Chance Oil and Gas, Eagle Plains Project: Wildlife Baseline Studies

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Down to Earth Biology

EXECUTIVE SUMMARY

The Eagle Plains Project (the Project) is an oil and gas exploration program in north-central Yukon, approximately 605 km north of Whitehorse along the Dempster Highway. Chance Oil and Gas Ltd. intends to conduct exploratory activities over a 10-year period to confirm the quality, quantity, and areal extent of hydrocarbons. Project activities will include seismic exploration and exploratory wells supported by an expanded winter road network.

The Project's Regional Study Area (RSA) is approximately 2,400 km² and is spatially bounded by the Peel River and Ogilvie River to the south and the northern reaches of Chance Creek to the north. The Project is within the Eagle Plains ecoregion, an intermontane basin underlain by sedimentary rock. The regional land cover comprises subarctic coniferous forest with mixed forest and arctic/alpine tundra while also lying within a continuous permafrost zone.

For the Project to proceed, it must be evaluated under the *Yukon Environment and Socio-Economic Assessment Act*, which requires baseline wildlife information. As such, wildlife baseline studies were conducted to provide information about birds, American marten, grizzly bear, moose, and caribou to meet the information requirements to support a project proposal to the Yukon Environmental and Socio-economic Assessment Board. The following subsections provide an executive summary of each baseline study completed for the Project.

Birds

The purpose of the birds baseline study was to document the potential occurrence, relative abundance, and habitat associations of birds across the Project's RSA. This study consisted of a combination of a desktop assessment and field surveys. The desktop assessment included identifying ecosystem units across the RSA using predictive ecosystem mapping, collecting, and cleaning historic bird survey data in the broader area, and developing a comprehensive list of bird species with the potential for occurrence based on range and habitat requirements. Two types of field surveys were conducted, each targeted at broad habitat associations in the Project area: point count surveys (transects for terrestrial habitats) and wetland/pond surveys. The survey design followed a targeted, stratified habitat design to provide representative survey coverage across the range of habitat types that occur in the RSA. Point count stations were established along walking transects for efficient survey implementation, and sites were selected using a targeted, stratified habitat design. Ecosystem units for predictive ecosystem mapping were reclassified with field data to produce 32 ecosystem units that captured site-specific differences in vegetation. An average of 23 survey stations were located in each ecosystem unit, with a minimum of eight stations in uncommon habitats. Field surveys were conducted during the 2019 breeding season (June 25 to 30) by two experienced biologists.

To better explain broad patterns of habitat occupation by species of birds in the RSA, the initial 32 ecosystem units were consolidated into ten broad avian habitat types: Herb, Deciduous/Mixed Shrub, Tall Shrub – Black Spruce, Deciduous/Mixed Forest, Spruce Forest, Riparian/Wetland Deciduous Shrub, Riparian Coniferous Shrub, Riparian Spruce Forest, Open Water, and a classification ("Unknown") for distant (>100 m) or flyover observations that prevented associating birds with habitat.

Based on range and habitat, 128 bird species potentially occur in or adjacent to the RSA. Forty-eight bird species were recorded in adjacent areas during North American Breeding Bird Surveys. Possible species include eight listed either under the federal *Species at Risk Act* or identified in the Yukon *Wildlife Act*, and 67 are considered a priority and management concern under the federal *Bird Conservation Region 4 Plan*. Species listed in the *Species at Risk Act* include (with those in bold observed in the RSA): Horned Grebe (*Podiceps auritus*), Peregrine Falcon (*Falco peregrinus*), Short-eared Owl (*Asio flammeus*), **Red-necked Phalarope** (*Phalaropus lobatus*), **Common Nighthawk** (*Chordeiles minor*), **Olive-sided Flycatcher** (*Contopus cooperi*), Bank Swallow (*Riparia riparia*), and **Rusty Blackbird** (*Euphagus carolinus*).

During field surveys, nine hundred and seventy-nine birds from 53 species were observed in the RSA. Point counts identified 743 birds of 42 species, and wetland surveys identified 231 birds of 37 species. Five Swainson's Hawk (*Buteo swainsoni*) were also identified as incidental observations. Patterns of species relative abundance and richness (number of species) varied among the different habitat types. These patterns were consistent with regional habitat and known bird range-use and habitat requirements. Average relative abundance and species richness were greatest in Spruce Forest, Deciduous and Mixed Shrub, and Riparian/Wetland Deciduous Shrub habitats; and lowest in Herb and Tall Shrub – Black Spruce habitats. These patterns were generally related to the structural complexity and productivity of these different habitat types. However, the number of unique species in a given habitat did not depend on structural complexity. Many unique species were found in the Herb and Open Water habitats.

The general patterns of bird occurrence and habitat associations observed in this study are consistent with the limited information available for birds in the area.

Marten

Marten were selected as a Valued Component for the Project due to their value as a furbearer to the Vuntut Gwitchin First Nation and as an indicator species for mature and old forest values. Marten are a good species for assessing potential effects on habitat because they are more closely associated with habitat (mature forest) than many other species of medium-sized carnivore. However, little is known about basic marten ecology in northern boreal forest and taiga ecosystems. The RSA is located entirely within the Eagle Plains Ecoregion, where tree growth is limited by the presence of permafrost and short cool summers that limit the structural development of forests. The most common climax forest community is black spruce woodlands with open canopies and relatively small trees. The size and number of mature forest structures that marten use, such as large trees, snags, and coarse woody debris is much smaller than in forests used by marten in more southern latitudes. Therefore, indices of marten habitat suitability were evaluated in a relative context in this northern setting.

A habitat suitability index model was developed for marten to examine the amount, quality, and habitat distribution for the species in the RSA. Habitat was assigned a suitability ranking of High, Moderate, Low, or Nil/Very Low, relative to the range of habitat quality across the RSA. The rating categories correspond to qualitative predictions of the relative suitability of the habitat for supporting five life requisites of marten: reproduction, thermal cover, escape cover, foraging, and dispersal. High-quality habitat supports all five life requisites. Moderate-quality habitat supports escape cover, foraging, and dispersal. Low-quality habitat only supports limited foraging and dispersal. Nil/Very Low-quality habitat does not contribute significantly to any life requisites; however, herb/shrub structural stages and stunted disclimax forest areas likely function as permeable barriers and allow intra-territorial movements within marten home ranges. Key habitat associations include selection for mature/old conifer structural stages and avoidance of herb/shrub structural stages (mostly resulting from fire), natural openings, wetlands, and stunted black spruce stands. The model also accounts for avoiding anthropogenic linear features, with greater rating reductions for wider linear features. The model uses two types of source information to provide a spatially explicit quantification of marten habitat across the RSA: vegetation mapping (Ecological and Landscape Classification mapping) and human disturbance, including the Dempster Highway, winter roads, and two types of seismic lines.

The model indicates a patchwork of High (16%), Moderate (23%), and Low (60%) quality marten habitats across the RSA. High-quality marten habitat is associated with mesic, spruce-dominant ecosites in mature to old structural stages. Concentrations of High-quality habitat include the southern portion of the study area, in the Enterprise and Dalglish Creeks watersheds, a band running east-west, north of the Dempster Highway, and the western portion of the northern half of the RSA. Moderate-quality habitat is associated with wetter and/or younger ecosystem units than High-quality habitat and is widespread across the RSA. High and Moderate quality habitat is also concentrated in narrow strips of mature/old riparian forests along some of the major watercourses in the RSA, including Chance and Greaves Creeks in the northwest and McParlon Creek west of the Dempster Highway. Low-quality habitat is associated with regenerating burns, wetlands, and stunted, open, black spruce areas. Concentrations of Low-quality habitat include recent burns on both sides of the Dempster Highway and wetlands and open, stunted spruce areas in valley bottoms in the lower reaches of the Chance watershed in the northwestern portion of the RSA. Nil/Very Low habitat constitutes only 1% of the RSA.

Linear features had a relatively minor effect on overall quality, amount, and distribution of potential habitat for marten in the RSA. This was due to the narrow width of linear features and small overall extent they comprise relative to the overall RSA. Though existing linear features result in reduced habitat quality at the site-level, their effects on habitat supply for marten at the home range scale are very limited.

Grizzly Bear

Grizzly bears (*Ursus arctos horribilis*) were selected as a Valued Component for the Project due to their conservation status and social, cultural, and economic value. Grizzly bears are Special Concern on Schedule 1 of the federal *Species at Risk Act*. The grizzly bear section provides baseline information about population trends, distribution, sources of mortality, diet, and habitat selection within the RSA. This section draws from multiple sources, including published and unpublished literature, personal communications with biologists, and traditional knowledge where available. Few studies on grizzly bears have been conducted in the Project area. Literature from surrounding regions was consulted when local information was not available.

Grizzly bear densities are thought to be low throughout the RSA. The most current grizzly bear population estimate for the broader Eagle Plains Ecoregion (which encompasses the RSA) is 184 individuals, based on expert opinion of grizzly bear habitat capacity from the 1980s. Little is known about seasonal grizzly bear distribution and movements within the RSA and surrounding areas. However, the Richardson and Ogilvie

Mountains (north and south of the RSA, respectively) are thought to have higher grizzly bear densities than the comparatively flat Eagle Plains Ecoregion. Grizzly bears congregate at the Fishing Branch River (20 km west of the RSA) in the fall to feed on spawning salmon. Grizzly bears may also follow the spring and fall migration of the Porcupine caribou herd to take advantage of the seasonal abundance of caribou as a food source.

Key threats to grizzly bear populations in the Yukon are human-wildlife conflict and harvest mortality. Licenced grizzly bear harvest rates are low in the RSA relative to other parts of the Yukon. Annual grizzly bear harvest in Game Management Zone 1 (which encompasses the RSA) has historically varied from zero to three bears per year. Other potential sources of grizzly bear mortality in the RSA include the defence of life and property kills, collisions with vehicles, and predation from other bears or large carnivores.

Seasonal grizzly bear diets reflect the phenological progression of key food resources such as herbaceous plants, roots, ungulate calves, berries, and fish. Terrestrial wildlife are likely an important food source for grizzly bears in northern Yukon, particularly barren-ground caribou (*Rangifer tarandus groenlandicus*) and arctic ground squirrels (*Spermophilus parryii*). The distribution of available food strongly influences habitat selection by grizzly bears during spring, summer, and fall seasons and the supply of suitable den sites in winter. Grizzly bears in the RSA may select habitats with abundant herbaceous vegetation, roots, or berries, such as riparian valleys and slopes. Grizzly bears may also travel to nearby mountain ranges to feed on ground squirrels, particularly in fall, as berry availability declines. Grizzly bears may follow caribou during spring and fall as they migrate to and from their calving grounds, targeting calves or opportunistically preying on adults.

Grizzly bears in northern Yukon hibernate in winter from approximately October to May. They prefer to den in mountainous regions; however, in areas with relatively flat topography (such as the RSA), grizzly bars will select small topographic features such as hills, steep riparian banks, or lakesides to excavate their dens. Grizzly bears in the taiga of northern Yukon have large home range sizes (females: 442–750 km², males: 760–1,250 km²). They travel long distances to find suitable winter denning habitats in the mountains.

Moose

Moose (*Alces alces*) were selected as a Valued Component for the project's environmental assessment due to their value as a game species and their cultural values to local First Nations. The purpose of the moose study was to summarize existing baseline information for moose and develop a habitat model for the species within the Eagle Plains RSA. The habitat model quantifies the suitability, amount, and distribution of potential habitat for moose in the RSA. This information can be used to assess the Project's potential effects on moose and develop measures to mitigate effects if required.

There is limited incidental knowledge about moose population levels, distribution and habitat use within the Eagle Plain RSA. Formal population surveys of moose have not been conducted, but local knowledge suggests that, while moose densities in Eagle Plains are relatively low compared to areas in southern Yukon, they are relatively high compared to other areas in North Yukon. Information from two historical aerial surveys examining the distribution of moose (and other large mammals) indicates that moose occur across the RSA throughout the year, consistent with the relatively low elevation, subdued topography, and moderate snowpacks that occur in the area. Several large, regenerating burns and smaller extents of riparian and wetland shrublands offer shrubby browse that moose depend on during winter.

The habitat model was developed specifically for the winter season because winter is the most limiting season for moose — forage is most limited, and energetic demands are greatest due to cold temperatures and the extra effort required to travel through snow. The model explicitly focussed on forage availability, which was believed to be the most significant factor affecting habitat selection in winter. During winter, moose feed almost exclusively on the stems and branches of certain shrubs. Vegetation surveys in the area found that several species of willows (*Salix spp.*) were the most abundant potential forage species and the species with the most frequent evidence of browsing by moose.

The habitat model included three variables, ecosystem type, structural stage, and fire disturbance status, all from recent vegetation mapping (Ecological and Landscape Classification mapping) conducted in the RSA. Habitat suitability ratings were developed for each combination of ecosystem type, structural stage, and fire disturbance based on the observed or potential abundance of willow. The highest-rated areas included natural shrublands, regenerating burns in riparian areas, and small extents of deciduous and mixed-wood ecosystems on mesic and moist sites. Moderate-rated areas were predominantly regenerating burns on mesic to wet sites. Low-rated sites were mostly undisturbed stands of open, stunted spruce on mesic to wet sites, ranging from tall shrub to old forest structural stages. Differentiating ratings between Moderate and Low areas was often difficult. Many burned and unburned sites had an average willow cover less than 15%, with high variation in cover among sites in the same ecosystem units. Generally, 7% willow cover was used as the threshold to differentiate between Moderate and Low sites. This is a relatively low value of willow cover but using a higher threshold would have resulted in large areas of regenerating burn being classified the same (Low) as undisturbed areas.

The habitat model indicates that High-suitability moose winter habitat is quite limited across the RSA, and Moderate habitat is widespread: High (12%), Moderate (43%), Low (44%), and Nil/Very Low (1%). Due to the scattered occurrence of High-suitability habitat across the RSA, some moose are expected to occur across the RSA in winter. However, local densities are likely to vary with the portions of Low and Moderate suitability habitats that form the matrix of habitat at a larger scale. This pattern of having extensive areas in Moderate suitability winter habitat is different than occurs in other parts of Yukon, especially in more mountainous regions, where suitable winter habitat (i.e., High and Moderate) are often constrained by elevation and broad vegetation patterns to a relatively small proportion of the landscape (e.g., <25%). In Eagle Plains, a substantial amount of winter forage occurs within large areas with relatively low willow cover (i.e., the Moderate suitability areas).

Caribou

The Porcupine Caribou Herd (PCH) is a subpopulation of barren-ground caribou (*Rangifer tarandus*), known for large population aggregations, dramatic population fluctuations, lengthy migrations, and significant cultural and social value to northern Indigenous peoples. Within the North Yukon Land Use Plan, the PCH is considered "the most significant and culturally important wildlife resource in the planning region." The PCH has been assessed as Threatened by the Committee on the Status of Endangered Wildlife in Canada, but the subspecies is not listed on Schedule 1 of the federal *Species at Risk Act*. Within Yukon, barren-ground caribou are considered Vulnerable/Apparently Secure.

The specific objectives of this study were to:

- summarize existing information about the ecology of the PCH,

and, use telemetry data and analysis outputs from the Porcupine Caribou Technical Committee to:

- quantify the degree of seasonal range overlap by the PCH with the Eagle Plains Oil and Gas Exploration Project RSA during late fall and winter, when seasonal range use overlaps the RSA.
- quantify habitat use patterns and selection by the PCH during late fall and winter.
- quantify movement rates and residency periods of the PCH during late fall and winter.
- quantify potential effects of exiting linear features on the occurrence and movements of the PCH.

There is a long history of co-management of the PCH among indigenous, state, territorial and federal governments in Canada and the United States. In Canada, management initiatives are led by the Porcupine Caribou Management Board with technical support from the Porcupine Caribou Technical Committee. The Porcupine Caribou Technical Committee leads most monitoring and research work on the PCH, including population and demographic monitoring, seasonal movement monitoring (via GPS telemetry tracking), caribou body condition monitoring, habitat and human disturbance assessments, and annual snow surveys. The portion of the PCH annual range that occurs within Yukon is protected by a network of parks, special management areas, conservation areas, wilderness areas, protected areas, ecological preserves, habitat protection areas, and Integrated Management Area zones within the North Yukon Regional Land Use Plan and the Peel Watershed Regional Land Use Plan. In total, 54% of the annual range of the PCH within Yukon falls within some type of protected area where industrial activity is prohibited, 36% of the annual range occurs within regional land use plan Integrated Management Area zones where development is limited, and 9% of the annual range is not covered by any land management zonation.

Although most barren-ground caribou subpopulations are declining, the PCH numbers have increased over the last two decades. Since the first survey in 1972, the PCH has had two periods of population growth, with an interceding decline. The last successful population survey in 2017 estimated a record high of 218,457 caribou.

Like most barren-ground caribou subpopulations, the PCH has a large annual range and makes long-distance migrations, hundreds or thousands of kilometres, among different seasonal ranges. After calving on the north slope and Arctic coastal plains, the PCH typically splits in two, with portions of the herd moving southwest in Alaska and southeast in Yukon. Animals in the Yukon typically follow a clockwise movement through the seasonal ranges from the calving grounds on the north slope, to the British Mountains in summer, to the Richardson Mountains in late summer, dispersing widely and variably across northern Yukon (as far south as the Ogilvie Mountains) in fall and winter, before returning north to the coastal plains in spring. The PCH has historically overlapped the RSA in the rut/late fall and winter periods. However, the RSA overlaps a small portion of those ranges — 6.0% of the late fall range and 6.5% of the winter range, and the RSA does not overlap with the most frequently used portions of those ranges.

Habitat selection by the PCH for late fall and winter was estimated using resource selection functions using GPS collar data from 2012 to 2021 for 164 caribou in late fall and 172 caribou in winter. Spatial habitat data included a set of plant functional type layers (light macrolichens, graminoids, forbs, evergreen shrubs, deciduous shrubs, and conifer trees), elevation, aspect, slope, terrain ruggedness, and distance to waterbodies >1 ha. PCH caribou tended to select and avoid similar resources in both late fall and winter. Key covariates in models for both seasons that were statistically significant (i.e., $P < 0.05$) included macrolichen cover (positive coefficient), conifer tree cover (negative coefficient), slope percent (negative coefficient), elevation (variable in fall and winter), and aspect (greater selection for south- and west-facing). Coefficients associated with lichen cover were of the greatest magnitude, suggesting that the selection of lichen is the primary driver of habitat selection in late fall, especially in winter. The resource selection function models were used to derive habitat quality maps with four ratings (Very Low, Low, Moderate, and High), which were determined by assessing selection ratios across resource selection function predictions. The distribution and proportion of selected habitat (Moderate and High) was then examined within the RSA and broader seasonal ranges. The proportion of selected habitat was equivalent between the RSA (0.404) and the broader range during late fall (0.415 ± 0.025) but was less in the RSA (0.265) than the broader range during winter (0.411 ± 0.026). Selected habitat, especially areas of High quality, were mostly dependent on the amount and distribution of macrolichen cover.

The potential for linear features (i.e., the Dempster Highway, winter roads, 2D seismic and 3D seismic) to mediate the base habitat model via avoidance of those features was assessed using a zone of influence (ZOI) framework. Although ZOIs were determined for some features, confidence in the outcomes was low because (i) the magnitude of the ZOI effects were weak (i.e., including the ZOI effects in the habitat models had little effects on the habitat predictions); (ii) the ZOI distance estimates were sensitive to the data and analytical methods used; (iii) the pattern of ZOI effects were not consistent with other studies and basic understanding of the PCH ecology. Developing ZOIs for assessment and management purposes will integrate results from other studies adapted to the Eagle Plains setting and the ecology of the PCH.

To better understand factors affecting PCH caribou movement, two analyses were conducted: (1) a comparison of daily movement rates and residency times of caribou in the Project RSA relative to the broader landscape, and (2) a delineation of movement paths to assess broad-scale movement patterns and the potential for caribou to interact with the Project. The PCH typically exhibits movements of several kilometres per day in late fall and winter. Late fall daily movements (8.7 km/day in the RSA) were substantially greater than during winter (4.4 km/day), and caribou tended to occupy portions of the landscape for shorter periods during late fall than during winter. Caribou residency times in both seasons were two-fold greater in the broader landscape than within the Project RSA, suggesting that, on average, the RSA is used as more of a transitory area than other portions of the seasonal ranges. There were relatively few collared caribou that travelled through the RSA during late fall. However, in the fall of 2015, 14 collared caribou made clear, directed movements along the height of land parallel to the Dempster Highway, from the northeast to the southwest. Most caribou appeared to avoid crossing the Dempster Highway while travelling through the Eagle Plains region, but all animals eventually crossed the highway farther south, in the Ogilvie Mountains. The movements through Eagle Plains crossed numerous 2D seismic lines, winter roads and a large 3D seismic grid within the RSA.

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ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Definition
2D	Two Dimensional
3D	Three Dimensional
AIC	Akaike's Information Criterion
asl	above sea level
BBMM	Brownian Bridge Movement Model
BC	British Columbia
BCR	Bird Conservation Region
BMU	Bear Management Unit
°C	degrees Celsius
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CWCS	Canadian Wetland Classification System
CWD	Coarse Woody Debris
CWS	Canadian Wildlife Service
DBH	Diameter at Breast Height
DEM	Digital Elevation Model
DLP	Defence of Life and Property Kill
ELC	Ecosystem and Landscape Classification
GAM	Generalized Additive Modelling
GIS	Geographic Information System
GMS	Game Management Subzone
GMZ	Game Management Zone
GPS	Global Positioning System
ha	hectares
HSI	Habitat Suitability Index
HMP	Harvest Management Plan
IMA	Integrated Management Area
IPCB	International Porcupine Caribou Board
km	kilometers
km^2	square kilometers
LF	Linear Feature
LIS	Low Impact Seismic
m	meter
mm	millimeter
NABBS	North American Breeding Bird Survey
NND	Na-cho Nyäk Dun
NWT	Northwest Territories
NYLUP	North Yukon Land Use Plan

PCH	Porcupine Caribou Herd
PCMB	Porcupine Caribou Management Board
PCTC	Porcupine Caribou Technical Committee
PEM	Predictive Ecosystem Mapping
PFT	Plant Functional Type
PWLUP	Peel Watershed Land Use Plan
RISC	Resources Information Standards Committee
RSA	Regional Study Area
RSF	Resource Selection Function
SARA	*Species at Risk Act*
the Project	the Eagle Plains Project (proposed by Chance Oil and Gas Ltd.)
TGC	Tetlit Gwich'in Council
THFN	Tr'ondëk Hwëchin First Nation
TRI	Terrain Ruggedness Index
VC	Valued Component
VGFN	Vuntut Gwitchin First Nation
YESAA	*Yukon Environmental and Socio-Economic Assessment Act*
YESAB	Yukon Environmental and Socio-Economic Assessment Board
ZOI	Zone of Influence

1 INTRODUCTION

Baseline wildlife information and data are required for proposed oil and gas projects submitted to the Yukon Environmental and Socio-economic Assessment Board (YESAB) Executive Committee for screening under the *Yukon Environment and Socio-Economic Assessment Act* (YESAA), as well as applications submitted for an Industrial Licence and Type A Water Licence from the Yukon Water Board, among other permits and licences. To receive authorization for the Eagle Plains Project to proceed, the Project must be evaluated under YESAA. Specific wildlife objectives, as identified in YESAB's Proponent's Guide to Information Requirements for Executive Committee Project Proposal Submissions (2005), are to:

- describe the abundance and distribution characteristics of major wildlife species within the project area and vicinity;
- describe the habitat classifications used in the project area and any implications concerning the distribution and abundance of habitat types that may influence the project;
- provide a map showing the spatial arrangement of habitats of special interest, if applicable;
- identify and describe the transportation corridor and critical, key, and sensitive habitats;
- identify any species listed on the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and Species at Risk lists;
- describe any special management requirements due to vulnerability, threatened, or endangered status; and,
- identify and describe any ongoing studies and monitoring programs concerning wildlife in the project area and vicinity.

1.1 PROJECT OVERVIEW

The Eagle Plains Project (the Project) encompasses a 2,386 km² area in north-central Yukon, centred approximately 605 km north of Whitehorse and 40 km south and west of Eagle Plains hotel, along the Dempster Highway. The Project occurs within the Eagle Plains sedimentary basin, north of the Ogilvie River and west of the Richardson Mountains. The basin contains proven natural gas and oil reserves (Peel Watershed Planning Commission 2019), including 4.6 billion m³ of gas and 3.2 million m³ of oil (Hannigan 2014).

The Regional Study Area (RSA) has had intermittent periods of oil and gas exploration since the 1950s. That activity has established winter roads, seismic lines, and exploratory well sites across parts of the current RSA. Approximately 40 exploration wells have been drilled in the Eagle Plains sedimentary basin. Eight (8) wells are currently being maintained in suspended status, and the remaining wells have been plugged and abandoned. Seismic exploration has included approximately 10,000 km of two-dimensional (2D) lines (mostly before 1985), and about 325 km² of three-dimensional (3D) seismic was conducted in 2013/2014 (Northern Cross (Yukon) Ltd. 2014).

The current exploration program will build on past exploration to better define the extent, amount and quality of oil and gas deposits in the area. Under the current program, Chance Oil and Gas Ltd. proposes conducting additional 2D and 3D seismic data acquisition programs over large extents of the RSA and drilling up to 30 exploratory wells. Depending on the drilling program results, extended flow testing lasting up to two years may be conducted at wells where crude oil and/or natural gas are discovered to determine the quantity, quality and extent of the oil and gas deposit(s). The existing winter road network will be expanded to support the seismic, drilling, and flow testing programs. Most work is expected to be conducted in the winter (e.g., seismic line clearing and drilling); however, seismic recordings and extended flow testing may also occur during summer or year-round.

1.2 STUDY AREA

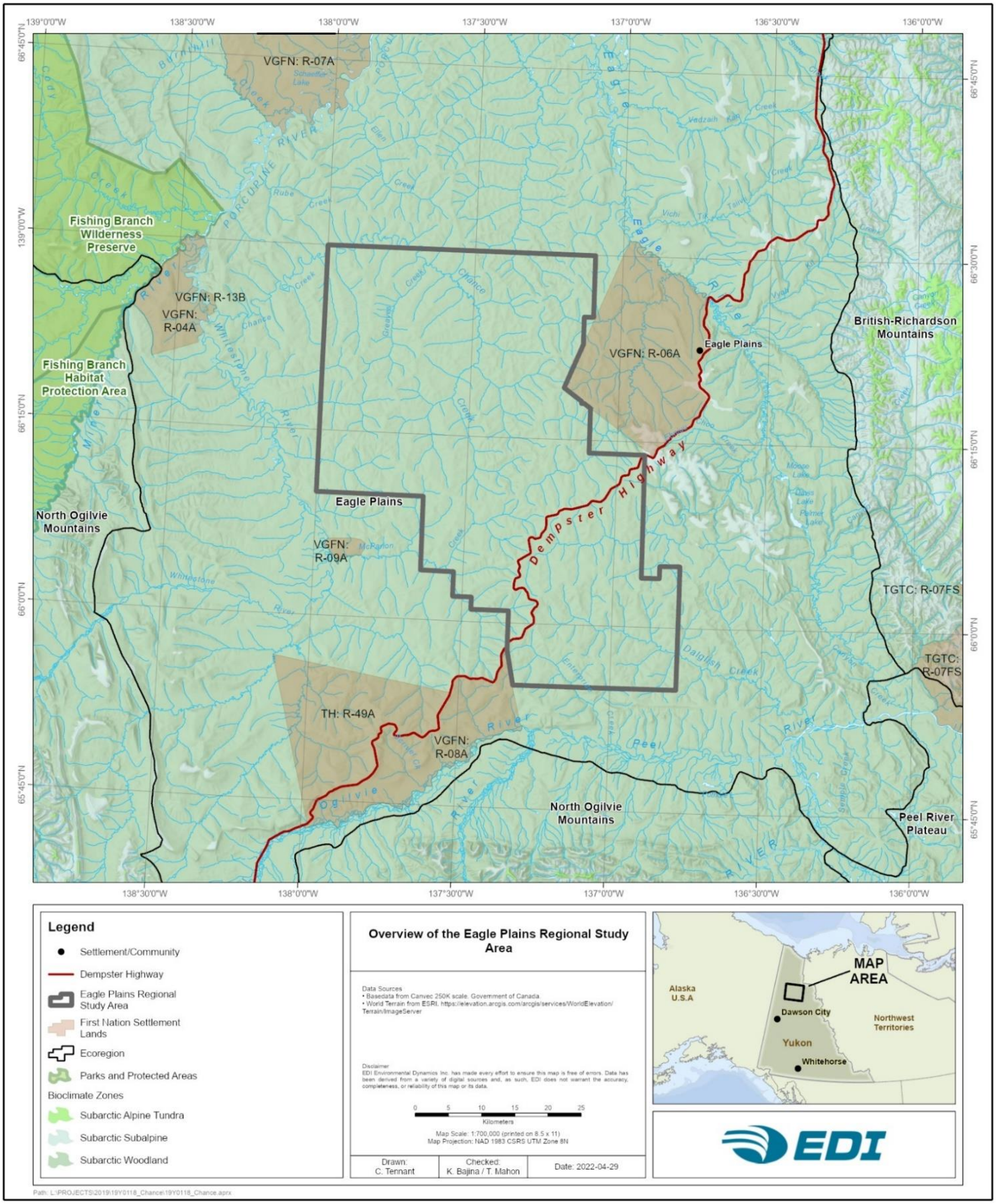
The Eagle Plains Project Regional Study Area (RSA; Map 1-1) is 2,386 km² (238,566 ha), centred in the Eagle Plains Ecoregion in north Yukon. The area consists of subdued topography of rolling hills and sloping plains. The Dempster Highway crosses the RSA along the local height of land. From there, the area drains into the Porcupine River watershed to the north (via Chance Creek) and west (via McParlon Creek and the Whitestone River) and into the Peel River watershed to the southeast (via Dalglish Creek).

The RSA overlaps four First Nation Traditional Territories. Most of the RSA is within the Vuntut Gwitchin First Nation (VGFN) Traditional Territory. The southeastern portion is in an area of overlapping Traditional Territories of VGFN, the Tetlit Gwich'in Council (TGC), the First Nation of Na-cho Nyäk Dun (NND), and Tr'ondëk Hwëchin First Nation (THFN). Although the RSA is outside any First Nation Settlement Lands, it adjoins VGFN Settlement Lands on parts of its east and southwest borders.

Development in the RSA and the surrounding Eagle Plains is low. The Dempster Highway is the main vehicle access corridor, running from approximately Dawson City, Yukon in the southwest to Inuvik, Northwest Territories (NWT) to the northeast and transiting the RSA along the way. Several winter access roads also branch off the Dempster Highway. A network of seismic lines (Photo 1-1) from historical exploration are found in the RSA. The Eagle Plains settlement is located on the Dempster Highway, approximately 30 km east of the RSA boundary and consists of the Eagle Plains Hotel and the Government of Yukon's Highway Maintenance camp.

The Project is within the North Yukon Planning Region and Peel Watershed Planning Region. Therefore, it is subject to the North Yukon Land Use Plan (NYLUP) and Peel Watershed Land Use Plan (PWLUP). The project falls within the Integrated Management Area (IMA) Zone IV of both plans, a zone with lower ecological and cultural values and the highest permissible development of the four IMA zones.

Photo 1-1. Seismic lines from historical exploration activities within the Regional Study Area.



Map 1-1. Overview of the Eagle Plains Regional Study Area.

1.3 ECOLOGICAL OVERVIEW

The Project falls within the Eagle Plains Ecoregion (Map 1-1), a 20,400 km² region in north Yukon between the Richardson and Ogilvie Mountains. The ecoregion consists of low-altitude rolling topography between 300 m and 600 m above sea level (masl), with few scattered peaks above and around 1,000 masl (Ecological Stratification Working Group 1995).

The Eagle Plains Ecoregion experiences moderate precipitation, with annual amounts around 400 mm. Most precipitation falls as rain throughout the summer, averaging 50 to 80 mm per month, from June through August. Precipitation is lighter through September to April and falls as snow, with average winter snowpacks of 80 cm peaking in April. The climate in this region is strongly affected by its latitude, with extended winter conditions that usually last from October through to early May. There is a substantial variation in seasonal temperatures in the Eagle Plains, with cool short summers and long cold winters. Average winter temperatures are between −30°C and −25°C, with extremes as low as −60°C. Average summer temperatures are around 13°C, with extremes as high as 30°C. Due to the northern latitude, this region experiences brief periods of continuous sun above and below the horizon in summer and winter, respectively.

Most of the Ecoregion, including the northeast portion of the RSA, drains north into the Yukon River via the Whitestone, Porcupine and Eagle rivers. That part of the RSA includes the headwaters of the Eagle River and several other tributaries of the Porcupine River, along with the Chance and McParlon Creek subdrainages of the Whitestone River. The southeast corner of the Ecoregion drains east to the Mackenzie River via the Peel, Wind and Ogilvie Rivers. Dalglish and Enterprise creeks flow directly into the Peel River. The few lakes in the Ecoregion are generally oxbow or thermokarst lakes (Yukon Ecoregions Working Group 2004a). Several wetland complexes are found to be associated with larger creeks in the RSA.

The Eagle Plains Ecoregion is dominated by the Crysolic soils that occupy much of the northern third of Canada, characterized by near-surface permafrost. Turbic Cryosols predominate, exhibiting patterned ground formations and hummocks, and are often associated with open stands of black spruce (*Picea mariana*), tamarack (*Larix laricina*) and birch (*Betula* spp.). The active permafrost layer in these ecosystems generally ranges between 20 cm and 90 cm below the surface. The active layer depth is generally deeper under hummocks and shallower under inter-hummock areas (Yukon Ecoregions Working Group 2004a).

The RSA is entirely within the Subarctic Bioclimate Zone (Environment Yukon 2014a). Vegetation in the RSA is characterized by open-canopy, spruce-dominated habitats where permafrost generally limits tree growth and results in stunted, disclimax vegetation communities (Environment Yukon 2016a). Hummocky, black spruce and white spruce (*Picea glauca*) woodlands with well-developed shrub communities are common in upland areas, with white spruce and ground lichens increasing in abundance in well-drained sites. Areas with low slope gradients and fine-textured soils often have ground cover dominated by cottongrass tussocks beneath a shrub layer of birch, black spruce, Labrador tea (*Rhododendron groenlandicum*), and occasionally tamarack (Yukon Ecoregions Working Group 2004a).

Evidence of forest fires can be observed throughout the RSA (Photo 1-2 and Photo 1-3). Alaskan paper-birch (*Betula neoalaskana*) is often the first tree species to colonize burn areas, and the extent of old burns is generally correlated with young black spruce – Alaskan paper birch woodlands (Yukon Ecoregions Working Group 2004a). Fires increase the depth of the active permafrost layer, causing slope failures and changes in ecosystem moisture regimes.

Photo 1-2. Example of a regenerating moist forest stand after a fire within the RSA.

Photo 1-3. Example of a recently burnt area of the RSA.

2 BIRDS

2.1 PURPOSE AND OBJECTIVES

This section documents the occurrence, relative abundance, and habitat associations of birds occurring or likely occurring in the RSA. It includes a desktop assessment to collect and summarize existing information about birds; and field surveys to document the occurrence, relative abundance, and habitat associations of birds within the RSA. Field surveys were recommended by the regulator responsible for migratory birds (Environment and Climate Change Canada — Canadian Wildlife Service [CWS]) because no systematic bird surveys have been previously conducted in the Project area. Surveys in adjacent areas were limited and mainly were road-based surveys, which had limited or no coverage of particular habitat types. Two field survey types were used to provide representative coverage of broad avian habitat types and associated avian communities: (1) point count surveys and (2) pond and wetland surveys.

2.2 BIRD HABITAT OVERVIEW

The Project falls within Bird Conservation Region 4 (BCR 4), the Northwestern Interior Forest (Environment Canada 2013a). BCR 4 is home to 211 regularly occurring bird species, including 31 waterfowl species, 19 water bird species, 23 shorebird species, and 138 land bird species (Environment Canada 2013a). Most species are breeding season migrants, few are year-round residents. The Project is also within ~30 km of two other bird conservation regions: region 3 (BCR 3), the Arctic Plains and Mountains, and region 6 (BCR 6), the Boreal Taiga Plains. BCR 3 habitats are influenced by a short growing season and continuous permafrost; upland habitats range from heavily vegetated heath communities to sparse cryptobiotic crusts, lichens, and moss; in the southern end, dwarfed spruce trees are often found in restricted patches (Environment Canada 2013b). BCR 6 is primarily characterized by gently rolling or undulating landscapes, vegetation dominated by the boreal forest and interspersed with wetlands and several major river systems (Environment Canada 2013c). In total, BCR 3 has 159 species of birds, while BCR 6 has 288. This current study did not find species uniquely associated with either of these two conservation regions.

The RSA has three predominant bird habitat types: black spruce upland, willow and scrub birch shrubland, and scrub fens and bogs. Upland forests provide potential breeding habitat for resident Northern Goshawk (*Accipiter gentilis*), Spruce Grouse (*Canachites canadensis*), Northern Hawk Owl (*Surnia ulula*), American Three-toed Woodpecker (*Picoides dorsalis*), Canada Jay (*Perisoreus canadensis*), Boreal Chickadee (*Poecile hudsonicus*), White-winged Crossbill (*Loxia leucoptera*), and Common Redpoll (*Acanthis flammea*) (Frisch 1987, YEWG 2004, Environment Canada 2013). Migrants that breed in upland forests include Swainson's Thrush (*Catharus ustulatus*), Gray-cheeked Thrush (*Catharus minimus*), Varied Thrush (*Ixoreus naevius*), Bohemian Waxwing (*Bombycilla garrulus*), Yellow Warbler (*Setophaga petechia*), Yellow-rumped Warbler (*Setophaga coronata*), American Tree Sparrow (*Spizelloides arborea*), and Dark-eyed Junco (*Junco hyemalis*) (Frisch 1987, YEWG 2004). American Kestrel (*Falco sparverius*), Say's Phoebe (*Sayornis saya*), American Robin (*Turdus migratorius*), Orange-crowned Warbler (*Leiothlypis celata*), and Chipping Sparrow (*Spizella passerina*), as well as other species of thrush, warbler, and sparrow, can be found in more open forests with a well-developed shrub layer, or shrublands with tall shrub and dwarfed spruce (Frisch 1987, YEWG 2004). A frequently occurring species in the Eagle Plains ecoregion, though rare elsewhere in Yukon, is Swainson's Hawk (*Buteo swainsoni*). This species is associated with isolated stands of productive white spruce for nesting habitat, mostly found in narrow riparian strips surrounded by open bogs and shrublands where they regularly forage.

Aquatic habitats for birds consist of open bodies of water (e.g., ponds, lakes), wetlands (mostly bogs and fens) and riparian zones dominated by sedges and shrubs. Open water bodies are limited in the RSA and are thus potentially inhabited by relatively few Tundra Swan (*Cygnus columbianus*), Greater White-fronted Goose (*Anser albifrons*), Canada Goose (*Branta canadensis*), American Wigeon (*Mareca americana*), Green-winged Teal (*Anas crecca*), and Bufflehead (*Bucephala albeola*) (Frisch 1987, YEWG 2004, Environment Canada 2013). Shorebirds such as Lesser Yellowlegs (*Tringa flavipes*), Solitary Sandpiper (*Tringa solitaria*), and Wilson's Snipe (*Gallinago delicata*) remain along the water's edge and in riparian zones consisting of coniferous and deciduous vegetation. Riparian zones also provide potential breeding habitat for Willow Ptarmigan (*Lagopus lagopus*), Alder Flycatcher (*Empidonax alnorum*), Yellow Warbler, Wilson's Warbler (*Cardellina pusilla*), American Tree Sparrow, and Lincoln's Sparrow (*Melospiza lincolnii*) (Frisch 1987, YEWG 2004). Spotted Sandpiper (*Actitis macularius*), Herring and Short-billed Gulls (*Larus argentatus* and *L. brachyrhynchus*), Belted Kingfisher (*Megaceryle alcyon*), Bank Swallows (*Riparia riparia*), and Cliff Swallows (*Petrochelidon pyrrhonota*) can be found along rivers (Frisch 1987, YEWG 2004).

Alpine/subalpine areas are absent from the RSA. Species that inhabit the alpine/subalpine in other parts of the ecoregion include Golden Eagle (*Aquila chrysaetos*), Rock Ptarmigan (*Lagopus muta*), Horned Lark (*Eremophila alpestris*), American Pipit (*Anthus rubescens*), Gray-crowned Rosy Finch (*Leucosticte tephrocotis*), Upland Sandpiper (*Bartramia longicauda*), and Townsend's Solitaire (*Myadestes townsendi*) (Frisch 1987, YEWG 2004).

The Project RSA does not include cliffs or bluffs that could be used by cliff-nesting raptors, such as Golden Eagle, Peregrine Falcon (*Falco peregrinus*) or Gyrfalcon (*Falco rusticolus*). These species' nearest suitable nesting cliffs are along the Porcupine River and Eagle River (Hayes and Mossop 1978).

Data on birds in the Project area are currently limited. The first evaluation of bird occurrences in Eagle Plains was *Birds by the Dempster* (Frisch 1987). Birds of the Yukon Territory (Sinclair et al. 2003) provided a more detailed description of species occurrences, habitat, and relative abundances. More recently, a general account of birds within the region was presented by Environment and Climate Change Canada in their report, *Bird Conservation Strategy for Bird Conservation Region 4 in Canada: Northwestern Interior Forest* (Environment Canada 2013a). The North American Breeding Bird Survey (NABBS) is the best local data source. Two NABBS routes along the Dempster Highway (routes 78 and 79) are close to the Project.

2.3 METHODS

This study consisted of two components: a desktop assessment to collect and summarize existing information about birds relevant to the Project area and field surveys to document the occurrence, relative abundance, and habitat associations of birds across the Project RSA. This approach, field survey design, and methods details were discussed with CWS representatives during the project planning stage. The methods used considered specific recommendations provided by CWS representatives and a broader set of recommendations in *A Framework for the Scientific Assessment of Potential Project Impacts on Birds* (Hanson et al. 2009). The methods selected and reporting herein also comply with the the ten key considerations identified in the DRAFT updated guidelines *Canadian Wildlife Service Guidance Regarding Information Needed to Support Assessment of Project Effects on Birds* (ECCC-CWS 2022).

2.3.1 DESKTOP ASSESSMENT

A list of bird species that had the potential to occur in the Project RSA was developed from a combination of historical occurrence data in adjacent areas, a territorial field guide, and a national bird conservation assessment.

Historical data were gathered from the NABBS database for two routes (routes 78 and 79) that run along the Dempster Highway in the Eagle Plains region (Pardieck et al. 2019). The NABBS is a long-term, large-scale monitoring program that began in 1966 to track trends in avifauna. It consists of annual (one day a year) standardized roadside surveys, during the peak breeding season, by skilled observers making 50 stops spaced 0.8 km apart, along 39.4 km long routes. Observers record the number of bird species heard from any distance or seen within a 0.4 km radius of each stop during a three-minute observation period. These data are then compiled and made freely available to analyze trends in relative abundance and species composition. From 2014 to 2018, NABBS identified 48 species along Eagle Plains' two routes (above) (Pardieck et al. 2019).

General information about bird species occurrences was obtained from *Birds by the Dempster* (Frisch 1987), *Birds of Yukon* (Sinclair et al. 2003), and the Federal conservation assessment, *Bird Conservation Strategy for Bird Conservation Region 4 in Canada: Northwestern Interior Forest* (Environment Canada 2013a). These sources ranked species as 'Likely' or 'Possible' in the RSA based on habitat requirements, range boundaries, and occurrence information. Likely species were those whose range overlapped with the RSA, and suitable habitat occurred in the RSA. Possible species included (1) those with suitable habitat in the RSA, but whose range was on the edge of the RSA, and (2) those whose range overlapped with the RSA, but for which the availability of suitable habitat was in question.

2.3.1.1 Conservation Status

The conservation status of bird species was identified based on the most recent recommendations by COSEWIC (COSEWIC 2018) and current lists in the *Species at Risk Act* (SARA) registry (i.e., the most recent amendment, Environment and Climate Change Canada 2019) and BCR 4 plan. The SARA registry groups species into one of three schedules:

- Schedule 1 — the official list of species at risk in Canada includes species that are either Extirpated, Endangered, Threatened or of Special Concern;
- Schedule 2 — species designated as Endangered or Threatened, but that have yet to be re-assessed by COSEWIC under the revised criteria; and,

- Schedule 3 — species designated as Special Concern but have yet to be re-assessed by COSEWIC under the revised criteria.

Birds that fall under conservation categories of Special Concern or higher were identified. All bird species of conservation concern, identified through the designation and ranking processes described above, were evaluated against their species conservation status assessment found in the national bird conservation strategy for BCR 4 (Environment Canada 2013a). The BCR 4 strategy outlines conservation planning and priorities to support the implementation of migratory bird conservation programs. The BCR species assessment considered population size, population trend, regional abundances and densities, and species and habitat threats to designate species warranting "Concern and Stewardship at the Regional, National, or Continental level". Stewardship species are based on "having a large proportion of their world population within BCR 4". Species managed by Environment Yukon under the Yukon *Wildlife Act* were also noted.

2.3.2 HABITAT STRATIFICATION

A broad avian habitat classification system was developed to provide representative survey coverage across the RSA. A habitat stratification approach was applied to site selection for all survey sites before field surveys. Avian habitat types were initially developed using Predictive Ecosystem Mapping (PEM), later verified with Ecological and Landscape Classification (ELC) mapping for habitat-related analyses. Two key components of the initial PEM mapping to define avian habitat types were: ecosystem units and structural stage, described below.

2.3.2.1 Ecosystem Units (Ecosites)

The North Yukon PEM was used to classify 16 ecosystem units in the Project RSA. However, the PEM model was unsatisfactory when assessing ecosite predictions in the field because of its low accuracy. The PEM ecosite codes were used to guide each survey location, but adjustments were made to the classifications according to the dominant vegetation. These changes were supplemented with detailed notes and descriptions of plant and tree species (i.e., lichen cover, percent shrubs, tree height and canopy closure), as well as photographs, with the intent of reclassification.

The purpose of reclassifying PEM ecosystem units was to describe site-specific vegetation at a finer resolution and, ultimately, develop more accurate associations between species of birds and habitat in the Project RSA. A detailed review was conducted of all point count and wetland survey forms, including a review of notes on species of vegetation and structural stage (Table 2-1) and analyzing each survey station's photographs. Deciduous and coniferous (i.e., primarily black spruce) vegetation were distinguished based on their relative densities at ecosites previously classified as mixed wood. Patterns of bird occupation were then analyzed to determine whether deciduous and mixed vegetation warranted separate ecosite codes. Shrub-stage and mature-stage spruce stands were differentiated based on tree height and the degree of canopy closure. Separating these two structurally distinct stands yields two ecological communities with different bird assemblages, e.g., species requiring mature trees for nest cavities, such as owls and woodpeckers, are unlikely to be found in shrub-stage forests. These new ecosites were summarized along with their previous PEM codes and descriptions of key vegetation characteristics. In total, 32 distinct ecosystem units were developed from the PEM model (Table 2-2).

Table 2-1. Structural and successional stages of vegetation associated with ecosystem units in the Eagle Plains Project Regional Study Area.[1]

Code	Structural Stage	Description
1	Non-vegetated	Very recent disturbance and no vegetation (or <5% vegetation).
2a	Sparse	Initial stages of primary and secondary succession with 5–10% vegetation cover maintained by environmental conditions.
2b	Cryptogram (Bryoid-dominated)	Bryophyte-dominated community maintained by environmental conditions.
3a	Herb (Forb-dominated)	Early successional stage of herbaceous communities maintained by environmental conditions or disturbance. Includes non-graminoid herbs and ferns.
3b	Herb (Graminoid-dominated)	Early successional stage of herbaceous communities maintained by environmental conditions or disturbance. Includes grasses, sedges, reeds, and rushes.
3c	Herb (Aquatic)	Early successional stage of herbaceous communities maintained by environmental conditions or disturbance. Dominated by floating or submerged plants.
4a	Tall Shrub	Early successional stage of forest or shrub communities dominated by shrub layer vegetation > 2 m tall.
4b	Low Shrub	Early successional stage of forest or shrub communities dominated by shrub layer vegetation <2 m tall.
5	Pole/Sapling	Trees >2 m tall and typically densely stocked. Vertical structure and layering not yet evident.
6	Young Forest	Forest canopy with distinct layers and somewhat open stand.
7	Mature Forest	Mature trees and well-developed understories at canopy openings.
8	Old Forest	Old and structurally complex stands composed mainly of shade-tolerant and regenerating tree species.

[1] Modified from Environment Yukon 2017.

Table 2-2. Modified predictive ecosystem mapping ecosites relative to original ecosites in the Eagle Plains Project Regional Study Area.

Modified PEM	PEM	*N*[1]	Vegetation Description
211-D	211	7	Wet deciduous shrub; predominantly willow and scrub birch. Structural stage 4b.
211-SB	211, 213	3	Wet black spruce shrub (peat bog). Structural stages 4a–6.
211-SB-ML	211, 213	2	Wet black spruce shrub with moderate lichen cover. Structural stages 4a–6.
213-tp	213	2	Wet black spruce dominant forest; tall and productive stands. Structural stages 6 and 8.
221	221	1	Moist mixed shrub; black spruce and deciduous (scrub birch and willow). Structural stage 4b.

Modified PEM	PEM	*N*[1]	Vegetation Description
221-D	221	12	Moist deciduous shrub; predominantly scrub birch and willow. Structural stages 4a–b.
221-SB	221, 223	18	Moist black spruce shrub. Structural stages 4a-6.
221-SB-LL	221, 223	3	Moist black spruce shrub with low lichen cover. Structural stage 4a.
221-SB-ML	223	2	Moist black spruce shrub with moderate lichen cover. Structural stage 6.
221-SB-HL	221	1	Moist black spruce shrub with high lichen cover. Structural stage 4a.
222	222	6	Moist mixed forest; spruce and deciduous (birch and/or alder). Structural stages 5-8.
222-D	222	1	Moist deciduous forest; birch dominant. Structural stage 6.
223-tp	222, 223	4	Moist black spruce forest; sometimes mixed with white spruce. Structural stages 6-7.
223-LL-tp	223	2	Moist black spruce forest; sometimes mixed with white spruce; low lichen cover. Structural stages 6-7.
230	230	1	Mesic herb with <15% shrub cover. Structural stages 2b and 4b.
231-D	231	4	Mesic deciduous shrub; predominantly willow and scrub birch. Structural stages 4a–b.
231-D-ML	231	1	Mesic deciduous shrub; predominantly willow and scrub birch; moderate lichen cover. Structural stage 4a.
231-SB	231, 233	7	Mesic black spruce shrub. Structural stages 4a–6.
231-SB-HL	233	3	Mesic black spruce shrub with high lichen cover. Structural stages 4a–6.
232	232	3	Mesic mixed forest; black spruce and deciduous (paper birch and/or trembling aspen). Structural stages 5–6.
232-D	232	3	Mesic deciduous forest; predominantly paper birch and willow. Structural stages 5–6.
233-tp	233	5	Mesic black spruce forest sometimes mixed with white spruce; tall and productive stands. Structural stages 6-7.
233-LL-tp	233	1	Mesic black spruce forest with some black spruce shrubs; low lichen cover; tall and productive stands. Structural stages 4b, 6–7.
233-HL-tp	233	1	Mesic black spruce forest; high lichen cover; tall and productive stands. Structural stage 6.
310	310	4	Riparian herb with little to no shrub cover. Structural stages 3b–c.
311-D	311	22	Riparian deciduous shrub; predominantly scrub birch and willow. Structural stages 4a-b.
311-SB	311, 313	4	Riparian black spruce shrub. Structural stages 4a–6.
311-SB-T	311	4	Riparian black spruce and tamarack shrub. Structural stages 4a–6.
313	313	11	Riparian spruce forest; mix of black and white spruce, as well as hybrids. Structural stages 6–8.
400	400	4	Wetland herb. Structural stage 3b.
401-D	401	1	Wetland deciduous shrub; predominantly scrub birch and willow. Structural stage 4b.
500	500	17	Open water.

[1] Sample size, the number of survey stations (point count or pond) within each modified PEM ecosite.

2.3.2.2 Bird Habitat Types

Once ecosystem units were reclassified, they were grouped according to vegetation and structural stage similarities. Mixed and deciduous vegetation, while ecologically distinct, did not differ in their use by birds; therefore, they were grouped in a single category. Ultimately, 32 ecosystem units were consolidated into ten broad avian habitat types: Herb, Deciduous/Mixed Shrub, Tall Shrub – Black Spruce, Deciduous/Mixed Forest, Spruce Forest, Riparian/Wetland Deciduous Shrub, Riparian Coniferous Shrub, Riparian Spruce Forest, Open Water, and a classification ('Unknown') for distant (>100 m) or flyover observations that prevented associating birds with habitat (Table 2-3). As a post hoc exercise, ELC ecosite types were assigned to broad habitat types based on the spatial overlap with survey sites with the ELC map and verified using field-based habitat descriptions (Table 2-3). For a complete list of ELC codes, names, and descriptions, see Attachment Table 1 in Section 2.6.1 (Attachment 2-A).

Table 2-3. Avian habitat types developed by grouping modified Predictive Ecosystem Mapping ecosites, based on their similarities in vegetation and structural stages, in the Eagle Plains Project Regional Study Area. *A posteriori* classified ELC ecosites are provided for each habitat type.

Avian Habitat Type	Modified PEM Ecosite	ELC Ecosite[1]	Structural Stages	*N*[2]	Vegetation Description
Herb	230, 310, 400	31, 33, 42, B2	2b, 3b, 3c, 4b	9	Herb dominant sites found along crests and upper slopes, riparian zones, and wetlands; <20% shrub cover.
Deciduous and Mixed Shrub	211-D, 221, 221-D, 231-D, 231-D-ML	06, 22, 23, 31, 33, 34, 35, 42, B2	4a-b	24	Predominantly scrub birch and/or willow vegetation, sometimes with a mix of black spruce; lichen cover possible.
Tall Shrub – Black Spruce	211-SB, 211-SB-ML, 221-SB, 221-SB-LL, 221-SB-ML, 221-SB-HL, 231-SB, 231-SB-HL	05, 06, 14, 20, 23, 33, 34, 42	2b, 4a-b, 6	35	Tall shrub/dwarfed black spruce dominated area often with low to high lichen cover.
Deciduous and Mixed Forest	222, 222-D, 232, 232-D	04, 05, 06, 33, 34	5, 6, 7, 8	13	Birch dominant forest or mix of spruce and deciduous (e.g., birch, aspen, and alder) stands.
Spruce Forest	213-tp, 223-tp, 223-LL-tp, 233-tp, 233-LL-tp, 233-HL-tp	05, 33, 42, B1	6, 7, 8	14	Black spruce dominant forest, sometimes mixed with white spruce, and often with low to high lichen cover. Ranges from intermediate height stands with open canopy to tall and closed canopy forest.
Riparian/Wetland Deciduous Shrub	311-D, 401-D	20, 23, 31, 33, 35, 42, 43, 44	2b, 3b, 4a-b	23	Predominantly scrub birch and willow shrub along riparian zones and wetlands.
Riparian Coniferous Shrub	311-SB, 311-SB-T	22, 33, 35, 42, 43, B1	2b, 4a-b, 6	8	Black spruce and tamarack dominant riparian shrub.
Riparian Spruce Forest	313	22, 23, 31, 35, 42, 43, B2	6, 7, 8	11	Dominated by mix of black and white spruce, as well as spruce hybrids.
Open Water	500	LA, PD	1	17	Non-vegetated open water.
Unknown	UNK	UNK	UNK	74	Unknown habitat due to distant observations (>100 m) or flyovers.

[1] Broad ELC polygons within which survey stations were located.

[2] Sample size, the number of survey stations (point count or pond) within each habitat group.

2.3.3 OCCURRENCE AND DISTRIBUTION SURVEYS

Two experienced bird biologists conducted field surveys in the Project RSA between June 25 to 30, 2019. Each biologist had more than 15 years of experience conducting point count surveys and could reliably identify all bird species by sight and vocalizations that had the potential to occur. All surveys employed a targeted, stratified habitat design to provide sampling across all broad avian habitat types.

2.3.3.1 Breeding Bird Point Count Surveys

'Point count' surveys were conducted in terrestrial habitats following standardized survey methods (Ralph et al. 1995, Resources Inventory Committee 1999a, Matsuoka et al. 2014). Point count stations were visited along walking transects to facilitate efficient survey productivity (i.e., versus individual point counts spaced more widely, which would have resulted in longer travel time and a lower number of survey stations). Point count survey stations were established within a Geographic Information System (GIS) using guided site selection to provide coverage across all avian habitat types and broad spatial coverage across the RSA (Map 2-1). Random site selection approaches were explored but ultimately not used because of challenges associated with safety (steep terrain), logistics (access), and reduced sample sizes (i.e., randomization resulted in much smaller sample sizes due to greater travel times to transect starting stations and between stations). Site selection targeted a minimum of four stations in each habitat type. The location of existing and proposed development features was also considered to ensure the surveys covered those areas. Stations were spaced approximately 500 m apart, with a minimum spacing of 400 m, to avoid counting the same birds from multiple stations. Point count locations were chosen in two ways to associate bird occurrences with habitat types: (1) locating stations within one PEM polygon, at least 100 m from the polygon edge; and (2) locating the station on the boundary between two PEM polygons where the location of birds in different habitat types could be reliably determined (e.g., on the transition between shrubland and forest type). Each point count station was surveyed once to maximize the number of sampled sites.

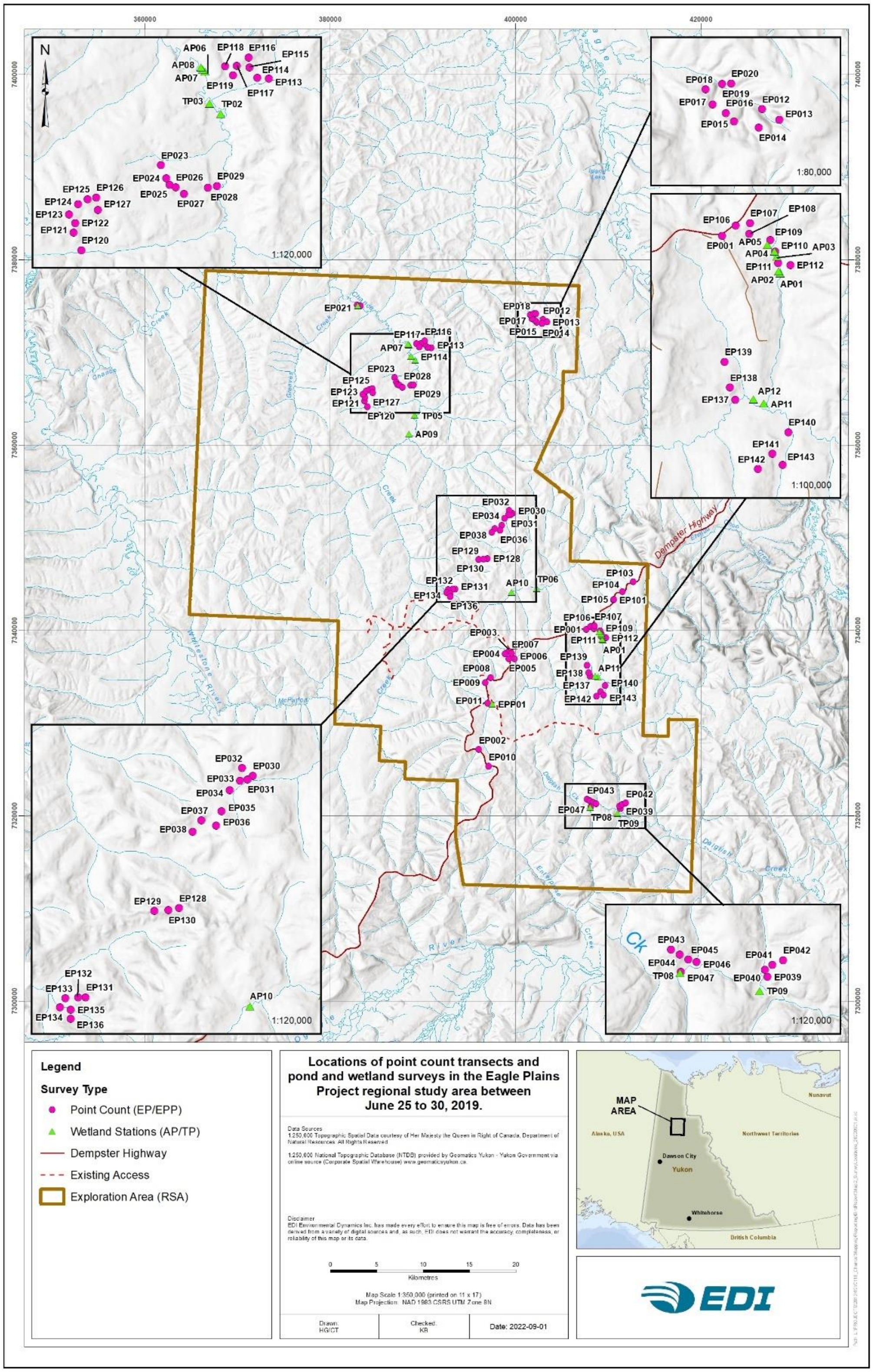
Survey methods followed standard point count survey methodologies (Ralph et al. 1995, Resources Inventory Committee 1999a, Matsuoka et al. 2014). Surveys used a 10-minute detection period and an unlimited recording distance. Biologists conducted surveys during the dawn chorus (i.e., a half-hour before dawn to ~8:30) when territorial singing rates are highest. Upon arriving at the predetermined survey station location, surveyors evaluated the station location and, where appropriate, revised the location by up to 50 m to aid in accurately plotting bird locations in their associated habitat types. Once on station, surveyors waited two minutes to allow any birds disturbed by the surveyor's arrival to settle and resume their activities. Once the official observation period began, surveyors recorded all birds detected (visual or auditory) during the 10-minute detection period by plotting their locations on a point count map form and recording the standardized four-letter species name abbreviation, time of detection, sex, age, number, behaviour, and the habitat type in which they occurred (i.e., ecosystem unit and structural stage). Surveyors assigned birds estimated to be >100 m distant at a distance of 101 m due to the high uncertainty of estimates at those distances. Following the surveys, a bearing and distance were measured on the point count map from the station location for each bird observation (<100 m) used to calculate coordinates for each observation. A total of 91 point count stations were surveyed over six days.

2.3.3.2 Pond and Wetland Surveys

For wetland surveys, protocols were adapted from the BC RISC Standards *Inventory Methods for Waterfowl and Allied Species* (Resources Inventory Committee 1999b). Before surveys, ponds and open water wetlands within 3 km of existing or proposed project development were identified using the PEM map. Shoreline surveys were conducted at 19 unique ponds, and observations were made from stations along the shoreline using binoculars and scopes. The number of stations varied from one to five, depending on the size and shape of the ponds. Approximately half of a pond's total perimeter was traversed along a section of shoreline parallel to the longest axis of the feature to provide complete visual coverage of the waterbody. Surveyors approached waterbodies covertly and began surveys behind screening vegetation to avoid flushing birds from the ponds before they were tallied. Ground-based surveys were thought to provide a census of birds present at each pond. However, a few birds obscured by shoreline vegetation may not have been counted. Biologists recorded the following information for each pond for all detected birds: species, sex, age, number, and habitat associations.

2.3.3.3 Cliff-nesting Raptors Habitat Assessment

Cliff-nesting raptors, including Peregrine Falcon, Gyrfalcon, and Golden Eagle, are relatively common in parts of North Yukon with suitable cliffs, such as the Ogilvie Mountains, south of Eagle Plains. Nesting occurrences of these species are not known in the Eagle Plains area. Due to the subdued topography of the Eagle Plains area, suitable nesting cliffs are likely to be uncommon or non-existent. We systematically assessed the potential for suitable nesting cliffs across the study area by mapping areas with a slope >30 degrees (the lowest gradient in which EDI Environmental Dynamics Inc. (EDI) staff have found cliff nests in other parts of the Yukon). This mapping exercise did not identify any suitable cliffs in the area. Therefore, targeted field surveys for this species group were not conducted.



Map 2-1. Locations of point count transects and pond and wetland surveys in the Eagle Plains Project Regional Study Area between June 25 to 30, 2019.

2.4 RESULTS AND DISCUSSION

2.4.1 DESKTOP ASSESSMENT

Based on range and habitat requirements, 128 species can occur in the Eagle Plains Project RSA. This includes 99 'Likely' species (52 confirmed by surveys and incidental observations presented in this report) and 29 'Possible' species. These 'Possible' species included Common Nighthawk (*Chordeiles minor*) observed once in the RSA during these surveys. Despite the confirmed occurrence, the species is still considered 'Possible' because it is outside its regular range, and none were observed during NABBS between 2014 and 2018 (i.e., the single observation during these surveys could have been an extralimital record). A summary of these potential species and conservation statuses, ordered by species groups, is provided in Table 2-4. A more detailed discussion of the species identified within the Project RSA is provided in Section 2.4.2. For an exhaustive list of all potential bird species, see Attachment Table 2 in Section 2.6.2 (Attachment 2-B).

The NABBS database is a valuable information source for the occurrence and distribution of bird species in the region because they are a recent and systematic survey. Of the two survey routes near the Project area (i.e., routes 78 and 79), route 79 was surveyed annually between 2014 and 2018, and route 78 was surveyed in each of those years except 2016. In total, observers who participated in these surveys identified 1,945 birds from 48 species (Table 2-4). Though these data are useful in identifying species common to the region, road-side surveys introduce bias in estimating species occurrences and relative abundances, especially when extrapolating to off-road areas (Sólymos et al. 2020). This may explain why 'Possible' species (e.g., Harlequin Duck [*Histrionicus histrionicus*], Surfbird [*Calidris virgata*], and Golden-crowned Sparrow [*Zonotrichia atricapilla*]) were recorded on the NABBS routes but not within the RSA, and why 18 species confirmed during surveys within the RSA (e.g., Red-necked Phalarope [*Phalaropus lobatus*], Great Gray Owl [*Strix nebulosa*], and American Three-toed Woodpecker), were not detected over five years of road-side surveys.

Overall, species occurrence and relative abundance patterns differed among years in both NABBS routes. The total number of detections decreased from 2014 to 2018, and this pattern was consistent for most bird species. This may partly correspond to the survey effort. The number of species identified and the number of birds detected were similar between route 78 (920 counts from 34 species) and route 79 (1,025 counts from 39 species) during the five-year period. No species-specific trends were evident in the data.

The NABBS data also included three species (six detections) federally designated as Special Concern: Short-eared Owl (*Asio flammeus*; one occurrence in both 2015 and 2016, and two occurrences in 2018), Rusty Blackbird (*Euphagus carolinus*; one occurrence in 2015), and Olive-sided Flycatcher (*Contopus cooperi*; one occurrence in 2018).

Table 2-4. Total number of potential (likely and possible) bird species in the Eagle Plains Project Regional Study Area, June 2019, grouped by higher-order classification. North American Breeding Bird Survey (2014–2018) confirmed species and counts are provided.

Order	Likely	Possible	Likely + Possible (Total)	NABBS Confirmed (2014–2018)[1]
Grebes – Podicipediformes	2	0	2	0
Loons – Gaviiformes	3	0	3	0
Waterfowl – Anseriformes	17	7	24	6 (24)
Shorebirds – Charadriiformes	12	9	21	3 (13)
Grouse – Galliformes	2	4	6	2 (2)
Diurnal Birds of Prey – Accipitriformes	9	0	9	4 (5)
Falcons – Falconiformes	4	0	4	1 (1)
Owls – Strigiformes	5	0	5	2 (6)
Rails – Gruiformes	1	0	1	0
Kingfishers – Coraciiformes	1	0	1	0
Nightjars – Caprimulgiformes	0	1	1	0
Woodpeckers – Piciformes	2	1	3	0
Songbirds – Passeriformes	41	7	48	30 (1,894)
Jays, Crows and Allies	2	0	2	2 (59)
Blackbirds	1	0	1	1 (1)
Thrushes and Allies	6	1	7	6 (381)
Shrikes and Vireos	1	0	1	0
Flycatchers and Allies	4	0	4	2 (2)
Swallows	3	1	4	0
Sparrows, Finches and Allies	11	3	14	10 (1,204)
Chickadees, Nuthatches and Wrens	2	1	3	0
Warblers	8	1	9	8 (245)
Others	3	0	3	1 (2)
Totals	**99**	**29**	**128**	**48 (1,945)**
SARA Schedule 1	**7**	**1**	**8**	**3**
BCR 4 Priority	**51**	**12**	**63**	**20**

[1] Count of individual bird observations for each group in brackets.

2.4.2 OCCURRENCE AND RELATIVE ABUNDANCE

A total of 974 birds from 52 species were detected during the breeding bird surveys (i.e., point count transects and wetland/pond surveys). One raptor species not included in these counts—Swainson's Hawk—was identified, incidentally, on four separate occasions between June and August 2019, totalling five individuals. These additional observations bring the number of total detections to 979 birds from 53 species.

Songbirds (*Passeriformes*) were the most diverse and abundant group of birds, while falcons (*Falconiformes*), owls (*Strigiformes*), and nightjars (*Caprimulgiformes*) were the least diverse and abundant (Table 2-5). Proportionally, more waterfowl and shorebirds were identified during wetland/pond surveys, and more songbirds and raptors were identified during point count transects. More birds were counted during point count transects (743 versus 231), but a similar number of species were identified during point counts transects and wetland/pond surveys (42 in point counts and 37 in wetlands; Table 2-5).

Table 2-5. Total counts and species of birds observed during point count transects and wetland/pond surveys in the Eagle Plains Project Regional Study Area, June 2019, grouped by higher-order classification.

Order	**Point Count Transects**		**Wetland/Pond Surveys**		**Combined**	
	Count	**No. Species**	**Count**	**No. Species**	**Count**	**No. Species**
Waterfowl – Anseriformes	3	2	99	7*	102	7
Shorebirds – Charadriiformes	18	4	38	7*	56	7
Diurnal Birds of Prey – Accipitriformes	2	2	0	0	2	2
Falcons – Falconiformes	1	1	0	0	1	1
Owls – Strigiformes	1	1	1	1*	2	1
Nightjars – Caprimulgiformes	1	1	0	0	1	1
Woodpeckers – Piciformes	3	1	0	0	3	1
Songbirds – Passeriformes	714	30	93	22*	807	32
Jays, Crows and Allies	52	2	6	1*	58	2
Blackbirds	3	1	16	1*	19	1
Thrushes and Allies	155	5	12	3*	167	5
Flycatchers and Allies	16	3	3	2*	19	3
Swallows	0	0	3	1	3	1
Sparrows, Finches and Allies	340	10	33	8*	373	10
Chickadees, Nuthatches and Wrens	9	2	0	0	9	2
Warblers	139	7	16	5*	155	7
Others	0	0	4	1	4	1
Totals	743	42	231	37*	**974**	**52**

* Number of species from wetland/pond surveys were not all unique from those in point count transects.

2.4.3 SPECIES AND HABITAT ASSOCIATIONS

Analyses of the association between bird species and habitat type controlled for survey effort (i.e., average counts per point count station). The average number of birds (i.e., relative abundance) and the average number of species varied considerably among survey stations and the different avian habitat types (Figure 2-1; Table 2-6). The average relative abundance was greatest in Open Water, Deciduous and Mixed Shrub, Riparian/Wetland Deciduous Shrub, and Spruce Forest habitats; it was lowest in Riparian Spruce Forest, Herb, and Tall Shrub – Black Spruce habitats. Among habitat types, the proportion of (average) detections to the (average) number of species was consistent, with a higher relative abundance being associated with a greater number of species. In general, this pattern was related to the structural complexity and productivity of the various habitat types. For example, Herb habitat is less structurally complex and consists exclusively of graminoid ground cover; it had the fewest species (but had a relatively high number of unique species; see Figure 2-2). In contrast, Spruce Forest habitat can be structurally complex due to variations in canopy cover, understory, and ground cover, and older stands may contain a variety of forest structures that provide habitat for a variety of bird species and life requisites including nesting (e.g., Yellow-rumped Warbler), perching (e.g., Olive-sided Flycatcher), and insect foraging (either on the ground [e.g., Gray-cheeked Thrush] or on live/dead trees [e.g., American Three-toed Woodpecker]). Consequently, Spruce Forest had the greatest species richness of all avian habitat types. The exception to the general association between relative abundance and species richness was Open Water habitat, which had the highest relative abundance but one of the lowest average number of species.

The number of species (i.e., species richness) and the number of unique species (i.e., species exclusive to a habitat type) were summarized for each avian habitat type. Unequal survey effort across habitat types could bias such comparisons of species totals across habitat types; however, it does provide a useful approach to examine general patterns of bird occurrence and assemblages within and across habitat types. Spruce Forest, Riparian/Wetland Deciduous Shrub, and Deciduous and Mixed Shrub habitat types had the greatest species richness, while Herb and Open Water habitat types had the least species richness (Figure 2-2). Patterns of species richness may, in part, be due to the distribution of survey stations in each habitat type, especially in Herb habitat (only nine stations). The Open Water habitat also had low species richness despite surveys at 17 survey stations. This may reflect the limited availability of waterbodies and wetlands in the broader region (i.e., relatively few water-associated bird species occur because the habitat is so limited and dispersed).

No clear association was found between species richness and the number of unique species. For example, Open Water was one of the least species-rich habitat types but had the most unique species. This is not surprising because Open Water is a unique habitat compared to the other terrestrial habitats, and a different complement of bird species occurs there. Other habitat types with many species (e.g., 21 species in Deciduous and Mixed Shrub) had no species unique to those habitats. Likely, riparian habitat types did not have unique species because species that occupy riparian habitat often have broad, rather than specific, requirements. For example, Rusty Blackbird and Lesser Yellowlegs were found in Riparian Coniferous Shrub, Riparian/Wetland Deciduous Shrub, and Herb habitat types.

Patterns of bird occurrences were analyzed in terms of species-specific detection rates (Table 2-6). Songbird species had the highest detection rates overall because these species consistently occupied several different habitat types. Only 15 species occupied a single habitat, and the remaining 47 species occupied multiple habitats (most frequently two or three habitats; Figure 2-3). Species that occupied four or more habitat types were exclusively songbirds and had the highest detection rates. This included species groups such as thrushes, sparrows, and their respective allies. Only 10 species occurred in six or more habitats: Canada Jay, American Robin, Gray-cheeked Thrush, Swainson's Thrush, Common Redpoll, Fox Sparrow (*Passerella iliaca*), White-crowned Sparrow (*Zonotrichia leucophrys*), American Tree Sparrow, Lincoln's Sparrow, and Yellow Warbler. Overall, species with high detection rates included a combination of habitat specialists and habitat generalists. Waterfowl and obligatory wetland species (e.g., Red-necked Phalarope), which were restricted to Open Water habitat, had high detection rates in that habitat (Table 2-6).

In contrast, thrushes (e.g., Gray-cheeked Thrush) and warblers (e.g., Yellow Warbler), which occupied several different habitat types, had high detection rates in many of the habitats they occupied (Table 2-6). The five species with the highest overall (average) detection rates (i.e., across all 110 survey stations in the RSA) were Canada Jay, Swainson's Thrush, Lincoln's Sparrow, White-crowned Sparrow and Yellow-rumped Warbler. For a general overview of bird species assemblages within each habitat type, ordered by highest to lowest detection rates, see Table 2-7. General patterns of frequency and use of habitat types by species in the RSA are consistent with expectations and correspond to patterns reported in other studies (Schieck and Song 2006, Mahon et al. 2016).

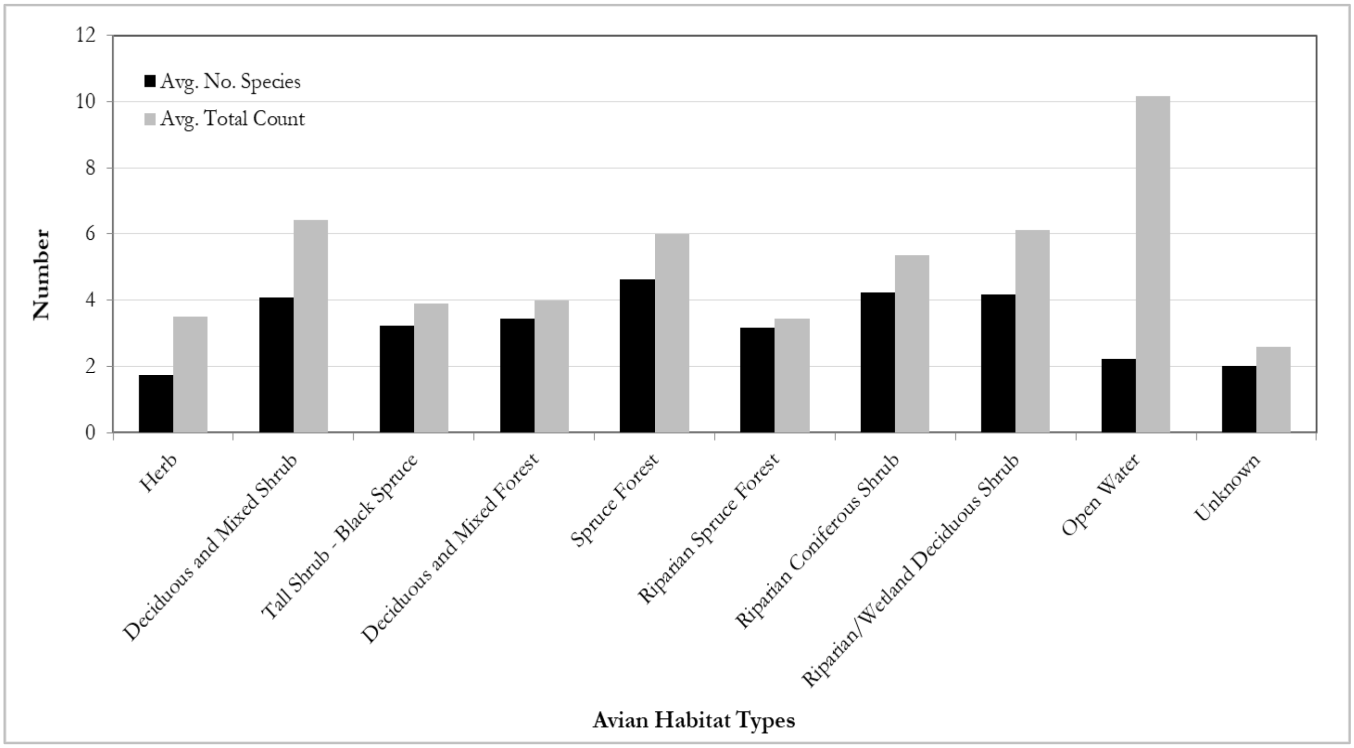


Figure 2-1. The average number of species and average total counts of birds observed among the avian habitat types in the Eagle Plains Project Regional Study Area, June 2019.

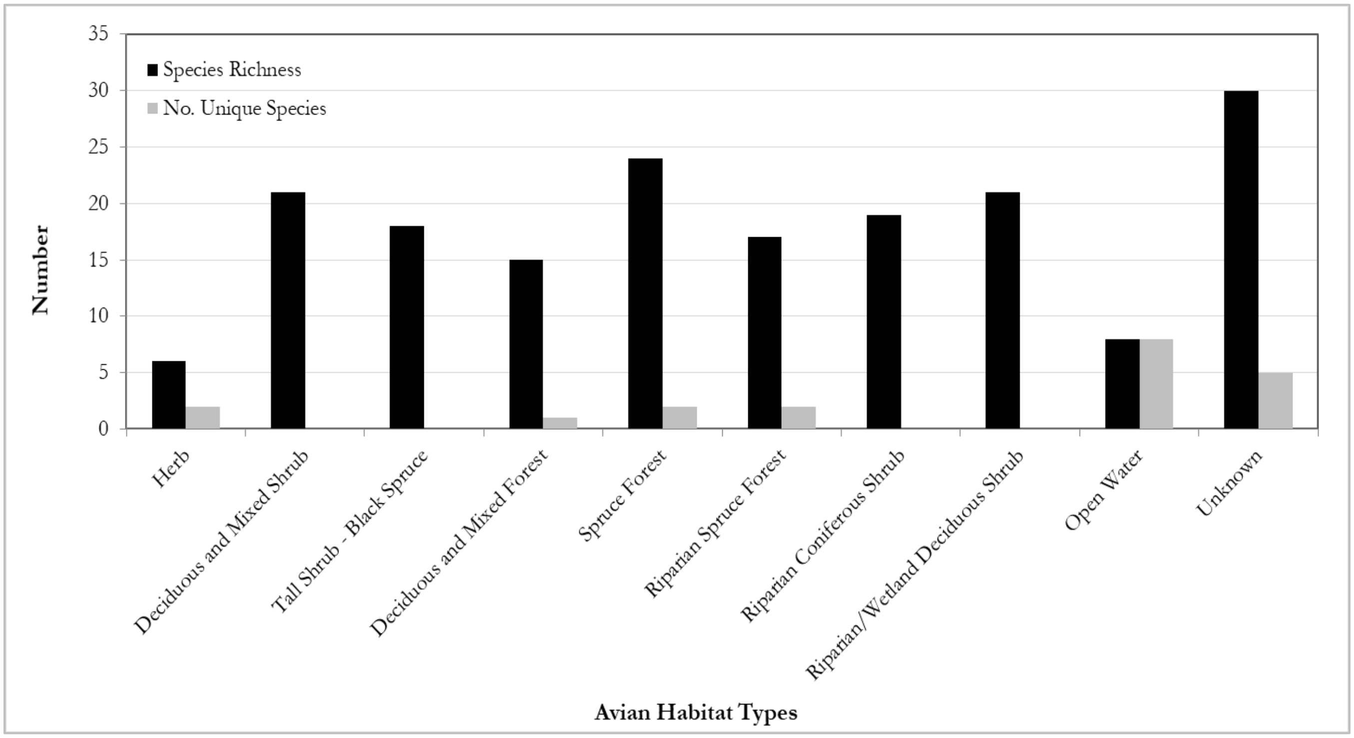


Figure 2-2. Species richness and number of unique birds observed among the avian habitat types in the Eagle Plains Project Regional Study Area, June 2019.

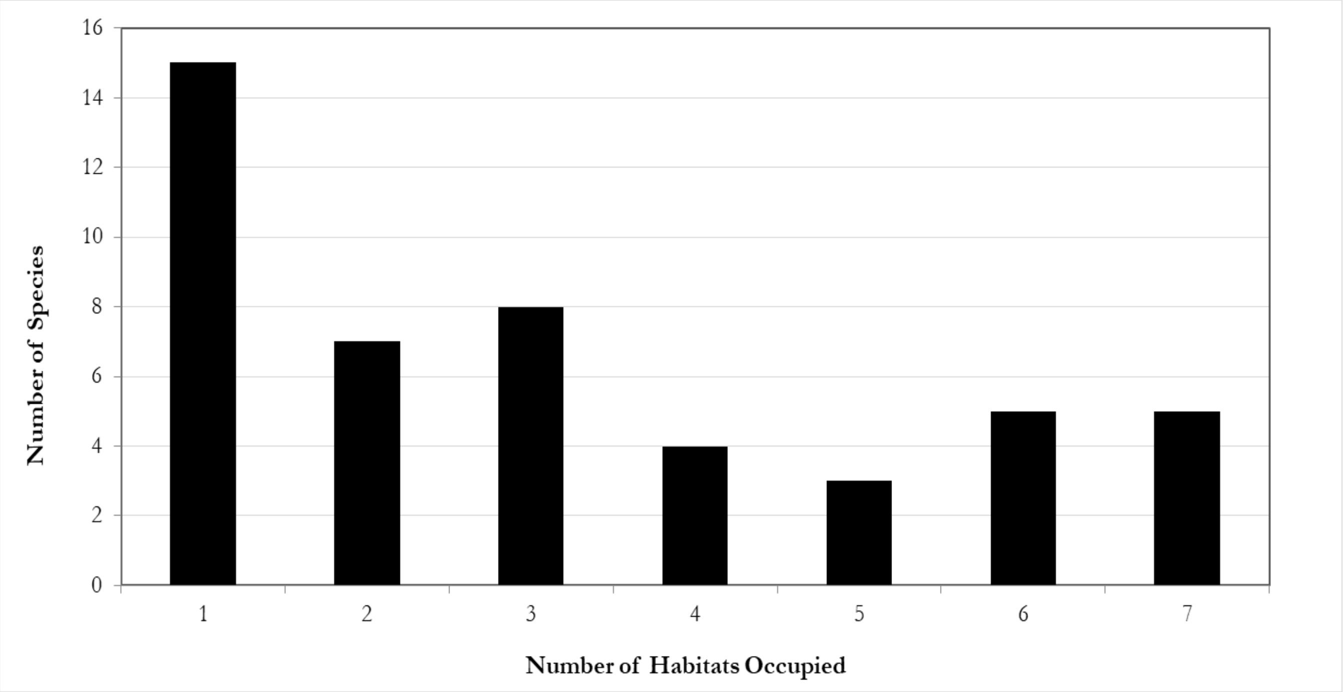


Figure 2-3. Frequency distribution of the number of habitats occupied by bird species in the Eagle Plains Project Regional Study Area, June 2019.

Table 2-6. Average detection rates (birds per survey station) for 52 bird species across 10 avian habitat types in the Eagle Plains Project Regional Study Area, June 2019.[1]

Species Common Name	Species Scientific Name	Herb (9)	Deciduous/Mixed Shrub (24)	Tall Shrub – Black Spruce (35)	Deciduous/Mixed Forest (13)	Spruce Forest (14)	Riparian Spruce Forest (11)	Riparian Coniferous Shrub (8)	Riparian/Wetland Deciduous Shrub (23)	Open Water (17)	Unknown (74)	Average Species Detection Rate	Total Species Detections
Waterfowl													
American Wigeon	*Mareca americana*									1.29		0.20	22
Mallard	*Anas platyrhynchos*									0.29		0.05	5
Northern Shoveler	*Spatula clypeata*									0.65		0.10	11
Northern Pintail	*Anas acuta*									0.47		0.07	8
American Green-winged Teal	*Anas crecca*									2.47		0.38	42
Lesser Scaup	*Aythya affinis*									0.41		0.06	7
Bufflehead	*Bucephala albeola*									0.41		0.06	7
Shorebirds													
Red-necked Phalarope	*Phalaropus lobatus*									0.88		0.14	15
Spotted Sandpiper	*Actitis macularius*	0.22										0.02	2
Solitary Sandpiper	*Tringa solitaria*							0.13	0.13		0.01	0.05	5
Lesser Yellowlegs	*Tringa flavipes*	1.44						0.13	0.09		0.01	0.15	17
Baird's Sandpiper	*Calidris bairdii*										0.03	0.02	2

Species Common Name	Species Scientific Name	Herb (9)	Deciduous/Mixed Shrub (24)	Tall Shrub – Black Spruce (35)	Deciduous/Mixed Forest (13)	Spruce Forest (14)	Riparian Spruce Forest (11)	Riparian Coniferous Shrub (8)	Riparian/Wetland Deciduous Shrub (23)	Open Water (17)	Unknown (74)	Average Species Detection Rate	Total Species Detections
Least Sandpiper	*Calidris minutilla*	0.22										0.02	2
Wilson's Snipe	*Gallinago delicata*	0.22	0.04						0.09		0.11	0.12	13
Diurnal Birds of Prey													
Northern Harrier	*Circus hudsonius*										0.01	0.01	1
Red-tailed Hawk	*Buteo jamaicensis*										0.01	0.01	1
Falcons													
Merlin	*Falco columbarius*				0.08							0.01	1
Owls													
Great Gray Owl	*Strix nebulosa*				0.08	0.07						0.02	2
Nightjars													
Common Nighthawk	*Chordeiles minor*						0.09					0.01	1
Woodpeckers													
American Three-toed Woodpecker	*Picoides dorsalis*					0.14		0.13				0.03	3
Songbirds — Jays, Crows and Allies													
Canada Jay	*Perisoreus canadensis*		0.38	0.57	0.69	0.79	0.18	0.25	0.09		0.01	0.51	56
Common Raven	*Corvus corax*										0.03	0.02	2

Species Common Name	Species Scientific Name	Herb (9)	Deciduous/Mixed Shrub (24)	Tall Shrub – Black Spruce (35)	Deciduous/Mixed Forest (13)	Spruce Forest (14)	Riparian Spruce Forest (11)	Riparian Coniferous Shrub (8)	Riparian/Wetland Deciduous Shrub (23)	Open Water (17)	Unknown (74)	Average Species Detection Rate	Total Species Detections
Songbirds — Blackbirds													
Rusty Blackbird	*Euphagus carolinus*	0.78						0.25	0.39		0.01	0.17	19
Songbirds — Thrushes and Allies													
American Robin	*Turdus migratorius*		0.13	0.20	0.31	0.21		0.50	0.13		0.03	0.24	26
Gray-cheeked Thrush	*Catharus minimus*		0.46	0.43		0.14	0.27	0.25	0.04		0.16	0.42	46
Swainson's Thrush	*Catharus ustulatus*		0.25	0.31	0.85	0.79	0.36	0.13	0.09		0.55	0.79	87
Hermit Thrush	*Catharus guttatus*						0.09					0.01	1
Varied Thrush	*Ixoreus naevius*				0.08	0.14					0.05	0.06	7
Songbirds — Flycatcher and Allies													
Olive-sided Flycatcher	*Contopus cooperi*		0.08			0.07	0.09	0.13			0.01	0.05	6
Yellow-bellied Flycatcher	*Empidonax flaviventris*		0.13	0.03				0.13				0.05	5
Alder Flycatcher	*Empidonax alnorum*		0.17			0.07		0.13	0.09			0.07	8
Songbirds — Swallows													
Tree Swallow	*Tachycineta bicolor*										0.04	0.03	3
Songbirds — Sparrows, Finches and Allies													
Pine Grosbeak	*Pinicola enucleator*			0.03		0.14		0.13			0.01	0.05	5

Species Common Name	Species Scientific Name	Herb (9)	Deciduous/Mixed Shrub (24)	Tall Shrub – Black Spruce (35)	Deciduous/Mixed Forest (13)	Spruce Forest (14)	Riparian Spruce Forest (11)	Riparian Coniferous Shrub (8)	Riparian/Wetland Deciduous Shrub (23)	Open Water (17)	Unknown (74)	Average Species Detection Rate	Total Species Detections
American Tree Sparrow	*Spizelloides arborea*		0.54	0.09	0.08	0.07	0.09	0.13	0.39		0.04	0.29	32
Chipping Sparrow	*Spizella passerina*			0.14		0.14					0.04	0.09	10
Savannah Sparrow	*Passerculus sandwichensis*	0.22	0.25					0.13	0.70		0.01	0.24	26
Fox Sparrow	*Passerella iliaca*		0.38	0.09		0.21	0.09	0.38	0.35		0.08	0.30	33
Lincoln's Sparrow	*Melospiza lincolnii*		0.92	0.17	0.08	0.36	0.18	1.50	1.09		0.03	0.68	75
White-crowned Sparrow	*Zonotrichia leucophrys*		1.08	0.29		0.14	0.09	0.63	0.52		0.24	0.67	74
Dark-eyed Junco	*Junco hyemalis*		0.08	0.37	0.15	0.07			0.09		0.08	0.24	26
White-winged Crossbill	*Loxia leucoptera*			0.23		0.36					0.43	0.41	45
Common Redpoll	*Acanthis flammea*		0.25	0.20	0.08	0.07	0.36		0.26		0.30	0.43	47
Songbirds — Chickadees, Nuthatches and Wrens													
Boreal Chickadee	*Poecile hudsonicus*		0.04	0.06		0.21	0.09					0.06	7
Red-breasted Nuthatch	*Sitta canadensis*				0.08		0.09					0.02	2
Songbirds — Warblers													
Ruby-crowned Kinglet	*Corthylio calendula*			0.11	0.23	0.29	0.18		0.04		0.07	0.17	19
Northern Waterthrush	*Parkesia noveboracensis*		0.21				0.36		0.57		0.01	0.21	23
Orange-crowned Warbler	*Leiothlypis celata*		0.25		0.31			0.13			0.03	0.12	13

Species Common Name	**Species Scientific Name**	**Herb (9)**	**Deciduous/Mixed Shrub (24)**	**Tall Shrub – Black Spruce (35)**	**Deciduous/Mixed Forest (13)**	**Spruce Forest (14)**	**Riparian Spruce Forest (11)**	**Riparian Coniferous Shrub (8)**	**Riparian/Wetland Deciduous Shrub (23)**	**Open Water (17)**	**Unknown (74)**	**Average Species Detection Rate**	**Total Species Detections**
Yellow Warbler	*Setophaga petechia*		0.17	0.03	0.38	0.14	0.55	0.25	0.57		0.03	0.32	35
Blackpoll Warbler	*Setophaga striata*					0.07						0.01	1
Yellow-rumped Warbler	*Setophaga coronata*		0.25	0.51	0.46	0.79			0.17		0.04	0.44	48
Wilson's Warbler	*Cardellina pusilla*		0.38				0.09		0.26			0.15	16
Songbirds — Others													
Bohemian Waxwing	*Bombycilla garrulus*					0.29						0.04	4
Total Habitat Detections		28	154	135	51	81	36	43	141	117	188	-	**974**

[1] Brackets in column headings indicate the number of survey stations in each avian habitat type. Birds are ordered taxonomically, first by species group then by species. Shaded cells indicate five most abundant species in each habitat (some have up to eight shaded cells due to equivalent detection rates).

Table 2-7. Bird associations for the 10 primary avian habitat types within the Eagle Plains Regional Study Area, June 2019.[1]

Herb (9)[2]	Deciduous/Mixed Shrub (24)	Tall Shrub – Black Spruce (35)	Deciduous/Mixed Forest (13)	Spruce Forest (14)
Lesser Yellowlegs - 1.44	White-crowned Sparrow - 1.08	Canada Jay - 0.57	Swainson's Thrush - 0.85	Canada Jay - 0.79
Rusty Blackbird - 0.78	Lincoln's Sparrow - 0.92	Yellow-rumped Warbler - 0.51	Canada Jay - 0.69	Swainson's Thrush - 0.79
Spotted Sandpiper - 0.22	American Tree Sparrow - 0.54	Gray-cheeked Thrush - 0.43	Yellow-rumped Warbler - 0.46	Yellow-rumped Warbler - 0.79
Least Sandpiper - 0.22	Gray-cheeked Thrush - 0.46	Dark-eyed Junco - 0.37	Yellow Warbler - 0.38	Lincoln's Sparrow - 0.36
Wilson's Snipe - 0.22	Canada Jay - 0.38	Swainson's Thrush - 0.31	American Robin - 0.31	White-winged Crossbill - 0.36
Savannah Sparrow - 0.22	Fox Sparrow - 0.38	White-crowned Sparrow - 0.29	Orange-crowned Warbler - 0.31	Bohemian Waxwing - 0.29
	Wilson's Warbler - 0.38	White-winged Crossbill - 0.23	Ruby-crowned Kinglet - 0.23	Ruby-crowned Kinglet - 0.29
	Swainson's Thrush - 0.25	American Robin - 0.20	Dark-eyed Junco - 0.15	American Robin - 0.21
	Orange-crowned Warbler - 0.25	Common Redpoll - 0.20	Merlin - 0.08	Fox Sparrow - 0.21
	Yellow-rumped Warbler - 0.25	Lincoln's Sparrow - 0.17	Great Gray Owl - 0.08	Boreal Chickadee - 0.21
	Savannah Sparrow - 0.25	Chipping Sparrow - 0.14	Varied Thrush - 0.08	American Three-toed Woodpecker - 0.14
	Common Redpoll - 0.25	Ruby-crowned Kinglet - 0.11	American Tree Sparrow - 0.08	Gray-cheeked Thrush - 0.14
	Northern Waterthrush - 0.21	American Tree Sparrow - 0.09	Lincoln's Sparrow - 0.08	Varied Thrush - 0.14
	Alder Flycatcher - 0.17	Fox Sparrow - 0.09	Common Redpoll - 0.08	Pine Grosbeak - 0.14
	Yellow Warbler - 0.17	Boreal Chickadee - 0.06	Red-breasted Nuthatch - 0.08	Chipping Sparrow - 0.14
	American Robin - 0.13	Yellow-bellied Flycatcher - 0.03		White-crowned Sparrow - 0.14
	Yellow-bellied Flycatcher - 0.13	Pine Grosbeak - 0.03		Yellow Warbler - 0.14
	Olive-sided Flycatcher - 0.08	Yellow Warbler - 0.03		Great Gray Owl - 0.07
	Dark-eyed Junco - 0.08			Olive-sided Flycatcher - 0.07
	Wilson's Snipe - 0.04			Alder Flycatcher - 0.07
	Boreal Chickadee - 0.04			American Tree Sparrow - 0.07
				Dark-eyed Junco - 0.07
				Common Redpoll - 0.07
				Blackpoll Warbler - 0.07

Riparian Spruce Forest (11)	Riparian Coniferous Shrub (8)	Riparian/Wetland Deciduous Shrub (23)	Open Water (17)
Yellow Warbler - 0.55	Lincoln's Sparrow - 1.50	Lincoln's Sparrow - 1.09	American Green-winged Teal - 2.47
Swainson's Thrush - 0.36	White-crowned Sparrow - 0.63	Savannah Sparrow - 0.70	American Wigeon - 1.29
Common Redpoll - 0.36	American Robin - 0.50	Northern Waterthrush - 0.57	Red-necked Phalarope - 0.88
Northern Waterthrush - 0.36	Fox Sparrow - 0.38	Yellow Warbler - 0.57	Northern Shoveler - 0.65
Gray-cheeked Thrush - 0.27	Canada Jay- 0.25	White-crowned Sparrow - 0.52	Northern Pintail - 0.47
Canada Jay - 0.18	Rusty Blackbird - 0.25	Rusty Blackbird - 0.39	Lesser Scaup - 0.41
Lincoln's Sparrow - 0.18	Gray-cheeked Thrush - 0.25	American Tree Sparrow - 0.39	Bufflehead - 0.41
Ruby-crowned Kinglet - 0.18	Yellow Warbler - 0.25	Fox Sparrow - 0.35	Mallard - 0.29
Common Nighthawk - 0.09	Solitary Sandpiper - 0.13	Common Redpoll - 0.26	
Hermit Thrush - 0.09	Lesser Yellowlegs - 0.13	Wilson's Warbler - 0.26	
Olive-sided Flycatcher - 0.09	American Three-toed Woodpecker - 0.13	Yellow-rumped Warbler - 0.17	
American Tree Sparrow - 0.09	Swainson's Thrush - 0.13	Solitary Sandpiper - 0.13	
Fox Sparrow - 0.09	Olive-sided Flycatcher - 0.13	American Robin - 0.13	
White-crowned Sparrow - 0.09	Yellow-bellied Flycatcher - 0.13	Lesser Yellowlegs - 0.09	
Boreal Chickadee - 0.09	Alder Flycatcher - 0.13	Wilson's Snipe - 0.09	
Red-breasted Nuthatch - 0.09	Pine Grosbeak - 0.13	Canada Jay - 0.09	
Wilson's Warbler - 0.09	American Tree Sparrow - 0.13	Swainson's Thrush - 0.09	
	Savannah Sparrow - 0.13	Alder Flycatcher - 0.09	
	Orange-crowned Warbler - 0.13	Dark-eyed Junco - 0.09	
		Gray-cheeked Thrush - 0.04	
		Ruby-crowned Kinglet - 0.04	

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[1] Birds listed in descending order of average detection rate (values after the bird names) in each avian habitat type.

[2] Values in the column headings indicate the number of samples per habitat type.

2.4.4 SPECIES OF CONSERVATION CONCERN

Four species observed in the Project RSA (Red-necked Phalarope, Common Nighthawk, Olive-sided Flycatcher, and Rusty Blackbird) were federally listed as either Special Concern or Threatened (Table 2-8). These species are either of regional, national, or continental concern, and two are designated with regional stewardship in BCR 4. The conservation statuses of all potential bird species in the Project area are listed in Attachment Table 2 in Section 2.6.2 (Attachment 2-B). Of those species, three additional species of Conservation Concern are likely to occur in the Project RSA, including Horned Grebe (*Podiceps auritus)*, Short-eared Owl, and Bank Swallow (Table 2-8). Two cliff-nesting raptors listed as 'specially protected' species under the Yukon *Wildlife Act*, Peregrine Falcon and Gyrfalcon, can occur in the broader region but are unlikely to occur in the Project RSA because of a lack of appropriate cliffs. Another 'specially protected' species, Trumpeter Swan (*Cygnus buccinator*; not listed below), is exclusive to southern Yukon and Alaska during the breeding season and, thus, is unlikely to occur in the Project RSA.

Table 2-8. The conservation status and counts of bird species in the Eagle Plains Project RSA.

Species Common Name	COSEWIC[4]	SARA[5]	BCR 4 Priority[6]	Yukon *Wildlife Act*	RSA Count	NABBS Count (2014–2018)
Horned Grebe[1]	SC (Apr 2009)	1 – SC	R – stewardship N/C – concern	No	0	0
Red-necked Phalarope	SC (Nov 2014)	1 – SC	N/C – concern	No	15	0
Peregrine Falcon[2]	NAR (Nov 2017)	–	R – stewardship N/C – concern	Yes	0	0
Gyrfalcon[2]	NAR (Apr 1987)	–	–	Yes	0	0
Short-eared Owl[1]	T (May 2021)	1 – SC	N/C – concern	No	0	4
Common Nighthawk[3]	SC (Apr 2018)	1 – T	N/C – concern	No	1	0
Olive-sided Flycatcher	SC (Apr 2018)	1 – T	R – stewardship R/N/C – concern	No	6	1
Bank Swallow[1]	T (May 2013)	1 – T	–	No	0	0
Rusty Blackbird	SC (Apr 2017)	1 – SC	R – stewardship R/N/C – concern	No	19	1
				Totals	**41**	**6**

[1] Species that are 'Likely' to occur in the Eagle Plains Project RSA.

[2] Cliff-nesting raptors that are 'Likely' to occur in the broader region, but do not have suitable habitat in the Eagle Plains Project RSA.

[3] A species that is 'Possible' in the Eagle Plains Project RSA because of its range limits. One occurrence was observed but status remains uncertain.

[4] Most recent COSEWIC assessments; E = Endangered, NAR = Not at Risk, SC = Special Concern, T = Threatened.

[5] SARA statuses from the latest amended list in May 2023 (Legislative Services Branch 2023); Schedule 1 codes equivalent to COSEWIC.

[6] Priorities, concerns, and stewardships from BCR 4 2013 report; C = Continental, N = National, R = Regional.

2.4.5 ADEQUACY OF ONE YEAR OF SURVEYS

The official guidance provided by the Canadian Wildlife Service for avian baseline studies usually is to conduct at least two years of field surveys (Hanson et al. 2009), and the DRAFT 2022 guidelines emphasize a statistical review of the power to detect changes (ECCC-CWS 2022). Repeat surveys account for annual variation in patterns of bird occurrences and distribution and imperfect detectability associated with bird survey methods. During our initial consultation with CWS we proposed conducting a single year of surveys, dependent on the outcome of the surveys. CWS indicated that they always prefer to see multiple years of data collected. However, they may not raise objections to the Project Proposal if significant avian conservation concerns or information uncertainties do not occur. In our opinion, the one year of multi-species field surveys that we conducted, in combination with the desktop assessment, provides sufficient baseline information about bird species to proceed with the Project Proposal.

2.5 SUMMARY

The purpose of this study was to document the potential occurrence, relative abundance, and habitat associations of birds across the Project's RSA. This study consisted of a combination of a desktop assessment and field surveys. The information presented in this report was collected by Professional Biologists and qualified environmental practitioners, following generally accepted scientific survey designs and methods. The field survey design used a targeted, stratified habitat design to provide a representative sample across the RSA.

Based on range and habitat, 128 species potentially occur in or adjacent to the RSA. Forty-eight (48) were recorded from the North American Breeding Bird Survey data in adjacent areas. Possible species include eight listed under the SARA or identified in the Yukon *Wildlife Act*, and 67 are considered a priority and management concern under the federal Bird Conservation Region 4 Plan. Birds listed under the SARA observed during surveys included Red-necked Phalarope, Common Nighthawk, Olive-sided Flycatcher, and Rusty Blackbird.

Field surveys observed 53 species in the RSA. Point counts identified 42 species, and wetland surveys identified 37 species. Swainson's Hawk was identified via incidental sightings and is an interesting species. It has a disjunct breeding range in North Yukon separated by several hundred kilometres from their primary range to the south. Patterns of species relative abundance and richness (number of species) varied among the different habitat types. Average relative abundance and species richness were the greatest in Spruce Forest, Deciduous and Mixed Shrub, Riparian/Wetland Deciduous Shrub habitats, and lowest in Herb and Tall Shrub – Black Spruce habitats. These patterns were generally related to the structural complexity and productivity of these different habitat types. However, the number of unique species in each habitat did not depend on structural complexity. Many unique species were found in the Herb and Open Water habitats. General patterns of bird occurrence and habitat associations in the RSA are consistent with expectations and correspond with the limited existing information about birds in the area.

2.6 BIRD SECTION ATTACHMENTS

2.6.1 ATTACHMENT 2–A — ECOLOGICAL AND LANDSCAPE CLASSIFICATION ECOSYSTEM UNITS

Ecological and Landscape Classification (ELC) Ecosystem Units (Ecosites)

Codes, names, and descriptions of ecosites assigned *a posteriori* to habitat groups in the Project RSA are listed below.

Attachment Table 1. Ecological Landscape Classification ecosystem units developed for the Eagle Plains Project Regional Study Area.

Code	Name	Description and typical situation
10	Sparsely Vegetated	Vegetative cover <10%.
11	Dry Herb	Area dominated with herbaceous vegetation with very low shrub cover (<5%).
12	Dry Lichen	*Cladonia* sp. (i.e., caribou forage species) dominated areas with very low shrub cover (<5%) typically on south facing slopes.
13	Dry Mix Shrub	Dry shrub dominated areas with very low *Cladonia* sp. (i.e., caribou forage species) cover (<10%); disclimax community.
14	Dry Shrub/ Spruce – Lichen	Dry areas with spruce cover >5% and *Cladonia* sp. (i.e., caribou forage species) cover >10%.
15	Dry Shrub/ Aspen – Lichen	Dry areas with aspen cover >5% and *Cladonia* sp. (i.e., caribou forage species) cover >10%.
16	Dry Spruce – Birch – Lichen	Dry areas with either white spruce, black spruce, and/or Alaskan paper birch cover; spruce, scrub birch, and *Cladonia* sp. (i.e., caribou forage species) cover >10%.
17	Dry Aspen	Dry areas with aspen dominant canopy and very low *Cladonia* (i.e., caribou forage species) cover (<5%).
01	Mesic Herb	Area dominated by herbaceous vegetation with very low shrub cover (<5%); neither disclimax nor successional pathway known. No distinct mottles or seepage present; some sites may have permafrost (frozen layer contains no ice crystals or ice layers).
02	Mesic Birch – Willow	Area has a history of anthropogenic disturbance; regeneration is dominated by either Alaskan paper birch and/or willow species. No distinct mottles or seepage present, some sites may have permafrost (frozen layer contains no ice crystals or ice layers).
03	Mesic White Spruce – Alaskan Paper Birch – Alder	Area dominated by Alaskan paper birch with mixed-wood understory (i.e., white spruce and alder). Usually found along upper slope to crest positions on gentle to moderate slopes. No distinct mottles or seepage present, some sites may have permafrost (frozen layer contains no ice crystals or ice layers).
04	Mesic Black Spruce – Alaskan Paper Birch	Area dominated by black spruce and Alaskan paper birch with >30% shrub cover; mid-slope position. No distinct mottles or seepage present, some sites may have permafrost (frozen layer contains no ice crystals or ice layers).
05	Mesic Alaskan Paper Birch	Area dominated by Alaskan paper birch stands with > 30% shrub cover; mid- to upper-slope position. No distinct mottles or seepage present, some sites may have permafrost (frozen layer contains no ice crystals or ice layers).
06	Mesic Black Spruce – Labrador Tea	Area dominated by black spruce with Labrador tea shrub layer; level or mid- to upper-slope position on gentle slopes. No distinct mottles or seepage present, some sites may have permafrost (frozen layer contains no ice crystals or ice layers).

Code	Name	Description and typical situation
20	Shrubby Riparian Birch – Willow	Shrubby riparian area dominated by scrub birch, tea-leaved willow, or diamond leaved willow and bog cranberry; disclimax community.
21	Riparian White Spruce – Prickly Rose	Treed riparian zone dominated by white spruce with a mixture of shrub species; rose usually present.
22	Riparian Spruce – Birch – Willow	Treed riparian zone dominated by white and black spruce, possibly some Alaskan paper birch, and a mixture of shrub species such as scrub birch and willow.
30	Moist Herb	Area dominated with herbaceous vegetation with very low shrub cover (<5%) on gentle to moderate slopes. Faint to distinct mottles can be observed; no seepage or slight seepage present. Permafrost is present but at variable depths; some ice crystals can be observed in frozen layer.
31	Moist Shrub/ Scrub Birch – Labrador Tea – Willow	Area dominated by scrub birch and Labrador tea with <10% spruce cover; shrub layer has tea-leaved willow. Typically found at level or mid- to upper-slope position on gentle slopes. Successional pathway unknown but considered a shrub disclimax site. Faint to distinct mottles can be observed; no seepage or slight seepage present. Permafrost is present; some ice crystals can be observed in frozen layer.
32	Moist Shrub/ Spruce – Scrub Birch – Labrador Tea	Area dominated by >10% spruce cover, <5% willow cover, and >15% lowbush cranberry. Typically found at mid to upper slope position on gentle slopes; disclimax community. Faint to distinct mottles can be observed; no seepage or slight seepage present. Permafrost is present but at variable depths; some ice crystals can be observed in frozen layer.
33	Moist Spruce – Labrador Tea	Area dominated by >15% spruce tree cover. Presence of *Cladonia* sp. (i.e., caribou forage species). Typically found at level or upper-slope position on gentle slopes. Faint to distinct mottles can be observed; no seepage or slight seepage present. Permafrost is present but at variable depths due to frost boils; some ice crystals can be observed in frozen layer.
34	Moist Spruce – Alder – Labrador Tea	Area dominated by >15% spruce tree cover; alder and *Cladonia* sp. (i.e., caribou forage species) present. Typically found at mid-slope position on gentle slopes. Faint to distinct mottles can be observed; no seepage or slight seepage present. Permafrost is present but at variable depths due to frost boils; some ice crystals can be observed in frozen layer.
35	Moist Spruce – Scrub Birch – Labrador Tea	Area dominated by <15% spruce tree cover with *Cladonia* sp. (i.e., caribou forage species) present. Typically found at level or gentle slopes. Faint to distinct mottles can be observed; no seepage or slight seepage present. Permafrost is present but at variable depths due to frost boils; some ice crystals can be observed in frozen layer.
36	Moist Birch – Willow	Area dominated by willow and birch trees, often associated with old anthropogenic disturbances; successional pathway unknown. Faint to distinct mottles can be observed; no seepage or slight seepage present. Permafrost is present but at variable depths due to frost boils; some ice crystals can be observed in frozen layer.
40	Wet Herb	Area dominated with herbaceous vegetation with very low shrub cover (<5%) on level to lower-slope positions. Distinct to prominent mottles; seepage present; permafrost near surface. Ice layer present within or above frozen soil or frozen organic layer.
41	Wet Shrub – Tamarack	Area with >5% tamarack; low presence of *Cladonia* sp. (i.e., caribou forage species) and high presence of *Sphagnum* sp. or glow moss. Scrub birch and Labrador tea present. Distinct to prominent mottles; seepage present; permafrost near surface. Ice layer present within or above frozen soil or frozen organic layer.
42	Wet Shrub – Black Spruce – Tussock Cottongrass	Area dominated by >5% black spruce and >10% tussock cottongrass. Labrador tea, scrub birch, *Sphagnum* sp. and *Cladonia* sp. (i.e., caribou forage species) present. Typically found on level ground but also from toe to mid-slope positions; disclimax community. Distinct to prominent mottles; seepage present; permafrost near surface. Ice layer present within or above frozen soil or frozen organic layer.

Code	Name	Description and typical situation
43	Wet Shrub – Black Spruce – Sphagnum	Area dominated by >5% black spruce, <10% tussock cottongrass, and >25% *Sphagnum* sp.; disclimax community. Distinct to prominent mottles; seepage present; permafrost near surface. Ice layer present within or above frozen soil or frozen organic layer.
44	Wet Shrub – Scrub Birch – Tussock Cottongrass	Area dominated by <5% black spruce, >10% scrub birch, and >30% tussock cottongrass; disclimax community. Distinct to prominent mottles; seepage present; permafrost near surface. Ice layer present within or above frozen soil or frozen organic layer.
45	Wet Shrub – Scrub Birch – Graminoid	Burned area composed of <5% black spruce; dominant shrub is scrub birch, while dominant graminoid is either spruce muskeg sedge or bluejoint reedgrass; disclimax community. Distinct to prominent mottles; seepage present; permafrost near surface. Ice layer present within or above frozen soil or frozen organic layer.
46	Wet Black Spruce – Labrador Tea – Cladonia	Area with >15% black spruce, >20% *Cladonia* sp. (i.e., caribou forage species), and <5% tussock cottongrass. Distinct to prominent mottles; seepage present; permafrost near surface. Ice layer present within or above frozen soil or frozen organic layer.
47	Wet Black Spruce – Tussock Cottongrass – Sphagnum	Area with >15% Labrador tea and <10% *Cladonia* sp. (i.e., caribou forage species). Distinct to prominent mottles; seepage present; permafrost near surface. Ice layer present within or above frozen soil or frozen organic layer.
48	Wet Black Spruce – Carex	Area dominated by either a spruce muskeg sedge or bluejoint reedgrass herbaceous layer; shrub layer is a mixture of Labrador tea, scrub birch, and willow species with >30% cover. Distinct to prominent mottles; seepage present; permafrost near surface. Ice layer present within or above frozen soil or frozen organic layer.
B1	Bog – Black Spruce – Lichen	Treed or shrubby peatland ecosystem unit with poor nutrient regime within the rooting zone. Stunted black spruce with <50% *Sphagnum* sp. and >10% *Cladonia* sp. (i.e., caribou forage species) ground cover.
B2	Bog – Black Spruce – Sphagnum	Treed or shrubby peatland ecosystem unit with poor nutrient regime within the rooting zone. Stunted black spruce with >50% *Sphagnum* sp. ground cover.
F	Fen	Treed, shrubby, or graminoid peatland ecosystem unit where groundwater inflow maintains relatively high mineral content within the rooting zone. Graminoid fen has >20% *Sphagnum* sp. or moss cover.
M	Marsh	Shallowly flooded mineral wetland ecosystem dominated by emergent vegetation. Area dominated by graminoids and has less than 10% Sphagnum or moss cover.
S	Swamp	Treed or shrubby mineral wetland ecosystem unit with a flowing or fluctuating, semi-permanent, near-surface water table.
W	Shallow Water	Shallow water ecological communities dominated by rooted, water submerged, and floating aquatic plants.
AN	Anthropogenic	An area of anthropogenic disturbance not included in other definitions (e.g., areas cleared for camps).
ES	Exposed Soil	Any area of exposed soil not included in other definitions. Includes areas of recent disturbance (e.g., terrain slides) and human-made disturbances where vegetation cover is <5%.
Fa	Flood Active Channel	Ecological communities scoured by river floodwaters for prolonged periods. Usually dominated by annuals or herbs that can re-sprout from underground structures.
LA	Lake	A body of water >2 m deep or large enough to be classified as a lake (>8 ha).
PD	Pond	A small body of water greater than 2 m deep, but not large enough to be classified as a lake (<8 ha).

Code	Name	Description and typical situation
Rc	Rock Cliff	Ecological communities of vertical rocky sites commonly with some bryophyte cover (rock crusts); small pockets of soils may support vascular vegetation. Also used to map non-vegetated cliffs.
RI	River	A watercourse formed when water flows between continuous, definable banks. The flow may be intermittent or perennial.
Ro	Rock Outcrop	Bluffs and knobs of solid rock with limited soil development and high cover of exposed rock; drought tolerant cryptogams often prominent.
Rt	Rock Talus	Active and inactive talus (i.e., large rocks) and scree (i.e., smaller rocks and more soil); small pockets of soils may support some vascular plants.
RZ	Road	An area cleared and compacted for the purpose of transporting goods and services by vehicle.

2.6.2 ATTACHMENT 2–B — LIST OF ALL POTENTIAL BIRD SPECIES AND THEIR CONSERVATION STATUSES

All bird species with the potential to occur in the Project area:

Names, federal conservation statuses (SARA, COSEWIC), BCR 4 priority, territorial status (i.e., species highlighted by Environment Yukon and those considered of conservation concern in the Yukon Conservation Data Centre track list), and indication of occurrence in the Project RSA for all 128 bird species, are listed below:

Attachment Table 2. List of species with the potential to occur in the Eagle Plains Project Regional Study Area.

Species Common Name[1]	Documented in RSA[2]	COSEWIC[3]	SARA[4]	Environment Yukon (YCDC Track List)[5]	BCR 4 Priority Species[6]
Horned Grebe [L]		SC (Apr 2009)	1 – SC	*	R – stewardship N/C – concern
Red-necked Grebe [L]					R – stewardship
Red-throated Loon [L]					
Pacific Loon [L]					R – stewardship N/C – concern
Common Loon [L]					C – stewardship N/C – concern
American Wigeon [L]	✓				R – stewardship R/N/C – concern
Mallard [L]	✓				R – stewardship N/C – concern
Blue-winged Teal [P]					N/C – concern
Northern Shoveler [L]	✓				R – stewardship
Northern Pintail [L]	✓				R – stewardship N/C – concern
Green-winged Teal [L]	✓				R – stewardship
Canvasback [L]					R – stewardship N/C – concern
Ring-necked Duck [P]					
Greater Scaup [L]					
Lesser Scaup [L]	✓				R – stewardship R/N/C – concern
Harlequin Duck [P]				✓	R – stewardship
Surf Scoter [L]					R – stewardship N/C – concern
White-winged Scoter [L]					R – stewardship N/C – concern
Long-tailed Duck [L]					N/C – concern
Bufflehead [L]	✓				R – stewardship
Common Goldeneye [L]					N/C – concern
Barrow’s Goldeneye [L]					R – stewardship

Species Common Name[1]	Documented in RSA[2]	COSEWIC[3]	SARA[4]	Environment Yukon (YCDC Track List)[5]	BCR 4 Priority Species[6]
Red-breasted Merganser ^{L}					
Greater White-fronted Goose ^{L}					C – stewardship
Snow Goose ^{P}				✓	
Brant ^{P}				✓	
Cackling Goose ^{P}					
Canada Goose ^{L}					
Tundra Swan ^{P}				✓	R – stewardship
Ruffed Grouse ^{P}					
Spruce Grouse ^{L}					
Sharp-tailed Grouse ^{P}				✓	
Willow Ptarmigan ^{L}					
Rock Ptarmigan ^{P}					
White-tailed Ptarmigan ^{P}					R – stewardship
Bald Eagle ^{L}					
Golden Eagle ^{L}					R – stewardship
Osprey ^{L}				✓	
Northern Harrier ^{L}	✓				
Sharp-shinned Hawk ^{L}					
Northern Goshawk ^{L}					R – stewardship
Swainson’s Hawk ^{L}	✓			✓	N/C – concern
Red-tailed Hawk ^{L}	✓				
Rough-legged Hawk ^{L}					
Gyrfalcon ^{L}					
Peregrine Falcon ^{L}		NAR (Nov 2017)		✓*	R – stewardship N/C – concern
American Kestrel ^{L}				✓	R – stewardship
Merlin ^{L}	✓				
Great Horned Owl ^{L}					
Northern Hawk Owl ^{L}					R – stewardship
Great Gray Owl ^{L}	✓				R – stewardship
Short-eared Owl ^{L}		T (May 2021)	1 – SC	✓*	N/C – concern
Boreal Owl ^{L}					R – stewardship
American Golden-Plover ^{P}					N/C – concern
Semipalmated Plover ^{L}					N/C – concern
Wandering Tattler ^{P}				✓	R – stewardship
Whimbrel ^{P}				✓	N/C – concern
Surfbird ^{P}				✓	R – stewardship N/C – concern
Long-billed Dowitcher ^{P}					
Red-necked Phalarope ^{L}	✓	SC (Nov 2014)	1 – SC	*	N/C – concern

Species Common Name[1]	Documented in RSA[2]	COSEWIC[3]	SARA[4]	Environment Yukon (YCDC Track List)[5]	BCR 4 Priority Species[6]
Spotted Sandpiper ^{L}	✓				R – stewardship
Solitary Sandpiper ^{L}	✓				R – stewardship N/C – concern
Lesser Yellowlegs ^{L}	✓				R – stewardship R/N/C – concern
Upland Sandpiper ^{L}					N/C – concern
Baird's Sandpiper ^{L}	✓				
Least Sandpiper ^{L}	✓				
Pectoral Sandpiper ^{P}					
Semipalmated Sandpiper ^{P}					
Wilson's Snipe ^{L}	✓				N/C – concern
Long-tailed Jaeger ^{P}					
Bonaparte's Gull ^{P}					R/C – stewardship N/C – concern
Short-billed Gull ^{L}					R – stewardship
Herring Gull ^{L}					N/C – concern
Arctic Tern ^{L}					N/C – concern
Sandhill Crane ^{L}				✓	
Belted Kingfisher ^{L}					
Common Nighthawk ^{P}	✓	SC (Apr 2018)	1 – T	✓*	N/C – concern
Hairy Woodpecker ^{P}					
American Three-toed Woodpecker ^{L}	✓				R – stewardship
Northern Flicker ^{L}					
Olive-sided Flycatcher ^{L}	✓	SC (Apr 2018)	1 – T	*	R – stewardship R/N/C – concern
Yellow-bellied Flycatcher ^{L}	✓				
Alder Flycatcher ^{L}	✓				C – stewardship
Say's Phoebe ^{L}					
Northern Shrike ^{L}					R – stewardship
Canada Jay ^{L}	✓				C – stewardship
Common Raven ^{L}	✓				
Horned Lark ^{L}					
Tree Swallow ^{L}	✓				
Violet-green Swallow ^{L}					
Bank Swallow ^{L}		T (May 2013)	1 – T	✓*	
Cliff Swallow ^{P}					
Boreal Chickadee ^{L}	✓				R/C – stewardship
Gray-headed Chickadee ^{P}				✓	R – stewardship
Red-breasted Nuthatch ^{L}	✓				
American Dipper ^{P}					

Species Common Name[1]	Documented in RSA[2]	COSEWIC[3]	SARA[4]	Environment Yukon (YCDC Track List)[5]	BCR 4 Priority Species[6]
Ruby-crowned Kinglet L	✓				
Northern Waterthrush L	✓				
Orange-crowned Warbler L	✓				
Yellow Warbler L	✓				
Blackpoll Warbler L	✓				R – stewardship
Palm Warbler P					
Yellow-rumped Warbler L	✓				
Townsend's Warbler L					R – stewardship
Wilson's Warbler L	✓				R – stewardship
American Robin L	✓				
Townsend's Solitaire L					
Gray-cheeked Thrush L	✓				
Swainson's Thrush L	✓				
Hermit Thrush L	✓				
Varied Thrush L	✓				R – stewardship
American Pipit L					
Bohemian Waxwing L	✓				R/C – stewardship
Lapland Longspur L					
Snow Bunting P					
Pine Grosbeak L	✓				R/C – stewardship
American Tree Sparrow L	✓				
Chipping Sparrow L	✓				
Savannah Sparrow L	✓				
Fox Sparrow L	✓				
Lincoln's Sparrow L	✓				
Harris's Sparrow P		SC (Apr 2017)			
White-crowned Sparrow L	✓				R – stewardship
Golden-crowned Sparrow P					R – stewardship
Dark-eyed Junco L	✓				
Rusty Blackbird L	✓	SC (Apr 2017)	1 – SC	✓*	R – stewardship R/N/C – concern
White-winged Crossbill L	✓				C – stewardship
Common Redpoll L	✓				

[1] Species identified as either 'Likely' (L) or 'Possible' (P) in the Project RSA.

[2] (✓) species observed during surveys or as incidental observations.

[3] Most recent COSEWIC assessments; E = Endangered, NAR = Not at Risk, SC = Special Concern, T = Threatened.

[4] SARA statuses from 2023; Schedule 1 codes equivalent to COSEWIC.

[5] (✓) Yukon Conservation Data Centre 2019 track list species; (*) species at risk highlighted by Environment Yukon

[6] Priorities, concerns, and stewardships from BCR 4 2013 report; C = Continental, N = National, R = Regional.

3 MARTEN

3.1 PURPOSE AND OBJECTIVES

American marten (*Martes americana*; hereafter marten) were selected as a Valued Component (VC) for the Project due to their value as a furbearer, as well as their relevance as an indicator species for mature and old forest values (Buskirk and Ruggiero 1994, Suffice et al. 2017). The VGFN have a community trapline within the RSA and value marten as a furbearer for its economic value, social values associated with trapping, and environmental values as a component of the regional wildlife community.

This section provides a summary of marten ecology in the subarctic taiga. That information is used to develop a habitat model to quantify the quality, amount, and distribution of potential marten habitat across the RSA. A Habitat Suitability Index (HSI) model was developed using relevant environmental data in a GIS to quantify the amount of marten habitat into relative quality categories (i.e., High, Moderate, Low, and Nil/Very Low).

3.2 TRAPPING

According to trapping records, marten were the most heavily trapped species in the two group trapping concessions that overlap the RSA between 2012 and 2018 (Figure 3-1,). Between 2012 and 2018, 715 marten were reported from the two concessions (i.e., 401, 402) overlapping the RSA. The number of marten reported varied widely among the trapping seasons: the greatest harvest was 240 marten reported in 2015 compared to the lowest harvest of 0 marten the following year. Unfortunately, trapping records from 2019 onwards were unavailable for those concessions.

Trapping mortality in marten is biased towards males and juveniles, and harvests that include a high proportion of adult females indicate potential overharvesting (Strickland and Douglas 1987, Hodgman et al. 1994, Fortin and Cantin 2005). Exhaustive trapping removes resident adult marten from the population and allows juveniles to establish home ranges in vacant areas, thus lowering the overall age of the population. Juveniles have lower reproductive output relative to adults; therefore, this change in age structure can lower population fecundity and growth rates (Archibald and Jessup 1984, Fortin and Cantin 2005). Without knowledge of the age and sex structure of harvested marten, it is not possible to assess the sustainability of trapping in the RSA.

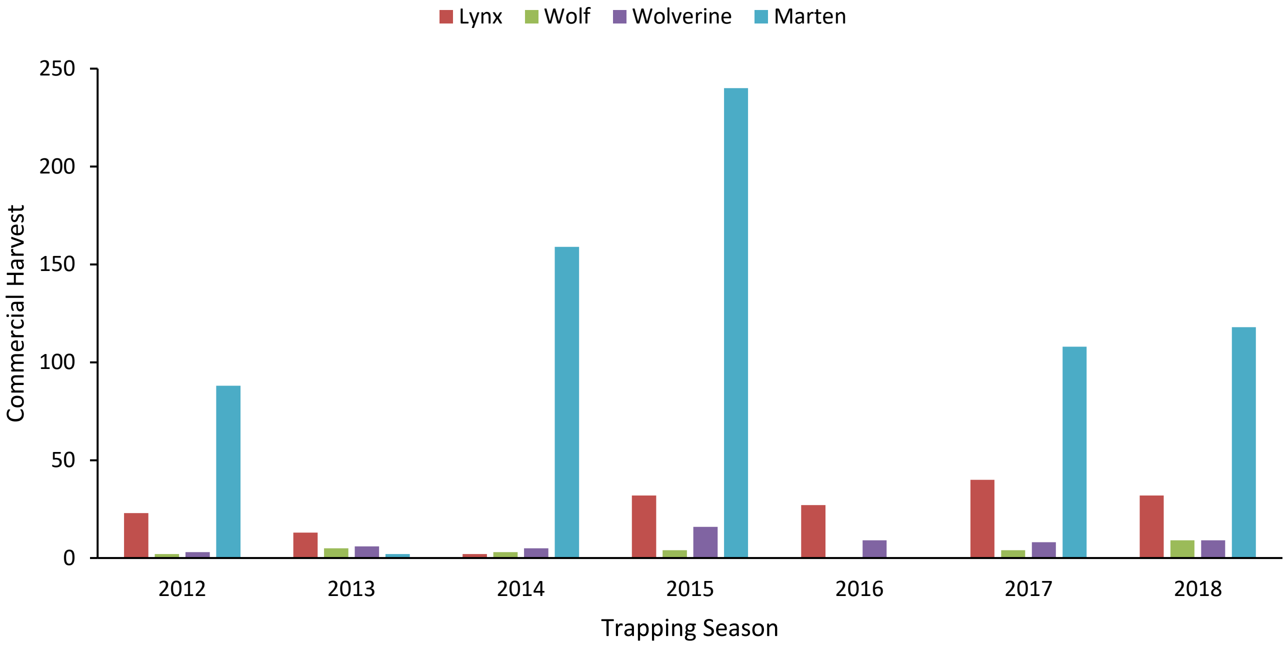
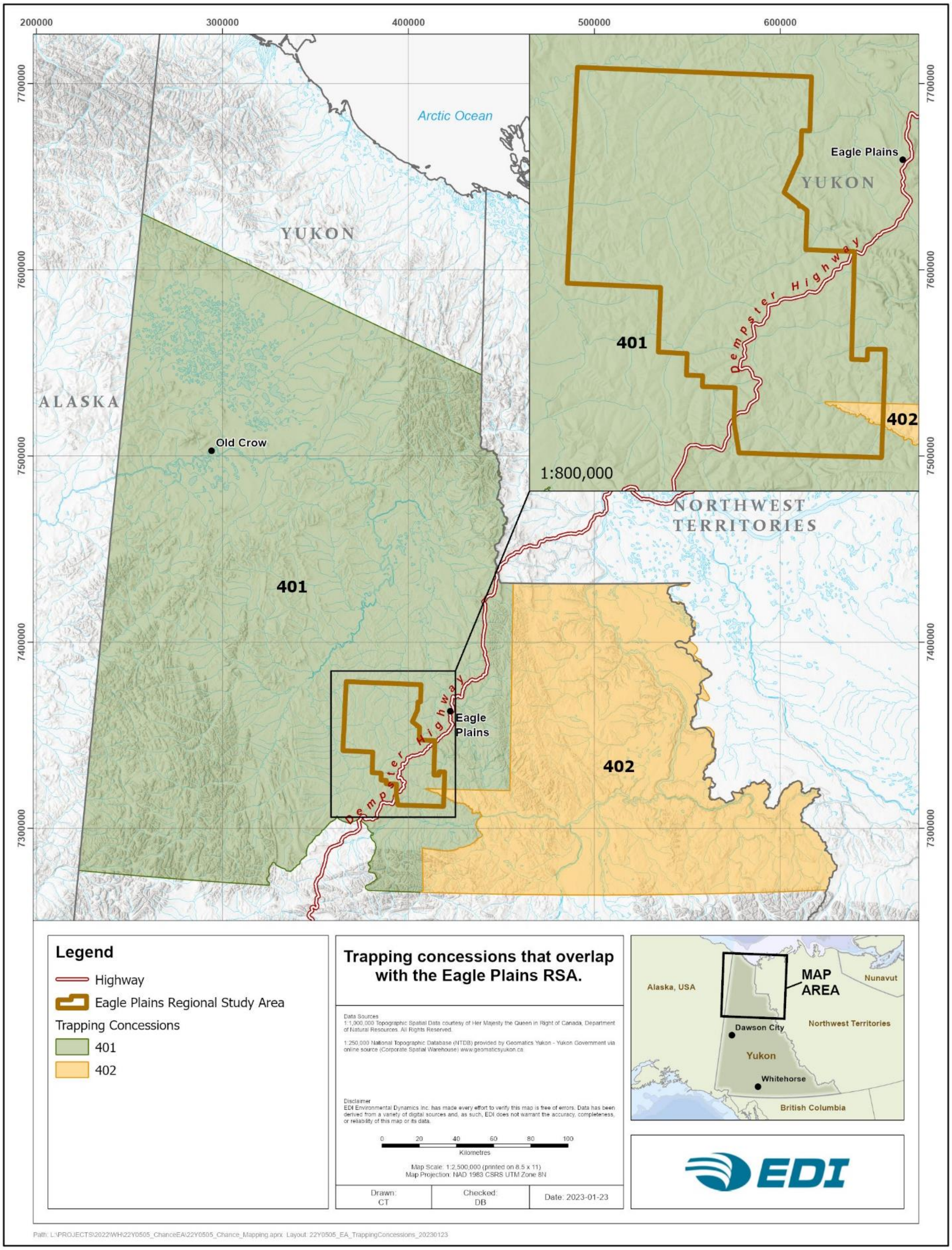


Figure 3-1. Commercial harvest returns for group trapping concessions overlapping the RSA for which records were available.



Trapping concessions that overlap with the Eagle Plains RSA.

Data Sources
1:1,000,000 Topographic Spatial Data courtesy of Her Majesty the Queen in Right of Canada, Department of Natural Resources. All Rights Reserved.

1:250,000 National Topographic Database (NTDB) provided by Geomatics Yukon - Yukon Government via online source (Corporate Spatial Warehouse) www.geomaticsyukon.ca

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Map Scale: 1:2,500,000 (printed on 8.5 x 11)
Map Projection: NAD 1983 CSRS UTM Zone 8N

Drawn: CT	Checked: DB	Date: 2023-01-23

Path: L:\PROJECTS\2022\WH\22Y0505_ChanceEA\22Y0505_Chance_Mapping.aprx Layout: 22Y0505_EA_TrappingConcessions_20230123

Map 3-1. Trapping concessions that overlap with the Eagle Plains RSA.

3.3 GENERAL HABITAT ECOLOGY OF MARTEN

The RSA occurs in the boreal taiga, at the northern limit of marten range (Buskirk and Ruggiero 1994, Yukon Ecoregions Working Group 2004a). While marten occur over a contiguous range across northern North America from Labrador to Alaska (Snyder and Bissonette 1987, Buskirk and Ruggiero 1994, Drew 1995, Paragi et al. 1996), little is known about their basic ecology in northern boreal forest and taiga ecosystems (Latour et al. 1994). In more productive forests to the south, marten are often associated with mature forest structures, such as large trees, snags, and coarse woody debris (CWD; Buskirk and Ruggiero 1994, Thompson et al. 2012). However, there is some evidence that in northern boreal forests, marten exploit structural stages with short, stunted trees that are sparsely distributed (Latour et al. 1994, Paragi et al. 1996). Marten in the Alaskan taiga selected habitat types with the greatest amount of CWD and the greatest abundance of vole, rather than canopy cover (Paragi et al. 1996). Across the Yukon forest-to-tundra ecotone, marten preferred open taiga areas rather than boreal forest, and were positively associated with small mammal (i.e., taiga vole [*Microtus xanthognatus*], and red-backed vole [*Myodes* spp.]) biomass (Pretzlaw 2006). Therefore, occurrence and habitat selection patterns for marten in northern boreal and taiga ecosystems can differ from those described elsewhere in North America (Pretzlaw 2006).

During 2015 and 2016, EDI performed snow tracking surveys to quantify the presence and distribution of furbearers and ungulates south of Dawson, Yukon (EDI Environmental Dynamics Inc. 2017). Snow tracking transects covered various habitat types, including 49% shrub, 13% coniferous, 10% herbs, 8% exposed land, 7% frozen rivers, and 13% other classes (i.e., broadleaf, mixedwood, rock/rubble, wetland). Marten tracks occurred in shrubland 51% of the time, coniferous forest 15% of the time, and herb sites 10% of the time. These results indicate that marten occurred across all major vegetated habitat types approximately in proportion to their availability on the landscape (EDI Environmental Dynamics Inc. 2017).

Home ranges of marten in the taiga are larger than in other regions of North America (Latour et al. 1994). In the Mackenzie Valley, NWT, mean home range sizes of adult males were 1,420 ha, and those of adult females were 680 ha. Overall, mean home range size of adult marten was 1,110 ha (Latour et al. 1994). In contrast, the average size of a marten home range in British Columbia (BC) is 525 ha for males and 316 ha for females, and in Ontario, the size of a typical marten home range is between 390 and 660 ha (Lofroth 1993, Manlick et al. 2017a). Marten density in the taiga (the carrying capacity) is likely limited by the availability of arboreal cavities for natal denning, subnivean CWD sites and underground shelters, small mammal abundance, predation, and intraguild competition (Brainerd et al. 1995). The estimated minimum density of marten was 0.0016/ha in the Mackenzie Valley, NWT (Latour et al. 1994), and 0.0025/ha in the Alaskan taiga (Paragi et al. 1996). The estimated fall density of resident adults in the northern boreal region of the Yukon was 0.006/ha (Archibald and Jessup 1984).

3.3.1 FORAGING

Marten habitat selection in the Eagle Plains Ecoregion may depend largely on prey distribution and availability (Paragi et al. 1996). Taiga vole are the prey most selected by marten in the Alaskan taiga, likely due to their larger size (mean weight = 54 g) relative to red-backed vole (mean weight = 20 g; Paragi et al. 1996). Potential and confirmed mammalian prey in the taiga includes snowshoe hare (*Lepus americanus*), red squirrel (*Tamiasciurus hudsonicus*), red-backed vole, taiga vole, lemmings (*Lemmus* spp., *Dicrostonyx* spp.), and to a lesser extent, deer mice (*Peromyscus maniculatus*) (Paragi et al. 1996). Non-migratory grouse, including willow ptarmigan and spruce grouse, are available year-round and are likely prey for marten in the taiga (Paragi et al. 1996). However, marten are dietary generalists and their diet fluctuates seasonally with the breeding cycles of small mammal prey, bird migration and nesting periods, and fruiting periods of understory plants (Ben-David et al. 1997, Carlson et al. 2014, Twining et al. 2019).

In northern latitudes, marten foraging and population dynamics are influenced by fluctuations in the abundance of small mammal prey (Zielinski 2000). Multiple scat analyses in the NWT and Alaska found that small rodents, including vole and lemming, were the most important diet item for marten (Buskirk and Ruggiero 1994). Small rodents in northern regions undergo relatively large periodic fluctuations in population size (Krebs 1996). Marten populations are likely tightly coupled with these small mammal population cycles due to the relatively low diversity of mammalian prey species in the Eagle Plains Ecoregion (Yukon Ecoregions Working Group 2004a, Roth et al. 2007). Marten abundance and fecundity are correlated with temporal variability in the abundance of preferred prey, likely due to nutritionally demanding processes associated with reproduction and juvenile recruitment (Carlson et al. 2014, Flynn and Schumacher 2016).

Previous research has shown berries to be most important for marten diet during the summer and fall (July–November) when fruit availability is greatest (Baker 1992, Schaumann and Heinken 2002, Twining et al. 2019). Further, there is recent evidence that *Vaccinium* fruit are also an important winter food item for marten in coastal areas where they remain accessible year-round (Banner et al. 2014, Eriksson et al. 2019). Similarly, common juniper (*Juniperus communis*) berries are an important winter food item for marten in other regions (Hargis and McCullough 1984). Therefore, marten in the RSA likely consume fruit from several species of shrub depending on habitat and season, including blueberry and lowbush cranberry in upland woodlands, and crowberry (*Empetrum nigrum*), lingonberry, cloudberry (*Rubus chamaemorus*), and bog cranberry (*Vaccinium oxycoccos*) in lowland black spruce-shrub sites (Yukon Ecoregions Working Group 2004a).

The diet of marten in interior regions of North America is typically dominated by species of voles associated with structurally complex forests (Thompson and Colgan 1994, Poole et al. 2004, Eriksson et al. 2019). Habitat structures normally associated with old forests, including stumps, snags, and large pieces of downed wood, provide subnivean access to small mammal prey in areas with deep snow (Zielinski et al. 1983, Baker 1992, Delheimer et al. 2019). However, within the Yukon, red-backed voles are present across all vegetation types and appear to be more abundant in subalpine shrub habitats than lower elevation boreal forests (Pretzlaw 2006, EDI Environmental Dynamics Inc. 2017). Taiga vole are restricted to the taiga and avoid forest cover (Pretzlaw 2006). Taiga vole in Alaska appear to select post-fire structural stages and are found in black spruce forests, birch forests, forest-grassland edge, and grasslands (Wolff and Lidicker Jr. 1980). Provided there is sufficient understory shrub cover, habitat used for foraging is probably directly associated with increased prey availability regardless of forest age or structural stage (Keim et al. 2011, Vigeant-Langlois and Desrochers 2011).

3.3.2 COVER

Across much of their distribution, marten select home ranges with old or late-mature forests and avoid recently cut forests (Chapin et al. 1998, Bridger et al. 2017, Suffice et al. 2017). Older forests contain complex woody structures, including mature trees, stumps, snags, and large pieces of CWD that marten require to meet many life history requirements, including thermal cover and escape cover from predators (Zielinski et al. 1983, Mowat 2006a, Andruskiw et al. 2008). Shrub cover can also be an important factor influencing marten habitat quality, as marten use understory shrubs as cover from aerial predators such as Northern Goshawk (*Accipiter gentilis*; Poole et al. 2004, Zielinski et al. 2005, Slauson et al. 2007).

Important habitat features typically associated with old forests, including stumps, snags, and large pieces of downed wood, provide subnivean access to winter denning in areas with deep snow (Zielinski et al. 1983, Baker 1992, Delheimer et al. 2019). A winter den is a structure that may be used repeatedly for resting for prolonged periods (Birks et al. 2005). Natal dens are used for parturition and kit rearing during the breeding season, and may be used as resting sites in other seasons (Birks et al. 2005). A scarcity of tree cavities leads marten to use denning sites that provide suboptimal thermal cover and escape from predators (Birks et al. 2005). Marten dens may be found in tree branches, bird nests, rock crevices, underground burrows, occupied houses, nest boxes, or barns (Birks et al. 2005). Therefore, marten may use a range of below or above-ground structures for winter denning in the RSA, regardless of forest age or structural stage.

3.3.2.1 Thermal Cover

In winter, marten possess limited energy reserves and must reduce energetic costs by seeking insulated resting sites (Spencer 1987, Buskirk et al. 1989, Brainerd et al. 1995). Marten are shown to be more dependent on subnivean resting sites at more northern latitudes (Brainerd et al. 1995). Marten's choice of resting above or below snow cover depends on the ambient air temperature relative to the temperature in a microenvironment; in other words, marten are more likely to rest wherever is warmest (Buskirk et al. 1989). In Scandinavia, marten seek underground or subnivean resting sites instead of arboreal sites when the ambient air temperature is very low (Brainerd et al. 1995). Any subnivean spaces not entirely surrounded by snow are suitable; however, CWD is best in terms of thermal properties (Buskirk et al. 1989). Therefore, thermal cover generally increases with increased coniferous cover and associated CWD. Rock provides some protection from digging predators; however, rock provides poor insulation than wood, and rock dens may contain organic bedding for insulation (Buskirk et al. 1989, Birks et al. 2005).

3.3.2.2 Escape Cover

As a mesocarnivore, pressure from competition and predation can play an important role in the population dynamics of marten populations (Kiseleva 2012, Manlick et al. 2017b). Aside from marten, wolf (*Canis lupus*), red fox (*Vulpes vulpes*), lynx (*Lynx canadensis*), and wolverine (*Gulo gulo*) are the primary mammalian predators in the Eagle Plains Ecoregion. Marten likely select habitat with sufficient escape cover (e.g., medium-sized coniferous trees and CWD) to avoid risk of intraguild predation by these species (Slauson et al. 2007, Eriksson et al. 2019). Furthermore, marten within the Eagle Plains Ecoregion compete with least weasel (*Mustela nivalis*), lynx, and red fox for shared small mammal prey (Slough and Jung 2007).

Marten in North America select home ranges that contain vertical forest or understory shrub cover where they perceive lower risk of predation from aerial predators as well as larger carnivores that, depending on the system they occupy, includes mustelid, canid, and felid species (Slauson et al., 2007; Eriksson et al., 2019). Red fox are the most generalist and widespread carnivore in the northern boreal-tundra ecotone, and may limit marten populations through intraguild predation (Lindström et al. 1995, Birks et al. 2005, Pretzlaw 2006). Therefore, fox predation may force marten to remain arboreal and den above ground (Birks et al. 2005). Aerial predators include Northern Goshawk and Great Horned Owl (*Bubo virginianus*), both of which are predators of marten in other regions and occur year-round in forests in the Yukon (Bull and Heater 2001, Doyle and Smith 2001, Sinclair et al. 2003). Golden Eagle also occur in northern Yukon during the breeding season and may be predators of marten. However, marten may perceive a lower risk of predation in open woodlands and shrublands of the Eagle Plains due to the absence of several predators of marten in more southern biomes, including bobcat (*Lynx rufus*) and coyote (*Canis latrans*; Thompson and Colgan 1994, Bull and Heater 2000, Moriarty et al. 2016).

3.3.3 REPRODUCTION

Natal dens are used for the parturition and rearing of neonates and are critical for recruitment and population viability (Buskirk and Ruggiero 1994). Across North America, most natal dens are found in structurally complex sites (Buskirk and Ruggiero 1994). Marten prefer arboreal cavities for parturition and rearing neonates due to the shelter they provide from terrestrial predators, including red fox (Spencer 1987, Brainerd et al. 1995). Marten kits are very vulnerable to fox predation when kits move out of arboreal dens (Brainerd et al. 1995). However, scarcity of arboreal cavities may force marten to use alternative structures for natal denning (Birks et al. 2005). For example, arboreal cavities are rarely used as resting sites in Finland and northern Russia (Brainerd et al. 1995). In the NWT, an adult female marten denned and produced young within a 21-year-old burn (Latour et al. 1994). Therefore, a better understanding of habitat selection by adult female marten in the taiga is needed (Paragi et al. 1996).

3.3.4 DISPERSAL

North American marten are sensitive to forest fragmentation and are found across landscapes with greater amounts of contiguous forest (Thompson et al. 2012). Previous studies show that 5 km of nonforested habitat between forest patches is an effective barrier to dispersal for marten (Buskirk and Ruggiero 1994). Timber harvesting and extensive road networks increase the density of forest edges and generally reduce habitat connectivity for species such as marten adapted to forest interiors (Robitaille and Aubry 2000, Mowat 2006b). However, marten use narrow strips of forest and abandoned roads as movement corridors between more suitable patches of mature forest (Potvin and Bertrand 2004, Breault et al. 2021).

Furthermore, there is evidence that in regions with sparse forest cover, marten may be adapted to meet certain resource requirements in nonforested habitats. For example, in Scotland, forest habitat is limited and pine marten (*Martes martes*) consistently use matrix habitats, including scrub and tussock grassland, to meet life history requirements (Caryl et al. 2012). Intensively managed forests in Scotland lack resources such as den sites and important prey (e.g., short-tailed field vole [*Microtus agrestis*]), abundant in grasslands long thought to be impermeable to marten movement or at best suboptimal marten habitat (Caryl et al. 2012).

Cold temperatures and high seasonality result in different patterns of habitat use among marten in North America (Zielinski et al. 1983). Marten habitat selection was investigated in the Alaskan taiga in a landscape composed of mature coniferous forests of black spruce and larch (*Larix laricina*) from 5–20 cm diameter at breast height (DBH) 100–115 years post-fire, as well as dense, young forests 30 years post-fire, and tall shrub and pole sapling forests with some moss and herb structural stages 10 years post-fire (Paragi et al. 1996). Marten abundance, hunting intensity (based on snow-tracking), and CWD density were the greatest in 10-year burns relative to 30-year burns and mature forests (Paragi et al. 1996).

However, this study found that juveniles were more common in recent burns than in mature stands, and recent burns were likely used only by nonbreeding marten (Paragi et al. 1996). Non-transient marten used coniferous forest more often than transient adult and juvenile marten, which were more likely to use scrub habitat (Paragi et al. 1996). For natal denning, resources are limited in herb and shrub structural stages and prey populations are unpredictable relative to mature forests (Paragi et al. 1996). Therefore, post-fire clearings may be only suitable for dispersing juveniles and transient adult marten (Paragi et al. 1996). Herb and shrub structural stages may function as population sinks for immature and transient marten dispersing from contiguous mature forest (Paragi et al. 1996). Previous HSI models for marten in the taiga have ranked nonforested habitats, including post-fire clearing and shrubland as low-suitability habitat (EDI Environmental Dynamics Inc. 2018). However, habitat requirements of breeding marten in the taiga are not well-understood (Paragi et al. 1996).

3.3.5 DISTURBANCE

3.3.5.1 Fire

Marten are dietary generalists and are not limited to prey associated with mature/old forest structural stages (Baker 1992, Paragi et al. 1996, Poole et al. 2004). Marten in the Alaskan taiga use snags and windthrown trees as winter cover in recent burns before coniferous regeneration occurs (Paragi et al. 1996). Trappers in Alaska view fire as beneficial to furbearer populations. Rodent prey, including red-backed vole, tundra vole (*Microtus oeconomus*), meadow vole (*Microtus drummondii*), and taiga vole, are abundant in dense herbaceous vegetation growth following recent fires (Stephenson 1984). Extensive use of post-fire clearings occurred by marten 1– 3 years post-fire. High population abundance occurs within 3–10 years post-burn, with activity centred in unburned inclusions and burn edges (Stephenson 1984).

In the Alaskan taiga, marten abundance, frequency of investigations, hunting intensity, and CWD density were greatest in 10-year burns relative to older burns and mature forest (Paragi et al. 1996). Subnivean access based on tracks was greatest in 10-year burns relative to mature forests and 30-year burns (Paragi et al. 1996). Small mammal biomass and diversity were greatest in the 10-year burn. This structural stage provided a more stable prey base due to greater diversity of rodents and more stable populations of red-backed vole (Paragi et al. 1996). Young forests 30 years post-fire had the least stable small mammal populations and lacked taiga voles, the prey most selected by marten in this study (Paragi et al. 1996). The suitability of post-fire clearings for marten may be low at first and increase 6–10 years post-fire as ground cover recovers and small mammals occupy the habitat (Paragi et al. 1996). Suitability begins to decrease 15–20 years post-fire and reaches minimum suitability 25–30 years post-fire when CWD has fully decayed and young forests establish. These forests lack near-ground structures for subnivean foraging, escape cover, denning, and resting sites (Paragi et al. 1996).

Adult marten in the NWT were more likely to have home ranges in unburned stands than burned stands (Latour et al. 1994). Unburned forests were open, 90-year-old black spruce-herb, or black spruce-bog forests with average tree height from 5–10 m, and average DBH from 4–14 cm (Latour et al. 1994). Burned stands were characterized by regeneration of open to sparse deciduous vegetation (40% bare ground), a primarily willow shrub layer, and a birch/balsam fir canopy (Latour et al. 1994). Wet areas were characterized by moss, lichen, and Labrador-tea in the understory with sparse, stunted black spruce in the tree layer (Latour et al. 1994). Long-term use by adult marten within home ranges indicated greater use of unburned forests relative to burned forests (Latour et al. 1994). In burns, most snags remained standing and deadfall lay directly on the ground; therefore, burns did not provide access to subnivean spaces, and hunting was mostly on the surface of snow with little protection from predation (Latour et al. 1994). However, an adult female marten with a home range partially within a burn, denned and produced young within the 21-year-old burn (Latour et al. 1994). Furthermore, home ranges of 1 adult and 1 juvenile tracked for 14 and 15 months were entirely within the burns (Latour et al. 1994). Using post-fire structural stages by breeding marten in the taiga is not well understood and should be explored in future studies (Paragi et al. 1996).

3.3.5.2 Roads

The Dempster Highway runs roughly southwest to northeast through the southern half of the RSA. The RSA includes numerous winter roads (15 m average width) from previous exploration activities dating back to the 1960s. Project activities will be accessed via existing and new winter roads. Generally, marten avoid open areas and areas of high human disturbance, including roads (Hargis et al. 1999, Potvin et al. 2000). Marten in North America generally avoid roads due to increased predation risk and lower availability of preferred prey; however, predation risk is assumed to be low in the RSA because primary predators of adult marten are absent or at low density in the Eagle Plains Ecoregion (Yukon Ecoregions Working Group 2004a, Moriarty et al. 2011, 2015, Joyce 2018). Therefore, marten may perceive a lower risk of predation along roads within the RSA due to the absence of several predators of marten in more southern biomes (Bull and Heater 2001, Mowat 2006a, Thompson et al. 2012). Further, abandoned roads (5 m average width) may provide easier pathways for marten movement than undisturbed forest and greater cover from aerial predators than openings (Breault et al. 2021). However, extensive road networks may fragment woodland and shrubland, reducing habitat connectivity and limiting marten dispersal (Caryl et al. 2012).

3.3.5.3 Seismic Lines

The RSA contains numerous 2D seismic lines (range = 5–8 m wide, mean = 5.4 m wide) from previous exploration activities dating back to the 1960s. Most 2D exploration occurred between 1961 and 1984, with new 2D exploration in 2001 incorporating Low Impact Seismic (LIS) techniques(Access Consulting Group and EBA Engineering Consultants Ltd. 2001, GEOTIR 2014). Approximately 2,200 km of new 3D LIS exploration (1.5–3 m wide) was conducted in a 32,500 ha area between November 2013 and April 2014 (GEOTIR 2014). This new 3D exploration is located near the RSA's centre, north and south of the Dempster Highway. The entire RSA, including legacy and contemporary seismic lines, was assessed as a linear feature study. There were signs of normal and magnified succession on 2D and 3D seismic lines. Among 2D lines, 89% had growth >1.5 m height and were considered fully recovered, and 22% of 2D lines made in the 1950s and 1960s showed magnified succession. All 3D lines were made in 2014 and showed normal succession.

In the northern boreal forest (i.e., southwest NWT, northeast BC, and northwest Alberta), marten use of seismic lines is strongly influenced by line width and state of regeneration (Tigner et al. 2015). In this study, forests were open black spruce bogs in lowlands, and upland white spruce-aspen with dense shrubs. Remote wildlife cameras were used to quantify marten use of seismic lines relative to adjacent interior forests. Marten were detected in open lines >3 m wide up to 90% less than forest interiors, but were detected in open lines <2 m wide or lines >6 m with at least partially recovery roughly equally to forest interiors (Tigner et al. 2015). Use of seismic lines is thought to be driven by the perceived risk of predation; marten avoid open habitats but use disturbed habitats following sufficient recovery of overhead and lateral cover (Tigner et al. 2015).

3.3.6 HABITAT SUMMARY

In more productive forests to the south, marten are often associated with mature forest structures, such as large trees, snags, and CWD (Buskirk and Ruggiero 1994, Thompson et al. 2012). Marten select habitats with structural complexity which provides subnivean access to small mammal prey, thermal cover, escape cover from predators, as well as natal denning sites (Spencer et al. 1983, Buskirk and Ruggiero 1994, Latour et al. 1994, Paragi et al. 1996). Within the Subarctic Bioclimate Region, characterized by stunted, open canopy spruce-dominated habitats, tree growth is often limited by the presence of permafrost resulting in disclimax vegetation communities with tall and low shrub structural stages. Therefore, patterns of habitat selection of marten in the RSA may differ from those in southern biomes (Pretzlaw 2006).

Habitat quality in the RSA should be evaluated within the context of reduced availability of old forest structures and lack of contiguous, coniferous forests in the Eagle Plains Ecoregion. Marten select habitat types with the most large pieces of downed wood and the largest standing live and dead trees available at the landscape scale (Zielinski et al. 1983, Baker 1992, Delheimer et al. 2019). Trees, snags, and CWD >30 cm in diameter are associated with older structural stages within the RSA. These structures would be considered too small to provide thermal cover and support natal denning requirements for marten elsewhere in North America (Buskirk et al. 1989, Delheimer et al. 2019). However, these structures are likely large enough to provide thermal cover and support natal denning requirements for marten in the northern context of the RSA (Spencer 1987, Brainerd et al. 1995).

3.4 METHODS

An HSI model was used to estimate habitat quality across the RSA (U.S. Fish and Wildlife Service 1980). An HSI model, also referred to as a knowledge-based habitat suitability model (Clarke 2012), is a common method for assessing habitat quality for wildlife species, and a method adapted for use in environmental impact assessments (U.S. Fish and Wildlife Service 1980). Habitat is defined as the particular place occupied by a specific population within a community and usually characterized by the dominant plant form or physical characteristics (U.S. Fish and Wildlife Service 1980). Each species requires habitat to supply space, food, cover, water, and other requirements for survival (U.S. Fish and Wildlife Service 1980). Suitability is defined as the habitat's ability, in its current structural stage, to provide the life requisites of the species (Resources Inventory Committee 1999c).

3.4.1 HABITAT SUITABILITY MODELLING

HSI modelling uses spatial datasets such as land cover, disturbance history, and topography. It ranks available habitats according to their ability to support a selected species. The habitat rankings can be based on various sources, including ecological survey data, local knowledge, expert knowledge, and traditional knowledge. HSI models can be based on suitability ratings for one habitat variable or the combination of ratings for multiple variables to quantify the quality, amount and distribution of potential habitat for the species (Dijak and Rittenhouse 2009).

3.4.1.1 Rating Scheme

Habitat ranking schemes reflect knowledge of the species' habitat use and ecology (Resources Inventory Committee 1999). A 4-class system was chosen to rank habitat suitability in this study because there is an intermediate level of knowledge of habitat quality for marten in the taiga (Resources Inventory Committee 1999, EDI Environmental Dynamics Inc. 2018). Thus, habitat was assigned a suitability ranking of High (H), Moderate (M), Low (L), or Nil/Very Low (N/VL) relative to the range of habitat quality across the RSA. Using a mathematical equation, the HSI score was produced by combining suitability ratings for several specific habitat variables (e.g., vegetation community type) into one final HSI score.

The developed habitat model produced HSI scores ranging from 0 to 1. Scores were used rather than classes to combine scores and adjustments from multiple variables into a final HSI score. Scores were categorized into four qualitative categories: High (>0.75 to 1.0), Moderate (>0.50 to 0.75), Low (>0.25 to 0.50), Nil/Very Low (>0.0 to 0.25; Resources Inventory Committee 1999). The rating categories correspond to qualitative predictions of the relative suitability of the habitat for supporting five life requisites of marten: reproduction, thermal cover, escape cover, foraging, and dispersal. High-quality habitat supports all five life requisites. Moderate-quality habitat supports escape cover, foraging, and dispersal. Low-quality habitat only supports limited foraging and dispersal. Nil/Very Low-quality habitat does not contribute significantly to any life requisites; however, herb and shrub structural stages and stunted disclimax forest areas likely function as permeable barriers and allow intra-territorial movements within marten home ranges (Caryl et al. 2012). Habitat conditions and suitability interpretations for each rating class are provided in Table 3-1.

Table 3-1. Description of habitat rating classes used in the marten HSI model.

HSI Score	Habitat Rating	Description
>0.75 to 1.0	High	Suitable (optimal). Provides conditions for natal denning (large live conifer trees, large snags, large CWD), thermal cover (medium/large-sized elevated CWD subnivean), escape cover, foraging, and dispersal.
>0.50 to 0.75	Moderate	Suitable (suboptimal). Provides conditions for escape cover (small/medium-sized live or dead conifer trees, and/or small CWD, and/or dense shrub cover), foraging, and dispersal.
>0.25 to 0.50	Low	Limited Suitability. Provides conditions for foraging (i.e., any size or species of tree that would support prey species and CWD large enough for subnivean access; grass and/or horsetails for hare, voles, birds, and/or berries for prey or marten), and dispersal (i.e., some herb or sparse deciduous/shrub cover).
>0.0 to 0.25	Nil/Very Low	Unsuitable. Non-vegetated areas, such as alpine, water, or highways, that do not provide conditions to support any life requisites for marten. Non-vegetated areas may be used for intra-territorial movements.

3.4.1.2 Habitat Variables

Habitat variables were identified as potentially important for describing marten habitat (Table 3-2). Variables were evaluated for inclusion based on the strength of relationships found in other studies, the ecological relevance to marten in the Eagle Plains Ecoregion, and the availability of the variable in GIS databases for the RSA. Based on these criteria, ELC and Linear Feature (LF) data were included in marten habitat modelling.

Distance to riparian areas was considered for inclusion in the model. Riparian areas are important foraging habitat for marten in North America (Spencer et al. 1983, Ben-David et al. 1997), and elder members of the VGFN observed good marten habitat in the area where the Blackstone and Peel rivers meet (Sherry and Vuntut Gwitchin First Nation 1999, p. 140). Riparian areas generally have greater prey availability relative to the surrounding landscape due to higher densities of prey and greater volumes of CWD, which increase access to subnivean spaces (Buskirk et al. 1989). ELC data accurately represent increased habitat quality in mature/old riparian forests found as narrow strips along most major watercourses in the RSA, including Chance Creek in the northwest and Dalglish Creek in the southeast. Therefore, a variable for distance to riparian was redundant with the ELC mapping and was not included in the model.

The history of fire disturbance has influenced marten distribution and was considered for inclusion in the model. However, the nature of the relationship between fire history and patterns of use by marten is unclear for the taiga biome. Recent burns and post-fire clearings are generally considered suboptimal habitat. They are used mainly by nonbreeding and dispersing juvenile marten (Paragi et al. 1996). In the NWT, adult martens were likelier to locate home ranges in unburned stands than burned ones (Latour et al. 1994). However, recent burns may provide foraging opportunities not present in older burns or mature forests (Paragi et al. 1996). Furthermore, fire history was explicitly accounted for in the structural stage of the ELC mapping. Therefore, a separate variable for fire history was determined to be redundant with ELC mapping and was not included in the model.

Elevation was considered as a variable for inclusion in the model. Marten generally occur at higher elevations than similarly-sized mesocarnivores, due to adaptations for travelling over snowpack and hunting in subnivean spaces (Grinnell et al. 1937, Zielinski et al. 2005, 2017). However, elevation within the rolling topography of the RSA does not vary substantially (range = 343–752 m asl) and was likely not a significant driver of marten distribution. Therefore, elevation was not included as a variable in the model.

Table 3-2. Summary of habitat variables commonly associated with marten habitat quality from published literature relevant to the Regional Study Area.

Variable	Included in model?	Rationale
Ecosite (ELC)	Yes	Marten select conifer-dominated stands with dense shrub cover.
Structural Stage (ELC)	Yes	Marten select mature/old forests with complex structure.
Distance to Riparian	No	Most ecosites defined by permafrost rather than riparian. ELC data more accurately represent increased habitat quality in mature/old riparian forests than distance to riparian.
Linear Features	Yes	Generally, marten avoid linear features due to increased predation risk. It is included as a habitat modifier/downgrade to adjacent habitat.
Fire History	No	Different patterns of use by marten depending on study. Fire may affect habitat quality positively or negatively, dependent on ecosite and time since disturbance. Fire history was explicitly accounted for in the structural stage of the ELC mapping. Therefore, it would be redundant to include it in the model.
Elevation	No	Range in elevation within RSA (343–752 m asl) is not enough to affect marten distribution.

Ecological and Landscape Classification

ELC mapping refers to an integrated approach to mapping and classifying land units according to their ecological similarity (Environment Yukon 2016a). As part of another study in the RSA (EDI Environmental Dynamics Inc 2021), field plots were used to establish preliminary classification units and site/soil conditions across various ecological communities. The vegetation association organization and ecosite and coding system follows the Yukon ELC Mapping Guidelines (Environment Yukon 2016a). Non-forested and sparsely/non-vegetated ecosystem were assigned to group/realm following *Biogeoclimatic Ecosystem Classification of Non-forested Ecosystems in British Columbia* (BC MFLNRORD and BC MOE 2010, Mackenzie 2012), and anthropogenic units were classified following *Standards for Terrestrial Ecosystem Mapping in British Columbia* (Resources Inventory Committee 1998a). Wetland sites were classified according to the Canadian Wetland Classification System for class, form, subform, type and subtype.

The remaining ecosites were coded with a two-digit number that indicates, by its number series, a certain range of soil moisture conditions: 10s are dry sites, 00s are mesic sites, 20s are riparian sites, 30s are moist sites, and 40s are wet sites. Ecosite names reflect plant species that are important indicators of the vegetation found within the ecosite (e.g., 33 – Moist Spruce – Labrador Tea).

Biologists delineated ELC polygons in a GIS based on discernible differences among vegetation, topography, terrain, soils, gradients, and patterns (relationship patterns between ecosystem units, polygon shape and orientation). Three or fewer ecosystem units (i.e., ecosites) were entered per polygon. Each ecosite had an associated structural stage modifier (e.g., pole sapling) and decile, representing the percent area of the polygon in each ecosite (i.e., all deciles sum to 100%).

A subsample (n = 97) of ELC field plots were used to describe habitat suitability rankings for marten within the context of the Eagle Plains Ecoregion. Field plots were identified as High (n = 10), Moderate/high (n = 21), Moderate (n = 20), Moderate/low (n = 44), and Low (n = 2). No field plots were in Nil/Very Low habitat suitability. ELC ecosites and structural stages were used to generalize habitat rankings from field plots to ELC GIS data (Table 3-3).

Every combination of ecosite and structural stage was assigned an initial HSI score of High (HSI >0.67 to 1.0), Moderate (HSI >0.33 to 0.67), Low (HSI >0 to 0.33), or Nil/Very Low (HSI = 0). Only ecosites and structural stages represented in the RSA were included in habitat modelling. All non-vegetated ecosites (AN, ES, Fa, LA, PD, RI, RZ) were ranked as Nil/Very Low (0.0). Vegetated ecosites in the non-vegetated structural stage (1) were ranked as Nil/Very Low (0.0). Ecosite 10 (sparsely vegetated) was ranked as Nil/Very Low (0.0) regardless of structural stage. All other vegetated ecosites with Sparse/cryptogram (2/2a) or Herb/graminoid-dominated (3/3b) structural stage were all ranked as Low quality (0.1). Vegetated ecosites in Low shrub (4b) structural stage were ranked as Low quality (0.33) and ranks increased with structural stage to a maximum of 1.0 (High quality) for conifer/mixedwood ecosites, and a maximum of 0.67 (Moderate quality) for deciduous/shrub ecosites, and 0.33 (Low quality) for wetland (bog, marsh, fen) ecosites.

Linear Features

Linear features (LF) were surveyed in the RSA as a companion study for the exploration project proposal (EDI Environmental Dynamics Inc., unpublished study). LFs were classified as 2D, 3D, winter roads (any trails or limited use roads with an obviously curving path), and the Dempster Highway. A subsample (n = 64) of field plots from the LF surveys were used to investigate habitat suitability for marten on-line and off-line. Determining the relative level of impact of various types of LFs established empirical evidence for modelling.

No linear features contained high suitability habitat; the average difference between off-line and on-line habitat suitability rankings across all types of LFs was 0.81 (SD = 0.79, range = 0–3, n = 64). All 2D lines (average width = 5.4 m, n = 27) were moderate-low habitat suitability on-line, and when compared to off-line habitat, the average difference in suitability ranking was 0.85 (off – on), (SD = 0.82, range = 0–2). 3D lines (width range = 1.75–5 m, n = 27) were mostly moderate-low habitat suitability (n = 24), and the average difference between off-line and on-line suitability was 0.63 (SD = 0.69, range = 0–2). The average difference among winter roads (average width = 5 m, n = 8) was 0.88 (SD = 0.64, range = 0–2). Along the Dempster Highway (average width = 15 m, n = 2), the average difference was 2.5 (SD = 0.71, range = 2–3). The average difference in HSI between off-line and on-line field plots was scaled to a score from 0–1 for downgrading:

- Dempster Hwy (30.0 m wide) = (2.5*0.25) = 0.625
- Winter Roads and 2D lines (10.0 m wide) = (0.87*0.25) = 0.218
- 3D lines (10.0 m wide) = (0.63*0.25) = 0.158

2D and 3D lines were mapped using a 10 m width due to limitations of the spatial scale of modelling (10 m raster). The 2D lines are wider than 3D lines and thus have a greater local effect on marten habitat suitability. The difference in effect between 2D and 3D lines on marten habitat was accounted for by applying a greater value for downgrading 2D lines (–0.218) compared to 3D lines (–0.158).

Table 3-3. HSI ratings for marten habitat quality in the Eagle Plains RSA based on an assessment of ELC field plots.

Ecosite Name	Ecosite Code	Structural Stage											
		Non-vegetated	Sparse / cryptogram	Sparse (5–10% cover)	Herb	Graminoid dominated	Low shrub	Shrub	Tall shrub	Pole sapling	Young Forest	Mature Forest	Old Forest
		1	2	2a	3	3b	4b	4	4a	5	6	7	8
Mesic Birch - Willow	2	0.00	0.10	0.10	0.10	0.10	0.35	0.40	0.45	0.50	0.60	0.60	0.60
Mesic White Spruce – Alaska Paper Birch - Alder	3	0.00	0.10	0.10	0.10	0.10	0.35	0.40	0.45	0.60	0.75	0.90	1.00
Mesic Black Spruce – Alaska Paper Birch (mixedwood)	4	0.00	0.10	0.10	0.10	0.10	0.35	0.40	0.45	0.60	0.75	0.90	1.00
Mesic Alaska Paper Birch (Deciduous)	5	0.00	0.10	0.10	0.10	0.10	0.35	0.40	0.45	0.50	0.60	0.60	0.60
Mesic Black Spruce – Labrador Tea (Conifer)	6	0.00	0.10	0.10	0.10	0.10	0.35	0.40	0.45	0.60	0.75	0.90	1.00
Sparsely Vegetated	10	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry Spruce-Lichen (Conifer)	14	0.00	0.10	0.10	0.10	0.10	0.35	0.40	0.45	0.60	0.75	0.90	1.00
Dry Aspen-Lichen (Deciduous)	15	0.00	0.10	0.10	0.10	0.10	0.35	0.40	0.45	0.50	0.60	0.60	0.60
Dry Spruce-Birch-Lichen (mixedwood)	16	0.00	0.10	0.10	0.10	0.10	0.35	0.40	0.45	0.60	0.75	0.90	1.00
Dry Aspen (Deciduous)	17	0.00	0.10	0.10	0.10	0.10	0.35	0.40	0.45	0.50	0.60	0.60	0.60
Shrubby Riparian Birch – Willow	20	0.00	0.10	0.10	0.10	0.10	0.35	0.40	0.45	0.50	0.60	0.60	0.60
Riparian White Spruce – Prickly Rose	21	0.00	0.10	0.10	0.10	0.10	0.35	0.40	0.45	0.60	0.75	0.90	1.00
Riparian Spruce – Birch - Willow	22	0.00	0.10	0.10	0.10	0.10	0.35	0.40	0.45	0.60	0.75	0.90	1.00
Drainage Shrubby Riparian	23	0.00	0.10	0.10	0.10	0.10	0.35	0.40	0.45	0.50	0.60	0.60	0.60

		Structural Stage											
Ecosite Name	**Ecosite Code**	**Non-vegetated**	**Sparse / cryptogram**	**Sparse (5–10% cover)**	**Herb**	**Graminoid dominated**	**Low shrub**	**Shrub**	**Tall shrub**	**Pole sapling**	**Young Forest**	**Mature Forest**	**Old Forest**
		1	**2**	**2a**	**3**	**3b**	**4b**	**4**	**4a**	**5**	**6**	**7**	**8**
Moist Shrub \ Scrub Birch – Labrador Tea – Willow	31	0.00	0.10	0.10	0.10	0.10	0.35	0.40	0.45	0.50	0.60	0.60	0.60
Moist Spruce – Labrador Tea	33	0.00	0.10	0.10	0.10	0.10	0.35	0.40	0.45	0.60	0.75	0.90	1.00
Moist Spruce – Alder – Labrador Tea	34	0.00	0.10	0.10	0.10	0.10	0.35	0.40	0.45	0.60	0.75	0.90	1.00
Moist Spruce – Scrub birch – Labrador Tea	35	0.00	0.10	0.10	0.10	0.10	0.35	0.40	0.45	0.60	0.75	0.90	1.00
Moist Birch – Willow	36	0.00	0.10	0.10	0.10	0.10	0.35	0.40	0.45	0.50	0.60	0.60	0.60
Wet Shrub – Tamarack	41	0.00	0.10	0.10	0.10	0.10	0.35	0.40	0.45	0.50	0.60	0.60	0.60
Wet Shrub – Black Spruce – Tussock Cottongrass	42	0.00	0.10	0.10	0.10	0.10	0.35	0.40	0.45	0.50	0.60	0.60	0.60
Wet Shrub – Black Spruce - Sphagnum	43	0.00	0.10	0.10	0.10	0.10	0.35	0.40	0.45	0.50	0.60	0.60	0.60
Wet Shrub – Scrub Birch – Tussock Cottongrass	44	0.00	0.10	0.10	0.10	0.10	0.35	0.40	0.45	0.50	0.60	0.60	0.60
Wet Shrub – Scrub Birch - Graminoid	45	0.00	0.10	0.10	0.10	0.10	0.35	0.40	0.45	0.50	0.60	0.60	0.60
Wet Black Spruce – Labrador Tea – Cladonia	46	0.00	0.10	0.10	0.10	0.10	0.35	0.40	0.45	0.60	0.75	0.90	1.00
Wet Black Spruce – Tussock Cottongrass - Sphagnum	47	0.00	0.10	0.10	0.10	0.10	0.35	0.40	0.45	0.60	0.75	0.90	1.00
Wet Black Spruce – Carex	48	0.00	0.10	0.10	0.10	0.10	0.35	0.40	0.45	0.60	0.75	0.90	1.00
Anthropogenic	AN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bog – Black spruce – Lichen	B1	0.00	0.10	0.10	0.10	0.10	0.25	0.25	0.25	0.25	0.25	0.25	0.25

Ecosite Name	Ecosite Code	Structural Stage Non-vegetated 1	Sparse / cryptogram 2	Sparse (5–10% cover) 2a	Herb 3	Graminoid dominated 3b	Low shrub 4b	Shrub 4	Tall shrub 4a	Pole sapling 5	Young Forest 6	Mature Forest 7	Old Forest 8
Bog – Black Spruce – Sphagnum	B2	0.00	0.10	0.10	0.10	0.10	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Exposed Soil	ES	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fen	F	0.00	0.10	0.10	0.10	0.10	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Flood Active Channel	Fa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lake	LA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Marsh	M	0.00	0.10	0.10	0.10	0.10	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Pond	PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
River	RI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Road	RZ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

3.4.1.3 Model Structure

Each ELC polygon contains up to three ecosites with deciles indicating percent cover relative to the total area of the polygon. A weighted average HSI score was calculated for each polygon using the following equation:

$$ELC_r = \frac{\sum_{i=1}^{n} d_i h_i}{\sum_{i=1}^{n} d_i}$$

where ELC_r is the initial weighted average, d_i is the decile value, and h_i is the HSI score for each ecosite. HSI polygons were converted to a 10x10 m resolution raster, and linear feature adjustments were applied to the initial HSI scores for each cell:

$$HSI = ELC_r - LF_r$$

where LF_r is the LF adjustment.

3.5 RESULTS AND DISCUSSION

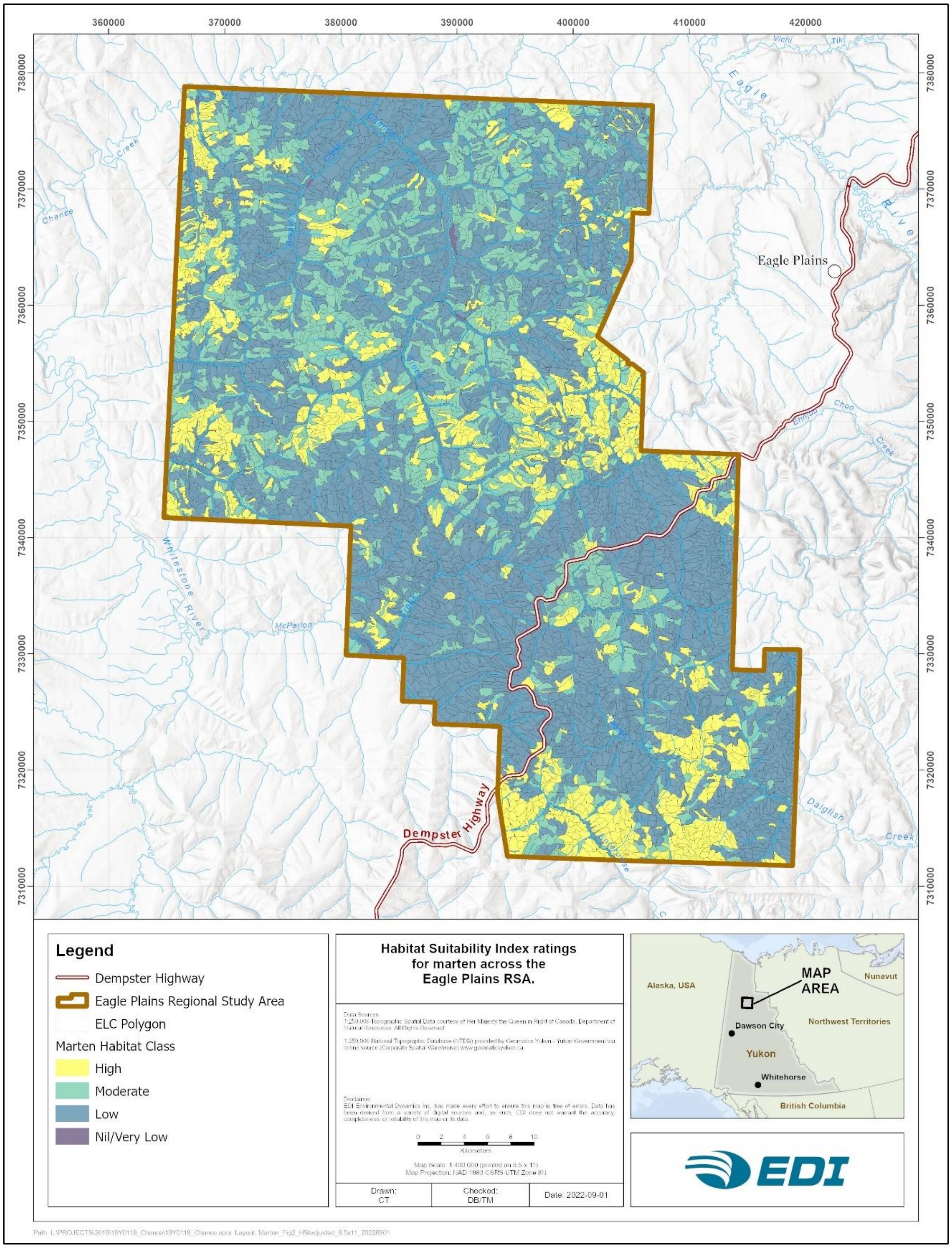
The model indicated a patchwork of High, Moderate, and Low-quality marten habitat, across the RSA (Table 3-4; Map 3-1). High-quality marten habitat is associated with mesic, spruce-dominant ecosites in mature to late structural stages. It includes some of the most common ecosystem units in the RSA, including Moist Spruce – Labrador Tea (33), Moist Spruce – Alder – Labrador Tea (34), and Mesic Black Spruce – Alaska Paper Birch (04; Figure 3-1). Concentrations of High-quality habitat include Enterprise and Dalglish Creeks watersheds in the south, a band running east-west north of the Dempster Highway, and the western part of the northern half of the RSA. Moderate-quality habitat is associated with wetter or younger ecosystem units than High-quality habitat and is widespread across the RSA. High and Moderate-quality habitat is also concentrated in narrow strips of mature/old riparian forests along some of the major watercourses in the RSA, including Chance and Greaves Creeks in the northwest and McParlon Creek west of the Dempster Highway.

There is extensive Low-quality habitat, represented by vegetation communities in tall and low shrub structural stages found throughout the RSA (Figure 3-1). These habitats generally lack mature forest structures, such as large trees, snags, and CWD, which marten require for subnivean foraging, escape/thermal cover, and denning (Buskirk and Ruggiero 1994, Thompson et al. 2012). Low-quality habitat was associated with shrubby wetlands and stunted black spruce sites in low valley bottoms in the Chance watershed in the northwestern portion of the RSA and regenerating fire-disturbed areas on both sides of the Dempster Highway in the southern part. Completely non-vegetated areas are rare in the RSA; thus, there is almost no Nil/Very Low-quality habitat (Table 3-4; Map 3-1).

Linear features had a relatively minor effect on the overall quality, amount, and distribution of potential habitat for marten. The effect of linear features on habitat suitability for marten is mainly limited to site-level effects (Map 3-2). This effect was due to the narrow width of linear features (Moriarty et al. 2016, 2017) and their small extent relative to the overall RSA. Though existing linear features reduce habitat quality at the site level, their effects are negligible to habitat supply at the home range scale for marten (Table 3-4). The Dempster Highway was likely the only linear feature in the RSA that could limit the movement of marten. Marten avoid crossing open areas due to increased predation risk relative to areas that provide escape cover (Slauson et al. 2017). However, the highway likely functions as a barrier, not an obstacle or constraint to their movement (Beyer et al. 2016). Therefore, it is likely that marten can and will cross the highway, so the potential barrier limits to their movement likely do not affect habitat availability at the home range scale.

Table 3-4. Relative availability of marten habitat in the Eagle Plains RSA.

Habitat Rating	HSI Scores	Area (ha)	Area (%)
High	>0.75 to 1.0	38,049.63	15.94
Moderate	>0.50 to 0.75	55,202.05	23.12
Low	>0.25 to 0.50	142,484.78	59.68
Nil/Very Low	>0.0 to 0.25	3,015.79	1.26
Total		238,752.25	100



Habitat Suitability Index ratings for marten across the Eagle Plains RSA.

Data Sources
1:250,000 Topographic Spatial Data courtesy of Her Majesty the Queen in Right of Canada, Department of Natural Resources. All Rights Reserved.

1:250,000 National Topographic Database (NTDB) provided by Geomatics Yukon - Yukon Government via online source (Corporate Spatial Warehouse) www.geomaticsyukon.ca.

Disclaimer
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Map Scale: 1:400,000 (printed on 8.5 x 11)
Map Projection: NAD 1983 CSRS UTM Zone 8N

Drawn: CT
Checked: DB/TM
Date: 2022-09-01

Path: L:\PROJECTS\2019\19Y0118_Chance\19Y0118_Chance.aprx Layout: Marten_Fig2_HSIadjusted_8.5x11_20220901

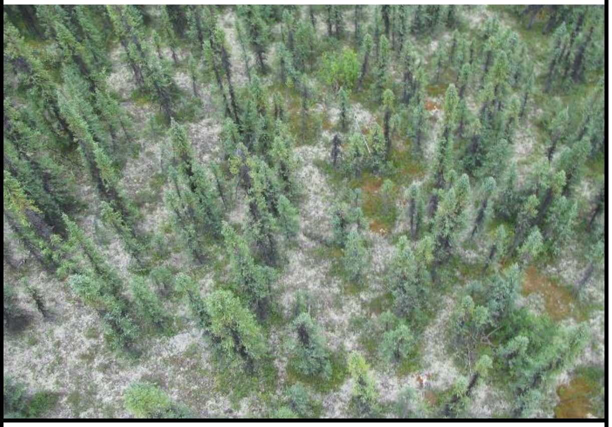
Map 3-2. Habitat Suitability Index model ratings for marten across the Eagle Plains RSA.

Moist Spruce – Labrador Tea, Old Forest

Moist Spruce – Alder – Labrador Tea, Mature Forest

Mesic Birch – Willow, Young Forest

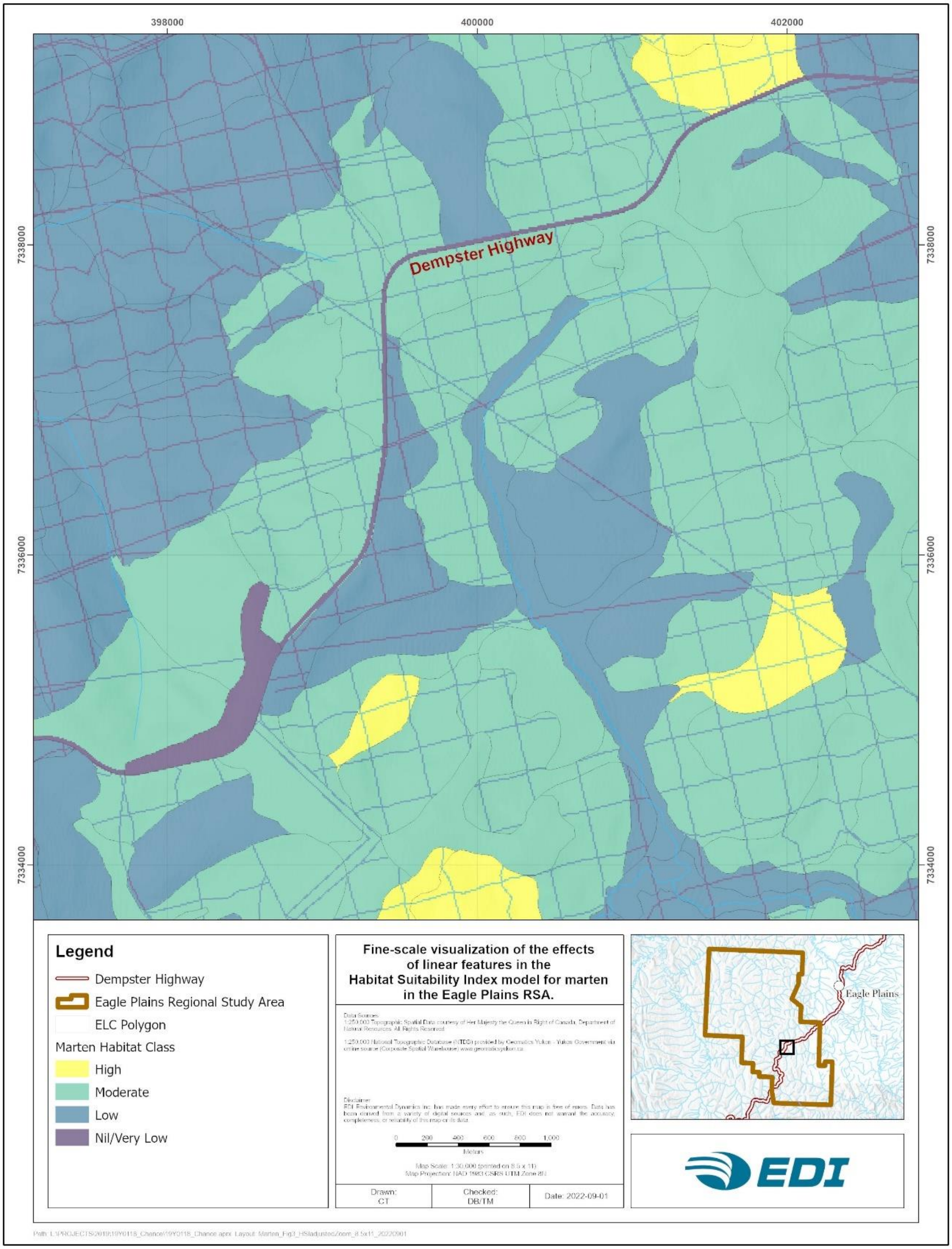
Moist Spruce – Labrador Tea, Tall Shrub



Moist Spruce – Labrador Tea, Low Shrub

Bog – Black Spruce – Sphagnum, Low Shrub

Figure 3-2. Examples of High (top row), Moderate (middle row), and Low (bottom row) quality marten habitat in the Eagle Plains RSA.



Fine-scale visualization of the effects of linear features in the Habitat Suitability Index model for marten in the Eagle Plains RSA.

Data Sources:
1:250,000 Topographic Spatial Data courtesy of Her Majesty the Queen in Right of Canada, Department of Natural Resources. All Rights Reserved.

1:250,000 National Topographic Database (NTDB) provided by Geomatics Yukon - Yukon Government via online source (Corporate Spatial Warehouse) www.geomaticsyukon.ca.

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Map Scale: 1:30,000 (printed on 8.5 x 11)
Map Projection: NAD 1983 CSRS UTM Zone 8N

Drawn: CT
Checked: DB/TM
Date: 2022-09-01

Path: L:\PROJECTS\2019\19Y0118_Chance\19Y0118_Chance.aprx Layout: Marten_Fig3_HSIadjustedZoom_8.5x11_20220901

Map 3-3. Fine-scale visualization of the effects of linear features in the Habitat Suitability Index model for marten in the Eagle Plains RSA.

3.5.1 MODEL VERIFICATION AND CONFIDENCE

The frequency of use of habitat by marten in the RSA is expected to correlate to the ordinal habitat classes used in the model. However, independent marten occurrence data were not available to test that expectation. The overall confidence in the model is moderate based on moderate knowledge of marten in northern ecosystems and the lack of local field verification.

3.6 SUMMARY

The quality, amount, and distribution of potential habitat for marten were quantified across the RSA using a Habitat Suitability Index model. Ecosite and vegetation structural stages were used to assign areas an initial HSI score, which was then modified based on the presumed adverse effects of linear features on marten habitat. The HSI model indicates a patchwork of High (16%), Moderate (23%), and Low (60%) quality marten habitat across the RSA. High-quality marten habitat occurred in relatively large areas of contiguous mature/old spruce forests and narrow strips of mature/old riparian forests along major watercourses. The RSA contains extensive Low-quality habitat, associated with vegetation communities in tall and low shrub structural stages, including regenerating burns and open, stunted black spruce forest. Non-vegetated areas that constitute Nil/Very Low habitat are a minor component of the RSA. Linear features reduce habitat quality at the site level, but their effects on habitat supply at the scale of a marten's home range are limited.

4 GRIZZLY BEAR

4.1 PURPOSE AND OBJECTIVES

Grizzly bears (*Ursus arctos horribilis*) were selected as a VC for the Project due to their conservation status and social, cultural, and economic value. Grizzly bear have been assessed as a species of Special Concern in Canada, indicating their populations are at risk of becoming threatened if not adequately managed (COSEWIC 2007). Grizzly bears have cultural significance for Indigenous people of Yukon, some of which have traditional uses for their fur, fat, and meat (Benson 2014, Yukon Grizzly Bear Conservation and Management Plan Working Group 2019a). In addition, grizzly bears are managed as a Big Game species in Yukon (Government of Yukon 2002) and harvested by Yukon residents and non-residents (i.e., outfitting operations) throughout much of the territory. Grizzly bear are considered an iconic Yukon species and the opportunity to view grizzly bears attracts tourists from around the world (Yukon Grizzly Bear Conservation and Management Plan Working Group 2019a).

This section summarizes the current state of knowledge about grizzly bear ecology in the Project and broader areas, including population trends, distribution, habitat selection, diet, and sources of mortality. This report emphasizes grizzly bear ecology specific to the Taiga Cordillera Ecozone where the Project is located. The behavioural ecology and population characteristics of grizzly bears in the taiga are likely distinct from bears inhabiting coastal, boreal, and arctic barren-ground ecosystems, given substantial variation in habitat and food availability across these regions (Mowat and Heard 2006, Mowat et al. 2013). This report draws from multiple sources, including published and unpublished literature, personal communications with biologists, and traditional knowledge where available. Few studies on grizzly bears have been conducted in the region and the broader Taiga Cordillera. Thus, literature from surrounding regions was consulted when local information was unavailable.

4.2 POPULATION STATUS AND DISTRIBUTION

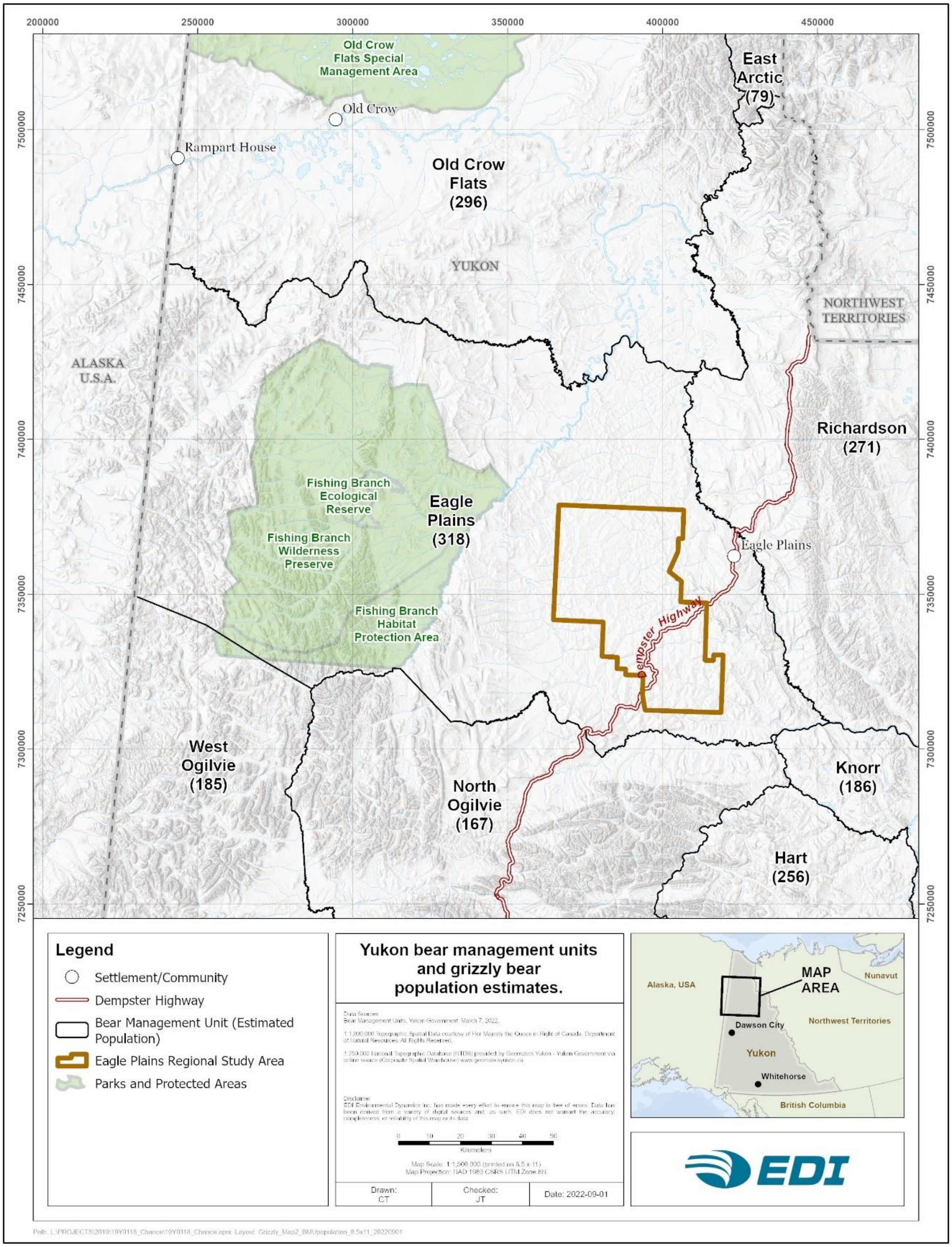
4.2.1 POPULATION

Yukon's grizzly bear population is estimated at 6,000 to 7,000 individuals, comprising approximately 25% of Canada's total grizzly bear population (COSEWIC 2007). The Yukon population estimate was derived from expert-opinion-based estimates of grizzly bear densities in each Yukon Ecoregion, using habitat information and local knowledge collected in the 1980s (Smith and Osmond-Jones 1990, Yukon Grizzly Bear Conservation and Management Plan Working Group 2019b). The exceptions are the Southern Lakes Region and Yukon North Slope, where more recent estimates are available from population assessments using genetic mark-recapture methods (Yukon Fish and Wildlife Branch 2016, 2017). The RSA is located within the Eagle Plains Ecoregion, which has a grizzly bear population estimate of 184 individuals (Yukon Grizzly Bear Conservation and Management Plan Working Group 2019b).

Yukon's grizzly bear populations are managed within bear management units (BMU), generally delineated by outfitting concession boundaries. The Inuvialuit Settlement Region is an exception, where grizzly bears are managed under a separate co-management agreement (WMAC [NS] and WMAC [NWT] 1998). Population estimates for each BMU were derived from the original expert-based Ecoregion estimates (except the Southern Lakes Region and North Slope). Population estimates for BMUs range from 43 to 503 bears; with variation attributed to differences in habitat quality and the sizes of BMUs.

The Eagle Plains BMU, which encompasses the RSA, has a population estimate of 318 bears (Map 4-1). However, the population estimate for the Eagle Plains BMU includes Ni'iinli Njik (Fishing Branch) Territorial Park, which likely has much higher grizzly bear densities than the RSA due to abundant salmon and winter denning habitat (Vuntut Gwitchin Government and Environment Yukon 2010). Grizzly bear densities are considered low throughout the RSA, although limited information is available (Pongracz and Suitor, pers. comm., 2022). Population densities for the adjacent Richardson Mountains are estimated at approximately 23 bears per 1,000 km^2 (Clarkson et al. 1993), but grizzly bears are more abundant in the mountains than the taiga plains that characterize the RSA (Benson 2014).

Grizzly bear population trends in Yukon are primarily tracked through harvest monitoring. The Yukon population is stable (Yukon Grizzly Bear Conservation and Management Plan Working Group 2019a). There is minimal data on population trends within the Eagle Plains BMU, given low grizzly bear harvest rates (refer to Section 3.1), but traditional knowledge provides some insight. Gwich'in knowledge holders suggest that grizzly bears in the Gwitch'in Settlement Area have a generally stable population (Benson 2014). However, elders noted that grizzly bears have declined in some areas from 1940 to the early 2000s due to increased hunting pressure, the opening of the Dempster Highway, increased use of snow machines, and a general northward range shift towards the Inuvialuit Settlement Region.



Yukon bear management units and grizzly bear population estimates.

Data Sources
Bear Management Units, Yukon Government. March 7, 2022.

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1:250,000 National Topographic Database (NTDB) provided by Geomatics Yukon - Yukon Government via online source (Corporate Spatial Warehouse) www.geomaticsyukon.ca.

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Map Scale: 1:1,500,000 (printed on 8.5 x 11)
Map Projection: NAD 1983 CSRS UTM Zone 8N

Drawn: CT	Checked: JT	Date: 2022-09-01

Path: L:\PROJECTS\2019\19Y0118_Chance\19Y0118_Chance.aprx Layout: Grizzly_Map2_BMUpopulation_8.5x11_20220901

Map 4-1. Yukon bear management units and grizzly bear population estimates.

4.2.2 DISTRIBUTION

Grizzly bears occur throughout the Yukon, ranging from the BC/Yukon border to the Arctic coast. They are generalist omnivores that may live in various habitat types (Mowat et al. 2013), and they occur in all Ecoregions within Yukon.

In northern Yukon, seasonal grizzly bear distribution generally tracks the availability of key food resources such as berries, fish, ungulate calves, and ground squirrels (MacHutchon and Wellwood 2003). Very little information exists about grizzly bear distribution within the RSA. The Whitestone River adjacent to the RSA (Map 1-1) is an area of higher grizzly bear concentration in the region (Pongracz and Suitor, pers. comm., 2022). During the fall, grizzly bears congregate in Ni'iinli Njik (Fishing Branch) Territorial Park, approximately 20 km west of the RSA, to feed on spawning salmon in the Fishing Branch River (Vuntut Gwitchin Government and Environment Yukon 2010).

In and adjacent to the Gwitch'in Settlement Region, grizzly bears are more common in the Richardson Mountains, the Ogilvie Mountains, and the barren arctic coast than in the flat, low-elevation taiga that overlaps the RSA (Benson 2014). These distributional patterns are attributed to a lack of ground squirrels and other key food sources in the moist, hummocky spruce forest that characterizes much of the RSA.

4.2.3 CONSERVATION STATUS AND THREATS

COSEWIC has assessed grizzly bears as a species of Special Concern (COSEWIC 2007). The Western Canadian grizzly bear population is listed under Schedule 1 of the SARA, which requires measures to prevent grizzly bears from becoming Threatened or Endangered. Within Yukon, grizzly bears are not currently considered a species of conservation concern (Yukon Conservation Data Centre 2019), although a conservation plan was developed for grizzly bears in 2019 to promote healthy and viable grizzly bear populations into the future (Yukon Grizzly Bear Conservation and Management Plan Working Group 2019a).

The greatest threats to the Canadian grizzly bear population are considered to be 1) human-caused mortality, including illegal and legal hunting, conflict kills, and railway or road mortalities, and 2) habitat loss and fragmentation (COSEWIC 2007). Members of the VGFN had observed in the late 1990s that Grizzly bears did not come near to the Dempster highway but were concerned with the old garbage dump areas along the highway possibly attracting bears (Sherry and Vuntut Gwitchin First Nation 1999, p. 286, 289). Key threats to grizzly bear populations in the Yukon are human-wildlife conflict and harvest mortality, although habitat loss and climate-related changes to food availability may also be significant (Yukon Grizzly Bear Conservation and Management Plan Working Group 2019a). Northern grizzly bear populations cannot sustain high mortality rates due to their low reproductive rates and low densities (Nagy et al. 1983). Sources of mortality in the RSA and surrounding region are discussed in detail in Section 4.4.

4.3 MORTALITY AND HARVEST

Grizzly bears are managed as a big game species in Yukon (Government of Yukon 2002), and harvest is permitted in most parts of the territory outside of National Parks, including resident, non-resident, and subsistence harvest. The overall mortality management system is based on estimated total sustainable mortality rates of ≤ 2% of the female population, ≤ 6% of the male population, and ≤ 4% of the total population (Yukon Grizzly Bear Conservation and Management Plan Working Group 2019a). Total allowable mortality rates account for mortality from harvest, and other sources, including vehicle collisions and defence of life and property (DLP) kills (i.e., conflict kills).

Yukon grizzly bear harvest is managed within BMUs, although harvest rates are often reported at the scale of Game Management Subzones (GMS) or broader Game Management Zones (GMZ). The bag limit is one grizzly bear every three years in open subzones, and hunters must report all bear kills (Government of Yukon 2021). The RSA is located within GMZ 1, with the lowest licenced grizzly bear harvest rates in the Yukon. Between 1980 and 2014, the annual grizzly bear harvest in GMZ 1 varied from zero to three bears (Milligan 2018). More specifically, within the Eagle Plains BMU (Map 4-1), only two grizzly bears were harvested from 1995 to the present (Pongracz and Suitor, pers. comm., 2022). The Eagle Plains BMU does not overlap any outfitter concessions (i.e., no non-resident harvest), so reported harvest rates are attributed to licenced resident harvest.

Other sources of grizzly bear mortality include DLP kills, collisions with vehicles, and predation from other bears or large carnivores. Grizzly bear mortality rates in the Eagle Plains BMU are low relative to other BMUs in the territory, with an annual average mortality density of < 0.1 bears per 1,000 km², based on records from 2005 to 2016 (Yukon Grizzly Bear Conservation and Management Plan Working Group 2019b). Mortality rates tend to be higher in southern Yukon, where both the human population and road densities are comparatively high, with mortality densities up to 0.6 bears per 1,000 km² in some BMUs (Yukon Grizzly Bear Conservation and Management Plan Working Group 2019b). However, these rates do not account for unreported human-caused mortality (e.g., unreported DLP kills) or natural sources of mortality. Reported DLP kills accounted for an average of 11 grizzly bear mortalities per year in Yukon from 1980 to 2016. DLP mortality rates are very low within the Eagle Plains BMU; from 1995 to 2021, only one grizzly bear DLP kill was reported (Pongracz and Suitor, pers. comm., 2022).

The correlation between road density and grizzly bear mortality has been well documented in other parts of western North America (McLellan 1990, Mace et al. 1996, Boulanger and Stenhouse 2014, Proctor et al. 2019). Most historical grizzly bear mortalities in central BC and Alberta were related to human activity and occurred within 500 m of a road (Ciarniello et al. 2004, Boulanger and Stenhouse 2014). In BC, grizzly bear mortality rates are known to increase in areas where road densities exceed 0.6 km/km² (Lamb et al. 2018). Mortalities were caused by higher rates of legal harvest, poaching, and conflict kills near roads, in addition to direct mortalities from road collisions. Roadside hunting of grizzly bears is currently permitted in Yukon, although this is under review in some local areas (Yukon Grizzly Bear Conservation and Management Plan Working Group 2019a).

Grizzly bear mortalities from vehicle collisions are rare in Yukon. Fifteen grizzly bear mortalities resulted from collisions with vehicles from 2003 to 2014 on all Yukon Highways (EDI Environmental Dynamics Inc. 2015). Collisions tended to occur in spring and summer when grizzly bears were foraging on roadside vegetation. Most collisions occurred on the Alaska Highway (60%), which has higher traffic volumes than other roads in the territory. The only major road in the RSA is the Dempster Highway, which has comparatively low traffic volumes and is unpaved. From 2003 to 2014, only one bear collision was reported on the Dempster Highway near Dawson City. The bear species was unidentified.

Predation is a source of mortality for grizzly bears, but predation rates are generally unknown in the Yukon. Male grizzly bears occasionally prey on females and cubs on the North Slope (Clarkson and Liepins 1994). Wolves in packs have also been known to kill grizzly bears in northern Yukon (Benson 2014).

4.4 REGIONAL HABITAT ECOLOGY AND DIET

The distribution of available forage strongly influences habitat selection by grizzly bears during spring, summer, and fall seasons (Nielsen et al. 2010, Milakovic et al. 2012) and the supply of suitable den sites in winter (Smereka et al. 2017). Security and thermal cover are also important (McLellan 1990). However, they are generally selected with nearby foraging habitats (Milakovic et al. 2012).

Much of the available information on seasonal grizzly bear habitat selection and diet comes from the interior mountains and coastal regions of western North America (e.g., Hamilton 1978, McCormick 1999, McLellan and Hovey 2001, Ciarniello et al. 2007, Maraj 2007, Nielsen et al. 2010, Milakovic et al. 2012, McClelland et al. 2020). However, the ecological characteristics of these populations may differ substantially from that of grizzly bears in northern Yukon. At a finer spatial scale, grizzly bear ecology within the RSA differs from grizzly bears elsewhere in northern Yukon, such as the Yukon North Slope or the nearby Ogilvie and Richardson Mountains (Pongracz and Suitor, pers. comm., 2022), but very little information exists about grizzly bears within the RSA. Literature and traditional knowledge from similar ecosystems in northern Yukon have been summarized to the extent possible, including the Taiga Cordillera and adjacent Taiga Plains Ecozones. When information specific to the region was unavailable, literature from other parts of the Yukon or western North America was consulted.

4.4.1 SEASONAL DIET

Grizzly bears have broad omnivorous diets, including plants, fish, terrestrial wildlife, and insects (MacHutchon and Wellwood 2003, Ciarniello and River 2018). Grizzly bear diets differ among regions due to variations in food availability across local climates (Mowat and Heard 2006, McLellan 2011, Coogan et al. 2014). Individual grizzly bear diets are also highly variable and dependent on seasonal and annual availability of food items within their home ranges (MacHutchon and Wellwood 2003, McClelland et al. 2020).

Seasonal grizzly bear diets generally reflect the phenological progression of key food resources such as herbaceous plants, ungulate calves, berries, and fish (Hamer and Herrero 1987, MacHutchon and Wellwood 2003, McClelland et al. 2020). Vegetation is a major component of grizzly bear diet in northern Yukon; for example, vegetation comprised more than 30% of grizzly bear diet in the Richardson Mountains (Koizumi 2012). During spring, important plant foods for grizzly bears in the Taiga Cordillera include the roots of alpine hedysarum (*Hedysarum alpinum*), sedges (*Carex* spp.), grasses, horsetail (*Equisetum spp.),* and berries leftover from winter such as kinnikinnik (*Arctostaphalos uva-ursi*), bearberry (*Arctostaphalos rubra* or *A. alpina*), and crowberry (MacHutchon 2000, MacHutchon and Wellwood 2003). In summer and early fall, grizzly bear diet in northern Yukon includes a variety of berries such as blueberry (*Vaccinium uliginosum*), soapberry (*Shepherdia canadensis*), crowberry, bearberry, kinnikinnik, cranberry (*Vaccinium vitis-idaea*), and cloudberry (MacHutchon 2000, MacHutchon and Wellwood 2003). When berries are unavailable, grizzly bears may forage on herbaceous vegetation such as sedges, grasses, and horsetails. As berry availability declines in late fall, grizzly bears may dig for alpine hedysarum more frequently (MacHutchon and Wellwood 2003).

In northern Yukon, grizzly bear diets incorporate a relatively high proportion of terrestrial wildlife, comprising up to 70% of their diet (Mowat and Heard 2006, Koizumi 2012). Mammals are likely an important food source throughout the spring, summer, and fall whenever they are available, including caribou (*Rangifer tarandus*), moose (*Alces alces*), arctic ground squirrels (*Spermophilus parryii*), and small rodents (MacHutchon 2000, MacHutchon and Wellwood 2003, Koizumi 2012). Arctic ground squirrels are an important food source, and grizzly bears may spend increasing effort pursuing them as berry availability declines in late fall (MacHutchon and Wellwood 2003). Arctic ground squirrels tend to select slopes with well-drained soils and avoid wet, flat, or hummocky terrain (Barker and Derocher 2010), which characterizes much of the RSA. Thus, grizzly bears with home ranges that overlap the RSA may rely heavily on other food sources (e.g., alpine hedysarum or ungulates). Traditional knowledge suggests that bears may travel to the nearby Richardson Mountains to forage on ground squirrels in fall (Benson 2014).

Ungulates may be a particularly important food source in spring, when grizzly bears in northern Yukon and Alaska prey on caribou and moose calves (Boertje et al. 1988, MacHutchon 2000, MacHutchon and Wellwood 2003). Barren-ground caribou (*Rangifer tarandus groenlandicus*) are a focal food source for grizzly bears in northern Yukon during caribou calving and seasonal migration periods (MacHutchon and Wellwood 2003). Grizzly bears may follow caribou as they migrate to and from their calving grounds (Reynolds and Garner 1987, Benson 2014), targeting calves or opportunistically preying on adults (MacHutchon and Wellwood 2003). Northern grizzly bear populations that prey on caribou during calving or migration have higher reproductive rates and population densities than those that do not overlap caribou range (Reynolds and Garner 1987). Grizzly bear diet has not been studied within the RSA, and there is no scientific data on the relative importance of caribou as a food source. However, the Porcupine caribou herd migrates through the RSA en route to calving grounds on the arctic coastal plain and again during their return to winter range in the Richardson and Ogilvie mountains (Russell et al. 1993, Ryder et al. 2007). Grizzly bears within the RSA likely use caribou during spring and fall migration.

Salmon, trout, and char are important seasonal foods for grizzly bears (Mowat and Heard 2006, Adams et al. 2017). During fall, grizzly bears congregate at the Fishing Branch River in Ni'iinlii Njik Territorial Park to feed on chum salmon (*Oncorhynchus keta*) (Vuntut Gwitchin Government and Environment Yukon 2010). Grizzly bears on the north slope are also known to feed on Dolly Varden trout (*Salvelinus malma*) (MacHutchon and Wellwood 2003). Baseline fish inventories for the Project found that salmon and trout were absent within the

RSA (EDI Environmental Dynamics Inc. 2022a). Arctic grayling (*Thymallus arcticus*) were the most common fish species, although longnose sucker (*Catostomus catostomus*) and round whitefish (*Prosopium cylindraceum*) were also present. Grizzly bear in the Richardson Mountains have been observed feeding on arctic grayling (Benson 2014), and whitefish and sucker are known food sources in the central Canadian arctic (Gau et al. 2002, Barker 2011).

4.4.2 FORAGING HABITAT

The availability, abundance, and distribution of important grizzly bear forage directly influence grizzly bear abundance and distribution during the growing season (McLoughlin et al. 2002a, Nielsen et al. 2017, McClelland et al. 2020). Grizzly bear populations in the subarctic and arctic are generally considered limited by food (McLoughlin et al. 2002a). Grizzly bears may balance the selection of high-quality food patches with avoidance of landscape features associated with high mortality risk, such as areas with dense human developments and roads (Nielsen et al. 2010, Proctor et al. 2017). However, given the relatively low harvest rates and low levels of human development in the RSA, it is likely that grizzly bear habitat selection is driven by food availability.

The literature on grizzly bear foraging habitat selection in the mountains, boreal forest, and coastal regions of western North America is extensive (e.g., Hamilton 1978, McCormick 1999, McLellan and Hovey 2001, Ciarniello et al. 2007, Maraj 2007, Nielsen et al. 2010, Milakovic et al. 2012, McClelland et al. 2020), but far less is known about habitat use in northern ecosystems. Studies in northern Yukon, Alaska, and NWT have focused mainly on arctic barren-ground grizzly bears (Phillips 1987, MacHutchon 1996, Gau 1998, McLoughlin et al. 2002a, Barker 2011), leaving a substantial knowledge gap about grizzly bear ecology in the Taiga Cordillera (particularly non-mountainous areas such as the Eagle Plains Ecoregion).

Grizzly bear distribution was clumped in the Richardson Mountains rather than uniform; bear densities were comparatively high in habitats with abundant food such as riparian valleys and low in flat tundra plains (Clarkson et al. 1993). Local traditional knowledge suggests that mountains are better grizzly bear habitat than taiga or barren-ground plains due to the abundance of berries and ground squirrels, and the earlier snowmelt on windblown and south-facing slopes in spring (Benson 2014). Grizzly bears in northern Yukon have large home range sizes (up to 1,250 km^2) and travel long distances to reach suitable foraging habitat (MacHutchon 2000). Thus, grizzly bears in the RSA may travel to the Richardson or Ogilvie Mountains for seasonal forage. This is consistent with the knowledge that grizzly bears have low densities in the RSA, and their behaviour is characterized by seasonal movements through the area (Pongracz and Suitor, pers. comm., 2022).

In the central Canadian arctic, barren-ground grizzly bears selected eskers, shrubby riparian zones, and tussock tundra throughout the spring, summer, and fall, corresponding with the spatial and temporal availability of food (Phillips 1987, McLoughlin et al. 2002a). Esker slopes support a relatively high abundance of berry-producing shrubs and arctic ground squirrels (Gau 1998, Barker and Derocher 2010, Barker 2011), whereas riparian zones and tussock tundra may provide herbaceous forage such as horsetails, sedges, and cotton grasses (*Eriophorum* spp.) (Gau 1998, Gau et al. 2002). Barren-ground grizzly bears also selected habitat with abundant lichen, which may attract caribou (McLoughlin et al. 2002a). During the Porcupine caribou migration on the Yukon north slope, grizzly bears travelled along river channels or selected hillsides with long sight-lines, presumably to increase their chances of detecting caribou (MacHutchon 2001).

4.4.3 COVER (SECURITY AND THERMAL HABITAT)

Security habitat includes areas of dense vegetation that provide visual screening from other grizzly bears or humans (Mace and Waller 1997). Security cover may be particularly important for sub-adult male bears and sows with cubs to avoid adult males defending their territories or killing cubs to bring females into estrus (LeFranc et al. 1987, McLellan 2005). Female grizzly bears may select lower-quality foraging habitat if it provides high security values or spatial separation from potentially aggressive male bears (Pearson 1975, McLellan and Shackleton 1988). For example, female grizzly bears in the arctic are thought to occupy the Mackenzie Delta to avoid male bears in adjacent mountain ranges (Benson 2014).

Thermal cover includes habitat that provides relief from the elements, such as solar exposure or extreme weather. Cover from heat and solar exposure is provided by various habitats such as open water (e.g., rivers, streams, lakes), permanent snow patches, steep north aspects, and mature forest patches with high canopy closure (Pearson 1975, LeFranc et al. 1987). Grizzly bears may also select forests with high canopy closure for day beds to seek shelter from heavy rains (Pearson 1975, Munro et al. 2006). The importance of thermal cover for grizzly bears in the Taiga Cordillera has not been studied.

4.4.4 WINTER DENNING HABITAT

Grizzly bears in northern Yukon hibernate in winter from approximately October to May (Nagy et al. 1983, MacHutchon 2000), although the timing for den entry and emergence depends on annual weather patterns. Grizzly bears will enter their dens as late as mid-November and emerge as early as March if the weather is warm (Benson 2014).

No records exist of grizzly bears dens within the RSA, although grizzly bears are known to den in the mountains of Ni’iinli Njik (Fishing Branch) Territorial Park, approximately 20 km west of the RSA (Pongracz and Suitor, pers. comm., 2022). Grizzly bears in the arctic and subarctic typically excavate their dens in locations with suitable soil, such as sand, gravel, or glacier-deposited rock (MacHutchon 2000, Smereka et al. 2017). Grizzly bears in Vuntut National Park in northern Yukon preferentially select den sites in the mountainous regions of the park and avoid denning in Old Crow Flats, which is characterized by flat topography, large wetland complexes, and spruce forests (MacHutchon 2000). Denning within Old Crow Flats is likely limited to dry, steep riverbank slopes (MacHutchon 2000). Grizzly bears throughout the Gwitch’in Settlement Area are known to prefer denning in the mountains; however, in areas with flat topography (such as the RSA), grizzly bears will select small topographical features such as hills, steep riparian banks, or lakesides to excavate their dens (Benson 2014). Grizzly bears in northern Yukon have large home ranges (Section 4.5.5) and may travel long distances to reach winter den sites (up to 65 km; Craighead 1976). Thus, some grizzly bears with home ranges overlapping the RSA may travel to nearby mountain ranges (Richardson Mountains, Ogilvie Mountains, or Ni’iinli Njik Territorial Park) to hibernate.

In arctic barren-ground ecosystems, grizzly bears select river banks, lakesides, or eskers with silty or sandy soil for denning (Harding 1976, Mueller 1995) and avoid open spruce forest (Smereka et al. 2017). Grizzly bears prefer to excavate their dens on steep south-facing slopes with abundant shrub cover in the arctic (Mueller 1995, McLoughlin et al. 2002b) and the boreal forest of southern Yukon (Libal et al. 2012). The root structures of tall shrubs such as willow (*Salix* spp) and dwarf birch (*Betula glandulosa*) may provide support to the ceilings of excavated grizzly bear dens (McLoughlin et al. 2002b).

4.4.5 HOME RANGE AND SEASONAL MOVEMENTS

Grizzly bear home range sizes are variable and have an inverse relationship with food availability (Nagy and Haroldson 1990, McLoughlin et al. 2000). Thus, grizzly bear home ranges in productive coastal or interior mountain habitats of BC are typically smaller and have greater overlap than those in less productive boreal, taiga, or arctic barren-ground ecosystems (McLoughlin et al. 2000, Edwards et al. 2009, Hamilton et al. 2018). Additionally, the size of individual home ranges may vary annually in response to fluctuations in the quality and abundance of food (McLoughlin et al. 2000). The largest recorded grizzly bear home range sizes in North America were in the central Canadian Arctic, where mean home range sizes for female and male bears were 2,100 km² and 7,245 km², respectively (McLoughlin et al. 2003).

No data on grizzly bear home range sizes within the RSA are available, but studies conducted in other parts of the Taiga Cordillera provide some insight. Grizzly bear home range sizes in the Old Crow flats of Vuntut National Park were estimated at 650 – 750 km² for females and 1,150 – 1,250 km² for males (MacHutchon 2000). In the Richardson Mountains north of the RSA, female grizzly bears had mean annual home ranges of 442 km² and males had home ranges of 760 km² (Koizumi 2012). The smaller home ranges in the Richardson Mountains may be attributed to more food resources, such as berries and ground squirrels relative to the taiga plains (Benson 2014).

Grizzly bears have low fidelity to home ranges in unproductive arctic ecosystems, where food distribution is spatially and temporally heterogenous, and grizzly bear population densities are low (Edwards et al. 2009). Under these conditions, it is beneficial for grizzly bears to adjust the size and location of their home ranges to maximize forage availability. For example, in northern Yukon and Alaska, grizzly bears may travel long distances to follow the seasonal migration of barren-ground caribou (Reynolds and Garner 1987, MacHutchon 2001). Grizzly bears in northern Yukon are also thought to travel long distances to find suitable winter denning habitat in the mountains (Benson 2014).

4.5 SUMMARY

Available data suggest that a low density of grizzly bears are distributed throughout the RSA. Rates of recorded harvest mortality are low within the Eagle Plains BMU, but other sources of mortality are largely unknown and unrecorded. Grizzly bear diet in the RSA and surrounding region predominantly consists of vegetation (berries, roots, and herbaceous plants) and terrestrial wildlife, including caribou, moose, and arctic ground squirrels. Grizzly bears may rely heavily on caribou (particularly calves) during the seasonal migration of the Porcupine caribou herd through the region. Habitat quality in the RSA is generally poor compared to the adjacent mountain ranges, where berries and ground squirrels are more abundant. Lastly, grizzly bears in the RSA may excavate their winter dens in riverbanks, lakesides, and hills where suitable soil can be found, or they may travel to nearby mountain ranges to den on steep south-facing slopes. Most of the information presented in this review was based on scientific studies.

5 MOOSE

5.1 PURPOSE AND OBJECTIVES

Moose (*Alces alces*) were selected as a VC for the Project due to their importance as a managed game species, and their cultural values to First Nations living in the Yukon. Winter, and especially the late winter season, is often a difficult time for moose due to the limited availability of forage and increased energetic demands to move through crusted or deep snow. A winter habitat suitability map was developed for moose in the RSA to identify high-suitability winter forage habitat areas. The map quantifies the winter forage habitat in each habitat class (high, moderate, low/nil/very low) within the RSA.

This section summarizes information and data on moose use and ecology in the subarctic taiga that was used to develop habitat suitability mapping to quantify the suitability, amount, and distribution of potential habitat for moose in the RSA.

5.2 GENERAL HABITAT ECOLOGY OF MOOSE

5.2.1 EXISTING INFORMATION

There is limited knowledge of moose within the RSA. In 2001, Anderson Resources Ltd submitted a project application and a mitigation plan for an Eagle Plains 2001–2003 Seismic Survey Program (Access Consulting Group and EBA Engineering Consultants Ltd. 2001). This report describes moose knowledge of the area as being limited and incidental. The authors reviewed the existing data and had discussions with local wildlife biologists and other resource users about winter usage patterns by moose in the general vicinity of the Eagle Plains project area. At that time, moose were only superficially studied in the Eagle Plains Area (Access Consulting Group and EBA Engineering Consultants Ltd. 2001).

The 2001 project application report stated that an approximate moose density of about 0.05 moose/km² was estimated for the project area based on general habitat assessment. The application also provided the following information:

> "*Within the project area, moose are not commercially exploited and there are no outfitting concessions. There is limited off-road access and the moose population density within the project area is known to be low, hence the subsistence harvest is minor. YTG Renewable Resources harvest data show that, in the last twenty years, only 13 moose have been harvested in the Dempster Corridor subzones (Game Management Zone 1-55 and 1-56).*
>
> *Anderson conducted a post-rut moose survey in early November of 2000, to augment the currently very limited knowledge regarding moose populations in the project area. The survey was conducted to provide baseline information on the level of range usage by moose within the project area. During the course of the 2-day survey, 30 moose were observed and an additional 64 sets of tracks were encountered. In general, moose were more frequently associated with the higher elevations (between 400 m and 700 m above sea level), but were widely dispersed throughout all of project*

> *area's drainages. From the survey results, an overall population of approximately 60-90 moose was estimated (Access Consulting Group and EBA Engineering Consultants Ltd. 2001).*"

These observations of greater moose abundance at higher elevations are consistent with observations from VGFN elders around the same time (Sherry and Vuntut Gwitchin First Nation 1999, p. 7). They discussed that Eagle Plains was an important moose range, but that some animal populations had changed their land use after the Dempster highway was built and there was low density near the highway (Sherry and Vuntut Gwitchin First Nation 1999, p. 287, 299).

In 2001, an aerial survey was completed from June 18–22 within the 2001 project area. During that survey, 19 moose were incidentally observed, with most observations noted in the South Eagle River and Dalglish Creek area. A general point of interest was that moose calving was expected in several drainages, but was particularly noteworthy in the South Eagle River (Access Consulting Group and EBA Engineering Consultants Ltd. 2001).

In 2013 Environment Yukon conducted an 'Eagle Plains Mammal Occupancy Aerial Survey' from March 19 to March 24, 2013 (Environment Yukon, unpublished data). The survey aimed to assess the occurrence and distribution of large mammals within the broader Eagle Plains Ecoregion. Over the 6 survey days, 64 moose were observed, including cow and calf observations. The data indicated that moose were widely distributed within the Eagle Plains area, but the area was not comprehensively surveyed, and formal analyses/reporting were not included with the data.

From October 2014 through August 2016, Yukon Environment deployed 37 (2014) to 48 (2015) pairs of remote cameras in the Eagle Plains area (Burden 2016). The objective was to assess the use of linear features by medium to large mammals (wolves, caribou, and moose) by comparing the use of wildlife on and off seismic lines by placing cameras at random locations on seismic lines, and camera locations off seismic lines. The report is a data summary with no statistical analysis, and the results are non-standardized (e.g., lacking a catch per unit effort reporting metric). Regardless, there was some information collected for moose relevant to this study. Over the two years of study, moose encounters were infrequent and varied slightly among years (0.33 moose/100 camera days in 2014–2015, 0.43 moose/100 camera days in 2015–2016). Moose were found in the study area throughout the year but were observed more often from May through November (spring through fall). No statistical analyses or apparent trends were used to determine moose associations with linear disturbances.

EDI did not complete other population or distribution surveys for moose as part of the current baseline studies. Efforts focused on developing a winter habitat model to quantify habitat suitability, amount, and distribution across the RSA.

5.2.2 HABITAT ECOLOGY OF MOOSE

Moose are one of the most widely distributed ungulates and range from the Arctic coasts of North America, Europe, and Asia down to the southern limits of the boreal forest and farther south where suitable montane biomes are located exist. In the Yukon, moose densities generally range between 100 and 250 moose for every 1,000 km^2 of suitable moose habitat (Environment Yukon 2016b). The Regional Biologist has indicated that, based on his observations, moose densities in Eagle Plains are relatively low compared to some parts of the southern Yukon, but that moose densities in Eagle Plains are high compared to other parts of North Yukon (Mike Suitor, pers comm).

Moose make seasonal movements to various habitats such as calving, summer, rutting, and winter habitats. These seasonal movements may range from a few to many kilometres (Clarke et al. 2017, Government of Yukon 2022). Changing environmental conditions can affect the quality, quantity, distribution, and accessibility of cover and forage over a landscape. Key habitat requirements are rarely distributed evenly over space or time, so moose move to access various resources as availability changes. Periodic disturbances, such as wildfire and vegetation clearing change the abundance and availability of moose cover and forage. Moose are generally not evenly distributed across the landscape; they concentrate in particular habitats offering higher forage opportunities(Government of Yukon 2022). Moose with access to large quantities of forage are known to travel less than those in areas where forage is less abundant (McCulley et al. 2017). There is a wide variation in home range sizes for moose across the boreal forest and between seasons (Phillips et al. 1973, Addison et al. 1980, Clarke et al. 2017, McCulley et al. 2017). Moose that frequent the Old Crow Flats wetland complexes in northern Yukon are known to spend summer months within this area and then migrate 250 km to spend the winter within the Alaska Arctic National Wildlife Refuge (McCulley et al. 2017).

Moose habitat selection patterns vary among populations, individuals, seasons, and sexes (Clarke et al. 2017, McLeod and Clarke 2017). Furthermore, habitat use by moose can differ depending on the type of land cover and the availability of resources in a particular area. In northern Yukon, moose appear to frequent narrow strips of forest along the rivers (Photo 5-1), and VGFN elders have observed good moose habitat just south of the RSA along the Blackstone and Ogilvie rivers and the wetlands of the Blackstone Uplands (Sherry and Vuntut Gwitchin First Nation 1999, p. 303). In the south, moose frequent the treeline in the subalpine shrub zone. Moose in the Yukon also tend to concentrate in recent burns and along waterways with interconnecting ponds, marshes and meandering streams (Government of Yukon 2022).

Moose inhabit numerous stand-cover types and structural stages. Conifer stands are generally used primarily as cover to moderate extremes of cold, wind, heat, deep snow, and security from predators (Timmermann and McNicol 1988, McCulley et al. 2017). Early seral areas are usually shrub-dominated and used by moose because shrub species comprise more than 60% of a moose's annual diet (Renecker and Schwartz 2007). During the spring and summer, moose forage primarily on the leaves of woody plants, aquatic plants, and forbs. During winter, the diet shifts to highly lignified woody stems, resulting in higher ruminating times (Renecker and Hudson 1986). Plant form and twig diameter have also been shown to affect digestion rates, influencing moose winter foraging (Vivas et al. 1991). Some preferred moose forage species include:

- Willows (*Salix* spp.)
- Red-osier dogwood (*Cornus sericea*)
- Saskatoon serviceberry (*Amelanchier alnifolia*)
- Highbush cranberry (*Viburnum edule*)
- Mountain ash (*Sorbus sitchensis*)
- Scrub birch (*Betula glandulosa / nana*)

- Trembling aspen (*Populus tremuloides*)
- Lodgepole pine (*Pinus contorta*)
- Paper birch (*Betula papyrifera*)

These browse species may be used preferentially due to their height and growth form (Baker 1990, Van Ballenberghe et al. 1989). The palatability of shrub species can also vary from region to region. Soopolallie (*Shepherdia canadensis*) was recorded as an important forage species for moose on the Kenai Peninsula, Alaska (Edwards 1940) but appears to be unpalatable in other parts of the boreal forest (Rolley and Keith 1980). In northeast Alberta, the preferred browse species was Saskatoon serviceberry; even in areas where it was uncommon, the species was still heavily used when it was present (Nowlin 1978). In the Peace-Athabasca Delta, moose feed primarily on willow, red-osier dogwood, paper birch and balsam poplar. In one study done in the taiga region ranging from northwestern Manitoba to Great Slave Lake NWT, winter moose diet was mainly composed of *Betula papyrifera* bark (Thomas 1990). Risenhoover (1989) found that willows accounted for more than 94% of the winter moose diet in Denali National Park and Preserve.

Within the RSA, willows and scrub birch are the dominant browse species available for moose. Willows often form the predominant diet in other northern areas. Willows are well adapted to wetter soils and are commonly found in wetland and riparian habitats (Photo 5-2). Willows are also an early successional species and are often abundant in early seral habitats resulting from forest fires and human-disturbed areas (e.g., seismic lines, cutblocks, and road rights-of-way). Moose have been reported selecting previously burned habitats and areas within 100 m of streams and waterbodies, presumably due to the abundant forage (Wasser et al. 2011). In habitats with low availability of twigs and leaves, moose sometimes use a foraging technique called 'bark-stripping' where long, linear strips of bark are peeled from certain trees, such as aspen (LeResche and Davis 1973, Miquelle and Van Ballenberghe 1989). However, the bark is usually a relatively small component of moose diets (Miquelle and Van Ballenberghe 1989). It is unlikely to be a significant food source in Eagle Plains due to the dominance of spruce, whose bark is non-palatable.

Across Canada, heavily used areas by moose include wetlands, floodplains of major rivers, riparian areas, regenerating cut blocks and burns, and avalanche chutes. Their preferred habitat types include recent burns, logged areas, lake and river shores, willow and alder swamps and other wetland areas MacCracken et al. 1997). Food (including forage quality) and climate are considered important aspects of habitat for moose (Franzmann 1981). Analyses of moose range commonly stress the abundance, production, and use of woody shrubs as important characteristics when describing moose habitat requirements (LeResche and Davis 1973; Jung et al. 2009).

In Labrador, moose can be observed more often in riparian areas and hardwood stands and less often in string bogs, open conifer-lichen stands, barren hilltops than expected based on the availability of those habitat types during the winter (Jung et al. 2009). Riparian areas are often high suitability habitats for moose in winter due to the availability of high-quality forage species such as willows. Willows and birch found within the riparian shrub communities are often adjacent to a strip of closed-canopy conifer-dominated forest that provides thermal cover and snow interception. The combination of shrub communities and closed-canopy mature riparian forests offer a highly suitable habitat mosaic for moose (Jung et al. 2009).

During the winter, moose are influenced by snow depth, snow density and hardness. Moose movements begin to be impeded at snow depths of 70 cm, and moose strongly avoid areas with >100 cm of snow. Moose generally winter in areas where snow depths are less than 70 cm (Coady 1974, Franzmann 1981). In mountainous areas, where snow accumulation can vary substantially, this can result in strong patterns of seasonal range use, with moose avoiding mid an upper elevation where snow accumulation is higher. For example, in the Pelly-Macmillan River area (Central Yukon), moose concentrated along the major river valleys during late winter, where the combination of shallower snow under mature forest canopies and dense willows in wetland areas provided moose with optimal habitat (O'Donoghue 2005). However, snow is not expected to strongly influence the distribution or habitat selection in the RSA in most years. This is due to the relatively modest elevation range within the RSA. The average maximum snow depths of approximately 80 cm are just on the edge of the range that moose avoid (EDI Environmental Dynamics Inc. 2021). Over much of the winter, snow depths are less than 70 cm.

Predation is recognized as a major factor affecting the dynamic of moose populations (Gasaway et al. 1992, Ballard and Van Ballenberghe 2007). In general, prey species select security habitats at multiple scales based on various factors that can affect their perceived predation risk. Perceived security is also a dynamic factor that varies over time and is dependent on the density and behaviour of predators, including humans. Moose population growth and density in Yukon are thought to be limited by wolves (Hayes et al. 2003). Consequently, moose may avoid habitats that increase the potential for wolf encounters. However, predator avoidance may be a more prominent factor in habitat selection at the landscape scale than within a home range (Dussault et al. 2005). Habitat types with taller and denser vegetation likely provide some protection from wolves during winter. Habitat types that provide cover from predators may also contain taller trees that intercept snow, reducing snow depth and reducing the energy required to move.

At a minimum, security habitat should conceal a moose from predators. It can be assumed the security habitat for moose can be provided by any forest stand of adequate density with trees and shrubs taller than 2 m. Security cover for moose is most critical during spring calving when cow moose seek out islands and gravel bars on river floodplains for calving. At calving time, cow moose and calves can find secure habitat in dense deciduous or mixedwood stands, or tall shrubs with canopy cover >50% (MacCracken et al. 1997). During winter, deep, and persistent snow has been shown to have a greater impact on the physical condition of moose and thus increasing its risk of predation. Within one study (Dickie et al. 2020), moose seem to select riparian areas to facilitate movement instead of selecting them only for foraging opportunities. In the RSA, most wildlife trails were observed adjacent to riparian areas.

Photo 5-1. A moose observed adjacent to a narrow treed riparian area in the RSA (Photo provided by Palmer Environmental 2019).

Photo 5-2. Shrubby riparian area, on the edge of a burn, where willows have been browsed by moose.

5.2.3 DISTURBANCE

5.2.3.1 Fire

Burns are often a major factor affecting the distribution and abundance of moose across the boreal forest, with densities peaking 20 to 25 years after fire (LeResche 1974). Studies have shown that moose populations are often denser in burned areas where browse is of higher quality and greater abundance than adjacent, unburned areas (Gasaway et al. 1989). Moose have been reported selecting previously burned habitats that are 10–30 years old (Maier et al. 2005) and less than 40 years old (Wasser et al. 2011). Overall, fire creates favourable forage conditions for moose when regenerating shrubs are available for browse.

Several large wildfires have affected the RSA, occurring between 1959 and 2018. Areas that were affected by fire, and are still regenerating, were labelled with a fire disturbance code in the ELC vegetation maps. For older burn areas, the adjacent non-burned area was compared to the burn area to see if there was a noticeable difference in vegetation. Areas that did not have a noticeable difference were not characterized as fire disturbed as they were considered regenerated. The appropriate structural stage was assigned to reflect the stage of regeneration.

The post-fire successional pathways for many of the ecosystem units in the RSA were the same or very similar, making the differentiation of ecosystem units based on revegetation difficult. For example, almost all ecosystem units regenerate initially with deciduous shrubs (willow and scrub birch) and a mix of spruce and deciduous trees (primarily paper birch), and, as succession progresses, the prominence of spruce increases and deciduous shrubs and trees decreases. Often the post-fire succession also varied within an ecosystem unit depending on several factors, including the number and frequency of fires, the intensity of the fire, and the amount of permafrost present before and after the fire. Field observations suggest that hot fires likely melted a larger portion of the permafrost, permanently altering the moisture regime of the affected area; therefore, site moisture regimes are altered, and some sites do not return to the same ecosystem unit that had been established before the fire. From a moose habitat perspective, the result is that, except for some ecosystem units in riparian areas, the abundance of browse species is affected more by regeneration status and structural stage than ecosystem unit type.

The current structural stage for some of the more recent fire-disturbed areas was difficult to determine due to the range in age and variety of the imagery. To be consistent, the mappers assigned a shrub structural stage to all fire disturbed areas unless there was strong evidence suggestion another structural stage (i.e., a plot stating it was graminoid dominant, Photo 5-3).

Photo 5-3. **Recent burn in a graminoid structural stage. Generally, regenerating shrubs become available as browse to moose about 10 years after fire disturbance.**

5.2.3.2 Linear Features

Linear features are the primary type of anthropogenic disturbance in the Project area. However, there are many uncertainties regarding the extent, impacts, and recovery status of linear features in the area. Linear features include narrow, linear clearings on the landscape, typically used for transportation and seismic exploration activities. The Project area has numerous 2D seismic lines (e.g., Photo 5-4) and winter roads from previous exploration activities dating back to the 1960s. The majority of 2D exploration occurred between 1961 and 1984. Some 2D exploration occurred in 2001 that incorporated LIS techniques (Access Consulting Group and EBA Engineering Consultants Ltd. 2001, GEOTIR 2014). More recently, approximately 2,200 km of 3D low-impact seismic (LIS) exploration was conducted in a 325 km² area between November 2013 and April 2014 (GEOTIR 2014). This 3D exploration grid is near the centre of the Project area, spanning north and south of the Dempster Highway.

Linear features can affect predation risk on moose. Facilitated predation operates by increasing the spatiotemporal overlap and interactions between wolves and prey species (Serrouya et al. 2016, Dickie et al. 2020). The magnitude and extent of such overlap are dependent on the extent and use of linear features across the contiguous woodland habitat. Linear features may enhance predation rates by increasing predator abundance via travel corridors and, ultimately, by optimizing hunting efficiency (Serrouya et al. 2016, Dickie et al. 2017, DeMars and Boutin 2018). The degree to which facilitated predation operates and affects prey species is context dependent. The primary features possibly associated with facilitated predation in the Project area are winter roads/trails, 2D and 3D seismic lines, and the Dempster Highway. In winter, clearing and compaction of snow on linear features by plowing or snowmobiles can elevate predator movements (Keim et al. 2019b), further exacerbating predation risk.

The Dempster Highway runs roughly southwest to northeast through the southern half of the RSA. The RSA includes numerous winter roads (15 m average width) from previous exploration activities dating back to the 1960s. The Project will be accessed via existing and new winter roads. Moose have been shown to avoid human development and activity, but response varies by season, sex, and population. Reduced use by moose has been documented near roads (Rolley and Keith 1980).

Moose use of seismic lines is variable. In a study completed in northern Alberta by Dickie et al. (2020), moose selected to be closer to riparian areas and avoided being closer to linear features. Another study demonstrated that seismic lines could increase encounter rates between prey and predator by facilitating predator movement (McKenzie et al. 2012). Moose, wolves and even people tend to move faster on linear features since these features create a path with less visual and physical resistance to movement but in some cases the ease of movement can increase the risk of prey species encountering a predator. Dickie et al. (2020) noted that moose had tendency to move faster while on linear features which could support the theory that moose perceive LFs as a risk to wolf encounters.

Many uncertainties surrounding the ecological impacts and recovery potentials for linear features, particularly of 2D and 3D seismic lines, in the taiga ecosystem that characterizes Eagle Plains. EDI completed a linear feature study. The purpose of that study was to systematically describe and quantify the current conditions of linear features across the RSA by providing a baseline inventory and assessing the successional and functional status of linear features. Six types of successional pathways were defined on linear features in the Eagle Plains area (Table 5-1; after Simpson 2008).

Most sites surveyed (79%) were undergoing normal succession, and that vegetation was either in a low shrub (56.1%) or tall shrub (29.0%) structural stage along the linear features sampled. Almost all 3D plots were at a low shrub structural stage (67% less than 1 m), while 2D plots and winter roads were distributed more evenly through low shrub, tall shrub, and forested structural stages (21% greater than 4 m and 5% greater than 8 m). The analyses suggested that 2D seismic lines regenerate to a more shrub-dominated community relative to pre-disturbance conditions, 3D seismic lines had lower woody cover than off-line plots after five years of regeneration, and fire has the potential to increase shrub and tree growth on linear disturbances. Sightlines along linear features decreased substantially as the height of vegetation increased, and ease of travel along linear features decreased with the amount of woody cover. Fire played an important role in shaping functional recovery by increasing the amount of woody cover and the structural stage of vegetation.

Under normal succession, 2D seismic lines had 12% to 19% greater mean shrub cover than the corresponding off-line sites in burnt and unburnt conditions, respectively. In unburnt conditions, 2D seismic lines had considerably shorter and sparser trees than paired off-line plots, but in burnt conditions, the 2D lines showed denser trees. Burn status appeared to influence some successional classes. Magnified succession was more common at burnt sites (19 burnt versus 5 unburnt), while stagnated succession was more common at unburnt sites (3 burnt versus 7 unburnt). Sites on a normal successional trajectory did not appear to have any relationship to burnt status, while other successional classes were too uncommon to draw any conclusions.

Studies focusing on the use of linear features by moose are limited. However, Keim et al. (2019a) found that moose used 3D seismic lines the least and used well-defined 2D seismic lines and pipelines the most.

Photo 5-4. Example of a low shrub 2D seismic line within the RSA.

Table 5-1. Descriptions of successional classes documented in the RSA (Simpson 2008).

Successional Class	Description
Normal succession	Similar to adjacent forest, but at an earlier seral stage. E.g., young trees that may be surrounded by early successional shrub and forb or graminoid species. Disturbance is likely only the removal of trees and shrubs, with little to no disturbance to soil or permafrost.
Magnified succession	Increased moisture and nutrient availability due to soil disturbance. Often new seral species due to removal of original trees and shrubs. Resulting vegetation is likely shrub or deciduous tree dominant, typically with more productive growth than adjacent sites. Disturbance is likely the removal of trees and shrubs, with significant disturbance to soil or permafrost.
Retrogressive succession	Removal of insulating peat layer causes a change in the soil thermal regime. Active permafrost layer depth increases, releasing water content. Resulting habitat is likely moss, graminoid, forb, or low shrub dominated, with high moisture content. Disturbance includes the complete removal of trees and shrubs, and soil or active permafrost layer.
Successional stagnation	Suspension of succession at herb or low shrub stage. Likely dominated by graminoids; area may have been seeded. Check line age to differentiate from normal succession. Disturbance to soil or permafrost is likely. Ground may have been compacted.
No succession	No ecological differences except that the forest opening is linear instead of random. Disturbance is likely only the removal of trees and shrubs, with little to no disturbance to soil or permafrost.
Recent disturbance	Newer seismic line where successional patterns cannot yet be determined. Line age was checked to differentiate from other successional patterns.

5.2.4 HABITAT SUMMARY

The late winter season is often a difficult time for moose due to the limited availability of forage and increased energetic demands to move through crusted or deep snow. A winter habitat suitability map was developed for moose in the RSA to identify high-suitability winter forage habitat areas. Moose select winter habitat based on three criteria: food availability, snow conditions, and predator avoidance (Dussault et al. 2005). Within the RSA, moose primarily select winter habitat based on browse availability.

The development of the moose habitat model will focus on the following key points:

- Habitat use is believed to be driven by forage availability.
- Winter is the most limiting season for forage availability.
- Winter forage in the RSA is primarily willow species.
- Areas with high willow cover in the RSA are riparian areas, burn areas and some mesic and moist ecosystem units with moderate willow understory.
- Elevation and snow are not likely a significant factor given the limited topography within the RSA; and
- Linear features like seismic lines and trails may provide small patches with elevated willow cover, but their extent are too small to affect habitat selection.

Willows are the primary winter food for moose and signs of moose browsing were commonly observed in the areas that contain abundant willow during the Project baseline surveys. As willow is an early succession species, the shrub is most abundant in disturbed areas such as burns. Anthropogenic disturbances in the RSA, such as 2D seismic lines, may also have a high willow cover, but the extent of these areas is too small to provide significant forage opportunities to moose. Outside of regenerating areas, the high cover of willows is mainly associated with riparian shrublands along streams and disclimax shrublands within the RSA.

5.2.5 HABITAT SUITABILITY MAPPING

Habitat suitability mapping identifies the current ability of an ecosystem unit to provide certain life requisites for a given wildlife species or provide the environmental conditions needed for cover, food and space. A habitat suitability rating is a value given to each structural stage of each ecosystem unit in a project area. The rating is the suitability value assigned to a habitat for its potential to support a particular species for a specified season and activity. It is often expressed as a percentage of the best habitat. It also reflects the species' expected use of a habitat (Resources Inventory Committee 1999c). Habitat ratings are a product of knowledge and assumptions.

The important role of vegetation is incorporated into any wildlife habitat evaluation. Biophysical factors which are considered to influence wildlife habitats can include vegetation type, slope, aspect, and other geographic features. Since vegetation cover type is an expression of various biophysical conditions such as soil moisture, aspect, and relief, it generally offers a current and valid prediction of habitat for many terrestrial wildlife species, at least at broad scales.

The wildlife habitat evaluation is essentially a modelling process that has two primary requirements:

1. Good knowledge of the habitat needs of a species, and how these habitat needs relate to the described ecosystem units; and
2. A standard approach to establishing wildlife species-habitat relationships and ratings for ecosystem units consistently.

The suitability maps use ecosystem attributes for assigning suitability values to a polygon. Wildlife habitat suitability ratings are a widely applicable method of wildlife habitat assessments. While there are recognized limitations to any habitat evaluation and assessment procedure, suitability ratings using ecosystem unit classification have the following advantages (Resources Inventory Committee 1999c):

1. It is predictive.
2. The methodology is consistent.
3. Large areas can be covered.
4. It is flexible and can be applied to a range of map scales, wildlife species, and general to detailed habitat assessments.
5. It provides strategic planning for habitat management.
6. It ties the wildlife resource to other resource uses (e.g., forestry, recreation, and corridor analyses).

The results of this type of model can provide information on the suitability, amount and distribution of potential moose foraging habitat within the RSA.

5.3 METHODS

The moose habitat suitability model was based on habitat suitability mapping standards and methodology (Resources Inventory Committee 1999c). This methodology is commonly used in habitat assessment. The habitat suitability methodology involves three key steps:

1. Selection of relevant habitat variables to include in the model.
2. Development of rating scores for each habitat variable.
3. Building a relationship among the variables to produce overall habitat suitability scores.

A moose winter forage habitat suitability model was developed based on professional opinion and the availability of suitable datasets. Land cover datasets (vegetation, linear disturbances, and fire history) were considered for the suitability modelling. Other variables were considered but not included in the model. They were assumed to correlate with the vegetation cover types and associated structural stages.

5.3.1 RATING SCHEME

This model uses a categorical rating scheme where each category represents an ordinal measure of habitat suitability. The number of categories used in a rating scheme reflects knowledge of the species' ecology and habitat use (Resources Inventory Committee 1999c). For species like moose, where our understanding of the species and the availability of relevant base environmental data to support habitat modelling is relatively good, 4- and 6-class schemes are typically used. A 6-class system was initially chosen to rank the base habitat units because the 6-class system facilitated finer differentiation of ratings across the numerous habitat types that occur in the RSA (Table 5-2). However, for interpretive purposes, the ratings were generalized into a 4-class system for most model outputs. In the 4-class system, High and Moderately-High were combined into one category (High) and Nil and Very Low were combined into one category (Nil/Very Low).

High and Moderately High suitability habitat provides some of the best winter foraging opportunities for moose within the RSA. Moderate suitability habitat provides some winter foraging opportunities. Low and very low-quality habitat has limited winter foraging opportunities for moose in the RSA. Nil suitability habitat provides no winter foraging opportunities. It is often associated with features without vegetation (e.g., rivers, streams, roads) or with very sparse vegetation cover.

Within the RSA, the highest rated areas included natural shrublands and regenerating burns in riparian areas, as well as small extents of deciduous and mixed-wood ecosystems on mesic and moist sites. Moderate rated areas were predominantly regenerating burns on mesic to wet sites. Low rated sites were mostly undisturbed stands of open, stunted spruce on mesic to wet sites, ranging from tall shrub to old forest structural stages. Differentiating ratings between Moderate and Low areas was often difficult. Many sites, both burned and unburned, had average willow cover less than 15%, with high variation in cover among sites in the same ecosystem units. Generally, 7% willow cover was used as the threshold to differentiate between Moderate and Low sites. This is a relatively low value of willow cover but using a higher threshold would have resulted in large areas of regenerating burn being classified the same (Low) as undisturbed areas. In Eagle Plains, a substantial amount of total winter forage appears to occur within large areas with relatively low willow cover (i.e., the Moderate suitability areas).

Although the vegetation field data confirmed that the amount of shrubby browse (i.e., willow cover) was greater in fire disturbed areas than undisturbed areas, the amount of browse in regenerating burns was not as high as reported in some other studies. For example, the percent cover of willow in burns in the most common ecosystem unit, EU33-Moist Spruce Labrador Tea, was 11% compared to 7% in unburned areas. As a result of this pattern, areas with fire disturbance attributes in the ecosystem mapping database were generally rated one class higher than the same ecosystem unit that was not burned (mostly Moderate for burns and Low for unburned areas).

Table 5-2. Rating scheme used to rate moose habitat suitability.

Rating	Code	HS Score	Description
High	1	95	Suitable. Conditions at optimal. The best foraging opportunities for moose are expected to be found in these areas of the RSA. Willow percent cover is greater than 15%. Includes both disclimax and seral shrublands areas.
Moderately High	2	75	Suitable. Conditions near optimal. Above average foraging opportunities for moose is expected to be found in these areas. Willow percent cover also typically greater than 15% but, on average, less than High.
Moderate	3	50	Suitable. Suitability is lower than optimal conditions but meet minimum requirements from an energy balance perspective. Willow percent cover generally ranges between 7% to 15%.

Rating	Code	HS Score	Description
			Although willow cover is moderate to low in absolute terms, the large extent in this rating category contributes a substantial amount of the total available forage across the RSA.
Low	4	30	Suitability Unknown. Areas in this rating class offer some forage but the amount is so low and dispersed that the energetic return of using these areas are, on average, mostly negative. Willow species present but typically less than 7% cover.
Very Low	5	10	Unsuitable. Willow species presence and cover is usually less than 2%. Moose are expected to strongly avoid these areas.
Nil	6	0	Unsuitable. Willow presence not expected.

5.3.2 SELECTION OF RELEVANT HABITAT VARIABLES

Potentially relevant foraging habitat variables were identified from published literature, other habitat models, and personal experience. A suite of different habitat variables was identified as candidates in this habitat model, based on their known importance to winter foraging ecology (Table 5-3). The variables were evaluated for inclusion based on availability in GIS database, the ecological relevance to moose in the RSA, and relationships found in other studies. Based on these criteria, ecosystem unit, structural stage data and fire disturbance, all from the ELC mapping database, were included in the moose habitat modelling. Other variables were not included in the model as they were not expected to play a major role in winter habitat use by moose or because they were correlated with one of the three selected variables.

Distance to riparian areas was considered for inclusion in the model. Riparian areas are important foraging habitats for moose (Clarke et al. 2017, McCulley et al. 2017). Within the RSA, riparian areas generally contain abundant browse species relative to the adjacent ecological units. The ELC developed ecosystem units specific to riparian habitats. The ecosystem unit data accurately represent increased habitat suitability in riparian areas found as narrow strips along most watercourse and drainages in the RSA. Therefore, a variable for distance to riparian was redundant and was not included in the model.

Elevation was considered as a variable for inclusion in the model. In winter, moose generally occur at lower elevations to minimize the energetic costs of travelling through deep snow. Moose generally start avoiding areas with >70 cm of snow and rarely occur in areas with >100 cm. However, elevation within the rolling topography of the RSA does not vary substantially (range = 343–752 masl) and was likely not a significant driver of moose distribution. Therefore, elevation was not included as a variable in the model.

Slope was considered as a variable for inclusion in the model. Moose avoid very steep slopes (i.e., generally >35 degrees). In more southerly locations, moose will select moderately steep, south aspect slopes in winter where the combination of slope and aspect reduces snow depth and favours shrubby browse cover. However, steep slopes >35 degrees do not occur in the area, and south aspect slopes do not play a significant role in snow depths at this northern latitude. Therefore, slope was not included as a variable in the model.

Linear features were considered for inclusion in the model. LFs were surveyed in the RSA as a companion study for exploration project proposal (EDI Environmental Dynamics, unpublished study). LFs that were classified as 2D had an average width of 5.4 m and, under normal succession, had greater mean shrub cover than the corresponding off-line sites. The 3D lines had narrower widths and were not as shrubby, or shrubs were not consistent in shrub cover and species present. The few winter roads also were not consistent in available browse species. The greater shrub cover does not signify the presence of higher quality browse species such as willows. The combination of shrub species cover found within LFs, and the small extent of LF did not warrant including them as a variable in the model because these two factors would not substantially affect habitat use by moose.

Table 5-3. Summary of habitat variables commonly associated with moose habitat suitability from published literature relevant to the Regional Study Area.

Habitat Variable	Ecological Rational	Included in Model (Yes or No)
Ecosystem Unit (ELC)	Ecosystems units have specific vegetation communities associated with them and are the best predictor of winter browse species occurrence.	Yes
Structural Stage (ELC)	Moose typically select shrub structural stages or open mature forest habitats as forage habitat.	Yes
Distance to Riparian	Any shrubby feature influenced by a creek or stream was given a riparian code in the ELC. ELC data more accurately represent increased habitat quality in riparian forests than the distance to riparian	No
Elevation	Elevation can strongly affect snowpack depth, with depths >70 cm limiting winter movements by moose. The limited range in elevation within RSA (343 – 752 m), combined with average winter snowpacks just reaching critical depths for moose, is assumed to be insufficient to affect moose distribution in winter.	No
Slope	Moose avoid steep slopes (>35%) and prefer south-facing slopes. A combination of slope and aspect reduces snow depth and favors shrubby browse cover. However, steep slopes >35 degrees do not occur in the area, and south aspect slopes do not play a significant roll in snow depths at this northern latitude.	No
Fire History (ELC)	Fire may increase forage habitat quality for moose, but it is dependent on time since the disturbance and ecosystem unit. The ELC mapping accounts for the fire history by using the structural stage and a disturbance code.	Yes
Linear features	Moose may avoid linear features due to increased predation risk depending on the region. Linear features may provide foraging opportunities. Linear features within the RSA may affect habitat quality positively or negatively, dependent on ecosystem unit and time since disturbance.	No

5.3.2.1 Ecological and Landscape Classification Based Variables

Ecosystems units have specific vegetation communities associated with them and are the best predictor available of winter browse species occurrence. Moose typically select shrub structural stages or open mature forest habitats as forage habitats. The ecosystem unit and structural stage variables are based on the recently completed ELC mapping of the RSA. A summary of ELC methods and results are presented here. Refer to the separate baseline report for more detailed information about the ELC mapping (EDI Environmental Dynamics Inc 2021).

Ecosystem Unit Variable

ELC mapping refers to an integrated approach to mapping and classifying units of land according to their ecological similarity (Environment Yukon 2016a). ELC mapping aims to provide information on the biological and physical characteristics of various landscape components to facilitate a range of interpretations and assist in sustainable management (Rowe and Sheard 1981, Environment Yukon 2016a). For example, defining ecosystem units (i.e., ecosites, ecological communities) with similar vegetation, site and soil characteristics can provide information on the current condition of vegetation, can facilitate the development of vegetation mitigation measures during infrastructure development and aid in assessing habitat suitability for wildlife across a landscape.

To best meet the needs of the Project, a manual ELC mapping approach was completed, where mappers examine and interpret digital ortho-imagery to delineate and attribute polygons with ecological information manually. Using existing GIS datasets, this method typically provides a higher level of detail and accuracy than predictive modelling approaches. The mapping and classification methodology conforms to the Yukon Ecological and Landscape Classification and Mapping Guidelines, Version 1.0 (Environment Yukon 2016a), and the Standard for Terrestrial Ecosystem Mapping in British Columbia (Resources Inventory Committee 1998b) were used as guidelines.

To complete the ELC mapping of the RSA, new broad-ecosystem classification units were developed that had similar floristic composition and clearly interpretable ecological context in terms of site-scale climate, landscape position, substrate, hydrology conditions, and moisture and nutrient regimes. The goal was to develop Project-specific ecosystem units representing the range of ecological communities within the RSA while being reliably and repeatedly identifiable from a mapping perspective. The final ELC system used for the Project merged the methodology outlined by the YBEC system with aspects of the BEC system used in BC and referenced some of the existing units.

The most common ecosystem unit mapped in the RSA is Moist Spruce – Labrador Tea (Code 33) (44%) followed by Moist Spruce – Alder – Labrador Tea (Code 34) (12%) and Mesic Black Spruce – Alaska Paper Birch (Code 04) (9%) (Table 5-4). The least common (0%) ecosystem units mapped in the RSA are Dry Sparsely Vegetation (Code 10) and Mesic Birch – Willow (Code 02), and Moist Birch – Willow (Code 36). Both Birch – Willow ecosystem units are influenced by anthropogenic disturbances. Other less common ecosystem units that occur more naturally are Dry Aspen (Code 17), Mesic White Spruce – Alaska Paper Birch – Alder (Code 03), and Wet Shrub Scrub Birch – Graminoid (Code 45).

Table 5-4. Ecosystem units mapped in the Eagle Plains RSA.

Code	Name	Total Area (ha)	% of RSA	Average percent cover of *Salix* sp.
10	Sparsely Vegetated	2.6	0.0	No data
14	Dry Spruce-Lichen (Conifer)	1,826.5	0.8	5.3%
15	Dry Aspen-Lichen (Deciduous)	280.8	0.1	No data
16	Dry Spruce-Birch-Lichen (Mixedwood)	2,103.6	0.9	4.5%
17	Dry Aspen (Deciduous)	80.1	0.0	No data
02	Mesic Birch - Willow	90.5	0.0	22.0%
03	Mesic White Spruce – Alaska Paper Birch – Alder	98.3	0.0	No data
04	Mesic Black Spruce – Alaska Paper Birch (Mixedwood)	21,150.0	8.9	4.6%
05	Mesic Alaska Paper Birch (Deciduous)	11,496.0	4.8	12.5%
06	Mesic Black Spruce – Labrador Tea (Conifer)	7,463.5	3.1	12.2%
20	Shrubby Riparian Birch – Willow	860.2	0.4	27.6%
21	Riparian White Spruce – Prickly Rose	192.1	0.1	12.0%
22	Riparian Spruce – Birch - Willow	674.4	0.3	15.3%
23	Drainage Shrubby Riparian	4,454.2	1.9	57.0%
31	Moist Shrub \ Scrub Birch – Labrador Tea – Willow	9,129.9	3.8	14.2%
33	Moist Spruce – Labrador Tea	103,696.5	43.5	6.6%
34	Moist Spruce – Alder – Labrador Tea	27,428.6	11.5	6.0%
35	Moist Spruce – Scrub birch – Labrador Tea	12,163.3	5.1	5.5%
36	Moist Birch – Willow	33.4	0.0	39.0%
41	Wet Shrub – Tamarack	177.3	0.1	1.7%
42	Wet Shrub – Black Spruce – Tussock Cottongrass	14,517.0	6.1	4.3%
43	Wet Shrub – Black Spruce - Sphagnum	3,315.6	1.4	5.6%
44	Wet Shrub – Scrub Birch – Tussock Cottongrass	6,844.7	2.9	8.3%
45	Wet Shrub – Scrub Birch – Graminoid	98.7	0.0	10.0%
46	Wet Black Spruce – Labrador Tea – Cladonia	2,498.0	1.0	7.0%
47	Wet Black Spruce – Tussock Cottongrass – Sphagnum	4,232.3	1.8	4.0%
48	Wet Black Spruce – Carex	196.6	0.1	14.0%
B1	Bog – Black spruce – Lichen	764.7	0.3	0.0%
B2	Bog – Black Spruce – Sphagnum	1,960.9	0.8	2.0%

Code	Name	Total Area (ha)	% of RSA	Average percent cover of *Salix* sp.
F	Fen	42.5	0.0	9.0%
M	Marsh	59.5	0.0	3.2%
AN	Anthropogenic	34.9	0.0	0
ES	Exposed Soil	14.5	0.0	0
Fa	Flood Active Channel	5.1	0.0	No data
LA	Lake	6.5	0.0	0
PD	Pond	130.4	0.1	0
RI	River	457.1	0.2	0
RZ	Road	58.9	0.0	0
	Total Area	238,640		

Structural Stage Variable

Within the ELC database, the structural stage attribute (Table 5-5) describes the appearance of a stand or vegetation community and defined by the codes and criteria listed in the Field Manual for Describing Yukon Ecosystems (Environment Yukon 2017).

Most of the RSA is mapped in a Shrub structural stage (74%), with 45% of the RSA in a Low Shrub structural stage (Table 5-5). Approximately 1% of the RSA is in an Old Forest structural stage, and 21% is in a Mature Forest structural stage.

Table 5-5. Structural stages mapped in the Eagle Plains RSA.

Code	Structural Stage	Criteria	Area (ha)	% of RSA
1	Non-vegetated	No vegetation or less than 5% established vegetation, often due to recent disturbance (e.g., placer mining) or unvegetated rock.	8.0	0
2	Sparse / cryptogram	Either the initial stages of primary and secondary succession or a cryptogram community maintained by environmental conditions; sparsely vegetated or dominated by bryophytes and lichens; may be prolonged where there is little or no soil development (e.g., bedrock).	76.9	0.03
2a	Sparse (5–10% vegetation cover)	5–10% vegetation cover.	2.6	0
2b	Bryoid	Bryophyte-dominated	0	0
2c	Lichen	Lichen-dominated	0	0

Code	Structural Stage	Criteria	Area (ha)	% of RSA
3	Herb	Early successional stage or herbaceous communities maintained by environmental conditions or disturbance (e.g., wetlands, post-fire forest succession); herb dominated, including forbs, graminoids and ferns; some invading or residual shrubs and trees may be present but are usually sparse or absent; many herbaceous communities are continually maintained in this stage.	7.8	0
3a	Forb - dominated	Herbaceous communities dominated (greater than 1/2 of the total herb cover) by non-graminoid herbs, including ferns.	0	0
3b	Graminoid – dominated	Herbaceous communities dominated (greater than 1/2 of the total herb cover) by grasses, sedges, reeds and rushes.	161.1	0.07
3c	Aquatic	Herbaceous communities dominated (greater than 1/2 of the total herb cover) by floating or submerged aquatic plants; does not include sedges growing in marshes with standing water.	0	0
3d	Dwarf shrub	Communities dominated (greater than 1/2 of the total herb cover) by dwarf woody species, such as kinnikinnick or dwarf willows.	0	0
4	Shrub	Early successional stage or shrub communities maintained by environmental conditions or disturbance (e.g., wetlands, flooding, post-fire forest succession); dominated by shrubby vegetation; either dominated by shrubby vegetation, including tree seedlings/saplings, or if sparsely vegetated overall, the dominance of shrubs characterizes the community as a shrubland. This may include sites where trees are stunted due to the presence of permafrost, preventing the stand from reaching a higher structural stage.	10,196.7	4.3
4a	Tall shrub	Communities dominated by tall shrub layer vegetation - woody plants > 2m tall and ≤ 7 cm dbh; may be a successional stage or may be in this stage perpetually due to environmental conditions or disturbance.	57,934.3	24.3
4b	Low shrub	Communities dominated by low shrub layer vegetation - woody plants < 2m tall; may be a successional stage or may be in this stage perpetually due to environmental conditions or disturbance.	107,861.2	45.2
5	Pole sapling	Trees > 5m tall and > 7 cm dbh, typically densely stocked. Self-thinning and vertical structure are not yet evident in the canopy. Younger stands are vigorous (usually > 15–20 years old); older stagnated stands (up to 100 years old) are also included; time since disturbance usually < 40 years; up to 100+ years for dense (5000 – 15000+ stems per ha) stagnant stands.	554.8	0.2
6	Young Forest	Self-thinning has become evident, and the forest canopy has begun to differentiate into distinct layers. A more open stand than the pole/sapling stage.	8,322.6	3.5

Code	Structural Stage	Criteria	Area (ha)	% of RSA
7	Mature Forest	Trees established after the last stand-replacing disturbance have matured; a second cycle of shade tolerant trees may have become established; shrub and herb understories become well developed as the canopy opens up.	50,518.9	21.2
8	Old Forest	Stands of old age with complex structure; patchy shrub and herb understories are typical; regeneration is usually of shade-tolerant species with composition similar to the overstory. Fire maintained stands may have a 'single-storied' appearance. Very old stands having complex structure with abundant large-sized trees, snags and CWD; snags and CWD occurring in all stages of decomposition; stands are comprised entirely of shade-tolerant overstory species with well-established canopy gaps.	2,302.7	1.0
n/a	Not Applicable (River, etc.)		692.4	0.3
	Total RSA		**238,640**	

5.3.2.2 Fire History

Fire disturbance was considered as a variable in the model. Numerous studies in boreal and sub-boreal regions have found that moose select areas regenerating from fires. Recent burns and post-fire clearings are generally considered optimal foraging habitat for moose. Forest fires are a significant component of the landscape ecology of the Eagle Plains Ecoregion. Typically, regenerating burns contain higher cover of shrubby browse species than undisturbed areas. This includes both deciduous shrubs like willow, as well as sapling deciduous trees like aspen and paper birch. Although burns are classified as Low and Tall Shrub in the ELC, structural stage alone does not uniquely identify them. Large extents of disclimax, stunted black and white spruce ecosystem unit types were also classified as Tall Shrub.

Numerous studies and data from the ELC mapping, indicate that fire disturbance results in increased shrubby browse cover during the Low and Tall Shrub structural stages of regeneration, and that regenerating burns are selected by moose in winter. Therefore, fire disturbance was included in the model.

5.3.3 WILDLIFE HABITAT RATINGS

Qualitative, categorical habitat suitability ratings were developed for each combination of ecosystem unit and structural stage in a lookup table format. For the Shrub structural stages separate ratings were provided depending on whether the area was recently burned or not. The difference in the amount of browse cover was minimal in other structural stages according to burn status and burned and unburned areas were rated equivalently. The development of ratings was based on expert opinion and primarily by the following assumptions:

- Winter habitat suitability is primarily driven by the amount of shrubby browse species that are predicted to occur and especially the percent cover of willow species. The average percent cover of willow species by ecosystem unit per structural stage was calculated using vegetation data collected during baseline surveys (Section 5.6.1).

- Low shrub structural stages, including disclimax shrublands (wetlands and shrubby drainages) and regenerating burns, generally offer the highest value forage and are generally rated High.
- The suitability of tall shrub areas depends on disturbance status. Tall shrub areas regenerating from fire disturbance are also rated Moderate (mostly) to High, depending on the ecosystem unit. However, Tall shrub stages also include extensive areas of disclimax stunted spruce (including multiple EUs) that generally offer low to moderate browse species, which are rated accordingly.
- Older structural stages (5–8) can have similar browse and are mostly rated depending on the EU (Table 5-4). On average stage 7 and 8 tend to have slightly more browse than stages 5 and 6.

Every combination of ecosystem unit and structural stage was assigned in initial habitat suitability score based on a 6-class rating scheme (Table 5-6). If there was no structural stage listed for an ecosystem unit, it received a rating of 6 (Nil) for moose winter forage.

The extent of areas with high cover of preferred browse species (mostly willow) is limited in the RSA. The ecosystem unit by structural stage combinations with >15% willow cover was generally rated High (1) and Moderately High (2) and account for only 12% of the extent in the RSA (Photo 5-5 to Photo 5-9). Large extents of the RSA have relatively low willow cover of 5–15% and were rated as Moderate (3) and Low (4) (Photo 5-10 to Photo 5-14). Differentiating the classifications between Low and Moderate was difficult because the differences in willow presence among different sites were not consistent, and variation in willow cover within the same site type was large (i.e., resulting in overlapping confidence intervals across sites). The basis for classifying sites as Low or Moderate considered (i) average cover of willow from field plots (>7% favouring classification to Moderate), (ii) fire history (fire disturbance within 40 years favouring classification to Moderate), and (iii) a qualitative assessment of the potential for each EU and structural stage combination to support willow and other browse species.

Although Moderate and Low rated habitats have relatively low cover of willow in an absolute sense, they likely provide a substantial proportion of total winter forage for moose in the RSA due to the large extents that Moderate and Low suitability habitats cover. That is, in Eagle Plains the overall, total availability of winter forage for moose appears to be distributed in relatively low levels across large portions of the RSA, versus being concentrated in relatively small portions of the landscape, which is typical in more mountainous portions of Yukon.

Overall, EUs in sparsely vegetated or herbaceous structural stages, non-vegetated EUs and certain wetland EUs were assigned Very Low (5) or Nil (6) ratings unless the presence of willow cover was observed (Photo 5-15 and Photo 5-16).

The effect of fire disturbance in boreal ecosystems in enhancing moose browse as the stand regenerates through the low shrub and tall shrub structural stages are well documented. Although evidence of this was observed in Eagle Plains, the degree to which regenerating burns resulted in an elevated cover of browse species was somewhat muted compared to values reported in other studies. For example, for the most extensive EU, Moist Spruce-Labrador Tea (code 33) (comprising 43% of the RSA), the average percent cover of willow was 11% in burns compared to 6% in unburned areas (Photo 5-11 and Photo 5-12). Similar patterns were evident for most other moist and wet EUs. On average, fire disturbance resulted in a modest increase in willow cover. As a result, areas with fire disturbance within the last 40 years were generally rated one class higher than unburned areas. Most frequently, this resulted in a rating change from Low to Moderate.

Table 5-6. Moose Habitat Ratings Table.

Map Code	Ecosystem Unit Name	Structural Stage														
		1	**2**	**2a**	**3**	**3b**	**4**	**4a**	**4b**	4_F	4a_F	4b_F	**5**	**6**	**7**	**8**
02	Mesic Birch – Willow	6	6	6	6	4	1	1	1	1	1	1	2	2	3	3
03	Mesic White Spruce – Alaska Paper Birch – Alder	6	6	6	6	5	3	3	3	3	3	3	4	4	3	3
04	Mesic Black Spruce – Alaska Paper Birch	6	6	6	6	5	3	3	3	3	3	3	4	4	3	3
05	Mesic Alaska Paper Birch	6	6	6	6	5	2	2	2	2	2	2	3	2	2	2
06	Mesic Black Spruce – Labrador Tea	6	6	6	6	5	3	3	3	2	2	2	4	4	4	3
10	Sparsely Vegetated	6	6	6	6	5	4	4	4	4	4	4	5	5	5	5
14	Dry Spruce – Lichen	6	6	6	6	5	4	4	4	3	3	3	4	4	3	3
15	Dry Aspen – Lichen	6	6	6	6	5	3	3	3	3	3	3	4	4	3	3
16	Dry Spruce – Birch – Lichen	6	6	6	6	5	4	4	4	3	3	3	4	4	3	3
17	Dry Aspen	6	6	6	6	5	3	3	3	3	3	3	4	4	3	3
20	Shrubby Riparian Birch – Willow	6	6	6	6	4	1	1	1	1	1	1	2	2	2	2
21	Riparian White Spruce – Prickly Rose	6	6	6	6	4	1	1	1	1	1	1	2	2	2	2
22	Riparian Spruce – Birch – Willow	6	6	6	6	4	1	1	1	1	1	1	2	2	1	1
23	Drainage Shrubby Riparian	6	6	6	6	4	1	1	1	1	1	1	2	2	2	2
31	Moist Shrub \ Scrub Birch – Labrador Tea – Willow	6	6	6	6	4	2	2	2	2	2	2	3	3	3	3
33	Moist Spruce – Labrador Tea	6	6	6	6	4	4	4	4	3	3	3	3	3	3	3
34	Moist Spruce – Alder – Labrador Tea	6	6	6	6	5	4	4	4	3	3	3	4	4	4	4
35	Moist Spruce – Scrub Birch – Labrador Tea	6	6	6	6	5	4	4	4	3	3	3	4	4	4	4
36	Moist Birch - Willow	6	6	6	6	4	1	1	1	1	1	1	2	2	3	3
41	Wet Shrub – Tamarack	6	6	6	6	5	5	5	5	4	4	4	5	5	5	5
42	Wet Shrub \ Black Spruce – Tussock Cottongrass	6	6	6	6	4	4	4	4	3	3	3	4	4	4	4
43	Wet Shrub \ Black Spruce – Sphagnum	6	6	6	6	5	4	4	4	3	3	3	4	4	4	4

Map Code	**Ecosystem Unit Name**	**Structural Stage**														
		1	**2**	**2a**	**3**	**3b**	**4**	**4a**	**4b**	4_F	4a_F	4b_F	**5**	**6**	**7**	**8**
44	Wet Shrub \ Scrub Birch – Tussock Cottongrass	6	6	6	6	4	4	4	4	3	3	3	4	4	4	4
45	Wet Shrub \ Scrub Birch – Graminoid	6	6	6	6	4	4	4	4	3	3	3	4	4	4	4
46	Wet Black Spruce – Labrador Tea – Cladonia	6	6	6	6	4	4	4	4	3	3	3	4	4	4	4
47	Wet Black Spruce – Tussock Cottongrass – Sphagnum	6	6	6	6	4	4	4	4	3	3	3	4	4	4	4
48	Wet Black Spruce - Carex	6	6	6	6	4	3	3	3	3	3	3	4	4	3	3
B1	Bog – Black Spruce – Lichen	6	6	6	6	5	5	5	5	4	4	4	5	5	5	5
B2	Bog – Black Spruce – Sphagnum	6	6	6	6	5	5	5	5	4	4	4	5	5	5	5
F	Fen	6	6	6	6	4	5	5	5	4	4	4	5	5	5	5
M	Marsh	6	6	6	6	5	5	5	5	5	5	5	5	5	5	5
AN	Anthropogenic	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
ES	Exposed Soil	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Fa	Flood Active Channel	6	6	6	6	4	3	3	3	3	3	3	4	4	4	4
LA	Lake	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
PD	Pond	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
RI	River	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
RZ	Road	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

Photo 5-5. Low shrub – shrubby riparian birch – willow habitat (code 20) rated as High winter forage habitat.

Photo 5-6. Low shrub – drainage shrubby riparian habitat (code 23) rated as High winter forage habitat.

Photo 5-7. Tall shrub – moist birch – willow habitat (code 36) rated as High moose winter forage.

Photo 5-8. Low shrub – moist shrub\scrub birch – Labrador tea – willow habitat (code 31) rated as Moderately High moose winter forage.

Photo 5-9. Young forest – mesic Alaska paper birch habitat (code 05) rated as Moderately High moose winter forage.

Photo 5-10. Mature forest – wet black spruce – carex habitat (code 48) rated as Moderate moose winter forage.

Photo 5-11. Shrubby burnt – moist spruce – Labrador tea habitat (code 33) rated as Moderate moose winter forage habitat (note that this is not rated higher than Moderate because much of the shrub cover is less preferred scrub birch).

Photo 5-12. Unburnt – moist spruce – Labrador tea habitat (code 33), in Tall Shrub structural stage, was rated as low moose winter forage habitat.

Photo 5-13. Tall shrub – wet black spruce – tussock cottongrass – Sphagnum habitat (code 47) rated as low moose winter forage habitat.

Photo 5-14. Mature forest – mesic black spruce – Labrador tea habitat (code 06) rated as low moose winter forage

Photo 5-15. Low shrub – bog – black spruce – Sphagnum habitat (code B2) rated as very low moose winter forage.

Photo 5-16. Low shrub – bog – black spruce – lichen habitat (code B1) rated as very low moose winter forage.

5.3.4 MODEL STRUCTURE

In the ELC map, each polygon contains up to three components. For example, a polygon could contain 80% EU34-Moist Spruce – Alder – Labrador Tea and 20% EU22-Shrubby Riparian Birch – Willow. These composite polygons occur because the pattern of ecosystem distribution occurs as a set of small patches that are too small to map as separate individual polygons. To account for this issue of composite polygons, habitat ratings were applied in two ways (1) an area weighted average of the habitat suitability scores for the components within each polygon, and (2) the proportion of High suitability habitat in each polygon.

The area-weighted average score was calculated using the habitat suitability scores from Table 5-2 and the decile proportion for each polygon component, following equation:

$$ELC_r = \frac{\sum_{i=1}^{n} w_i X_i}{\sum_{i=1}^{n} w_i}$$

Where ELC_r is the weighted average score, w_i is the decile proportion for each polygon component, and X_i is the habitat rating for each polygon component from Table 5-2. An example is provided in Table 5-7 for a polygon with two components:

Although this weighted average approach is a good approach for summarizing average habitat suitability across the study area, it has the disadvantage that, with the averaging process, you lose track of the occurrence of small extents of High suitability areas. This issue is addressed in the second version of model outputs, mapping the proportion of High suitability habitats within each polygon.

The two types of outputs compliment each other for assessment and management at different scales. The weighted average output is intended to be used for strategic assessments and planning, such as assessing the overall effects of the Project on moose habitat, or to compare the relative suitability of moose habitat in one sub-watershed to another. The proportion of High suitability habitat can be used to support finer-scale operational measures, such as locating roads and well sites to avoid high suitability winter moose habitat.

Although the initial habitat ratings for each ecosystem unit/structural stage/fire disturbance combination used a 6-class rating scheme, the composite ratings of the ELC polygon scores were generalized to a 4-class system for simpler interpretation, essentially combining Moderately High and High, and Nil and Very Low.

Due to the small size of many of the High and Moderately High habitats areas, they were frequently formed the second or third component of composite ELC polygons. Consequently, these areas of High were often 'lost' when calculating the weighted average rating for the polygon (i.e., the polygon they were in ended up being rated Moderate or even Low overall). To account for this issue, the amount and location of High and Moderately High areas were examined separately from the polygon weighted average score. This was done by mapping the amount of High and Moderately High areas in each polygon. For example, a polygon with a weighted average habitat score of Low, might contain 20% High+Moderately High.

Table 5-7. An example of a multiple component polygon habitat scoring.

Component	Proportion	Ecosystem Unit	Structural stage	Burn Status	Habitat Score
1	0.8	Moist Spruce – Alder – Labrador Tea	Tall Shrub	Not Burnt	30
2	0.2	Shrubby Riparian Birch – Willow	Low Shrub	Not Burnt	95

ELCr = 0.8*30 + 0.2*95 = 43, which corresponds to an overall categorical rating of Low

5.4 RESULTS AND DISCUSSION

The amounts of predicted moose winter habitat in the RSA are presented for the finer-scale 6-class rating scheme before averaging scores within ELC polygons in Table 5-8, and the consolidated 4-class rating scheme after averaging scores within ELC polygons, in Table 5-9. As mentioned in the Methods, the 4-class scheme essentially combines the High and Moderately High classes and the Nil and Very Low from the 6-class scheme. The 6-class scheme was originally used because it was assumed that there would be greater amounts of areas in the high and low ends of the habitat suitability gradient. However, since the amounts of highest and lowest suitability habitat are so low (i.e., 2.5% High and 0.4% Nil) it makes sense to use the 4-class scheme from this point forward.

The model results indicate that High-suitability winter moose habitat (12%) is limited, and that the remaining area is approximately split between Moderate and Low, with Nil/Very Low areas only accounting for approximately 1% of the RSA. The distribution of winter moose habitat shows clear spatial patterns across the RSA, when examining the average habitat suitability scores across ELC polygons (Map 5-1) and the percent of High-suitability habitats occurring in each polygon (Map 5-2 and Map 5-3). In the map of the average suitability scores (Map 5-1), areas of Moderate suitability are concentrated in the southern half and along the western and northern boundary in the northern portion of the RSA. These areas often correspond to regenerating burns. In the northern half of the RSA, much of the Chance Creek watershed is rated Low, corresponding to a lack of fire disturbance and dominance of open canopy, stunted spruce ecosystems, which offer limited browse for moose. High-suitability winter habitat is found scattered across the RSA, generally in much smaller patches than areas of Moderate and Low. High suitability areas are often in narrow riparian strips along streams and non-confined drainage areas (Map 5-2), but also includes certain deciduous and mixed-wood ecosystem units, like the Mesic Alaska Paper Birch (code 05), which accounts for the concentration of High suitability habitats in the northwest portion of Map 5-3.

This pattern of having a relatively large portion of the landscape in Moderate suitability winter habitat is different than occurs in other parts of Yukon, especially in more mountainous areas, where suitable winter habitat (i.e., High and Moderate suitability) are often constrained by elevation, snow depths and greater distribution of diverse vegetation communities (McCulley et al. 2017). In Eagle Plains, a substantial amount (74%) of the RSA is in a shrub structural stage mostly dominated by scrub birch and Labrador tea and almost half (44%) of the RSA is described as the Moist Spruce – Labrador tea ecological unit which are large areas with relatively low willow cover (i.e., the Moderate suitability areas).

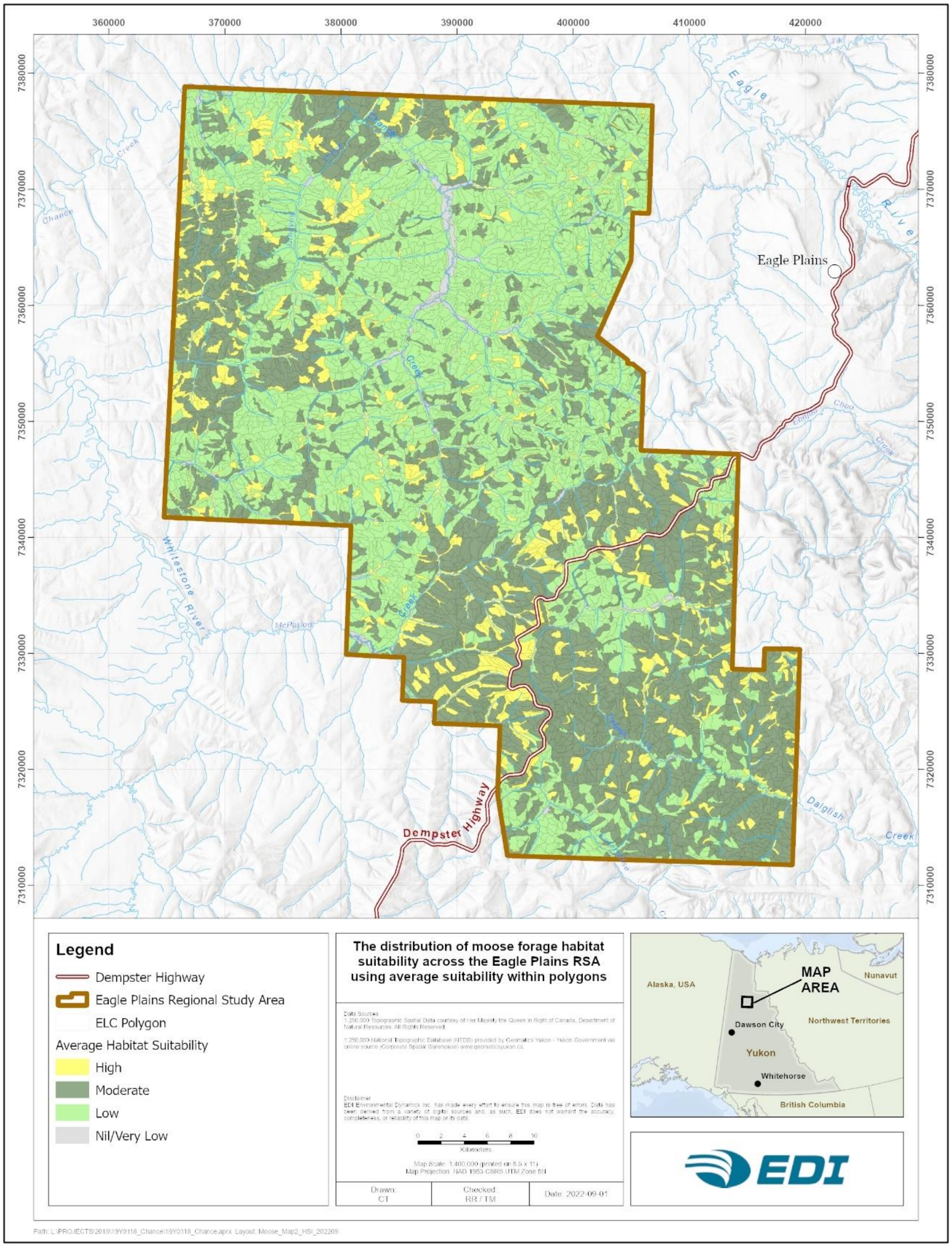
The pattern of winter habitat across the RSA is likely to affect the broad distribution of moose. Due to the scattered occurrence of High suitability habitat across the RSA, some moose are expected to occur across the RSA. However, local densities are likely to be vary in relation to the portions of Low and Moderate that form the matrix of habitat at a larger scale. Where most of the habitat matrix is Low, such as across most of the Chance watershed, moose densities are expected to be relatively low and habitat use is expected to be largely constrained to the scattered patches of High. Where most of the habitat matrix is Moderate, such as the southern half of the RSA, moose densities are expected to be substantially higher; and, although moose use is expected to still be relatively higher in the High habitats, considerable use of the Moderate suitability matrix is also expected.

Table 5-8. Estimated amounts of moose winter forage habitat across the Eagle Plains RSA using a 6-class rating scheme.

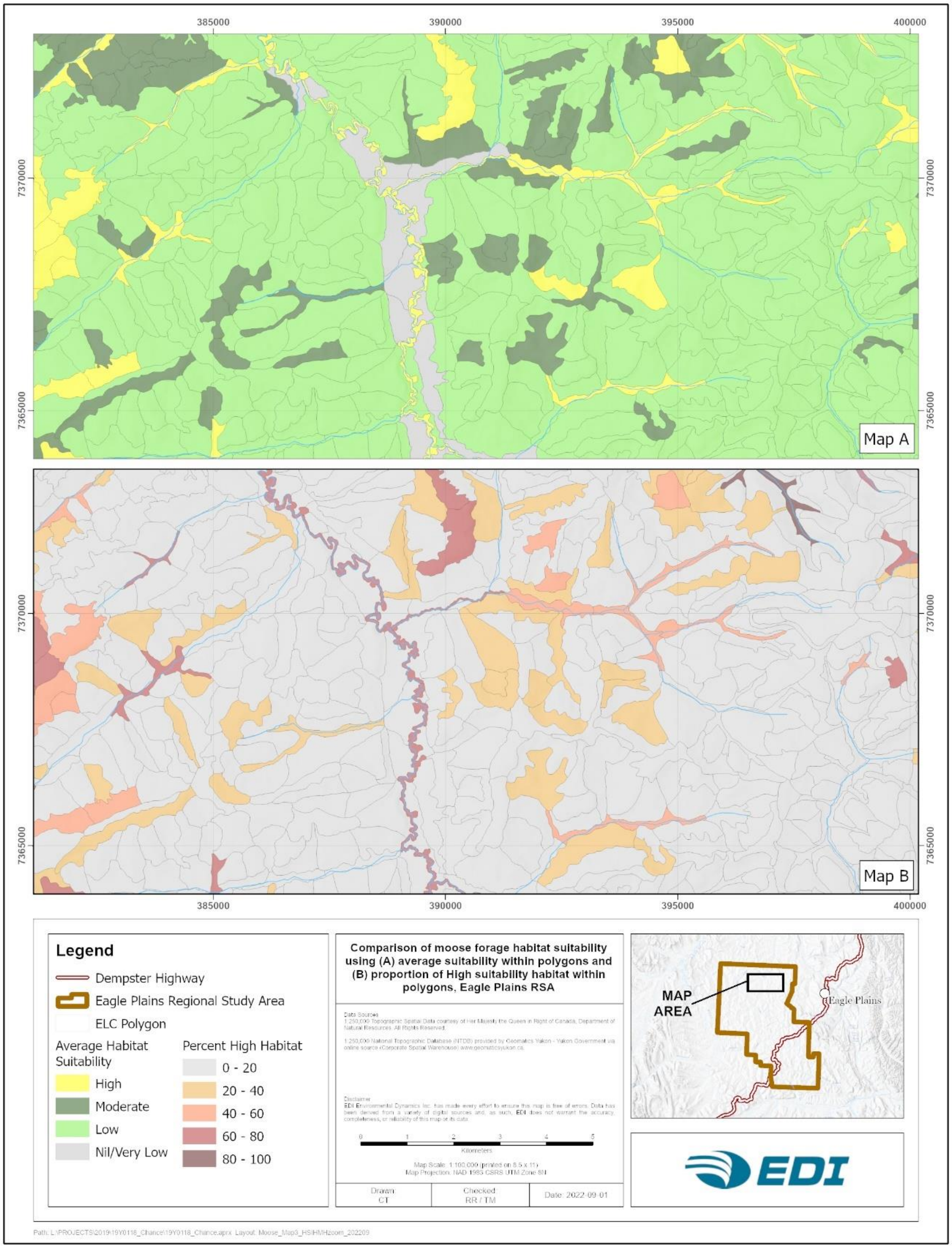
Habitat Rating	Area (ha)	Area (% of RSA)
High	5,961.9	2.5%
Moderately High	23,736.7	9.9%
Moderate	111,561.7	46.7%
Low	94,068.2	39.4%
Very Low	2,492.4	1.0%
Nil	842.6	0.4%
Total Area	238,663.5	100%

Table 5-9. Estimated amounts of moose winter forage habitat across Eagle Plains RSA averaging suitability scores within ELC polygons and generalizing to a 4-class rating scheme.

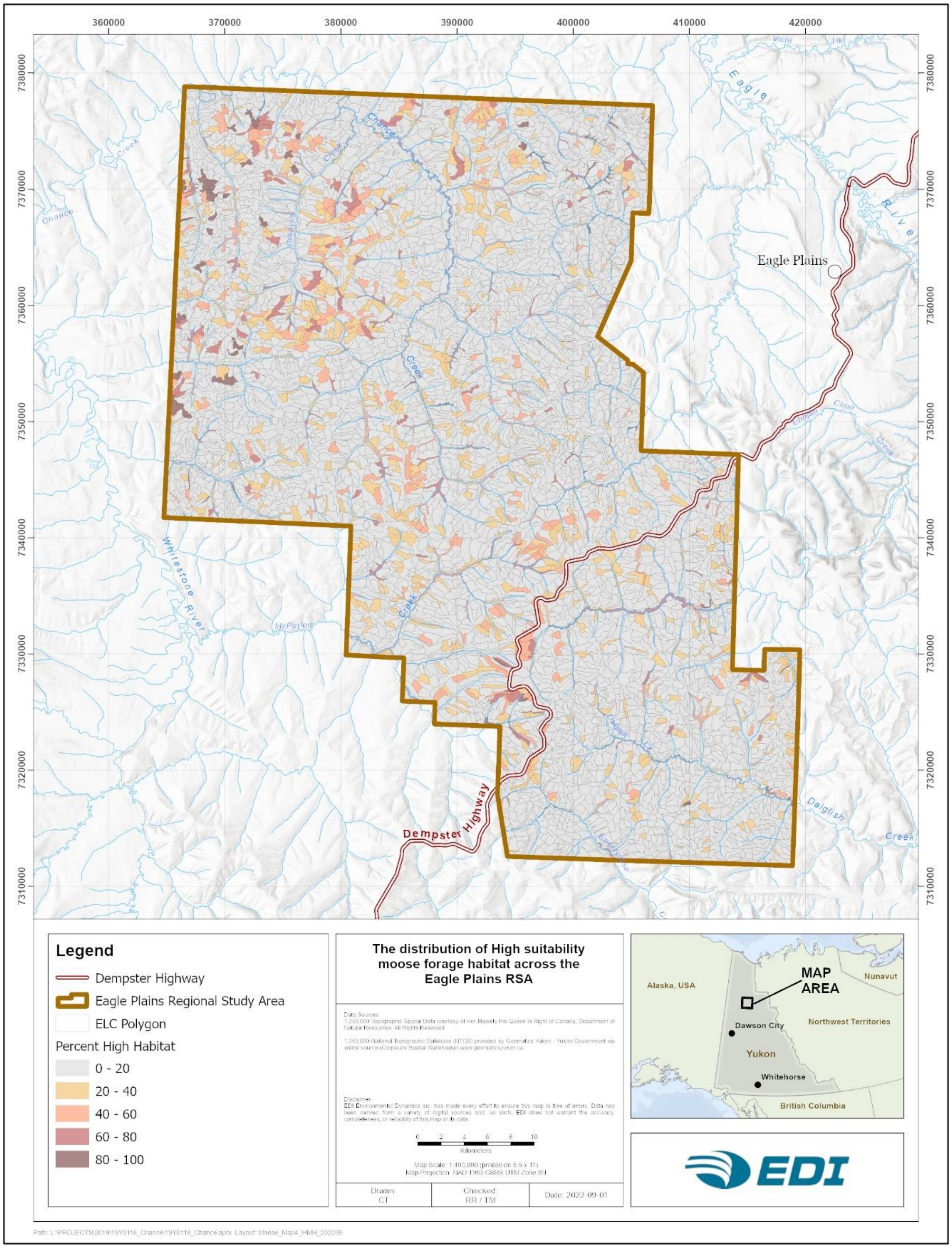
Average Habitat Suitability	Area (ha)	Area (% of RSA)
High	16,944.4	7.10%
Moderate	145,394.1	60.92%
Low	74,514.5	31.22%
Nil/Very Low	1,810.5	0.76%
Total	238,663.5	100%



Map 5-1. The distribution of moose forage habitat suitability across the Eagle Plains RSA using average suitability within polygons.



Map 5-2. Comparison of moose forage habitat suitability using (A) average suitability within polygons and (B) proportion of High suitability habitat within polygons, Eagle Plains RSA.



The distribution of High suitability moose forage habitat across the Eagle Plains RSA

Data Sources
1:250,000 Topographic Spatial Data courtesy of Her Majesty the Queen in Right of Canada, Department of Natural Resources. All Rights Reserved.

1:250,000 National Topographic Database (NTDB) provided by Geomatics Yukon - Yukon Government via online source (Corporate Spatial Warehouse) www.geomaticsyukon.ca

Disclaimer
EDI Environmental Dynamics Inc. has made every effort to ensure this map is free of errors. Data has been derived from a variety of digital sources and, as such, EDI does not warrant the accuracy, completeness, or reliability of this map or its data.

Map Scale: 1:400,000 (printed on 8.5 x 11)
Map Projection: NAD 1983 CSRS UTM Zone 8N

Drawn: CT
Checked: RR / TM
Date: 2022-09-01

Path: L:\PROJECTS\2019\19Y0118_Chance\19Y0118_Chance.aprx Layout: Moose_Map4_HMH_202209

Map 5-3. **The distribution of High suitability moose forage habitat across the Eagle Plains RSA.**

5.5 SUMMARY

The suitability, amount, and distribution of potential habitat for moose were quantified across the RSA using a habitat suitability model. The habitat model was for foraging habitat during winter because this life requisite and season are believed to be the most limiting to moose in the RSA. The model consisted of qualitative ratings applied to combinations of three variables from the ELC mapping: ecosystem unit, structural stage and fire disturbance. High suitability habitats consisted of disclimax shrublands, most commonly associated with riparian areas. Moderate suitability habitats were dominated by regenerating burns but also included small areas of mixed and deciduous forests with shrubby understories. Low suitability habitats were mostly open canopy, stunted spruce forests. High-suitability moose winter foraging habitat is limited across the RSA (12%), but Moderate habitat is extensive (43%). Although moose are expected to select the High-suitability areas preferentially, a substantial amount of total winter forage appears to occur within large areas with relatively low willow cover (i.e., the Moderate suitability areas). Due to the scattered occurrence of High-suitability habitat across the RSA, some moose are expected to occur across the RSA in winter. However, local densities are likely to vary with the portions of Low and Moderate habitats that form the habitat matrix at a larger scale.

5.6 MOOSE SECTION ATTACHMENTS

5.6.1 ATTACHMENT 5–A — WILLOW SPECIES PERCENT COVER

Attachment Table 3. **Calculated percent willow cover for each ecosystem unit by structural stage based on collected vegetation baseline data. In some cases, no data was collected (NDC) since no ground plots were established within the EU or within a specific structural stage.**

Map Code	Ecosystem Unit Name	Structural Stage 1	2	2a	3	3b	4a	4b	5	6	7	8	Total #Plots
02	Mesic Birch – Willow	NDC	NDC	NDC	NDC	NDC	NDC	NDC	NDC	NDC	22.0 n=2	NDC	2
03	Mesic White Spruce – Alaska Paper Birch – Alder	NDC	NDC	NDC	NDC	NDC	NDC	NDC	NDC	NDC	NDC	NDC	0
04	Mesic Black Spruce – Alaska Paper Birch	NDC	NDC	NDC	NDC	0.0 n=1	5.0 n=1	4.0 n=3	NDC	0.0 n=2	5.2 n=9	4.4 n=6	22
05	Mesic Alaska Paper Birch	NDC	NDC	NDC	NDC	NDC	9.5 n=2	NDC	NDC	13.7 n=3	13.3 n=5	NDC	10
06	Mesic Black Spruce – Labrador Tea	NDC	NDC	NDC	NDC	NDC	38.0 n=3	12.6 n=5	1.0 n=1	0.0 n=2	3.5 n=6	5.0 n=1	18
10	Sparsely Vegetated	NDC	NDC	NDC	NDC	NDC	NDC	NDC	NDC	NDC	NDC	NDC	0
13		NDC	NDC	NDC	NDC	NDC	7.0 n=1	8.5 n=2	NDC	NDC	NDC	0.0 n=1	4
14	Dry Spruce – Lichen	NDC	NDC	NDC	NDC	NDC	NDC	NDC	NDC	2.0 n=3	6.0 n=5	8.0 n=4	12
15	Dry Aspen – Lichen	NDC	0.0 n=1	NDC	NDC	NDC	0.0 n=1	NDC	NDC	NDC	NDC	NDC	2
16	Dry Spruce – Birch – Lichen	NDC	NDC	NDC	NDC	NDC	NDC	NDC	8.0 n=2	0.0 n=1	1.0 n=1	NDC	4
17	Dry Aspen	NDC	NDC	NDC	NDC	NDC	NDC	NDC	NDC	0.0 n=1	NDC	NDC	1
20	Shrubby Riparian Birch – Willow	NDC	NDC	NDC	NDC	NDC	33.0 n=1	26.3 n=4	NDC	NDC	NDC	NDC	5
21	Riparian White Spruce – Prickly Rose	NDC	NDC	NDC	NDC	NDC	NDC	NDC	NDC	NDC	NDC	12.0 n=6	6
22	Riparian Spruce – Birch – Willow	NDC	NDC	NDC	NDC	NDC	NDC	NDC	1.0 n=1	NDC	26.7 n=4	5.5 n=2	7
23	Drainage Shrubby Riparian	NDC	NDC	NDC	NDC	NDC	NDC	57.0 n=1	NDC	NDC	NDC	NDC	1
31	Moist Shrub \ Scrub Birch – Labrador Tea – Willow	NDC	NDC	NDC	NDC	NDC	NDC	14.2 n=6	NDC	NDC	NDC	NDC	6
33	Moist Spruce – Labrador Tea	NDC	NDC	NDC	NDC	4.0 n=1	3.2 n=11	8.6 n=12	NDC	9.0 n=2	7.1 n=21	6.3 n=3	38
34	Moist Spruce – Alder – Labrador Tea	NDC	NDC	NDC	NDC	NDC	11.0 n=3	5.5 n=4	NDC	NDC	3.2 n=7	0.0 n=1	15
35	Moist Spruce – Scrub Birch – Labrador Tea	NDC	NDC	NDC	NDC	NDC	7.0 n=4	7.3 n=3	NDC	NDC	4.2 n=9	NDC	16

Map Code	Ecosystem Unit Name	Structural Stage											Total #Plots
		1	**2**	**2a**	**3**	**3b**	**4a**	**4b**	**5**	**6**	**7**	**8**	
36	Moist Birch - Willow	NDC	NDC	NDC	NDC	NDC	43.0 n=1	NDC	NDC	35.0 n=1	NDC	NDC	2
41	Wet Shrub – Tamarack	NDC	NDC	NDC	NDC	NDC	NDC	1.7 n=5	NDC	NDC	0.0 n=1	NDC	6
42	Wet Shrub \ Black Spruce – Tussock Cottongrass	NDC	NDC	NDC	NDC	3.0 n=1	3.0 n=5	4.8 n=13	NDC	NDC	NDC	NDC	19
43	Wet Shrub \ Black Spruce – Sphagnum	NDC	NDC	NDC	NDC	NDC	5.0 n=4	6.5 n=9	NDC	NDC	NDC	NDC	13
44	Wet Shrub \ Scrub Birch – Tussock Cottongrass	NDC	NDC	NDC	NDC	NDC	NDC	8.3 n=19	NDC	NDC	NDC	NDC	19
45	Wet Shrub \ Scrub Birch – Graminoid	NDC	NDC	NDC	NDC	NDC	NDC	10.0 n=1	NDC	NDC	NDC	NDC	1
46	Wet Black Spruce – Labrador Tea – Cladonia	NDC	NDC	NDC	NDC	NDC	NDC	NDC	NDC	NDC	6.3 n=5	8.5 n=2	7
47	Wet Black Spruce – Tussock Cottongrass – Sphagnum	NDC	NDC	NDC	NDC	NDC	NDC	NDC	NDC	5.0 n=1	3.0 n=1	NDC	2
48	Wet Black Spruce - Carex	NDC	NDC	NDC	NDC	NDC	NDC	10.0 n=2	NDC	NDC	22.0 n=1	NDC	3
B1	Bog – Black Spruce – Lichen	NDC	NDC	NDC	NDC	NDC	NDC	0.0 n=8	NDC	NDC	NDC	NDC	8
B2	Bog – Black Spruce – Sphagnum	NDC	NDC	NDC	NDC	NDC	NDC	2.0 n=11	NDC	NDC	NDC	NDC	11
F	Fen	NDC	NDC	NDC	NDC	9.0 n=7	NDC	0.0 n=1	NDC	NDC	NDC	NDC	8
M	Marsh	NDC	NDC	NDC	NDC	3.2 n=6	NDC	NDC	NDC	NDC	NDC	NDC	6

6 CARIBOU

The Porcupine Caribou Technical Committee (PCTC) provided telemetry data and seasonal range polygons for the Porcupine Caribou Herd (PCH). Technical discussions and feedback provided by the PCTC also helped align subsequent analyses conducted in this section. This section and much of the technical content reflect responses to their detailed technical review.

6.1 PURPOSE AND OBJECTIVES

Caribou were selected as a VC for the Project due to their importance to the Gwich'in people for subsistence hunting and their cultural and ecological values. The Project occurs exclusively within the range of the PCH, which is a subpopulation of the barren-ground subspecies of caribou (*Rangifer tarandus groenlandicus*). Within the North Yukon Land Use Plan, the PCH is considered "the most significant and culturally important wildlife resource in the planning region" (Vuntut Gwitchin Government and Yukon Government 2009). The herd has been the mainstay of Gwich'in culture for centuries. It is considered a keystone species whose presence or absence influences the composition and dynamics of the wildlife communities and ecosystems in North Yukon. The PCH is a migratory herd with an extensive annual range that spans most of North Yukon and a large area in north-eastern Alaska. The PCH overlaps the Project area primarily during the rut/late fall and winter seasons.

This section summarizes existing information about the ecology of the PCH, and, using telemetry data and analysis outputs to: i) Quantify the degree of seasonal range overlap by the PCH with the RSA during fall and winter, when seasonal range use overlaps the RSA; ii) Quantify habitat use patterns and selection by the PCH during fall and winter; iii) Quantify movement rates and residency periods of the PCH during fall and winter; and, iv) Quantify the potential effects of linear features on the occurrence and movements of the PCH.

6.1.1 SPATIAL BOUNDARIES

Three spatial extents were considered as part of this study:

- The Eagle Plains Project RSA (2,386 km²)
- The Eagle Plains Ecoregion (20,400 km²), and
- The Yukon portion of the PCH's rut and late fall and winter seasonal ranges (65,000 km² and 58,000 km², respectively).

The Eagle Plains Project RSA includes all proposed exploration areas. The RSA has relatively similar patterns of vegetation communities and historical exploration disturbances across it. The Eagle Plains Ecoregion (see Section 1.3) encompasses the Project RSA and provides an ecologically similar area, beyond the proposed exploration areas, that allows certain comparisons between the RSA and adjacent undisturbed areas (e.g., habitat distribution and within-season movement patterns).

The Yukon portion of the PCH's fall and winter seasonal ranges is the largest extent and covers much of North Yukon. This area occurs predominantly within the Taiga Cordillera Ecozone. This Ecozone covers most of the northern Yukon and the southwest corner of the NWT. The Taiga Cordillera includes mountainous areas (e.g., British Mountains, Richardson Mountains, and North Ogilvie Mountains) separated by subdued basins (e.g., Eagle Plains, Old Crow Flats, and Old Crow Basin). The area consists of glaciated and unglaciated terrain and continuous permafrost. The climate in the Taiga Cordillera is variable from its northern to southern extent, with summers ranging from cool to warm with extended periods of daylight, while winters are generally long, cold, and dark. The vegetation in the taiga is dominated by stunted, open spruce forests, which result from short, cool growing seasons, and poor soils over permafrost (Ecological Stratification Working Group 1995). This extent was used to reference spatially broad questions, such as the PCH's seasonal distribution and movement patterns.

6.2 GENERAL ECOLOGY OF THE PORCUPINE CARIBOU HERD

6.2.1 CONSERVATION STATUS

The PCH is a subpopulation of barren-ground caribou in Canada, known for large aggregations of individuals, dramatic population fluctuations, lengthy migrations, and significant cultural and social value to northern Indigenous peoples and other Canadians (COSEWIC 2016). All caribou belong to one species, *Rangifer tarandus*. Within Canada, caribou populations are classified within 12 "Designatable Units" based on a suite of biological, genetic, and evolutionary traits (COSEWIC 2011). All 14–15 subpopulations of barren-ground caribou are considered part of one Designatable Unit (DU 3). Barren-ground caribou were assessed as Threatened by COSEWIC (COSEWIC 2016). The subspecies is not listed on Schedule 1 of the federal SARA. Within Yukon, barren-ground caribou are considered Vulnerable/Apparently Secure (Yukon Government 2020).

6.2.2 SEASONAL RANGES AND MOVEMENTS

Like most barren-ground caribou subpopulations, the PCH has a large annual range and makes long-distance migrations, hundreds or thousands of kilometres, among different seasonal ranges. Often, seasonal ranges vary across and within years in response to variation in forage availability, snow cover, and predation or parasite risk (Russell et al. 1993). The PCH's annual range extends approximately 250,000 km² from Alaska, through Yukon, and into the western edge of NWT. The herd undertakes long-distance migrations across seasonal ranges necessary for key aspects of their life cycle. Eight (8) primary life cycle periods occur for the PCH (Porcupine Caribou Technical Committee 1993). Key information for the eight periods are summarized in Table 6-1 (using information from Russell et al. 1993, Porcupine Caribou Technical Committee 1993, Ryder et al. 2007). The Porcupine Caribou Technical Committee (1993) assessed the relative importance of seasonal ranges using six criteria: energy balance, reproductive contribution, tolerance to disturbance, escape requirements, the intensity of use, and whether alternative habitats are available. Although all seasons are important to meeting the annual life requisites of the PCH, the calving and post-calving seasons are considered of highest importance and fall and winter are considered of lowest importance (Porcupine Caribou Technical Committee 1993).

Key information associated with each of the eight seasons is provided below, elaborating on summary information in Table 6-1, and including a combination of scientific knowledge (Russell et al. 1993, Porcupine Caribou Technical Committee 1993, Ryder et al. 2007) and traditional ecological knowledge (Sherry and Vuntut Gwitchin First Nation 1999, Ryder et al. 2007). Typical patterns of seasonal range use are shown in Map 6-1. After calving on the north slope and Arctic coastal plains, the PCH typically splits in two, with portions of the herd moving southwest in Alaska and southeast in Yukon. Animals in the Yukon typically follow a clockwise movement through the seasonal ranges from the calving grounds on the north slope, to the British Mountains in summer, to the Richardson Mountains in late summer, dispersing widely and variably across northern Yukon (as far south as the Ogilvie Mountains) in fall and winter, before returning north to the coastal plains in spring. The PCH can potentially overlap the RSA primarily in the rut/late fall and winter periods.

During the Calving and Post-Calving periods cows and bulls tend to occupy different habitats and exhibit different movement patterns, so their ranges are described separately for these periods. During the relatively short calving period (June 1–10), cows occur in the Arctic coastal plains and adjacent uplands and foothills in Alaska and Yukon. Concentrated use often occurs in the Jago Uplands between the Hulahula and Aichilik rivers in Alaska. The calving season is one of the seasons of greatest importance (rank 1) (Porcupine Caribou Technical Committee 1993). Adult females are generally in their poorest body condition and have the largest energy deficits. The calving period is critical to the survival and development of calves (i.e., the source of initial annual population recruitment). The herd occurs in a relatively concentrated range, which appears to offer reduced predation risk and abundant forage that coincides with the timing of calving, and no alternative areas of similar value are available.

During the Post-Calving and Movement period (June 11–30) cows (and new calves) travel away from the calving areas. Cows that calved in the Yukon tend to move west into Alaska. Often, movements are higher into the foothills and uplands, following melting snow and newly emerging vegetation. However, the herd can occur anywhere from the coastline well into the foothills during this period. Selection of local habitats to avoid insect harassment is often a factor by the end of June. The Post-Calving period is also considered a period of highest importance (rank 1) (Porcupine Caribou Technical Committee 1993). Lactating females have their highest energy demands. Movement rates and group sizes increase through June, and cow/calf groups are believed to be relatively intolerant to disturbance.

During the calving to post-calving movement period (June 1–30) most bulls, juveniles, and non-productive cows occur in north Yukon between the Babbage and Firth rivers across a range of habitats within the coastal plains and the British Mountains. Animals tend to be quite mobile and follow plant emergence across habitats and elevations as spring progresses. This period is considered to have relatively low importance (rank 3) for bulls and non-productive cows (Porcupine Caribou Technical Committee 1993) because they are not tending young-of-the-year, high-quality forage is becoming abundant, and insect harassment is limited.

During Early Summer (July 1–15), both cows and bulls remain concentrated in the general north slope area, but the overall range continues to expand. Group sizes increase to the tens of thousands, and movement rates can average 25 km per day. Early summer often marks the beginning of the split of the herd between Alaska and Canada. In Alaska, distribution is widespread into the Brooks Range, and, in Canada, animals typically move into the southern British Mountains by mid-July. Local habitat use is driven by both selection for high-quality forage and insect avoidance. Insect avoidance strategies include using coastal areas adjacent to the Beaufort Sea (often primarily females) and higher elevation snow patches and barren ground in the Brooks Ranges and British Mountains (mostly males). Early summer is considered to have an importance rank of 2. Though food is generally abundant, the energy balance is limited by insect avoidance, resulting in reduced feeding times and selection of areas with less forage. Animals are still susceptible to disturbance, but tolerance is higher than during the calving and post-calving periods (e.g., calves have greater mobility, and more range is available due to snow melt).

By mid-summer (July 16–August 7), the majority of the PCH has left the coastal plains. Animals in Alaska have moved into the southern portion of the Brooks Range, and animals in Yukon have moved southeast into, or are en route to, the northern Richardson Mountains. Daily movement rates remain high through the mid-summer period, and though group sizes are often still large, groups are often breaking up and more dispersed than the aggregations that occur during post-calving and early summer. Mid-summer has an importance rating of 2 for the same reasons identified for early summer. Mid-summer is the period of potentially highest insect harassment, and, similar to early summer, habitat selection may favour insect avoidance over areas with the highest forage. Lactating females suffering insect harassment may be in an energy deficit.

During late summer and fall migration (August 8–October 7), insect harassment declines dramatically. Forage quality and abundance also begin to decline but are generally still abundant. Caribou exhibit high feeding rates during this period and gain fat reserves for the winter. During this period, the herd breaks up into smaller groups and disperses widely across North Yukon, mostly staying north of the treeline for most of the period. Fall migration often follows terrain features like ridges and valleys, but movement routes are unpredictable from year to year. Late-summer and fall migration is considered to have less importance (rank 3) due to the abatement of insect harassment, the relative abundance of forage across a variety of habitat types, the dispersed distribution of the herd, and relatively high tolerance to disturbance (Porcupine Caribou Technical Committee 1993).

The rut and late fall (October 8–November 30) continue to be a period of broad distribution and movement by the PCH, including widespread movement south of the treeline. In Yukon, the rut can occur from the Richardson Mountains to the southern Ogilvie Mountains. The areas where the rut occurs do not appear to have affinity from year to year. Rather, the rut appears to occur wherever the herd happens to be at that time along the fall migration. The rut and late fall period has the lowest level of importance(rank 4), due to the lack of insects, large range extent, ample food, the dispersed distribution of the herd, and relatively high tolerance to disturbance (Porcupine Caribou Technical Committee 1993).

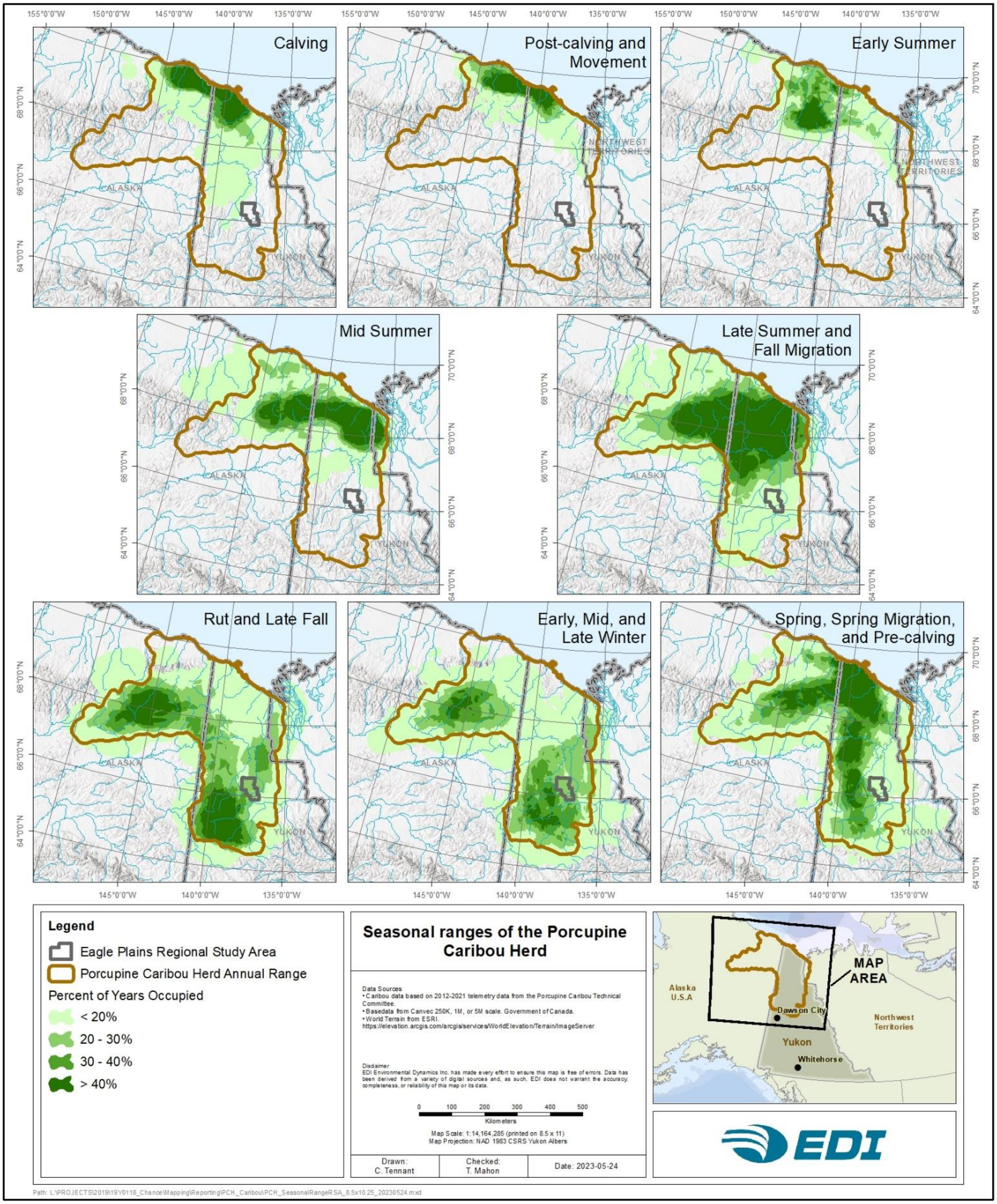
During early, mid, and late winter (December 1–March 31), the PCH is at its most dispersed stage, both in terms of the extent of the range it uses and group aggregations. Average daily movement distances (2 km per day [km/day] to 5 km/day) (Russell and Gunn 2017) are lower than in other seasons, except for cows during calving (Russell and Gunn 2017). Winter range use varies from year to year, depending on snow depth and condition. In Yukon, during deep snow years, use is concentrated in the Richardson Mountains and the Ogilvie-Hart basins. The Whitestone River and Eagle Plains areas are used more in low snow years. Forage during winter consists primarily of lichens. Unlike reports for some other caribou herds, winter habitat is generally not considered limiting for the PCH (Russell et al. 1993). In shallow to average snow years, the caribou maintain neutral to surplus energy balances (Russell et al. 1993). The PCH is relatively tolerant to human activity during the winter (Porcupine Caribou Technical Committee 1993). Similar to the rut and late fall period, winter has the lowest level of importance (rank 4) due to the lack of insects, large range extent, ample food, the dispersed distribution of the herd, and relatively high tolerance to disturbance (Porcupine Caribou Technical Committee 1993).

During the spring, spring migration, and pre-calving season, (April 1–May 31) caribou begin moving north toward the calving grounds. Average daily movement rates increase from approximately 6 km/day at the start of the season to approximately 24 km/day through May. Similar to the fall migration, no well-defined migration corridors are used consistently from year-to-year during spring migration, but certain terrain feature types like ridges and valleys are regularly used. During spring migration, local snow conditions often affect movement patterns and routes. In years or locations with low snow levels, migration tends to be more dispersed. In years or locations with high snow levels, movements tend to be more concentrated along trail networks on ridges (Porcupine Caribou Technical Committee 1993). Caribou, especially pregnant cows, typically enter an energy deficit during spring due to reduced forage availability as they leave the lichen-rich taiga and before forbs have emerged; in addition, higher energy expenditure is associated with migration. Spring is rated as higher in importance than winter, but still relatively low overall (rank 3), due to lack of association with specific habitats, relatively low threats from predators, and lack of insect harassment (Porcupine Caribou Technical Committee 1993).

Table 6-1. Key life cycle periods for the Porcupine Caribou Herd (after Porcupine Caribou Technical Committee 1993). The Porcupine Caribou Herd overlaps the Project Regional Study Area during Rut and Late Fall and Early, Mid, and Late Winter.

Season	Dates	Characteristics	Importance*
Early, Mid, and Late Winter	Dec. 1 – Mar. 31	The herd is at its most dispersed at this time across 2 winter ranges: in Yukon, mostly south of the Porcupine River in boreal taiga and in Alaska, centred in the Chandalar River/Arctic Village area. Winter range use varies from year to year, depending on snow depth and condition. Caribou at this time of year are relatively tolerant to human activity. In shallow to normal snow years, animals can gain weight.	4
Spring, Spring Migration, and Pre-Calving	Apr. 1 – May 31	Herd distribution varies depending on snowmelt; migration routes vary yearly. Pregnant females are typically in an energy deficit due to reduced forage once they leave the lichen-rich taiga.	3
Calving (cows)	June 1 – 10	Calving occurs on the coastal plain of NE Alaska and, to a lesser degree, NW Yukon. This area offers reduced predators and abundant spring forage; no alternative range is available. Cows are at the lowest point of physical condition and are least tolerant to human disturbance.	1
Post-Calving and Movement (cows)	June 11 – 30	As calves develop over the first two weeks of life, the cows and calves tend to aggregate into larger groups and increase movement rates to track plant green-up. The post-calving period imposes high energetic demands on lactating females, and cow/calf groups are relatively intolerant of disturbance. The post-calving range is primarily in Alaska, and cows that calved in Yukon tend to move west along the foothills into Arctic National Wildlife Refuge. Insect avoidance can affect distribution by the end of June.	1
Calving to Movement (bulls)	June 1 – 30	Bulls, non-pregnant cows, and subadults tend to concentrate east of the calving grounds in northern Yukon. Animals track the progression of green-up from the coastal plains to the northern foothills and into intermountain regions.	3
Early Summer	July 1 – 15	Cows continue to require a high-energy intake for milk production, but insect avoidance also drives distribution. Key areas selected for insect avoidance are the coastal plain adjacent to the Beaufort Sea (mostly cows/calves) and mountains in the Brooks and British Mountains (mostly bulls and cows without calves). Long-distance movements during this period are also an insect avoidance behaviour.	2
Mid Summer	July 16 – Aug. 7	Mid-summer continues to be a period of high insect harassment. Two areas are consistently used – the northern Richardson Mountains in Yukon and the southern portion of the Brooks Range in Alaska. Females with cows may be in energy deficit.	2
Late Summer and Fall Migration	Aug. 8 – Oct. 7	As insect activity declines, the herd disperses widely but mostly stays north of the tree line until the latter part of the period – in Alaska south of the Brooks Range and in Yukon north of the Porcupine River. Animals exhibit high feeding rates and gain fat for the winter.	3
Rut and Late Fall	Oct 8 – Nov. 30	The region where rut occurs has no affinity from year to year; rut occurs wherever the herd happens to be along fall migration. In Yukon, distribution can occur from the southern Ogilvie Mountains to the Richardson Mountains.	4

* 1 = highest importance, 4 = lowest.



Data Sources
- Caribou data based on 2012-2021 telemetry data from the Porcupine Caribou Technical Committee.
- Basedata from Canvec 250K, 1M, or 5M scale. Government of Canada.
- World Terrain from ESRI.
https://elevation.arcgis.com/arcgis/services/WorldElevation/Terrain/ImageServer

Disclaimer
EDI Environmental Dynamics Inc. has made every effort to ensure this map is free of errors. Data has been derived from a variety of digital sources and, as such, EDI does not warrant the accuracy, completeness, or reliability of this map or its data.

Map Scale: 1:14,164,285 (printed on 8.5 x 11)
Map Projection: NAD 1983 CSRS Yukon Albers

Drawn:
C. Tennant

Checked:
T. Mahon

Date: 2023-05-24

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Map 6-1. Seasonal ranges of the Porcupine Caribou Herd from 2012–2021.

6.2.3 DIET AND HABITAT

Barren-ground caribou are generalist foragers who feed on grasses, sedges, forbs, lichens, and shrubs during the growing season. During winter lichens constitute the primary forage of most barren-ground caribou populations (Photo 6-1 and Photo 6-2). Over three winters, the composition of PCH fecal samples was similar, consisting of, on average, 64% fruticose lichens, 11% evergreen shrubs, 8% moss, 6% horsetails, and 5% foliose lichens (Russell et al. 1993).

Russell et al. (1993) surveyed lichen distribution across the Yukon portion of the PCH range. Fruiticose lichens were widespread across survey plots and overall biomass estimates were similar to values reported in other western barren-ground caribou ranges (Joly and Cameron 2018). Within the PCH's Yukon range, lichen biomass varied across regions, habitat (range) types and stand ages. Average lichen biomass varied substantially among regions, with the highest biomass occurring in Eagle Plains (78.3 g/m^2), followed by North Fork Pass (45.0 g/m^2), Chapman Lake (33.6 g/m^2), Ogilvie Valley (32.5 g/m^2), and Richardson Mountains (29.9 g/m^2). In terms of habitat type, lichen biomass varied over three-fold across the seven habitats (range) that Russell et al. (1993) surveyed. Open conifer forest types had the greatest lichen biomass, and the forb herbaceous type had the lowest.

In terms of stand age, the generally accepted theory is that lichen biomass is greatly reduced following a fire, increases in abundance up to 125–175 years, and decreases as lichens are overtaken by mosses and shrubs (Klein 1982). Field surveys by Russell et al. (1993) found that lichen biomass in the PCH range was actually highest in stands <50 years since fire, and that lichen biomass decreased across all subsequent older age classes, to a nearly 50% reduction in the oldest age class (>270 years) (Photo 6-3). This local data suggests that younger stands may make a greater contribution to lichen forage than previously believed. Russell et al. (1993) emphasizes the importance of a mosaic of stand age classes, resulting primarily from wildlife, to maintaining lichen biomass at the regional level over time.

Although habitat selection is often driven by forge availability, especially in winter, reducing predation risk (Latham et al. 2011) and minimizing exposure to insect harassment during summer (Russell and Nixon 1990) also factor into habitat selection by caribou.

6.2.3.1 Effects of Snow

The regional patterns of PCH distribution in winter vary among years, often related to snow accumulation, which can limit forage availability (Russell et al. 1993). During the 1970s and 1980s, the distribution of the PCH in winter varied in a regular pattern across four regions with different snow regimes: Yukon/Alaska border, Richardson Mountains, Ogilvie/Hart region, and the Whitestone/Eagle region (Russell et al. 1993).

On average, the Ogilvie/Hart region had the lowest mean snow accumulation. During winters when most animals occupied this region snow depths were normal to high across the overall winter range. Heavy snows in the north early in the season seemed to emphasize concentrated use in this region, pushing animals to the south during the fall migration and rut. Once animals moved into the Ogilvie/Hart basin they typically remained in the region, taking advantage of the comparatively shallow snows, until spring migration.

During the winters when most Yukon wintering animals occupied the Richardson Mountains, snow depths tended to be normal to above normal. Strong winds in the Richardson Mountains resulted in uneven snow distribution, with many areas having reduced snowpacks, including some areas being blown completely bare. During the winters when most Yukon wintering animals occupied the Whitestone/Eagle area, snowpacks were invariably below normal. This area generally had the highest lichen biomass, but snow depths appeared prohibitive during years with normal to deep snow. In the two years when most of the Yukon wintering animals occupied the Yukon/Alaska border area (overlapping with the Fortymile Herd), snows were deeper than average in all other wintering areas.

Photo 6-1. Mesic, mature forest, with mat-forming terrestrial lichens in the Eagle Plains RSA.

Photo 6-2. **Lichen communities are often diverse in Eagle Plains. This lichen mat includes *Cladonia spp.* (lighter green) that are preferred forage for caribou, as well as *Stereocaulon spp.* (darker grey) and *Flavocetraria spp.*, which are both also eaten by caribou but less preferred.**

Photo 6-3. **Lichen cover is generally reduced in regenerating burns. However, EDI observed high lichen abundance in some regenerating burns, consistent with previous work by other researchers (Russell et al. 1993).**

6.2.4 POPULATION LEVELS AND TREND

Although most barren-ground caribou subpopulations are declining (COSEWIC 2016), the PCH numbers have increased over the last two decades. The last successful population survey in 2017 estimated the population at 218,457 (95% CI = 202,106 – 234,808) caribou (Porcupine Caribou Technical Committee 2019). Population surveys of the PCH began in the 1970s. The objective is to survey the herd every two to three years, but that period is sometimes extended depending on herd behaviour (aggregation patterns), funding, and logistical issues. Since the first survey in 1972, the PCH has had two periods of population growth, with an interceding decline (Figure 6-1). From 1972 to 1979 the population was relatively stable at just over 100,000 animals. By 1989 the herd had increased to approximately 178,000. Over the next 12 years, the herd declined by 55,000 to 123,000 in 2001. By 2010, the herd had recovered to 169,000 and increased to 218,000 in the last survey in 2017. During the latest growth phase, 2010 to 2017, the estimated population growth rate of 3.7% is almost identical to the growth rate during the 1972 to 1989 growth phase (Porcupine Caribou Technical Committee 2019).

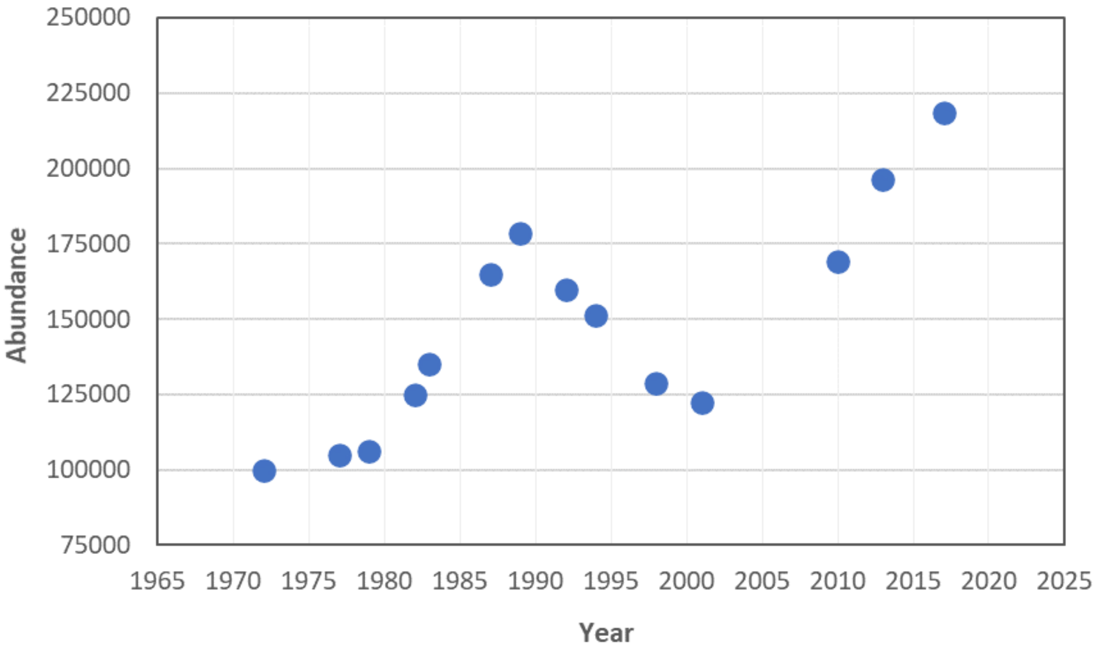

Figure 6-1. The population size of the Porcupine Caribou Herd from 1972 to 2017 (Porcupine Caribou Technical Committee 2019).

6.2.5 POPULATION DYNAMICS

Large magnitude population fluctuations are a key ecological trait of barren-ground caribou. Subpopulations (herds) often experience declines of >80% and increases >500%, which occur over several decades and caribou generations (COSEWIC 2016). Based on scientific studies and Indigenous Traditional Knowledge, the interval between population highs varies from approximately 30–80 years among subpopulations (Ferguson et al. 1998, Gunn 2003, COSEWIC 2016). There has long been debate about whether the intervals between population highs and lows, and the population levels that occur at highs and lows, are regular enough to be considered cycles (Gunn 2003, COSEWIC 2016, Bongelli et al. 2020). A recent analytical study found that historical population fluctuations of the barren-ground caribou population overall and 9 of 11 sub-populations fit a sine-cyclic model with periods ranging from 26–55 years (Bongelli et al. 2020). However, COSEWIC (2016) points out that cumulative changes in the environment, habitat, climate, and harvest regimes for many caribou subpopulations are without historical precedent, and therefore it is uncertain whether future populations patterns will follow historical patterns.

Despite large magnitude changes in the abundance of barren-ground caribou, there is still a poor understanding of how limiting factors regulate population change. Predation, human harvest[1], parasites and disease, and food supply are all considered limiting factors of barren-ground caribou (COSEWIC 2016); however, no single factor has been conclusively demonstrated as a primary limiting factor across subpopulations and over time. Despite strong advocacy for certain factors by certain researchers (e.g., for predation by Bergerud (1996)), the weight of evidence is that population dynamics involve complex interactions among limiting factors that vary over time and among subpopulations (Klein 1991, Whitten 1996). Over the 50 years that the PCH has been monitored, the population has not exhibited population fluctuations as large as other barren-ground caribou populations (COSEWIC 2016). This may be due to the large annual and seasonal ranges and diversity of habitats across ranges (Russell et al. 1993, Whitten 1996). Whitten (1996) suggests that periods of decline are caused by nutritional stress and predation exacerbated by adverse weather. Population growth during periods of favourable weather is dampened by a combination of poor nutrition, predation, and human harvest and disease. No true density dependent regulation or equilibrium was observed for the PCH from the 1970s to early 1990s (Whitten 1996).

6.2.6 LIMITING FACTORS

6.2.6.1 Food Supply and Overgrazing

The amount and distribution of forage have implications for population distribution and demography of barren-ground caribou (COSEWIC 2016). In general, food limitation is most prevalent during winter, when caribou diet consists primarily of lichen, and does not pose a constraint to caribou from late-spring through fall when graminoids, forbs, and deciduous shrubs are bountiful and predominate their diet (Thompson and McCourt 1981, Russell et al. 1993). Lichen availability depends on both density-dependent and density-independent factors, but the degree to which either is a limiting factor depends on ecological context. For example, density-dependent competition for forage, when local densities are high, and competition is intense, can cause overgrazing of lichen and reduce its abundance (Ferguson et al. 2001, Joly 2009). Recovery of lichen communities following overgrazing can take more than 20 years (Klein 1987).

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[1] Human harvest is considered a natural population factor for barren-ground caribou because hunting has occurred for centuries (Sherry and Vuntut Gwitchin First Nation 1999, COSEWIC 2016). However, it is recognized that the nature of hunting has dramatically changed over the last century with the advent of high-powered rifles and snowmobiles.

The potential for lichen supply to regulate caribou herd size and demography is most likely for herds with small ranges on low productivity tundra islands (e.g., Klein 1987). For large, widely-distributed herds, it is more likely that density-independent factors, such as climate and natural disturbance, contribute to limitations in lichen supply that affect caribou distribution (Gunn et al. 2011). Lichen is a slow-growing food source; its distribution is affected by fire (see Joly 2009) and its accessibility depends on regional snow conditions, such as snow hardness and depth (Collins and Smith 1991, COSEWIC 2016). Therefore, caribou tend to shift winter ranges and foraging locations based on burn and snow conditions so that they may access areas with higher lichen abundance (Jandt et al. 2008, Pedersen et al. 2021). In the PCH, annual variation in the distribution of caribou during winter is thought to be a result of caribou tracking available and accessible lichen patches (Russell et al. 1993, WMAC 2009).

The potential for food supply, especially lichen, to regulate the PCH is limited because of their large annual and seasonal ranges and the diversity of habitats (e.g., several broad ecoregions) found within those ranges. Variation in distribution and range use may counteract any limitations on food supply at local scales (Hinkes et al. 2005). PCH migration from the tundra, at the northern extent of their range, to the taiga cordillera, at the southern extent of their range, may serve as a strategy to maximize the available food supply. Overall, the PCH winter range is relatively rich in lichen resources and is comparable to, or better than, those of other herds that winter in taiga regions (Russell et al. 1993).

Forest Fires

Forest fires are a significant natural disturbance agent in taiga forests and play a substantial role in the availability of caribou forage, especially lichen. Occasional fires are important to maintaining lichen biomass at a landscape level. Peak lichen biomass is generally associated with forests 125-1750 years old before lichen volumes decrease due to competition from other species like moss and shrubs (Klein 1982). However, frequent fires can reduce the extent of mature and old forests where productive lichen biomass occurs. For example, forest fires in the winter range of the Bathurst Herd reduced the area of forest by 30% between 1990 and 2000 (Chen et al. 2013). More broadly, the average area burned by large fires in Canada's taiga has increased since the 1960s (Krezek-Hanes et al. 2010). Climate change modelling suggests a further increase in fire extent of 25% by 2030 and 75% by the end of the century (Wotton et al. 2010). Generally, caribou avoid burned areas in winter for several decades until lichen biomass increases to the point where it is favourable for caribou to forage. Changes in landscape vegetation patterns due to fire are believed to affect regional seasonal use areas and migration routes of caribou (Gunn et al. 2011).

The PCTC monitors the extent of burn areas across the forested portion of the PCH annual range; since 1960, 18% of the area has burned (Porcupine Caribou Technical Committee 2021a). The five-year average of the area burned in the Yukon portion of the PCH annual range is 1,552 km² (Porcupine Caribou Technical Committee 2021a).

6.2.6.2 Predation

Wolves are the primary predators of barren-ground caribou (COSEWIC 2016). However, grizzly bears can also be significant predators of caribou, especially calves (Gau et al. 2002). Predation is an important factor affecting many facets of caribou ecology, as caribou movements and habitat choices are often made to minimize exposure to predators (Bergerud 1996). One of the hypotheses about why barren-ground caribou migrate is that it reduces predation risk. The idea is that moving throughout the year limits the numerical response of wolves (Hayes and Russell 2000). In the NWT, wolf densities in the arctic tundra calving grounds were only 22% compared to wolf densities in the taiga, where the herd wintered. However, as caribou numbers increase, their range expands, causing some caribou to return earlier to the ranges of taiga denning wolves, which results allows wolf numbers to increase (Heard et al. 1996).

A study of wolf predation on the PCH estimated that wolves killed about 7,600 adult caribou each year, regardless of herd size (Hayes and Russell 2000). In 1992 this corresponded to a predation rate of 5.8%, or about one-third of adult mortality. As the PCH declined through the 1990s, the predation rate by wolves increased from 5.8% to 7.4%. Migratory movements effectively reduced wolf predation during the calving through summer seasons due to the combination of smaller ranges and lower densities of wolves in the arctic tundra. Only 16% of the mortality occurred during the calving/summer seasons compared to 84% during the fall and winter seasons, when wolves were predominantly in the taiga zone.

Generally, wolf predation does not appear to regulate barren-ground caribou subpopulations (Crête and Huot 1993, Messier 1995, Hayes and Russell 2000). Hayes and Russell (2000) estimated that the predation rate would have had to be near twice the observed level to cause the PCH to decline during their study. However, the limiting effect of predation increases as population size decreases, which can result in a cumulative effect with other limiting factors as the population declines (COSEWIC 2016).

6.2.6.3 Hunting

Human hunting of barren-ground caribou has occurred for centuries over much of the species range in North America (Sherry and Vuntut Gwitchin First Nation 1999, COSEWIC 2016). Although humans and caribou have co-existed for centuries, technological changes (e.g., high-powered rifles, snowmobiles, and aircraft) and social changes (e.g., commercial hunting) have changed the potential effects human hunting can have on some barren-ground caribou populations (COSEWIC 2016). Over the last half-century, there has been clear evidence of population-level impacts from harvesting. From 2008 to 2011 the estimated harvest rate on north Baffin Island was 41%. During the mid-2010s harvest rates of the Southampton population were considered well beyond sustainable limits (COSEWIC 2016). Harvest is more likely to pose a threat when population monitoring data is poor and/or harvest management decisions lag population declines. For example, in the Bathurst subpopulation, a constant harvesting level during a period of population decline resulted in an increase in the harvest rate (i.e., as a percent of population size) from 2–4% to 10–16% of abundance (Boulanger et al. 2011).

There is no simple, sustainable harvest level applicable to all barren-ground caribou populations. Effects of harvesting depend on herd size, population trend, and the proportion of females that are harvested (Boulanger and Adamczewski 2016). Harvesting may also interact with other limiting factors, such as predation and weather (Klein 1991). Most harvest plans target a total harvest rate of 0–5%, depending on herd status, and with restrictions on harvesting females (e.g., Environment and Natural Resources 2013).

Recognizing the importance of effective harvest management for both the conservation and continued long-term harvest of the Porcupine Caribou, the Porcupine Caribou Management Board led the development of a comprehensive *Harvest Management Plan for the Porcupine Caribou Herd in Canada* (HMP) in 2010 (Porcupine Caribou Management Board et al. 2010)[2]. Key components of the plan include the determination of specific management actions related to the estimated herd size and a set of general best hunting practices. Management actions are determined each year using a set of six population indicators: 1) estimated herd size, 2) harvest information, 3) adult cow survival, 4) calf birth rate, 5) calf survival to nine months, and 6) body condition. In addition, descriptive indicators from people on the land include caribou health, hunting success, and weather conditions that affect caribou. The results from the indicators are rolled up into a 4-class colour chart, and management actions are specified for each colour zone. Management actions become more restrictive across each zone once the herd falls below 115,000 animals, including ceremonial harvests only below 45,000 animals (Porcupine Caribou Management Board et al. 2010).

Implementation of the HMP is guided by a formal Implementation Plan (Porcupine Caribou Management Board 2016). Key components of the Implementation Plan are to 1) guide annual monitoring of the population indictors and harvest levels, 2) provide a forum for all the HMP Parties to review and discuss the population indicators and harvest levels and 3) provide an annual recommended harvest management colour zone plus any additional management actions that are deemed appropriate. Population indictors are monitored each year by the PCTC and summarized in an annual report (e.g., Porcupine Caribou Technical Committee 2021). Annual harvest levels are monitored by each Party or user group and are compiled by the PCTC into an annual report (e.g., Porcupine Caribou Technical Committee 2021b). Each year, the HMP Parties hold an annual meeting to discuss the results of the population and harvest monitoring and determine the harvest management zone for the following year and any additional management actions the Parties feel may be required.

Over the eight-year period, 2013–2014 to 2020–2021, the annual reported harvest rates of Porcupine Caribou have ranged from 749 to 3,367 caribou. The reported annual harvest rates are considered the minimum estimated harvest (Porcupine Caribou Management Board 2022). Due to reporting challenges faced by some Parties, significant harvest may be missed in some regions in some years. Notwithstanding the reporting challenges, the reported Canadian harvest is estimated to be between 1% and 2% of the 2017 population estimate of 218,000 caribou and is not considered a threat to population decline (Porcupine Caribou Management Board 2022). The comprehensive measures within the HMP to monitor and respond to declines in the PCH (i.e., by reducing harvest) provide a solid system to minimize the potential effects that harvesting could have on the herd.

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[2] The HMP was agreed to by eight Parties with authorities and responsibilities managing the PCH within Canada, including Gwich'in Tribal Council, Inuvialuit Game Council, Vuntut Gwitch'in Government, Tr'ondëk Hwëch'in Government, First Nation of Na-Cho Nyäk Dun, Government of the Northwest Territories, Government of Yukon, and Government of Canada.

6.2.6.4 Parasites and Disease

Biting and parasitic insects, pathogens (i.e., viruses and bacteria) and internal parasites are important factors in caribou ecology and population dynamics (Gunn and Irvine 2003, Kutz et al. 2012, COSEWIC 2016).

Harassment by parasitic insects can be a key driver of behaviour, movement, and body condition of caribou during summer (Downes et al. 1986, Russell and Nixon 1990). Warble flies (*Hypoderma tarandi*) and nose botflies (*Cephenemyia trompe*), both of the family Oestridae, are the primary source of harassment for Arctic caribou, though mosquitoes (Culicidae), blackflies (Simuliidae), and horseflies (Tabanidae) also are known to cause harassment (Downes et al. 1986, Toupin et al. 1996, Witter et al. 2012a). There are two primary harmful effects of insects. The direct effects of the parasitic burden can result in decreased body condition and reproduction (Albon et al. 2002, Cuyler et al. 2012). Indirect effects include the behavioural response to avoid insects, which includes a reduction in time spent foraging, increased energy expenditure, and selection of low-quality habitats such as ridge tops, coastal regions, snow patches, and unvegetated areas (Downes et al. 1986, Russell and Nixon 1990, Walsh et al. 1992, Toupin et al. 1996, Witter et al. 2012a). These behavioural responses can result in reduced body condition going into the winter with negative implications for survival and fecundity (Russell et al. 1993, Cuyler et al. 2012).

The responses of caribou to disease and other parasites are less evident and less studied than responses to insects. Most occurrences of disease and internal parasites in caribou are at subclinical levels (not severe enough to produce observable symptoms) but can still result in reduced body condition and fitness (Gunn and Irvine 2003). A range of pathogens and parasites observed in caribou includes viruses, bacteria (e.g. brucellosis), helminths (e.g., roundworms, tapeworms, and flukes) and protozoa (Tessaro and Forbes 1986, Gunn and Irvine 2003, Kutz et al. 2012, COSEWIC 2016). Gunn and Irvine (2003) suggest that caribou may have evolved foraging strategies to minimize exposure to parasites. Similar to parasitic insects, internal parasites can reduce caribou body condition and pregnancy rates resulting in population-level impacts (Albon et al. 2002, Kutz et al. 2012).

6.2.6.5 Climate Change

Climate change can potentially affect barren-ground caribou populations negatively and positively through various mechanisms. A recent literature review on this topic identified five primary factors that affect caribou population dynamics that could be affected by climate change: (i) summer range conditions, (ii) parasites and disease, (iii) movement, migration, and distribution, (iv) extreme weather and icing events, and (v) winter range conditions (Mallory and Boyce 2018). The effects of these factors are likely to be complex and interact with climate and non-climate-related factors that will result in substantial local variation and uncertainty in potential outcomes to caribou (Cebrian et al. 2008, COSEWIC 2016).

On balance, climate change is predicted to have mostly positive effects on the summer range condition of barren-ground caribou. Increasing temperatures will likely lead to longer growing seasons, increases in plant productivity, and an earlier onset of spring. Pearson et al. (2013) predict dramatic increases of 29-68% in above-ground plant biomass in the arctic by 2050. These effects could increase caribou body condition and reproductive success by lengthening the summer period of food availability, by increasing the amount of forage and providing earlier access to forage (i.e., relative to the energetically demanding periods of birthing and lactation) (Tews et al. 2007, Cebrian et al. 2008, Mallory and Boyce 2018). This prediction is supported by a 20-year study in Norway, 1994–2015, where reindeer body mass resulted from greater plant productivity associated with warmer summer temperatures (Albon et al. 2017). In the PCH, earlier and warmer springs over the last thirty years have resulted in more food available for nursing cows, correlated with higher early calf survival (Griffith et al. 2002). However, positive effects on caribou summer range may not occur uniformly across all ranges. Some researchers have suggested the potential for a trophic mismatch between the timing of caribou and vegetation phenologies (Vors and Boyce 2009). Also, a predicted shift to greater cover of woody shrubs may be negative to caribou because shrubs tend to have greater chemical and structural defenses against herbivory and lower available protein than other forage such as grasses, forbs and sedges (Thompson and Barboza 2014).

Most studies suggest that climate change is predicted to increase the potential effects of parasitic insects and disease on barren-ground caribou (Mallory and Boyce 2018). Warmer and longer summers are likely to increase the length and severity of insect harassment, leading to lower body condition of caribou, including lactating cows and calves (Witter et al. 2012b). Climate change is also predicted to increase parasitism by other taxa, such as protozoans and helminths, and the northern expansion of some parasitic species has already been observed (Kutz et al. 2013). Certain ungulate diseases are also expanding northward as the climate warms (Arifin et al. 2020). Arctic ecosystems and species may be more susceptible to the spread of parasites and diseases than southern populations because they have had less exposure and opportunity to develop resistance from an evolutionary perspective.

Extreme weather, such as icing events, large changes in snowfall patterns, and summer heat episodes, is predicted to increase with climate change and negatively affect caribou (Mallory and Boyce 2018). Restricted or total loss of access to forage due to icing in the winter range can significantly affect survival and body condition for barren-ground caribou (Tyler 2010, Hansen et al. 2014). These events tend to be more catastrophic in the high Arctic but have been reported broadly across caribou ranges; including within the VGFN territory where the refreezing of wet snow one winter restricted access to food and greatly affected the health of a caribou herd (Sherry and Vuntut Gwitchin First Nation 1999, p. 186). Ice crusts on snow can also negatively affect travel abilities, body condition, and predation risk of caribou (Griffith et al. 2002). Deep snowpacks can reduce the availability of terrestrial lichen forage in winter. The Porcupine Caribou are known to vary winter range use in response to regional weather patterns (Russell et al. 1993). Changes to regional snow patterns may make areas, such as Eagle Plains, less available to the herd (Russell and Gunn 2017).

Several studies have predicted that climate change could affect the movements, migration and distribution of barren-ground caribou (Mallory and Boyce 2018). Effects are predicted to be most dramatic for subpopulations that travel over ice during the winter and where warming temperatures are already reducing the extent and duration of ice (Poole et al. 2010). Changes in regional snow conditions predicted due to climate change can also affect the migration patterns and seasonal distributions of barren-ground caribou. Russell et al. (1993) observed that the PCH adjusted the concentration of winter range use in relation to winter snowpacks. Areas such as Eagle Plains, which receive the greatest use during low snow years may become less available if regional snowpacks increase. Other studies have indicated that snow depths and snow conditions (e.g., crusting) affect the migration routes, behaviours, and energetic costs of Porcupine Caribou during spring migrations (Whitten 1996, Griffith et al. 2002).

During winter, many barren-ground caribou subpopulations forage primarily on terrestrial lichen. Climate change is predicted to reduce terrestrial lichen biomass due to increased productivity from other plants (notably shrubs) and, in the boreal/taiga forest, due to increased forest fires (Mallory and Boyce 2018). Some studies indicate the area burned each year in northern Canada could double by the end of the century (Wotton et al. 2010). The potential adverse effects of climate change on caribou winter range depend mainly on the assumption that caribou require lichen-rich diets in winter. Some researchers have long questioned the need for lichens during the winter (Bergerud 1974), and more recent studies suggest that winter diets dominated by graminoids rather than lichens were not detrimental to caribou populations (Heggberget et al. 2002, van der Wal 2006). However, in the Western Arctic Herd a decline in recruitment and abundance in the herd occurred when the winter diet showed increased graminoids and decreased lichens being consumed (Joly 2009). In the past, the conditions of winter range and winter weather were not considered to be limiting to the PCH (Russell et al. 1993, Porcupine Caribou Technical Committee 1993). However, the combination of reduced lichen forage, deeper snow in some areas, and extreme weather events that are predicted to occur with climate change has the potential to increase the limiting effect of the winter range on the PCH.

6.3 PORCUPINE CARIBOU HERD MANAGEMENT

There is a long history of co-management of the PCH among indigenous, state, territorial and federal governments, with international and national management boards formalizing in the mid-1980s. Canada and the United States of America co-manage the herd under the *Agreement Between the Government of Canada and the Government of the United States of America on the Conservation of the Porcupine Caribou Herd (1987)*. The International Porcupine Caribou Board (IPCB) is comprised of Canadian and American representatives. The Porcupine Caribou Management Board (PCMB) is a co-management board for the Canadian portion of the herd's range, formed under the *Porcupine Caribou Management Agreement (1985)*. The *Porcupine Caribou Management Agreement (1985)* was established to coordinate management efforts toward conserving the herd and maintaining and protecting special harvesting rights in the Porcupine Caribou for indigenous users while providing for other users to share in the harvest. The PCMB and IPCB have led or contributed to the development of several plans for the PCH, including:

- *Plan for the International Conservation of the Porcupine Caribou Herd (1987),*
- *Wildlife Conservation and Management Plan for Yukon North Slope (2002),*
- *Porcupine Caribou Harvest Management Plan (2010)* and an associated *Implementation Plan (2010, revised 2016),*
- *Porcupine Caribou Herd Strategic Framework 2015-16 to 2019-20.*

The international agreement also provided for a joint technical committee to coordinate research and monitoring activities and advise the IPCB on scientific matters surrounding the herd. This committee, known as the "Porcupine Caribou Technical Committee" (PCTC), has been functioning since the 1970s. Over time, the PCTC has taken on the role of advising the Canadian PCMB and the IPCB. The PCTC comprises biologists and scientists from Yukon, Alaskan, Canadian and American government agencies, university researchers, and other caribou experts.

The PCTC leads most of the monitoring and research initiatives associated with the PCH on behalf of the PCMB and the IPCB. Core monitoring work that the PCTC does includes population abundance surveys (normally every two to five years depending on herd behaviour, funding, and logistics), population demographic monitoring (e.g., calf birth and survival rates and important age and sex ratios), seasonal movement monitoring (via GPS telemetry tracking), caribou body condition monitoring, habitat and human disturbance assessments, and annual snow surveys. Monitoring results are normally provided to the PCMB and the IPCB via annual reports (e.g., Porcupine Caribou Technical Committee 2019) and via presentations at the annual harvest meetings. The PCTC also intermittently conducts specific data analyses, such as habitat selection studies and seasonal range mapping, to support land use planning and other management initiatives.

6.3.1 PROTECTED AREAS AND MANAGEMENT AREAS AND PLANS

A network of parks protects the portion of the PCH annual range that occurs within Yukon, special management areas, conservation areas, wilderness areas, protected areas, ecological preserves, habitat protection areas, and IMA zones within the North Yukon Regional Land Use Plan and the Peel Watershed Regional Land Use Plan (Map 6-2). In total, 54% of the annual range of the PCH within Yukon falls within some type of protected area where industrial activity is prohibited, 36% of the annual range occurs within regional LUP IMA zones, and 9% of the annual range is not covered by any type of land management zonation. A summary of the overlap of different types of protected areas and management areas with the seasonal ranges of the PCH is provided in Table 6-2.

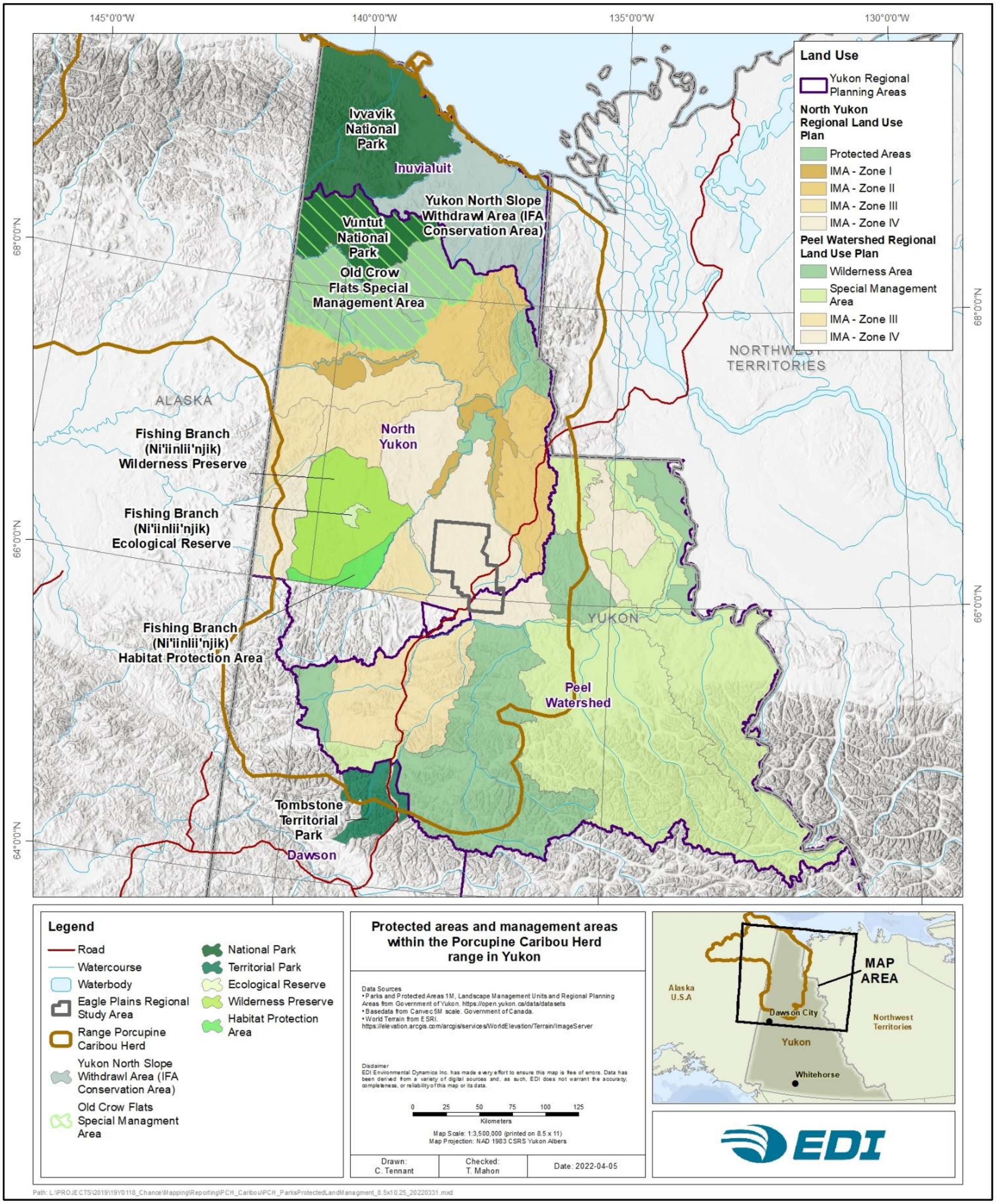
The Project is within the North Yukon Planning Region and Peel Watershed Planning Region and is subject to the NYLUP (Vuntut Gwitchin Government and Yukon Government 2009) and PWLUP (Peel Watershed Planning Commission 2019). The project falls within IMA Zone IV of both plans, a zone with lower ecological and cultural values and the highest permissible development of the four IMA zones. The NYLUP and PWLUP include management objectives and strategies to minimize the effects of human development activities on wildlife and wildlife habitat, generally, and specific objectives and strategies for caribou.

In addition to the Regional Land Use Plans, the Habitat Programs Section of the Yukon Department of Environment, Yukon Government maintains an inventory of important habitat areas for focal management species, including caribou, within the Wildlife Key Area Inventory (Environment Yukon 2014b). Wildlife Key Areas are specific geographic locations used by wildlife for critical, seasonal life functions, such as calving areas and mineral licks. No Wildlife Key Areas for caribou occur within the Project RSA (Government of Yukon 2015).

Table 6-2. Summary of the overlap of different types of protected areas and management areas with the seasonal ranges of the Porcupine Caribou Herd.

Season	Area (km²)	% of Seasonal Range					
		Protected Areas [1]	IMA I	IMA II	IMA III	IMA IV	Not Zoned
Early, Mid, Late Winter	58,090	37	2	8	19	18	15
Spring, Migration and Pre-calving	68,463	55	1	7	21	7	9
Calving	14,636	100	0	0	0	0	0
Post-Calving and Movement	7,622	100	0	0	0	0	0
Early Summer	5,901	100	0	0	0	0	0
Mid Summer	24,417	86	0	14	0	0	0
Late Summer and Fall Migration	57,928	60	4	15	13	8	0
Rut and Late Fall	65,249	31	3	10	23	13	20

[1] including parks, special management areas, conservation areas, wilderness areas, protected areas, ecological preserves, and habitat protection areas.



Data Sources
- Parks and Protected Areas 1M, Landscape Management Units and Regional Planning Areas from Government of Yukon. https://open.yukon.ca/data/datasets
- Basedata from Canvec 5M scale. Government of Canada.
- World Terrain from ESRI. https://elevation.arcgis.com/arcgis/services/WorldElevation/Terrain/ImageServer

Disclaimer
EDI Environmental Dynamics Inc. has made every effort to ensure this map is free of errors. Data has been derived from a variety of digital sources and, as such, EDI does not warrant the accuracy, completeness, or reliability of this map or its data.

Map Scale: 1:3,500,000 (printed on 8.5 x 11)
Map Projection: NAD 1983 CSRS Yukon Albers

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Checked: T. Mahon
Date: 2022-04-05

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Map 6-2. Protected areas and management areas within the Porcupine Caribou Herd range in Yukon.

6.4 SEASONAL DISTRIBUTION

Considerable effort has been placed towards quantifying and mapping space use of PCH caribou in Yukon. Satellite-telemetry collaring programs have allowed for the tracking of individuals within the herd to delineate the herd's seasonal distributions. The PCTC supplied EDI with spatial polygons of PCH seasonal ranges spanning 37 years (1970–2016), which provided an opportunity to determine the amount of overlap between seasonal ranges and the RSA. Simple measures of overlap (%) can yield useful insight into the historical frequency of occupation and how PCH caribou are likely to interact with the Project.

The Project RSA overlaps a relatively small proportion of late fall (October 8 to November 30) and winter (December 1 to March 31) ranges. Most of the overlap occurs in portions of the ranges that are less frequently used on an annual basis. No overlap occurs with frequently used portions of late fall and winter ranges.

6.4.1 METHODS

The seasonal ranges used for this analysis consisted of mapped 'sensitive habitat' polygons provided by the PCTC that correspond to eight seasonal life cycle periods for the PCH (Porcupine Caribou Technical Committee 1993). Within each season, the PCTC identified four levels of use based on the frequency of overlap among annual estimates of seasonal home ranges computed for collared caribou, 1970–2016. The four use levels correspond to the proportion of years that home range estimates overlapped any given area: >40 %, 30–40 %, 20–30 %, and <20 %. The lowest category (<20 %) corresponds to very low use and is not considered part of the regular seasonal ranges of the PCH. The degree of overlap of the Project RSA with the PCH seasonal ranges was calculated in a GIS by measuring the overlap of the RSA with each 'frequency of use' category for each seasonal range. All eight life cycle periods were considered for the analysis, but only late fall (including rut, October 8 to November 30) and winter (December 1 to March 31) ranges overlapped the RSA. The overlap analysis was constrained to Yukon because fall and winter ranges in Yukon and Alaska are functionally discrete. Including the Alaskan ranges would dilute the degree of overlap of the RSA with the Yukon ranges.

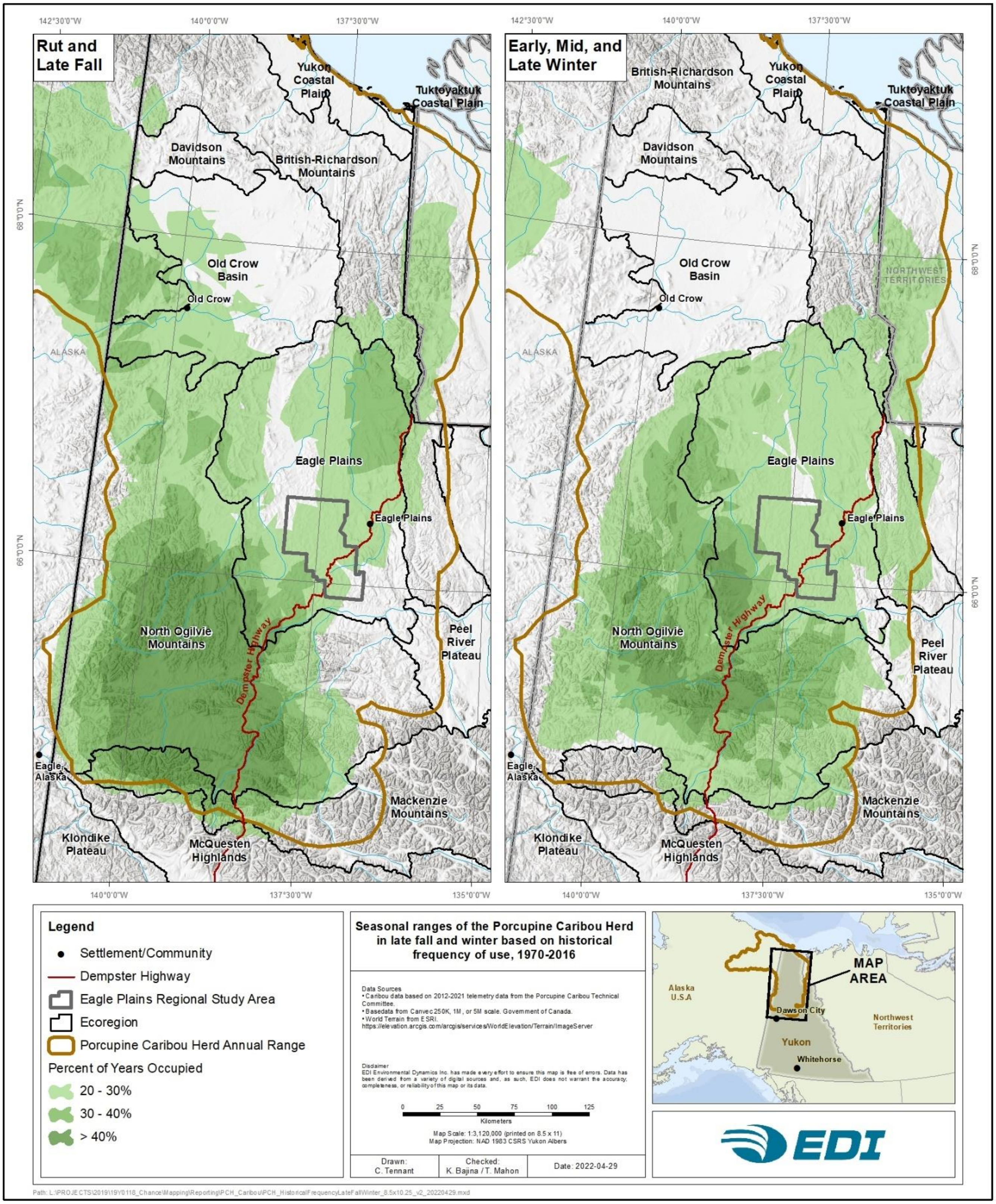
6.4.2 RESULTS

Only two seasonal life cycle periods had relatively frequent overlap (i.e., >20 % across years) with the RSA: (1) rut and late fall, and (2) early, mid, and late winter. For simplicity in this and subsequent analyses, these two periods are referred to as 'late fall' and 'winter' seasons. The RSA overlaps a relatively small portion of the seasonal ranges for both late fall and winter seasons: 5.97% in late fall and 6.54% in winter (Map 6-3). The greatest overlap occurred with the 20–30 % frequency of use areas; 5.90% and 6.12% of late fall and winter ranges, respectively (Table 6-3). No overlap occurred between the Project RSA and the most frequently used areas (>40 %) for either season.

PCH caribou have a wide-ranging distribution in late fall and winter and occupy a large portion of northern and central Yukon. Though some use occurs in the Project RSA and the broader Eagle Plains ecoregion, more frequent use occurs further southwest in the taiga cordillera of the North Ogilvie Mountains in late fall and winter, and in the Richardson Mountains in late fall (Map 6-3). As discussed in the background sections, Section 6.2.2 *Seasonal Ranges and Movements* and Section 6.2.3.1 *Effects of Snow*, the distribution of the PCH in winter varies across four regions with different snow regimes: Yukon/Alaska border, Richardson Mountains, Ogilvie/Hart region, and the Whitestone/Eagle region (Russell et al. 1993). Use of the Whitestone/Eagle region is highest in years with lower than average snowpacks.

Table 6-3. Percent overlap of the Porcupine Caribou Herd late fall and winter ranges with the Project RSA based on the annual frequency of use by caribou, 1970–2016.

Seasonal Range	Annual Use by Caribou (%)	Percent Overlap with RSA (%)
Late Fall	< 20%	0.55
	20–30%	5.90
	30–40%	0.07
	> 40%	0.00
Winter	< 20%	0.07
	20–30%	6.12
	30–40%	0.42
	> 40%	0.00



Seasonal ranges of the Porcupine Caribou Herd in late fall and winter based on historical frequency of use, 1970-2016

Data Sources
- Caribou data based on 2012-2021 telemetry data from the Porcupine Caribou Technical Committee.
- Basedata from Canvec 250K, 1M, or 5M scale. Government of Canada.
- World Terrain from ESRI. https://elevation.arcgis.com/arcgis/services/WorldElevation/Terrain/ImageServer

Disclaimer
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Map Scale: 1:3,120,000 (printed on 8.5 x 11)
Map Projection: NAD 1983 CSRS Yukon Albers

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C. Tennant	K. Bajina / T. Mahon	Date: 2022-04-29

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Map 6-3. Annual frequency of use by the Porcupine Caribou Herd in late fall and winter ranges relative to the RSA, 1970–2016.

6.5 HABITAT USE

The general distribution of PCH caribou across seasons provides some context for their potential interaction with, and overlap of, the Project RSA. However, to caribou, all space on the landscape is not equivalent. Habitat needs to be considered to predict how often caribou might occur in the area based on the amount and distribution of necessary resources, such as forage. To better understand how PCH caribou use habitat across their late fall (including rut) and winter (i.e., early, mid, and late season) ranges, statistical models were developed to describe the relationship between caribou locations and relevant habitat components. These models considered habitat available to caribou broadly across their seasonal range. Habitat models were developed for late fall and winter using GPS location data (2012–2021) of satellite-collared caribou provided by the PCTC. Habitat model outputs were used to estimate the amount and distribution of habitat within the Project RSA and across the PCH's late fall and winter ranges.

The chosen models for late fall and winter performed reasonably well in predicting PCH caribou habitat selection based on several measures of model performance. Light macrolichen cover was the key driver of caribou habitat use in both seasons, though preference for lichen was strongest during winter. During late fall, caribou tended to select flat, mid-elevation regions near large waterbodies. During winter, caribou tended to select flat areas at low and high elevations while remaining distant from waterbodies. Caribou also avoided areas with dense conifer trees, shrub (deciduous and evergreen), forb, and graminoid cover. Base habitat models predicted the distribution and proportion of selected habitat in the Project RSA to be approximately equivalent during late fall and less during winter relative to the full extent of those seasonal ranges.

6.5.1 METHODS

6.5.1.1 Spatial Extent

Habitat modelling was conducted across the Yukon portion of the late fall and winter seasonal ranges defined in Section 6.5, *Seasonal Distribution* (i.e., areas with >20% frequency of annual use). Analyses were limited to the Yukon portion of late fall and winter ranges because of the potential differences in the ecology of caribou occupying Alaska versus Yukon. Using the full Yukon range yields the benefit of identifying broad patterns of habitat selection that affect the territory-wide distribution of the PCH. However, use of a broader scale may dilute patterns of habitat selection at local scales, e.g., only within Eagle Plains ecoregion. Whether such dilution leads to a loss of information depends on caribou habitat preferences in different ecoregions.

6.5.1.2 Data Preparation

The PCTC provided EDI with GPS location data (2012–2021) of satellite-collared PCH caribou. These data covered the entire annual range of the PCH and were reduced to include locations only within the late fall and winter range extents, as described above. The reduced data set consisted of 164 caribou in late fall and 172 caribou in winter. Most of these data (39.02% in late fall and 42.74% in winter) were attributed to locations collected in 2020–2021.

Spatial habitat data were acquired to relate caribou locations to environmental conditions within fall and winter seasonal ranges (as defined above) and, where appropriate, account for variation in conditions across time. For example, temporal changes (from 2010 to 2020) in the distribution of plant functional types (PFTs) due to grazing, fire, and climate-driven vegetation dynamics were captured using predicted top cover percentage (%) raster layers developed by Macander et al. (2022). Based on initial data exploration exercises, the PFTs that were considered ecologically relevant to habitat use of the PCH included light macrolichens (also see Macander et al. 2020), graminoids, forbs, evergreen shrubs, deciduous shrubs, and conifer trees. Data for topography on the landscape were acquired from a Digital Elevation Model (DEM; 1:250,000) for Yukon and were used to develop measures of absolute elevation (metres), slope percent (slope tool in the Spatial Analyst extension, ArcGIS 10.7; ESRI 2019), aspect (degrees), and a terrain ruggedness index (TRI; Sappington et al. 2007). A measure of relative elevation was created by combining absolute elevation and a simplified stream network (CanVec; nearest main watercourse from a 1:1,000,000 scale watercourse layer) and then employing the HAR tool from the Riparian Topography Toolbox in ArcGIS (Dilts 2015). A CanVec (1:1,000,000) waterbody layer was also used to map distances to waterbodies >1 ha. Caribou may use frozen waterbodies as an antipredator tactic to increase sightlines. They may also be mineral licks (Ferguson and Elkie 2005).

6.5.1.3 Statistical Models

Determining which resources (habitat features) are selected most often by animal populations is important because it provides information about how those animals meet fundamental requirements for survival and reproduction (Manly et al. 2002). Resource selection functions (RSF) are a statistical method that quantifies how resources are chosen by relating animal observations to resources available across the landscape. RSFs predict the probability of an animal occurring at specific locations (e.g., within a study extent) based on the combination of resources available at those locations. Results of a RSF can be mapped to identify important areas of resource selection for caribou and, therefore, can inform the conservation and management of the species.

Caribou observations were first overlayed with environmental spatial data layers to develop RSFs for PCH late fall and winter ranges. Environmental values were extracted for each known location of caribou plus ten times as many randomly sampled locations (spaced a minimum distance of 50 m apart). Availability was deemed global, so available locations were randomly selected within the late fall and winter study areas. Independence among observations of caribou was assumed by resampling caribou locations to a maximum of one per day. Available locations were compared to locations known to be occupied or 'used' by caribou to identify the combination of resource units preferred by caribou. Logistic regression was used to develop RSFs within a generalized linear mixed model framework. The general formula for logistic regression is as follows:

$$logit(P) = \beta_0 + \beta_1 x_1 \dots \beta_n x_n + Y$$

where the predicted value P is dependent on the linear predictor ($\beta_0 + \beta_1 x_1 \dots \beta_n x_n$) through a logit-link function, and x is the *i*-th environmental covariate and β is its associated coefficient. An interaction was included between Ecoregion and macrolichen cover to account for the varied distribution, and possibly selection, of lichen among ecoregions. An additional random effect term, Y, was added to account for (a) the variation in habitat selection associated with each caribou year and (b) the unequal sample sizes among years. Large weights were applied to all available locations ($\text{weight}_{\text{avail}} = 1{,}000$) relative to used locations ($\text{weight}_{\text{used}} = 1$) to ensure that parameter estimates were not biased by the sampling ratio of used and available points (Muff et al. 2020). The linear predictor was used to calculate the probability of selection P:

$$P = \frac{e^{(\beta_0+\beta_1 x_1 \ldots \beta_n x_n + Y + E)}}{1 + e^{(\beta_0+\beta_1 x_1 \ldots \beta_n x_n + Y + E)}}$$

where e is the natural exponential function and P is bounded by $0 < P < 1$.

6.5.1.4 Exploring Covariate Relationships

Before analyses, all continuous covariates, such as PFT top covers, elevation, slope, TRI, HAR, and distance to waterbodies, were standardized to have a mean of zero and a standard deviation of one. Standardizing the values across covariates ensures model convergence and improves the ability to rank the relative importance of each covariate in a model. The aspect was converted from continuous (degrees) to categorical (cardinal directions) based on 90° intervals. To prevent biased estimates of coefficients and inflated errors, multicollinearity among covariates was assessed using a correlation matrix (dropping variables with Pearson's product moment correlation $|r| > 0.7$ [see Dormann et al. 2013]) and variance inflation factor scores (dropping variables with VIF scores > 3 [Zuur et al. 2009]). For example, absolute and relative (HAR) elevation in winter were highly correlated ($r = 0.69$). The decision to choose one over the other was based on univariate response curves assessed using generalized additive modelling (GAM; see below). In other words, of the highly correlated covariates, the one with the greatest selection response (slope) was chosen. In this case, absolute elevation was retained over HAR.

Data exploration consisted of (1) univariate analyses with the response variable (i.e., used versus available), and (2) univariate and multivariate GAMs to assess the potential marginal effect of each covariate on the (non-linear) shape of the response curve (i.e., probability of use). These exercises informed model development. For example, rather than assuming a linear increase for percent light macrolichen cover, the variable was logarithmically transformed to fit the expectation that the probability of selection increased at incrementally smaller values as the quantity of lichen in a patch increased (Figure 6-2). Additionally, different patch sizes were considered for PFT covers by estimating the mean percent cover within 100 m, 500 m, and 1,000 m buffers around used and available points.

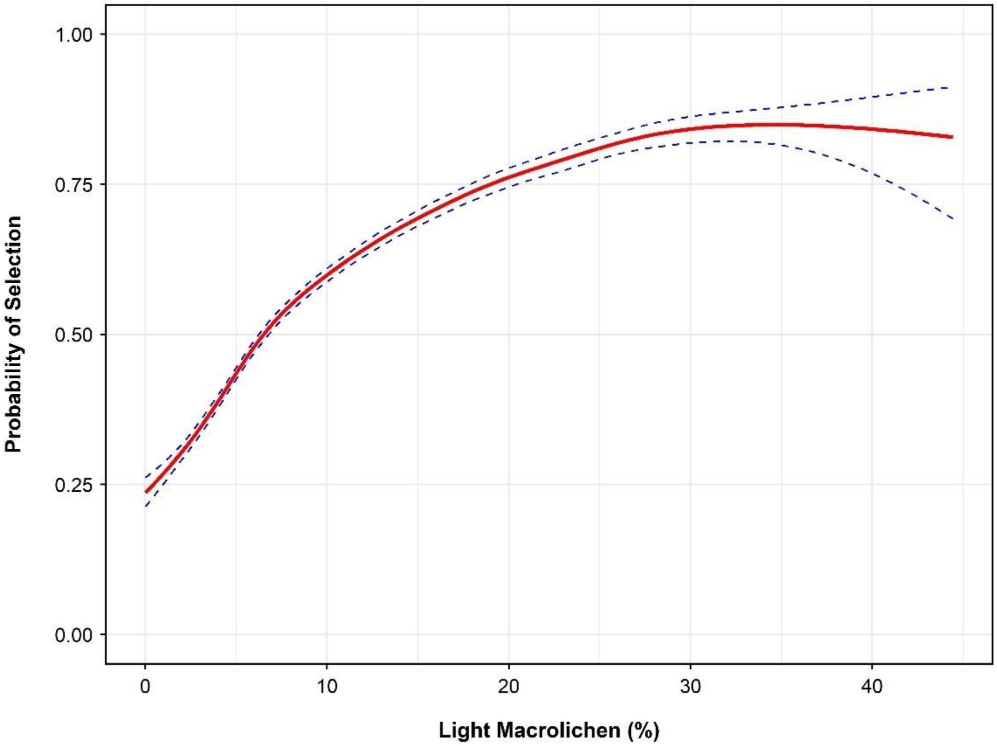


Figure 6-2. Generalized additive model assessing the probability of selection of light macrolichens by PCH during winter.

6.5.1.5 Model Selection and Validation

Habitat models were selected for late fall and winter by implementing 'full' models (with all relevant covariate terms) and assessing the variation explained by the inclusion of each covariate. The best models were chosen based on (1) statistical considerations using Akaike's information criterion (AIC; Burnham and Anderson 2002), which balances the trade-off in the amount of variance explained (i.e., model likelihood) with the number of parameters considered, and (2) ecological significance to caribou in the late fall and winter seasons. Since the goal of the model was prediction, as many covariates as necessary were retained. Thus, alternative candidate models were considered not by testing competing hypotheses but rather by dropping covariates with low magnitude (scaled) coefficients < |0.1|. Model diagnostics were run on simulated residuals to assess (a) goodness-of-fit (i.e., Kolmogorov-Smirnov test), (b) issues related to dispersion, (c) the frequency of outliers, (d) variance among categorical predictors, and (e) quantile regressions of observed versus expected residuals.

The predictive performance of late fall and winter models were assessed using a 5-fold cross-validation approach as per the steps outlined in Johnson et al. (2006). (1) The original data were partitioned into 5-fold groups. For each iteration of the evaluation procedures, four groups were combined into the training dataset. The remaining group was used as the testing dataset. (2) The RSF was estimated for each training dataset. (3) RSF values from the training dataset were predicted in a GIS and reclassified into 10 quantile rank bins. (4) Midpoint (median) values of raw RSF scores were calculated for each quantile bin. (5) Percent utilization was calculated for each quantile bin using equation 4 in Johnson et al. (2006). (6) The number of used observations from the testing dataset that fell in each quantile bin were counted. (7) The number of expected observations from the testing dataset was calculated for each quantile bin using equation 5 in Johnson et al. (2006). (8) Observed versus expected counts and proportions from the testing dataset were compared and tested formally using linear regression, spearman's rank correlation, chi-square goodness-of-fit (i.e., observed versus expected counts), and tests of proportions for each quantile bin (i.e., chi-square observed versus expected proportions). These steps were repeated until each fold was used as the testing dataset. The 5-fold cross-validation procedure was implemented for several candidate models for both late fall and winter to determine whether simpler models yielded more accurate predictions.

6.5.1.6 Habitat Quality, Amount, and Distribution

Models selected for late fall and winter were used to generate predictive habitat maps across those seasonal ranges. These mapped predictions aimed to identify the amount and distribution of habitat available to PCH caribou. To facilitate the comparison of relative habitat quality across the study area, the RSF predictions were classified into four ordinal ratings: Very Low, Low, Moderate, and High. To help objectively define ecologically relevant classification of the RSF values we conducted a post-hoc selection-ratio test of the caribou locations against the RSF predictions. This approach identified the point within the RSF value range where values switch from avoided to being selected. The portion of the 'selected' RSF value range was divided at the midpoint into the Moderate and High ratings and the portion of the 'avoided' range was divided at the midpoint into the Very Low and Low ratings. For example, for RSF output with a range from 0 to 1, if the selection-ratio calculation determined the breakpoint between avoidance and selection occurred at 0.6, the habitat quality ratings would be Very Low = 0.0-0.3, Low = 0.3-0.6, Moderate = 0.6-0.8, and High = 0.8-1.0.

To determine the breakpoint within the RSF value range that switched from avoided to selected, the frequency distributions of mapped RSF predictions were partitioned into 50 quantile bins with each bin consisting of two-percentile intervals. Selection ratios were calculated for each quantile bin by associating mapped RSF predictions to used and available collar locations and then assigning each location to a quantile bin. The selection ratio for each bin was calculated as follows:

$$SR_{bin} = \frac{Used_{prop} - Avail_{prop}}{Avail_{prop}}$$

where $Used_{prop}$ and $Avail_{prop}$ are the proportion of used and available locations in each quantile bin. Selection ratios were used to categorize habitat quality into the discrete ratings discussed above (i.e., Very Low, Low, Moderate, and High). The bin at which selection ratios switched from negative to positive identified the threshold between Low and Moderate quality habitat. Very Low quality habitat was identified based on the midpoint between the smallest quantile bin and the Low/Moderate quality habitat threshold. Similarly, the midpoint between the Low/Moderate quality habitat threshold and the largest quantile bin differentiated Moderate and High quality habitat. For certain management questions or purposes, it may be adequate to just use two habitat classes—avoided or selected. Subdividing those into the four ratings provides further resolution for certain management questions or objectives. For example, when comparing different road route options that must traverse an area of 'selected' habitat, potential impacts are expected to be minimized by locating the road in Moderate versus High habitat areas.

RSF frequency distributions were extremely right skewed so that very high RSF values were low in frequency. This issue arises when dealing with RSFs with 'infinitely weighted' available locations, which has become standard practice in recent years (e.g., Muff et al. 2020). In late fall and winter RSFs, the ratio of used to available locations was 1:10 with an additional large weight (i.e., 1,000) assigned to each available location. These large weights effectively reduce RSF predictions to very small decimal numbers and skews their distribution. To ensure that this skew did not underestimate the amount of High versus Moderate quality habitat, all RSF values equal to or greater than the 98th percentile were fixed at that value. Thus, there were effectively 49 quantile bins, in total, because all predictions in the 50th bin were assigned to the 49th bin.

To compare the amount and distribution of selected habitat within the Project RSA (~2,386 km²) to the broader landscape, the amount of selected habitat was assessed within similar sized polygons across the seasonal ranges. A grid composed of 50 km x 50 km (2,500 km²) cells was placed over the Yukon extent of the PCH ranges, and the proportion of selected habitat was assessed for each cell.

6.5.1.7 Statistical and Geospatial Software

All statistical analyses were completed in R software for Statistical Computing, version 4.1.0 (R Development Core Team 2020). Package 'mgcv' (Wood 2011) was used to develop and assess non-linearity in response-covariate relationships using generalized additive modelling. Package 'glmmTMB' (Brooks et al. 2017) was used to fit generalized mixed-effects models. In addition to visual assessment of covariate-response relationships, package 'DHARMa' (Hartig 2021) was used to assess simulated model residuals (e.g., goodness of fit, dispersion, outliers, heteroscedasticity). Package 'groupdata2' was used to partition data into training and testing datasets; it was especially useful for partitioning a consistent number of used and available locations among the data folds. All geospatial analyses were completed in R, version 4.1.0 (R Development Core Team 2020), QGIS (QGIS Development Team 2020), and ArcGIS, version 10.7 (ESRI 2020).

6.5.2 RESULTS AND DISCUSSION

6.5.2.1 Habitat Models

The selection of late fall and winter habitat models required an iterative model fitting, testing, and cross-validation process. The appropriate patch size (i.e., 100 m, 500 m, or 1,000 m) of each PFT was selected based on GAM plots to identify which patch size corresponded with the greatest change (slope) in selection. Initial model selection procedures determined that 'full' models, with all possible covariates, were the most parsimonious for late fall (No. 1 in Table 6-4) and winter (No. 1 in Table 6-5) RSFs. However, the 'full' model for late fall did not yield the best predictive performance based on the 5-fold cross-validation procedure. The best performing model for late fall excluded the effects of all PFTs except lichen (No. 3 in Table 6-4; Table 6-6), which yielded a better fit between observed and expected proportions across 10 quantile bins based on regression (i.e., higher R^2; intercepts closer to zero and slopes closer to one), tests of proportions (i.e., greater number of equivalent observed/expected bins), and spearman rank correlations (i.e., larger correlation coefficients). See Section 5.6.1 for plots and summaries of 5-fold cross-validation results for the selected late fall RSF model. Regressions for each fold had very strong fits (all $R^2 > 0.93$) but did have intercepts that differed from zero and slopes that differed from one. The primary reason for this deviation was a greater number of observed proportions in the largest (10th) quantile bin, whereas all other bins were close to the line of unity (1:1 ratio). Spearman rank correlations were consistently very high (all $r > 0.98$ and $p < 0.001$). The mean number of bins in which observed proportions were no different than expected proportions, across all five folds, equalled 5.2 (low = 4, high = 8).

The best performing model for winter consisted of the full parameterization (No. 1 in Table 6-5; Table 6-7), which yielded a better fit between observed and expected proportions across 10 quantile bins based on regression (i.e., higher R^2; more intercepts closer to zero and slopes closer to one), tests of proportions (i.e., greater number of equivalent observed/expected bins), and spearman rank correlations (i.e., larger correlation coefficients) than any alternative candidate model. See Section 5.6.1 for plots and summaries of 5-fold cross-validation results for the selected winter RSF model. Regressions for each fold had strong fits (all $R^2 > 0.79$) and had intercepts that were no different than zero and slopes that were no different than one. Spearman rank correlations were consistently very high (all $r > 0.98$ and $p < 0.001$). The mean number of bins in which observed proportions were no different than expected proportions, across all five folds, equalled 5 (low = 3, high = 6). In conclusion, both late fall and winter model had a fair agreement between observed and expected proportions and had very high spearman rank correlations, which suggests that these models perform adequately for prediction (e.g., see Johnson and Russell 2014, White and Gregovich 2017, Johnson et al. 2020).

Habitat use varied moderately between late fall and winter. Although selection coefficients were highest for macrolichen cover and elevation in both seasons, the relationships varied somewhat, and the extent of Moderate and High rated habitat was reduced in winter compared to late fall. Selection (positive coefficient) for macrolichen cover, the most relevant plant functional type in either season, was greater in magnitude during winter (Table 6-7) than during late fall (Table 6-6). Though the magnitude of selection for macrolichen varied by ecoregion (i.e., interaction), the best-fitting patch size for the selection of macrolichen was consistently 100 m. However, patch size varied for other plant functional types considered during winter (Table 6-7; e.g., conifer tree cover versus forbs). During late fall, caribou selection (positive coefficients) of vegetation was solely driven by lichen cover. Meanwhile, during winter, caribou tended to avoid (negative coefficients) other PFTs such as conifer trees, forbs, graminoids, deciduous shrubs, and evergreen shrubs. The lack of selection/avoidance of other PFTs during late fall is likely the result of more diverse forage use in late fall than in winter and individual variation in habitat choice. Such variation is consistent with a broad habitat selection pattern at the population-level, which led to the poorer predictive performance of late fall models that included other PFT covers.

Preference of absolute elevation also varied between the seasons. Caribou occupied primarily mid elevations (approximately 750 m) during late fall (Table 6-6) but selected low and high elevations during winter (Table 6-7). Caribou also varied in their proximity to waterbodies >1 ha between seasons. Caribou tended to be closer to such waterbodies (negative coefficient) during late fall but remained farther (positive coefficient) during winter. The ecological basis for these relationships to waterbodies is unclear, but the covariates were retained in the models because they improved predictive performance.

Coefficients associated with lichen cover were of the greatest magnitude, which suggests that the selection of lichen is the primary driver of habitat selection in late fall and winter. This pattern in vegetation use across both seasons is consistent with what is expected of PCH caribou diet and ecology (Thompson and McCourt 1981, Russell et al. 1993). Late fall and winter diets are mostly composed of lichens (and mosses). Though there is some evidence that caribou may forage on evergreen shrubs and deciduous shrubs during late fall (Russell et al. 1993), this pattern was weak, and these covariates were not included in the final model. Another similarity in selection among seasons was in terms of slope and aspect. Caribou avoided steep slopes (negative coefficients, logarithmic) and selected south- and west-facing aspects, which receive greater solar radiation than east- and north-facing aspects. This pattern could be attributed to productive lichen patches during both seasons and to decreased snow depth due to melt and wind during winter.i

Selection gradients (i.e., the degree of preference/avoidance) were greater during winter than late fall. This is likely because forage was more broadly available across different habitats due to lower snowpacks in late fall and because more locations in the late fall were likely associated with travelling than foraging. Though caribou distribution is broader in winter, there was clearly a stronger preference (positive coefficient) for light macrolichens and a stronger avoidance (negative coefficient) of areas with high cover of conifer trees. Stronger preference and avoidance in winter may result in more concentrated forage on lichen and from snow constraints on caribou distribution.

Temporal patterns of habitat selection also varied between late fall and winter. Habitat selection seemed to be fairly consistent across years in late fall but varied from winter to winter. A very small portion of the overall variance ($\sigma^2 = 0.00021$) in habitat selection could be explained by year effects during late fall. This model contributed little to the overall model likelihood and was penalized for an additional parameter ($AIC_\Delta = 2$); thus, year effects were not included for the late fall model. However, during winter, a year effect explained a sufficient amount of variation ($\sigma^2 = 0.013$) in habitat selection to warrant inclusion in the final model (i.e., $AIC_\Delta = -90.9$ with year effect). Variation among years was likely greater in winter due to the effects of snow across the landscape, which can broadly affect the distribution of PCH caribou and their foraging habits.

Snow accumulation and distribution is invariably an important factor affecting habitat selection by PCH caribou at multiple scales. At fine spatial scales, snow depth, density, and hardness can limit access to terrestrial lichens (Johnson et al. 2001). Although snow depth data were not available, elevation was considered as a suitable surrogate. In the winter RSF, caribou exhibited selection for low and high elevations and avoidance of mid elevations, where snowpacks are often deepest. Indeed, Pedersen et al. (2021) identified a significant correlation ($r > 0.6$) between elevation and snow depth in 33% of winters during their study of another barren-ground caribou herd, the Central Arctic Herd. The amount of snowfall and snowpack at broad spatial scales can cause the PCH to occupy different core wintering regions. For example, PCH caribou occupy the Ogilvie/Hart and Richardson Mountains regions on a rotational basis because these regions receive less snow than adjacent areas (Russell et al. 1993). This pattern is consistent with the current data, whereby GPS-collared PCH caribou occupied different ecoregions at different intensities (i.e., number of individuals and locations) across time.

Though snow depth could not be considered explicitly in habitat models, the variation estimated among years and differences in the use of ecoregions and elevations were considered to partially account for the influence of snow. These variables are considered coarse correlates of snowpack patterns across the landscape (Russell et al. 1993), yet, the exclusion of an explicit snowpack covariate does limit fine-scale predictions of how snow affects caribou resource selection. Ultimately, snow depth is probably the primary, ecologically relevant metric that would supplement the current covariate suite and provide greater insight on winter selection patterns. Available snow covariates were examined and deemed not to be useful. For example, information on snow prevalence, date of the first snow, or snow cover are not inherently useful because caribou (and other ungulates) are not constrained in their movements and foraging by shallow snow. Given these considerations, it was deemed more appropriate to account for the coarser effects of snow depth using ecoregion and elevation rather than using a snow cover that may be misleading both ecologically and mechanistically, resulting in a spurious correlation.

Table 6-4. Model selection of global-availability resource selection (RSF) by Porcupine Caribou Herd caribou in Eagle Plains during late fall.

No.	Model	*K*	AIC	Δ AIC
1	~ 1 + Ecoregion * log(Lichen_100 + 1) + Conifer_Tree_100m + Forbs_100m + Deciduous_Shrub_1000m + Graminoid_1000m + Evergreen_Shrub_100m + log(Slope Percent + 1) + Absolute Elevation + (Absolute Elevation)^2 + Distance to Waterbodies + Aspect	22	167,637.4	0.0
2	~ 1 + Ecoregion * log(Lichen_100 + 1) + Conifer_Tree_100m + Deciduous_Shrub_1000m + Evergreen_Shrub_100m + log(Slope Percent + 1) + Absolute Elevation + (Absolute Elevation)^2 + Distance to Waterbodies + Aspect	20	167,644.0	6.6
3*	~ Ecoregion * log(Lichen_100 + 1) + log(Slope Percent + 1) + Absolute Elevation + (Absolute Elevation)^2 + Distance to Waterbodies + Aspect	17	167,750.7	113.3
4	~ Ecoregion * log(Lichen_100 + 1) + log(Slope Percent + 1) + Absolute Elevation + (Absolute Elevation)^2 + Distance to Waterbodies	14	167,783.0	145.6
5	~ 1 (null model)	1	169,964.2	2,326.8

* Chosen model based on best predictive performance in 5-fold cross-validation.

Table 6-5. Model selection of global-availability resource selection (RSF) by Porcupine Caribou Herd caribou in Eagle Plains during winter.

No.	Model	*K*	AIC	Δ AIC
1*	~ 1 + Ecoregion * log(Lichen_100 + 1) + Conifer_Tree_1000m + Forbs_500m + Deciduous_Shrub_1000m + Graminoid_1000m + Evergreen_Shrub_100m + log(Slope Percent + 1) + Absolute Elevation + (Absolute Elevation)^2 + Distance to Waterbodies + Aspect	21	255,398.7	0
2	~ 1 + Ecoregion * log(Lichen_100 + 1) + Conifer_Tree_1000m + Forbs_500m + Graminoid_1000m + Evergreen_Shrub_100m + log(Slope Percent + 1) + Absolute Elevation + (Absolute Elevation)^2 + Distance to Waterbodies + Aspect	20	255,428.0	29.3
3	~ 1 + Ecoregion * log(Lichen_100 + 1) + Conifer_Tree_1000m + Forbs_500m + Deciduous_Shrub_1000m + Graminoid_1000m + log(Slope Percent + 1) + Absolute Elevation + (Absolute Elevation)^2 + Distance to Waterbodies + Aspect	20	255,500.1	101.4
4	~ 1 + Ecoregion * log(Lichen_100 + 1) + Conifer_Tree_1000m + Forbs_500m + Graminoid_1000m + log(Slope Percent + 1) + Absolute Elevation + (Absolute Elevation)^2 + Distance to Waterbodies + Aspect	19	255,538.9	140.2
5	~ 1 (null model)	1	265,758.0	10,359.3

* Chosen model based on best predictive performance in 5-fold cross-validation.

Table 6-6. Base habitat model of global-availability resource selection (RSF) by Porcupine Caribou Herd caribou in Eagle Plains during late fall.

Model Term	Estimate	Std. Error	*Z*-statistic	*P*
Intercept				
Eagle Plains & North *(Reference)*	-9.697	0.035	-273.568	<0.0001
Ecoregion (factor)				
North Ogilvie Mountains	-0.136	0.075	-1.803	0.0714
British-Richardson Mountains	0.533	0.047	11.312	<0.0001
Old Crow Basin	0.341	0.038	9.082	<0.0001
Davidson Mountains	0.666	0.041	16.132	<0.0001
Aspect (factor)				
South	0.099	0.032	3.147	0.00165
East	0.003	0.032	0.082	0.935
West	0.161	0.031	5.162	<0.0001
Ecoregion–Lichen_100m Interaction				
Eagle Plains * Lichen_100m Percent[1,2] *(Reference)*	0.694	0.029	23.880	<0.0001
North Ogilvie Mountains * Lichen_100m Percent[1,2]	0.062	0.063	0.990	0.322
British-Richardson Mountains * Lichen_100m Percent[1,2]	-0.311	0.043	-7.300	<0.0001
Old Crow Basin * Lichen_100m Percent[1,2]	-0.157	0.037	-4.216	<0.0001
Davidson Mountains * Lichen_100m Percent[1,2]	-0.224	0.042	-5.324	<0.0001
Digital Elevation Model				
Slope Percent[1,2]	-0.311	0.017	-18.006	<0.0001
Absolute Elevation[2] (linear)	0.865	0.073	11.907	<0.0001
Absolute Elevation[2] (quadratic)	-0.813	0.070	-11.661	<0.0001
Distances				
Distance to Waterbodies[2]	-0.184	0.016	-11.827	<0.0001

[1] covariate transformation = $\log_e(x + 1)$.

[2] covariate estimates based on standardized covariate values = (x – mean[x])/std. deviation(x).

Table 6-7. Base habitat model of global-availability resource selection (RSF) by Porcupine Caribou Herd caribou in Eagle Plains during winter.

Model Term	Estimate	Std. Error	*Z*-statistic	*P*
Intercept				
Eagle Plains & North *(Reference)*	-10.007	0.051	-195.485	<0.0001
Ecoregion (factor)				
North Ogilvie Mountains	0.616	0.040	15.502	<0.0001
British-Richardson Mountains	0.738	0.039	19.152	<0.0001
Old Crow Basin	0.281	0.034	8.229	<0.0001
Aspect (factor)				
South	0.196	0.025	7.671	<0.0001
East	0.030	0.026	1.154	0.249
West	0.329	0.025	13.294	<0.0001
Ecoregion– Lichen_100m Interaction				
Eagle Plains * Lichen_100m Percent^{1,2} *(Reference)*	1.119	0.018	62.823	<0.0001
North Ogilvie Mountains * Lichen_100m Percent^{1,2}	-0.154	0.034	-4.485	<0.0001
British-Richardson Mountains * Lichen_100m Percent^{1,2}	-0.614	0.036	-17.203	<0.0001
Old Crow Basin * Lichen_100m Percent^{1,2}	-0.123	0.034	-3.602	0.000316
Other Plant Functional Types				
Conifer_Tree_1000m Percent^{2}	-0.256	0.009	-27.241	<0.0001
Forbs_500m Percent^{2}	-0.166	0.010	-17.068	<0.0001
Deciduous_Shrub_1000m Percent^{2}	-0.096	0.009	-10.137	<0.0001
Graminoid_1000m Percent^{2}	-0.120	0.009	-12.706	<0.0001
Evergreen_Shrub_100m Percent^{2}	-0.052	0.009	-5.580	<0.0001
Digital Elevation Model				
Slope Percent^{1,2}	-0.216	0.012	-18.678	<0.0001
Absolute Elevation^{2} (linear)	-1.369	0.056	-24.410	<0.0001
Absolute Elevation^{2} (quadratic)	0.889	0.053	16.627	<0.0001
Distances				
Distance to Waterbodies^{2}	0.201	0.010	20.321	<0.0001

[1] covariate transformation = $\log_e(x + 1)$.

[2] covariate estimates based on standardized covariate values = (x – mean[x])/std. deviation(x).

6.5.2.2 Predicted Habitat Distribution

Predicted habitat quality, amount, and distribution depended on the magnitude of resource selection and the distribution of habitat covariates across the landscape (i.e., primarily light macrolichen cover). Predictions from habitat models for late fall and winter were classified into four ordinal habitat quality ratings (i.e., Very Low, Low, Moderate, or High quality). See Section 6.9.2 for plots that demonstrate the switch from negative to positive selection ratios across quantile (two-percentile) bins for late fall (31st quantile bin [60th–62nd percentile]; Attachment Figure 11 and Attachment Figure 12) and winter (30th quantile bin [58th–60th percentile]; Attachment Figure 15 and Attachment Figure 16). Furthermore, Section 6.9.2 provides plots of (a) selection ratios associated with each habitat rating and (b) the proportion of the late fall and winter ranges composed of each habitat rating. In general, Very Low quality habitat had low, negative selection ratios while High quality habitat had high, positive selection ratios. Approximately 60% of the late fall and winter ranges consisted of avoided (Very Low and Low) habitat, and 40% consisted of selected (Moderate and High) habitat.

The distribution of habitat across the landscape differed between late fall (Map 6-4) and winter (Map 6-5) ranges. The proportion of selected late fall habitat in the Project RSA (0.404) was equivalent to the mean proportion in the broader late fall range when accounting for variance in that estimate (Table 6-8). In contrast, the proportion of selected winter habitat in the Project RSA (0.265) was substantially less than the mean proportion in the broader winter range (0.411) (Table 6-8). Though mean estimates of selected habitat in the broader late fall and winter ranges were approximately 0.40, there was considerable variation among the 50 km x 50 km cells used in the analyses. In the late fall range, the lowest and highest proportions of selected habitat were 0.140 and 0.881, respectively. Cells with the lowest proportions were located mostly along the western edge of the late fall range (i.e., high elevations in the North Ogilvie Mountains), and cells with the highest proportions were located mostly along the eastern edge of the late fall range (i.e., Eagle Plains ecoregion transitioning into Richardson Mountains). The lowest and highest proportions of selected habitat in the winter range were 0.106 and 0.764, respectively. Cells with the lowest proportions were located centrally in the winter range (i.e., Eagle Plains ecoregion) and cells with the highest proportions were located mostly along the eastern and southern edge of the winter range (i.e., Richardson mountains and North Ogilvie Mountains).

In the Project RSA, selected late fall habitat was concentrated at mid-elevation plateaus and depended on the amount of lichen cover. For example, a large patch of High quality habitat occurred adjacent (south side) to the Dempster Highway (inset in Map 6-4); this patch occurred on a large mid-elevation plateau, in proximity to waterbodies >1 ha in size, and relatively high amounts of lichen cover. In fact, several portions of the Dempster Highway intersected either Moderate or High quality habitat at mid-elevations and with moderate lichen cover. Across the broader landscape, the greatest amount of selected habitat occurred within the southern extent of the North Ogilvie Mountains ecoregion, the western extent of the British-Richardson Mountains ecoregion, and in large areas at the eastern extent of the Eagle Plains ecoregion (Map 6-4). Avoided habitat primarily occurred at low elevation valley bottoms or high elevations (> 750 m, e.g., at the peaks of British-Richardson Mountains) in areas with low lichen and vegetative cover.

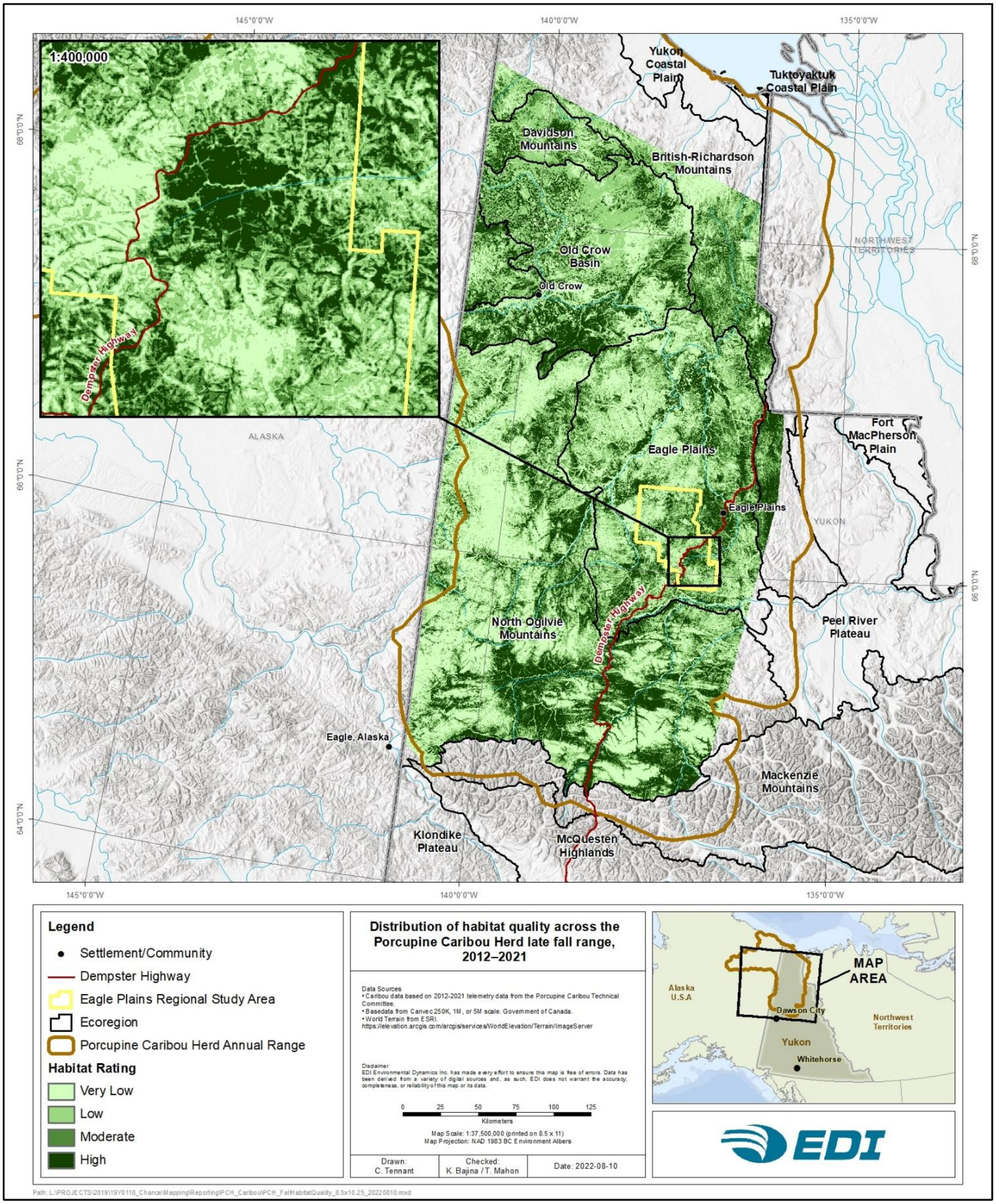
Winter habitat occurred primarily at either valley bottoms with open stunted spruce or high elevations with sparse tree cover and high macrolichen cover. Selected habitat was also distant from large waterbodies and wet environments containing forbs and graminoids, as well as areas with high cover of deciduous or evergreen shrub. In the RSA, selected habitat was localized in specific regions. For example, a large extent of High quality habitat occurred at the northern extent of the RSA, on the west side of Chance creek (Map 6-5). This area is low in elevation and has relatively high lichen cover. Two other large patches of High quality habitat occur at the southern extent of the RSA, both associated with low elevation and very high lichen cover. Although mid-elevations have relatively lower RSF predictions, in general, certain mid-elevation areas with high lichen cover, such as the areas along the Dempster Highway for late fall habitat are also predicted to offer Moderate or High quality winter habitat (inset in Map 6-4). Across the broader landscape, large extents of selected habitat occurred in the Richardson Mountains, the Ogilvie Mountains, and northern extents of Eagle Plains ecoregion. The greatest amount of avoided habitat (Very Low and Low) also occurred in Eagle Plains due to large areas of recent wildfire and its vast mid-elevation plateaus.

The use of multiple habitat ratings, as opposed to a binary classification (e.g., suitable versus unsuitable), was necessary to retain high resolution information on the distribution of habitat quality. For example, there were stark differences in the amount of lichen cover in areas of Moderate versus High quality habitat, and this can have implications for timing and extent of Project operations. Map 6-6 provides a comparison between winter habitat quality ratings and macrolichen cover in the Project RSA. There is a clear distinction between areas of high versus low macrolichen cover. There are several High quality ratings that occur along circular and N-S oriented ridges at the southwest corner of the RSA. Adjacent areas of similar elevation but with low macrolichen cover, transition from Moderate to Very Low in quality. Since macrolichen cover is the strongest driver of resource selection by PCH caribou during winter, it is important to be able to distinguish these high-value regions for management purposes.

Table 6-8. Proportion of selected (Moderate and High) caribou habitat in the Project RSA relative to the mean (and std. error) of 50 km x 50 km cells covering late fall and winter range extents.

Season	Scale	Proportion of Moderate and High Quality Habitat	Std. Error
Late Fall	Project RSA (2,387 km² total)	0.404	–
	Late Fall Range (88,149 km²) [1] (2,500 km² per cell) – 53 cells total	0.415	± 0.025
Winter	Project RSA (2,387 km² total)	0.265	–
	Winter Range (65,077 km²) [1] (2,500 km² per cell) – 40 cells total	0.411	± 0.026

[1] Late fall and winter ranges were subsampled using 2,500 km² cells (approximately the same size and the RSA) to facilitate estimation of mean and variance.



Distribution of habitat quality across the Porcupine Caribou Herd late fall range, 2012–2021

Data Sources
- Caribou data based on 2012-2021 telemetry data from the Porcupine Caribou Technical Committee.
- Basedata from Canvec 250K, 1M, or 5M scale. Government of Canada.
- World Terrain from ESRI.
https://elevation.arcgis.com/arcgis/services/WorldElevation/Terrain/ImageServer

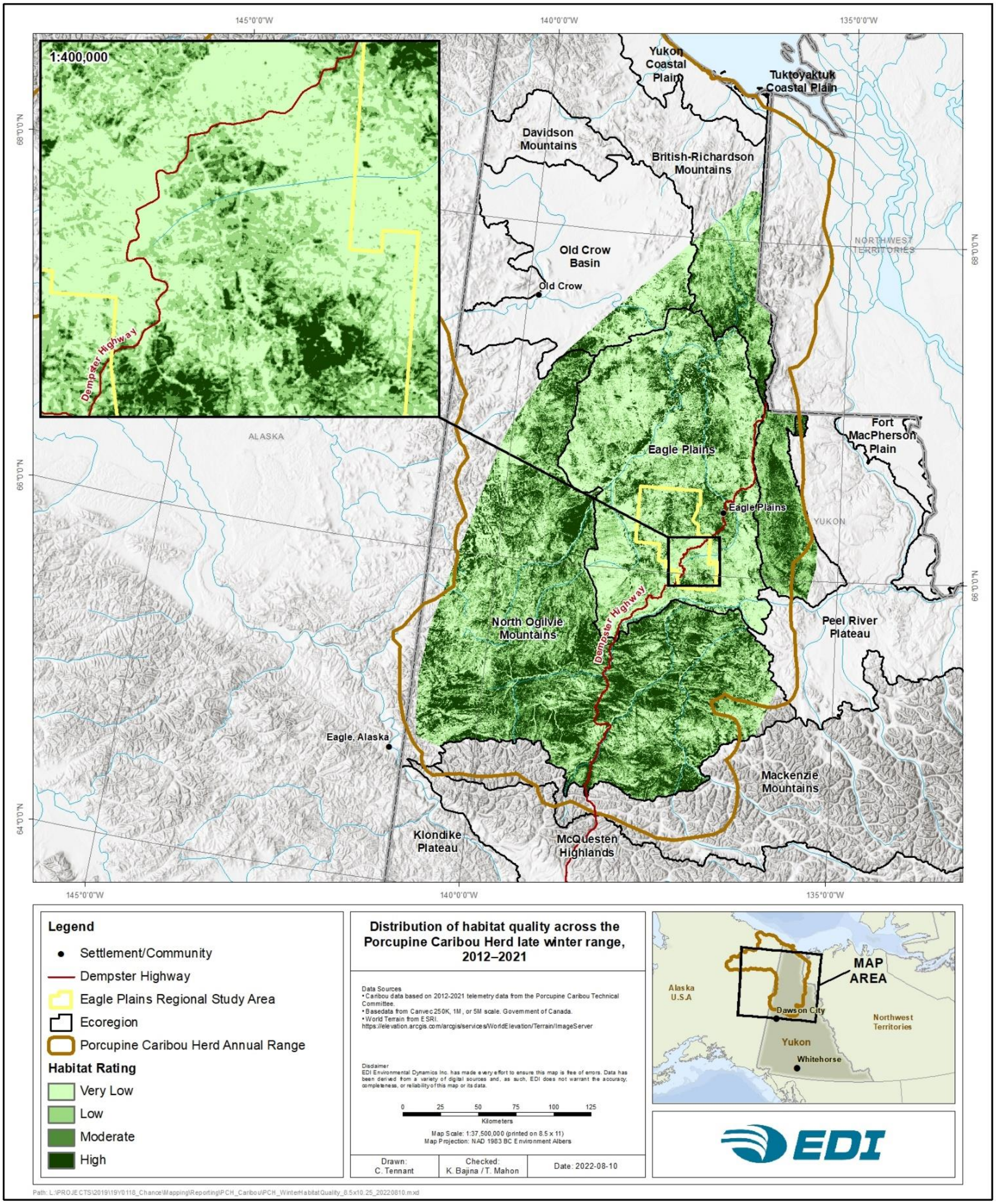
Disclaimer
EDI Environmental Dynamics Inc. has made every effort to ensure this map is free of errors. Data has been derived from a variety of digital sources and, as such, EDI does not warrant the accuracy, completeness, or reliability of this map or its data.

Map Scale: 1:37,500,000 (printed on 8.5 x 11)
Map Projection: NAD 1983 BC Environment Albers

Drawn: C. Tennant	Checked: K. Bajina / T. Mahon	Date: 2022-08-10

Path: L:\PROJECTS\2019\19Y0118_Chance\Mapping\Reporting\PCH_Caribou\PCH_FallHabitatQuality_8.5x10.25_20220810.mxd

Map 6-4. Distribution of habitat quality across the Porcupine Caribou Herd late fall range, 2012–2021.



Distribution of habitat quality across the Porcupine Caribou Herd late winter range, 2012–2021

Data Sources
- Caribou data based on 2012-2021 telemetry data from the Porcupine Caribou Technical Committee.
- Basedata from Canvec 250K, 1M, or 5M scale. Government of Canada.
- World Terrain from ESRI. https://elevation.arcgis.com/arcgis/services/WorldElevation/Terrain/ImageServer

Disclaimer
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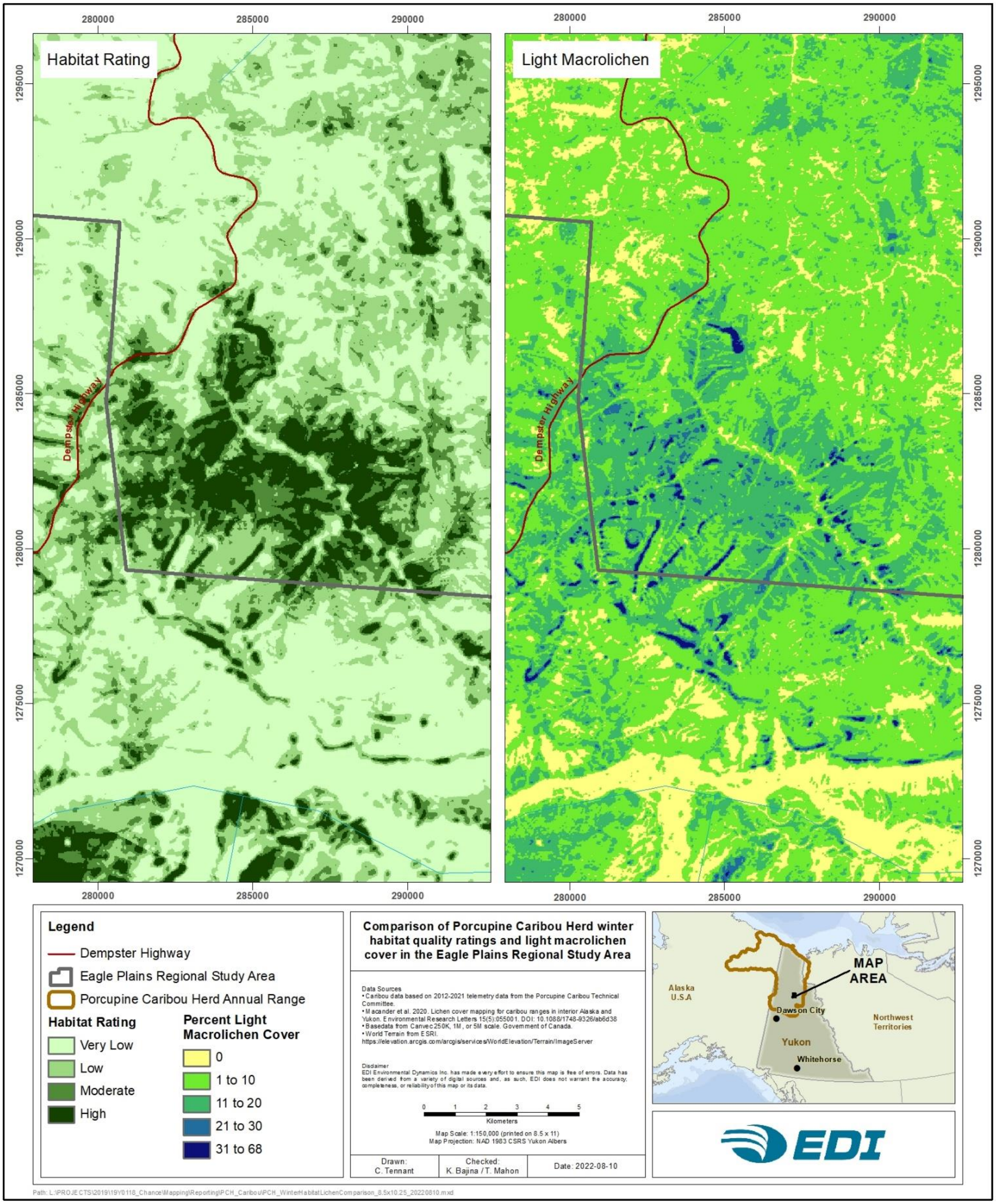
Map Scale: 1:37,500,000 (printed on 8.5 x 11)
Map Projection: NAD 1983 BC Environment Albers

Drawn:	Checked:	Date: 2022-08-10
C. Tennant	K. Bajina / T. Mahon	

Path: L:\PROJECTS\2019\19Y0118_Chance\Mapping\Reporting\PCH_Caribou\PCH_WinterHabitatQuality_8.5x10.25_20220810.mxd

Map 6-5. Distribution of habitat quality across the Porcupine Caribou Herd winter range, 2012–2021.



Comparison of Porcupine Caribou Herd winter habitat quality ratings and light macrolichen cover in the Eagle Plains Regional Study Area

Data Sources
- Caribou data based on 2012-2021 telemetry data from the Porcupine Caribou Technical Committee.
- Macander et al. 2020. Lichen cover mapping for caribou ranges in interior Alaska and Yukon. Environmental Research Letters 15(5):055001. DOI: 10.1088/1748-9326/ab6d38
- Basedata from Canvec 250K, 1M, or 5M scale. Government of Canada.
- World Terrain from ESRI. https://elevation.arcgis.com/arcgis/services/WorldElevation/Terrain/ImageServer

Disclaimer
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Map Scale: 1:150,000 (printed on 8.5 x 11)
Map Projection: NAD 1983 CSRS Yukon Albers

Drawn:	Checked:	Date: 2022-08-10
C. Tennant	K. Bajina / T. Mahon	

Path: L:\PROJECTS\2019\19Y0118_Chance\Mapping\Reporting\PCH_Caribou\PCH_WinterHabitatLichenComparison_8.5x10.25_20220810.mxd

Map 6-6. **Comparison of Porcupine Caribou Herd winter habitat quality ratings and light macrolichen cover in the Eagle Plains Regional Study Area.**

6.6 MOVEMENT

In addition to habitat selection, movement patterns across the seasonal ranges and within the vicinity of the Project RSA are important to understanding how the PCH may interact with the Project. Metrics such as daily travel rates and duration of residency (i.e., how long caribou spend in an area before moving on) help quantify how caribou use the landscape and how they may react to features, such as the Dempster Highway. In addition to movement metrics, the spatial locations of travel movements can define areas of concentrated movement during migration. To better understand factors affecting PCH caribou movement, two analyses were conducted: (1) calculation of daily movement rates and residency times of caribou in the Project RSA relative to the broader landscape, and (2) delineation of movement paths to assess broad-scale movement patterns and the potential for caribou to interact with the Project.

The PCH typically exhibit movements of several kilometres per day in both late fall and winter. Late fall daily movements (8.7 km/day in the RSA) were substantially greater than those during winter (4.4 km/day in the RSA), and caribou tended to occupy portions of the landscape for shorter periods during late fall than during winter. Caribou residency times in both seasons were two-fold greater in the broader landscape than within the Project RSA, suggesting that, on average, the RSA, is used as more of a transitory area than other portions of the seasonal ranges. The locations and patterns of movement during late fall (i.e., the end of the fall migration period) was variable within and across years and, overall, there was little evidence of dedicated migration corridors. However, in late fall of 2015, several caribou made directed movements along the height of land parallel to the Dempster Highway, from the northeast to the southwest. Although a small number of movements crossed the Dempster Highway, most movements stayed north of the Dempster Highway, potentially reflecting avoidance of the Dempster Highway. However, this series of movements did cross numerous 2D seismic lines, winter roads and a large 3D seismic grid in the RSA.

6.6.1 METHODS

6.6.1.1 Daily Movement Rates and Residency Times

Daily movement rates and residency times were calculated for each radio-collared caribou that occurred in late fall and winter range extents. The locations of each caribou were resampled to obtain one GPS fix per day. Movement rates were calculated as the speed (km/day) travelled between consecutive relocations and residency time was calculated as the number of days within a specified area. Movement rates and residency times were calculated for caribou occurring within the Project RSA (2,387 km^2) and, to compare to the broader landscape, metrics were also calculated within 50 km x 50 km (2,500 km^2) grid cells that covered fall and winter ranges. Means and standard errors of movement rates and residency times were calculated for all 50 km x 50 km cells and compared to mean values in the Project RSA.

6.6.1.2 Migration Movements

Travel routes were delineated by developing occurrence-use polygons that assessed the trajectory of each collared caribou during late fall, 2012-2021. These polygons were created using Brownian bridge movement models (BBMMs), which account for autocorrelated movements in animal relocations and assume that an animal's trajectory follows a diffusion-based (Brownian motion) process (Horne et al. 2007). BBMMs were developed, and kernel density estimation was used to predict 95% utilization distributions (UDs) for each animal, assuming a GPS location error of 100 m and implementing a grid-cell size of 500 m. Analysis was bounded to a 100 km buffer around the RSA to identify spatially relevant movement trajectories. BBMMs and UD polygons were created using the R package 'adehabitatHR' (Calenge 2006).

6.6.2 RESULTS AND DISCUSSION

6.6.2.1 Daily Movement Rates and Residency Times

Mean daily movement rates and residency times varied considerably between late fall and winter and between the Project RSA and the broader landscape. On average, caribou tended to move faster during late fall than during winter, and this was evident both in the Project RSA and across the full late fall range. The movement rates between the Project RSA and the broader landscape were greatest during late fall, i.e., at least a two-fold difference in movement rates outside versus inside the RSA. A similar outcome was evident for residency time inside versus outside the Project RSA. In both seasons, the residency time was at least twice as long outside the RSA than within it (Table 6-9).

Patterns in movement and residency were consistent with what is known about PCH caribou ecology. Caribou are at their most dispersed in both late fall and winter. Except for cows during the calving period, daily movements are lowest in winter and second lowest in late fall (Russell and Gunn 2017). Normally, faster movement rates are associated with shorter residency periods, but this was not the case for the PCH in late fall (Table 6-9). During late fall, caribou in the RSA had slower movement rates but also had shorter residency periods compared to the broader late fall range. A review of the movement trajectories indicates that although travel rates were slower inside the RSA, those paths had greater directional bias (i.e., movement in a single direction) than paths outside the RSA, which exhibited much more tortuosity. These more directed movement paths resulted in shorter residency periods, despite the slower movement rates.

During winter, caribou movement rates inside the RSA were similar to the broader landscape, but, similar to late fall, their residency time inside the RSA was significantly shorter than in the broader late fall range. This suggests that similar to the pattern in late fall, caribou tended to pass through the RSA in winter more quickly than other portions of the broader winter range. This pattern may be explained by the lower predicted habitat quality within the RSA relative to the broader landscape (see Section 6.5.2.2, *Predicted Habitat Distribution*, above). The faster movements and shorter residency times in late fall compared to winter likely reflect the tail end of fall migration movements. Notwithstanding the important differences in movement patterns between late fall and winter, the key results of these analyses are that, in both late fall and winter, PCH caribou (1) travel several kilometres per day, on average, and (2) the RSA (or similar sized areas outside the RSA) are used for a relatively short portion of the overall season.

Table 6-9. Mean daily movement rates and residency times of the Porcupine Caribou Herd in the Project RSA relative to the mean (and standard error) of 50 km x 50 km cells covering late fall and winter range extents.

Season	Scale[1]	Daily Movement (km/day)		Residency Time (days) [2]	
		Mean	Std. Error	Mean	Std. Error
Late Fall	Project RSA (2,387 km² total)	8.95	± 0.64	4.50 (8.33 %)	± 0.83
	Late Fall Range (88,149 km²) [1] (2,500 km² per cell) – 53 cells total	15.03	± 2.06	7.65 (14.17 %)	± 0.66
Winter	Project RSA (2,387 km² total)	4.02	± 0.64	15.69 (12.86 %)	± 5.11
	Winter Range (65,077 km²) [1] (2,500 km² per cell) – 40 cells total	4.77	± 0.51	25.93 (21.25 %)	± 2.13

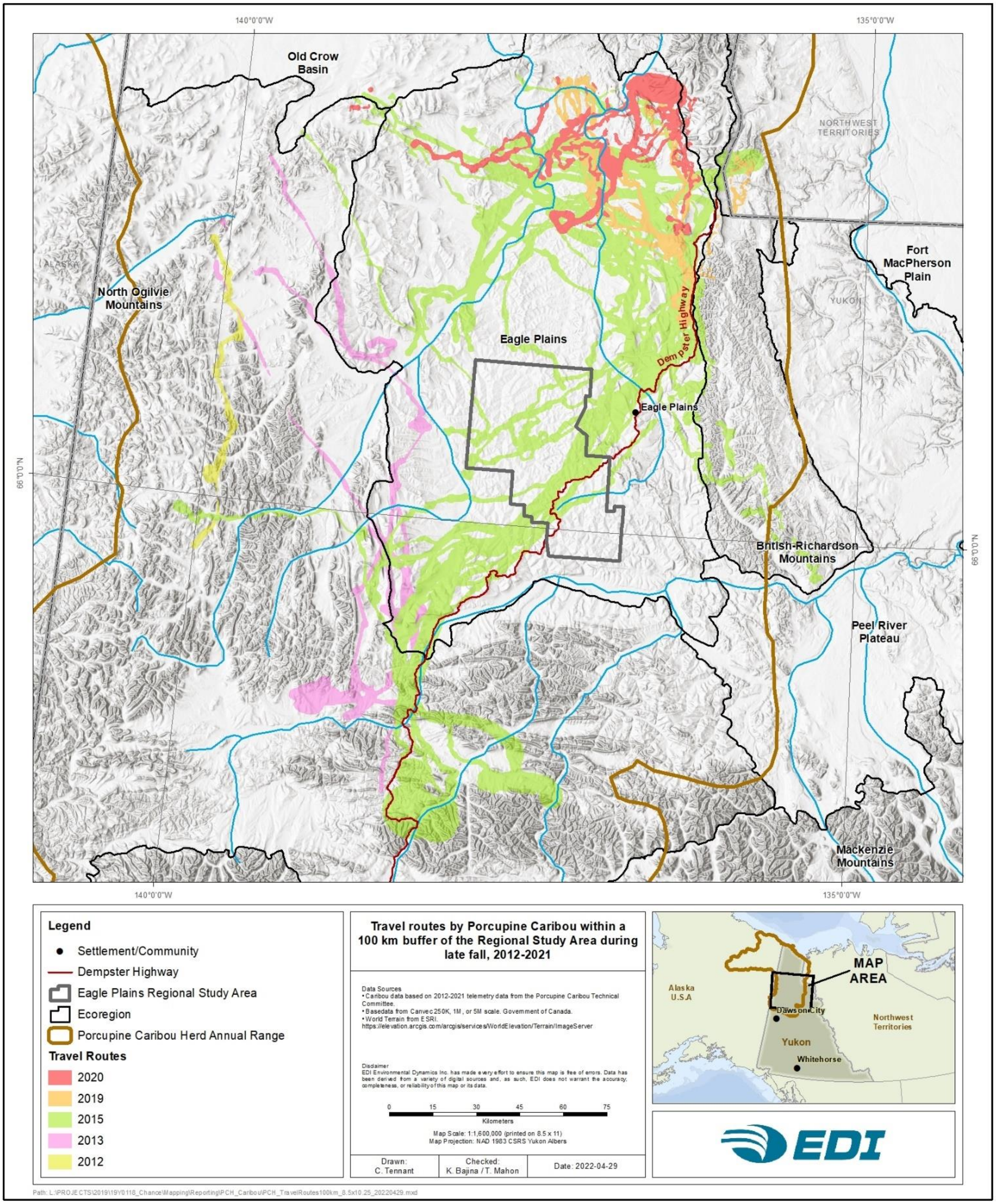
[1] Late fall and winter ranges were subsampled using 2,500 km² cells (approximately the same size and the RSA) to facilitate estimation of mean and variance. Estimates of mean and variance within the RSA are derived from differences in rates and residencies of individual caribou.

[2] Percent of the season indicated in brackets. Total days: late fall = 54 days, winter = 122 days.

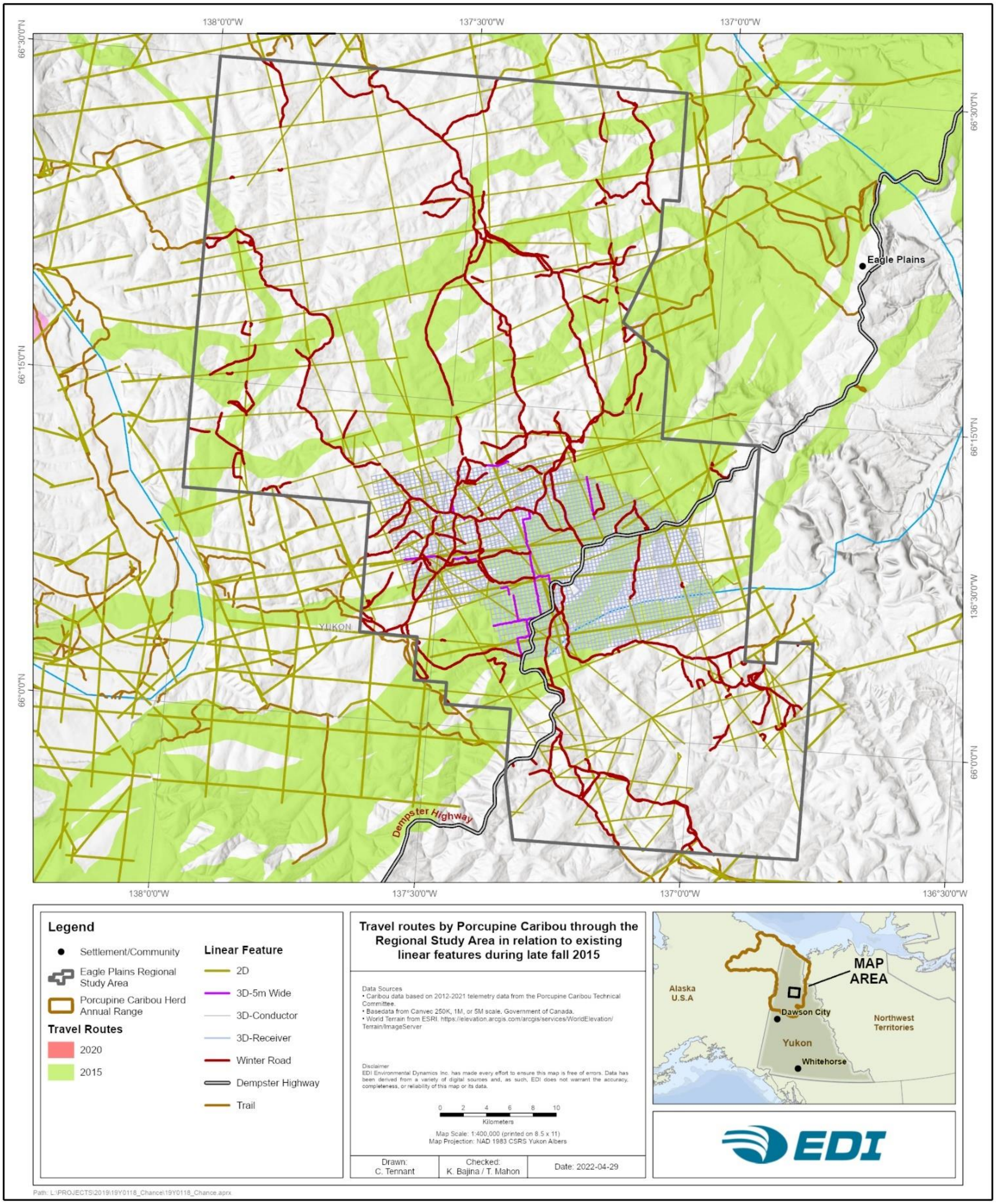
6.6.2.2 Migration Movements

Travel routes through the Project RSA were only evident in late fall of 2015. At that time, 14 caribou travelled from the northeast quadrant of the Eagle Plains ecoregion to either the southwestern portions of that ecoregion or to the North Ogilvie Mountains, along the Dempster Highway (Map 6-7). Although two caribou did cross the highway in the vicinity of the RSA, most of the caribou (12) travelled parallel to the Dempster Highway, along its northwest side, before eventually crossing the highway south of the RSA in the Ogilvie Mountains (Map 6-7). The location of the movement routes in 2015 predominantly northwest of the Dempster Highway was previously noted by Russell and Gunn (2017), who suggested the caribou may have been avoiding crossing the highway. Although this is a valid hypothesis, supported by observations from VGFN elders (Sherry and Vuntut Gwitchin First Nation 1999, p. 288), it is important to note that the set of travel routes in 2015 did eventually cross the Dempster Highway south of the RSA in the Ogilvie Mountains. These crossings may be done at times of lower traffic such as nighttime, as elders had witnessed various unsuccessful attempts of herds to cross the Dempster as vehicles were passing during the day (Sherry and Vuntut Gwitchin First Nation 1999, p. 288). It is also important to note that travel routes in 2015 coincided with a broad, regional height of land (separating the Porcupine and Peel watersheds), which caribou sometimes travel on during migration movements (Russell et al. 1993). On an absolute scale, the height of land along the Dempster Highway, and proximate locations used by caribou as travel routes (~550–650 m), coincide with the mid elevations selected by caribou during fall (see Section 6.5.2.1, *Habitat Models*). The 12 caribou that paralleled the Dempster Highway in the vicinity of the RSA did cross several inactive winter roads, numerous old 2D seismic lines, and a 350 km^2 area consisting of one-year-old 3D seismic exploration (Map 6-8).

Inferences about caribou movements are limited by the relatively small numbers of caribou that were collared (<0.1% of the herd annually) and the relatively small number of collared caribou that occurred within the RSA. Collared caribou only occurred in the Eagle Plains ecoregion in half of the years from 2012–2021; however, it is known from local knowledge that caribou occur in the ecoregion in most, if not all years. VGFN elders have discussed to importance of Eagle Plains for caribou winter habitat and noted that if caribou find a good feeding place with many trees, they will stay all winter (VGFN p185). During interviews in the late 1990's, they observed many caribou performing fighting, mating and rutting rituals around Blackstone Flats (Sherry and Vuntut Gwitchin First Nation 1999, p. 188). For the years when collared caribou were present in Eagle Plains, it is unknown how representative the collar locations are of the overall herd. For example, the concentration of travel routes through the RSA in 2015 suggests a potential movement corridor, but the proportion of caribou that is collared is too small to conclude this with confidence. The lack of movements in the same area in any other year does not support the idea that the cluster of movements in 2015 represent a regular travel corridor (but, again, this could reflect the small proportion of caribou collared).



Map 6-7. Travel routes identified for the Porcupine Caribou Herd within a 100 km buffer of the Project Regional Study Area during late fall, 2012–2021.



Travel routes by Porcupine Caribou through the Regional Study Area in relation to existing linear features during late fall 2015

Data Sources
- Caribou data based on 2012-2021 telemetry data from the Porcupine Caribou Technical Committee.
- Basedata from Canvec 250K, 1M, or 5M scale. Government of Canada.
- World Terrain from ESRI. https://elevation.arcgis.com/arcgis/services/WorldElevation/Terrain/ImageServer

Disclaimer
EDI Environmental Dynamics Inc. has made every effort to ensure this map is free of errors. Data has been derived from a variety of digital sources and, as such, EDI does not warrant the accuracy, completeness, or reliability of this map or its data.

Map Scale: 1:400,000 (printed on 8.5 x 11)
Map Projection: NAD 1983 CSRS Yukon Albers

Drawn: C. Tennant	Checked: K. Bajina / T. Mahon	Date: 2022-04-29

Path: L:\PROJECTS\2019\19Y0118_Chance\19Y0118_Chance.aprx

Map 6-8. Travel routes by Porcupine Caribou through the regional Study Area in relation to existing liner features during late fall 2015.

6.7 RELATIONSHIP TO LINEAR FEATURES

A key issue concerning the PCH is how anthropogenic development may alter caribou distribution, habitat use, and, ultimately, whether changes may influence population demography and access to the herd by First Nations and Inuvialuit harvesters. Linear features are the primary source of disturbance in the Project RSA and the broader Eagle Plains ecoregion. There is uncertainty about how caribou may respond to these features. To better understand the relationship between caribou and linear features, base habitat models were extended to assess the potential for habitat avoidance using a zone of influence (ZOI) framework. The ZOI delineates the area within which caribou behaviour is altered. ZOIs were estimated for three functionally distinct linear feature types (i.e., 2D seismic, winter roads and trails; 3D seismic; and the Dempster Highway). If ZOI estimates are statistically and ecologically significant (i.e., alter the selection of habitat and forage by caribou), they can be used to quantify effective habitat loss (i.e., perceived reduction in habitat quality by caribou due to avoidance) in the Project RSA and Eagle Plains ecoregion.

Statistical ZOIs were determined for 2D seismic lines (including winter roads and trails) in Eagle Plains in late fall and winter. However, confidence in those estimates is relatively low due to several factors. Statistical ZOIs were identified corresponding to 4 km avoidance of 2D seismic lines during late fall and 2 km avoidance of 2D seismic lines during winter. The analysis also identified that the PCH were attracted to the Dempster Highway and 3D seismic areas in both late fall and winter. Sufficient observations were associated with this pattern in relation to the Dempster Highway, but results for 3D seismic areas could be spurious due to a relatively low number of caribou locations in proximity to these features.

Although the analyses determined ZOIs associated with 2D seismic lines (and winter roads and trails), they should be interpreted with caution. (1) The magnitude of the ZOI effects was weak (i.e., including the ZOI effects in the habitat models had little effects on the habitat predictions). (2) Threshold distances estimated from ZOI analyses tend to be very sensitive to spatial and temporal contexts as well as the data and analytical methods used. Estimates of ZOIs can vary dramatically from year-to-year. This can include selecting to be closer to human features in some years and exhibiting dramatic difference in the threshold distances in years when human disturbances are thought to be avoided. The number of caribou locations in this study unevenly distributed with respect to the various linear features both spatially and across years. (3) The pattern of ZOI effects were not consistent with expectations and results from other studies. For example, having a 2 km ZOI for 2D lines and no ZOI for the Dempster Highway is counterintuitive. A previous study estimated a relatively large ZOIs for the Dempster (Johnson and Russell 2014). Based on these factors, it is recommended that these results not be used solely to estimate the effects of linear features on the PCH. Rather, it is recommended that the results be used in conjunction with results from other studies, adapted to the Eagle Plains setting and the ecology of the PCH, to develop a set of ZOIs for assessment and management purposes.

6.7.1 METHODS

A zone of influence framework evaluated the influence of linear features on PCH caribou distribution and habitat selection. Base habitat models developed for late fall and winter were extended by incorporating a 'distance to' covariate for each relevant linear feature and estimating the breakpoint beyond which the likelihood of observing caribou remained unchanged. If a ZOI was present, the likelihood of observing caribou would increase from linear feature footprint until the identified breakpoint. The primary method used to evaluate the presence and magnitude of a ZOI was a segmented regression approach (Boulanger et al. 2012, 2021).

Three functionally distinct types of linear features were considered based on their widths, densities, and extents in PCH fall and winter ranges: (1) 2D seismic, winter roads, and trails; (2) 3D seismic (grid); and (3) the Dempster Highway. The minimum distance between used/available locations and each feature was calculated and treated as a continuous covariate. To limit potential bias in ZOI estimates arising from broad-scale spatial patterns in distribution and habitat selection (see Boulanger et al. 2021, EDI Environmental Dynamics Inc. 2022b), GAMs were used to assess how the distribution of caribou changed at increasing distances from each linear feature type and to identify an 'iteration zone' to test for ZOIs. The iteration zone is defined as the boundary within which caribou distribution and habitat use are minimally affected by broad-scale patterns in climatic (e.g., snowfall) and biotic (e.g., caribou density and forage) processes. Practically, this refers to an initial range of distances (starting at 0 km) where selection is relatively flat (slope = 0) (see Boulanger et al. 2021). For example, during late fall, selection was fairly flat up to 100 km from the Dempster Highway, after which selection decreased sharply (see Attachment Figure 21 in Section 6.9.3). In other cases, such as the relationship to 2D lines during late fall, the slope was substantially greater than zero at very close distances (see Attachment Figure 19 in Section 6.9.3). Selection increased up until approximately 18 km, then sharply decreased until 25 km, and then, once again, sharply increased up until approximately 35 km. Given such non-linearity in the response, the iteration zone was identified within the first major bout of increase/decrease, i.e., within the first 25 km. This approach was taken in each case where a drastic, non-linear selection gradient occurred at very close distances to the linear feature.

Within the iteration zone, several distance thresholds were tested to identify a ZOI. The assumptions were that caribou presence would be reduced and resource selection altered within the threshold distance. We assigned all distances at or beyond the defined threshold the same distance value. For example, if a ZOI distance of 2 km was tested, then all distances up to 2 km retained their values (i.e., numbers ranging from 0 km to 1.99 km), but all distances at or greater than the ZOI were assigned a value of 2 km (e.g., 3 km or 4 km were assigned values of 2 km). A unique model was fit for each threshold tested, and the number of models corresponded to the outer boundary of the iteration zone identified for each linear feature type. In other words, if the iteration zone was deemed between 0 km and 25 km, then 25 models were tested — one for each kilometre interval. The best model, which corresponded with the most likely ZOI, was selected by evaluating the log-likelihoods of all models as a function of the distance thresholds. The highest log-likelihood corresponded with the model with the most statistical support (Boulanger et al. 2012). The magnitude of avoidance was estimated as the odds of caribou occurring at or beyond the ZOI relative to the odds of being on the linear feature (i.e., odds ratio = $e^{coefficient \times ZOI}$).

6.7.2 RESULTS AND DISCUSSION

The influence of linear features on PCH distribution and habitat selection varied between late fall and winter seasons and among functional linear feature types. ZOIs were detected for 2D seismic lines (including winter roads and trails) during late fall (4 km, Attachment Figure 25) and winter (2 km, Attachment Figure 28). These results were derived from analyses that considered only spatially relevant scales (i.e., iteration zones) (see GAM plots for 2D lines in Section 6.9.3). For example, relationships with 2D lines were evaluated only within the Eagle Plains ecoregion because most of these features occurred within this extent. The GAM plots in Section 6.9.3 also demonstrate that, though selection increased/decreased relative to 2D lines, these changes were low in magnitude. For example, within the iteration zones of 2D lines, there was an approximate 0.08 (or 8 %) increase in the probability of selection at far distances from these features. When estimated using a defined threshold, changes in the probability of selection necessarily increased (relative to GAMs) based on the imposed shape of the response (i.e., fitting a linear increase followed by a flat slope at distances equal to and beyond the ZOI). In practical terms, the odds of caribou occurring at distances equal to or beyond the ZOIs for 2D lines are 1.45 (odds ratio = $e^{0.000093 \times 4\,km}$) and 1.27 (odds ratio = $e^{0.00012 \times 2\,km}$) times greater, during late fall and winter, respectively, than the odds of caribou occurring on 2D lines. The ZOIs estimated for 2D lines in the current study were smaller than those previously estimated by Johnson and Russell (2014)—11 km from 1985–1998 and 6 km from 1999–2012 for wells, trails, winter roads, and seismic lines.

Although analysis of 2D seismic lines (including winter roads and trails) did identify statistically significant ZOIs, the results should be interpreted with caution. An important indicator to contextualize these results is whether estimated ZOIs influenced the selection of important habitat components. A comparison of coefficients between habitat models with and without ZOI terms provides a test of the ecological significance of estimated ZOIs (Boulanger et al. 2012). To accomplish this, predictions were made using the estimated ZOIs across the late fall and winter ranges to match the same spatial scale as base habitat models (see Table 6-10 and Table 6-11). During late fall, coefficients associated with macrolichen cover ($\beta_{\text{lichen.base}} = 0.694 \pm 0.029$ versus $\beta_{\text{lichen.ZOI}} = 0.689 \pm 0.029$) in Eagle Plains were invariant (Table 6-4 versus Table 6-10). Similarly, during winter, coefficients associated with lichen ($\beta_{\text{lichen.base}} = 1.119 \pm 0.018$ versus $\beta_{\text{lichen.ZOI}} = 1.114 \pm 0.018$) in Eagle Plains, and avoidance of other plant functional types, were consistent (Table 6-5 versus Table 6-11). So, even though ZOIs were determined for 2D lines, the magnitude of those effects was so small that it resulted in marginal changes to the habitat model predictions in both late fall and winter.

No ZOIs were detected for the Dempster Highway during either season. Instead, the segmented regression approach identified an attraction effect, rather than avoidance, for both late fall (9 km, Attachment Figure 27) and winter (11 km, Attachment Figure 30). Thus, caribou were more likely to occur within 9 km and 11 km of the Dempster Highway during late fall and winter, respectively, than beyond those distances. This result contradicts previous work by Johnson and Russell (2014), who identified ZOIs of major roads, including the Dempster Highway, to be as large as 30 km from 1985–1998 and 18.5 km during 1999–2012.

Similar to the results for the Dempster Highway, no ZOIs were determined for 3D seismic lines, but there is high uncertainty associated with those estimates due to the relatively small number of collared caribou that interacted with the 3D seismic area. Attraction effects were found within 16 km and 4 km of 3D seismic lines during late fall (Attachment Figure 26) and winter (Attachment Figure 29), respectively. As with 2D lines, the magnitude of the attraction effect for Dempster Highway and 3D seismic lines was small relative to base habitat selection. Additionally, considering the potential mechanisms of effects that 3D lines could have on caribou, the apparent attraction of caribou to the 3D seismic lines is likely a spurious result. Based on other studies examining the effects of 3D lines on caribou and their primary predators, wolves, it was expected that the PCH would exhibit a neutral or weak avoidance response to 3D lines due to the potential for facilitated predation to occur.

In addition to the weak effects exhibited by ZOIs relative to base habitat selection, there are other factors that warrant cautious interpretation and use of these analytic results. (1) ZOI estimates and their magnitude of effect can be sensitive to (a) sample sizes and (b) spatial and temporal coverage of the data. Though numerous overall, the data used in this analysis had relatively modest sample sizes near linear features and were unevenly distributed in relation to linear features in Eagle Plains. (2) Caribou can exhibit dramatically different ZOIs from year to year. Collared caribou were only present in modest numbers in 2012/13, 2014/15, 2017/18, and 2018/19, so the data had to be lumped across years to estimate a single ZOI. (3) ZOIs estimated for the PCH in this analysis are substantially smaller than those estimated by Johnson and Russell (2014). The issues associated with these factors are discussed below.

The spatial and temporal context of ZOI studies can influence outcomes. Estimates of ZOIs are a consequence of broad- and fine-scaled space use, and these patterns of distribution can emerge from population demography, biotic interactions (e.g., density-dependent competition or predator-prey interactions), abiotic conditions (e.g., snowfall, forage availability), habitat selection, and potential sources of disturbance (e.g., dust fall, sensory disturbance) (Messier et al. 1988, Johnson et al. 2001, Mahoney and Schaefer 2002, Hinkes et al. 2005, Bowyer et al. 2014, Chen et al. 2017, Boulanger et al. 2021, Pedersen et al. 2021). These sources of variation in space use do not negate the importance of quantifying indirect effects of anthropogenic development, but they do point to underlying issues with the ZOI framework and its utility for management and mitigation. For example, Boulanger et al. (2021) documented ZOI responses by Bathurst caribou to the Ekati-Diavik mine complex (Northwest Territories) that have varied dramatically from year-to-year, which the authors attribute to changes in drought conditions. Similarly, Johnson et al. (2020) found that ZOIs around energy infrastructure (North Slope of Alaska, USA) reduced during periods of high mosquito activity for the Central Arctic Herd (CAH). In these examples, fine-scale changes in caribou space use was primarily driven by selection for areas adjacent to large, open bodies of water: Lac de Gras by Bathurst caribou and the Arctic Ocean by CAH caribou.

Another issue regarding the interpretation of ZOIs is their sensitivity to the data and analytical methods used. For example, Boulanger et al. (2021) found that GPS-collared caribou exhibited ‘avoidance’ (a ZOI) in only four out of nine years at the Ekati-Diavik mine complex (range = 6–13 km). In five of those nine years, caribou exhibited either no relationship or attraction to mine infrastructure. Additionally, when comparing an overlapping year (2012) between GPS data and aerial survey data for Bathurst caribou, a ZOI was identified using GPS collar data (ZOI = 7.09 km, odds ratio not overlapping zero; see Table 3 in publication) but was not identified using aerial survey data (ZOI = 11.4 km, odds ratio overlapping zero; see Table 4 in publication). During the data exploration phase of the current study, ZOI results also varied considerably based on different subsets of the PCH data. For example, the estimates of a ZOI around 2D seismic lines (including winter roads and trails) changed by several kilometres when assessing not only different years but different spatial extents (e.g., ecoregions).

The ZOI analysis conducted by Johnson and Russell (2014) for the PCH used a similar approach to the current analysis and other studies, but yielded very different results for seismic lines and major roads. Johnson and Russell (2014) also caution against interpreting their results based on several factors, including a large change in the PCH's population size over their study duration, variation in animal behaviour across the range of development types, and relatively small effect sizes for caribou-disturbance responses. The potential reason for differences between the results in this study and those of Johnson and Russell (2014) are not apparent and may reflect the sensitivity of results to the differences in sample sizes and spatiotemporal patterns in the data used between the two studies. Landscape conditions and land use activities were similar between the two study periods and likely included some of the same data (e.g., winter 2012). Both Johnson and Russell (2014) and the current study dealt with trade-offs in spatial and temporal coverage. Though Johnson and Russell (2014) had data with longer temporal coverage (27 years), these data suffered from poorer spatial resolution associated with larger interval collar fixes (on average, once every seven days), smaller sample sizes ($N = 2{,}127$), and coarser habitat variables (i.e., landcover classification). In contrast, the current study used data with shorter temporal coverage (8 years) but had higher spatial resolution associated with collar fixes (on average, one per day), larger sample sizes ($N_{fall} = 8{,}323$ and $N_{winter} = 13{,}014$), and high resolution habitat variables (i.e., 30 m x 30 m plant functional type percent and digital elevation model). The current study had the advantage of higher spatial resolution, which is especially important for ZOIs, which are, by nature, a spatial phenomenon. A limitation to both this study and Johnson and Russell (2014) is the lack of sufficient interaction between caribou and linear features each year, which prevented the estimation of annual ZOIs.

ZOI analyses, including the analyses in this study, often do not explicitly test specific mechanisms that could be causing caribou to avoid anthropogenic features. It is assumed, correctly or incorrectly, that caribou avoid these areas because they perceive elevated predation risk (Frid and Dill 2002, Semeniuk et al. 2012). This can include avoidance due to direct sensory disturbances associated with the features and learned behaviours that could result in avoidance beyond sensory perception distances (Boulanger et al. 2021). Assuming the ZOIs detected in this study are 'real', potential mechanisms that cause caribou to avoid 2D seismic lines, winter roads, and trails are perceived mortality risk associated with human hunting (Wolfe et al. 2000, Plante et al. 2017) and facilitated predation by wolves (James and Stuart-Smith 2000, Dickie et al. 2017).

Ultimately, the purpose of measuring and testing caribou responses to linear features is to inform management and mitigation. Given the weak effects associated with the ZOIs generated here, and the analytical issues discussed above, it is recommended that these results not be used solely to estimate the effects of linear features on the PCH. Rather, it is recommended that the results be used in conjunction with results from other studies, adapted to the Eagle Plains setting and the ecology of the PCH, to develop a set of ZOIs for assessment and management purposes.

Table 6-10. Zone of influence habitat model of global-availability resource selection (RSF) by Porcupine Caribou Herd caribou in Eagle Plains during late fall.

Model Term	Estimate	Std. Error	*Z*-statistic	*P*
Intercept				
Eagle Plains & North *(Reference)*	-9.579	0.038	-254.424	<0.0001
Ecoregion (factor)				
North Ogilvie Mountains	-0.281	0.077	-3.649	0.000263
British-Richardson Mountains	0.357	0.051	7.033	<0.0001
Old Crow Basin	0.171	0.042	4.050	<0.0001
Davidson Mountains	0.462	0.047	9.814	<0.0001
Aspect (factor)				
South	0.103	0.032	3.251	0.00115
East	0.004	0.032	0.127	0.899
West	0.157	0.031	5.028	<0.0001
Ecoregion–Lichen_100m Interaction				
Eagle Plains * Lichen_100m Percent[1,2] *(Reference)*	0.689	0.029	23.628	<0.0001
North Ogilvie Mountains * Lichen_100m Percent[1,2]	0.065	0.063	1.041	0.298
British-Richardson Mountains * Lichen_100m Percent[1,2]	-0.296	0.043	-6.929	<0.0001
Old Crow Basin * Lichen_100m Percent[1,2]	-0.137	0.037	-3.665	0.000248
Davidson Mountains * Lichen_100m Percent[1,2]	-0.216	0.042	-5.117	<0.0001
Digital Elevation Model				
Slope Percent[1,2]	-0.309	0.017	-17.947	<0.0001
Absolute Elevation[2] (linear)	0.810	0.073	11.091	<0.0001
Absolute Elevation[2] (quadratic)	-0.785	0.070	-11.219	<0.0001
Distances				
Distance to Waterbodies[2]	-0.177	0.016	-11.402	<0.0001

[1] covariate transformation = $\log_e(x + 1)$.

[2] covariate estimates based on standardized covariate values = (x – mean[x])/std. deviation(x).

Note: the zone of influence estimate derived within the iteration zone was used to predict habitat selection across the late fall range for the purpose of comparing habitat coefficients only.

Table 6-11. Zone of influence habitat model of global–availability resource selection (RSF) by Porcupine Caribou Herd caribou in Eagle Plains during winter.

Model Term	Estimate	Std. Error	*Z*-statistic	*P*
Intercept				
Eagle Plains & North *(Reference)*	-9.982	0.051	-196.452	<0.0001
Ecoregion (factor)				
North Ogilvie Mountains	0.569	0.040	14.207	<0.0001
British-Richardson Mountains	0.675	0.039	17.242	<0.0001
Old Crow Basin	0.242	0.034	7.018	<0.0001
Aspect (factor)				
South	0.192	0.025	7.536	<0.0001
East	0.032	0.026	1.223	0.221
West	0.324	0.025	13.074	<0.0001
Ecoregion– Lichen_100m Interaction				
Eagle Plains * Lichen_100m Percent^{1,2} *(Reference)*	1.114	0.018	62.639	<0.0001
North Ogilvie Mountains * Lichen_100m Percent^{1,2}	-0.154	0.034	-4.511	<0.0001
British-Richardson Mountains * Lichen_100m Percent^{1,2}	-0.602	0.036	-16.842	<0.0001
Old Crow Basin * Lichen_100m Percent^{1,2}	-0.119	0.034	-3.495	0.000474
Other Plant Functional Types				
Conifer_Tree_1000m Percent^{2}	-0.253	0.009	-26.810	<0.0001
Forbs_500m Percent^{2}	-0.165	0.010	-16.910	<0.0001
Deciduous_Shrub_1000m Percent^{2}	-0.094	0.009	-9.980	<0.0001
Graminoid_1000m Percent^{2}	-0.121	0.009	-12.829	<0.0001
Evergreen_Shrub_100m Percent^{2}	-0.052	0.009	-5.607	<0.0001
Digital Elevation Model				
Slope Percent^{1,2}	-0.220	0.012	-19.034	<0.0001
Absolute Elevation^{2} (linear)	-1.441	0.056	-25.507	<0.0001
Absolute Elevation^{2} (quadratic)	0.941	0.054	17.572	<0.0001
Distances				
Distance to Waterbodies^{2}	0.206	0.010	20.711	<0.0001

[1] covariate transformation = $\log_e(x + 1)$.

[2] covariate estimates based on standardized covariate values = (x – mean[x])/std. deviation(x).

Note: the zone of influence estimate derived within the iteration zone was used to predict habitat selection across the winter range for the purpose of comparing habitat coefficients only.

6.8 SUMMARY

The PCH is known for large population aggregations, dramatic population fluctuations, lengthy migrations, and significant cultural and social value to northern Indigenous peoples. Within the NYLUP, the PCH is considered "…*the most significant and culturally important wildlife resource in the planning region.*" Habitat, food supply, predation, hunting, disease and climate range likely play interactive roles as limiting factors to the PCH population. Factors have limited potential to regulate the PCH, individually.

- The potential for food supply, especially lichen, to regulate the PCH is more limited than other barren ground caribou herds because of the PCH's very large annual and seasonal ranges and the diversity of habitats found within those ranges (e.g., including several ecoregions). Overall, the PCH winter range is relatively rich in lichen resources and is comparable to, or better than, those of other herds that winter in taiga regions.
- Predation does not seem to play a role in limiting PCH growth while the herd is at high numbers. One study suggested that the predation rate had to be near twice the observed level to cause the PCH to decline.
- The comprehensive measures within the Harvest Management Plan to monitor and respond to declines in the PCH (i.e., by reducing harvest) provide a solid system to minimize the potential effects that harvesting could have on the herd.

The portion of the PCH annual range that occurs within Yukon is protected by a network of parks, special management areas, conservation areas, wilderness areas, protected areas, ecological preserves, habitat protection areas, and IMA zones within the North Yukon Regional Land Use Plan and the Peel Watershed Regional Land Use Plan. In total, 54% of the annual range of the PCH within Yukon falls within some type of protected area where industrial activity is prohibited, 36% of the annual range occurs within Integrated Management Area zones where development is limited, and 9% of the annual range is not covered by any land management zonation. The Eagle Plains RSA occurs within IMA Zone IV, which permits the highest level of development.

The PCH have historically overlapped the Eagle Plains RSA in the rut/late fall and winter periods. However, the RSA constitutes only a small portion of those ranges — 6.0% of the late fall range and 6.5% of the winter range. The RSA does not overlap with the most frequently used portions of the late fall and winter ranges.

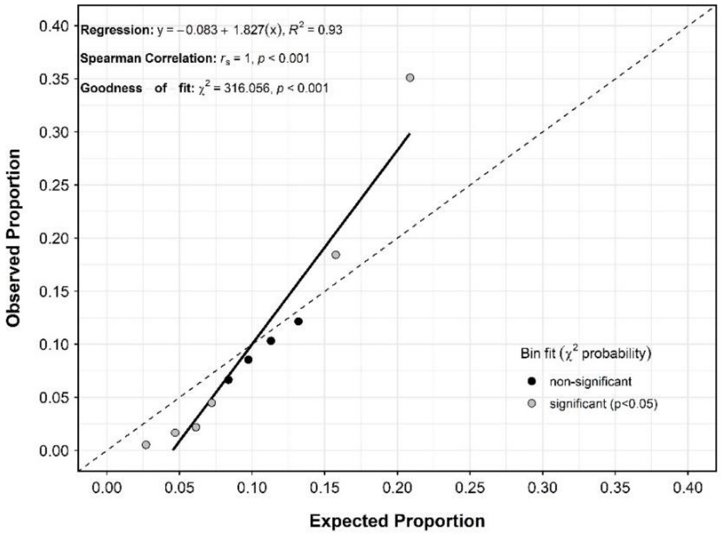
Habitat selection by the PCH in late fall and winter was estimated using resource selection functions. Selected habitats were dependent primarily on the distribution of macrolichen cover. Distance to linear features had a small effect on habitat model predictions. Overall, the strength of selection was greater in winter than late fall, which corresponds to broader movement patterns and use of more diverse habitats by the PCH in fall. In terms of regional habitat distribution, the RSA had similar proportions of selected habitat in fall as the full late fall range; however, the RSA had a much lower proportion of selected habitat in winter compared to the full winter range. Within the RSA, lichen distribution (and caribou use) was strongly affected by extensive recent burns, which had lower lichen cover than unburned areas.

The PCH typically exhibits movements of several kilometres per day in late fall and winter. Late fall daily movements (8.7 km/day in the RSA) were substantially greater than during winter (4.4 km/day). Caribou tended to occupy portions of the landscape for shorter periods during late fall than winter. Caribou residency times in both seasons were two-fold greater in the broader landscape than within the Project RSA, suggesting that, on average, the RSA is more of a transitory area than other portions of the seasonal ranges.

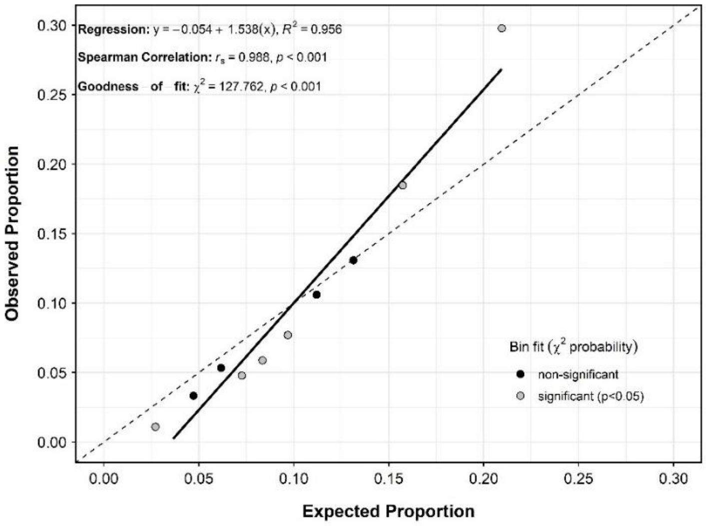
6.9 CARIBOU SECTION ATTACHMENTS

6.9.1 ATTACHMENT 6–A — 5-FOLD CROSS-VALIDATION

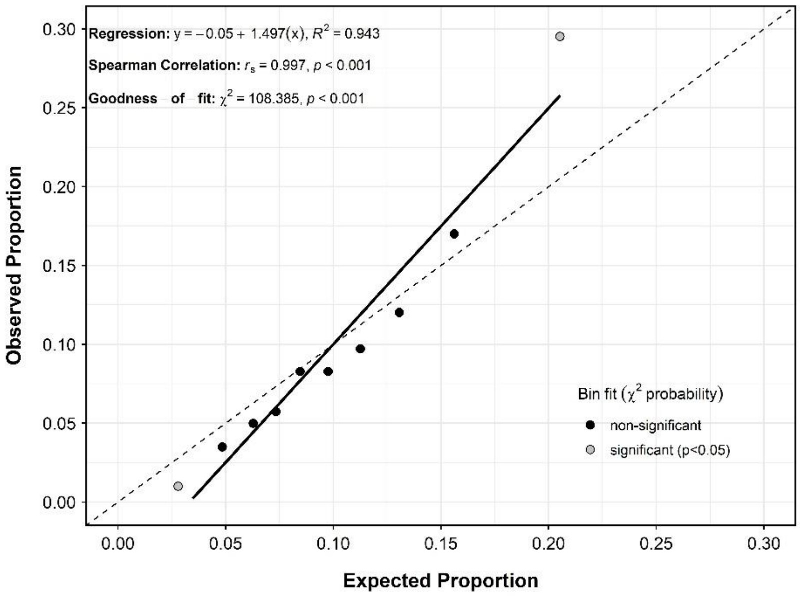
Late Fall



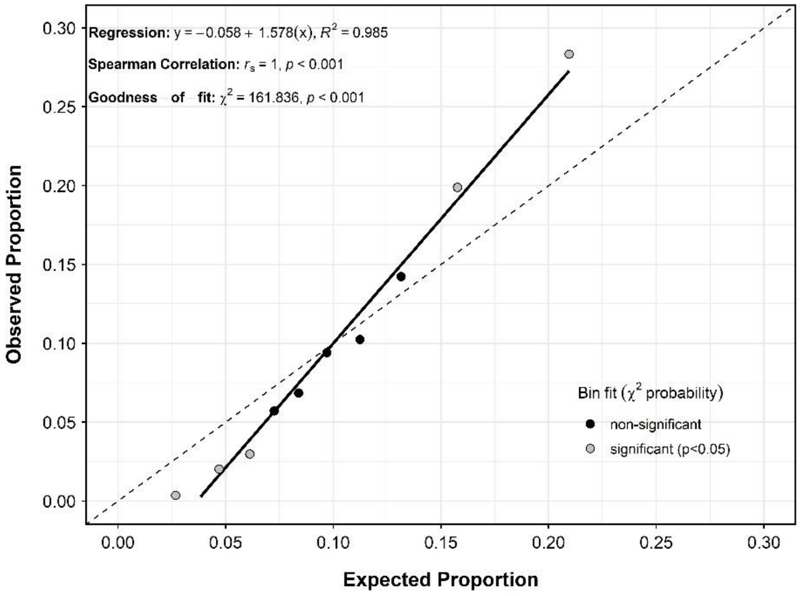
Attachment Figure 1. Cross-validation results comparing expected versus observed proportion of GPS telemetry observations (n = 18,310) of caribou during late fall across 10 quantile bins (Fold 1). Dashed line shows the line of unity (observed = expected). Black line shows the fitted regression; points are either black (not statistically different than expected) or grey (statistically different from expected) for each bin.



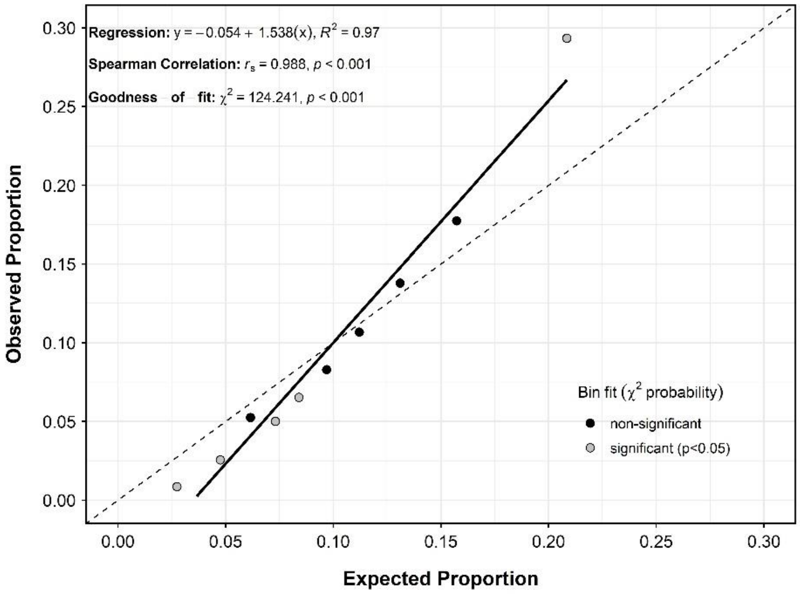
Attachment Figure 2. Cross-validation results comparing expected versus observed proportion of GPS telemetry observations (n = 18,310) of caribou during late fall across 10 quantile bins (Fold 2). Dashed line shows the line of unity (observed = expected). Black line shows the fitted regression; points are either black (not statistically different than expected) or grey (statistically different from expected) for each bin.



Attachment Figure 3. Cross-validation results comparing expected versus observed proportion of GPS telemetry observations (n = 18,310) of caribou during late fall across 10 quantile bins (Fold 3). Dashed line shows the line of unity (observed = expected). Black line shows the fitted regression; points are either black (not statistically different than expected) or grey (statistically different from expected) for each bin.

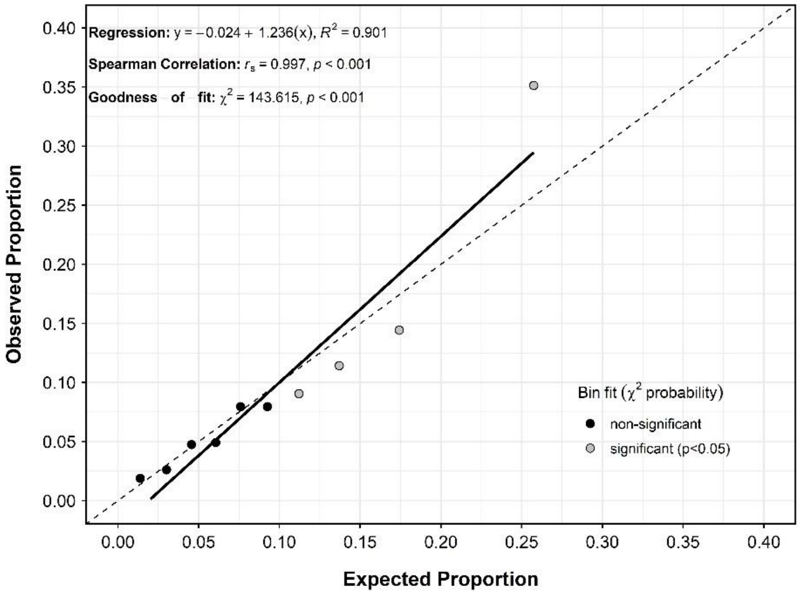


Attachment Figure 4. Cross-validation results comparing expected versus observed proportion of GPS telemetry observations (n = 18,310) of caribou during late fall across 10 quantile bins (Fold 4). Dashed line shows the line of unity (observed = expected). Black line shows the fitted regression; points are either black (not statistically different than expected) or grey (statistically different from expected) for each bin.

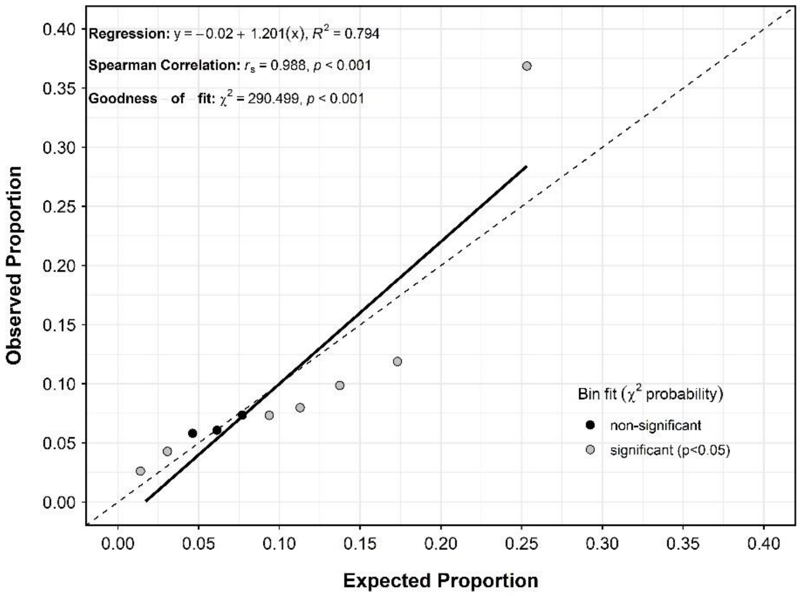


Attachment Figure 5. Cross-validation results comparing expected versus observed proportion of GPS telemetry observations (n = 18,310) of caribou during late fall across 10 quantile bins (Fold 5). Dashed line shows the line of unity (observed = expected). Black line shows the fitted regression; points are either black (not statistically different than expected) or grey (statistically different from expected) for each bin.

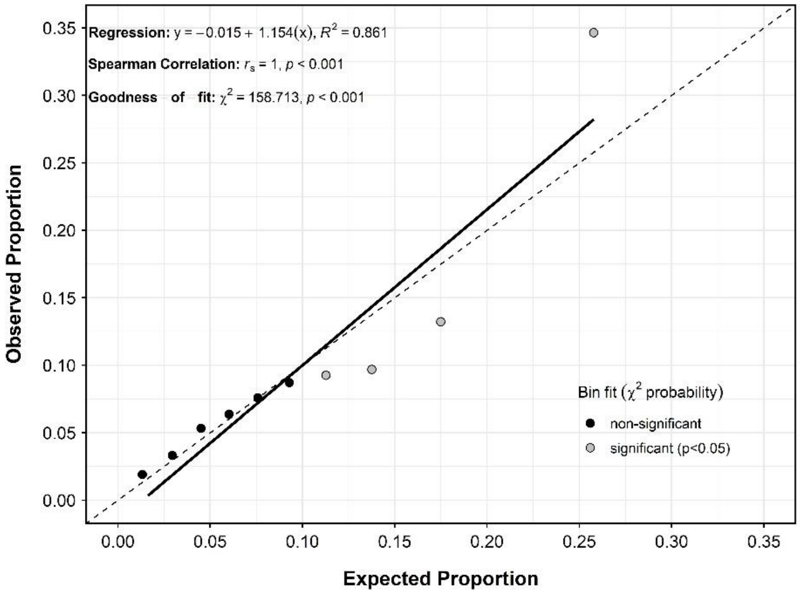
Winter



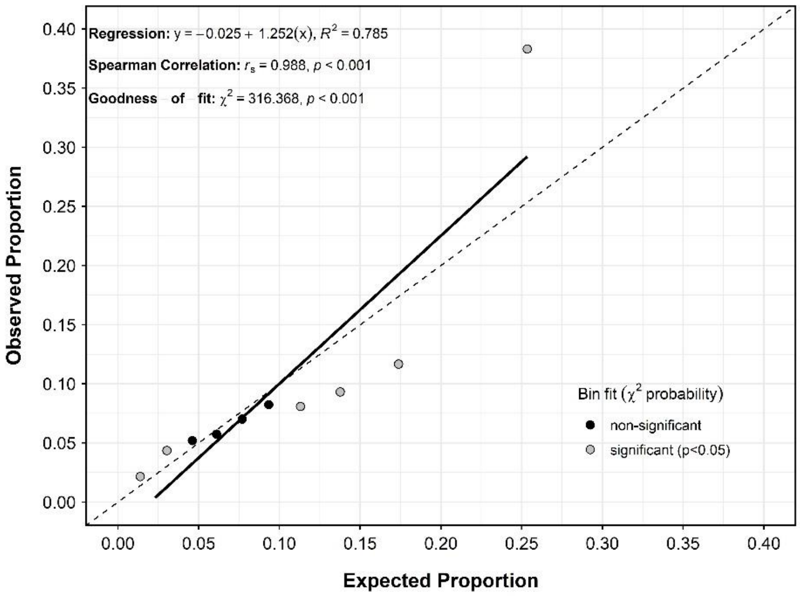
Attachment Figure 6. Cross-validation results comparing expected versus observed proportion of GPS telemetry observations (n = 28,630) of caribou during winter across 10 quantile bins (Fold 1). Dashed line shows the line of unity (observed = expected). Black line shows the fitted regression; points are either black (not statistically different than expected) or grey (statistically different from expected) for each bin.



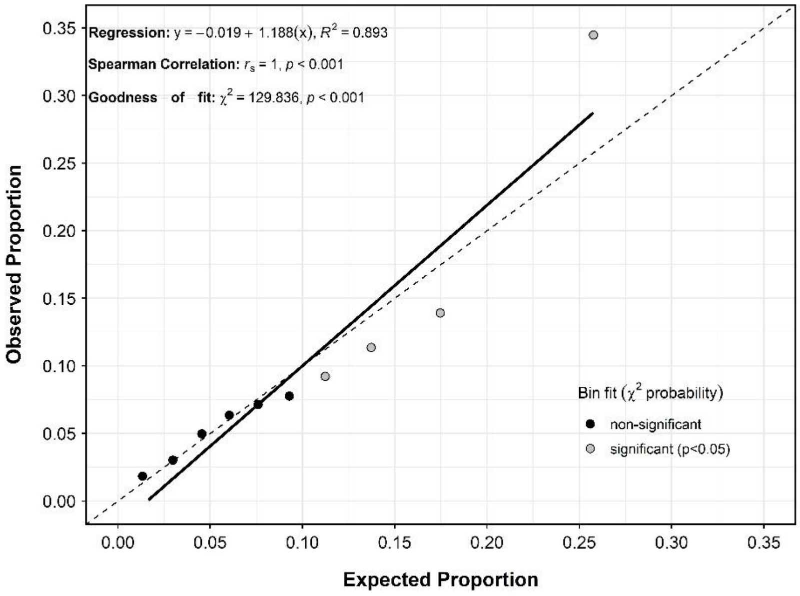
Attachment Figure 7. Cross-validation results comparing expected versus observed proportion of GPS telemetry observations (n = 28,630) of caribou during winter across 10 quantile bins (Fold 2). Dashed line shows the line of unity (observed = expected). Black line shows the fitted regression; points are either black (not statistically different than expected) or grey (statistically different from expected) for each bin.



Attachment Figure 8. Cross-validation results comparing expected versus observed proportion of GPS telemetry observations (n = 28,630) of caribou during winter across 10 quantile bins (Fold 3). Dashed line shows the line of unity (observed = expected). Black line shows the fitted regression; points are either black (not statistically different than expected) or grey (statistically different from expected) for each bin.



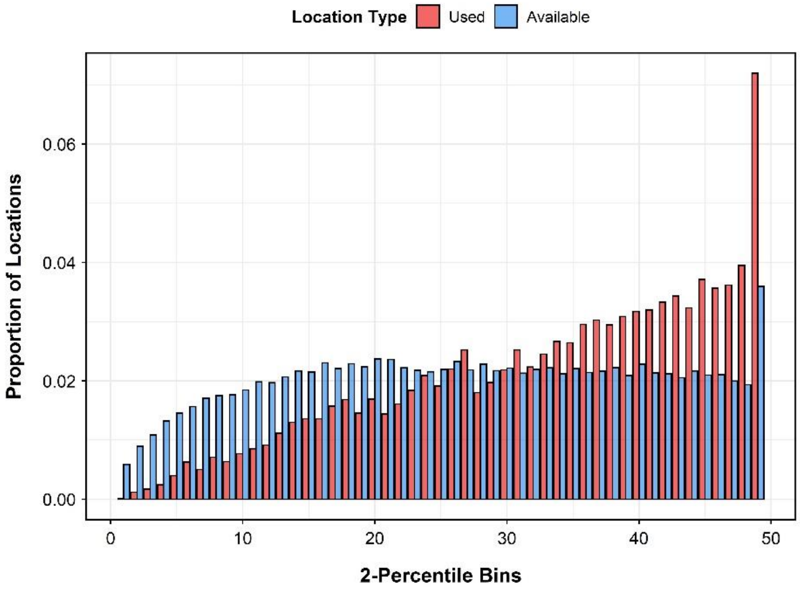
Attachment Figure 9. Cross-validation results comparing expected versus observed proportion of GPS telemetry observations (n = 28,630) of caribou during winter across 10 quantile bins (Fold 4). Dashed line shows the line of unity (observed = expected). Black line shows the fitted regression; points are either black (not statistically different than expected) or grey (statistically different from expected) for each bin.



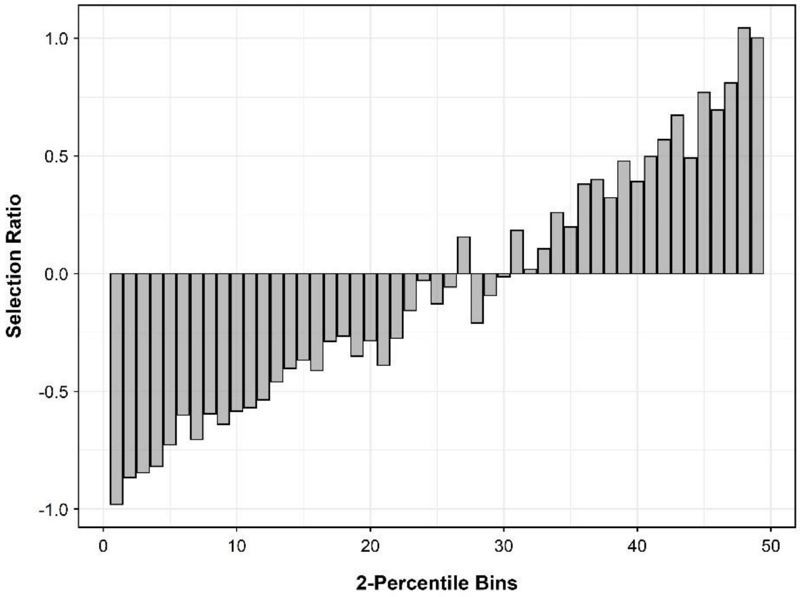
Attachment Figure 10. Cross-validation results comparing expected versus observed proportion of GPS telemetry observations (n = 28,630) of caribou during winter across 10 quantile bins (Fold 5). Dashed line shows the line of unity (observed = expected). Black line shows the fitted regression; points are either black (not statistically different than expected) or grey (statistically different from expected) for each bin.

6.9.2 ATTACHMENT 6–B — SELECTION RATIOS AND HABITAT RATINGS

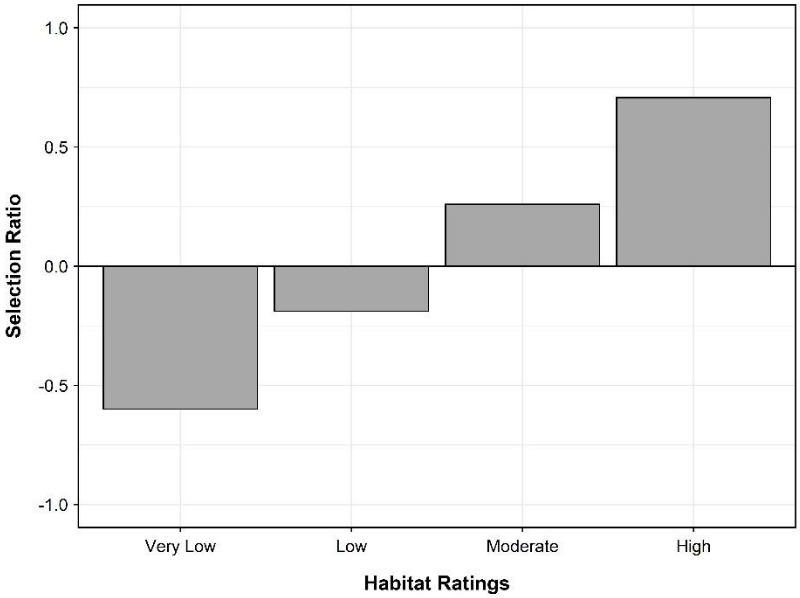
Late Fall



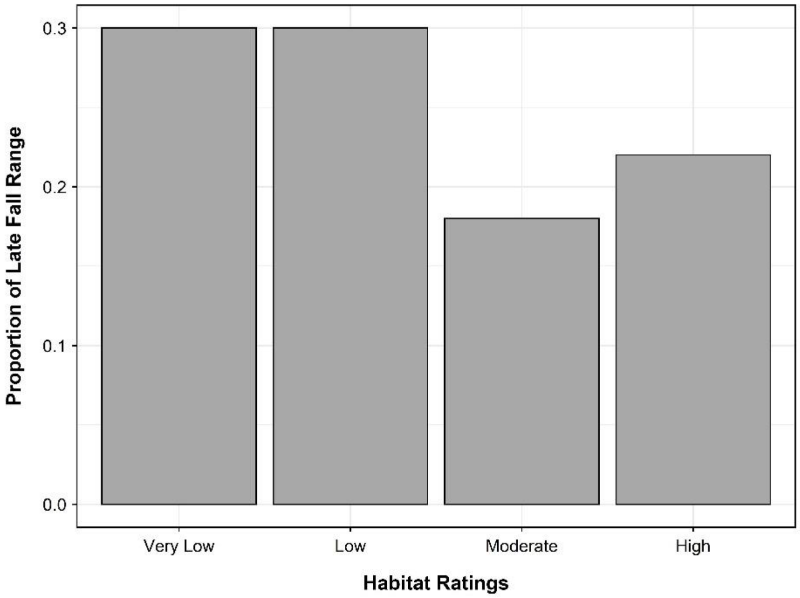
Attachment Figure 11. Proportions of used and available locations across 2-percentile (49 quantiles) interval bins of resource selection predictions during late fall, 2012–2021.



Attachment Figure 12. Selection ratios comparing the proportion of used to available locations across 2-percentile (49 quantiles) interval bins of resource selection predictions during late fall, 2012–2021.

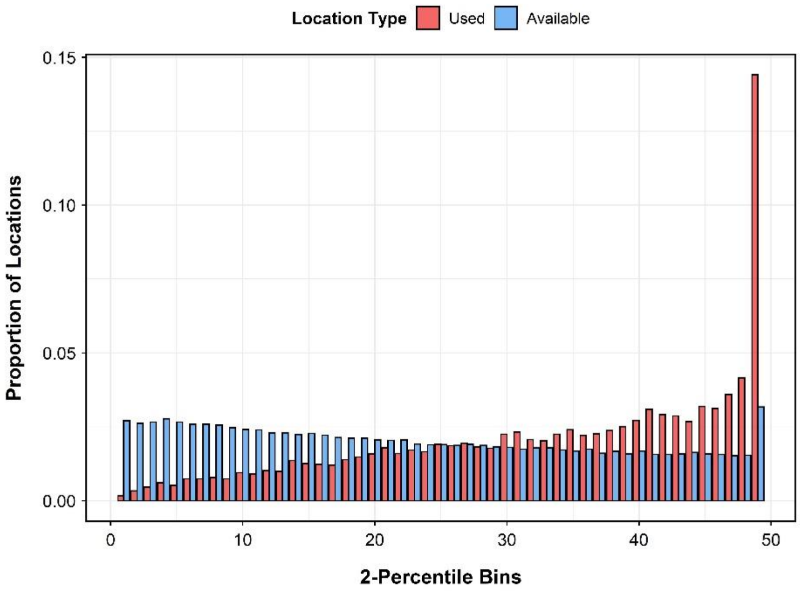


Attachment Figure 13. Selection ratios comparing the proportion of used to available locations across habitat rating classifications during late fall, 2012–2021.

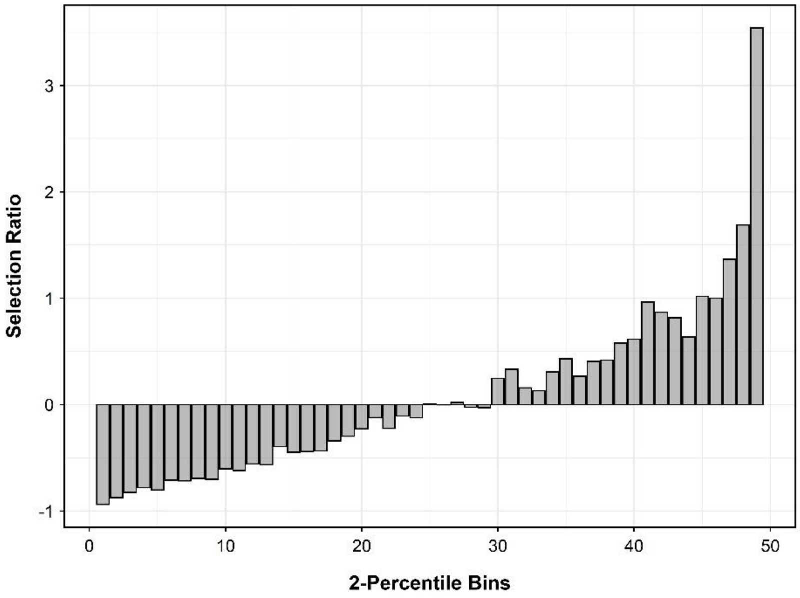


Attachment Figure 14. Proportion of the PCH late fall range composed by each habitat rating classification.

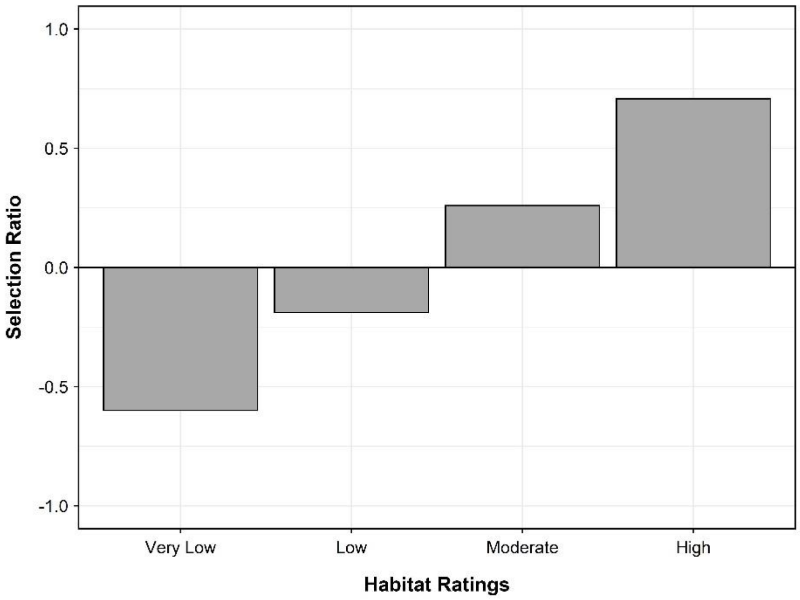
Winter



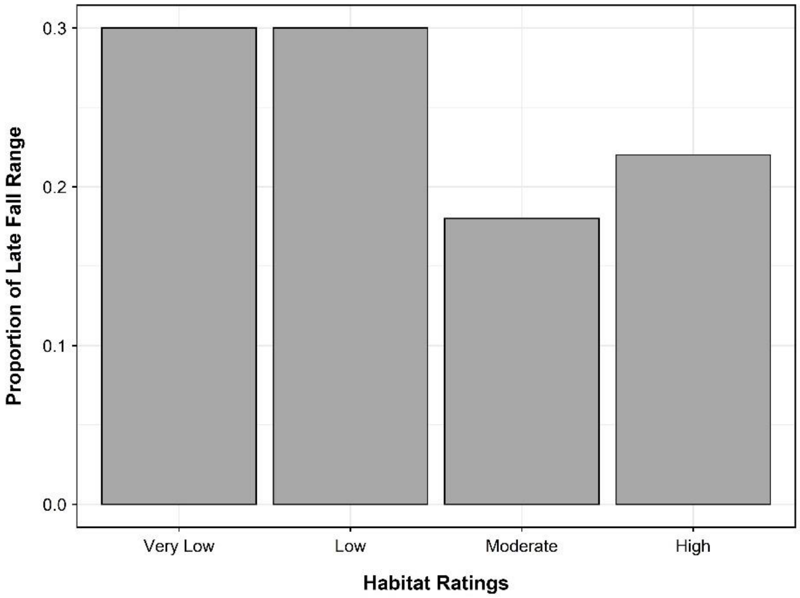
Attachment Figure 15. Proportions of used and available locations across 2-percentile (49 quantiles) interval bins of resource selection predictions during winter, 2012–2021.



Attachment Figure 16. Selection ratios comparing the proportion of used to available locations across 2-percentile (49 quantiles) interval bins of resource selection predictions during winter, 2012–2021.



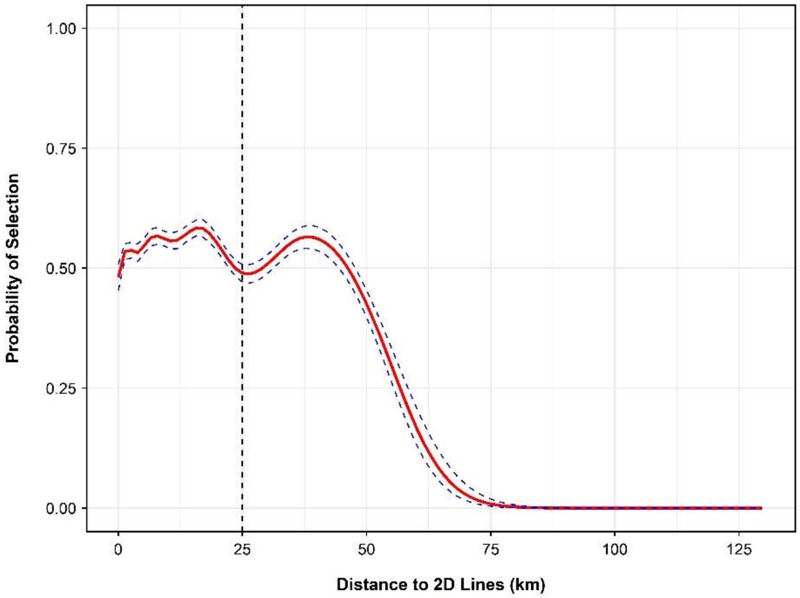
Attachment Figure 17. Selection ratios comparing the proportion of used to available locations across habitat rating classifications during winter, 2012–2021.



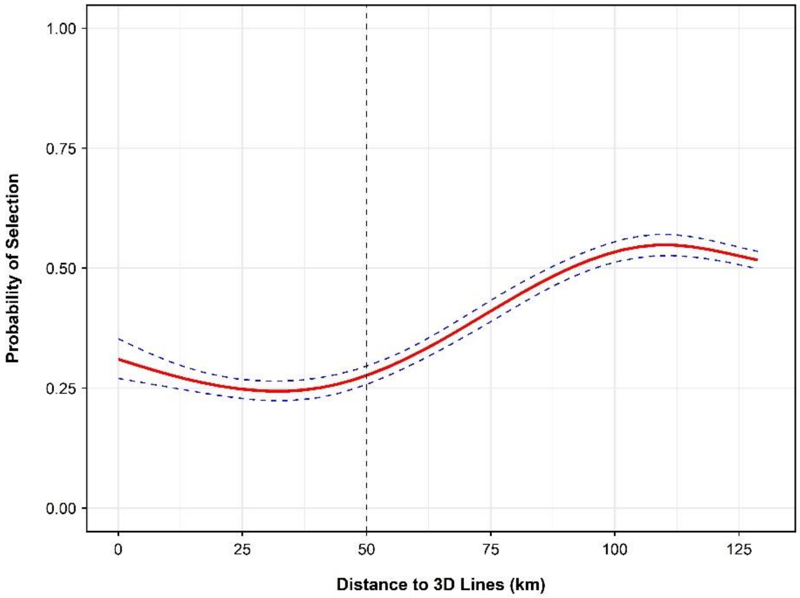
Attachment Figure 18. Proportion of the PCH winter range composed by each habitat rating classification.

6.9.3 ATTACHMENT 6–C — ZONE OF INFLUENCE ANALYSES

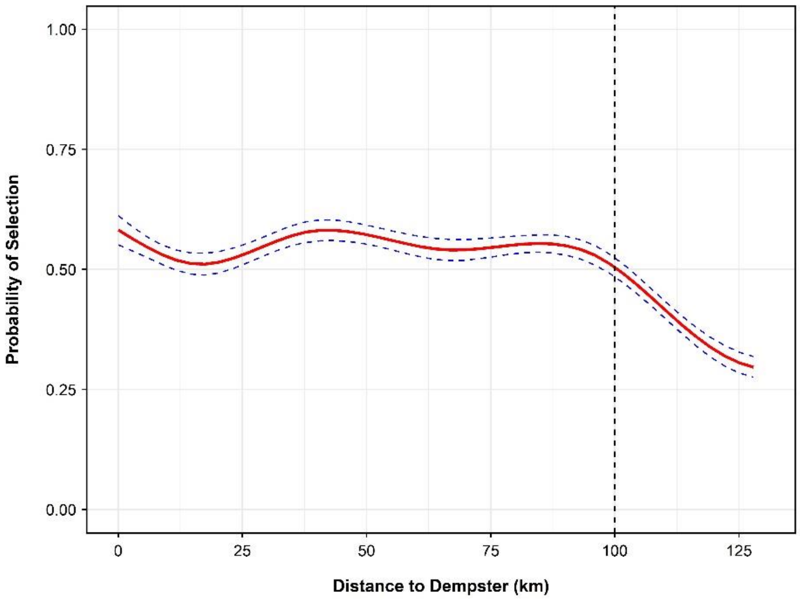
Late Fall



Attachment Figure 19. Marginal effect of distance to 2D seismic lines (including winter roads and trails) on the probability of selection by caribou during late fall (2012–2021) based on a generalized additive model with cubic regression splines. Solid red and dashed blue lines are the fitted mean and 95% confidence intervals, respectively. Vertical dashed line indicates iteration zone cut-off.

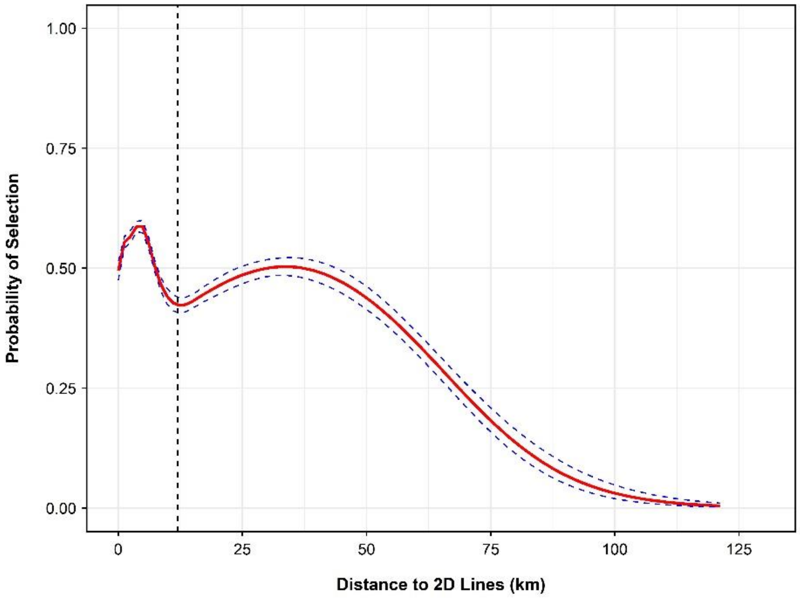


Attachment Figure 20. Marginal effect of distance to 3D seismic lines (single grid in Project RSA) on the probability of selection by caribou during late fall (2012–2021) based on a generalized additive model with cubic regression splines. Solid red and dashed blue lines are the fitted mean and 95% confidence intervals, respectively. Vertical dashed line indicates iteration zone cut-off.

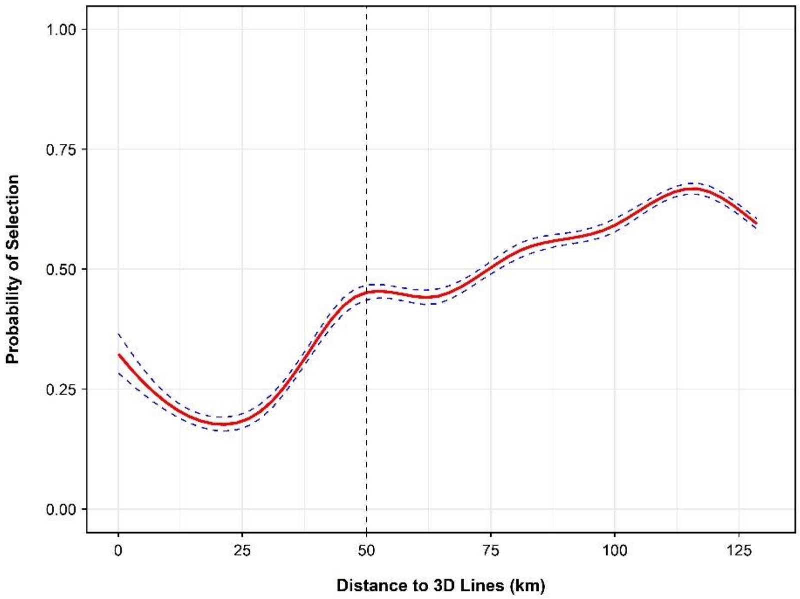


Attachment Figure 21. Marginal effect of distance to the Dempster Highway on the probability of selection by caribou during late fall (2012–2021) based on a generalized additive model with cubic regression splines. Solid red and dashed blue lines are the fitted mean and 95% confidence intervals, respectively. Vertical dashed line indicates iteration zone cut-off.

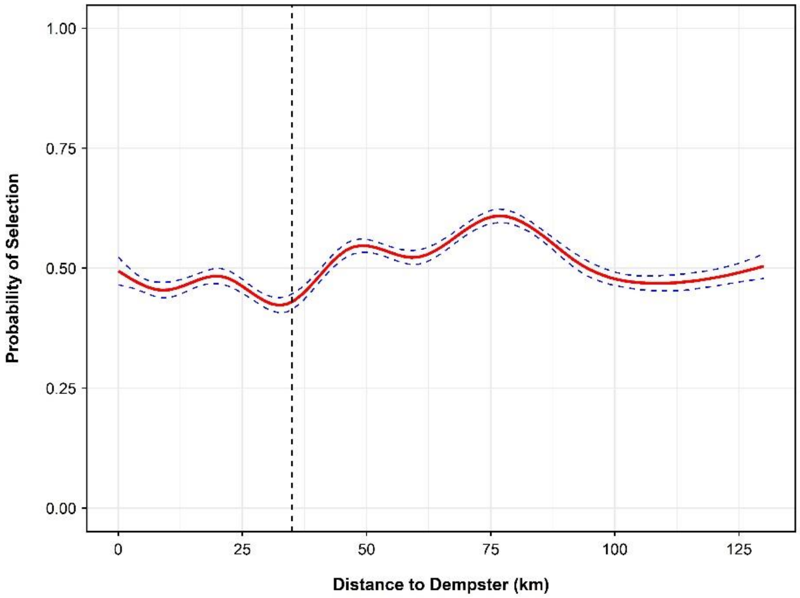
Winter



Attachment Figure 22. Marginal effect of distance to 2D seismic lines (including winter roads and trails) on the probability of selection by caribou during winter (2012–2021) based on a generalized additive model with cubic regression splines. Solid red and dashed blue lines are the fitted mean and 95% confidence intervals, respectively. Vertical dashed line indicates iteration zone cut-off.

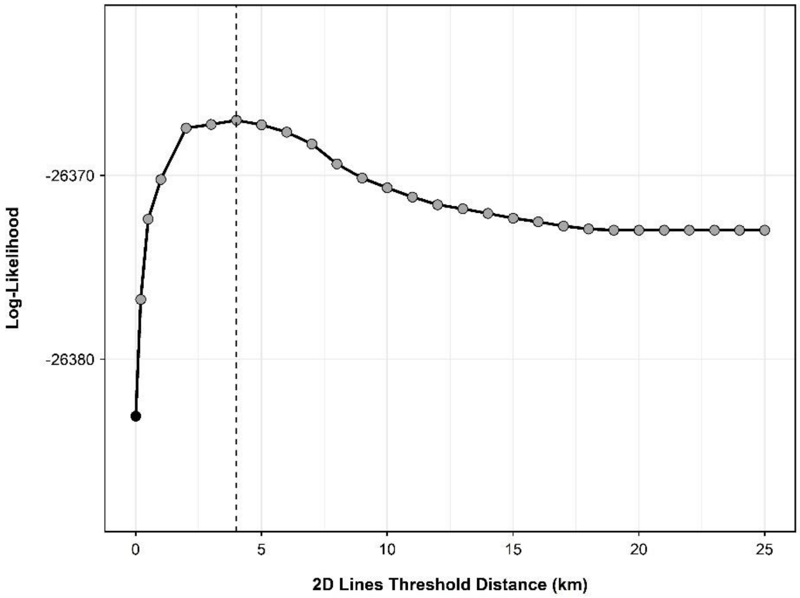


Attachment Figure 23. Marginal effect of distance to 3D seismic lines (single grid in Project RSA) on the probability of selection by caribou during winter (2012–2021) based on a generalized additive model with cubic regression splines. Solid red and dashed blue lines are the fitted mean and 95% confidence intervals, respectively. Vertical dashed line indicates iteration zone cut-off.

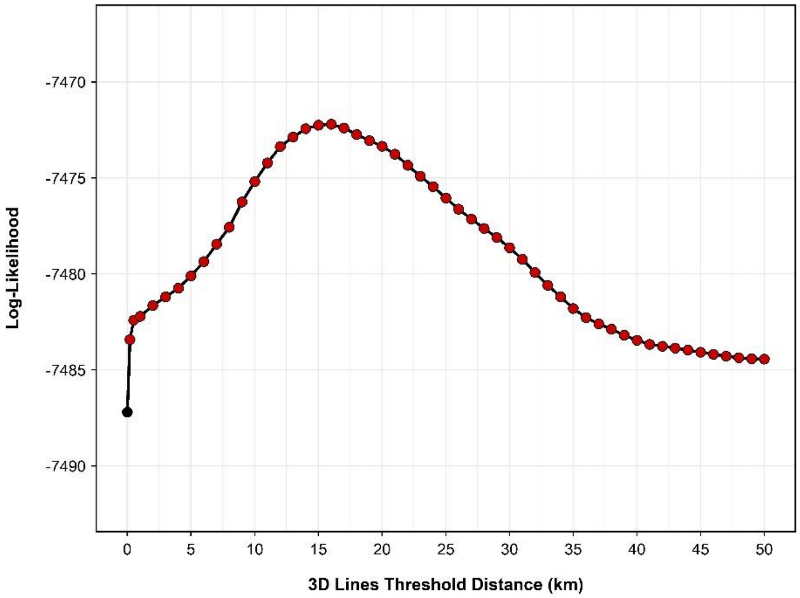


Attachment Figure 24. Marginal effect of distance to the Dempster Highway on the probability of selection by caribou during winter (2012–2021) based on a generalized additive model with cubic regression splines. Solid red and dashed blue lines are the fitted mean and 95% confidence intervals, respectively. Vertical dashed line indicates iteration zone cut-off.

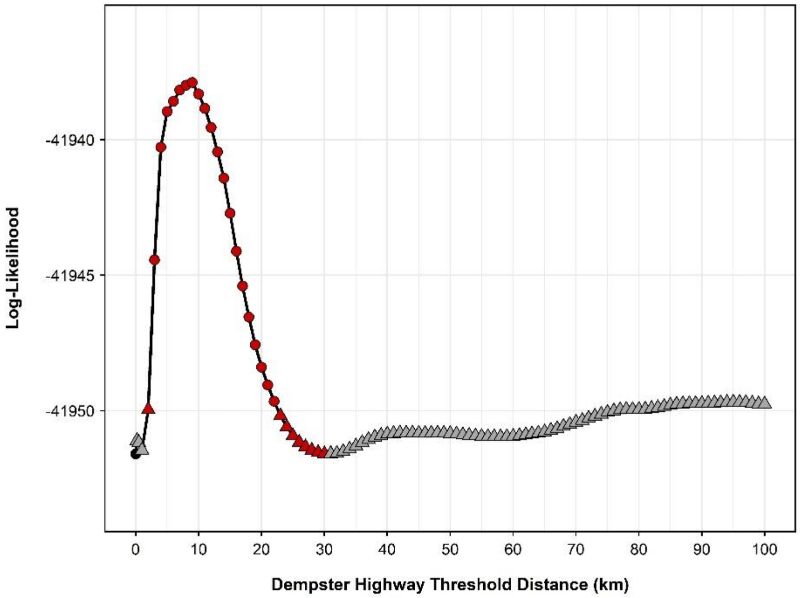
Late Fall



Attachment Figure 25. Segmented regression approach to estimating a zone of influence (ZOI) relative to 2D seismic lines (including winter roads and trails) using GPS collar data from PCH caribou during late fall, 2012–2021. The threshold distance with the highest log-likelihood corresponds with the most likely ZOI. Circles and triangles indicate statistically significant and non-significant ZOI distances, respectively. Grey and red fills indicate positive and negative coefficients, respectively. Vertical dashed line indicates ZOI at 4 km.

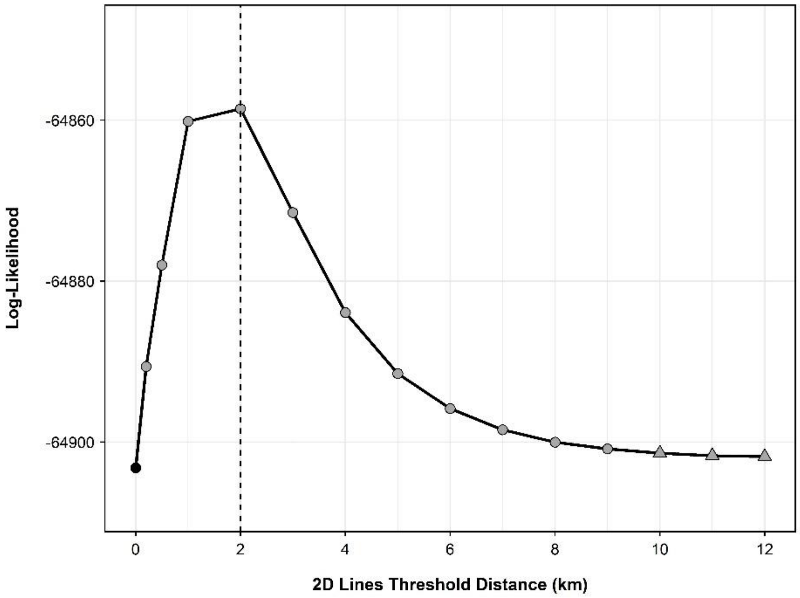


Attachment Figure 26. Segmented regression approach to estimating a zone of influence (ZOI) relative to the lone 3D seismic grid using GPS collar data from PCH caribou during late fall, 2012–2021. The threshold distance with the highest log-likelihood corresponds with the most likely ZOI. Circles and triangles indicate statistically significant and non-significant ZOI distances, respectively. Grey and red fills indicate positive and negative coefficients, respectively.

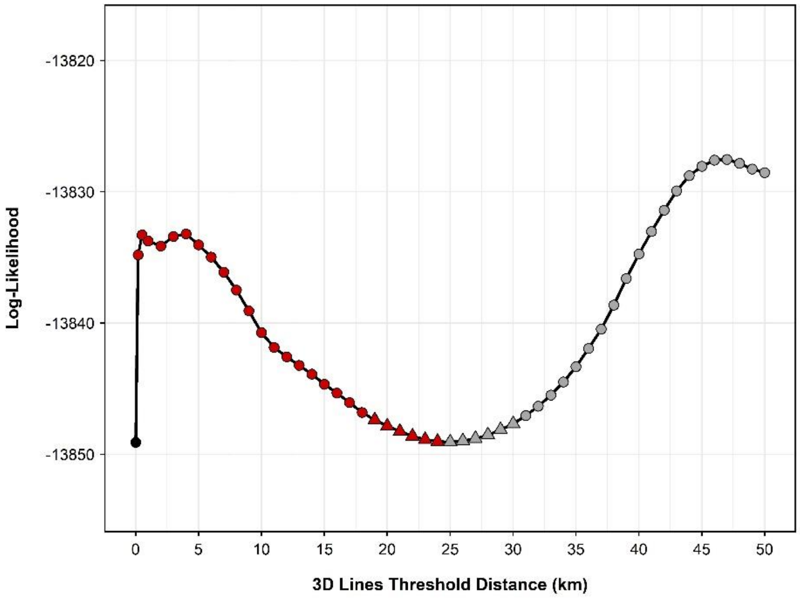


Attachment Figure 27. Segmented regression approach to estimating a zone of influence (ZOI) relative to the Dempster Highway using GPS collar data from PCH caribou during late fall, 2012–2021. The threshold distance with the highest log-likelihood corresponds with the most likely ZOI. Circles and triangles indicate statistically significant and non-significant ZOI distances, respectively. Grey and red fills indicate positive and negative coefficients, respectively.

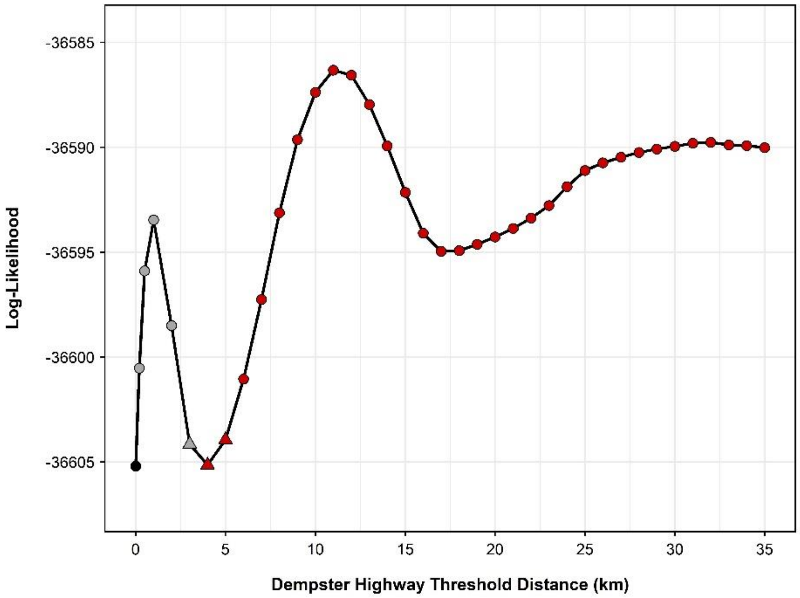
Winter



Attachment Figure 28. Segmented regression approach to estimating a zone of influence (ZOI) relative to 2D seismic lines (including winter roads and trails) using GPS collar data from PCH caribou during winter, 2012–2021. The threshold distance with the highest log-likelihood corresponds with the most likely ZOI. Circles and triangles indicate statistically significant and non-significant ZOI distances, respectively. Grey and red fills indicate positive and negative coefficients, respectively. Vertical dashed line indicates ZOI at 2 km.



Attachment Figure 29. Segmented regression approach to estimating a zone of influence (ZOI) relative to the lone 3D seismic grid using GPS collar data from PCH caribou during winter, 2012–2021. The threshold distance with the highest log-likelihood corresponds with the most likely ZOI. Circles and triangles indicate statistically significant and non-significant ZOI distances, respectively. Grey and red fills indicate positive and negative coefficients, respectively.



Attachment Figure 30. Segmented regression approach to estimating a zone of influence (ZOI) relative to the Dempster Highway using GPS collar data from PCH caribou during winter, 2012–2021. The threshold distance with the highest log-likelihood corresponds with the most likely ZOI. Circles and triangles indicate statistically significant and non-significant ZOI distances, respectively. Grey and red fills indicate positive and negative coefficients, respectively.

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