Black spruce treed on thin peatland	6	8	3.25	61.49	0.10
Low vegetation on shallow peatland	1	9	3.24	64.73	0.10
Low vegetation on mineral or thin peatland	3	10	3.02	67.75	0.09
Low vegetation on wet peatland	1	11	3.00	70.75	0.09
Black spruce treed on mineral soil	1	12	2.53	73.28	0.08
Human infrastructure	1	13	2.38	75.66	0.07
Black spruce treed on shallow peatland	3	14	2.21	77.87	0.07
Low vegetation on shallow peatland	5	15	2.04	79.91	0.06
Nelson River	1	16	1.95	81.86	0.06

Table 4B-8: Ranking of Coarse Habitat Types Based on Quantity Within a 250 m Buffer of Moose Sampling Locations in Winter 2009 and 2010

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Average Area (ha)
Black spruce treed on shallow peatland	1	1	19.97	19.97	3.89
Black spruce treed on thin peatland	1	2	14.44	34.41	2.82
Black spruce treed on shallow peatland	6	3	6.31	40.73	1.23
Shallow water	1	4	5.85	46.58	1.14
Low vegetation on mineral or thin peatland	4	5	5.68	52.26	1.11
Black spruce treed on thin peatland	6	6	4.84	57.11	0.94
Low vegetation on shallow peatland	4	7	4.57	61.68	0.89
Human infrastructure	1	8	2.67	64.34	0.52
Low vegetation on shallow peatland	3	9	2.40	66.74	0.47
Low vegetation on shallow peatland	1	10	2.28	69.02	0.44
Low vegetation on mineral or thin peatland	3	11	2.25	71.28	0.44
Nelson River	1	12	2.24	73.51	0.44
Black spruce treed on mineral soil	1	13	2.11	75.62	0.41
Low vegetation on shallow peatland	5	14	1.95	77.57	0.38
Low vegetation on wet peatland	1	15	1.88	79.45	0.37
Black spruce treed on shallow peatland	3	16	1.84	81.29	0.36

Table 4B-9: Ranking of Coarse Habitat Types Based on Quantity Within a 500 m Buffer of Moose Sampling Locations in Winter 2009 and 2010

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Average Area (ha)
Black spruce treed on shallow peatland	1	1	17.99	17.99	14.10
Black spruce treed on thin peatland	1	2	14.03	32.02	11.00
Black spruce treed on shallow peatland	6	3	6.50	38.51	5.09
Shallow water	1	4	6.11	44.63	4.79
Black spruce treed on thin peatland	6	5	6.38	51.01	5.00
Low vegetation on mineral or thin peatland	4	6	4.41	55.41	3.45
Low vegetation on shallow peatland	4	7	3.86	59.27	3.03
Black spruce treed on mineral soil	1	8	3.06	62.34	2.40
Nelson River	1	9	3.00	65.33	2.35
Low vegetation on shallow peatland	5	10	2.95	68.29	2.31
Low vegetation on shallow peatland	3	11	2.33	70.61	1.82
Human infrastructure	1	12	2.31	72.92	1.81
Low vegetation on mineral or thin peatland	3	13	2.09	75.01	1.64
Low vegetation on shallow peatland	1	14	1.66	76.67	1.30
Black spruce treed on shallow peatland	3	15	1.65	78.32	1.29
Black spruce treed on thin peatland	3	16	1.48	79.80	1.16
Low vegetation on mineral or thin peatland	5	17	1.44	81.24	1.13

Table 4B-10: Ranking of Coarse Habitat Types Based on Quantity Within a 1000 m Buffer of Moose Sampling Locations in Winter 2009 and 2010

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Average Area (ha)
Black spruce treed on shallow peatland	1	1	17.32	17.32	54.37
Black spruce treed on thin peatland	1	2	15.38	32.70	48.29
Black spruce treed on shallow peatland	6	3	7.65	40.3	24.03
Nelson River	1	4	6.40	46.76	20.10
Black spruce treed on thin peatland	6	5	6.40	53.16	20.09
Shallow water	1	6	5.29	58.44	16.60
Low vegetation on mineral or thin peatland	4	7	3.18	61.62	9.97
Black spruce treed on mineral soil	1	8	2.81	64.43	8.83
Low vegetation on shallow peatland	5	9	2.61	67.04	8.19
Low vegetation on shallow peatland	4	10	2.60	69.64	8.16
Black spruce treed on thin peatland	3	11	2.23	71.87	7.00
Human infrastructure	1	12	2.10	73.97	6.59
Low vegetation on shallow peatland	1	13	1.85	75.82	5.82
Black spruce treed on shallow peatland	3	14	1.81	77.64	5.70
Low vegetation on mineral or thin peatland	5	15	1.71	79.34	5.36
Black spruce treed on thin peatland	4	16	1.40	80.74	4.38

Table 4B-11: Ranking of Coarse Habitat Types Based on Quantities Within a 100 m Buffer of Moose Observations During Winter 2009 and 2010 Compared with Study Zone 4 as a whole

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Tamarack treed on wet peatland	6	1	0.11	0.11	11323
Low vegetation on riparian peatland	3	2	0.51	0.62	7454
Low vegetation on wet peatland	5	3	0.89	1.51	4885
Black spruce treed on shallow peatland	5	4	1.45	2.97	4631
Black spruce treed on wet peatland	4	5	0.65	3.62	3157
Black spruce treed on riparian peatland	6	6	0.47	4.09	2279
Black spruce treed on riparian peatland	4	7	0.22	4.31	1818
Tall shrub on riparian peatland	3	8	0.02	4.33	1650
Black spruce treed on mineral soil	4	9	0.53	4.86	1585
Low vegetation on mineral or thin peatland	4	10	5.67	10.53	1208
Black spruce treed on shallow peatland	4	11	1.90	12.44	1011
Low vegetation on shallow peatland	4	12	4.75	17.19	945
Nelson River shrub and/or low vegetation on ice scoured upland	1	13	0.51	17.70	933
Black spruce treed on wet peatland	6	14	0.43	18.13	879
Tall shrub on wet peatland	1	15	0.65	18.78	755
Jack pine treed on mineral or thin peatland	4	16	0.31	19.10	734
Tamarack treed on wet peatland	1	17	0.76	19.85	665
Low vegetation on mineral or thin peatland	3	18	3.02	22.87	600
Low vegetation on shallow peatland	3	19	3.25	26.12	554
Tall shrub on mineral or thin peatland	3	20	0.01	26.13	546

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Human infrastructure	6	21	0.77	26.90	535
Broadleaf treed on all ecosites	1	22	0.71	27.61	511
Black spruce treed on shallow peatland	3	23	2.21	29.82	507
Low vegetation on mineral or thin peatland	6	24	0.10	29.93	457
Broadleaf treed on all ecosites	5	25	1.01	30.94	402
Black spruce treed on shallow peatland	6	26	7.36	38.30	337
Tall shrub on shallow peatland	1	27	0.27	38.57	323
Low vegetation on wet peatland	1	28	3.00	41.56	284
Low vegetation on riparian peatland	4	29	0.05	41.62	282
Tamarack treed on shallow peatland	1	30	0.62	42.23	226
Shallow water	1	31	6.07	48.30	204
Black spruce treed on thin peatland	3	32	1.09	49.39	200
Human infrastructure	1	33	2.38	51.77	188
Low vegetation on shallow peatland	5	34	2.04	53.81	172
Low vegetation on shallow peatland	1	35	3.24	57.05	168
Black spruce treed on thin peatland	6	36	3.25	60.30	137
Low vegetation on riparian peatland	1	37	1.32	61.62	106
Black spruce treed on shallow peatland	1	38	20.12	81.73	101

Table 4B-12: Ranking of Coarse Habitat Types Based on Quantities Within a 250 m Buffer of Moose Observations During Winter 2009 and 2010 Compared with Study Zone 4 as a whole

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Tamarack treed on wet peatland	6	1	0.25	0.25	25573
Jack pine mixedwood on mineral or thin peatland	4	2	0.13	0.38	13176
Low vegetation on riparian peatland	3	3	0.32	0.70	4587
Tall shrub on mineral or thin peatland	3	4	0.04	0.74	4098
Tall shrub on riparian peatland	3	5	0.04	0.78	2953
Black spruce treed on wet peatland	4	6	0.43	1.21	1689
Black spruce treed on wet peatland	6	7	0.68	1.89	1251
Black spruce treed on mineral soil	4	8	0.50	2.39	1042
Nelson River shrub and/or low vegetation on ice scoured upland	1	9	0.49	2.89	896
Low vegetation on wet peatland	3	10	0.06	2.95	896
Black spruce treed on riparian peatland	6	11	0.14	3.09	698
Black spruce treed on riparian peatland	4	12	0.13	3.22	690
Tall shrub on shallow peatland	3	13	0.01	3.23	635
Human infrastructure	6	14	0.91	4.14	632
Black spruce treed on shallow peatland	4	15	1.62	5.76	628
Low vegetation on mineral or thin peatland	4	16	5.68	11.44	597
Tamarack treed on wet peatland	1	17	0.67	12.11	588
Black spruce treed on shallow peatland	5	18	0.54	12.64	562
Low vegetation on shallow peatland	4	19	4.57	17.21	554
Jack pine treed on mineral or thin peatland	4	20	0.43	17.65	469

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Tamarack treed on shallow peatland	6	21	0.11	17.76	465
Broadleaf treed on all ecosites	5	22	1.12	18.88	404
Low vegetation on mineral or thin peatland	3	23	2.25	21.13	393
Low vegetation on shallow peatland	3	24	2.40	23.53	377
Low vegetation on wet peatland	4	25	0.22	23.74	357
Black spruce treed on shallow peatland	3	26	1.84	25.58	341
Low vegetation on shallow peatland	6	27	0.20	25.78	325
Broadleaf treed on all ecosites	1	28	0.43	26.21	303
Black spruce treed on shallow peatland	6	29	6.31	32.53	281
Tall shrub on shallow peatland	1	30	0.23	32.76	273
Tall shrub on wet peatland	1	31	0.23	33.00	271
Black spruce treed on mineral soil	5	32	0.18	33.18	265
Low vegetation on mineral or thin peatland	6	33	0.06	33.24	251
Black spruce treed on thin peatland	4	34	0.81	34.04	243
Human infrastructure	1	35	2.67	36.71	211
Black spruce treed on thin peatland	6	36	4.84	41.56	203
Shallow water	1	37	5.85	47.41	196
Tall shrub on mineral or thin peatland	5	38	0.22	47.63	196
Low vegetation on riparian peatland	4	39	0.07	47.69	184
Black spruce treed on thin peatland	3	40	1.15	48.84	180
Low vegetation on wet peatland	1	41	1.88	50.72	178
Low vegetation on wet peatland	5	42	0.03	50.75	163
Black spruce treed on mineral soil	3	43	0.18	50.93	148
Low vegetation on shallow	5	44	1.95	52.89	136

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
peatland					
Nelson River shrub and/or low vegetation on sunken peat	1	45	0.14	53.03	131
Low vegetation on riparian peatland	1	46	1.59	54.61	128
Tamarack treed on shallow peatland	1	47	0.36	54.97	124
Tamarack- black spruce mixture on wet peatland	6	48	0.02	54.99	110
Low vegetation on shallow peatland	1	49	2.28	57.27	110
Black spruce treed on shallow peatland	1	50	19.97	77.24	97
Tamarack- black spruce mixture on riparian peatland	1	51	0.02	77.26	87
Low vegetation on mineral or thin peatland	5	52	0.96	78.22	82
Black spruce mixedwood on mineral or thin peatland	1	53	0.13	78.35	79
Black spruce treed on thin peatland	1	54	14.44	92.79	73

Table 4B-13: Ranking of Coarse Habitat Types Based on Quantities Within a 500 m Buffer of Moose Observations During Winter 2009 and 2010 Compared With Study Zone 4 as a whole

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Jack pine mixedwood on mineral or thin peatland	4	63	0.07	0.07	7064
Jack pine treed on shallow peatland	4	82	0.01	0.08	7064
Tamarack treed on wet peatland	6	65	0.07	0.14	6676
Tall shrub on wet peatland	6	79	0.01	0.15	3665
Tall shrub on riparian peatland	3	69	0.03	0.18	2340
Low vegetation on riparian peatland	3	49	0.13	0.32	1919
Tall shrub on mineral or thin peatland	3	76	0.01	0.33	1335
Low vegetation on wet peatland	3	62	0.08	0.41	1211
Black spruce treed on wet peatland	4	40	0.28	0.69	1099
Tamarack- black spruce mixture on wet peatland	6	48	0.14	0.83	1042
Tamarack- black spruce mixture on riparian peatland	5	87	0.00	0.83	996
Jack pine treed on mineral or thin peatland	4	22	0.89	1.72	959
Nelson River shrub and/or low vegetation on ice scoured upland	1	31	0.48	2.21	872
Black spruce treed on wet peatland	6	34	0.44	2.65	809
Human infrastructure	6	21	1.02	3.66	705
Black spruce treed on mineral soil	3	24	0.79	4.45	636
Black spruce treed on riparian peatland	6	53	0.12	4.57	596
Tall shrub on shallow peatland	3	80	0.01	4.58	468
Low vegetation on shallow peatland	4	7	3.86	8.45	468
Low vegetation on mineral or thin peatland	4	6	4.41	12.85	463
Black spruce treed on shallow peatland	4	20	1.19	14.04	459

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Black spruce treed on riparian peatland	4	61	0.08	14.12	449
Black spruce treed on mineral soil	4	43	0.20	14.32	413
Tamarack treed on shallow peatland	3	77	0.01	14.33	387
Low vegetation on shallow peatland	3	11	2.33	16.66	366
Low vegetation on mineral or thin peatland	3	13	2.09	18.75	364
Tall shrub on mineral or thin peatland	5	36	0.39	19.14	357
Low vegetation on shallow peatland	6	41	0.22	19.36	354
Black spruce treed on shallow peatland	3	15	1.65	21.01	306
Black spruce treed on shallow peatland	6	3	6.50	27.51	289
Tamarack treed on shallow peatland	6	64	0.07	27.57	283
Low vegetation on mineral or thin peatland	6	66	0.06	27.63	282
Low vegetation on riparian peatland	4	57	0.10	27.73	274
Black spruce treed on thin peatland	4	23	0.91	28.64	273
Black spruce treed on thin peatland	6	5	6.38	35.02	267
Broadleaf treed on all ecosites	5	25	0.73	35.75	261
Tamarack treed on wet peatland	1	39	0.29	36.03	254
Black spruce treed on riparian peatland	3	83	0.01	36.04	238
Tall shrub on shallow peatland	1	42	0.20	36.24	235
Broadleaf treed on all ecosites	1	38	0.33	36.57	232
Black spruce treed on thin peatland	3	16	1.48	38.05	232
Low vegetation on shallow peatland	5	10	2.95	41.00	205
Shallow water	1	4	6.11	47.11	205
Tamarack treed on shallow	1	28	0.57	47.68	197

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
peatland					
Tamarack treed on shallow peatland	2	73	0.02	47.70	190
Human infrastructure	1	12	2.31	50.01	183
Tamarack treed on shallow peatland	4	85	0.00	50.02	163
Black spruce treed on mineral soil	5	56	0.11	50.13	159
Black spruce treed on mineral soil	6	27	0.60	50.73	154
Black spruce treed on shallow peatland	5	47	0.15	50.88	153
Low vegetation on wet peatland	5	70	0.03	50.91	153
Broadleaf treed on all ecosites	6	86	0.00	50.91	141
Off-system marsh	1	54	0.12	51.03	135
Black spruce treed on shallow peatland	2	26	0.71	51.74	126
Low vegetation on wet peatland	1	19	1.29	53.03	122
Black spruce treed on riparian peatland	1	29	0.53	53.56	122
Low vegetation on mineral or thin peatland	5	17	1.44	54.99	122
Nelson River shrub and/or low vegetation on sunken peat	1	52	0.12	55.12	117
Low vegetation on riparian peatland	1	18	1.43	56.55	116
Human infrastructure	5	51	0.13	56.68	113
Tall shrub on riparian peatland	1	33	0.45	57.13	111
Jack pine mixedwood on mineral or thin peatland	1	58	0.09	57.22	106
Tamarack- black spruce mixture on wet peatland	3	90	0.00	57.22	101
Low vegetation on mineral or thin peatland	2	55	0.12	57.34	101
Tall shrub on wet peatland	1	60	0.08	57.42	96
Black spruce mixedwood on mineral or thin peatland	1	45	0.16	57.58	94
Jack pine treed on mineral or thin peatland	1	30	0.49	58.07	92
Low vegetation on mineral or thin peatland	1	32	0.46	58.54	88

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Black spruce treed on shallow peatland	1	1	17.99	76.53	87
Low vegetation on riparian peatland	5	71	0.03	76.55	86
Low vegetation on shallow peatland	1	14	1.66	78.21	80
Black spruce treed on thin peatland	5	35	0.59	78.80	79
Broadleaf mixedwood on all ecosites	1	50	0.13	78.93	74
Black spruce treed on thin peatland	1	2	14.03	92.96	71

Table 4B-14: Ranking of Coarse Habitat Types Based on Quantities Within a 1000 m Buffer of Moose Observations During Winter 2009 and 2010 compared with Study Zone 4 as a whole

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Jack pine mixedwood on mineral or thin peatland	4	76	0.04	0.04	3703
Jack pine treed on shallow peatland	4	100	0.00	0.04	1960
Black spruce mixedwood on mineral or thin peatland	3	62	0.07	0.11	1897
Tamarack treed on wet peatland	6	84	0.02	0.13	1852
Jack pine treed on mineral or thin peatland	6	38	0.27	0.40	1530
Tall shrub on wet peatland	6	96	0.00	0.41	1349
Nelson River shrub and/or low vegetation on ice scoured upland	1	28	0.52	0.92	939
Tamarack- black spruce mixture on wet peatland	6	55	0.10	1.03	758
Jack pine treed on mineral or thin peatland	4	25	0.67	1.70	723
Tamarack treed on shallow peatland	4	83	0.02	1.71	700
Broadleaf mixedwood on all ecosites	6	73	0.05	1.76	686
Black spruce treed on wet peatland	4	47	0.17	1.93	663
Low vegetation on wet peatland	3	74	0.04	1.97	642
Human infrastructure	6	23	0.82	2.79	567
Tamarack treed on shallow peatland	6	50	0.13	2.92	562
Black spruce treed on shallow peatland	4	18	1.35	4.27	524
Black spruce treed on wet peatland	6	39	0.27	4.54	489
Jack pine mixedwood on mineral or thin peatland	6	79	0.02	4.56	461
Black spruce treed on mineral soil	4	44	0.21	4.77	440
Black spruce treed on wet peatland	3	72	0.05	4.82	438

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Tamarack- black spruce mixture on wet peatland	3	95	0.00	4.82	422
Black spruce treed on thin peatland	4	16	1.40	6.22	419
Low vegetation on shallow peatland	6	41	0.26	6.47	412
Black spruce treed on mineral soil	3	29	0.50	6.97	402
Tamarack- black spruce mixture on wet peatland	4	88	0.01	6.98	383
Human infrastructure	5	32	0.42	7.41	376
Black spruce treed on thin peatland	3	11	2.23	9.64	349
Black spruce treed on shallow peatland	6	3	7.65	17.29	340
Black spruce treed on shallow peatland	3	14	1.81	19.10	337
Low vegetation on mineral or thin peatland	6	61	0.08	19.18	334
Low vegetation on mineral or thin peatland	4	7	3.18	22.35	334
Black spruce treed on riparian peatland	6	65	0.07	22.42	332
Low vegetation on shallow peatland	4	10	2.60	25.02	315
Broadleaf treed on all ecosites	6	91	0.01	25.03	297
Tamarack treed on shallow peatland	3	89	0.01	25.04	297
Jack pine treed on mineral or thin peatland	2	69	0.05	25.09	294
Low vegetation on wet peatland	6	86	0.01	25.10	292
Black spruce treed on riparian peatland	4	68	0.05	25.15	288
Tall shrub on riparian peatland	2	97	0.00	25.16	281
Off-system marsh	1	43	0.24	25.40	280
Black spruce treed on thin peatland	6	5	6.40	31.80	268
Tall shrub on mineral or thin peatland	5	37	0.28	32.08	251
Broadleaf treed on all ecosites	1	35	0.33	32.40	231
Tall shrub on wet peatland	1	45	0.19	32.59	218

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Tall shrub on shallow peatland	6	99	0.00	32.60	215
Low vegetation on mineral or thin peatland	3	20	1.19	33.79	208
Black spruce treed on mineral soil	6	24	0.78	34.57	199
Low vegetation on riparian peatland	4	64	0.07	34.64	196
Low vegetation on shallow peatland	3	19	1.22	35.86	192
Jack pine treed on mineral or thin peatland	3	82	0.02	35.88	191
Low vegetation on shallow peatland	5	9	2.61	38.49	182
Shallow water	1	6	5.29	43.78	177
Tall shrub on mineral or thin peatland	1	70	0.05	43.83	171
Human infrastructure	1	12	2.10	45.93	166
Tall shrub on wet peatland	5	85	0.01	45.94	158
Low vegetation on mineral or thin peatland	5	15	1.71	47.65	145
Tamarack treed on shallow peatland	1	33	0.41	48.05	141
Tall shrub on riparian peatland	1	27	0.52	48.58	129
Low vegetation on wet peatland	5	80	0.02	48.60	123
Low vegetation on mineral or thin peatland	2	49	0.13	48.73	115
Black spruce treed on riparian peatland	1	30	0.49	49.23	114
Low vegetation on riparian peatland	1	17	1.36	50.59	110
Tall shrub on shallow peatland	1	56	0.09	50.68	109
Nelson River shrub and/or low vegetation on sunken peat	1	53	0.12	50.80	108
Broadleaf treed on all ecosites	5	36	0.29	51.09	106
Low vegetation on riparian peatland	5	77	0.03	51.12	106
Tall shrub on riparian peatland	5	81	0.02	51.15	104
Black spruce treed on shallow peatland	2	26	0.57	51.71	100
Low vegetation on shallow peatland	2	52	0.12	51.83	96

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Jack pine mixedwood on mineral or thin peatland	1	60	0.08	51.91	95
Tamarack treed on wet peatland	1	54	0.11	52.02	94
Jack pine treed on mineral or thin peatland	1	31	0.49	52.51	91
Low vegetation on wet peatland	1	21	0.96	53.47	91
Low vegetation on shallow peatland	1	13	1.85	55.32	90
Young regeneration on mineral or thin peatland	5	46	0.18	55.50	86
Black spruce treed on shallow peatland	1	1	17.32	72.82	84
Broadleaf treed on all ecosites	3	92	0.01	72.83	83
Young regeneration on wet peatland	5	93	0.01	72.83	82
Black spruce treed on thin peatland	1	2	15.38	88.22	78
Low vegetation on mineral or thin peatland	1	34	0.39	56.10	87
Black spruce treed on shallow peatland	1	1	17.32	73.42	87
Jack pine mixedwood on mineral or thin peatland	5	63	0.07	73.49	84
Broadleaf treed on all ecosites	3	92	0.01	73.50	83
Black spruce treed on thin peatland	1	2	15.38	88.88	80

Table 4B-15: Ranking of Coarse Habitat Types Based on Quantity Within a 100 m Buffer of Moose Sampling Locations in Stephens Lake During Summer 2010 and 2011

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Average Area (ha)
Black spruce treed on mineral soil	1	1	45.30	45.30	1.39
Nelson River	1	2	19.06	64.36	0.59
Black spruce treed on shallow peatland	1	3	11.72	76.08	0.36
Nelson River shrub and/or low vegetation on sunken peat	1	4	9.91	85.99	0.31

Table 4B-16: Ranking of Coarse Habitat Types Based on Quantity Within a 250 m Buffer of Moose Sampling Locations in Stephens Lake During Summer 2010 and 2011

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Average Area (ha)
Nelson River	1	1	47.45	47.45	9.25
Black spruce treed on mineral soil	1	2	26.76	74.21	5.22
Black spruce treed on shallow peatland	1	3	8.56	82.77	1.67

Table 4B-17: Ranking of Coarse Habitat Types Based on Quantity Within a 500 m Buffer of Moose Sampling Locations in Stephens Lake During Summer 2010 and 2011

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Average Area (ha)
Nelson River	1	1	63.91	63.91	50.10
Black spruce treed on mineral soil	1	2	16.27	80.18	12.76

Table 4B-18: Ranking of Coarse Habitat Types Based on Quantity Within a 1000 m Buffer of Moose Sampling Locations in Stephens Lake During Summer 2010 and 2011

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Average Area (ha)
Nelson River	1	1	67.64	67.64	212.34
Black spruce treed on mineral soil	1	2	10.30	77.94	32.34
Black spruce treed on thin peatland	1	3	8.56	86.50	26.88

Table 4B-19: Ranking of Coarse Habitat Types Based on Quantity Within a 100 m Buffer of Moose Sampling Locations on Peatland Complexes During Summer 2010 and 2011

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Average Area (ha)
Black spruce treed on shallow peatland	1	1	41.80	41.80	1.29
Low vegetation on riparian peatland	1	2	17.54	59.34	0.54
Low vegetation on shallow peatland	1	3	14.87	74.22	0.46
Low vegetation on wet peatland	1	4	4.45	78.67	0.14
Shallow water	1	5	3.41	82.08	0.10

Table 4B-20: Ranking of Coarse Habitat Types Based on Quantity Within a 250 m Buffer of Moose Sampling Locations on Peatland Complexes During Summer 2010 and 2011

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Average Area (ha)
Black spruce treed on shallow peatland	1	1	45.48	45.48	8.86
Low vegetation on shallow peatland	1	2	9.62	55.09	1.87
Low vegetation on riparian peatland	1	3	8.88	63.98	1.73
Shallow water	1	4	8.42	72.40	1.64
Black spruce treed on thin peatland	1	5	7.51	79.91	1.46
Low vegetation on wet peatland	1	6	3.52	83.44	0.69

Table 4B-21: Ranking of Coarse Habitat Types Based on Quantity Within a 500 m Buffer of Moose Sampling Locations on Peatland Complexes During Summer 2010 and 2011

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Average Area (ha)
Black spruce treed on shallow peatland	1	1	42.28	42.28	33.14
Black spruce treed on thin peatland	1	2	15.88	58.16	12.45
Shallow water	1	3	10.78	68.94	8.45
Low vegetation on shallow peatland	1	4	6.77	75.71	5.31
Low vegetation on riparian peatland	1	5	5.82	81.53	4.56

Table 4B-22: Ranking of Coarse Habitat Types Based on Quantity Within a 1000 m Buffer of Moose Sampling Locations on Peatland Complexes During Summer 2010 and 2011

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Average Area (ha)
Black spruce treed on shallow peatland	1	1	39.60	39.60	124.31
Black spruce treed on thin peatland	1	2	23.35	62.94	73.30
Shallow water	1	3	8.23	71.17	25.84
Low vegetation on shallow peatland	1	4	4.88	76.06	15.33
Low vegetation on riparian peatland	1	5	3.85	79.90	12.20
Black spruce treed on mineral soil	1	6	3.21	83.11	10.07

Table 4B-23: Ranking of Coarse Habitat Types Based on Quantities Within a 100 m Buffer of Sampled Moose Locations on Islands in Stephens Lake Compared to Study Zone 4 as a whole

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Nelson River shrub and/or low vegetation on sunken peat	1	1	9.91	9.91	9284
Black spruce mixedwood on mineral or thin peatland	1	2	1.83	11.74	1094
Black spruce treed on mineral soil	1	3	45.30	57.04	827
Broadleaf mixedwood on all ecosites	1	4	1.02	58.06	581
Nelson River shrub and/or low vegetation on upper beach	1	5	1.77	59.84	386
Black spruce treed on mineral soil	4	6	0.11	59.95	231
Low vegetation on wet peatland	1	7	1.27	61.22	121
Tall shrub on riparian peatland	1	8	0.42	61.64	102
Nelson River	1	9	19.06	80.70	89

Table 4B-24: Ranking of Coarse Habitat Types Based on Quantities Within a 250 m Buffer of Sampled Moose Locations on Islands in Stephens Lake Compared to Study Zone 4 as a whole

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Nelson River shrub and/or low vegetation on sunken peat	1	1	7.91	7.91	7409
Black spruce mixedwood on mineral or thin peatland	1	2	0.93	8.84	557
Black spruce treed on mineral soil	1	3	26.76	35.61	489
Black spruce treed on mineral soil	4	4	0.16	35.77	344
Nelson River	1	5	47.45	83.22	221

Table 4B-25: Ranking of Coarse Habitat Types Based on Quantities Within a 500 m Buffer of Sampled Moose Locations on Islands in Stephens Lake Compared to Study Zone 4 as a whole

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Nelson River shrub and/or low vegetation on sunken peat	1	1	7.91	7.91	7409
Black spruce mixedwood on mineral or thin peatland	1	2	0.93	8.84	557
Black spruce treed on mineral soil	1	3	26.76	35.61	489
Black spruce treed on mineral soil	4	4	0.16	35.77	344
Nelson River	1	5	47.45	83.22	221

Table 4B-26: Ranking of Coarse Habitat Types Based on Quantities Within a 1000 m Buffer of Sampled Moose Locations on Islands in Stephens Lake Compared to Study Zone 4 as a whole

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Nelson River shrub and/or low vegetation on sunken peat	1	1	4.04	4.04	3779
Broadleaf mixedwood on all ecosites	2	2	0.04	4.08	1008
Nelson River	1	3	67.64	71.71	314
Black spruce mixedwood on shallow peatland	1	4	0.03	71.75	305
Black spruce mixedwood on mineral or thin peatland	1	5	0.50	72.24	296
Black spruce treed on mineral soil	4	6	0.11	72.35	235
Black spruce treed on mineral soil	1	7	10.30	82.66	188

Table 4B-27: Ranking of Coarse Habitat Types Based on Quantities Within a 100 m Buffer of Sampled Moose Locations on Peatland Complexes Compared to Study Zone 4 as a whole

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Low vegetation on riparian peatland	1	2	17.54	17.54	1418
Low vegetation on shallow peatland	1	3	14.87	32.42	719
Broadleaf mixedwood on all ecosites	1	10	1.25	33.67	710
Tall shrub on shallow peatland	1	20	0.51	34.17	591
Young regeneration on shallow peatland	5	16	0.71	34.88	585
Low vegetation on wet peatland	1	4	4.45	39.33	422
Broadleaf treed on all ecosites	1	17	0.60	39.93	419
Tall shrub on wet peatland	1	21	0.36	40.29	419
Off-system marsh	1	22	0.35	40.64	396
Tamarack treed on shallow peatland	1	13	1.03	41.67	358
Low vegetation on shallow peatland	6	24	0.22	41.89	356
Black spruce treed on riparian peatland	1	8	1.37	43.26	317
Black spruce treed on wet peatland	1	6	3.14	46.40	228
Tamarack- black spruce mixture on wet peatland	1	9	1.32	47.72	208
Black spruce treed on shallow peatland	4	19	0.53	48.24	203
Black spruce treed on shallow peatland	1	1	41.80	90.04	203

Table 4B-28: Ranking of Coarse Habitat Types Based on Quantities Within a 250 m Buffer of Sampled Moose Locations on Peatland Complexes Compared to Study Zone 4 as a whole

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Tall shrub on shallow peatland	4	32	0.03	0.03	1230
Low vegetation on riparian peatland	1	3	8.88	8.92	718
Tamarack treed on shallow peatland	1	10	1.50	10.42	521
Tall shrub on riparian peatland	4	33	0.03	10.45	499
Tamarack- black spruce mixture on wet peatland	6	30	0.06	10.51	473
Low vegetation on shallow peatland	1	2	9.62	20.13	465
Young regeneration on shallow peatland	5	19	0.48	20.61	399
Tamarack treed on shallow peatland	6	29	0.08	20.70	366
Broadleaf mixedwood on all ecosites	1	18	0.63	21.33	359
Low vegetation on wet peatland	1	6	3.52	24.85	334
Tamarack- black spruce mixture on wet peatland	1	8	1.94	26.79	306
Shallow water	1	4	8.42	35.22	283
Tall shrub on shallow peatland	1	22	0.23	35.45	270
Broadleaf treed on all ecosites	1	20	0.38	35.83	268
Black spruce treed on riparian peatland	1	11	1.15	36.98	267
Off-system marsh	1	23	0.23	37.21	263
Low vegetation on wet peatland	6	35	0.01	37.22	252
Black spruce treed on wet peatland	6	26	0.14	37.36	250
Black spruce treed on shallow peatland	4	17	0.64	38.00	249
Black spruce treed on shallow peatland	1	1	45.48	83.48	221

Table 4B-29: Ranking of Coarse Habitat Types Based on Quantities Within a 500 m Buffer of Sampled Moose Locations on Islands in Peatland Complexes Compared to Study Zone 4 as a whole

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Human infrastructure	4	29	0.12	0.12	3592
Tall shrub on shallow peatland	4	33	0.05	0.17	1800
Low vegetation on riparian peatland	1	5	5.82	5.99	470
Tamarack treed on wet peatland	1	20	0.44	6.43	388
Shallow water	1	3	10.78	17.21	362
Low vegetation on shallow peatland	1	4	6.77	23.98	327
Tamarack treed on shallow peatland	1	12	0.92	24.91	321
Low vegetation on wet peatland	1	6	2.82	27.73	268
Tamarack treed on shallow peatland	6	32	0.06	27.79	246
Black spruce treed on shallow peatland	4	18	0.59	28.38	229
Tall shrub on shallow peatland	1	25	0.19	28.57	219
Off-system marsh	1	24	0.19	28.75	216
Tall shrub on riparian peatland	1	14	0.87	29.62	213
Black spruce treed on shallow peatland	1	1	42.28	71.90	205
Black spruce treed on riparian peatland	1	15	0.79	72.69	184
Low vegetation on shallow peatland	4	8	1.51	74.21	183
Young regeneration on shallow peatland	5	23	0.21	74.42	173
Tamarack- black spruce mixture on wet peatland	1	11	1.06	75.47	167
Tamarack- black spruce mixture on wet peatland	6	39	0.02	75.50	161
Low vegetation on mineral or thin peatland	6	38	0.03	75.53	146
Broadleaf mixedwood on all ecosites	1	22	0.25	75.78	141
Jack pine treed on mineral or thin peatland	1	17	0.75	76.53	141
Human infrastructure	6	26	0.18	76.71	127
Tall shrub on riparian peatland	4	41	0.01	76.72	124

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Black spruce treed on wet peatland	1	7	1.64	78.37	120
Broadleaf treed on all ecosites	1	27	0.15	78.51	103
Tall shrub on wet peatland	1	31	0.09	78.60	101
Black spruce treed on thin peatland	1	2	15.88	94.48	80

Table 4B-30: Ranking of Coarse Habitat Types Based on Quantities Within a 1000 m Buffer of Sampled Moose Locations on Peatland Complexes Compared to Study Zone 4 as a whole

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Tall shrub on wet peatland	4	49	0.01	0.01	1548
Human infrastructure	4	37	0.04	0.05	1253
Tall shrub on shallow peatland	4	47	0.01	0.07	476
Young regeneration on riparian peatland	5	52	0.01	0.07	387
Jack pine mixedwood on mineral or thin peatland	1	22	0.31	0.38	370
Jack pine treed on mineral or thin peatland	1	8	1.69	2.07	315
Low vegetation on riparian peatland	1	5	3.85	5.92	311
Human infrastructure	6	21	0.44	6.36	303
Shallow water	1	3	8.23	14.59	276
Low vegetation on shallow peatland	1	4	4.88	19.47	236
Off-system marsh	1	29	0.19	19.66	221
Young regeneration on shallow peatland	5	26	0.24	19.90	197
Black spruce treed on shallow peatland	1	1	39.60	59.50	192
Tamarack treed on shallow peatland	1	19	0.55	60.04	190
Tamarack treed on wet peatland	1	27	0.21	60.26	186
Jack pine treed on mineral or thin peatland	6	40	0.03	60.29	183
Tall shrub on riparian peatland	1	15	0.74	61.03	182
Low vegetation on wet peatland	1	7	1.73	62.76	165
Broadleaf mixedwood on all ecosites	1	25	0.27	63.03	155
Black spruce treed on riparian peatland	1	17	0.67	63.70	154
Tamarack treed on shallow peatland	6	39	0.04	63.74	152
Young regeneration on mineral or thin peatland	5	23	0.30	64.03	141
Tall shrub on wet peatland	1	32	0.12	64.15	135
Tamarack- black spruce mixture on riparian peatland	1	43	0.03	64.18	121

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Black spruce treed on wet peatland	4	42	0.03	64.21	119
Black spruce treed on thin peatland	1	2	23.35	87.56	118

Table 5B-1: Ranking of Coarse Habitat Types Based on Quantity Within a 100 m Buffer of Caribou Sampling Locations 2002-2006

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Average Area (ha)
Nelson River	1	1	21.54	21.54	0.66
Black spruce treed on shallow peatland	1	2	17.30	38.84	0.53
Black spruce treed on thin peatland	1	3	14.40	53.24	0.44
Low vegetation on mineral or thin peatland	5	4	5.41	58.65	0.17
Low vegetation on riparian peatland	1	5	5.29	63.94	0.16
Low vegetation on shallow peatland	1	6	4.18	68.11	0.13
Low vegetation on wet peatland	1	7	3.68	71.79	0.11
Black spruce treed on wet peatland	1	8	3.46	75.25	0.11
Shallow water	1	9	3.12	78.37	0.10
Black spruce treed on mineral soil	1	10	2.04	80.41	0.06

Table 5B-2: Ranking of Coarse Habitat Types Based on Quantity Within a 250 m Buffer of Caribou Sampling Locations 2002-2006

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Average Area (ha)
Black spruce treed on shallow peatland	1	1	20.92	20.92	4.02
Nelson River	1	2	19.01	39.93	3.66
Black spruce treed on thin peatland	1	3	15.17	55.10	2.92
Black spruce treed on mineral soil	1	4	4.99	60.09	0.96
Low vegetation on mineral or thin peatland	5	5	4.44	64.53	0.85
Low vegetation on riparian peatland	1	6	3.70	68.24	0.71
Low vegetation on wet peatland	1	7	3.30	71.54	0.64
Shallow water	1	8	3.30	74.84	0.63
Low vegetation on shallow peatland	1	9	3.27	78.10	0.63
Black spruce treed on wet peatland	1	10	2.11	80.21	0.40

Table 5B-3: Ranking of Coarse Habitat Types Based on Quantity Within a 500 m Buffer of Caribou Sampling Locations 2002-2006

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Average Area (ha)
Black spruce treed on shallow peatland	1	1	22.37	22.37	17.54
Black spruce treed on thin peatland	1	2	20.57	42.94	16.12
Nelson River	1	3	17.46	60.40	13.69
Black spruce treed on mineral soil	1	4	6.22	66.62	4.88
Shallow water	1	5	3.95	70.56	3.09
Low vegetation on mineral or thin peatland	5	6	3.74	74.31	2.94
Low vegetation on riparian peatland	1	7	2.92	77.23	2.29
Low vegetation on shallow peatland	1	8	2.42	79.65	1.90
Low vegetation on wet peatland	1	9	1.82	81.47	1.42

Table 5B-4: Ranking of Coarse Habitat Types Based on Quantity Within a 1000 m Buffer of Caribou Sampling Locations 2002-2006

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Average Area (ha)
Black spruce treed on thin peatland	1	1	25.35	25.35	71.18
Black spruce treed on shallow peatland	1	2	25.20	50.54	70.75
Black spruce treed on mineral soil	1	3	7.35	57.89	20.63
Nelson River	1	4	7.35	65.24	20.63
Shallow water	1	5	4.31	69.55	12.10
Low vegetation on riparian peatland	1	6	3.08	72.63	8.65
Low vegetation on mineral or thin peatland	3	7	2.74	75.36	7.68
Low vegetation on shallow peatland	1	8	2.62	77.98	7.36
Low vegetation on shallow peatland	6	9	1.80	79.78	5.05
Black spruce treed on wet peatland	1	10	1.71	81.50	4.81

Table 5B-5: Ranking of Coarse Habitat Types Based on Quantities Within a 100 m Buffer of Caribou Observations Winter Within Study Zone 4

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Black spruce mixedwood on shallow peatland	1	1	0.62	0.62	5440
Black spruce treed on riparian peatland	2	2	0.66	1.28	3760
Low vegetation on mineral or thin peatland	2	3	1.50	2.78	1300
Tall shrub on shallow peatland	1	4	0.77	3.55	899
Tall shrub on riparian peatland	5	5	0.16	3.71	778
Tamarack treed on shallow peatland	3	6	0.03	3.73	768
Black spruce mixedwood on mineral or thin peatland	1	7	0.81	4.54	482
Low vegetation on mineral or thin peatland	5	8	5.41	9.95	460
Tall shrub on mineral or thin peatland	1	9	0.14	10.08	459
Low vegetation on riparian peatland	1	10	5.29	15.37	428
Low vegetation on wet peatland	1	11	3.68	19.05	349
Broadleaf mixedwood on all ecosites	3	12	0.05	19.10	329
Tamarack treed on shallow peatland	1	13	0.90	20.00	311
Low vegetation on riparian peatland	5	14	0.09	20.09	280
Black spruce treed on thin peatland	2	15	1.82	21.91	265
Black spruce treed on shallow peatland	2	16	1.48	23.39	261
Black spruce treed on wet peatland	1	17	3.46	26.85	252
Low vegetation on shallow peatland	4	18	2.02	28.88	245
Low vegetation on mineral or thin peatland	1	19	1.26	30.13	237
Tall shrub on riparian peatland	1	20	0.96	31.09	236
Black spruce treed on riparian peatland	1	21	0.96	32.06	223
Low vegetation on shallow peatland	1	22	4.18	36.23	202

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Broadleaf mixedwood on all ecosites	1	23	0.35	36.58	199
Low vegetation on mineral or thin peatland	4	24	1.64	38.22	172
Tamarack treed on wet peatland	1	25	0.19	38.41	170
Tamarack- black spruce mixture on wet peatland	1	26	1.07	39.48	168
Broadleaf treed on all ecosites	1	27	0.19	39.67	130
Black spruce treed on shallow peatland	3	28	0.68	40.34	126
Shallow water	1	29	3.12	43.46	105
Black spruce treed on wet peatland	2	30	0.08	43.55	100
Nelson River	1	31	21.54	65.08	100
Black spruce treed on shallow peatland	1	32	17.30	82.38	84

Table 5B-6: Ranking of Coarse Habitat Types Based on Quantities Within a 250 m Buffer of Caribou Observations During Winter Within Study Zone 4

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Black spruce mixedwood on shallow peatland	1	1	0.24	0.24	2144
Black spruce treed on riparian peatland	2	2	0.30	0.54	1712
Tamarack- black spruce mixture on wet peatland	2	3	0.07	0.61	1630
Tamarack treed on riparian peatland	1	4	0.06	0.67	1446
Tall shrub on mineral or thin peatland	1	5	0.31	0.98	1051
Low vegetation on mineral or thin peatland	2	6	1.05	2.03	906
Black spruce treed on wet peatland	2	7	0.52	2.55	637
Tall shrub on shallow peatland	1	8	0.48	3.03	564
Low vegetation on riparian peatland	5	9	0.17	3.19	516
Nelson River shrub and/or low vegetation on sunken peat	1	10	0.52	3.71	485
Low vegetation on riparian peatland	2	11	0.18	3.89	425
Low vegetation on mineral or thin peatland	5	12	4.44	8.33	378
Black spruce mixedwood on mineral or thin peatland	1	13	0.60	8.94	360
Tamarack- black spruce mixture on riparian peatland	1	14	0.08	9.02	351
Broadleaf treed on all ecosites	1	15	0.47	9.49	331
Black spruce treed on mineral soil	2	16	0.36	9.84	324
Low vegetation on wet peatland	1	17	3.30	13.15	313
Low vegetation on riparian peatland	1	18	3.70	16.85	299
Tall shrub on wet peatland	1	19	0.25	17.10	287
Black spruce treed on riparian peatland	1	20	1.23	18.33	284
Broadleaf treed on all ecosites	5	21	0.76	19.09	274
Tamarack treed on wet	1	22	0.29	19.38	258

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
peatland					
Black spruce treed on thin peatland	2	23	1.70	21.08	246
Low vegetation on shallow peatland	4	24	1.93	23.00	233
Low vegetation on riparian peatland	4	25	0.07	23.07	205
Low vegetation on mineral or thin peatland	4	26	1.94	25.01	204
Tall shrub on riparian peatland	1	27	0.78	25.79	192
Tamarack treed on shallow peatland	1	28	0.48	26.27	166
Black spruce treed on shallow peatland	2	29	0.91	27.18	161
Tall shrub on shallow peatland	5	30	0.26	27.44	160
Low vegetation on shallow peatland	1	31	3.27	30.71	158
Broadleaf mixedwood on all ecosites	1	32	0.27	30.98	156
Black spruce treed on wet peatland	1	33	2.11	33.09	153
Low vegetation on mineral or thin peatland	1	34	0.81	33.90	153
Tamarack treed on shallow peatland	3	35	0.00	33.90	152
Nelson River shrub and/or low vegetation on upper beach	1	36	0.67	34.57	145
Tall shrub on riparian peatland	5	37	0.03	34.60	131
Black spruce treed on mineral soil	3	38	0.15	34.75	123
Shallow water	1	39	3.30	38.05	111
Black spruce treed on shallow peatland	1	40	20.92	58.96	102
Black spruce treed on mineral soil	1	41	4.99	63.95	91
Nelson River	1	42	19.01	82.97	88

Table 5B-7: Ranking of Coarse Habitat Types Based on Quantities Within a 500 m Buffer of Caribou Observations During Winter Within Study Zone 4

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Black spruce treed on riparian peatland	2	43	0.12	0.12	704
Nelson River shrub and/or low vegetation on sunken peat	1	17	0.62	0.74	582
Tall shrub on mineral or thin peatland	1	40	0.17	0.91	573
Black spruce mixedwood on shallow peatland	1	48	0.06	0.98	541
Tamarack treed on riparian peatland	1	56	0.02	1.00	482
Low vegetation on riparian peatland	4	41	0.17	1.16	472
Low vegetation on mineral or thin peatland	2	24	0.49	1.65	422
Tamarack- black spruce mixture on wet peatland	2	59	0.02	1.67	410
Black spruce treed on wet peatland	2	34	0.30	1.97	376
Tamarack treed on wet peatland	1	29	0.41	2.39	364
Broadleaf treed on all ecosites	5	12	0.93	3.32	336
Low vegetation on mineral or thin peatland	5	6	3.74	7.06	318
Tall shrub on shallow peatland	5	23	0.49	7.55	305
Broadleaf mixedwood on all ecosites	1	21	0.52	8.07	293
Black spruce mixedwood on mineral or thin peatland	1	26	0.48	8.55	284
Broadleaf treed on all ecosites	1	32	0.37	8.92	261
Black spruce treed on mineral soil	2	35	0.28	9.20	255
Low vegetation on riparian peatland	1	7	2.92	12.12	236
Black spruce treed on thin peatland	2	10	1.62	13.74	235
Black spruce treed on riparian peatland	4	52	0.04	13.78	224
Tall shrub on shallow peatland	1	38	0.18	13.96	215
Black spruce treed on riparian peatland	1	14	0.90	14.86	208
Black spruce treed on shallow peatland	4	20	0.53	15.38	203
Tamarack- black spruce mixture on riparian peatland	1	53	0.04	15.42	173

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Low vegetation on wet peatland	1	9	1.82	17.24	172
Tamarack treed on shallow peatland	3	63	0.01	17.24	161
Low vegetation on wet peatland	2	55	0.02	17.26	160
Tall shrub on mineral or thin peatland	5	39	0.17	17.44	156
Tamarack treed on shallow peatland	1	28	0.44	17.88	154
Low vegetation on riparian peatland	5	51	0.04	17.92	137
Shallow water	1	5	3.95	21.87	132
Broadleaf mixedwood on all ecosites	3	58	0.02	21.89	119
Nelson River shrub and/or low vegetation on upper beach	1	19	0.54	22.43	118
Low vegetation on riparian peatland	2	50	0.05	22.48	118
Low vegetation on shallow peatland	1	8	2.42	24.91	117
Low vegetation on mineral or thin peatland	1	18	0.62	25.53	117
Black spruce treed on wet peatland	1	11	1.58	27.10	115
Black spruce treed on mineral soil	1	4	6.22	33.32	114
Low vegetation on shallow peatland	4	13	0.91	34.24	111
Tall shrub on riparian peatland	1	27	0.45	34.68	110
Tall shrub on wet peatland	1	46	0.09	34.78	109
Black spruce treed on shallow peatland	1	1	22.37	57.15	109
Black spruce treed on mineral soil	3	42	0.13	57.28	107
Black spruce treed on thin peatland	1	2	20.57	77.85	104
Tall shrub on riparian peatland	5	57	0.02	77.87	98
Low vegetation on mineral or thin peatland	4	15	0.88	78.75	92
Black spruce treed on shallow peatland	2	22	0.51	79.26	90
Young regeneration on shallow peatland	5	44	0.11	79.37	90
Low vegetation on mineral or thin peatland	3	25	0.48	79.85	84
Nelson River	1	3	17.46	97.31	81

Table 5B-8: Ranking of Coarse Habitat Types Based on Quantities Within a 1000 m Buffer of Caribou Observations During Winter Within Study Zone 4

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Tall shrub on mineral or thin peatland	4	1	0.30	0.30	71616
Tall shrub on shallow peatland	4	2	0.42	0.72	15521
Low vegetation on shallow peatland	6	3	1.80	2.52	2895
Broadleaf treed on all ecosites	1	4	1.50	4.02	1057
Low vegetation on mineral or thin peatland	2	5	1.19	5.21	1032
Low vegetation on shallow peatland	2	6	1.28	6.50	1029
Broadleaf mixedwood on all ecosites	3	7	0.16	6.66	986
Low vegetation on wet peatland	5	8	0.15	6.82	828
Jack pine treed on mineral or thin peatland	2	9	0.14	6.96	790
Nelson River shrub and/or low vegetation on sunken peat	1	10	0.82	7.77	765
Tamarack- black spruce mixture on riparian peatland	2	11	0.00	7.77	618
Low vegetation on mineral or thin peatland	3	12	2.74	10.51	477
Tamarack treed on wet peatland	1	13	0.48	10.99	422
Jack pine treed on mineral or thin peatland	3	14	0.04	11.03	388
Broadleaf mixedwood on all ecosites	1	15	0.64	11.67	363
Tamarack treed on shallow peatland	3	16	0.01	11.68	362
Tamarack- black spruce mixture on wet peatland	2	17	0.01	11.69	342
Low vegetation on wet peatland	3	18	0.02	11.72	331
Low vegetation on riparian peatland	5	19	0.09	11.81	289
Black spruce treed on riparian peatland	2	20	0.04	11.85	257
Black spruce treed on wet peatland	3	21	0.03	11.88	254
Low vegetation on riparian peatland	1	22	3.08	14.96	249
Tall shrub on wet peatland	5	23	0.02	14.98	242
Tamarack- black spruce mixture on	4	24	0.01	14.99	229

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
wet peatland					
Young regeneration on shallow peatland	5	25	0.27	15.26	226
Broadleaf treed on all ecosites	5	26	0.58	15.84	208
Black spruce treed on riparian peatland	6	27	0.04	15.88	207
Black spruce treed on riparian peatland	1	28	0.88	16.76	205
Black spruce treed on wet peatland	2	29	0.17	16.93	204
Tamarack treed on shallow peatland	2	30	0.02	16.95	198
Tamarack- black spruce mixture on riparian peatland	1	31	0.04	16.99	175
Tamarack treed on riparian peatland	1	32	0.01	17.00	175
Black spruce mixedwood on shallow peatland	1	33	0.02	17.02	155
Tamarack treed on shallow peatland	1	34	0.44	17.46	153
Black spruce treed on thin peatland	2	35	1.01	18.46	147
Shallow water	1	36	4.31	22.78	145
Black spruce treed on shallow peatland	2	37	0.77	23.54	136
Black spruce treed on mineral soil	1	38	7.35	30.89	134
Tall shrub on wet peatland	1	39	0.12	31.01	134
Black spruce treed on thin peatland	1	40	25.35	56.36	128
Jack pine treed on shallow peatland	5	41	0.04	56.39	127
Low vegetation on shallow peatland	1	42	2.62	59.01	127
Black spruce treed on shallow peatland	4	43	0.32	59.34	125
Black spruce treed on wet peatland	1	44	1.71	61.05	125
Black spruce mixedwood on mineral or thin peatland	1	45	0.21	61.26	123
Black spruce treed on shallow peatland	1	46	25.20	86.45	122

Table 5B-9: Ranking of Coarse Habitat Types Based on Quantity Within a 100 m Buffer of Caribou Sampling Locations February 2013

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Average Area (ha)
Black spruce treed on shallow peatland	1	1	28.93	28.93	0.90
Black spruce treed on thin peatland	1	2	22.60	51.53	0.70
Nelson River	1	3	17.01	68.54	0.53
Black spruce treed on mineral soil	1	4	3.66	72.20	0.11
Shallow water	1	5	2.67	74.87	0.08
Low vegetation on riparian peatland	1	6	2.05	76.92	0.06
Low vegetation on shallow peatland	1	7	2.02	78.94	0.06
Low vegetation on shallow peatland	3	8	1.80	80.74	0.06

Table 5B-10: Ranking of Coarse Habitat Types Based on Quantity Within a 250 m Buffer of Caribou Sampling Locations February 2013

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Average Area (ha)
Black spruce treed on shallow peatland	1	1	29.05	29.05	5.66
Black spruce treed on thin peatland	1	2	22.59	51.64	4.40
Nelson River	1	3	18.13	69.77	3.53
Black spruce treed on mineral soil	1	4	4.71	74.48	0.92
Shallow water	1	5	2.92	77.40	0.57
Low vegetation on shallow peatland	1	6	2.10	79.50	0.41
Low vegetation on riparian peatland	1	7	1.75	81.25	0.34

Table 5B-11: Ranking of Coarse Habitat Types Based on Quantity Within a 500 m Buffer of Caribou Sampling Locations February 2013

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Average Area (ha)
Black spruce treed on shallow peatland	1	1	28.24	28.24	22.11
Black spruce treed on thin peatland	1	2	22.57	50.81	17.66
Nelson River	1	3	19.50	70.31	15.27
Black spruce treed on mineral soil	1	4	4.88	75.19	3.82
Shallow water	1	5	3.49	78.69	2.74
Low vegetation on shallow peatland	1	6	2.15	80.84	1.68

Table 5B-12: Ranking of Coarse Habitat Types Based on Quantity Within a 1000 m Buffer of Caribou Sampling Locations February 2013

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Average Area (ha)
Black spruce treed on shallow peatland	1	1	26.82	26.82	84.09
Black spruce treed on thin peatland	1	2	23.09	49.91	72.41
Nelson River	1	3	20.13	70.04	63.14
Black spruce treed on mineral soil	1	4	4.99	75.03	15.65
Shallow water	1	5	3.90	78.93	12.24
Low vegetation on shallow peatland	1	6	2.07	81.00	6.49

Table 5B-13: Ranking of Coarse Habitat Types Based on Quantities Within a 100 m Buffer of Caribou Sampling Locations Compared to habitat quantities in Study Zone 4

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Jack pine treed on mineral or thin peatland	2	22	0.48	0.48	2732
Tall shrub on shallow peatland	3	42	0.03	0.52	2144
Tall shrub on mineral or thin peatland	3	50	0.01	0.52	730
Black spruce mixedwood on mineral or thin peatland	1	15	1.15	1.67	686
Tamarack treed on shallow peatland	1	12	1.41	3.09	492
Jack pine mixedwood on mineral or thin peatland	1	24	0.37	3.46	439
Broadleaf mixedwood on all ecosites	1	19	0.72	4.18	409
Black spruce treed on wet peatland	3	43	0.03	4.21	323
Human infrastructure	6	23	0.43	4.64	301
Low vegetation on wet peatland	5	37	0.05	4.70	293
Low vegetation on shallow peatland	3	8	1.80	6.49	282
Low vegetation on riparian peatland	2	36	0.11	6.61	266
Black spruce treed on shallow peatland	2	11	1.48	8.09	262
Black spruce treed on mineral soil	3	29	0.25	8.34	203
Low vegetation on shallow peatland	2	30	0.24	8.58	193
Low vegetation on mineral or thin peatland	3	16	1.10	9.68	191
Nelson River shrub and/or low vegetation on upper beach	1	18	0.85	10.53	186
Off-system marsh	1	34	0.16	10.69	185
Low vegetation on riparian peatland	1	6	2.05	12.75	166
Black spruce treed on wet peatland	2	35	0.12	12.86	146
Black spruce treed on riparian peatland	1	21	0.62	13.48	143
Black spruce treed on shallow	1	1	28.93	42.41	140

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
peatland					
Low vegetation on shallow peatland	5	9	1.74	44.15	121
Low vegetation on wet peatland	1	13	1.27	45.42	120
Black spruce treed on wet peatland	1	10	1.65	47.07	120
Black spruce treed on thin peatland	1	2	22.60	69.67	114
Low vegetation on shallow peatland	4	17	0.85	70.53	103
Low vegetation on shallow peatland	1	7	2.02	72.55	98
Shallow water	1	5	2.67	75.21	89
Black spruce treed on riparian peatland	2	46	0.02	75.23	87
Black spruce treed on mineral soil	6	26	0.32	75.55	82
Nelson River	1	3	17.01	92.57	79

Table 5B-14: Ranking of Coarse Habitat Types Based on Quantities Within a 250 m Buffer of Caribou Sampling Locations Compared to habitat quantities in Study Zone 4

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Tall shrub on shallow peatland	3	55	0.02	0.02	1121
Jack pine treed on mineral or thin peatland	2	34	0.16	0.17	881
Young regeneration on riparian peatland	5	62	0.01	0.18	520
Tall shrub on riparian peatland	6	56	0.01	0.19	463
Low vegetation on riparian peatland	2	36	0.14	0.33	323
Black spruce mixedwood on mineral or thin peatland	1	21	0.54	0.87	323
Jack pine mixedwood on mineral or thin peatland	1	29	0.23	1.10	278
Broadleaf mixedwood on all ecosites	1	22	0.49	1.59	276
Tamarack treed on shallow peatland	1	17	0.72	2.31	250
Black spruce treed on shallow peatland	2	10	1.38	3.69	243
Tamarack treed on shallow peatland	6	46	0.05	3.74	237
Low vegetation on shallow peatland	2	28	0.28	4.02	221
Black spruce treed on riparian peatland	6	47	0.04	4.06	219
Human infrastructure	6	27	0.30	4.36	206
Low vegetation on shallow peatland	3	11	1.23	5.59	194
Black spruce treed on wet peatland	2	37	0.13	5.72	158
Low vegetation on mineral or thin peatland	3	14	0.82	6.54	144
Low vegetation on riparian peatland	1	7	1.75	8.29	141
Black spruce treed on shallow peatland	1	1	29.05	37.34	141
Off-system marsh	1	39	0.12	37.46	138
Black spruce treed on mineral soil	3	33	0.17	37.63	137
Black spruce treed on riparian peatland	1	20	0.57	38.21	133
Nelson River shrub and/or low vegetation on upper beach	1	19	0.58	38.78	125
Black spruce treed on wet peatland	1	9	1.65	40.44	120
Low vegetation on shallow peatland	5	8	1.71	42.15	119
Tall shrub on mineral or thin peatland	3	70	0.00	42.15	118
Black spruce treed on thin peatland	1	2	22.59	64.74	114
Low vegetation on riparian peatland	4	48	0.04	64.78	110
Black spruce treed on thin peatland	2	16	0.74	65.52	108
Tall shrub on riparian peatland	1	23	0.43	65.96	107

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Black spruce treed on riparian peatland	2	54	0.02	65.98	102
Low vegetation on shallow peatland	1	6	2.10	68.08	102
Tall shrub on shallow peatland	1	42	0.09	68.17	99
Shallow water	1	5	2.92	71.09	98
Low vegetation on wet peatland	5	53	0.02	71.11	98
Low vegetation on shallow peatland	4	15	0.76	71.87	92
Low vegetation on wet peatland	3	66	0.01	71.87	91
Black spruce treed on mineral soil	1	4	4.71	76.58	86
Nelson River	1	3	18.13	94.71	84

Table 5B-15: Ranking of Coarse Habitat Types Based on Quantities Within a 500 m Buffer of Caribou Sampling Locations Compared to habitat quantities in Study Zone 4

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Tamarack- black spruce mixture on riparian peatland	2	87	0.00	0.00	2053
Tamarack treed on shallow peatland	4	67	0.02	0.02	588
Tall shrub on mineral or thin peatland	3	76	0.01	0.02	568
Jack pine treed on mineral or thin peatland	2	44	0.08	0.11	470
Tamarack treed on shallow peatland	2	52	0.05	0.16	463
Tall shrub on shallow peatland	6	82	0.00	0.17	460
Black spruce treed on riparian peatland	2	46	0.07	0.24	402
Tall shrub on shallow peatland	3	75	0.01	0.24	401
Tall shrub on riparian peatland	6	72	0.01	0.25	394
Tall shrub on riparian peatland	3	79	0.01	0.26	393
Low vegetation on riparian peatland	3	60	0.02	0.28	319
Low vegetation on riparian peatland	2	38	0.13	0.41	302
Young regeneration on riparian peatland	5	83	0.00	0.41	288
Broadleaf mixedwood on all ecosites	1	25	0.34	0.75	192
Black spruce treed on mineral soil	3	30	0.23	0.98	187
Black spruce treed on shallow peatland	2	13	1.00	1.98	177
Jack pine mixedwood on mineral or thin peatland	1	35	0.14	2.13	171
Tall shrub on riparian peatland	2	88	0.00	2.13	170
Broadleaf treed on all ecosites	2	68	0.02	2.14	165
Black spruce treed on thin peatland	2	11	1.12	3.27	163
Low vegetation on shallow peatland	2	33	0.19	3.46	153
Jack pine treed on shallow peatland	5	56	0.04	3.50	145
Black spruce treed on riparian peatland	1	15	0.62	4.12	144
Human infrastructure	6	32	0.21	4.33	144
Black spruce treed on shallow peatland	1	1	28.24	32.57	137
Black spruce mixedwood on mineral or thin peatland	1	31	0.23	32.80	135
Tall shrub on riparian peatland	1	19	0.52	33.32	129

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Low vegetation on riparian peatland	1	7	1.58	34.90	128
Tamarack treed on shallow peatland	1	23	0.36	35.26	124
Black spruce treed on wet peatland	2	40	0.10	35.36	121
Black spruce mixedwood on shallow peatland	1	70	0.01	35.37	119
Shallow water	1	5	3.49	38.86	117
Black spruce treed on thin peatland	1	2	22.57	61.43	114
Tall shrub on shallow peatland	1	42	0.09	61.52	111
Off-system marsh	1	41	0.10	61.62	110
Low vegetation on shallow peatland	3	14	0.70	62.32	110
Low vegetation on shallow peatland	5	8	1.56	63.88	108
Low vegetation on mineral or thin peatland	3	16	0.62	64.49	108
Low vegetation on shallow peatland	1	6	2.15	66.65	104
Nelson River shrub and/or low vegetation on upper beach	1	22	0.46	67.10	99
Nelson River	1	3	19.50	86.60	91

Table 5B-16: Ranking of Coarse Habitat Types Based on Quantities Within a 1000 m Buffer of Caribou Sampling Locations Compared to habitat quantities in Study Zone 4

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Tamarack- black spruce mixture on wet peatland	5	67	0.02	0.06	846
Tamarack- black spruce mixture on riparian peatland	2	97	0.00	0.06	758
Jack pine treed on shallow peatland	2	88	0.00	0.06	584
Black spruce mixedwood on mineral or thin peatland	2	62	0.03	0.10	398
Black spruce treed on riparian peatland	2	54	0.06	0.15	319
Tamarack treed on shallow peatland	2	59	0.03	0.19	296
Low vegetation on riparian peatland	2	40	0.12	0.31	284
Jack pine treed on mineral or thin peatland	2	55	0.05	0.35	279
Tamarack treed on shallow peatland	4	79	0.01	0.36	266
Jack pine mixedwood on mineral or thin peatland	1	30	0.22	0.58	265
Broadleaf treed on all ecosites	2	65	0.02	0.60	225
Black spruce treed on shallow peatland	2	9	1.27	1.87	224
Human infrastructure	6	29	0.26	2.13	179
Black spruce treed on thin peatland	2	12	1.05	3.18	152
Black spruce treed on wet peatland	2	39	0.12	3.30	150
Black spruce treed on mineral soil	3	33	0.19	3.49	149
Shallow water	1	5	3.90	7.39	131
Black spruce treed on shallow peatland	1	1	26.82	34.21	130
Tall shrub on shallow peatland	6	93	0.00	34.21	122
Low vegetation on shallow peatland	2	36	0.15	34.36	122
Tall shrub on riparian peatland	6	84	0.00	34.36	119
Black spruce treed on thin peatland	1	2	23.09	57.45	117
Black spruce mixedwood on shallow peatland	1	70	0.01	57.47	116
Tamarack treed on shallow peatland	1	25	0.33	57.80	114

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Weighted Use (%)
Low vegetation on riparian peatland	1	7	1.40	59.19	113
Black spruce mixedwood on mineral or thin peatland	1	32	0.19	59.38	113
Black spruce treed on riparian peatland	1	18	0.48	59.86	112
Young regeneration on shallow peatland	5	38	0.13	60.00	110
Tall shrub on shallow peatland	1	47	0.09	60.09	108
Broadleaf mixedwood on all ecosites	1	34	0.18	60.27	105
Tall shrub on riparian peatland	1	20	0.43	60.70	104
Tall shrub on mineral or thin peatland	5	42	0.11	60.81	101
Black spruce treed on mineral soil	2	43	0.11	60.92	100
Low vegetation on shallow peatland	1	6	2.07	62.99	100
Off-system marsh	1	49	0.08	63.07	97
Nelson River shrub and/or low vegetation on upper beach	1	19	0.45	63.52	97
Nelson River	1	3	20.13	83.65	94

Table 6B-1: Ranking of Coarse Habitat Types Based on Quantity Within a 100 m Buffer of Beaver Lodge Locations

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Average Area (ha)
Black spruce treed on shallow peatland	1	1	18.13	18.13	0.56
Black spruce treed on thin peatland	1	2	16.02	34.15	0.49
Shallow water	1	3	12.59	46.74	0.39
Low vegetation on riparian peatland	1	4	12.41	59.15	0.38
Tall shrub on riparian peatland	1	5	5.39	64.55	0.17
Nelson River	1	6	4.85	69.40	0.15
Black spruce treed on riparian peatland	1	7	4.75	74.15	0.15
Black spruce treed on shallow peatland	6	8	3.09	77.24	0.10
Black spruce treed on wet peatland	1	9	2.68	79.91	0.08
Low vegetation on shallow peatland	1	10	2.14	82.05	0.07

Table 6B-2: Ranking of Coarse Habitat Types Based on Quantity Within a 250 m Buffer of Beaver Lodge Locations

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Average Area (ha)
Black spruce treed on shallow peatland	1	1	20.82	20.82	4.06
Black spruce treed on thin peatland	1	2	17.75	38.57	3.46
Shallow water	1	3	12.71	51.28	2.48
Low vegetation on riparian peatland	1	4	9.87	61.14	1.92
Nelson River	1	5	4.38	65.52	0.85
Tall shrub on riparian peatland	1	6	3.92	69.44	0.76
Black spruce treed on mineral soil	1	7	3.48	72.92	0.68
Black spruce treed on riparian peatland	1	8	3.35	76.27	0.65
Black spruce treed on thin peatland	6	9	3.01	79.28	0.59
Black spruce treed on shallow peatland	6	10	2.50	81.79	0.49

Table 6B-3: Ranking of Coarse Habitat Types Based on Quantity Within a 500 m Buffer of Beaver Lodge Locations

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Average Area (ha)
Black spruce treed on shallow peatland	1	1	25.53	25.53	19.86
Black spruce treed on thin peatland	1	2	19.11	44.65	14.87
Shallow water	1	3	9.57	54.21	7.44
Low vegetation on riparian peatland	1	4	5.32	59.53	4.14
Black spruce treed on thin peatland	6	7	4.69	64.22	3.65
Black spruce treed on mineral soil	1	5	4.34	68.56	3.38
Nelson River	1	6	4.13	72.70	3.21
Low vegetation on shallow peatland	1	8	2.34	75.03	1.82
Tall shrub on riparian peatland	1	9	2.25	77.28	1.75
Black spruce treed on riparian peatland	1	10	2.06	79.33	1.60
Black spruce treed on wet peatland	1	11	2.02	81.35	1.57

Table 6B-4: Ranking of Coarse Habitat Types Based on Quantity Within a 1000 m Buffer of Beaver Lodge Locations

Coarse Habitat Type	Fire Class	Rank	Proportion (%)	Cumulative Proportion (%)	Average Area (ha)
Black spruce treed on shallow peatland	1	1	27.67	27.67	86.86
Black spruce treed on thin peatland	1	2	21.75	49.42	68.28
Shallow water	1	3	7.54	56.96	23.67
Black spruce treed on thin peatland	6	4	4.91	61.87	15.43
Black spruce treed on mineral soil	1	5	4.16	66.03	13.06
Nelson River	1	6	3.96	69.99	12.42
Low vegetation on riparian peatland	1	7	3.29	73.27	10.32
Black spruce treed on shallow peatland	6	8	2.59	75.87	8.14
Low vegetation on shallow peatland	1	9	2.55	78.42	8.02
Black spruce treed on wet peatland	1	10	1.85	80.27	5.80

Appendix C
Radio-collared Pen Islands Caribou in the Keeyask Region

	2010											2011											2012										
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PEN01	5	4	-	3	3	3	5	5	4	4	3	6	6	-	-	3	5	5	5	5	4	4	3	4	5	5	5	4							
PEN03	5	4	-	6	6	6	6	-	5	-	6	5	-	-	-	-	6	6	6	6	6	-	-	-	-	-	-	6	6	6	6	6	-	-	5
PEN05	5	5	4	4	5	4	4	4	5	6	-	6	-	-	3	3																			
PEN06	5	5	-	-	-	-	5	5	5	6	6	5												-	-	-	-	-	-	-	-				
PEN09	5	5	4	4	4	4	4	4	6	4	5	5	6	-	-	-	4	4	4	4	5	-	-	-	-	-	-	4	4	4	-				
PEN10	5	4	-									6	-	-	-	-	-	-						-	-	-	-								
PEN11												6	-	-	-	-	-	-						-	-	-	-								
PEN12												6	-	-	-	3	3	3	3	3	3	3	3	5	5	5	4	4	4	4	4	3	3	4	
PEN13												6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-							
PEN14												6	-	-	-	-	-	-	-	-	-														
PEN15												6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
PEN16												6	-	-	-	-	-	-																	-
PEN17												6	-	-	-	-	-	-	-	6	6	-													
PEN18												-	-	-	-	-	-	-	-																
PEN19												5	-	-	-	-	-	-																	
PEN20												5	-	-	-	-	-	-						-	-	-	-	-	-	-	-	6	5	-	
PEN21												-	-	-	-	-	-	-						5	5	5	4	3	3	4	3	3	3	3	4
PEN22												-	-	-	-	-	-	-	-	-				-	-	-	-	-	-	-	-	-	-	-	5
PEN23																								5	5	5	5	4	4	4	3	3	3	3	4
PEN24																								5	5	5	4	3	3	4	3	3	3	3	3
PEN25																								5	5	5	4	3	3	3	3	3	3	3	3
PEN26																								5	5	5	4	3	4	3	3	3	3	3	4
PEN27																								5	5	5	5	4	5	5	5	5	5	3	4
PEN28																								-	-	-	-	-	-	-	-				
PEN30														-	-	-	-	-	-					-	-										-

3	**- Zone 1, 2 or 3 (Project Footprint + Zone of effective habitat loss)**
4	**- Zone 4 (Caribou Local Study Area)**
5	**- Zone 5**
6	**- Zone 6 (Caribou Regional Study Area)**
-	**- outside RSA**

Note: Numeric values indicate smallest zone of use during sampling period.

Figure 5C-1: Study Zone Use by 25 Radio-collared Pen Islands Caribou in the Keeyask Region 2010-2012

Appendix D
Trail Camera Studies

Trail camera results from 2010-2012 indicate the minimum number of unique caribou ranged from 6 to 19 animals, depending on survey year. Alternately, the maximum number of unique caribou ranged from 6 to 41 animals, depending on survey year. Minimum counts for each survey year were based on the lower number of animals identified in Period 1 or Period 2 whereas maximum counts were based on the addition of unique animals identified in Periods 1 and 2 minus those identified in both survey periods (Table D-1).

Table D-1: Number of Individual Caribou Identified on Islands Using Trail Cameras Primarily in the Local Study Area from 2010 to 2012

Year	Number of Caribou Identified in Period 1[1]	Number of Caribou Identified in Period 2[2]	Number of Caribou Identified in Periods 1 and 2[3]	Minimum Number of Unique Individuals	Maximum Number of Unique Individuals
2010	19	27	5	19	41
2011	19	17	4	17	32
2012	6	6	0	6	6

1. Mid-May to early July
2. Early July to mid-September
3. May to September

It is expected that the actual number of caribou using the islands in Stephens and Gull lakes and the peatland complexes in areas surrounding these lakes each summer is higher than the maximums presented. This is based on the limitations of cameras in photographing all caribou present in the region and the high number of animals that did not have distinguishing characteristics allowing them to be identified as individual animals. Hundreds of photos captured caribou that were not uniquely identifiable, based on camera frame or angle to the animal. Only 1 radio-collared caribou was photographed on Caribou Island in 2010, of the 9 animals that inhabited Study Zone 4 over the three year trail camera monitoring period.

Also, as detected from trail camera data, an alternate means of estimating the summer resident caribou population was derived from the number of islands occupied by caribou (Table D-2). To calculate values, each trail camera detection on an island (and reported per camera) is assumed to be a single animal. Estimates reported Table D-2 are from presence/absence data. Derivation of these values does not include individual identification at single or multiple islands or stations, or whether or not single or multiple animals were photographed on each island or at each station.

Based on field surveys conducted from 2010 to 2012, and reporting by the minimum and maximum number estimated for each survey period, the number of caribou reported by island ranged from 15 to 22 animals. A high of 28 animals was reported by camera sets. From spring to fall over all survey years, caribou numbers ranged from 15 (by island) to 36 (by camera set). Application of this estimate as representing the actual number of summer-resident caribou using Stephens Lake should be approached cautiously. Based on the identification of individual animals, in 2011 six individuals were recorded as having used two to five calving islands each. Also, some identified caribou were recorded

on camera with calves. Therefore, the assumptions applied above tend to overestimate and underestimate the number of animals in this population, respectively. Mark and recapture methods were not used to estimate the summer resident population because of sparse data and some uncertainties associated with individual identification.

Table D-2: Number of Individual Caribou Estimated on Islands with Trail Cameras Primarily in the Local Study Area from 2010 to 2012

Year	Number of Islands and (Camera Stations) Detecting Caribou in Period 1[1]	Number of Islands and (Camera Stations) Detecting Caribou in Period 2[2]	Number of Islands and (Camera Stations) Detecting Caribou in Periods 1 and 2[3]	Range
2010	24 (26)	22 (26)	32 (36)	22-36
2011	18 (24)	20 (27)	24 (35)	18-35
2012	15 (18)	22 (28)	25 (35)	15-35

1. Mid-May to early July
2. Early July to mid-September
3. May to September

Based on this information, the initial professional judgment estimate of 20-50 summer resident caribou occurring in the Keeyask region is corroborated by the probable range of animal occurrences found in the Local Study Area from spring to fall. Some seasonal variability in summer resident caribou numbers is expected through changes in animal movement patterns, habitat use, and from other factors including mortality.

The summer resident estimate of 20-50 animals is considered conservative because 1) the values do not account for island calving and rearing habitats on which caribou were detected by other means (*e.g.*, sign surveys) but where trail cameras were not located, and 2) these data were not extrapolated to other all other calving and rearing habitats located in the Local Study Area that were not sampled. Based on the trail camera data gathered between 2010 and 2012, it is reasonable to assume that other individuals occupy a proportion of the calving and rearing habitats identified in Section 5.2.3.1.5.

Appendix E
Intactness for Caribou Habitat

Intactness models were applied to the caribou habitat model and followed Environment Canada's (2012) methods for the quantifying critical habitat available to delineated boreal woodland caribou populations in Canada.

WOODLAND CARIBOU CRITICAL HABITAT CALCULATIONS FOR STUDY ZONE 5

Habitat intactness calculations were performed based on the methods used to calculate critical habitat for woodland caribou in the Environment Canada (2012) Boreal Woodland Caribou Recovery Strategy. The calculation of critical habitat varies from the calculation of intactness for Study Zone 5 based on criteria outlined in Table E-1. By this method the entirety of a delineated habitat area is considered potential caribou habitat but where that amount of recently burned habitat (<40 years) and buffered anthropogenic features are reduced from this amount. Through the calculation of undisturbed and disturbed habitat using this method, it is possible to assess the quantity of winter habitat potentially available for caribou while also demonstrating the effects of landscape fragmentation on reducing the amount of habitat available. With the use of buffered anthropogenic features, the potential for increased predator movement (*i.e.*, gray wolf movement on linear corridors) is also considered based the application of a 500-m buffer, where increased predator movements may occur and limit the effectiveness of caribou habitat in these areas.

Table E-1: Comparison of Methods to Determine Boreal Woodland Caribou Habitat: Environment Canada (2012) and Keeyask EIS

Environment Canada	EIS
CARIBOU HABITAT	
Range Area - Area Disturbed	Same except unsuitable habitat removed.
Range Area = The mapped range of a herd.	Zone 5 used as an approximation of a boreal woodland caribou range represented by average ranges across Canada.
Land and water used for range area.	Land area only. Water was any waterbody in National Hydrography Network (NHN) dataset.
Area Disturbed = Recent Burns + Human Disturbance – Large Waterbodies A 500 m diameter circle was used to eliminate island fragments in large disturbed areas.	Same except that all waterbodies in NHN were removed. Same except that fragments smaller than 5 ha were deleted.
Caribou Habitat Percentage = Caribou Habitat divided by Range Area	Same.
Percentage Disturbed = Area Disturbed divided by total range area	Same.
Percentage Burned and Percentage Human Disturbance values are also provided separately	Same. Areas where burns overlapped with human

Environment Canada	**EIS**
in the analysis.	disturbance reclassified as human disturbance.
HUMAN DISTURBANCE	
Human Disturbance = All linear and polygonal anthropogenic features buffered by 500 m.	Same.
Anthropogenic feature is defined as any human-caused disturbance to the natural landscape that could be identified from Landsat imagery at a scale of 1:50,000.	Same except as could be identified from remote sensing at a scale of 1:15,000.
Linear features include roads, powerlines, railways, seismic lines, pipelines, dams, airstrips and unknown.	Same plus narrow cutlines and trails.
Polygonal features include cut areas, mines, settlements, well sites, agriculture, oil and gas wells and unknown.	Same plus perhaps borrow areas.
Global Forest Watch data was the primary data source for linear features. Auxiliary sources used to supplement these features.	Large scale stereo air photos primary data source for all human features. Supplemented with DOIs, Landsat imagery and helicopter-based aerial surveys.
Island area in some reservoirs but not others is human disturbed habitat.	Island area in reservoirs is part of the total caribou land habitat area and not a disturbed area.
All of the remaining undisturbed area is treated as potential habitat before considering burns.	Same.
BURNS	
Recent burns classified as disturbed habitat. **Recent Burn** = Burns that are less than or equal to 40 years old	Same.
Provincial fire database used as the data source for burns.	Photo-interpreted burn history data source for Zone 4. Provincial fire database and multi-temporal satellite imagery for remaining portion of Zone 5. Burn polygons validated where feasible with available data.
Burns not buffered.	Same.
UNSUITABLE HABITAT	
None other than human disturbance and burns.	Human disturbance, burns, broadleaf treed, broadleaf mixedwood treed and tall shrub land cover classes.

Revised estimates of habitat intactness calculated in this report more closely follow those modeling considerations outlined by Environment Canada (2012), where the first iteration and the interpretation of the model, and the potential establishment of the benchmarks associated with it were unclear. As indicated by Environment Canada (2012) in their measurement of critical habitat,

some independent judgment of landscape features as being potential human disturbances was required and could not be removed from the modeling process.

BOREAL WOODLAND CARIBOU CRITICAL HABITAT CALCULATIONS FOR CARIBOU LOCAL AND REGIONAL STUDY AREAS

Based on the application of Environment Canada (2012) protocols to estimate habitat quality for woodland caribou in Study Zone 5, a habitat intactness estimate of 64.4% was calculated within the 1,416,193 ha range (Table E-2). This figure does not take into account the construction of any portion of the Keeyask Project and indicates the extent of hypothetical boreal woodland caribou habitat currently in Study Zone 5.

Estimates for the amount of undisturbed habitat in Study Zone 5 based on the methods used in the EIS indicated 48% of the area was intact. Variation between these two estimates occurred due to differences in the methods used for calculating habitat intactness. The inclusion of lakes and other bodies of water in the Environment Canada (2012) model served to expand the range size from that used in the EIS from 1,237,402 ha to 1,416,193 ha. The smaller range size used in the EIS model resulted in higher disturbance levels as, while amounts of burned habitat were similar between models, the portions of the range affected was 30.4%, using the EC model, compared to 34% for the EIS model.

Differences between calculated levels of habitat disturbance of the EC and EIS models can also be attributed to the spatial scale used to identify linear features. For the EIS model, anthropogenic features were examined at a finer spatial scale, which resulted in a variety of linear features, notably trails, being identified and buffered. Due to this the calculated portion of Study Zone 5 affected by anthropogenic disturbances occurred at higher levels in the EIS model (210, 214 ha) compared to in the EC model (155,135 ha).

Finally, the EIS model did not apply the total non-overlapping areas correctly, but rather treated all anthropogenic disturbances cumulatively.

Table E-2: Boreal Woodland Caribou Habitat in Study Zone 5 Based on Environment Canada and EIS Calculations

	Environment Canada		EIS	
	Area (ha)	Area (%)	Area (ha)	Area (%)
Range size	1,416,193	100	1,237,402	100
Fire	430,839	30.4	425,239	34
Anthropogenic	155,135	11	210,214	17
Total non-overlapping disturbances	501,923	35.4	-	51
Fragment smaller than 20 ha	2,379	0.2	-	-
Fragment smaller than 5 ha	-	-	262	0
Small fragments	-	-	1,046	0
Undisturbed habitat	911,891	64.4%	599,830	48
Disturbed habitat	504,302	35.6%	637,572	52

A comparison of the amounts of disturbed and undisturbed habitat, calculated through use of the EC model, and based on the addition of the Keeyask Project within Study Zone 5, indicated a 0.5% increase in disturbed habitat (Table E-3). Based on the Keeyask Project, the change in undisturbed habitat in Study Zone 5 decreased from 64.4% of the range to 63.9% of the range.

Table E-3: Boreal Woodland Caribou Habitat in Study Zone 5 Before and After Construction of the Keeyask Project

	Existing Environment		Post-Keeyask	
	Area (ha)	Area (%)	Area (ha)	Area (%)
Range size	1,416,193	100.0	1,416,193	100.0
Fire	430,839	30.4	430,839	30.4
Anthropogenic	155,135	11.0	164,635	11.6
Total non-overlapping disturbances	501,923	35.4	509,341	36.0
Fragment smaller than 20 ha	2,379	0.2	2,349	0.2
Undisturbed habitat	911,891	64.4	904,502	63.9
Disturbed habitat	504,302	35.6	511,691	36.1

Changes in the availability of habitat based on the addition of the Keeyask Project with Future Projects including Gillam Redevelopment, Bipole III and the Keeyask Transmission Project indicates a further decrease in the amount of habitat available in Study Zone 5 from 64.4% to 62.7% (Table E-4). This is due to an increase in the amount of anthropogenic disturbance through planned projects and despite a decrease in the total amount of burned habitat.

Table E-4: Boreal Woodland Caribou Habitat in Study Area 5 Before and After Construction of all Planned Projects in Keeyask Region

	Existing Environment		With Future Projects (incl. Keeyask)	
	Area (ha)	Area (%)	Area (ha)	Area (%)
Range size	1,416,193	100%	1,416,193	100.0
Fire	430,839	30.4%	501,923	35.4
Anthropogenic	155,135	11.0%	187,892	13.3
Total non-overlapping disturbances	501,923	35.4%	525,421	37.1
Fragment smaller than 20 ha	2,379	0.2	2,423	0.2
Undisturbed habitat	911,891	64.4	888,349	62.7
Disturbed habitat	504,302	35.6	527,844	37.3

In comparison to calculated levels for the Study Zone 5, intactness calculations for the Caribou Regional Study Area indicated a higher % undisturbed habitat prior to and following construction of the Keeyask Project (E-5). This is due to the Caribou Regional Study Area being approximately twice the geographic size of the Study Zone 5 and where a proportionately lower level of anthropogenic development is present.

Table E-5: Boreal Woodland Caribou Habitat in Caribou Regional Study Area Before and After Construction of the Keeyask Project

	Existing Environment		Post-Keeyask	
	Area (ha)	Area (%)	Area (ha)	Area (%)
Range size	3,049,905	100	3,049,905	100
Fire	959,532	31.5	959,532	31.5
Anthropogenic	193,214	6.3	202,726	6.6
Total non-overlapping disturbances	1,028,907	33.7	1,036,337	34.0
Fragment smaller than 20 ha	5,658	0.20	5,658	0.20
Undisturbed habitat	2,015,340	66.1	2,007,940	65.8
Disturbed habitat	1,034,565	33.9	1,041,965	34.2

Based on the expected increase in anthropogenic development coinciding with the construction of future projects, the quantity of undisturbed habitat in the Caribou Regional Study Area will decrease (E-6).

Table E-6: Boreal Woodland Caribou Habitat in Caribou Regional Study Area Before and After Construction of all Planned Projects in Keeyask Region

	Existing Environment		With Future Projects (incl. Keeyask)	
	Area (ha)	Area (%)	Area (ha)	Area (%)
Range size	3,049,905	100	3,049,905	100
Fire	959,532	31.5	897,072	29.4
Anthropogenic	193,214	6.3	225,982	7.4
Total non-overlapping disturbances	1,028,907	33.7	1,052,416	34.5
Fragment smaller than 20 ha	5,658	0.20	5,628	0.20
Undisturbed habitat	2,015,340	66.1	1,991,786	65.3
Disturbed habitat	1,034,565	33.9	1,058,119	34.7

Calculations to quantify disturbed and undisturbed habitat for boreal woodland caribou in Study Zone 5 varied based on the EIS and Environment Canada (2012) modeling protocols. For both models, the amount of burned habitat greatly contributed in calculations with over 30% of Study Zone 5 having been affected by fires in the past 40 years. The addition of buffered anthropogenic disturbances occurring in Study Zone 5 resulted in the 35% disturbed habitat threshold, identified by Environment Canada (2012), to be surpassed.

Based on calculated intactness estimates, the level of habitat disturbance in Study Zone 5 is expected to increase by 0.5% based on the construction of the Keeyask Project and by 1.7% overall based on the construction of the Keeyask Project in combination with other planned projects in Study Zone 5. The current level of undisturbed habitat in Study Zone 5 is slightly below the 65% threshold, bringing the sustainability of a hypothetical boreal caribou population into the range of uncertainty. Small increases in habitat disturbance based on known future projects will also have incremental effects on increasing the uncertainty with respect to the sustainability of caribou in the region. As Study Zone 5 does not represent a range where the occurrence of caribou is expected to be uniform, landscape disturbances in some areas of Study Zone 5 may not be equally representative of the loss of effective habitat everywhere in this range.

Habitat quality has been identified as a key feature in whether boreal woodland caribou ranges can sustain stable population growth. Of note, Environment Canada (2012), in the federal Woodland Caribou Recovery Strategy, identified a 35% disturbance threshold as being the maximum level of disturbance boreal woodland caribou ranges can sustain; where higher levels of disturbance will reduce the likelihood of population persistence. Factors associated with habitat disturbance, contributing to the 35% disturbance threshold, include recently burned habitat (<40 years of age) and the density of linear features and anthropogenic disturbances on the landscape buffered by 500 m as per expected rates of caribou avoidance. The importance of these factors was determined through research done by Environment Canada (2012) and published scientific findings (Sorensen *et al.* 2008). Table E-7, reproduced in part from Environment Canada (2012) indicates delineated

woodland caribou ranges in Manitoba which range in size from The Kississing range (317,029 ha) to the Manitoba North (6,205,520 ha) and Manitoba East (6,612,782 ha).

Based on a comparison of delineated Manitoba caribou ranges with Study Zone 5 and Study Zone 6, quantities of burned habitat, where present, play a large role in reducing the amount of intact habitat for use by caribou. As Study Zones 5 and 6 are not actual woodland caribou ranges, and were rather used as study areas for use in demonstrating Project effects, it is similar to the Manitoba North and Manitoba East ranges, for which there is also relatively little support for the exact number of animals ranging in these areas (Environment Canada 2012). Alternately, the Manitoba North and Manitoba East delineated ranges act to indicate that there is prospective caribou habitat beyond the well-established caribou ranges in Manitoba.

That the Manitoba North and Manitoba East ranges are indicated as regions of boreal Manitoba where woodland caribou may be supported in part, where large quantities of burned habitat is present is also a situation shared by Study Zone 5 and Study Zone 6. Differences between Keeyask and boreal woodland caribou ranges is that the regional fire disturbance in Zone 5 and 6 (30 and 32%) respectively, is one of the highest compared to all other ranges. Secondly, existing anthropogenic disturbances at Keeyask (11 and 6%) respectively, is one of the lowest disturbed areas compared to all other ranges. The Manitoba North range delineation also overlaps a small portion of the south-eastern extent of Study Zone 6 (Map 12). Based on the similarities between the Manitoba North, and to a more limited extent the Manitoba East range, the habitat attributes facing these ranges should be taken to be in part representative of those also facing caribou in the Keeyask Region. To this extent, the Manitoba North and Manitoba East ranges may be useful as proxies for use in evaluating habitat-related changes on caribou in boreal Manitoba, outside of those caused by marked increases in anthropogenic development.

Table E 7: Habitat Condition for Manitoba Woodland Caribou Ranges based on Environment Canada Woodland Caribou Recovery Strategy (2012)

Range	Range Size (ha)	Intact Habitat (%)	Total Disturbed Habitat (%)	Burned Habitat (%)	Anthropogenic Development (%)
The Bog	446,383	84	16	4	12
Kississing	317,029	49	51	39	13
Naosap	456,977	50	50	28	26
Reed	357,425	74	26	7	20
North Interlake	489,680	83	17	4	14
William Lake	488,219	69	31	24	10
Wabowden	629,938	72	28	10	19
Wapisu	565,044	76	24	10	14
Manitoba North	6,205,520	63	37	23	16
Manitoba South	1,867,255	83	17	4	13
Manitoba East	6,612,782	71	29	26	3
Atikaki-Berens	2,387,665	65	35	31	6
Owl-Flinstone	363,570	61	39	25	18

LITERATURE CITED

Environment Canada. 2012. Recovery strategy for the woodland caribou, boreal population (*Rangifer tarandus caribou*) in Canada. *Species at Risk Act* Recovery Strategy Series. Environment Canada, Ottawa, Ontario. 55 pp + appendices.

Appendix F
Power Analysis of Caribou Calving Islands

A compromise power analysis was performed to determine the statistical power of analyses for future monitoring of caribou on islands in lakes and peatland complex islands. In previous surveys within the Keeyask Region, 108 separate lake islands were surveyed and 87 peatland complex islands were surveyed for adult and calf caribou presence. Using the total number of lake islands and peatland complex islands, the statistical power of future monitoring analyses can be estimated.

For lake islands, a compromise power analysis was based on a Mann-Whitney U test, which could be used to test for differences between track densities, probability of occurrence, or numbers of caribou on islands surveyed in the past to future surveyed islands. The test used a two-tailed, normal distribution, an effect size= 0.2 (small), β/α ratio= 1, and a sample size of 108 islands. A two-tailed test was used as future monitoring may detect and increase or decrease in use of lake islands. Due to the absence of effect sizes of caribou on lake islands in the published literature, a small, conservative effect size of 0.2 was used. The analyses yielded a power of approximately 0.68. This corresponds to being able to detect a significant difference 68% of the time, providing there is a significant difference.

Due to the sample size being relatively fixed (only a certain number of islands that can be sampled), the actual power of the monitoring analyses will be largely dependent on the effect size observed on islands (Figure F-1). Increased power may be achieved by increasing the sample size (number of islands surveyed) in future monitoring efforts; the use of a Mann-Whitney U test to compare results will account for unequal sample sizes.

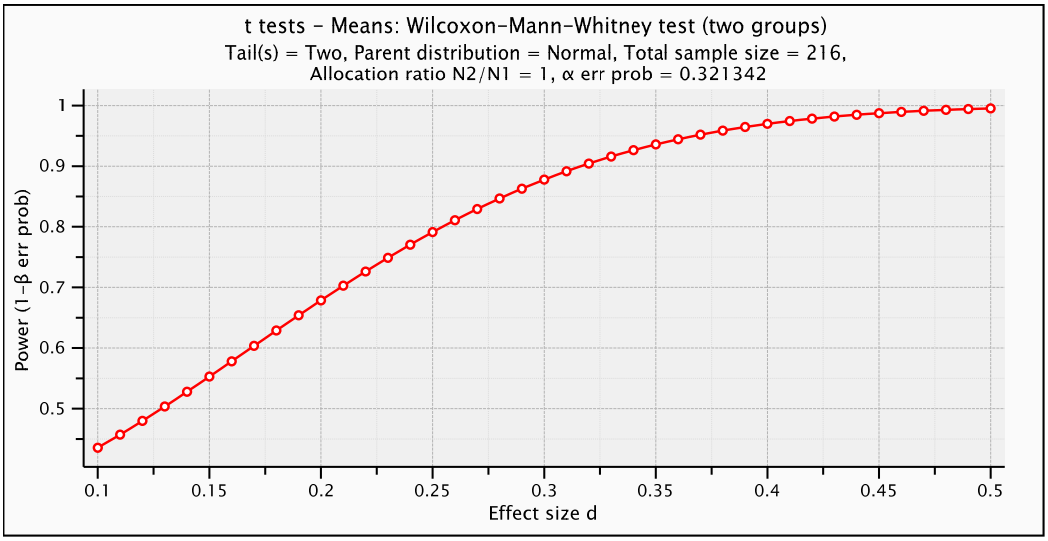


Figure F-1: Relationship Between Effect Size and Statistical Power for Lake Islands

For islands in peatland complexes, a compromise power analysis was based on a Mann-Whitney U test, which could be used to test for differences between track densities, probability of occurrence, or numbers of caribou on islands surveyed in the past to future surveyed peatland islands. The test used a two-tailed, normal distribution, an effect size= 0.2 (small), β/α ratio= 1, and a sample size of 87 peatland islands. A two-tailed test was used as future monitoring may detect and increase or decrease in use of peatland islands. Due to the absence of effect sizes of caribou on peatland islands in the published literature, a small, conservative effect size of 0.2 was used. The analysis yielded a power of

approximately 0.65. This corresponds to being able to detect a significant difference 65% of the time, providing there is a significant difference.

Similar to islands in lakes, the sample size is relatively fixed; therefore, the actual power of the monitoring analyses will be largely dependent on the effect size observed on islands (Figure F-2). Increased power may be achieved by increasing the sample size (number of islands surveyed) in future monitoring efforts; the use of a Mann-Whitney U test to compare results will account for unequal sample sizes.

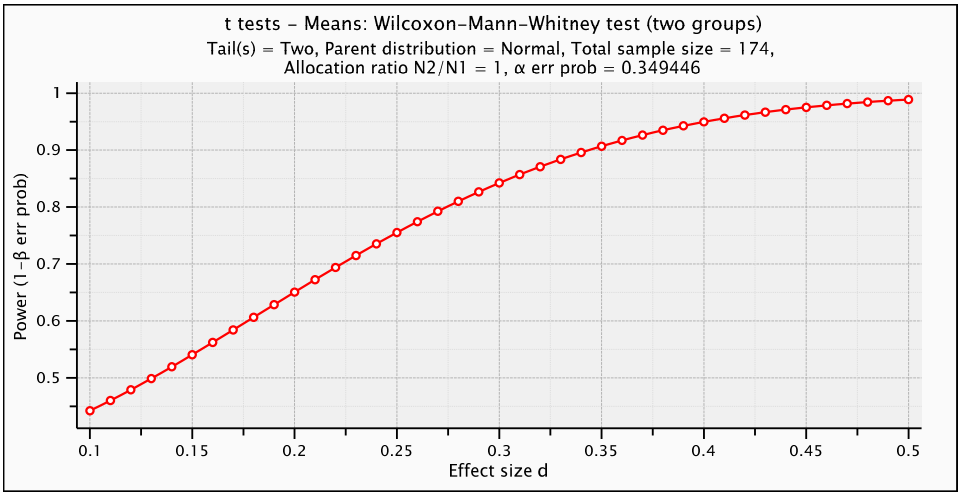


Figure F-2: Relationship Between Effect Size and Statistical Power for Peatland Complex Islands

Appendix G
Results of Habitat Quality Models for Moose, Caribou, and Beaver

Table G-1: Results of the Moose Habitat Quality Model

	V14 Coarse Habitat	Zone 2	Local Study Area		Regional Study Area	
		Existing Area (ha)	Existing Area (ha)	Habitat Loss (%)	Existing Area (ha)	Habitat Loss (%)
Primary Habitat	Broadleaf mixedwood on all ecosites	155.69	810.10	19.22	6123.25	2.54
	Broadleaf treed on all ecosites	180.47	978.80	18.44	7398.32	2.44
	Jack pine mixedwood on mineral and thin peatland	14.00	189.42	7.39	1431.75	0.98
	Jack pine treed on mineral and thin peatland	126.69	1227.69	10.32	9279.59	1.37
	Jack pine treed on shallow peatland	0.02	22.27	0.09	168.36	0.01
	Low vegetation on mineral and thin peatland	466.61	7461.60	6.25	56399.22	0.83
	Off-system marsh	11.86	193.21	6.14	534.08	2.22
	Tall shrub on mineral and thin peatland	77.24	315.81	24.46	2387.09	3.24
	Tall shrub on shallow peatland	33.87	561.63	6.03	4245.12	0.80
	Tall shrub on riparian peatland	230.16	973.51	23.64	7358.37	3.13
	Tall shrub on wet peatland	34.44	212.55	16.20	1606.58	2.14
	Nelson River shrub and/or low vegetation on sunken peat	79.32	236.54	33.53	236.54	33.53
	Nelson River shrub and/or low vegetation on upper beach	186.15	1018.02	18.29	1018.31	18.28
	Black spruce mixedwood on mineral or thin peatland	1.50	120.48	1.25	910.65	0.16
	Black spruce mixedwood on shallow peatland	2.89	25.23	11.45	190.70	1.52
	Black spruce treed on shallow peatland	933.07	6957.40	13.50	52588.17	1.79
	Black spruce treed on mineral soil	246.87	1404.62	17.58	10616.98	2.33
	Black spruce treed on thin peatland	1242.95	9081.80	13.75	68645.62	1.82
	Black spruce treed on riparian peatland	5.88	95.52	6.16	721.99	0.81
	Black spruce treed on wet peatland	15.54	204.87	7.70	1548.55	1.02
	Jack pine mixedwood on mineral or thin peatland	53.64	268.92	19.95	2032.66	2.64
	Jack pine treed on mineral or thin peatland	284.10	1784.96	15.92	13491.82	2.11

	V14 Coarse Habitat	Zone 2	Local Study Area		Regional Study Area	
		Existing Area (ha)	Existing Area (ha)	Habitat Loss (%)	Existing Area (ha)	Habitat Loss (%)
Primary	Jack pine treed on shallow peatland	22.74	62.61	36.32	473.28	4.80
Habitat	Tamarack- black spruce mixture on riparian peatland	1.31	6.08	21.55	45.97	2.85
	Tamarack- black spruce mixture on wet peatland	2.28	42.66	5.34	322.43	0.71
	Tamarack treed on riparian peatland	0.00	1.17	0.00	8.86	0.00
	Tamarack treed on shallow peatland	26.33	71.92	36.61	543.62	4.84
	Tamarack treed on wet peatland	0.44	6.15	7.15	46.47	0.95
	Young regeneration on mineral and thin peatland	0.12	467.89	0.03	3536.57	0.00
	Young regeneration on riparian peatland	0.02	3.45	0.58	26.04	0.08
	Young regeneration on shallow peatland	1.09	268.45	0.41	2029.13	0.05
	Young regeneration on wet peatland	0.13	19.20	0.68	145.15	0.09
Total Primary Habitat (ha)		4437.41	35094.55	12.64	256111.24	1.73
Total Terrestrial Area (ha)		12248.40	163879.39		1228642.26	
Total Habitat (ha)		36.23	21.36		20.79	
Secondary	Black spruce mixedwood on mineral or thin peatland	35.04	389.40	9.00	2943.33	1.19
Habitat	Black spruce mixedwood on shallow peatland	2.34	25.29	9.25	191.13	1.22
	Black spruce treed on mineral soil	1318.52	12374.50	10.66	93533.85	1.41
	Black spruce treed on shallow peatland	2147.21	46880.94	4.58	354354.06	0.61
	Black spruce treed on thin peatland	2845.54	45373.26	6.27	342958.08	0.83
	Black spruce treed on wet peatland	105.07	3225.66	3.26	24381.45	1.40
	Black spruce treed on riparian peatland	42.83	995.30	4.30	7523.05	0.57
	Low vegetation on shallow peatland	710.42	11416.80	6.22	86295.01	0.82
	Low vegetation on wet peatland	145.70	2563.17	5.68	19373.98	0.75
	Low vegetation on riparian peatland	225.58	3007.28	7.50	22730.83	0.99

	V14 Coarse Habitat	Zone 2	Local Study Area		Regional Study Area	
		Existing Area (ha)	Existing Area (ha)	Habitat Loss (%)	Existing Area (ha)	Habitat Loss (%)
Secondary Habitat	Tamarack- black spruce mixture on riparian peatland	0.70	49.56	1.41	374.62	0.19
	Tamarack- black spruce mixture on wet peatland	30.81	1417.41	2.17	10713.62	0.29
	Tamarack treed on riparian peatland	0.00	9.28	0.00	70.14	0.00
	Tamarack treed on wet peatland	2.89	256.04	1.13	1935.31	0.15
	Tamarack treed on shallow peatland	65.82	663.50	9.92	5015.10	1.31
Total Secondary Habitat (ha)		7678.46	128647.39	5.97	972393.56	0.79
Total Terrestrial Area (ha)		12248.40	163879.39		1228642.26	
Total Habitat (%)		62.69	78.50		79.14	
Total Primary and Secondary Habitat (ha)		*12115.87*	*163741.94*	*7.40*	*1228504.80*	*0.99*
Total Terrestrial Area (ha)		*12248.40*	*163879.39*		*1228642.26*	
Total Habitat (%)		*98.92*	*99.91*		*99.98*	

Table G-2: Results of the Caribou Winter Habitat Quality Model

	V14 Coarse Habitat	Zone of Effect (ha)	Local Study Area Existing Area (ha)	Local Study Area Habitat Loss (%)	Study Zone 5 Existing Area (ha)	Study Zone 5 Habitat Loss (%)
Winter Caribou Habitat (Physical Habitat Loss)[1]	Black spruce treed on mineral soil	1318.52	12374.63	10.66	93534.84	1.41
	Black spruce treed on shallow peatland	2147.21	46928.84	4.58	354716.12	0.61
	Black spruce treed on thin peatland	2845.54	45414.54	6.27	343270.10	0.83
	Black spruce treed on wet peatland	105.07	3228.63	3.25	24403.94	0.43
	Black spruce treed on riparian peatland	42.83	995.32	4.30	7523.26	0.57
	Jack pine treed on mineral and thin peatland	126.69	1230.00	10.30	9297.05	1.36
	Jack pine treed on shallow peatland	0.02	22.27	0.09	168.36	0.01
	Tamarack- black spruce mixture on riparian peatland	0.70	49.56	1.41	374.62	0.19
	Tamarack- black spruce mixture on wet peatland	30.81	1417.41	2.17	10713.62	0.29
	Tamarack treed on shallow peatland	65.82	664.59	9.90	5023.40	1.31
	Tamarack treed on riparian peatland	0.00	9.28	0.00	70.14	0.00
	Tamarack treed on wet peatland	2.89	256.04	1.13	1935.31	0.15
Total Primary Habitat (ha)		6686.10	112591.13	5.94	851030.76	0.78
Total Terrestrial Area (ha)		12248.40	163879.39		1228642.26	
Total Habitat (ha)		54.59	68.70		69.27	
Winter Caribou Habitat (Effective Habitat Loss)[2]	Black spruce treed on mineral soil	1029.88	12374.63	8.32	93534.84	1.10
	Black spruce treed on shallow peatland	6290.05	46928.84	13.40	354716.12	1.77
	Black spruce treed on thin peatland	5015.68	45414.54	11.04	343270.10	1.46
	Black spruce treed on wet peatland	360.52	3228.63	11.17	24403.94	1.48
	Black spruce treed on riparian peatland	117.40	995.32	11.80	7523.26	1.56
	Jack pine treed on mineral and thin peatland	200.47	1230.00	16.30	9297.05	2.16

	Jack pine treed on shallow peatland	0.36	22.27	1.62	168.36	0.21
Winter Caribou	Tamarack- black spruce mixture on riparian peatland	10.15	49.56	20.48	374.62	2.71
Habitat (Effective	Tamarack- black spruce mixture on wet peatland	101.01	1417.41	7.13	10713.62	0.94
Habitat Loss)[2]	Tamarack treed on shallow peatland	128.12	664.59	19.28	5023.40	2.55
	Tamarack treed on riparian peatland	0.94	9.28	10.13	70.14	1.34
	Tamarack treed on wet peatland	23.03	256.04	8.99	1935.31	1.19
Total Primary Habitat (ha)		13227.61	112591.13	11.75	851031.00	1.55
Total Terrestrial Area (ha)		20028.22	163879.39		1228642.26	
Total Habitat (%)		66.04	68.70		69.27	
	Black spruce treed on mineral soil	2348.41	12374.63	18.98	93534.84	2.51
Winter Caribou	Black spruce treed on shallow peatland	8437.26	46928.84	17.98	354716.12	2.38
Habitat (Total	Black spruce treed on thin peatland	7861.22	45414.54	17.31	343270.10	2.29
Habitat Loss)[3]	Black spruce treed on wet peatland	465.59	3228.63	14.42	24403.94	1.91
	Black spruce treed on riparian peatland	160.23	995.32	16.10	7523.26	2.13
	Jack pine treed on mineral and thin peatland	327.17	1230.00	26.60	9297.05	3.52
	Jack pine treed on shallow peatland	0.38	22.27	1.71	168.36	0.23
	Tamarack- black spruce mixture on riparian peatland	10.84	49.56	21.87	374.62	2.89
	Tamarack- black spruce mixture on wet peatland	131.82	1417.41	9.30	10713.62	1.23
	Tamarack treed on shallow peatland	193.94	664.59	29.18	5023.40	3.86
	Tamarack treed on riparian peatland	0.94	9.28	10.13	70.14	1.34
	Tamarack treed on wet peatland	25.92	256.04	10.12	1935.31	1.34
Total Primary Habitat (ha)		*19963.71*	*112591.13*	*17.73*	*851030.76*	*2.35*
Total Terrestrial Area (ha)		*32276.62*	*163879.39*		*1228642.26*	
Total Habitat (%)		*61.85*	*68.70*		*69.27*	

1. Physical habitat loss: Study Zone 2
2. Effective habitat loss: portion of Study Zone 3 not containing Study Zone 2
3. Total habitat loss: Study Zone 3

Table G-3: Habitat Quality Changes Following the Development of the Keeyask Generation Project Based on the Application of a Caribou Calving and Rearing Model for Islands in Stephens Lake

	Habitat Quality	Existing Environment (ha)	By Year 30 (ha)	% Change
Study Zone 2	Primary	509.49	384.24	-24.58
	Secondary	37.60	62.17	65.35
	Non	0.84	2.15	155.95
	Total	547.93	448.56	-18.14
Local Study Area	Primary	5,664.63	5,407.59	-4.54
	Secondary	316.95	341.52	+7.75
	Non	236.66	239.65	+1.26
	Total	6,218.24	5988.76	-3.69
Regional Study Area	Primary	13,107.54	12,850.50	-1.96
	Secondary	1,164.40	1,188.97	+2.11
	Non	937.63	940.35	+0.29
	Total	15,209.29	14,979.81	-1.51

Table G-4: Habitat Quality Changes Following the Development of the Keeyask Generation Project Based on the Application of a Caribou Calving and Rearing Model for Peatland Complexes in the Keeyask region

		Zone of Effect	Local Study Area		Regional Study Area[1]	
	Habitat Quality	**Existing Area (ha)**	**Existing Area (ha)**	**Habitat Loss (%)**	**Existing Area (ha)**	**Habitat Loss (%)**
Physical habitat loss (Study Zone 2)	Primary	0	5,675.95	0	144,593.70	0
	Secondary	69.02	2,596.44	1.56	45,374.61	0.09
	Non	0	253.12	0	7,651.39	0
	Total	69.02	8,525.51	0.34	189969.31	0.02
Effective habitat loss (Study Zone 3 without Study Zone 2)	Primary	0	5,675.95	<0.01	144,593.70	0
	Secondary	674.40	2,596.44	25.97	45,374.61	1.49
	Non	0	253.12	0	7,651.39	0
	Total	674.40	8,525.51	7.91	189969.31	0.36
Total habitat loss (Study Zone 3)	Primary	0	5,675.95	0	144,593.70	0
	Secondary	743.43	2,596.44	27.51	45,374.61	1.57
	Non	0	253.12	0	7,651.39	0
	Total	743.43	8,525.51	8.72	189969.31	0.39

Table G-5: Results of the Beaver Habitat Quality Model

	V14 Coarse Habitat	Zone 2 Existing Area (ha)	Local Study Area Existing Area (ha)	Local Study Area % Habitat Lost	Regional Study Area Existing Area (ha)	Regional Study Area % Habitat Lost
Primary Habitat Classes	Broadleaf mixedwood on all ecosites	4.17	9.61	43.39	36.11	11.55
	Broadleaf treed on all ecosites	20.65	46.11	44.78	90.74	22.76
	Tall shrub on mineral and thin peatland	5.80	17.36	33.41	83.99	6.91
	Tall shrub on shallow peatland	8.20	61.90	13.25	192.72	4.25
	Tall shrub on riparian peatland	97.56	197.83	49.32	547.31	17.83
	Tall shrub on wet peatland	11.10	38.65	28.72	132.25	8.39
	Nelson River shrub and/or low vegetation on sunken peat	12.37	14.02	88.21	24.99	49.49
	Off-system Marsh	11.86	30.67	38.67	193.21	6.14
Total Primary Habitat (ha)		171.71	416.15	39.62	1301.33	12.48
Total Terrestrial Area (ha)		12248.40	32276.62		163879.39	
Habitat:Terrestrial (%)		1.40	1.29		0.79	
Secondary Habitat Classes	Black spruce mixedwood on mineral or thin peatland	1.60	2.89	55.36	13.19	12.13
	Black spruce mixedwood on shallow peatland	0.98	1.85	52.97	2.03	48.28
	Black spruce treed on mineral soil	72.23	103.54	69.76	918.45	7.86
	Black spruce treed on shallow peatland	283.51	976.95	29.02	5377.93	5.27
	Black spruce treed on thin peatland	260.02	674.91	38.53	5628.26	4.62
	Black spruce treed on wet peatland	19.04	92.26	20.64	580.57	3.28
	Black spruce treed on riparian peatland	35.66	142.89	24.96	896.71	3.98
	Jack pine mixedwood on mineral and thin peatland	5.20	10.19	51.03	14.49	35.89
	Jack pine treed on mineral or thin peatland	1.78	28.98	6.12	143.88	1.23
	Jack pine treed on shallow peatland	0	0.56	0	3.80	0
	Low vegetation on mineral and thin peatland	16.28	130.14	12.51	883.89	1.84

	V14 Coarse Habitat	Zone 2 Existing Area (ha)	Local Study Area Existing Area (ha)	Local Study Area % Habitat Lost	Regional Study Area Existing Area (ha)	Regional Study Area % Habitat Lost
	Low vegetation on shallow peatland	44.19	264.45	16.71	1532.37	2.88
	Low vegetation on wet peatland	25.83	72.39	35.68	503.83	5.13
	Low vegetation on riparian peatland	148.86	438.53	33.95	2392.52	6.22
	Tamarack- black spruce mixture on riparian peatland	0.54	2.92	18.49	33.63	1.61
	Tamarack- black spruce mixture on wet peatland	3.81	12.66	30.09	180.28	2.11
	Tamarack treed on shallow peatland	9.15	28.21	32.42	107.43	8.51
	Tamarack treed on riparian peatland	0	1.66	0	6.95	0
	Tamarack treed on wet peatland	0.13	3.64	3.57	32.45	0.40
	Young regeneration on mineral and thin peatland	0	1.25	0.00	65.62	0.00
	Young regeneration on shallow peatland	0.94	2.64	35.61	31.29	3.00
	Young regeneration on wet peatland	0.12	0.12	100.00	1.92	6.25
	Young regeneration on riparian peatland	0.02	0.31	6.45	3.13	0.64
Total Secondary Habitat (ha)		929.88	2993.96	31.06	19354.63	4.80
Total Terrestrial Area (ha)		12248.40	32276.62		163879.39	
Habitat:Terrestrial (%)		7.59	9.28		11.81	
Total Habitat (ha)		*1101.59*	*3410.11*	*32.30*	*20655.96*	*5.33*
Total Terrestrial Area (ha)		*12248.40*	*32276.62*		*163879.39*	
Habitat:Terrestrial (%)		*8.99*	*10.57*		*12.60*	

Appendix H
Potential Importance of Food to Moose, Caribou, and Beaver in the Keeyask Region

MOOSE

Table H-1: Potential Importance of Moose Forage Plants Present in the Keeyask Region (Renecker and Schwartz 2007; ECOSTEM Ltd. 2012)

Common name	Scientific name	Summer/Winter/ Preferred	Value
Terrestrial plants			
Common yarrow	Achillea millefolium borealis	S	✓
Speckled alder	Alnus incana ssp. rugosa	SW	✓✓
Green or mountain alder	Alnus viridis	SW	✓✓
Dwarf birch	Betula glandulosa	SW	✓✓
White birch	Betula papyrifera	SWP	✓✓✓
Wild calla	Calla palustris	S	✓
Marsh-marigold	Caltha palustris	S	✓
Fireweed	Chamerion angustifolium	S	✓
Canada thistle	Cirsium arvense	S	✓
Bunchberry	Cornus canadensis	S	✓
Red osier dogwood	Cornus sericea	SWP	✓✓✓
Round-leaved sundew	Drosera rotundifolia	S	✓
Wolf-willow	Elaeagnus commutata	SW	✓✓
Common or Field horsetail	Equisetum arvense	SP	✓✓
Meadow horsetail	Equisetum pratense	SP	✓✓
Dwarf scouring rush	Equisetum scirpoides	SP	✓✓
Wood horsetail	Equisetum sylvaticum	SP	✓✓
Tamarack	Larix laricina	S	✓
Glaucous honeysuckle	Lonicera dioica	S	✓
Sweet gale	Myrica gale	S	✓
White spruce	Picea glauca	W	✓
Black spruce	Picea mariana	W	✓
Balsam-poplar	Populus balsamifera	SWP	✓✓✓
Trembling aspen	Populus tremuloides	SWP	✓✓✓
Pin-cherry	Prunus pensylvanica	SW	✓✓
Large-leaved white water-crowfoot	Ranunculus aquatilis	S	✓
Alder-leaved buckthorn	Rhamnus alnifolia	S	✓
Labrador-tea	Rhododendron groenlandicum	S	✓
Northern labrador-tea	Rhododendron tomentosum	S	✓
Wild black currant	Ribes americanum	S	✓

Common name	Scientific name	Summer/Winter/ Preferred	Value
Northern gooseberry	Ribes oxyacanthoides	S	✓
Red currant	Ribes triste	S	✓
Prickly rose	Rosa acicularis	S	✓
Cloudberry	Rubus chamaemorus	S	✓
Red raspberry	Rubus idaeus	S	✓
Shrubby willow	Salix arbusculoides	SWP	✓✓✓
Pussy-willow	Salix discolor	SWP	✓✓✓
Grey-leaved willow	Salix glauca L.	SWP	✓✓✓
Shining willow	Salix lucida ssp. Lasiandra	SWP	✓✓✓
Myrtle-leaved willow	Salix myrtillifolia	SWP	✓✓✓
Flat-leaved willow	Salix planifolia	SWP	✓✓✓
Canada buffalo-berry	Shepherdia canadensis	SW	✓✓
Snowberry	Symphoricarpos albus	SW	✓✓
Alsike clover	Trifolium hybridum	S	✓
Rock cranberry	Vaccinium vitis-idaea	S	✓
Low bush-cranberry	Viburnum edule	S	✓
Aquatic plants			
Water horsetail	Equisetum fluviatile	SP	✓✓
Marsh horsetail	Equisetum palustre	SP	✓✓
Small yellow pond-lily	Nuphar variegata	SP	✓✓
Various-leaved pondweed	Potamogeton gramineus	SP	✓✓
Richardson's pondweed	Potamogeton richardsonii	SP	✓✓
Robbin's pondweed	Potamogeton robbinsii	SP	✓✓
Sea-side arrow-grass	Triglochin maritima	S	✓
Common cat-tail	Typha latifolia	S	✓
Common bladderwort	Utricularia macrorhiza	S	✓

Table H-2: Potential Importance of Coarse Habitat Types to Moose (ECOSTEM Ltd. 2012; Renecker and Schwartz 2007)

Coarse Habitat Type	Tree and Shrub species present	Food	
		Summer	Winter
Black spruce mixedwood on mineral or thin peatland	**Trees:** black spruce mixed with trembling aspen and sometimes tamarack, occasional white spruce **Tall Shrubs:** often dense green alder, some speckled alder, willow, buffaloberry and/or bog birch **Understorey:** often rich in species, composed primarily of low shrubs including rock cranberry and Labrador tea, herbs including palmate-leaved coltsfoot and twinflower, and feather-mosses	✓✓	✓✓
Black spruce mixedwood on shallow peatland	**Trees:** black spruce, mixed with white birch or balsam poplar **Tall Shrubs:** often dense, speckled alder or green alder, usually mixed with willow and occasionally bog birch **Understorey:** usually rich, with widespread low shrubs including Labrador tea and rock cranberry; herbs including wood horsetail and bishop's cap; and stair-step moss	✓✓	✓✓
Black spruce treed on mineral soil	**Trees:** black spruce dominated, with occasional tamarack (moister), or jack pine, potential for broadleaf (drier) **Tall Shrubs:** green alder in varying densities, often with some willow. Occasionally bog birch **Understorey:** Occasionally rich, dominated by low shrubs including Labrador tea and rock cranberry; and abundant lichens and feather-mosses	✓✓	✓✓
Black spruce treed on riparian peatland	Specific vegetation composition information not available (Likely containing food)	✓✓	✓
Black spruce treed on shallow peatland	**Trees:** black spruce dominated Tall Shrubs: scarce	✓	✓

Coarse Habitat Type	Tree and Shrub species present	Food	
		Summer	Winter
	Understorey: dominated by low shrubs, including Labrador tea, rock and small cranberry; cloudberry and reindeer lichens are widespread, and sphagnum and feather-mosses comprise the remaining ground cover		
Black spruce treed on thin peatland	**Trees:** black spruce dominated, with occasional tamarack (moister), or jack pine, potential for broadleaf (drier) **Tall Shrubs:** green alder in varying densities, often with some willow. Occasionally bog birch **Understorey:** Occasionally rich, dominated by low shrubs including Labrador tea and rock cranberry; and abundant lichens and feather-mosses	✓✓	✓✓
Black spruce treed on wet peatland	**Trees:** small diameter black spruce, scattered tamarack often present **Tall Shrubs:** composed of bog birch and willow in varying densities **Understorey:** rich; low shrubs including leather-leaf, small bog cranberry, Labrador tea, rock cranberry and bog bilberry; herbs including sedges , three-leaved false Solomon's seal, cloudberry and wood horsetail; ground cover dominated by sphagnum and other moss species	✓	✓✓
Broadleaf mixedwood on all ecosites	**Trees:** white birch or trembling aspen mixed with jack pine or black spruce **Tall Shrubs:** green alder, denser on fresh sites, sparser on drier sites Understory: rich with low shrubs including prickly rose and rock	✓✓	✓✓✓

Coarse Habitat Type	Tree and Shrub species present	Food	
		Summer	Winter
	cranberry, herbs including bunchberry and twinflower; and mosses with feather-mosses more widespread on drier sites		
Broadleaf treed on all ecosites	**Trees:** trembling aspen or white birch dominated, some black spruce or jack pine **Tall Shrubs:** Dense, dominated by green alder Understory: rich with low shrubs including prickly rose, rock cranberry and Labrador tea; herbs including bunchberry and twinflower, and mosses	✓✓	✓✓✓
Human infrastructure	**Trees:** Varies Tall Shrubs: Varies		
Jack pine mixedwood on mineral or thin peatland	**Trees:** jack pine mixed with trembling aspen or white birch and black spruce **Tall Shrubs:** dense, dominated by green alder **Understorey:** Abundant low shrubs including rock-cranberry, Labrador tea and velvet-leaf blueberry; herbs including bunchberry, twinflower and fireweed; and abundant feathermosses	✓✓	✓✓✓
Jack pine treed on mineral or thin peatland	**Trees:** jack pine dominated, sometimes with black spruce **Tall Shrubs:** dominated by green alder at highly variable densities **Understorey:** Often rich, dominated by low shrubs including rock cranberry, Labrador tea and prickly rose; herbs include bunchberry, twinflower and fireweed; and feather-mosses are common	✓✓	✓✓✓
Jack pine treed on shallow peatland	**Trees:** jack pine in mixture with black spruce and occasionally tamarack	✓✓	✓✓✓

Coarse Habitat Type	Tree and Shrub species present	Food	
		Summer	Winter
	Tall Shrubs: predominately willow and/or bog birch **Understorey:** rich, with widespread low shrubs, including Labrador tea, bog bilberry and rock cranberry; herbs including alpine bearberry, dwarf scouring rush and sedges, as well as feather-mosses and lichens		
Low vegetation on mineral or thin peatland	**Trees:** scattered seedlings, small black spruce or white birch up to three meters tall **Tall Shrubs:** scarce, often may be scattered willow **Understorey:** dominated by low shrubs such as Labrador tea; lichens and mosses are also widespread	✓✓	✓✓
Low vegetation on riparian peatland	**Trees:** Occasional small scattered black spruce or tamarack usually less than two metres tall **Tall Shrubs:** occasionally sparse willow **Understorey:** Primarily sphagnum mosses, low shrubs including leather-leaf and small bog cranberry; herbs include three-leaved false Solomon's seal	✓	✓
Low vegetation on shallow peatland	**Trees:** scattered black spruce may occur **Tall Shrubs:** sparse willow and bog birch **Understorey:** low shrubs including Labrador tea, herbs including cloudberry and three-leaved Solomon's seal; and widespread sphagnum mosses and club lichens	✓	✓
Low vegetation on wet peatland	**Trees:** Occasional small scattered black spruce or tamarack usually less than two m tall **Tall Shrubs:** occasionally sparse	✓	✓

Coarse Habitat Type	Tree and Shrub species present	Food	
		Summer	Winter
	willow **Understorey:** Primarily sphagnum mosses, low shrubs including leather-leaf and small bog cranberry; herbs include three-leaved false Solomon's seal		
Nelson River marsh	Shallow water. Emergent vegetation dominated by water horsetail, with bottle sedge and water smartweed.	✓	✓
Nelson River shrub and/or low vegetation on ice scoured upland	Specific vegetation composition information not available – no field data.	✓✓	✓
Nelson River shrub and/or low vegetation on sunken peat	Specific vegetation composition information not available	✓✓	✓
Nelson River shrub and/or low vegetation on upper beach	**Trees:** Untreed **Tall Shrubs:** often dense flat-leaved willow when present, bog bilberry and sweet gale frequent in the Stephens reach **Low Vegetation:** silverweed and narrow reed grass and water sedge frequent in the Keeyask reach, and common horsetail, marsh-five-finger and sedge species more common in the Stephens reach	✓✓	✓✓
Off-system marsh	**Trees:** Untreed Tall Shrubs: None Emergent & vegetation: water horsetail and needle spike-rush, with creeping spike-rush on mineral substrates Floating-leaved vegetation: Various-leaved pondweed and yellow pond-lily, narrow-leaved bur-reed, large-leaved white water crowfoot and arum-leaved arrowhead Submerged vegetation: pondweeds, spiked water-milfoil	✓✓✓✓	

Coarse Habitat Type	Tree and Shrub species present	Food	
		Summer	Winter
	and common bladderwort		
Tall shrub on mineral or thin peatland	**Trees:** scattered stems of black spruce or white birch may be present **Tall Shrubs:** dense willow, often mixed with bog birch and speckled alder **Understorey:** rich in species, dominated by herbs including marsh reed grass, common horsetail and stemless raspberry. Labrador tea is widespread and various moss species usually are present	✓✓	✓✓✓
Tall shrub on riparian peatland	**Trees:** black spruce, white birch **Tall Shrubs:** willow, speckled alder or bog birch	✓✓	✓✓✓
Tall shrub on shallow peatland	**Trees:** scattered tamarack, white birch or black spruce may occur **Tall Shrubs:** willow, speckled alder and bog birch **Understorey:** rich, dominated by sphagnum and other mosses. Low shrubs include Labrador tea and leatherleaf; herbs include three-leaved false Solomon's seal, sedges, swamp horsetail and marsh five-finger	✓✓	✓✓✓
Tall shrub on wet peatland	**Trees:** occasionally scattered short black spruce or white birch **Tall Shrubs:** Dense, dominated by willow, sometimes with speckled alder or bog birch **Understorey:** primarily moss species; other scattered species include leather-leaf, sedges, three-leaved false Solomon's seal and marsh-five-finger	✓✓	✓✓✓
Tamarack- black spruce mixture on riparian peatland	Specific vegetation composition information not available	✓✓	✓
Tamarack- black spruce	**Trees:** small diameter black	✓✓	✓✓

Coarse Habitat Type	Tree and Shrub species present	Food	
		Summer	Winter
mixture on wet peatland	spruce, tamarack **Tall Shrubs:** usually dense, comprised of bog birch and willow **Understorey:** ground cover dominated by sphagnum mosses; low shrubs including leather-leaf, small bog cranberry and Labrador tea; herbs including swamp horsetail, three-leaved false Solomon's seal and marsh-five-finger		
Tamarack treed on riparian peatland	Specific vegetation composition information not available	✓✓	✓✓
Tamarack treed on shallow peatland	**Trees:** mixture of small black spruce and tamarack **Tall Shrubs:** sparse to abundant willow **Understorey:** Widespread and abundant Labrador tea and rock cranberry, widespread reindeer lichen, feathermoss, and bog bilberry	✓✓	✓✓
Tamarack treed on wet peatland	**Trees:** small diameter tamarack, often with scattered black spruce **Tall Shrubs:** often dense, mostly bog birch **Understorey:** Ground cover dominated by sphagnum mosses; low shrubs including leather-leaf and small bog cranberry; herbs include bogbean, bog rosemary, three-leaved false Solomon's seal, water horsetail, marsh-five-finger and round-leaved sundew	✓✓	✓
Young regeneration on mineral or thin peatland	**Trees:** Sparse white birch saplings and small trees, jack pine and black spruce saplings, black spruce seedlings where present. Occasionally scattered large jack pine. **Tall Shrubs:** absent to moderate green alder, to sparse willow	✓✓	✓✓

Coarse Habitat Type	Tree and Shrub species present	Food	
		Summer	Winter
	and/or bog birch. **Understorey:** Widespread Labrador tea, moss species and rock cranberry.		
Young regeneration on riparian peatland	No plot representation. See tall shrub on riparian peatland fact sheet; Figure 7-31 in terrestrial habitat technical report.	✓✓	✓✓
Young regeneration on shallow peatland	**Trees:** usually sparse black spruce seedlings and saplings when present. **Tall Shrubs:** absent to dense bog birch, occasionally willow **Understorey:** abundant sphagnum moss, small bog cranberry, sedges.	✓✓	✓
Young regeneration on wet peatland	One plot available: **Trees:** absent Tall Shrubs: absent **Understorey:** Widespread and abundant Labrador tea; widespread moss species and rock cranberry.	✓✓	✓

Table H-3: Potential Importance of Caribou Forage Species Present in the Keeyask Study Area (Kelsall 1968; Bergerud 1972; Bergerud 1977; Crête and Gauthier 1990; Bradshall *et al.* 1995; ECOSTEM Ltd. 2012)

Common name	Scientific name	Summer/Winter/	Preferred	Value
Terrestrial plants				
Water sedge	Carex aquatilis	SW		✓✓
Awned sedge	Carex atherodes	SW		✓✓
Golden sedge	Carex aurea	SW		✓✓
Bebb's sedge	Carex bebbii	SW		✓✓
Brownish sedge	Carex brunnescens	SW		✓✓
Brown sedge	Carex buxbaumii	SW		✓✓
Hoary sedge	Carex canescens	SW		✓✓
Hair-like sedge	Carex capillaris	SW		✓✓
Prostrate sedge	Carex chordorrhiza	SW		✓✓
Beautiful sedge	Carex concinna	SW		✓✓
Bent sedge	Carex deflexa	SW		✓✓
Lesser panicled sedge	Carex diandra	SW		✓✓
Two-seeded sedge	Carex disperma	SW		✓✓
Northern bog sedge	Carex gynocrates	SW		✓✓
Sand sedge	Carex houghtoniana	SW		✓✓
Lakeshore sedge	Carex lacustris	SW		✓✓
Lens-fruited sedge	Carex lenticularis	SW		✓✓
Bristle-stalked sedge	Carex leptalea	SW		✓✓
Bog Sedge	Carex magellanica	SW		✓✓
Wooly sedge	Carex pellita	SW		✓✓
Sartwell's sedge	Carex sartwellii	SW		✓✓
Rush-like sedge	Carex scirpoidea	SW		✓✓
Long-beaked sedge	Carex sychnocephala	SW		✓✓
Thin-flowered sedge	Carex tenuiflora	SW		✓✓
Three-seeded sedge	Carex trisperma	SW		✓✓
Bottle sedge	Carex utriculata	SW		✓✓
Sheathed sedge	Carex vaginata	SW		✓✓
Labrador-tea	Rhododendron groenlandicum	SW		✓
Shrubby willow	Salix arbusculoides	S		✓
Pussy-willow	Salix discolor	S		✓
Grey-leaved willow	Salix glauca L.	S		✓
Shining willow	Salix lucida ssp. Lasiandra	S		✓
Myrtle-leaved willow	Salix myrtillifolia	S		✓

Common name	Scientific name	Summer/Winter/	Preferred	Value
Flat-leaved willow	Salix planifolia	S		✓
Canada buffalo-berry	Shepherdia canadensis	S		✓
Snowberry	Symphoricarpos albus	S		✓
Common bearberry	Arctostaphylos uva-ursi	S		✓
Dwarf birch	Betula glandulosa	S		✓
Black crowberry	Empetrum nigrum	S		✓
Common juniper	Juniperus communis	SW		✓
Speckled alder	Alnus incana	S		✓
Green or mountain alder	Alnus viridis	S		✓
White spruce	Picea glauca	SW		✓
Black spruce	Picea mariana	SW		✓
Small bog cranberry	Vaccinium oxycoccos L.	S		✓✓
Bog bilberry	Vaccinium uliginosum L.	S		✓✓
Rock cranberry	Vaccinium vitis-idaea L.	S		✓✓
Aquatic plants				
Pondweed	Potamogeton spp.	S		✓
Baldderwort	Utricularia spp.	S		✓
Small yellow pond-lily	Nuphar variegata	S		✓
Terrestrial lichens				
Green reindeer lichen	Cladina mitis	SWP		✓✓✓
Grey reindeer lichen	Cladina rangiferina	SWP		✓✓✓
Northern reindeer lichen	Cladina stellaris	SWP		✓✓✓
Arboreal lichens[1]				
Wila	Alectoria jubata	SWP		✓✓✓
Witch's hair lichen	Alectoria sarmentosa	SWP		✓✓✓
American tuckermannopsis lichen	Cetraria ciliaris	SWP		✓✓✓
Boreal oakmoss lichen	Evernia mesomorpha	SWP		✓✓✓
Monk's hood lichen	Parmelia physodes	SWP		✓✓✓
Old man's beard	Usnea spp.	SWP		✓✓✓

1. Abundance and distribution of arboreal lichens was not determined in the Keeyask Regional Study Areas

BEAVER

Table H-4: Potential importance of beaver forage plants present in the Keeyask Study Area (Wheatley 1994; Baker and Hill 2003; ECOSTEM Ltd. 2012)

Common name	Scientific name	Summer/Winter/ Preferred	Value
Terrestrial plants			
Speckled alder	Alnus incana ssp. rugosa	SW	✓✓
Green or mountain alder	Alnus viridis	SW	✓✓
Dwarf birch	Betula glandulosa	SW	✓✓
White birch	Betula papyrifera	SW	✓✓
Bunchberry	Cornus canadensis	SW	✓✓
Red osier dogwood	Cornus sericea	SW	✓✓
Jack pine	Pinus banksiana	S	✓
Trembling aspen	Populus tremuloides	SWP	✓✓✓
Balsam-poplar	Populus balsamifera	SWP	✓✓✓
Red raspberry	Rubus idaeus	S	✓✓
Shrubby willow	Salix arbusculoides	SWP	✓✓
Pussy-willow	Salix discolor	SWP	✓✓
Grey-leaved willow	Salix glauca L.	SWP	✓✓
Shining willow	Salix lucida ssp. Lasiandra	SWP	✓✓
Myrtle-leaved willow	Salix myrtillifolia	SWP	✓✓
Flat-leaved willow	Salix planifolia	SWP	✓✓
Aquatic plants			
Canada waterweed	Elodea canadensis	S	✓
Water horsetail	Equisetum fluviatile	S	✓
Marsh horsetail	Equisetum palustre	S	✓
Small yellow pond-lily	Nuphar variegata	SP	✓✓
Various-leaved pondweed	Potamogeton gramineus	S	✓
Richardson's pondweed	Potamogeton richardsonii	S	✓
Robbin's pondweed	Potamogeton robbinsii	S	✓
Common cattail	Typha latifolia	S	✓

Appendix I
Additional Analyses and Results Used to Inform Expert Information Models for Beaver, Caribou, and Moose

BEAVER

Comparison of Study Zones 1-3 and Study Zones 4-5

Data from the 2001, 2003, 2006, and 2011 aerial surveys for beaver lodges were used to compare areas potentially impacted by the Keeyask Generation Project to areas in the region (Table I-1). Active beaver lodges within Study Zones 1, 2, and 3 were considered potentially impacted by the Project and lodge within Study Zones 4 and 5 were assumed to be unaffected. Beaver lodge densities within Study Zones 1, 2, and 3 were compared with lodge densities from Study Zones 4 and 5 using a Mann-Whitney U test.

Table I-1: Beaver lodge numbers and densities within Study Zones 1, 2, 3 and within Study Zones 4 and 5

	Zone 1-3			Zone 4-5		
Year	No. of Active Lodges	Transect Length (km)	Lodge Density (lodges/km)	No. of Active Lodges	Transect Length (km)	Lodge Density (lodges/km)
2001	60	416.95	0.14	231	976.12	0.24
2003	53	306.96	0.17	266	905.93	0.29
2006	18	59.03	0.30	97	315.35	0.31
2011	40	70.96	0.56	11	28.30	0.39
Total	171	853.90	0.20	605	2225.70	0.27

Results of the Mann-Whitney U test indicated that there was no significant differences in beaver lodge densities between Study Zones 1, 2, and 3, compared to Study Zones 4 and 5 (Mann-Whitney test statistic= 6.00, P= 0.564).

Comparison of Waterbody Types in the Beaver Regional Study Area

Data from the 2001 and 2003, fall, aerial surveys for beaver lodges were used to compare lodge densities between different waterbody types with the Beaver Regional Study Area (Study Zone 4). A Kruskal-Wallis test was used to compare lodge densities between lake, pond, river, and stream waterbodies (Table I-2).

Table I- 2 Beaver lodge densities in the Beaver Regional Study Area (Study Zone 4) in different waterbodies from fall, aerial surveys conducted in 2001 and 2003

Year	Lake			Pond			River			Stream		
	No. Active Lodges	Transect Length (km)	Lodge Density (lodges/km)	No. Active Lodges	Transect Length (km)	Lodge Density (lodges/km)	No. Active Lodges	Transect Length (km)	Lodge Density (lodges/km)	No. Active Lodges	Transect Length (km)	Lodge Density (lodges/km)
2001	18	253.2	0.07	12	51.34	0.23	5	204.28	0.02	30	76	0.39
2003	7	225.66	0.03	16	51.34	0.31	3	59.74	0.05	57	141.5	0.40
Total	25	478.86	0.05	28	102.68	0.27	8	264.02	0.03	87	217.5	0.40

Results of the Kruskal-Wallis test indicated that there was no significant difference between beaver lodge densities in lake, pond, river, or stream waterbodies (Kruskal-Wallis test statistic= 2.593, P= 0.459).

Comparison of Waterbody Types in Study Zone 1

Data from the 2011 fall, aerial survey for beaver lodges were used to compare lodge densities between unnamed lakes, ponds, streams, and the central Nelson River within Study Zone 1. Sample sizes were insufficient for unnamed lakes and the central Nelson River to make comparisons. Therefore, a Mann-Whitney U test was used to compare lodge densities between ponds and streams (Table I-3).

Table I-3: Beaver lodge densities in Study Zone 1 in different waterbodies from fall, aerial surveys conducted in 2001 and 2003

Water Type	No. Active Lodges	Lodge Density (lodges/km)
Unnamed Lakes	0	0
Ponds	4	0.1
Streams	18	0.44
Central Nelson River	1	0.02
Total	23	0.56

Results of the Mann-Whitney U test indicated that lodge densities in streams approached significantly higher levels compared to densities in ponds within Study Zone 1 (Mann-Whitney test statistic= 22.00, P=0.051).

Comparison of North and South Shores

Data from the lake perimeter and riparian sign survey transects in 2002 and 2003 were used to compare the frequency of beaver sign along the north and south shores of Gull and Stephens Lake (Table I-4). A Mann-Whitney U test was to compare beaver sign frequency along the north and south shores of Gull and Stephens Lake.

Table I-4: Frequency of beaver signs from riparian, sign survey transects along the north and south shores of Gull and Stephens Lake in the beaver Regional Study Area in 2002 and 2003

Shore	2002 No. of Signs	Mean Signs/ 100 m^2	2003 No. of Signs	Mean Signs/ 100 m^2	Total No. of Signs	Mean Signs/ 100 m^2
North	52	0.14	57	0.17	109	0.15
South	54	0.22	157	0.58	211	0.4

Results of the Mann-Whitney U test indicated that there was no significant differences in beaver sign density between the north and south shores of Gull and Stephens Lake (Mann-Whitney U test statistic= 34.00, P= 0.226).

Comparison Inside and Outside the Flood Zone

Data from the lake perimeter and riparian sign survey transects in 2002 and 2003 were used to compare the frequency of beaver sign inside and outside of the flood zone within Study Zone 1 (Table I-5). A Mann-Whitney U test was used to compare beaver sign frequencies.

Table I-5: Frequency of beaver signs from riparian, sign survey transects from inside and outside the flood zone in Study Zone 1 in 2002 and 2003

Flood Zone	2002 No. of Signs	Mean Signs/ 100 m^2	2003 No. of Signs	Mean Signs/ 100 m^2	Total No. of Signs	Mean Signs/ 100 m^2
Inside	46	0.19	94	0.29	140	0.24
Outside	60	0.16	120	0.46	180	0.31

Results of the Mann-Whitney U test indicated that there was no significant difference in beaver sign frequency inside and outside the flood zone in Study Zone 1 (Mann-Whitney U test statistic= 43.00, P= 0.597).

Comparison of Habitat Types

Data from the lake perimeter and riparian sign survey transects in 2002 and 2003 were used to compare the frequency of beaver sign between different habitat types. Sample sizes were insufficient for habitat types H03 (n= 3), H10, (n= 2), H15 (n= 3), and H16 (n=1). As a result a Mann-Whitney U test was used to compare beaver sign frequency between habitat types H01 and H04 (Table I-6).

Table I-6: Frequency of beaver signs from riparian, sign survey transects on different habitat types collected in 2002 and 2003

Habitat type	2002 No. of Signs	Mean Signs/ 100 m^2	2003 No. of Signs	Mean Signs/ 100 m^2	Total No. of Signs	Mean Signs/ 100 m^2
H01	44	0.21	37	0.15	81	0.18
H03	13	0.22	52	0.75	65	0.48
H04	20	0.11	98	0.6	118	0.35
H10	1	0.01	15	0.27	16	0.14
H15	15	0.33	7	0.11	22	0.22
H16	13	0.25	5	0.09	18	0.17

Results of the Mann-Whitney U test indicated no significant difference in beaver sign frequency between habitat types H01 and H04 (Mann-Whitney test statistic= 20.00, P= 0.685).

Comparison of Lake Perimeter Length

Data from lake perimeter and riparian sign survey transects in 2002 and 2003 were used to compare the frequency of beaver sign between lakes with different perimeter sizes. Lakes were grouped into three size classes: <2,000lm, 2,001-4,000 m, and 4,000-6,000 m. Sample sizes were insufficient for the 4,000-6,000 m class for any comparisons (n= 3). As a results a Mann-Whitney U test was used to compare beaver sign frequencies between lake classes <2,000 m and 2,001-4,000 m (Table I-7).

Table I-7: Frequency of beaver signs from riparian, sign survey transects from lakes of various sizes collected in 2002 and 2003

	2002		2003		Total	
Perimeter size (m)	No. of Signs	Mean Signs/100 m^2	No. of Signs	Mean Signs/100 m^2	No. of Signs	Mean Signs/100 m^2
<2000	67	0.22	151	0.5	218	0.36
2000-4000	22	0.15	28	0.21	50	0.18
4001-6000	17	0.06	35	0.12	52	0.09
Total	106	0.18	214	0.37	320	0.27

Results of the Mann-Whitney U test indicated no significant difference in beaver sign frequency between lake classes <2,000 m and 2,001-4,000 m (Mann-Whitney statistic= 23.00, P= 0.461).

CARIBOU

Use of Riparian Areas

A series of Mann-Whitney U tests were used to determine if differences in caribou sign frequency (sign/m) occurred between Gull Lake, Stephens Lake, and small, off-system lake riparian areas during 2002-2003. Sign frequency observed in 2002 and 2003 along each riparian, 500-m coarse habitat transect (Gull Lake and Stephens Lake), and lake perimeter transect (off-system lakes) was averaged. A 500-m transect was considered riparian if its start point was within 100 m of a waterbody. Only data collected in summer in common habitat types were used; data along islands were excluded. From 2002-2003 a total of 56 transects, covering 27,420 m were surveyed along Gull Lake riparian transects, 35 transects, covering 16,795 m, were surveyed along Stephens Lake riparian transects, and 20 transects, covering 43,260 m were surveyed along off-system lake perimeters.

Comparison of sign frequency along riparian areas indicated significantly more sign located along Gull Lake and off-system lake riparian areas, compared to Stephens Lake riparian areas. There was no difference in sign frequency between Gull Lake and off-system lake riparian areas (Table I-8).

Table I-8: Probability (P) Values of Comparisons of Average Caribou Sign Frequency (sign/m) From Gull Lake, Stephens Lake, and Off-system Lake Riparian Areas in 2002 and 2003; α = 0.05

	Gull Lake	Stephens Lake	Off-system Lakes	Average Sign Frequency (sign/m)
Gull Lake	1	--	--	0.43
Stephens Lake	<0.01	1	--	0.05
Off-system	0.16	<0.01	1	0.21

Comparison of Adult Caribou and Calf Presence on Selected Peatland Calving Areas and Non-Habitat Areas

The presence of caribou was determined using a tracking surveys conducted on peatland caribou calving islands throughout the Conawapa and Keeyask Study areas. Caribou use of peatland calving islands was measured as presence/absence based on sign evidence using timed searches and pre-determined transects. Timed searches for caribou activity were conducted in identified caribou calving habitat. Peatland island complexes in known caribou habitat were searched for scat, tracks, and other sign for 15 minutes or until evidence of caribou calves was found. Predetermined transect searches were conducted in areas not considered to be caribou habitat (non-habitat areas). Several different non-habitat types were surveyed, including black spruce dominant stands, jack pine dominated stands, mixed-wood dominated stands, bogs, and burned areas. Searchers followed a pre-determined, "L" shaped route, consisting of two, 250 m transects, perpendicular to one another. Searchers looked for scat, tracks, and other sign caribou signs within one meter of either side of the transect.

A Chi-square test of independence was conducted to compare the presence of adult caribou and the presence of caribou calves between peatland islands in known caribou habitat to all non-habitat areas.

Due to the proportionally large number of peatland islands in known caribou habitat surveyed (N= 184) compared to the number of non-habitat areas surveyed (N=36) in the Keeyask area, a random subset of peatland islands in known caribou habitat (n= 36) was used for data analysis.

A Fisher's exact test was used to compare the presence of caribou in peatland islands in known caribou habitat to presence of caribou in non-habitat areas of black spruce (n= 20), jack pine (n= 20), and mixed-wood (n= 19). Non-habitat, bog and jack pine areas were not included in analyses due to small sample sizes. A random sample of islands in known caribou habitat was used for data analysis due to account for large differences in sample sizes (n= 20).

In total, 70 peatland calving islands in known caribou habitat were surveyed. Of these, 61 (87%) had signs of adult caribou and 52 (74%) had signs of caribou calves. In the 20 randomly selected peatland islands in known caribou habitat, 17 (85%) had signs of adult caribou and 17 (85%) had signs of caribou calves (Table I-9).

Table I-9: Presence of adult and calf caribou in peatland islands in known caribou habitat and within the different types of non-habitat

		Total No. Surveyed	No. with Adult Presence (%)	No. with Calf Presence (%)
Peatland Islands in Known Caribou Habitat		70	61 (87)	52 (74)
Non-Habitat	Black Spruce	20	8 (40)	3 (15)
	Burned	20	4 (20)	7 (35)
	Mixed-wood	19	4 (20)	7(35)
	Bog	1	**	**
	Jack Pine	1	**	**
	Total	61	24 (39)	11 (18)

The Chi-square test of independence indicated that peatland islands in known caribou habitat had a significantly higher presence of adult caribou and a significantly higher presence of caribou calves compared to all non-habitat areas (Table I-10).

The Fisher's Exact tests indicated that peatland islands in known caribou habitat contained significantly higher presence of adult caribou compared to non-habitat, black spruce, burned, and mixed-wood areas (Table I-10). The peatland islands in known caribou habitat also had significantly higher presence of caribou calves compared to non-habitat, black spruce, burned, and mixed-wood areas (Table I-10).

Table I-10: Results of the Chi-square test of independence and Fisher's exact test

	Adults		Calves	
	P	**Chi-square**	**P**	**Chi-square**
Black Spruce	0.008	**	<0.001	**
Burned	<0.001	**	0.003	**
Mixed-wood	<0.001	**	0.003	**
Bog	**	**	**	**
Jack Pine	**	**	**	**
Total	<0.001	32.69	<0.001	41.32

Comparison Inside and Outside the Flood Zone

Data from lake perimeter sign surveys conducted in 2002 and 2003 were used to compare caribou sign frequencies between areas inside and outside the flood zone (Table I-11). Caribou sign frequencies were compared using a Mann-Whitney U test.

Table I-11. Frequency of caribou sign from lake perimeter sign surveys inside and outside the flood zone conducted in 2002 and 2003

	2002		2003		Total	
Flood Zone	No. of Signs	Mean Signs/ 100 m^2	No. of Signs	Mean Signs/ 100 m^2	No. of Signs	Mean Signs/ 100 m^2
Inside	63	0.23	78	0.23	141	0.20
Outside	129	0.29	59	0.14	188	0.21

Results of the Mann-Whitney U test indicated no significant difference between caribou sign frequencies inside and outside the flood zone (Mann-Whitney test statistic= 48.00, P= 0.88).

MOOSE

Comparison of North and South Shores

Data from lake perimeter sign surveys conducted in 2002 and 2003 were used to compare moose sign frequencies between the north and south shores of Gull and Stephens Lakes (Table I-12). A Mann-Whitney U test was used to compare moose sign frequencies.

Table I-12: Frequency of moose signs from lake perimeter sign survey transects along the north and south shores of Gull and Stephens Lake conducted in 2002 and 2003

	2002		2003		Total	
Shore	No. of Signs	Mean Signs/ 100 m^2	No. of Signs	Mean Signs/ 100 m^2	No. of Signs	Mean Signs/ 100 m^2
North	53	0.13	194	0.48	247	0.31
South	113	0.32	150	0.48	263	0.40

Results of the Mann-Whitney U test indicated no significant difference in moose sign frequency between the north and south shores of Gull and Stephens Lakes (Mann-Whitney test statistic= 39.00, P= 0.406).

Comparison Inside and Outside the Flood Zone

Data from lake perimeter sign surveys conducted in 2002 and 2003 was used to compare moose sign frequencies inside and outside the flood zone within Study Zone (Table I-13). A Mann-Whitney U test was used to compare moose sign frequencies.

Table I-13: Frequency of moose signs from lake perimeter sign survey transects inside and outside the flood zone in Study Zone 1 conducted in 2002 and 2003

	2002		2003		Total	
Flood Zone	**No. of Signs**	Mean Signs/ 100 m^2	No. of Signs	Mean Signs/ 100 m^2	No. of Signs	Mean Signs/ 100 m^2
Inside	95	0.26	215	0.58	310	0.42
Outside	71	0.19	129	0.38	200	0.28

Results of the Mann-Whitney U test indicated no significant difference in moose sign inside and outside the flood zone in Study Zone 1 (Mann-Whitney test statistic= 74.00, P=0.70).

Comparison of Lake Perimeters

Data from the lake perimeter transects in 2002 and 2003 were used to compare the frequency of moose sign between lakes with different perimeter sizes. Lakes were grouped into three size classes: <2,000m, 2,001-4,000 m, and 4,000-6,000 m (Table I-14). Sample sizes were insufficient for the 4,000-6,000 m class for any comparisons (n= 3). As a results a Mann-Whitney U test was used to compare moose sign frequencies between lake classes <2,000 m and 2,001-4,000 m.

Table I-14. Frequency of moose signs from riparian, sign survey transects from lakes of various sizes collected in 2002 and 2003

	2002		2003		Total	
Perimeter size (m)	No. of Signs	Mean Signs/100 m^2	No. of Signs	Mean Signs/100 m^2	No. of Signs	Mean Signs/100 m^2
<2000	94	0.28	174	0.49	268	0.39
2000-4000	20	0.11	97	0.58	117	0.35
4001-6000	52	0.18	73	0.27	125	0.23
Total	166	0.22	344	0.48	510	0.35

Results of the Mann-Whitney U test indicated no significant difference in moose sign frequency between lake classes <2,000 m and 2,001-4,000 m (Mann-Whitney statistic= 26.00, P= 0.673).

Comparison of Riparian Widths

Data from the riparian shoreline sign survey transects from 2001-2003 were used to compare moose sign frequencies between different riparian widths. Riparian areas were divided into three classes: 0-30 m, 31-100 m, and >100 m (Table I-15). A Kruskal-Wallis test was used to compare all classes.

Table I-15: Frequency of moose signs from riparian, sign survey transects along different widths of riparian zones from 2001-2003

	2001		2002		2003		Total	
Width (m)	No. Signs	Mean Signs /100 m^2	No. Signs	Mean Signs /100 m^2	No. Signs	Mean Signs /100 m^2	No. Signs	Mean Signs /100 m^2
0-30	6	0.08	154	1.97	69	0.86	229	0.97
31-100	2	0.11	31	1.72	32	1.78	65	1.2
>100	6	0.1	8	0.8	12	1.2	21	0.7

Results of the Kruskal-Wallis test indicated no significant differences of moose sign frequency between different riparian zone widths (Kruskal-Wallis test statistic= 0.693, P= 0.707).