

# TECHNICAL MEMORANDUM

TO:

**Impact Assessment Agency of Canada  
Ontario Ministry of Environment, Conservation and Parks**

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**FROM**

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**REF**

661910

**DATE**

08 April 2026

**SUBJECT**

**Webequie Supply Road Project – Addendum to the Final Environmental Assessment Report / Impact Statement Responses to Comments on the Assessment of Effects on Species at Risk – Caribou**

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The attached report is Addendum #7 to the Final Environmental Assessment Report / Impact Statement (EAR/IS) for the Webequie Supply Road Project (the Project, WSR). The purpose of the Addendum is to provide supplemental information in response to comments on Caribou in Section 13: Assessment of Effects on Species at Risk of the Webequie Supply Road (WSR) Environmental Assessment Report/Impact Statement (EAR/IS). Specifically, the addendum was prepared to address comments from:

- Ministry of Environment, Conservation and Parks - Species at Risk Branch (MECP-SAR): Comments 014, 019, 023, 024, 025, 028, 029, 033, 034, 035, 052, 053, 054, 055, 056, 057, 058, 060, 061, 062, 063, 099, 100, 102, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 129, 163, 172, 173, 174, and 179.
- Ministry of Natural Resources (MNR): Comments 205, 219, 224, 225, 228, and 231.

Details of these comments are presented in Appendix P2.M of the Record of Engagement and Consultation for the Project.

**Webequie Supply Road  
Environmental Assessment  
Report / Impact Statement**

April 8, 2026

AtkinsRéalis Ref: 661910

# ADDENDUM 7: Caribou

AtkinsRéalis



# Preface

The purpose of this report (Addendum #7) is to provide supplemental responses to address outstanding comments and items of concern received from the review of the Draft Environmental Assessment Report / Impact Statement (EAR/IS) from:

- Ministry of Environment, Conservation and Parks - Species at Risk Branch (MECP-SAR): Comments 014, 019, 023, 024, 025, 028, 029, 033, 034, 035, 052, 053, 054, 055, 056, 057, 058, 060, 061, 062, 063, 099, 100, 102, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 129, 163, 172, 173, 174, and 179.
- Ministry of Natural Resources (MNR): Comments 205, 219, 224, 225, 228, and 231.

Details of these comments are presented in Appendix P2.M of the Record of Engagement and Consultation that support the Final EAR/IS.

This Addendum #7 includes the following:

- 1) Additional data and analysis surrounding Migration differences between Eastern Migratory caribou and Boreal caribou (for MECP-SAR 023).
- 2) Additional data and analysis surrounding Use of the caribou RSA by Eastern Migratory caribou (for MECP-SAR 023, 25).
- 3) Ecotype evaluation (for MECP-SAR 173, 174).
- 4) Update analysis with additional available data sources (for MECP-SAR 024, 028, 173, 014, MNR-205).
- 5) Comprehensive assessment and quantification of known and potential Category 1 habitat (for MECP-SAR 19, 024, 028, 54, 118, 163).
- 6) Quantification of cumulative disturbance (for MECP-SAR-024, 028, 163).
- 7) Additional range level information (for MECP-SAR 029, 117).
- 8) Information on annual home range sizes (for MECP-SAR 033).
- 9) Information on seasonal movements (for MECP-SAR 033).
- 10) Additional information on the amount of habitat (Category 1,2, and 3) likely to be lost or likely to be altered or degraded (for MECP-SAR-053, 054, 056, 057, 058, 118).
- 11) The number of known and potential new Nursery Areas and Winter Use Areas that could be lost and habitat alteration and degradation (for MECP-SAR-052).
- 12) Additional information on seasonal use by caribou (for MECP-SAR-035).
- 13) Additional information on hydrological impacts (for MECP-SAR-060).
- 14) Additional information on caribou mortality (for MECP-SAR-061, 175, and 176).
- 15) Additional information on human access and its impacts (for MECP-SAR-062, 126).
- 16) Additional information on the threat assessment process (for MECP-SAR-063).
- 17) Additional information on the effects of browse on caribou (for MECP-SAR-099, and MNR 224, 225).
- 18) Consideration of Sensory disturbance as part of Net Effects (for MECP-SAR-100).
- 19) Elaboration on the scheduling of road maintenance activities (for MECP-SAR-102).
- 20) Elaboration on the rationale for the characterization of magnitude for various net effects (for MECP-SAR-119, 123, 125, 126, and 129).
- 21) Elaboration on the rationale for the characterization of duration for various net effects (for MECP-SAR-120 and 124).
- 22) Elaboration on the rationale for the characterization of geographic extent for various net effects (for MECP-SAR-121 and 122).
- 23) Elaboration on the rationale for the significance of sensory disturbance during operations (for MNR-228)
- 24) Locations within the final EAR/IS where requests were previously resolved (for MECP-SAR-034,179 and MNR-219).



The format of the Addendum #7 Technical Report is divided into two sections. The first part (Sections 1-3) contains additional information including methods and analysis that was requested by reviewers to inform the conclusion of the EAR/IS. The second part (**Section 4**) follows the format of a description of the reviewers' comment followed by the Project Team's response. **Section 5** is a Summary of Net effects in consideration of information provided in the Addendum and the EAR/IS.



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# 1 Introduction

This report serves as an Addendum #7 to the Webequie Supply Road (WSR) Project (“the Project”) Environmental Assessment Report/Impact Statement (EAR/IS) to strengthen the assessment of potential impacts on caribou.

This Addendum has been prepared to provide additional context, clarification, and supporting information regarding the assessment of potential effects on caribou associated with both Project-specific activities and cumulative effects. It aims to strengthen the understanding of how Project components may interact with existing environmental conditions.

The content of the Addendum reflects data, clarifications, and input received up to the submission of the Final EAR/IS. There are two main sections of this addendum. The first section provides additional information and analysis that was requested by Ontario Government Review Team to give additional context and support to the examination of potential effects on caribou at the Project, Local and Regional scales. The second section is intended to fulfill a commitment to respond and resolve the comments received from the Ministry of Natural Resources (MNR), Ministry of the Environment, Conservation and Parks - Species at Risk Branch (MECP) and Indigenous communities on the Draft and Final EAR/IS, associated with caribou.

## 2 Additional Information and Analysis

### 2.1 Comments Addressed

The following additional data is in response to MECP and MNR requests for additional data and is meant to address the following comments and requests:

- Migration differences between eastern migratory caribou and boreal caribou (for MECP-SAR 023);
- Use of the caribou RSA by eastern migratory caribou (for MECP-SAR 023, 25);
- Ecotype evaluation (for MECP-SAR 173, 174);
- Use of available data sources (for MECP-SAR 024, 173, 014, MNR-205);
- Comprehensive assessment and quantification of known and potential Category 1 habitat (for MECP-SAR 19, 54, 118, 163);
- Cumulative Disturbance (for MECP-SAR-163);
- Range Level information (for MECP-SAR 029, 117); and
- General request for all items (for MECP-SAR-014, 028, 033).

The general format in this section is to present a summary of the methods and results for each of the items addressed.

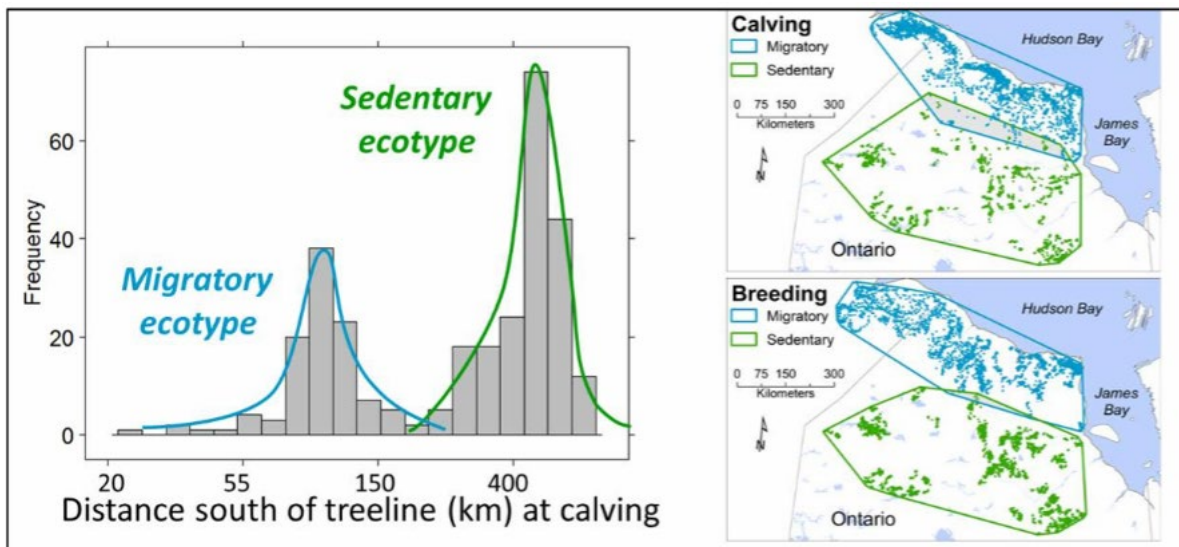


## 2.2 Eastern Migratory Caribou Background Review

### 2.2.1 Ecotype Separation and Overlap

There are two (02) distinct populations of caribou in Ontario: the boreal population (*Rangifer tarandus caribou*) (Threatened under the *Endangered Species Act (ESA)*) which receives species and habitat protection (regulated by MECP, and the eastern migratory population (*Rangifer tarandus*) (Special Concern under the ESA) which does not provide special protections and is only managed by the MNR for species conservation (Crins et al., 2009). In Canada the boreal population is Threatened under *Species at Risk Act (SARA)* and the eastern migratory population is Endangered under SARA, which is primarily influenced by the decline of the George River and Leaf River subpopulations in Quebec and Labrador (Government of Canada, 2017).

The boreal population is distributed broadly across northern Ontario from Manitoba border to Québec. The northern boundary for the boreal population occurs along the southern boundary of the Northern Taiga Ecoregion (1E) (Crins et al., 2009). The eastern migratory population uses tundra and forest-tundra transitional zones along the Hudson Bay coast during the spring and summer periods. In the far north, it is recognized that caribou movements across the Northern Taiga Ecoregion boundary do occur (Berglund et al., 2014; MNR, 2014a). In the fall and winter, the eastern migratory population moves south to boreal forest habitat within the Big Trout Lake (2W) and Hudson Bay Lowlands (2E) Ecoregions, which includes James Bay. Movement and habitat use by this population is complex, but males are thought to remain in the forest and forest-tundra areas during the spring calving season, while females move further north to the calving grounds. Forest-associated boreal caribou moving north will intermingle with tundra-associated eastern migratory caribou that have moved south (**Figure 2.1**) (Abraham et al., 2012; COSEWIC, 2014).



Source: Pond et al., 2016

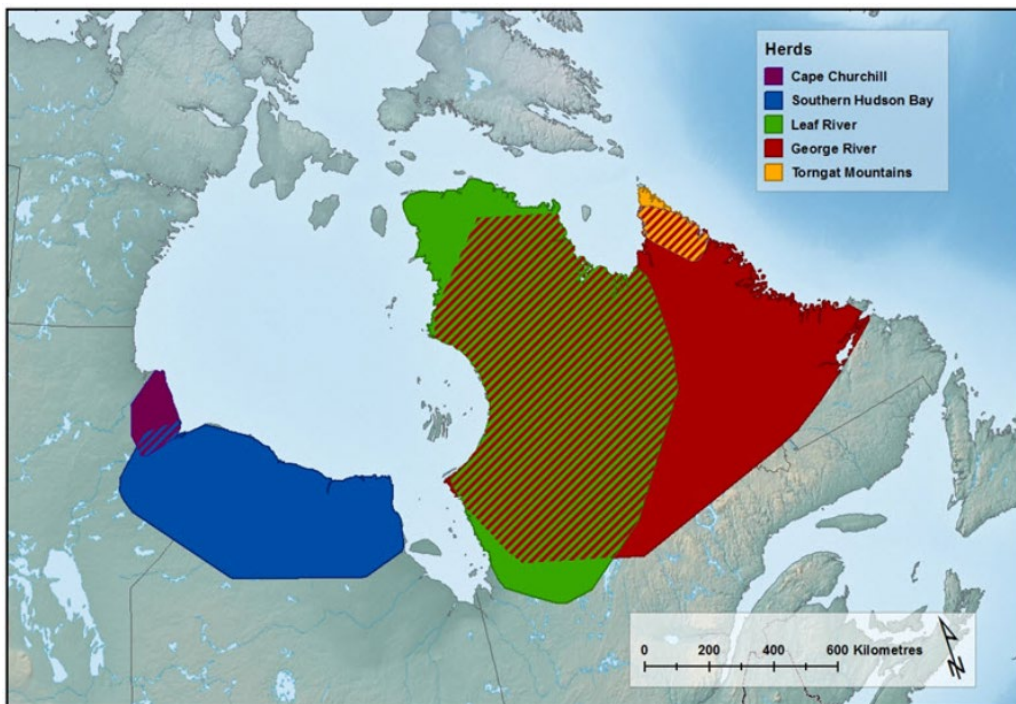
**Figure 2.1: Migratory ecotype (Eastern Migratory population) and Sedentary ecotype (Boreal population) distribution and overlapping range in northern Ontario**

## 2.2.2 Eastern Migratory Caribou Population

### 2.2.2.1 Range

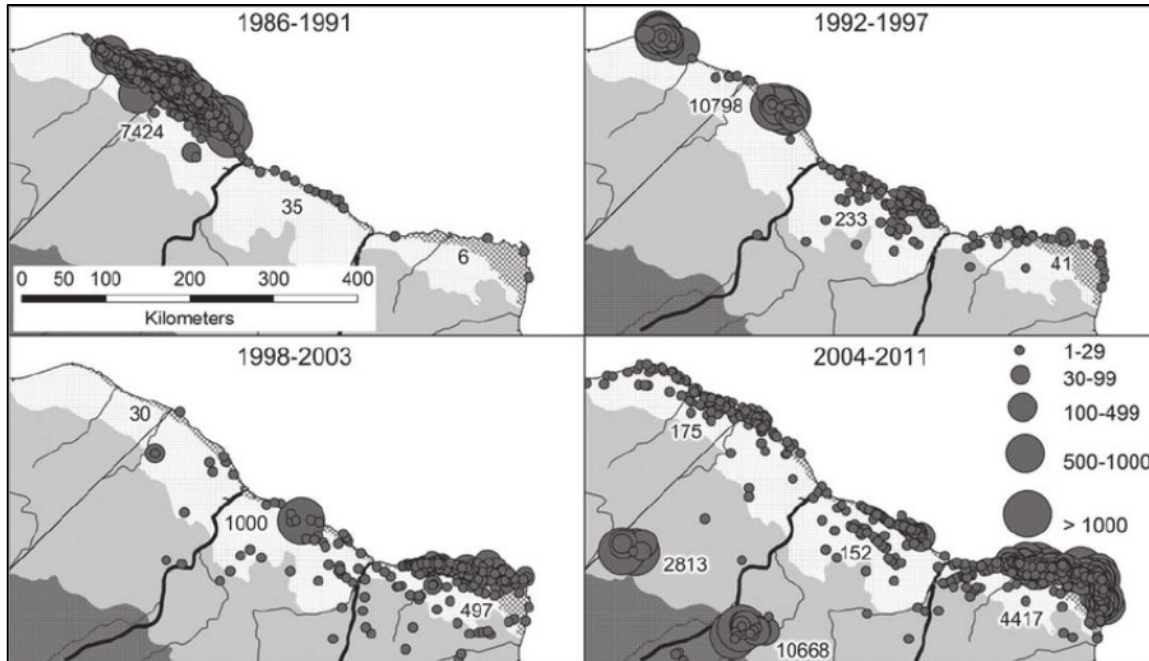
The eastern migratory caribou has four (04) subpopulations in Canada. Two (02) subpopulations west of James Bay: Cape Churchill and Southern Hudson Bay subpopulations, and two (02) east of James Bay: Leaf River and George River subpopulations (**Figure 2.2**) (COSEWIC 2017). The Southern Hudson Bay (SHB) subpopulation is the only eastern migratory caribou present in Ontario, but it also expands into Manitoba. 68% of this subpopulation is present in Ontario, and it makes up 14.1% of the total eastern migratory caribou population in Canada (COSEWIC 2017).

The SHB subpopulation in Ontario occurs in the Hudson Bay Lowlands and extends halfway down James Bay, overlapping in range with the boreal caribou at its southern range (COSEWIC 2011, 2017; Amec Foster Wheeler Environment & Infrastructure 2016). The SHB subpopulation spends the spring and summer on the coast of Hudson/James Bay moving south in the fall and winter to forested habitats (Newton et al., 2015). The summer distribution has shifted eastward over the last few decades, the Pen Island area, a previous calving and post-calving region, is largely no longer used (**Figure 2.3**) (Abraham et al., 2012; Newton et al., 2015).



Source: COSEWIC, 2017

**Figure 2.2: Distribution of the subpopulations of the Eastern Migratory Caribou in Canada**



Source: Newton et al., 2015

**Figure 2.3: Change in summer distribution from 1986 to 2011 on the Hudson Bay coast**

### 2.2.2.2 Life history, recruitment, and survival

Eastern migratory caribou do not breed until 2.5 years old, and each cow only produces a single offspring while other cervid species, such as deer and moose, calve at a much younger age, 0.5-1.5 years and 1.5 years, respectively, and often produce twins or triplets. While large numbers of eastern migratory caribou calves are born in Ontario each year, low population growth has suggested that calf mortality is high (Berglund et al., 2014). These low reproductive rates make eastern migratory caribou very sensitive to predation; they combat this by making large movements across the landscape to predator free areas (Berglund et al., 2014). Given these migrations they still have a high fidelity to their calving and post-calving habitat (Amec Foster Wheeler Environment & Infrastructure, 2016).

The eastern migratory caribou primarily feeds on lichen while also supplementing their diet with woody browse (Darby and Duquette, 1986). Lichen provides the caribou with the energy and nutrients required for their energy costly migration and predator avoidance habits (Joly et al, 2010).

### 2.2.2.3 Disturbance within range

The main disturbances in the SHB subpopulation's range are due to development such as mining and the associated roads. A road was constructed which cut through the caribou's northern range to allow for winter access (COSEWIC, 2017). ATV trails also lead to large disturbances and have led to a fragmentation of the caribou's summer habitat which is suspected to be partially responsible for the abandonment of their eastern range in the Pen Lakes area (Newton et al., 2015; Abraham et al., 2012). Caribou are highly sensitive to disturbance, and it was shown that they avoided ATV trails by 9.7 to 14.1 km. (Newton et al., 2015). As hunting of caribou increases so does the occurrence of ATV trails which are primarily used to access hunting grounds which was previously accessed by freighter canoes (Newton et al., 2015).

#### 2.2.2.4 Threats

Along with increased development and ATV trails, the SHB subpopulation is also threatened by hunting, climate change, and parasites. Although hunting pressure of eastern migratory caribou in Ontario is not fully known it has been rising since the early 1980s when approximately 400-500 eastern migratory caribou/year were harvested compared to > 700 caribou/year in the late 1980s into the 1990s (Abraham et al., 2011; COSEWIC 2017). Caribou hunting is distributed across the Hudson Bay lowlands, primarily occurring in the winter months (Amec Foster Wheeler Environment & Infrastructure 2016; Gray, 1978).

Climate change has greatly impacted the Hudson/James Bay Lowlands which has had negative impacts on the eastern migratory caribou. The increased vegetation due to climate change has led to a decrease in lichen, an important staple in the caribou's diet, decreasing food availability (COSEWIC, 2017). Increasing temperatures in the Hudson Bay lowlands has led to issues with the caribou's thermoregulation and an increase in arthropods potentially leading to an increase in disease transmission (COSEWIC, 2017; Kutz et al., 2009). Although there is no evidence that the SHB subpopulation has been affected, the eastern migratory caribou in Quebec has had an increase in infections of a parasite, *Besnoitia tarandi* (COSEWIC, 2017). This parasite affects the skin, lungs, and testes and can lead to ulcerated limbs and issues with coats (Ducrocq et al., 2011; Kutz et al., 2009).

Although the population trend data on the Ontario portion of the SHB subpopulation is lacking, the entire eastern migratory caribou population been declining in numbers. It is estimated that in three generations the population has declined by 80% (COSEWIC, 2014). Data appears to suggest that subpopulations of the eastern migratory caribou in Quebec are in stronger decline than those in Ontario (Newton et al., 2015). Ontario population numbers were estimated at 15,834 in 1996 and 12,479 in 2011, suggesting a decline, but current numbers are unknown due to a lack in monitoring (COSEWIC, 2017; Berglund et al., 2014; Cumming, 1998). Population numbers in Ontario are likely continuing to decline given that the threats they face are still present (COSSARO, 2017).

## 2.3 Classification of Female Caribou into Ecotype

### 2.3.1 Methods

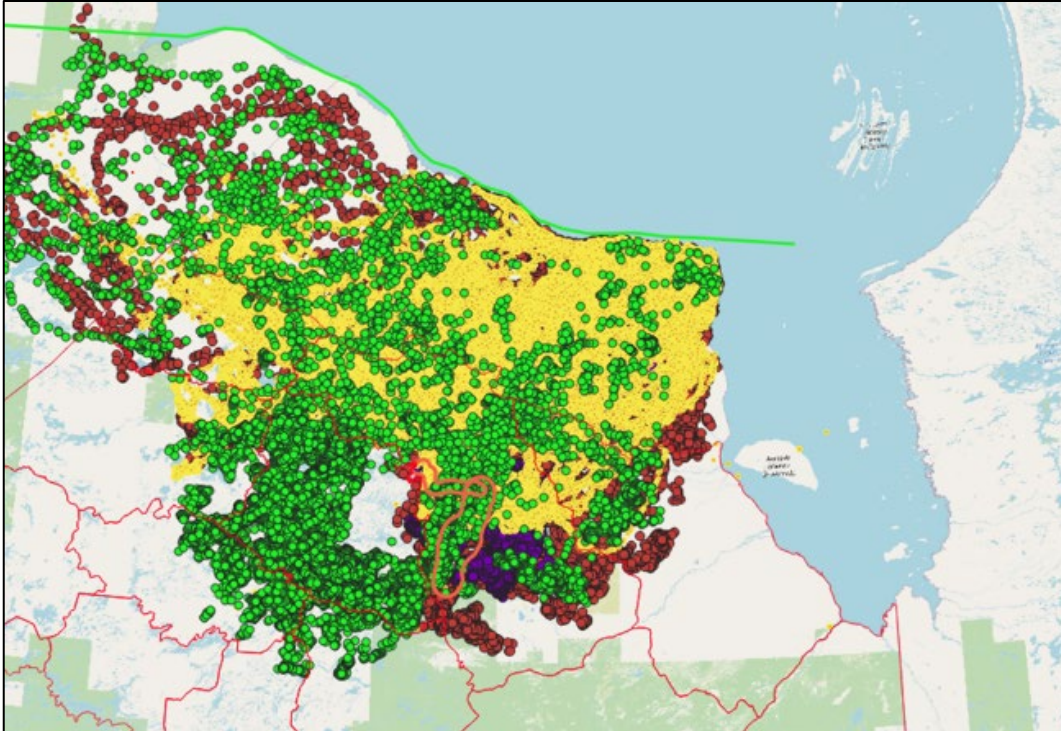
#### 2.3.1.1 Data Preparation

Female caribou collar-years were classified as eastern migratory or sedentary boreal using a two (02) stage approach based on calving-season distribution and seasonal movements, following Pond et al. (2016). Analyses were conducted at the individual-year level in R, and resulting classifications were applied to all GPS locations from each female-year.

GPS data from multiple survey sources were standardized, merged, and filtered to include only female collars and remove obvious spatial or temporal anomalies. After filtering, data from 203 females representing 478 female-years were retained. All spatial analyses used the Ontario MNR Lambert projection.

Classification was informed by three spatial layers: the treeline boundary, an area north of treeline, and Hudson Bay Lowland ecoregions (**Figure 2.4**). For each GPS fix, signed distance to treeline was calculated, and locations were assigned to relevant ecoregions to support ecotype classification. Detailed information on methods is available in **Appendix A7-1**.





**Figure 2.4: Caribou GPS collar locations (post-classification)**

### 2.3.1.2 Calving-season and movement-based ecotype classification

Female-years were first characterized using calving-season (1 May–9 June) location and movement metrics intended to separate migratory and sedentary ecotypes. Metrics summarized calving distribution relative to treeline and lowland regions, as well as calving-season movement (e.g., path length, MCP area, centroids, and net squared displacement), reflecting the expectation that migratory females calve farther north and more frequently in lowland environments.

**Stage 1 Ecotype classification from calving distribution;** classification used a two-component Gaussian mixture model based on 1) proportion of calving fixes in the Hudson Bay Lowland, and 2) mean signed distance to treeline. Female-years were assigned as Eastern Migratory, Sedentary, or Ambiguous using a posterior probability threshold of 0.80. A permissive outlier filter removed extreme distance-to-treeline values.

**Stage 2 Seasonal movement classification;** classified seasonal movement using summer (August–September) and winter (February–March) GPS data. Movement was defined by summer–winter centroid distance and seasonal utilization distribution overlap, producing Migratory, Sedentary, or Intermediate movement strategies based on empirical thresholds.

Final female-year classes combined ecotype and movement results into core, probable, contact-zone, or uncertain categories. These classifications were joined back to all GPS points and exported for mapping and analysis. Visual diagnostics (distributions, bivariate plots, and maps) were used to confirm expected separation between migratory and sedentary female-years.

## 2.3.2 Results

### 2.3.2.1 Classification into migratory and sedentary ecotypes

The two-stage workflow classified 478 female caribou collar-years (203 individuals) into eastern migratory and sedentary ecotypes using calving-season distribution and seasonal movement behaviour. Calving metrics showed clear separation: migratory females had higher use of the Hudson Bay Lowland and calved closer to (and north of) treeline, while sedentary females calved farther south and inland (**Figure 2.5**). Gaussian mixture modelling produced two distinct clusters, with a small subset classified as ambiguous due to low posterior probabilities.

Seasonal movement metrics further differentiated ecotypes (**Figure 2.6**). Migratory female-years exhibited large summer–winter centroid shifts and low seasonal range overlap, while sedentary female-years showed limited displacement and high overlap. Integrating calving and movement results yielded two (02) core groups (EMC core and sedentary core), along with contact-zone and probable classes where indicators were intermediate or partially inconsistent. A full list of caribou and their ecotype classification is available in **Appendix A7-2**.

Migratory caribou exhibit pronounced seasonal redistribution across a broad north–south gradient (**Figure 2.7**). In spring, migratory caribou undergo pronounced, directed northward movements from inland winter ranges toward coastal calving areas in the Hudson Bay Lowland. Movement intensity increases during the pre-calving period as individuals travel long distances across the north–south gradient, linking interior habitats with coastal areas near and north of treeline. By calving, locations become spatially concentrated along the coast, indicating strong fidelity to traditional calving grounds. In the summer individuals disperse along the coast until the fall, when there is a distinct inland shift, with individuals moving southward into transitional forested areas. By winter, migratory caribou occupy extensive inland ranges. Movements are generally less directional and more localized than during spring migration but still cover large areas relative to sedentary ecotypes. The WSR and Northern Road Link (NRL) study areas overlap primarily with these inland fall and winter ranges, as well as portions of migration corridors.

Sedentary caribou display relatively restricted and localized movements throughout the year (**Figure 2.8**). Calving occurs inland, largely within or adjacent to the caribou Regional Study Area (RSA), and seasonal distributions remain broadly similar through summer and fall, indicating limited post-calving dispersal. Locations remain within the same general region in the winter with some range expansion. This pattern reflects strong site fidelity and small home ranges, with all seasonal habitats overlapping substantially with the WSR and NRL study areas.

Contact-zone individuals displayed transitional behaviour, occupying ecotonal areas near treeline and showing variable seasonal movements. Their locations often occur near the transition between northern coastal and southern inland ranges, consistent with use of ecotonal regions near the treeline. This suggests that contact zone individuals may represent facultative or transitional movement strategies, with variable degrees of seasonal displacement. These individuals may be influenced by landscape constraints, including disturbance and climactic factors (Pereira et al, 2024). In terms of management, this behavioral plasticity in caribou may confer resilience to changes in their environment (Pereira et al, 2024).

In contrast “uncertain” classifications reflected limited or conflicting data rather than a distinct strategy. Aggregated results revealed a continuum from long-distance migration to localized residency.



Spatial patterns highlighted strong contrasts: migratory caribou used coastal Hudson Bay Lowland calving areas, dispersed along the coast in summer, shifted inland in fall, and occupied broad inland winter ranges. Sedentary caribou showed year-round localized movements with substantial seasonal overlap within the study area. Contact-zone individuals exhibited intermediate patterns near the transition between coastal and inland ranges.

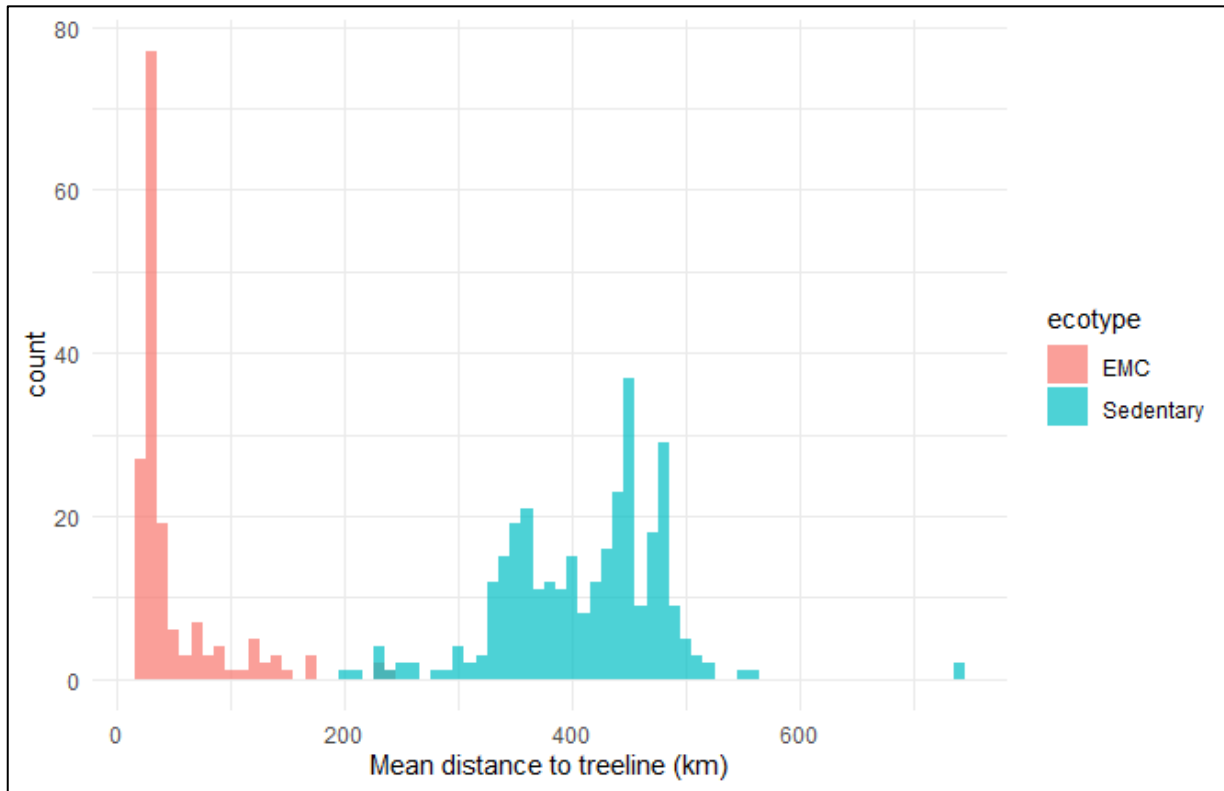
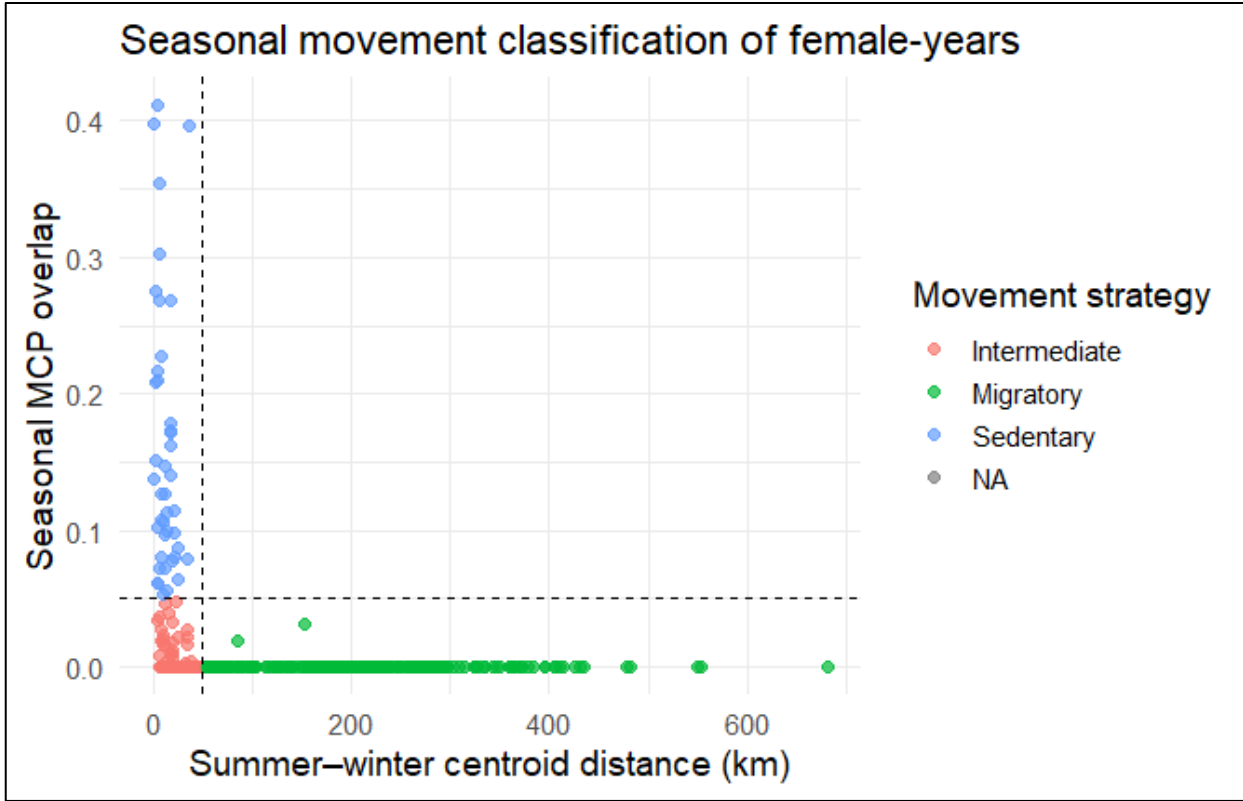


Figure 2.5: Mean Distance to the Tree line for Caribou Separated into EMC and Sedentary Caribou



**Figure 2.6: Classification of individual Caribou into migratory and sedentary classes based on seasonal displacement and seasonal overlap**

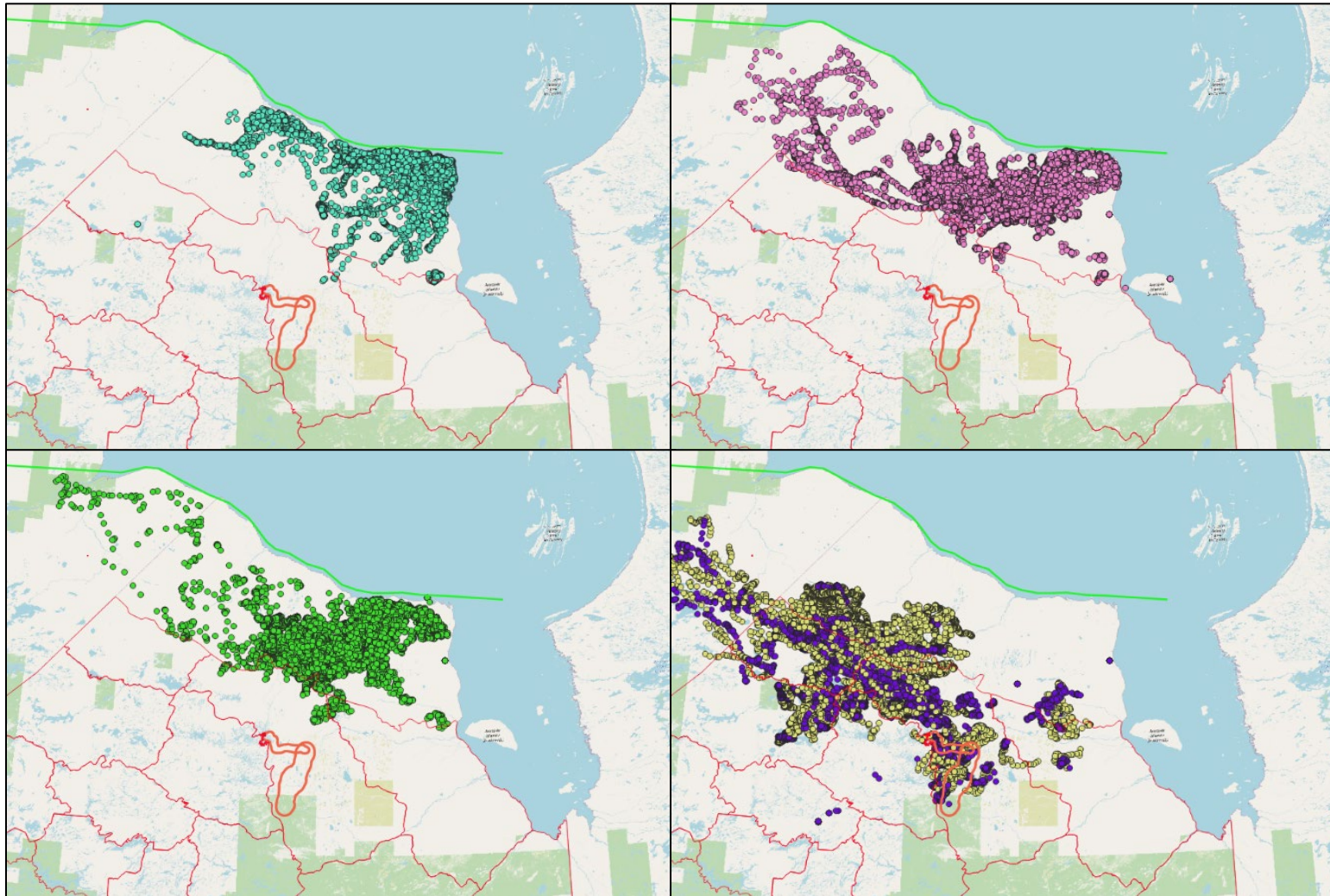


Figure 2.7: Seasonal locations for Eastern Migratory Caribou in (a) Spring, (b) Summer, (c) fall and (d) winter in relation to the WSR and NRL projects



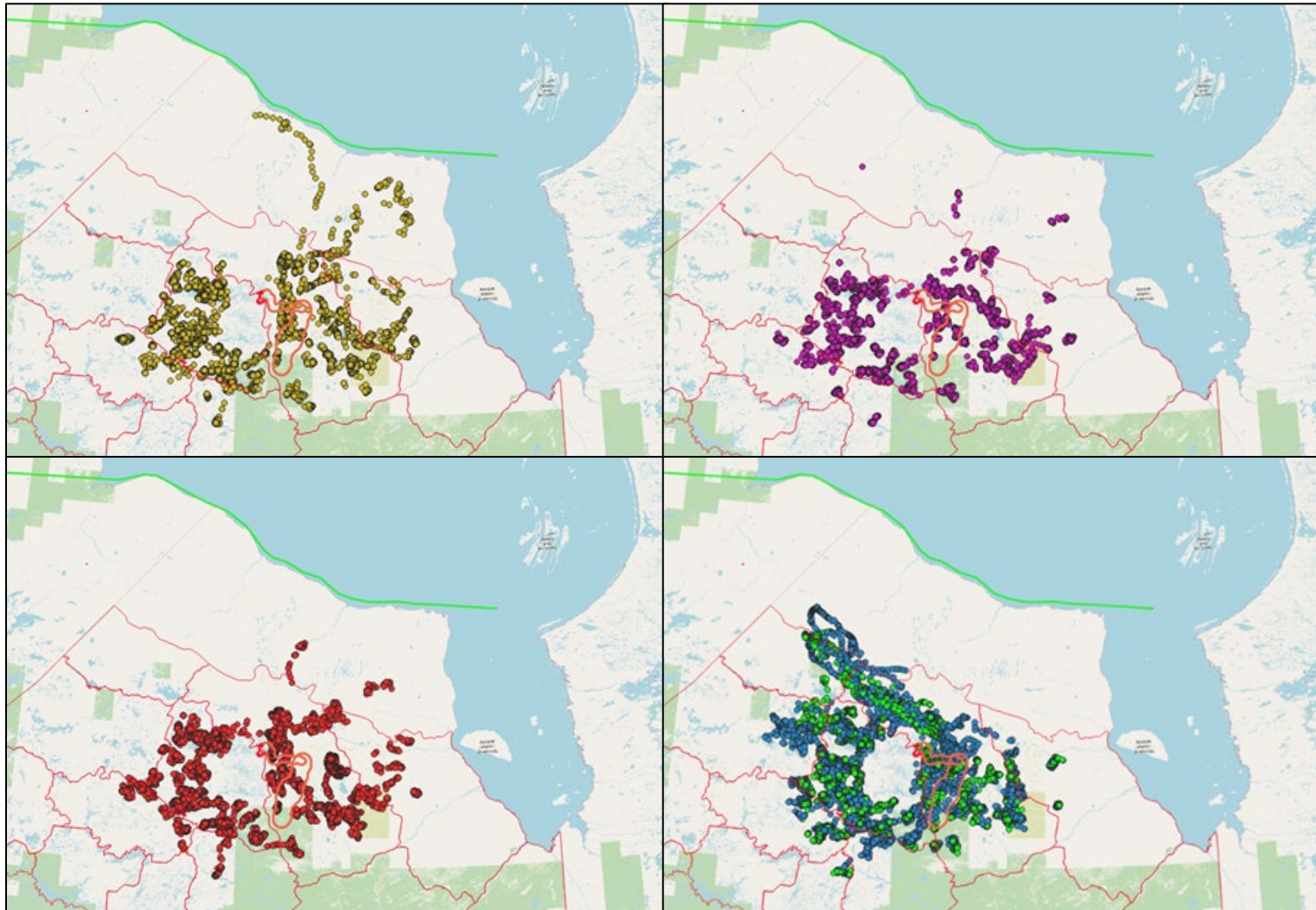


Figure 2.8: Seasonal locations for Sedentary (Boreal) Caribou in (a) Spring, (b) Summer, (c) fall, and (d) winter in relation to the WSR and NRL projects



## 2.4 Seasonal Movement Periods

### 2.4.1 Methods

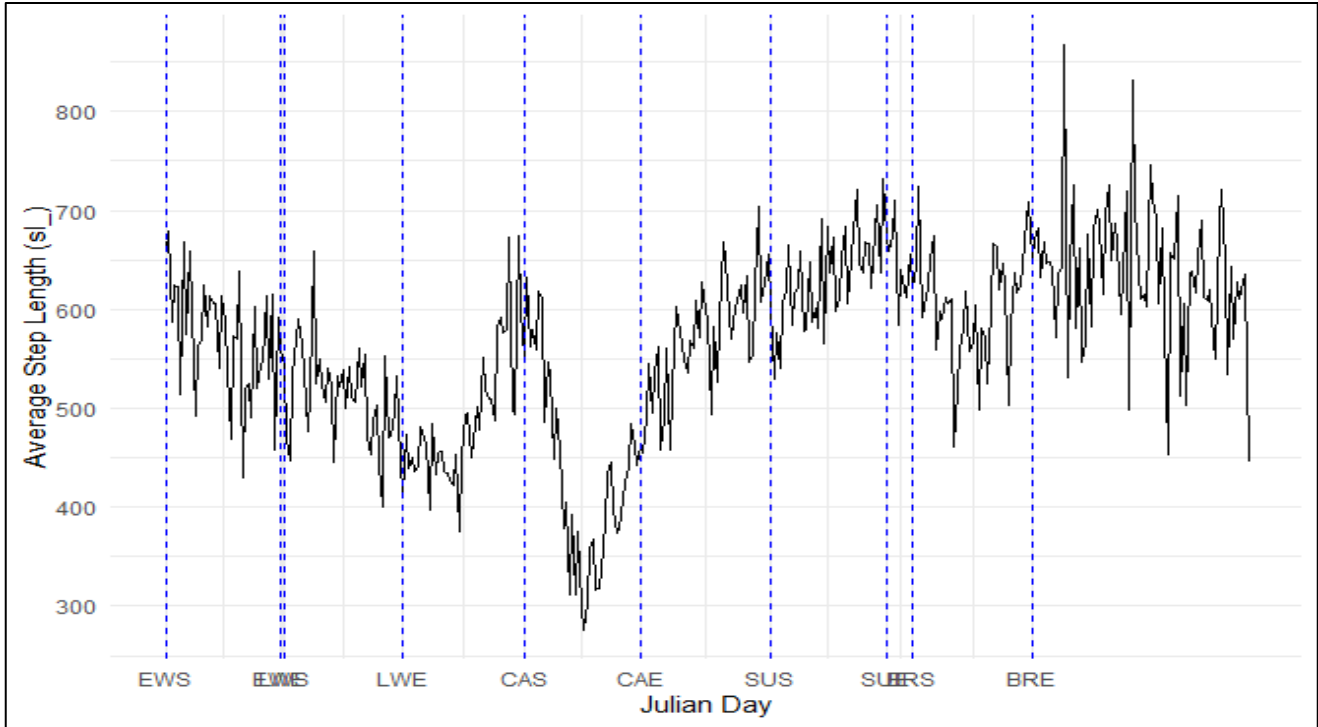
Seasonal movement periods were identified from GPS telemetry using daily summaries of step length and then visualized relative to seasonal windows adapted from Pond et al.

Seasonal movement patterns were quantified from GPS telemetry data using daily summaries of step length and then visualized relative to seasonal windows adapted from Pond et al. For each collared adult female caribou, consecutive GPS fixes were ordered temporally, and step length was calculated as the Euclidean distance between successive projected coordinates. Step lengths were converted to kilometres, and elapsed time between fixes (hours) and day of year (DOY) were extracted from timestamps. Records with missing, non-finite, or non-positive time intervals were excluded.

To characterize annual movement dynamics, step lengths were summarized by DOY across all available collars (**Figure 2.9**). Daily medians were used as the primary metric to reduce sensitivity to extreme values, and the interquartile range (IQR) and sample size were also calculated. Days with fewer than 10 observations were omitted from visualization. For final plots, daily medians were smoothed using a 15-day centered rolling mean, with an additional nonparametric smoother overlaid for display.

High-movement periods were identified from the annual pattern in daily median step length. In the classification process, days were designated as travel days when their median step length equaled or exceeded the 75<sup>th</sup> percentile of the annual distribution. Consecutive travel days were grouped into contiguous periods and summarized by duration and movement intensity. Based on these summaries and visual inspection of smoothed annual curves, three (03) broad movement windows were delineated for interpretation and visualization: pre-calving movement (DOY 85–135), post-calving movement (DOY 155–215), and fall migration (DOY 275–335). These intervals represent empirically derived periods of elevated movement rather than fixed biological seasons.



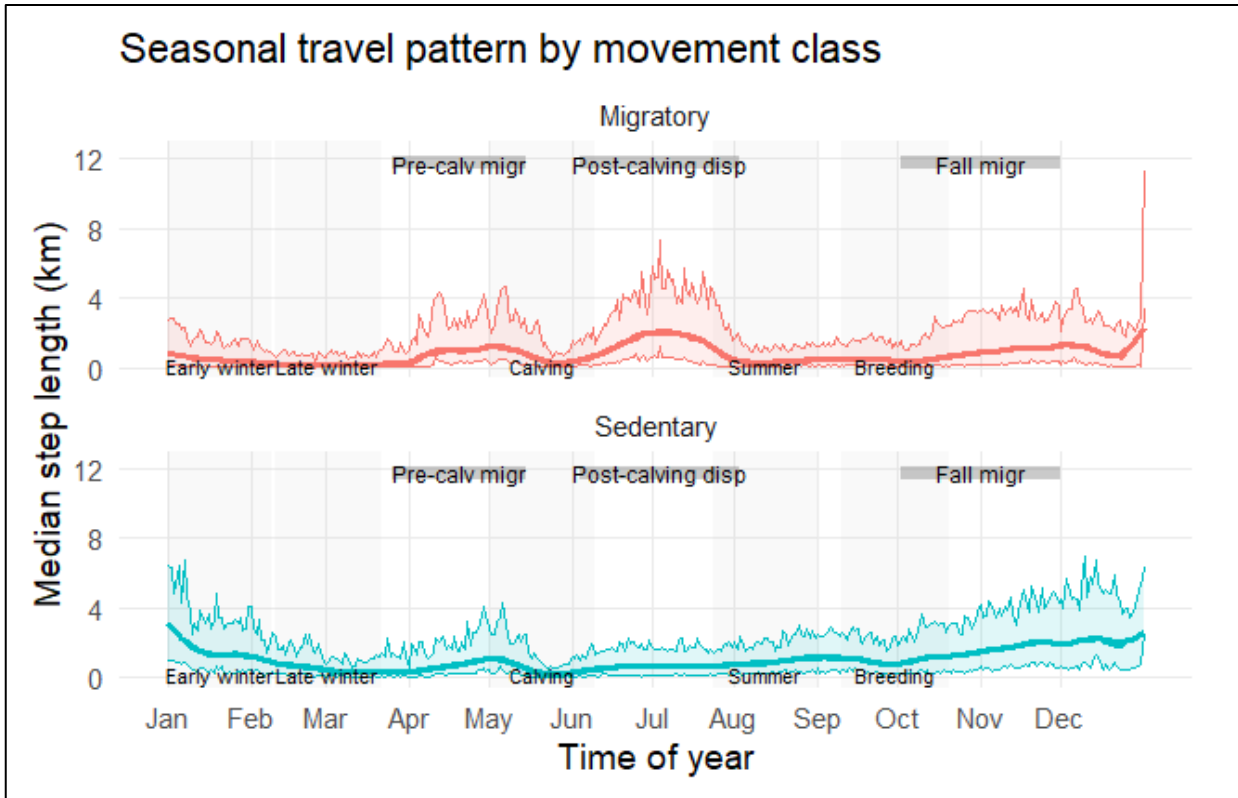


**Figure 2.9: Global movement rates by Julian day, with season start and end indicated by vertical lines**

## 2.4.2 Results

GPS step-length analysis identified three (03) distinct periods of elevated movement in eastern migratory caribou (**Figure 2.10**). The first occurred in late winter to early spring (approximately DOY 85–135) and corresponds to pre-calving migration from inland winter ranges to calving areas. A second increase in movement followed calving (approximately DOY 155–215), reflecting post-calving dispersal toward summer habitats. The third peak occurred in late autumn (approximately DOY 275–335) and represents fall migration toward rutting and wintering areas. Movement rates were low during calving and mid-winter, indicating localized range use. These seasonal peaks were pronounced in migratory caribou but weak or absent in sedentary individuals, supporting their interpretation as large-scale migratory movements.

Seasonal step-length patterns differed strongly between migratory and sedentary caribou. Migratory individuals showed a pronounced movement peak in late spring associated with migration to calving areas, followed by sharply reduced movement during calving, reflecting localized use of calving grounds. Movement increased again in late summer and autumn as animals shifted toward winter ranges. In contrast, sedentary caribou displayed relatively consistent movement throughout the year, lacking a distinct spring migration peak, although movement increased modestly in winter, likely due to local redistribution among winter foraging areas.



**Figure 2.10: Seasonal median step length (km) by day-of-year for migratory and sedentary eastern migratory Caribou**

**Note:** Light grey shading indicates seasonal windows defined by Pond et al., with the calving period adjusted for this analysis. Dark grey bands show empirically derived high-movement periods identified from seasonal step-length patterns.

## 2.5 Migration Corridors

### 2.5.1 Eastern Migratory Caribou

#### 2.5.1.1 Methods

Movement corridors of eastern migratory caribou were identified using GPS telemetry data and dynamic Brownian bridge movement models (dBBMMs). Analyses were restricted to animals previously classified as migratory and were conducted separately for spring and fall migration periods.

GPS locations assigned to the migratory movement class were filtered into empirically defined migration windows based on seasonal step-length analysis (spring: day of year 85–135; fall: day of year 275–335). Within each migration phase, telemetry data were grouped by individual and year and segmented into discrete migration episodes. Episodes were split whenever the time gap between successive fixes exceeded 24 hours to avoid modeling over major gaps in telemetry. Quality control was applied to each episode; only episodes with at

least 12 fixes, a duration of at least two (02) days, and a minimum spatial extent of five (05) km were retained for modelling.

A separate dBBMM was fit to each valid migration episode using the *move* package (Kranstauber et al., 2026). Episode-level utilization distributions (UDs) were generated and normalized so that cell values summed to one. Normalized episode-level UD were aggregated by migration phase. Episode-level UD were normalized and aggregated by migration phase. Normalized UD were resampled to common phase-specific raster templates and averaged to produce population-level spring and fall corridor surfaces, which were then re-normalized. A combined annual corridor surface was generated by averaging the spring and fall surfaces on a shared template. Mean utilization distributions were converted to cumulative-volume surfaces, and corridor polygons were delineated using 50% (core) and 95% (broad) isopleths to represent areas of concentrated migratory movement.

## 2.5.1.2 Results and Discussion

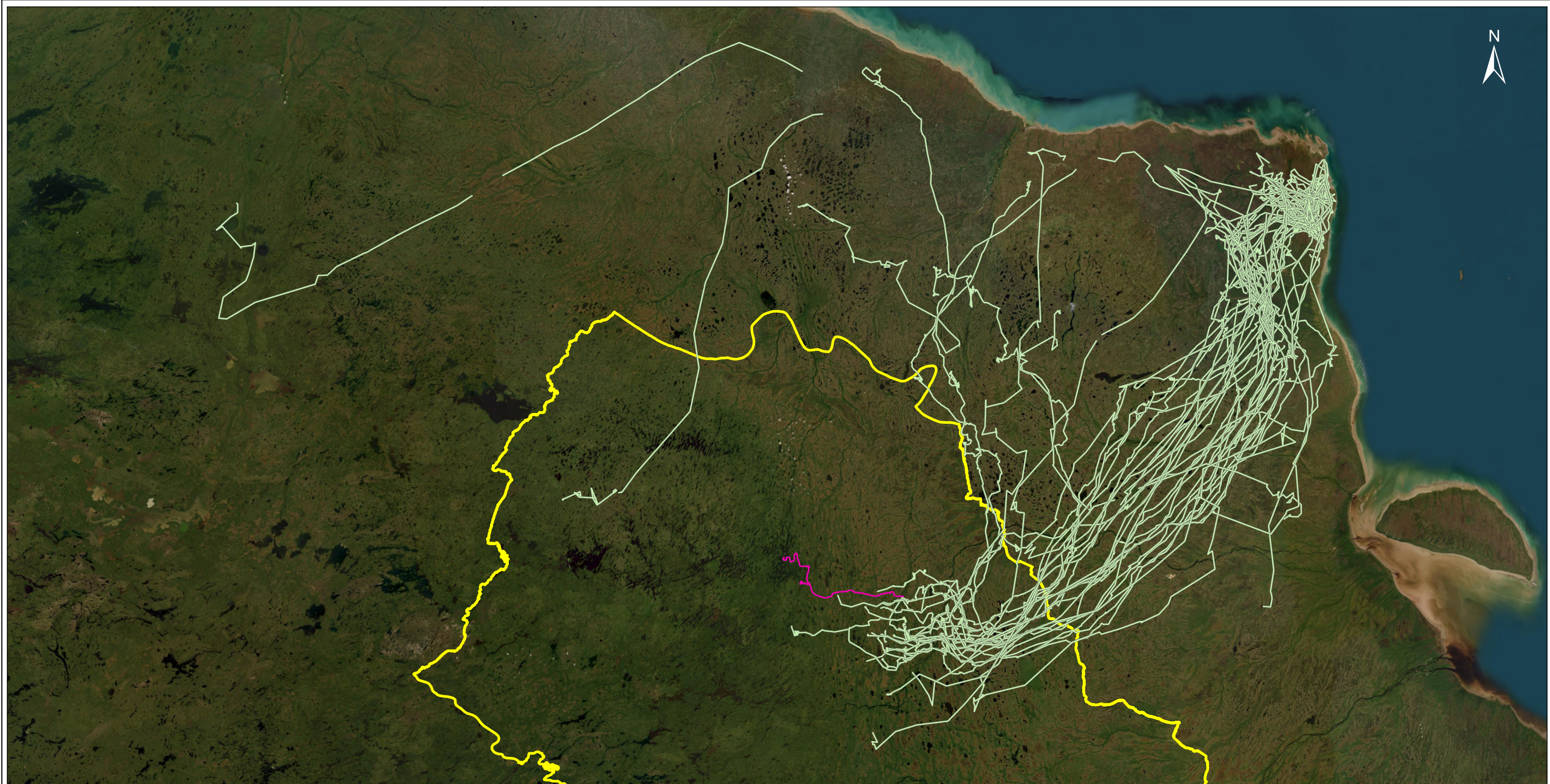
### 2.5.1.2.1 Spring Migration

Spring migration is characterized by directed northward movement from inland wintering areas toward coastal calving ranges in the Hudson Bay Lowlands. Spring migration movements by eastern migratory caribou between 2021 and 2024 are shown in **Figure 2.11** to **Figure 2.14**. Although movements initiate across disperse wintering areas, caribou progressively align and converge into more structured pathways as they approach calving areas. This spatial pattern indicates strong fidelity to northern calving grounds and a high degree of synchrony in migration timing.

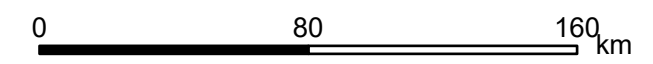
The caribou RSA intersects the southern portion of the spring migration pathways. Telemetry data indicate that these areas function as movement and transit habitat, facilitating seasonal migration rather than supporting calving. The density of tracks in this region indicates repeated use across individuals, suggesting that these corridors are important for facilitating movement between winter ranges and coastal calving areas. Annual use of interior areas also seems to vary by year (**Figure 2.11**) with migration paths in 2021 passing through the caribou LSA but not in other years.

From effects assessment perspective, these areas therefore contribute to movement capability and connectivity, rather than representing critical life-stage habitat. Potential direct effects during spring migration are therefore likely limited to behavioral responses (e.g., localized avoidance or altered movement paths) that could influence migration efficiency if not appropriately mitigated. Migration appears to occur across a broad network of pathways extending across multiple caribou ranges.





- Legend:**
- Project Footprint
  - Caribou RSA (Ozhiski and Missisa Ranges)
  - Caribou Migration (Spring 2021)



## Webequie Supply Road

Spring migration movements of Collared Eastern Migratory Caribou in 2021

**NOTES**

1. Coordinate System: NAD 1983 UTM Zone 18N.
2. Cadastral boundaries are for informational purposes only and should not be considered suitable for legal, engineering, or surveying purposes.
3. Topographic/landcover features obtained from CanVec v12.0 dataset, Natural Resources Canada Earth and Sciences Sector Centre for Topographic Information, and Land Information Ontario (LIO) Warehouse Open Data (<https://geohub.lio.gov.on.ca/>), Ontario Ministry of Natural Resources and Forestry (OMNRF)
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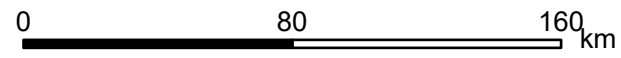
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- Legend:**
- Project Footprint
  - Caribou RSA (Ozhiski and Missisa Ranges)
  - Caribou Migration (Spring 2022)



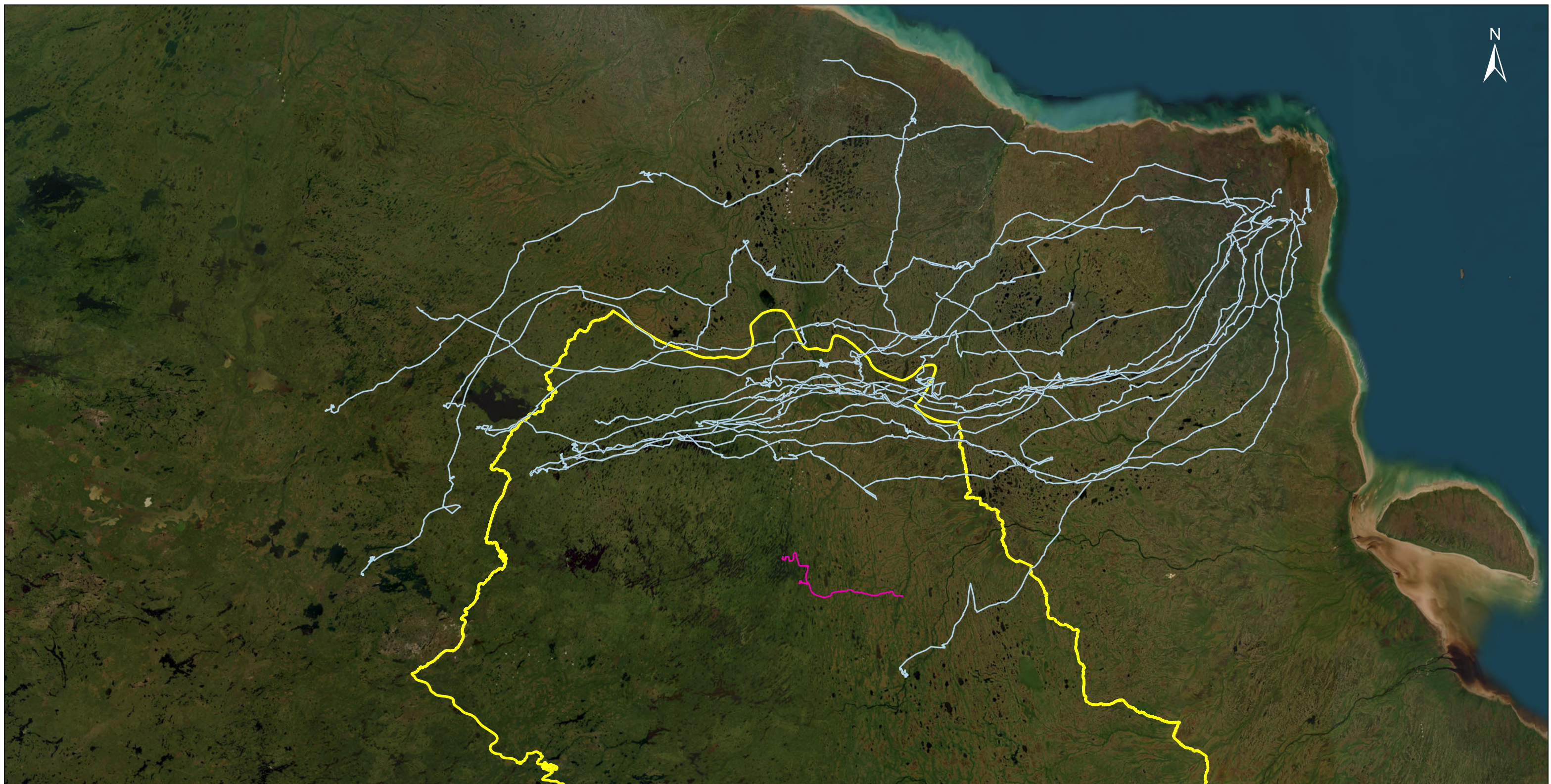
## Webequie Supply Road

Spring migration movements of Collared Eastern Migratory Caribou in 2022

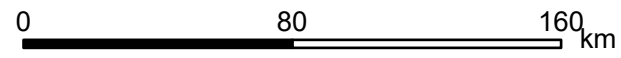
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		LZ	GS	GS



- Legend:**
- Project Footprint
  - Caribou RSA (Ozhiski and Missisa Ranges)
  - Caribou Migration (Spring 2023)



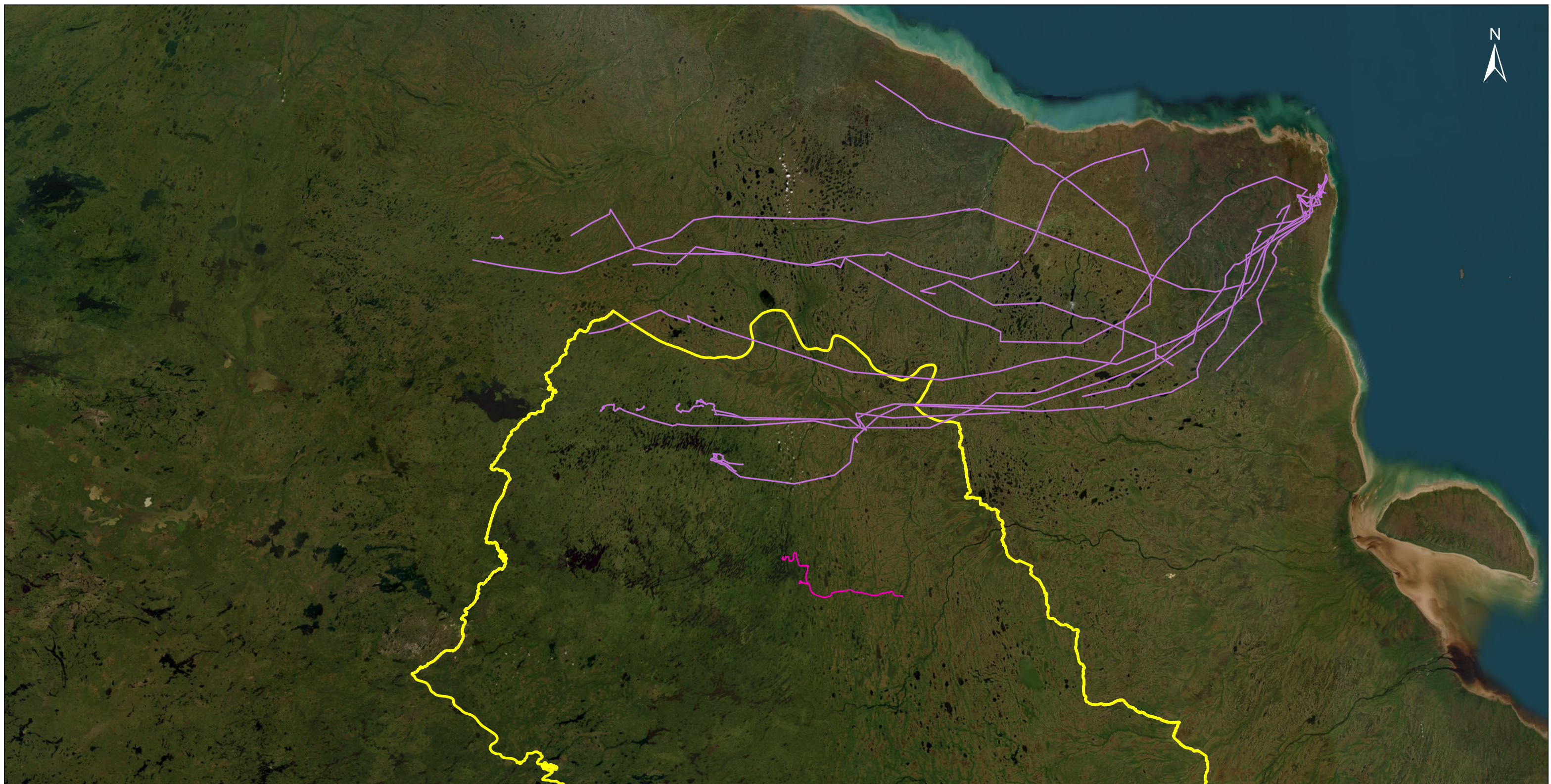
## Webequie Supply Road

Spring migration movements of Collared Eastern Migratory Caribou in 2023

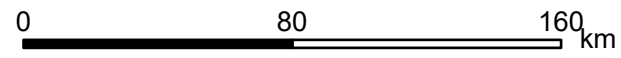
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		LZ	GS	GS



- Legend:**
- Project Footprint
  - Caribou RSA (Ozhiski and Missisa Ranges)
  - Caribou Migration (Spring 2024)



## Webequie Supply Road

Spring migration movements of Collared Eastern Migratory Caribou in 2024

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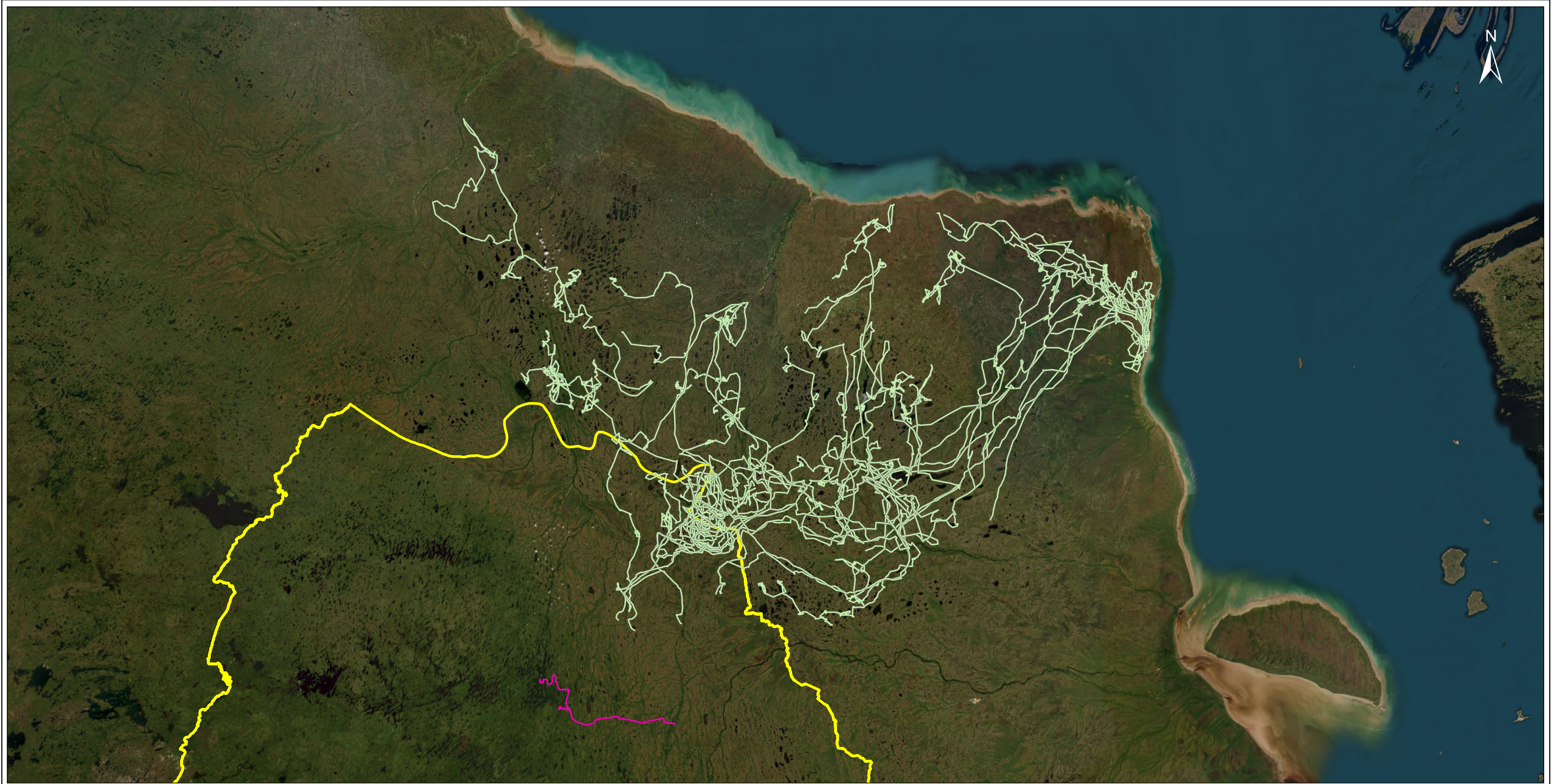
### 2.5.1.2.2 Fall Migration

Fall migration involves directional southward movement from northern summer ranges toward inland breeding and wintering areas (**Figure 2.15** to **Figure 2.18**). While movements are initially spatially dispersed, telemetry data show increasing convergence into preferred movement zones, resulting in elevated use of particular portions of the landscape. These convergence patterns indicate the presence of functionally important migration corridors that are repeatedly used across individuals and years. As individuals approach the southern end of the migration movement paths transition from long, directional trajectories into more localized and looping patterns, consistent with arrival on breeding ranges and is consistent with animals entering the rutting period. While the northeastern region of the Missisa range is used extensively by caribou virtually all the breeding area is north of the caribou LSA.

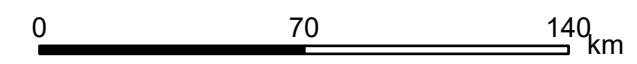
### 2.5.1.2.3 Annual Movement Corridors and Landscape Function

Taken together, the spring and fall telemetry patterns indicate that the project area occurs within a regional migration landscape characterized by broad movement fronts rather than discrete migration corridors. This spatial pattern indicates a degree of behavioral flexibility, that may allow caribou to adjust local movement paths in response to disturbance, provided that overall landscape permeability is maintained. From an assessment perspective, neither the spring nor fall migration patterns indicate the presence of a single critical migration bottleneck within the caribou LSA. The absence of a discrete migration bottleneck within the caribou LSA reduces the likelihood of population level effects on migration, provided that the functional role of movement habitat is preserved.





- Legend:**
- █ Project Footprint
  - █ Caribou RSA (Ozhiski and Missisa Ranges)
  - █ Caribou Migration (Fall 2021)



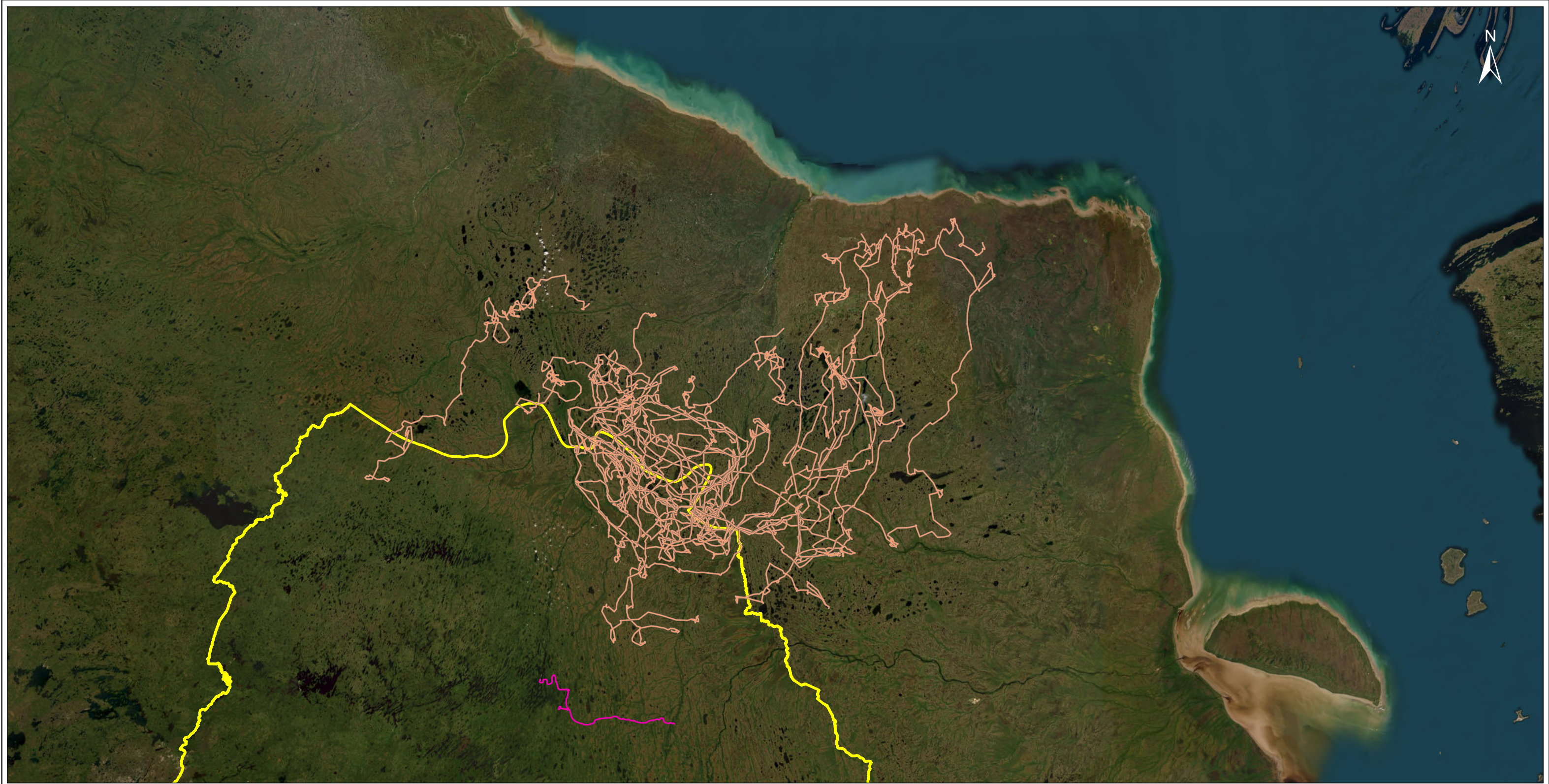
## Webequie Supply Road

Fall migration movements of Collared Eastern Migratory Caribou in 2021

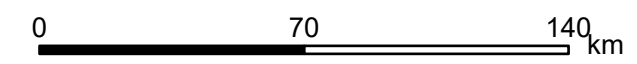
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- Legend:**
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  - Caribou Migration (Fall 2022)



## Webequie Supply Road

Fall migration movements of Collared Eastern Migratory Caribou in 2022

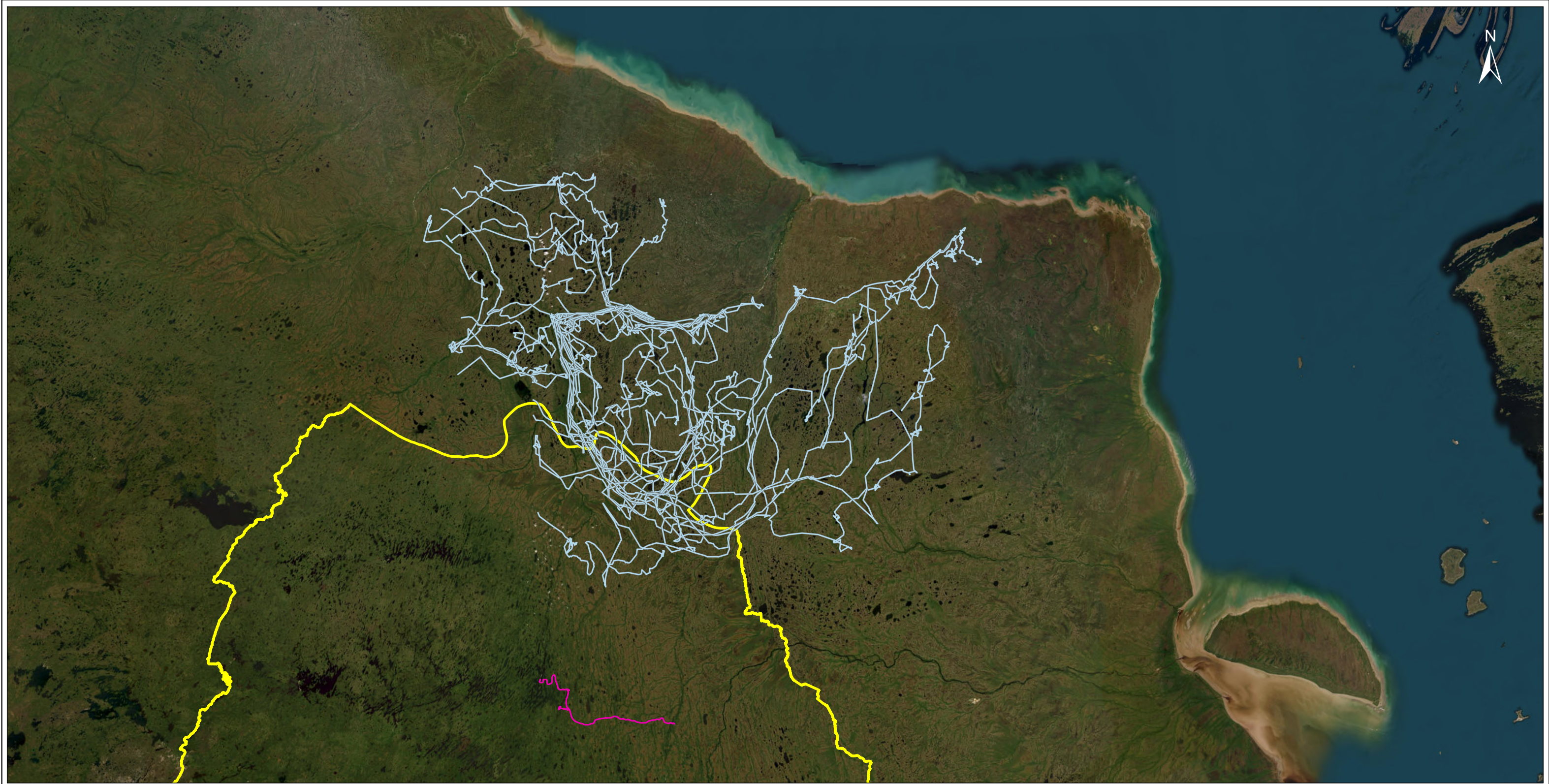
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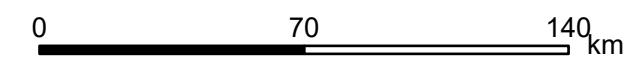
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DSC		DRN	CHK	APP
		LZ	GS	GS



- Legend:**
- Project Footprint
  - Caribou RSA (Ozhiski and Missisa Ranges)
  - Caribou Migration (Fall 2023)



## Webequie Supply Road

Fall migration movements of Collared Eastern Migratory Caribou in 2023

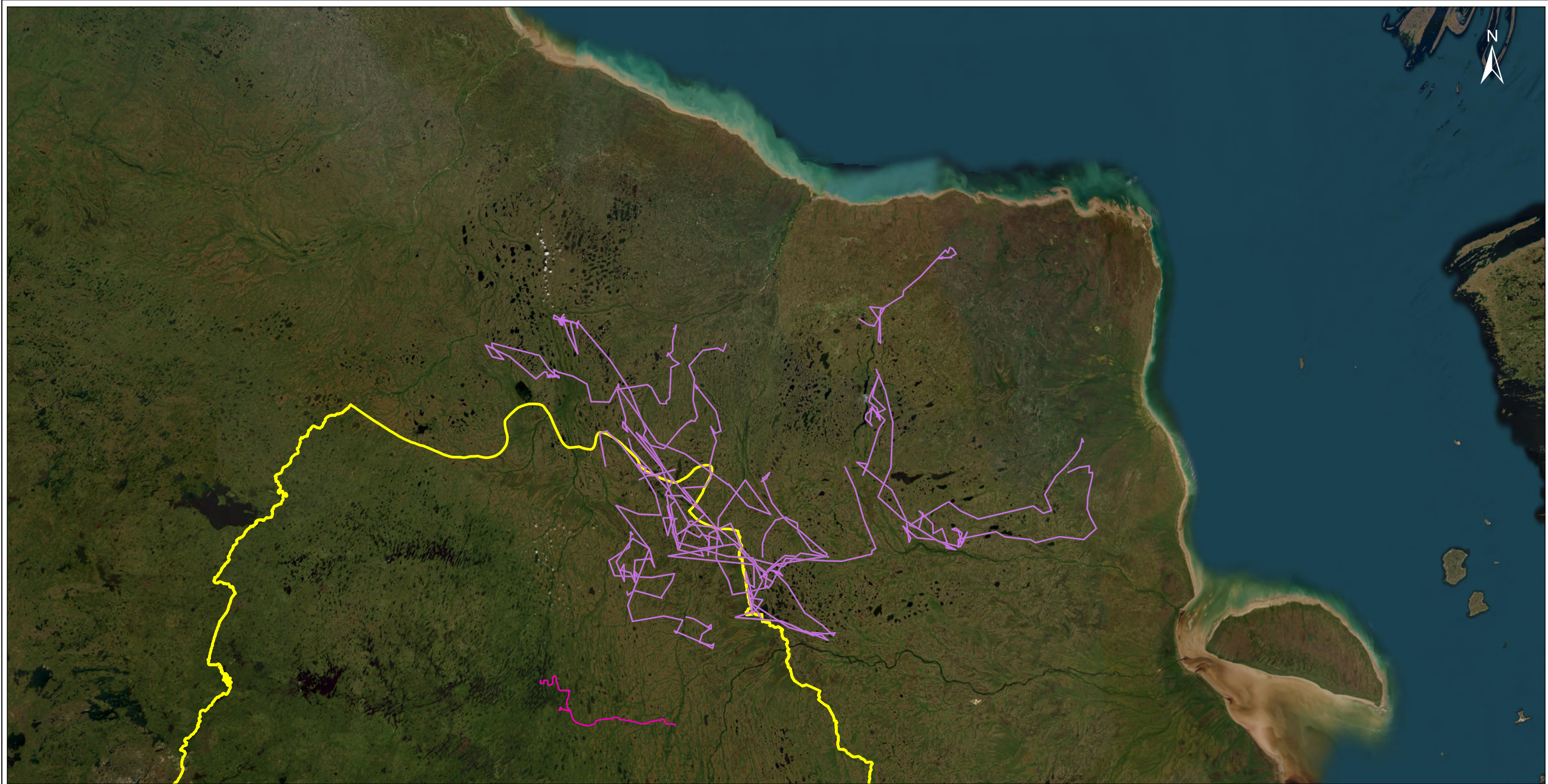
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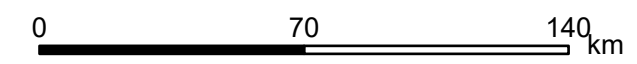
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DSC		DRN	CHK	APP
		LZ	GS	GS



- Legend:**
- Project Footprint
  - Caribou RSA (Ozhiski and Missisa Ranges)
  - Caribou Migration (Fall 2024)



## Webequie Supply Road

Fall migration movements of Collared Eastern Migratory Caribou in 2024

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<b>Client:</b> Webequie First Nation	<b>Project Number:</b> 661910	<b>Date:</b> 3/31/2026		
DSC		DRN	CHK	APP
		LZ	GS	GS

## 2.5.2 Sedentary Caribou Movement

### 2.5.2.1 Movement Patterns during Migration Periods

**Figure 2.20** to **Figure 2.23** show movements of caribou classified as sedentary caribou during the spring migration period. **Figure 2.24** to **Figure 2.27** show movements of caribou classified as sedentary caribou during the fall migration period. These movement paths were generated from the same dataset as the eastern migratory caribou. As discussed earlier sedentary individuals exhibited relatively stable movement rates throughout the year with no distinct spring migration peak. They displayed relatively restricted and localized movements throughout the year, reflecting strong site fidelity and small home ranges, with all seasonal habitats overlapping substantially with the caribou RSA. Movement distance did vary based on caribou with some caribou traveling less than 200 km during a migration period while other caribou travelled well over a thousand km. Spring migration distances on average were higher than fall migration distances. There was also a general trend of higher movement during migration periods in more northerly and eastern caribou which may reflect more interaction with eastern migratory caribou.

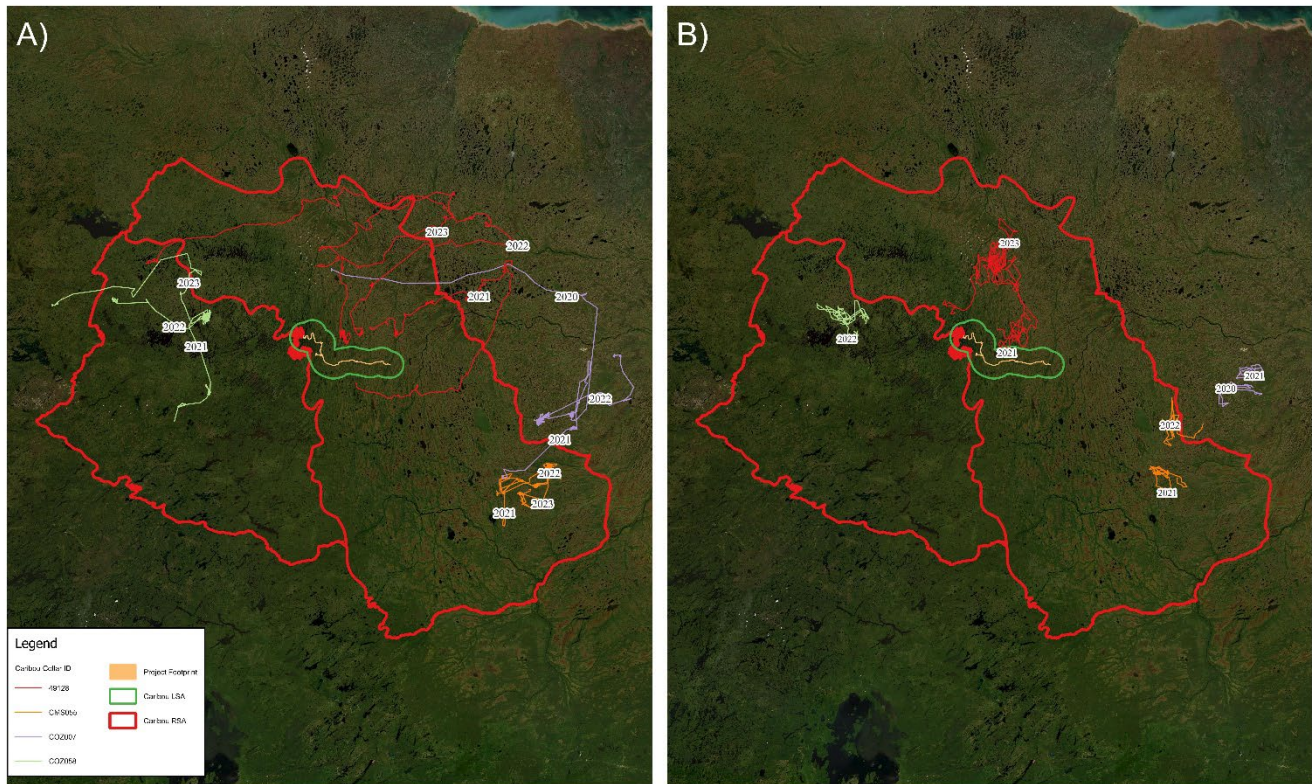
To illustrate these patterns, **Figure 2.19** shows migration pathways for four (04) sedentary caribou in different sections of the caribou RSA. **Figure 2.19a** shows the general pattern of larger movements in northern and eastern caribou with the total step length of caribou 49128 more than 2.5x the total step length of caribou CMS055 (**Table 2-1**). **Figure 2.19a** also shows the high nursery site fidelity of sedentary caribou with all four (04) caribou returning to the same general area to calf despite being three (03) of the four (04) caribou being located at widely different locations at the end of the late winter period. **Figure 2.19b** shows the reduced movement of the four (04) sedentary caribou during the fall migration period. Total step length during fall migration was only 55% of spring migration even though it was 10 days longer (60 vs 50 days). Movements for most caribou did not seem directional in nature, remaining in the general vicinity of spring and summer locations. As discussed in **Section 2.4.2** sedentary caribou did not show a fall migration burst in movement, showing instead moderately increased movement in the winter likely due to local redistribution among winter foraging areas.

**Table 2-1: Total Step Length for Four Collared Sedentary Caribou During the Spring and Fall Migration Periods**

Collar ID	Total Step length (km)	
	Spring Migration Period (DOY 85-135)	Fall Migration Period (DOY 275-335)
49128	765.4	189.3
CMS055	287.8	479.9
COZ007	380.6	159.9
COZ058	301.5	136.1

In terms of use of the caribou Local Study Area (LSA), for the 178 recorded spring migrations of sedentary caribou 16 seasons involved entering the caribou LSA and 11 seasons involved sedentary caribou crossing the Project Footprint. In terms of fall migration, the numbers were lower with nine (09) of the 214 recorded fall migrations of sedentary caribou crossing the footprint and 14 entering the caribou LSA.

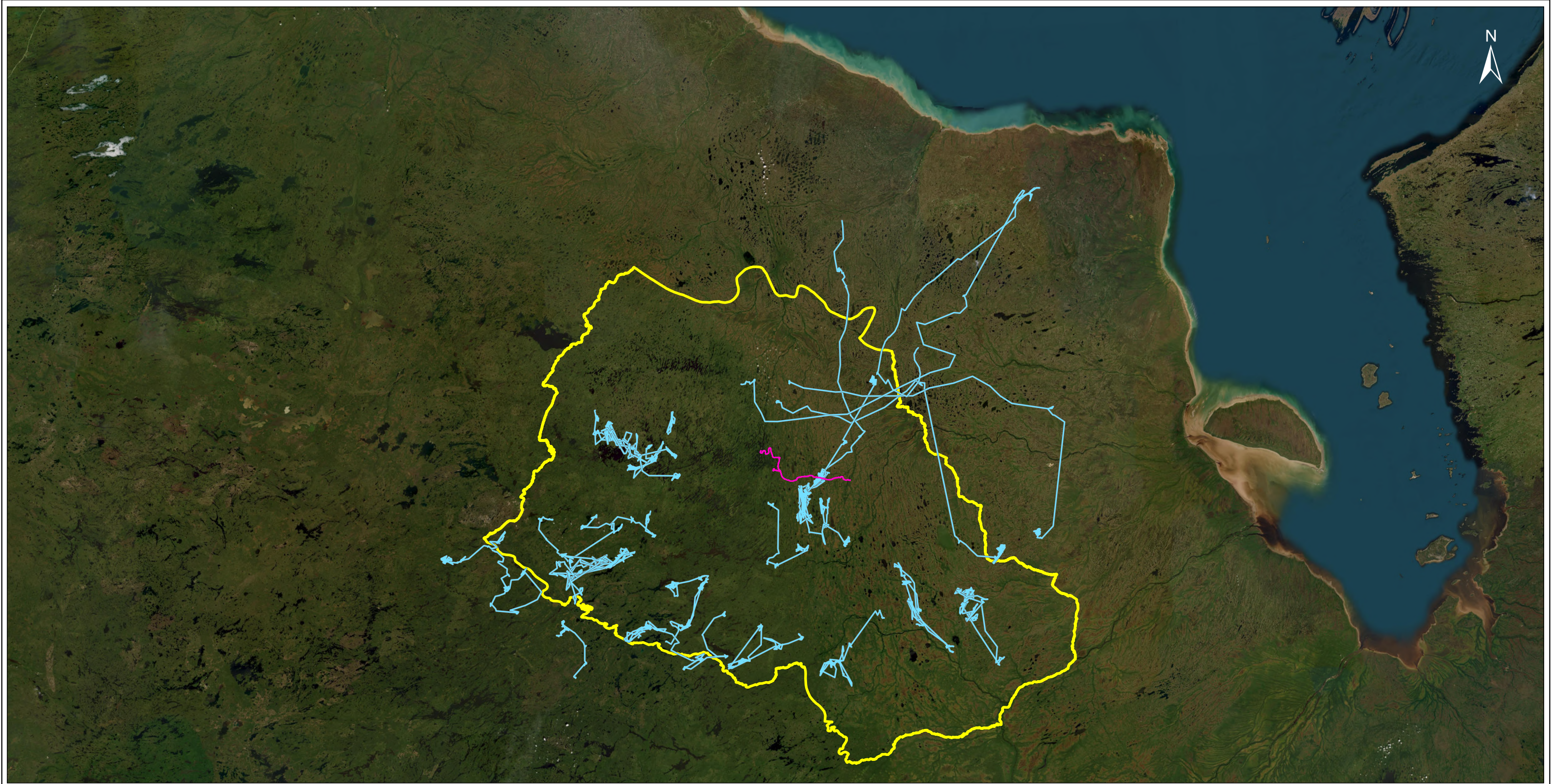




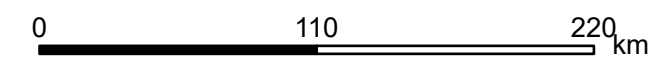
**Figure 2.19: Migration pathways for four Sedentary Caribou During A) Spring Migration and B) Fall Migration**

### 2.5.2.2 Annual Movement Corridors and Landscape Function

Taken together, the spring and fall telemetry patterns indicate that the Project area occurs within a regional migration landscape characterized by short individual migration movements and not discrete population level migration corridors. The movement patterns show high levels of individual nursery site fidelity with some behavioral flexibility in terms of winter use as sedentary caribou were often located at different locations at the start of the spring migration period. From an assessment perspective, the high fidelity to individual nursery locations suggests that some individual caribou may have reduced access to nursery site locations if they are located near the Project.



- Legend:**
- █ Project Footprint
  - █ Caribou RSA (Ozhiski and Missisa Ranges)
  - █ Collared Sedentary Caribou Migration (Spring 2020)



## Webequie Supply Road

Spring migration movements of Collared Sedentary Caribou in 2020

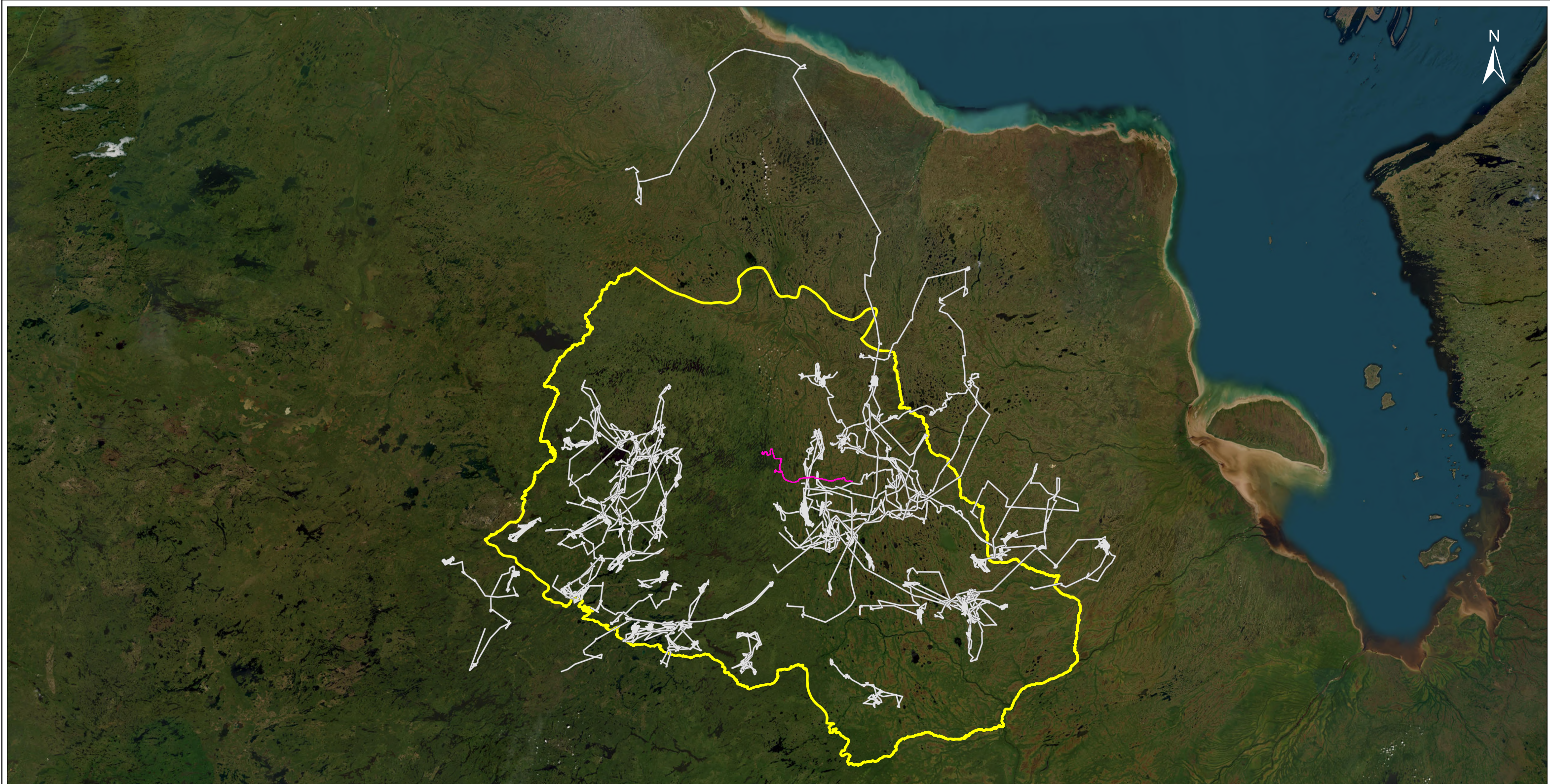
**NOTES**

1. Coordinate System: NAD 1983 UTM Zone 18N.
2. Cadastral boundaries are for informational purposes only and should not be considered suitable for legal, engineering, or surveying purposes.
3. Topographic/landcover features obtained from CanVec v12.0 dataset, Natural Resources Canada Earth and Sciences Sector Centre for Topographic Information, and Land Information Ontario (LIO) Warehouse Open Data (<https://geohub.lio.gov.on.ca/>), Ontario Ministry of Natural Resources and Forestry (OMNRF)
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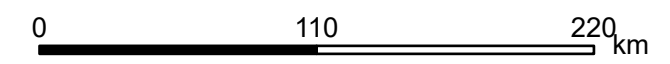
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<b>Client:</b> Webequie First Nation	<b>Project Number:</b> 661910	<b>Date:</b> 4/2/2026		
DSC		DRN	CHK	APP
		LZ	GS	GS



- Legend:**
- Project Footprint
  - Caribou RSA (Ozhiski and Missisa Ranges)
  - Collared Sedentary Caribou Migration (Spring 2021)



## Webequie Supply Road

Spring migration movements of Collared Sedentary Caribou in 2021

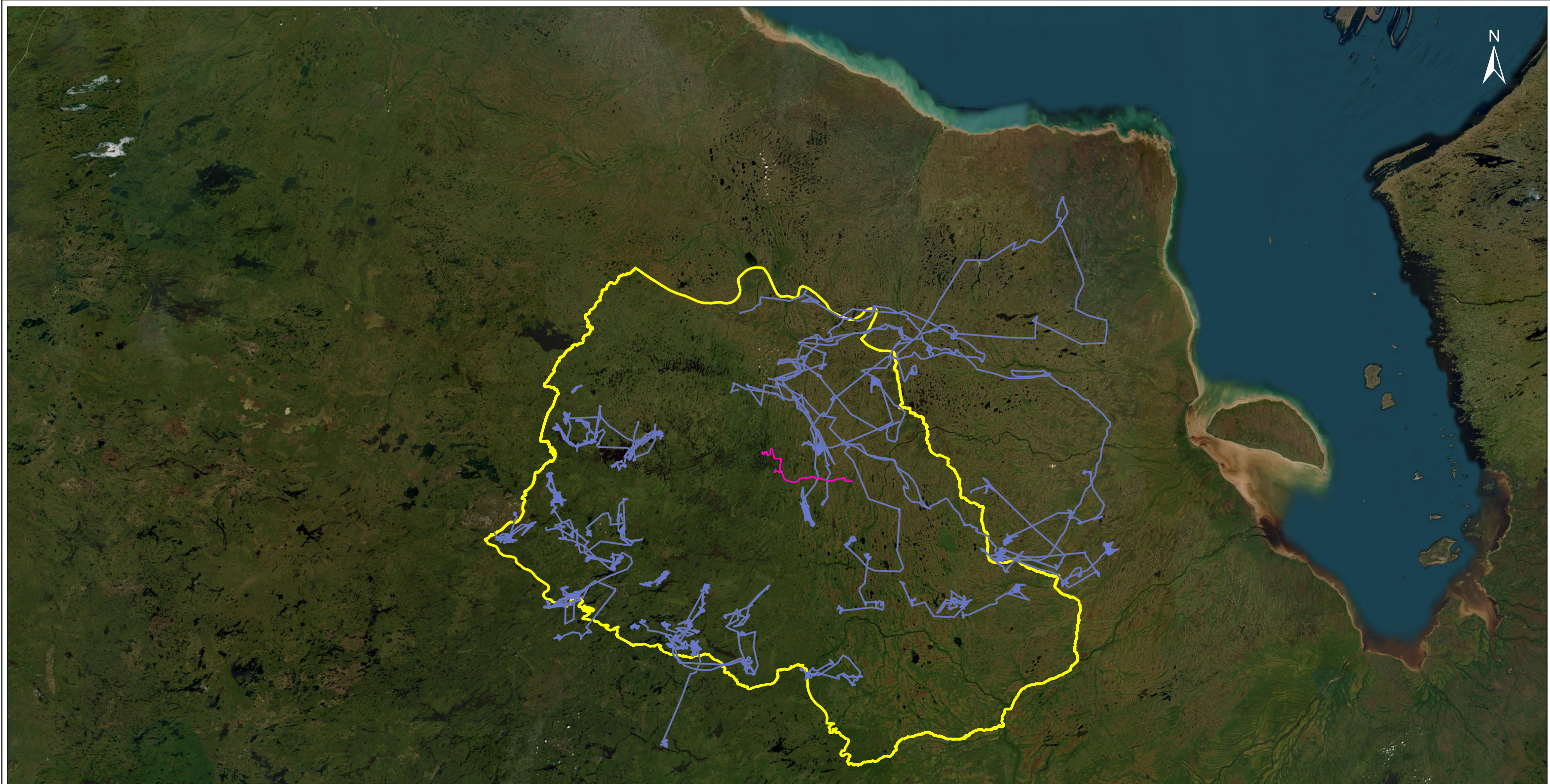
**NOTES**

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<b>Figure Number:</b> 2-21		<b>REV:</b> PA		
<b>Client:</b> Webequie First Nation	<b>Project Number:</b> 661910	<b>Date:</b> 4/2/2026		
DSC		DRN	CHK	APP
		LZ	GS	GS



- Legend:**
- Project Footprint
  - Caribou RSA (Ozhiski and Missisa Ranges)
  - Collared Sedentary Caribou Migration (Spring 2022)

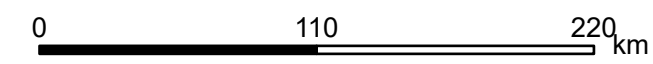


**NOTES**

1. Coordinate System: NAD 1983 UTM Zone 16N.
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3. Topographic/landcover features obtained from CanVec v12.0 dataset, Natural Resources Canada Earth and Sciences Sector Centre for Topographic Information, and Land Information Ontario (LIO) Warehouse Open Data (<https://geohub.lio.gov.on.ca/>), Ontario Ministry of Natural Resources and Forestry (OMNRF)
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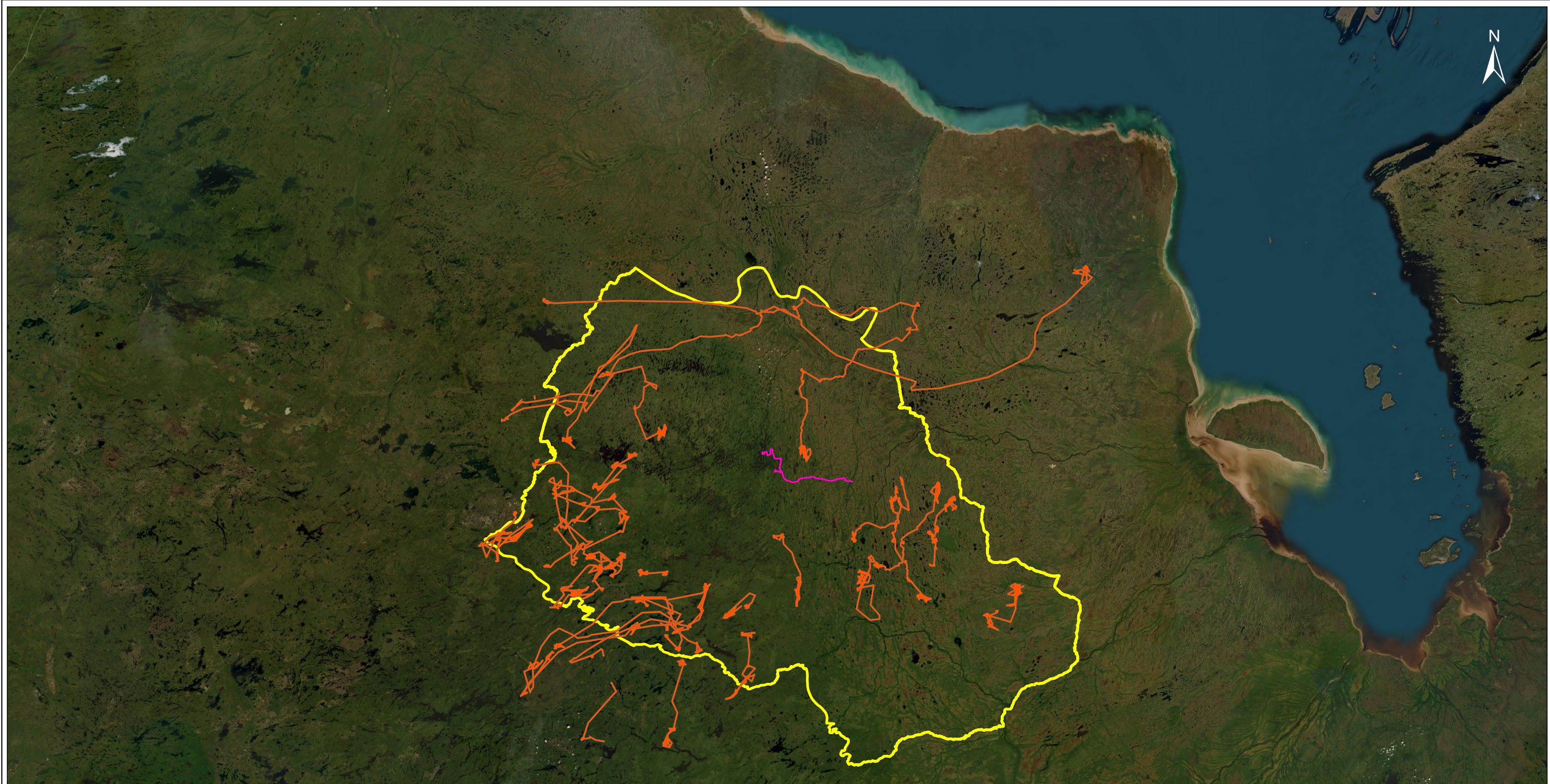
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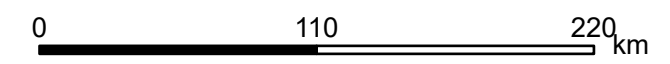
## Webequie Supply Road

Spring migration movements of Collared Sedentary Caribou in 2022

<b>Figure Number:</b> 2-22		<b>REV:</b> PA		
<b>Client:</b> Webequie First Nation	<b>Project Number:</b> 661910	<b>Date:</b> 4/2/2026		
DSC		DRN	CHK	APP
		LZ	GS	GS



- Legend:**
- █ Project Footprint
  - █ Caribou RSA (Ozhiski and Missisa Ranges)
  - █ Collared Sedentary Caribou Migration (Spring 2023)



## Webequie Supply Road

Spring migration movements of Collared Sedentary Caribou in 2023

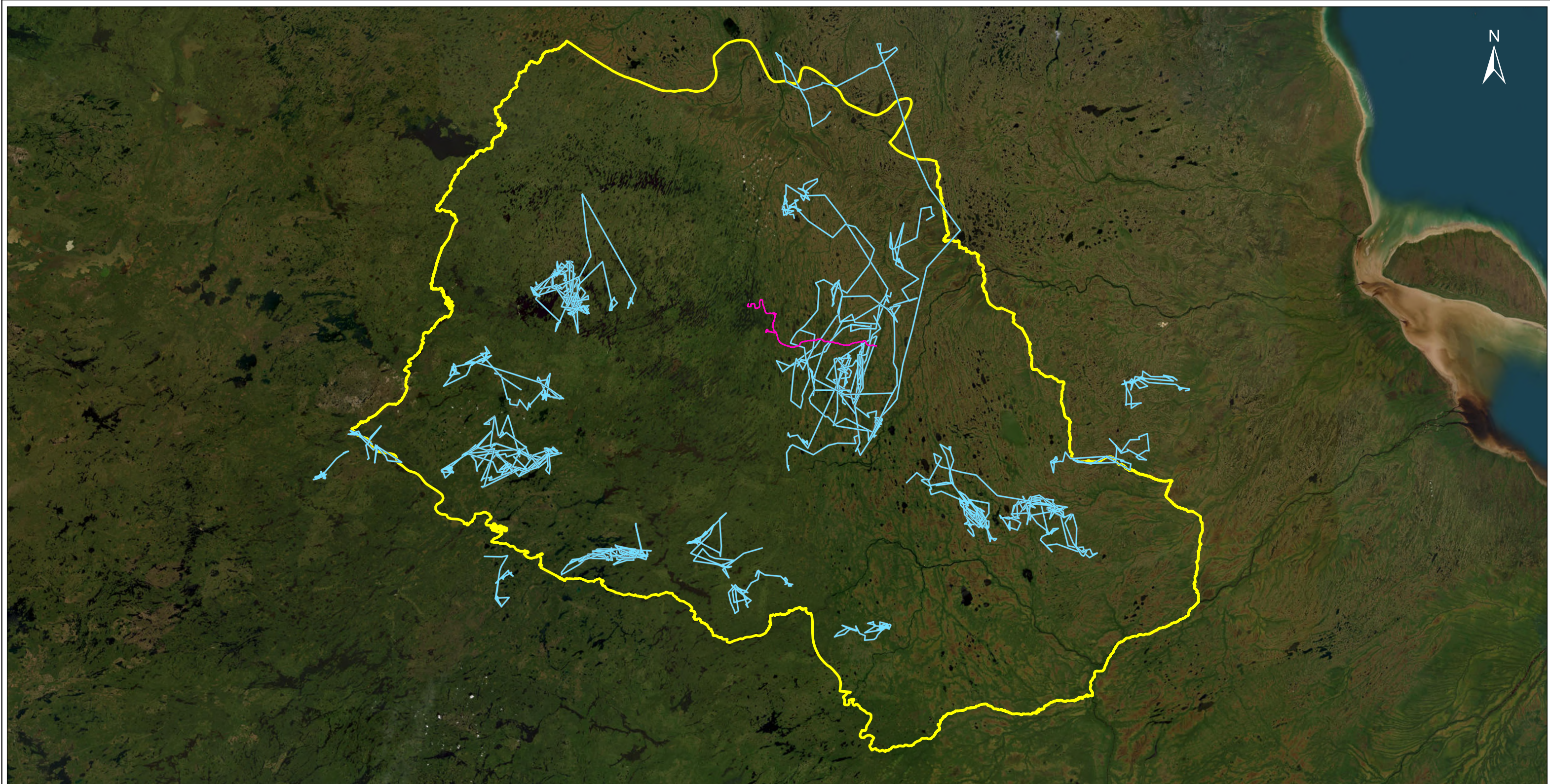
**NOTES**

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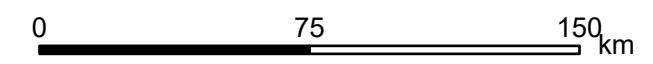
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<b>Figure Number:</b> 2-23		<b>REV:</b> PA		
<b>Client:</b> Webequie First Nation	<b>Project Number:</b> 661910	<b>Date:</b> 4/2/2026		
DSC		DRN	CHK	APP
		LZ	GS	GS



- Legend:**
- Project Footprint
  - Caribou RSA (Ozhiski and Missisa Ranges)
  - Collared Sedentary Caribou Migration (Fall 2020)



## Webequie Supply Road

Fall migration movements of Collared Sedentary Caribou in 2020

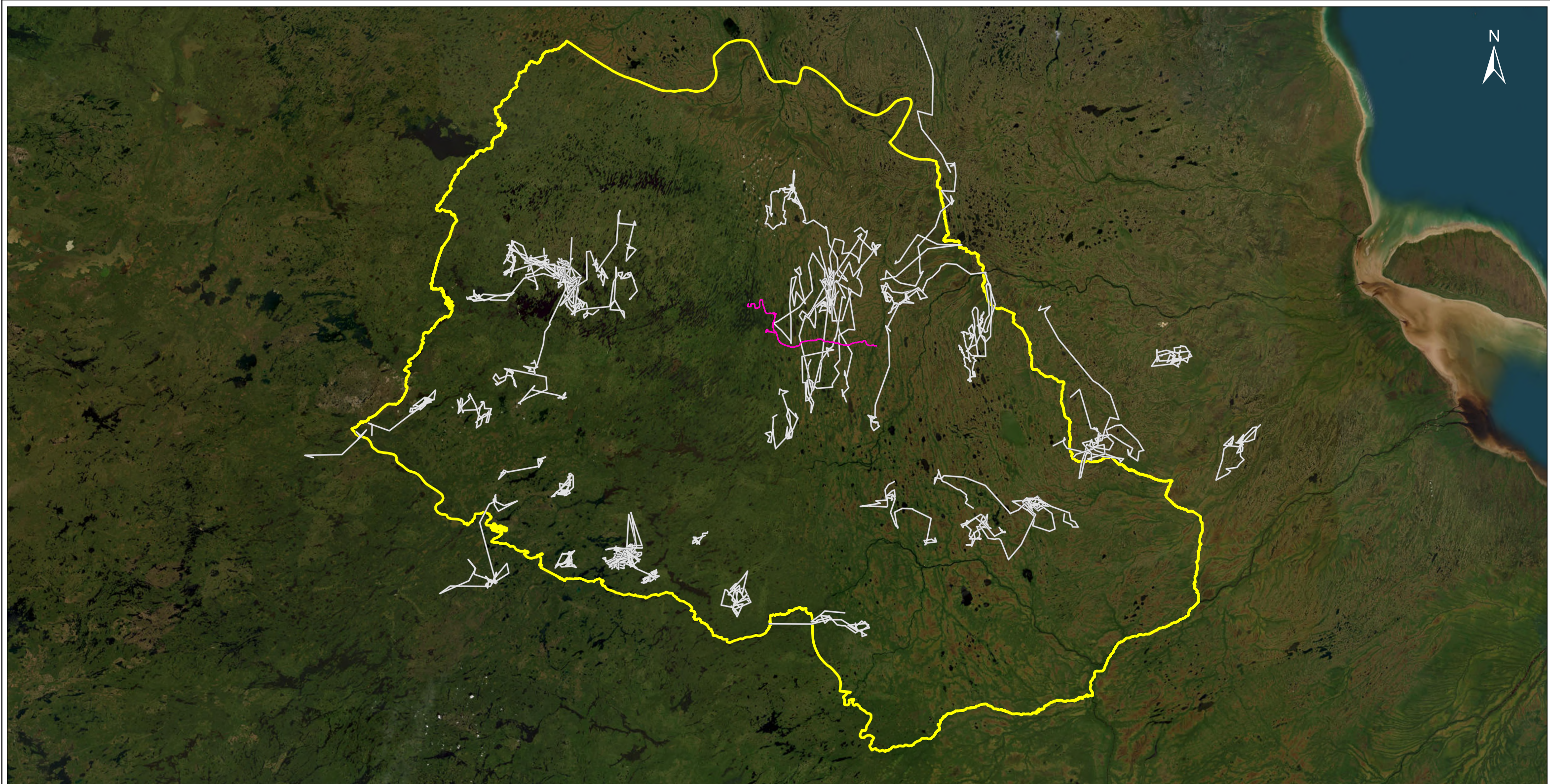
**NOTES**

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3. Topographic/landcover features obtained from CanVec v12.0 dataset, Natural Resources Canada Earth and Sciences Sector Centre for Topographic Information, and Land Information Ontario (LIO) Warehouse Open Data (<https://geohub.lio.gov.on.ca/>), Ontario Ministry of Natural Resources and Forestry (OMNRF)
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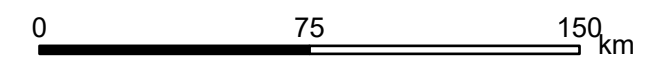
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<b>Client:</b> Webequie First Nation	<b>Project Number:</b> 661910	<b>Date:</b> 4/2/2026		
DSC		DRN	CHK	APP
		LZ	GS	GS



**Legend:**  
 ■ Project Footprint  
 ■ Caribou RSA (Ozhiski and Missisa Ranges)  
 — Collared Sedentary Caribou Migration (Fall 2021)



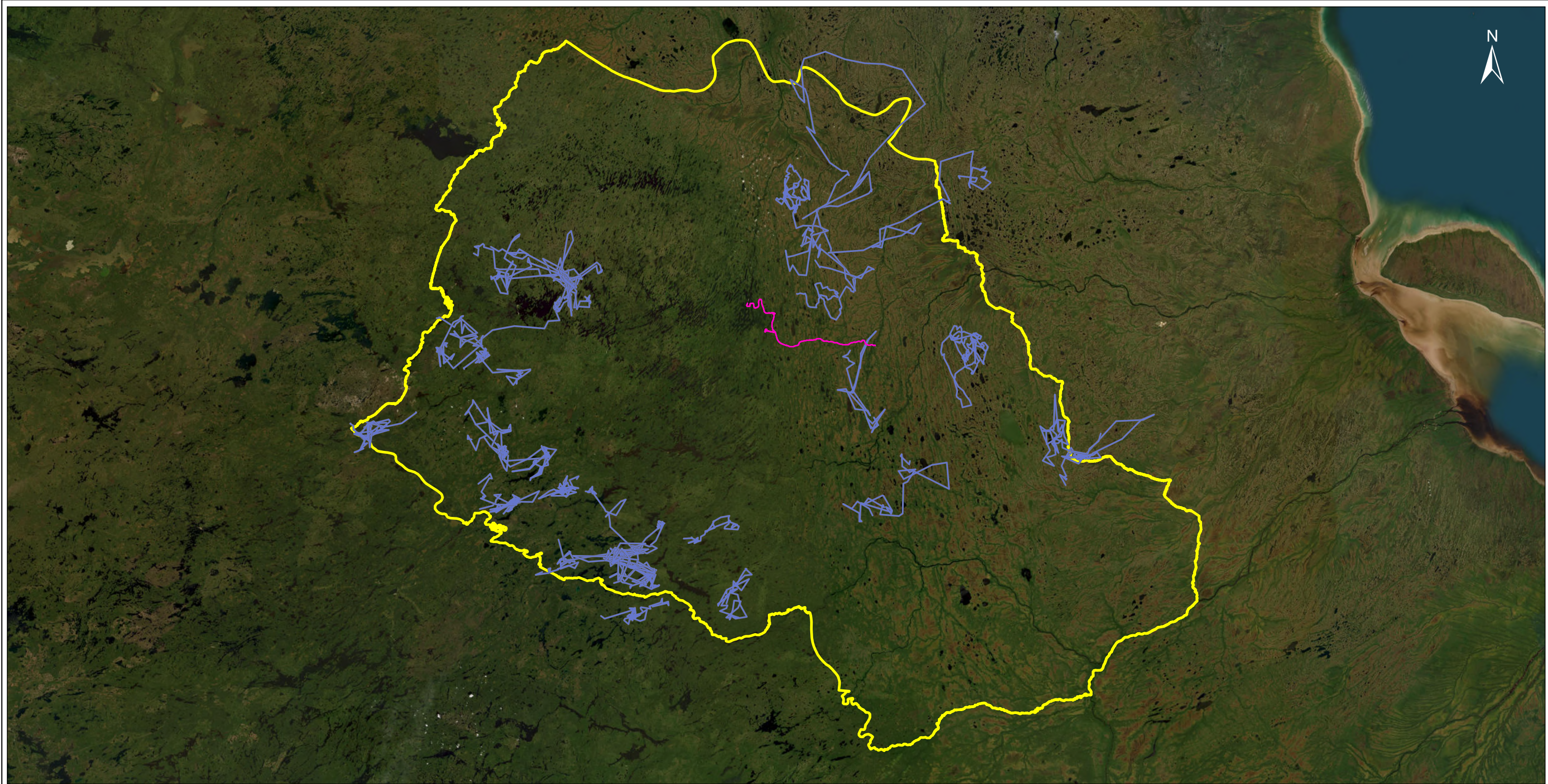
## Webequie Supply Road

Fall migration movements of Collared Sedentary Caribou in 2021

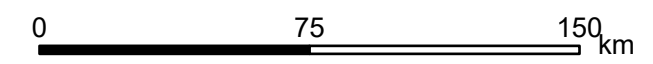
**NOTES**  
 1. Coordinate System: NAD 1983 UTM Zone 16N.  
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<b>Figure Number:</b> 2-25		<b>REV:</b> PA		
<b>Client:</b> Webequie First Nation	<b>Project Number:</b> 661910	<b>Date:</b> 4/2/2026		
DSC		<b>DRN</b>	<b>CHK</b>	<b>APP</b>
		LZ	GS	GS



- Legend:**
- █ Project Footprint
  - █ Caribou RSA (Ozhiski and Missisa Ranges)
  - █ Collared Sedentary Caribou Migration (Fall 2022)



## Webequie Supply Road

Fall migration movements of Collared Sedentary Caribou in 2022

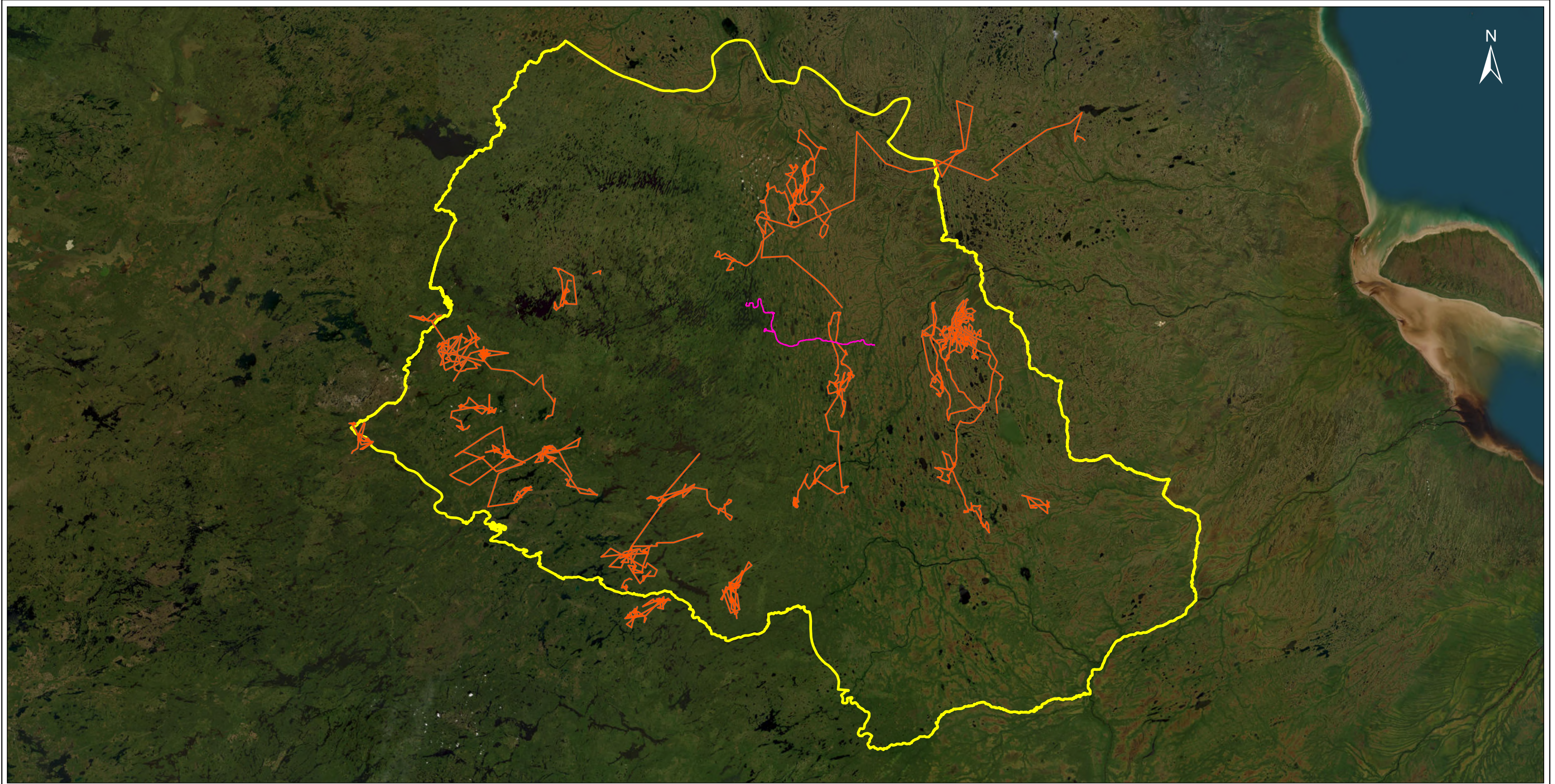
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4. Service Layer Credits: Earthstar Geographics

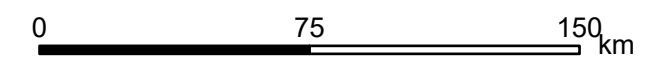
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<b>Figure Number:</b> 2-26		<b>REV:</b> PA	
<b>Client:</b> Webequie First Nation	<b>Project Number:</b> 661910	<b>Date:</b> 4/2/2026	
DSC		DRN	CHK
		LZ	APP
		GS	GS



- Legend:**
- Project Footprint
  - Caribou RSA (Ozhiski and Missisa Ranges)
  - Collared Sedentary Caribou Migration (Fall 2023)



## Webequie Supply Road

Fall migration movements of Collared Sedentary Caribou in 2022

**NOTES**

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<b>Figure Number:</b> 2-27		<b>REV:</b> PA		
<b>Client:</b> Webequie First Nation	<b>Project Number:</b> 661910	<b>Date:</b> 4/2/2026		
DSC		DRN	CHK	APP
		LZ	GS	GS

## 2.6 Parturition

### 2.6.1 Methods

Parturition was calculated for each individual caribou in the combined WSR, NRL and MNR dataset. Where individuals were represented in multiple years a parturition event was calculated for each individual year. Parturition events were inferred from GPS telemetry data by identifying abrupt and sustained reductions in movement rates during the calving period (1 May–15 June). Daily movement rates were calculated as the mean step length. For each individual-year, the date of minimum movement within the calving window was designated as the candidate parturition date. Individuals were classified as having calved if movement rates declined to <40% of pre-calving baseline levels and remained suppressed for a minimum of three (03) consecutive days. Further details on parturition methods are available in **Appendix A7-1**.

### 2.6.2 Results

Inferred parturition rates were consistently high across years, ranging from 85.5% to 99.1%, indicating strong reproductive output and effective detection of calving events using movement-based methods (**Table 2-2**). Mean parturition dates were tightly clustered among years (19–25 May; DOY 140–146), with moderate synchrony (SD ~6–9 days) and limited interannual variation, suggesting relatively stable calving phenology during the study period **Figure 2.28**.

Parturition metrics differed between movement classes. While calving rates remained high across movement classes, sedentary females showing the highest rates, followed by mixed and migratory individuals. Migratory caribou calved approximately 2–3 days later on average than sedentary and mixed individuals and exhibited greater synchrony (lower variance) in parturition timing. Movement-based detection patterns supported these results, with all groups showing reduced movement during the calving period. The decline was sharp and synchronous in migratory females, consistent with rapid settlement on calving grounds following long-distance movements, whereas sedentary and mixed individuals showed more gradual and variable declines in movement.

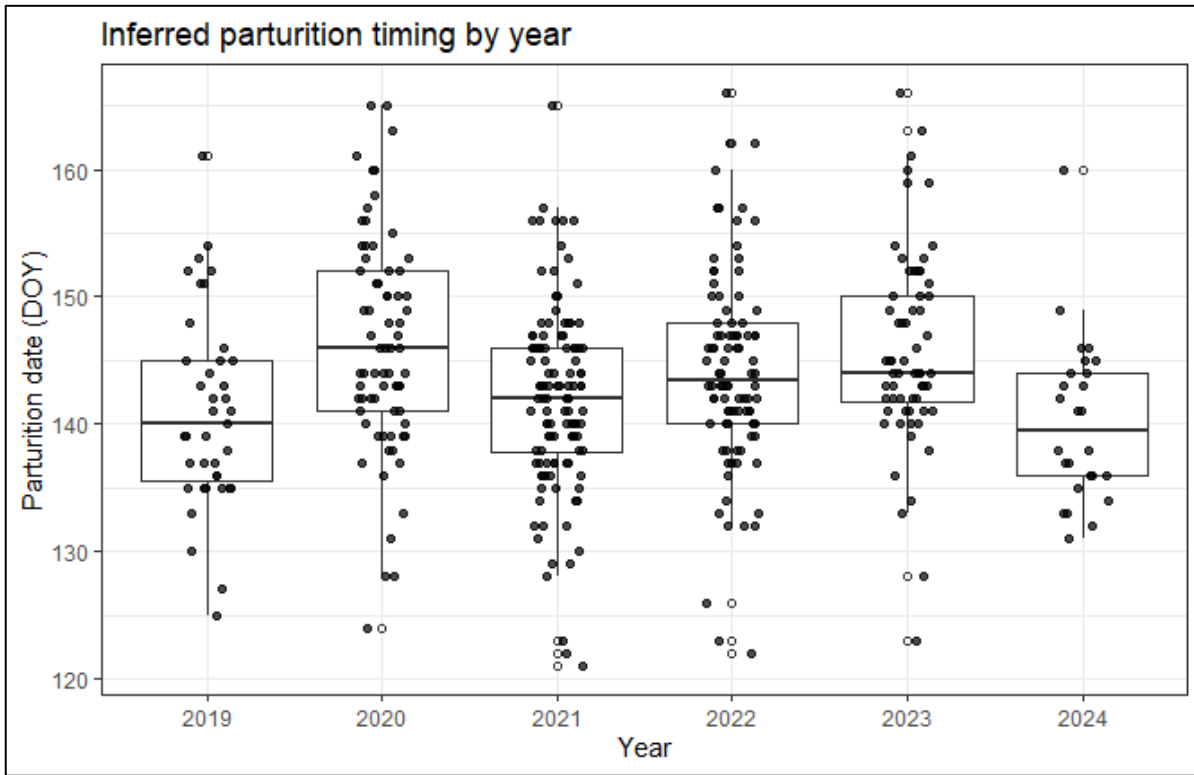
Inferred parturition dates differed modestly among caribou movement classes but showed clear contrasts in synchrony and temporal spread. Migratory caribou exhibited a later and tightly clustered calving peak in late May (approximately DOY 144–147), indicating high synchrony consistent with coordinated migration to coastal calving grounds and suggests strong coupling between reproductive timing and migration phenology. In contrast, sedentary and mixed (contact zone) caribou calved slightly earlier and across a broader time window, indicating greater variability in reproductive timing. Mixed individuals showed the widest distribution of dates, reflecting their intermediate movement strategies and use of more varied habitats.

Although mean differences among classes were small (on the order of days), variation in synchrony has important implications for sensitivity to disturbance. While migratory caribou may be vulnerable to short-term disturbances during a narrow calving window, their calving areas occur outside of the caribou RSA, and impacts would occur primarily during migration. In contrast sedentary and mixed caribou are more likely to experience disturbance from poorly timed Project disturbances due to their extended calving period which may also spatially overlap with the caribou LSA. The broader spread in parturition timing for mixed individuals suggests greater variability and potentially reduced predictability in reproductive behaviour, which may complicate mitigations based on timing.



**Table 2-2: Summary of Parturition Metrics by Movement Class**

Movement class	N classified	N inferred calved	% inferred calved	Mean parturition (DOY)	SD
Migratory	149	131	87.9	145.4	6.6
Mixed	179	166	92.7	142.4	8.3
Sedentary	118	111	94.1	143.3	8.6



**Figure 2.28: Mean Inferred Parturition Day (Julian Day) for Collared Caribou Between 2019 and 2024**

## 2.7 Annual Ranges

In their response MECP requests further information about range use and annual ranges.

### 2.7.1 Methods

Annual range use was documented from two (02) caribou collar data sets. Changes in range use between years was also examined. Female annual home range was classified using GPS-collar data collected from the WSR and NRL projects. Telemetry data were used to calculate caribou annual home range sizes (the area) using the kernel density method. Kernel density estimation (KDE) was chosen over the minimum convex polygon (MCP) approach because it captures intensity of space use and provides more realistic home range estimate.

GPS telemetry data were compiled from AtkinsRéalis data from (WSR and NRL caribou surveys) and standardized into a common format containing animal ID, timestamp, and projected coordinates. Collar records from all datasets were merged and ordered by individual and datetime. Only female collar data were included in the analysis.

All spatial data were analyzed in Ontario MNR Lambert projection (EPSG:3161). Telemetry records were converted to sf point objects, and year, month, and date fields were derived from the timestamp where needed. Prior to classification, obvious spatial or temporal anomalies were removed (**Table 2-3**). The dataset was screened for missing location data, and data collected during and after mortality events were removed. Data collected with limited satellite cover and low precision were removed. Specifically, when location was estimated from 2-D least squares and 3-D least squares with a Dilution of Precision (DOP) greater than 10. The higher DOP was used as the tolerance for error should be based on the intended use of the GPS collar data (Laver et al., 2015). Our intended use for kernel density estimation and broad scale habitat use allows a higher tolerance for error as it does not involve step length or movement calculations. Additionally, the first two weeks of data post-capture were excluded to remove potential behavioral effects from capture events (Werdel et al. 2021).

**Table 2-3: Location Records Removed during Data Cleaning**

Data Review Step	Number of Records Removed	
	NRL Telemetry Data	WSR Telemetry Data
Records from two weeks post capture	1794	3481
Duplicate Records	0	0
Records Missing Spatial Coordinates	9853	0
Records with 2-D least squares and 3-D least squares with a Dilution of Precision (DOP) greater than 10	1640	9
Records removed after mortality event	7087	11465
Total Removed	20374	14955
Percent Removed (%)		7.6

First of April was chosen as the start of the annual year as collaring was conducted at the end of February or the beginning of March in both programs. In addition, with the removal of the first two (02) weeks of data starting the year at the end of the winter period was deemed the most appropriate approach. Annual ranges were developed using a Gaussian normal 95% kernel density estimate (KDE) from the adehabitatHR package (Calenge, 2006) in R (R Core team, 2024). The bandwidth controls how spread out each kernel is and is the most critical parameter in Kernel Density Estimation (KDE) and a poorly chosen bandwidth can lead to a poor understanding or range use often by over or under smoothing which obscures true range use. For this analysis the Sheather and Jones method (Sheather and Jones, 1991) was used to select the bandwidth as which provides a data-driven estimate of and has been shown to be more stable and robust than cross-validation or rule-of-thumb approaches (Jones et al., 1996; Wand and Jones 1995).



## 2.7.2 Results

### 2.7.2.1 Webequie Supply Road Collared Animals

Annual home ranges for individual animals are available in **Appendix A7-5**. Substantial interannual variability was observed in both overall annual home range size and the proportional use of the RSA over the four (04) years of monitoring. Mean annual home-range size increased during each year of monitoring period from 2,380,520 ha in 2021 to 7,182,096 ha in 2024, although the estimates for 2024 were influenced by the reduced fix rate in that year (one (01) fix a day vs six (06) fixes for other years).

In contrast to consistently large annual ranges, only a modest proportion of the home range was contained within the RSA in all years which stems from the fact that most of the WSR collared animals being classified as eastern migratory caribou (**Appendix A7-2**). Mean RSA use peaked in 2022 at 32.6% of the annual home range, declining thereafter to 22.8% in 2023 and 20.8% in 2024. Use of the RSA was concentrated in the north (See **Figure 2.29** to **Figure 2.32**) with the same area north of the WSR project footprint used in all four years, four (04) caribou had estimated home-ranges extend within the caribou RSA in 2021, three (03) in 2022, one (01) in 2023 and two (02) in 2024.

Maximum RSA use was 94.3% in 2021 by caribou 49132) and 85% in 2022 by caribou 49128 both of which were classified as sedentary (boreal) caribou. The lowest use of the RSA was 0.3% by caribou 49303 in 2021; multiple other animals had the RSA make up less than 10% of their home-range indicating that multiple individuals only made rare use of the RSA.

Patterns of space use within the Missisa area closely paralleled those observed for the RSA. Mean proportional use was highest in 2022 (28.1%) and declined slightly in 2023 (23.8%) and further in 2024 (20.6%). As with the RSA, Missisa exhibited high maximum use in earlier years (up to 94.3% in 2021) by sedentary caribou alongside extremely low use by some eastern migratory caribou. Use of the Ozhiski area was consistently low relative to total home range size across all years, though a slight increase was observed in 2022. Mean proportional use was 4.5% in 2022, with caribou 49128 having 23% of its annual home-range in the Ozhiski. In contrast, mean use of the Ozhiski was negligible in 2021, 2023, and 2024, with a mean home-range percentage below 1% for all three (03) years.

While home range size expanded markedly in 2024 this primarily due to collar fixes being reduced to save battery life in the final year, **Table 2-4**. This results in larger smoothing distance for the KDE which makes home-range size comparisons with the other years problematic. However, space use comparisons are still valid. The fraction of space used within RSA and Missisa declined over time, indicating that increased movement was primarily directed into broader landscapes beyond the RSA, primarily to the north and west (**Figure 2.32**). Persistent low use of Ozhiski suggests it played a limited and intermittent role for collared animals. However, the distribution of annual home-ranges is dependent on the availability of telemetry. Both Marten Falls Community Access Road (MFCAR) and MNR data were received by the Project but were not incorporated into modeling. MNR data was incorporated into other modeling which suggest use of the western and southern portions of Ozhiski (see **Section 2.5 and 2.8**). MFCAR data will be incorporated into modeling done as part of detailed design of WSR.



### 2.7.2.2 North Road Link Collared Animals

Across the three study years, pronounced interannual variation was evident in both total annual home-range size and the spatial distribution of use across management units. Mean annual range area was greatest in 2024 (464,077 ha), substantially exceeding values observed in 2023 (177,928 ha) and 2025 (155,963 ha). Increased annual range in 2024 was driven by home-range increases in a few animals. The largest annual home-range (1,681,461 ha), by caribou 151318 was 56x greater than the home-range of caribou 151311 (29,844 ha).

Despite variability in total range size, **Table 2-5**, the majority of the annual range was consistently located within the RSA across all years. In 2023 and 2025, mean proportional use of the RSA was very high (96.2% and 95.1%, respectively), with high use by all animals (minimum use of 73% in 2023 and 84% in 2025). In 2024, however, mean RSA use declined to 77.7%, with a minimum of 40.6%, indicating both reduced proportional reliance on the RSA and greater among-individual variability during this year of expanded range size.

All animals primarily used the Missisa Range. In 2023 and 2025, Missisa accounted for approximately 95% of the annual home-range on average, and 77.6% in 2024 closely matching the patterns shown in the RSA. Use of the Ozhiski area was minimal across all years. In 2023, mean range use represented less than 1% of the annual home-range, with a maximum of only 5.4%, indicating very limited use of the range. Use declined further in 2024, with mean proportional use near zero (0.1%). In 2025, Ozhiski was entirely unused, indicating complete avoidance during that year by collared animals.

Overall, the results indicate that annual home-range size fluctuated strongly among years, with 2024 characterized by expanded and more variable spatial use. Nonetheless, core space use remained concentrated within the RSA and Missisa areas, particularly in 2023 and 2025, whereas Ozhiski contributed negligibly to annual ranges throughout the study period. This annual variability in range extent suggests that year-specific factors may be influencing the scale of movement. One potential explanation is environmental factors. Pereira et al. (2024) suggested that variation in migration distance for caribou in this area of the province was correlated to snow cover.



**Table 2-4: Annual Home-Range for Caribou Collared as part of the WSR Program (2021-2024)**

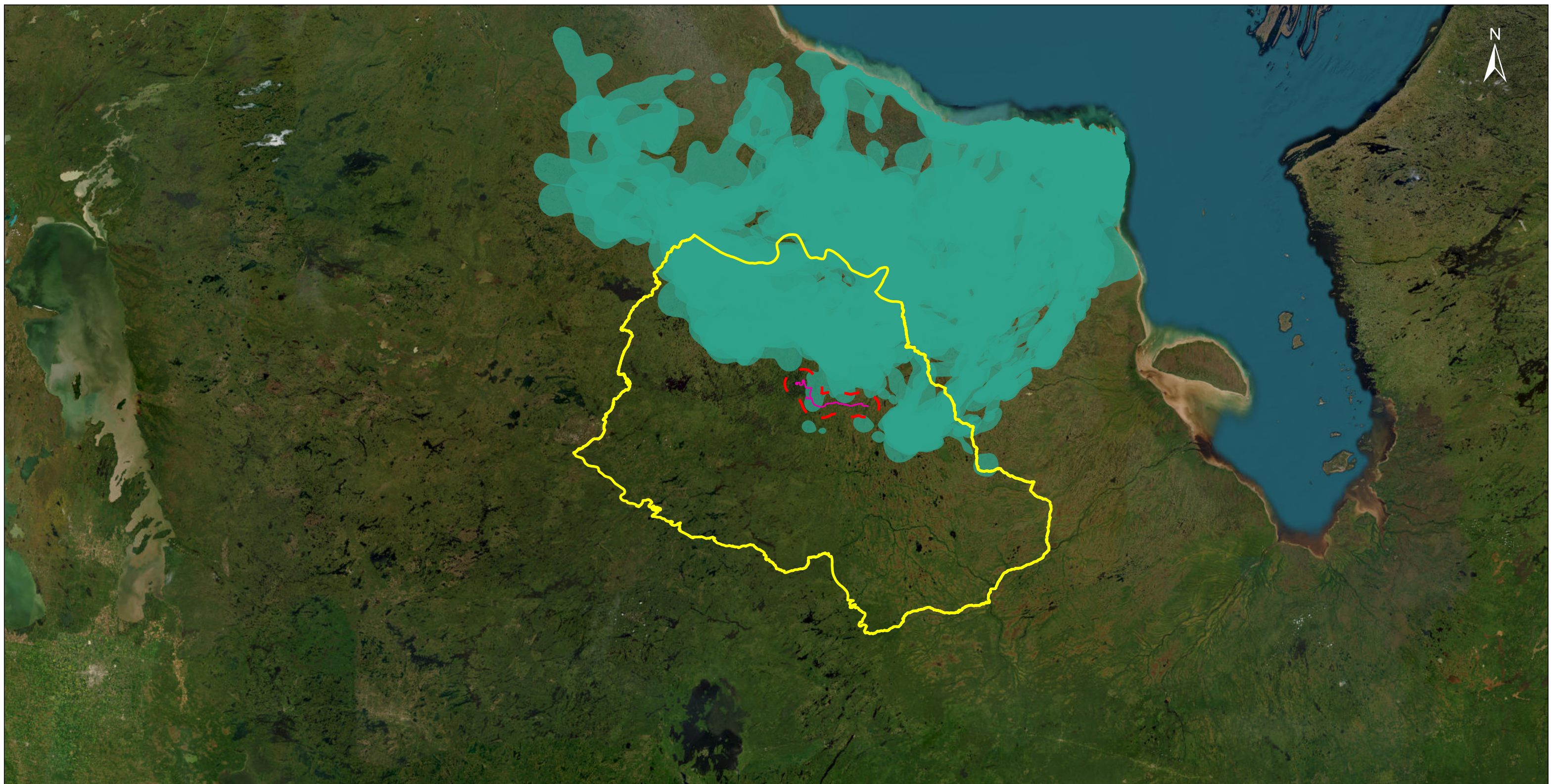
	2021 (N=25)			2022 (N=19)			2023 (N=13)			2024 (N=9)		
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
Annual Home-range	2380520	3828324	839955	3091920	4987223	548779	3159449	4495760	1223475	7182096	13066140	2241123
Home-range Area within RSA (ha)	555,348	1,195,887	6665	846,582	1,387,143	419,570	627,997	1,282,954	74,768	1,405,426	2,136,539	658,692
Percent of Home-range	28.2	94.3	0.3	32.6	85.9	17.9	22.8	63.2	2.8	20.8	29.4	15.0
Home-range Area within Missisa (ha)	547,654	1,181,239	6,665	735,896	1,387,143	342,952	606,165	1,271,006	74,768	1,390,784	2,121,462	658,692
Percent of Home-range	27.8	94.3	0.3	28.1	71.5	14.2	23.8	59.8	2.8	20.6	29.4	14.2
Home-range Area within Ozhiski (ha)	7,694	88,196	0	110,685	383,346	0	21,832	109,244	0	14,642	109,663	0
Percent of Home-range	0.4	3.3	0.0	4.5	23.4	0.0	0.8	3.4	0.0	0.1	0.8	0.0



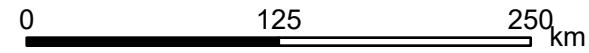
**Table 2-5: Annual Home-Range for Caribou Collared as part of the NRL Program (2023-2025)**

	2023 (N=13)			2024 (N=10)			2025 (N=6)		
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
Annual Home-range	177928	724163	21406	464077	1681461	29844	155963	377204	76249
Home-range Area within RSA (ha)	160,024	530,859	21,406	258,288	682,748	29,844	141,124	318,886	76,249
Percent of Home-range	96.2	100.0	73.3	77.7	100.0	40.6	94.2	100.0	84.5
Home-range Area within Missisa (ha)	156,635	492,101	21,406	257,515	678,026	29,844	141,124	318,886	76249
Percent of Home-range	95.3	100.0	68.0	77.6	100.0	40.3	94.2	100.0	84.5
Home-range Area within Ozhiski (ha)	3,390	38,758	0	773	4,721	0	0	0	0
Percent of Home-range	0.8	5.4	0.0	0.1	0.5	0.0	0.0	0.0	0.0





- Legend:**
- Project Footprint
  - Caribou LSA
  - Caribou RSA (Ozhiski and Missisa Ranges)
  - Caribou Annual Range Estimates for Collared Caribou – 2021



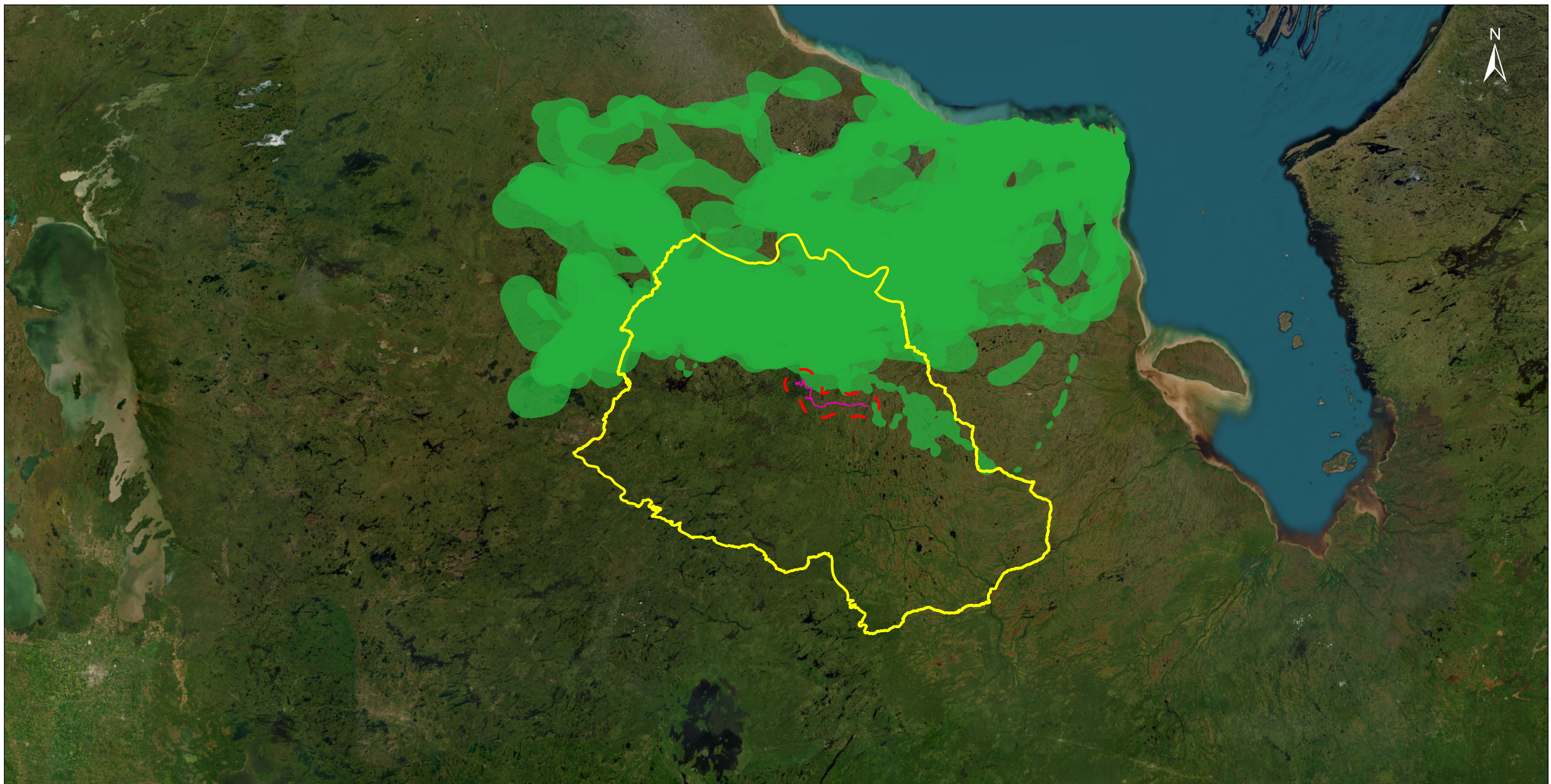
## Webequie Supply Road

Caribou Annual Range Estimates for Collared Caribou in Relation to the Caribou Regional Study Area – 2021

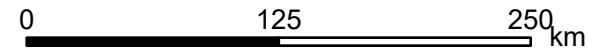
**NOTES**  
 1. Coordinate System: NAD 1983 UTM Zone 18N.  
 2. Cadastral boundaries are for informational purposes only and should not be considered suitable for legal, engineering, or surveying purposes.  
 3. Topographic/landcover features obtained from CanVec v12.0 dataset, Natural Resources Canada Earth and Sciences Sector Centre for Topographic Information, and Land Information Ontario (LIO) Warehouse Open Data (<https://geohub.lio.gov.on.ca/>), Ontario Ministry of Natural Resources and Forestry (OMNRF)  
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<b>Figure Number:</b> 2-29		<b>REV:</b> PA		
<b>Client:</b> Webequie First Nation	<b>Project Number:</b> 661910	<b>Date:</b> 3/27/2026		
DSC		DRN	CHK	APP
		TE	GS	GS



- Legend:**
- Project Footprint
  - Caribou LSA
  - Caribou RSA (Ozhiski and Missisa Ranges)
  - Caribou Annual Range Estimates for Collared Caribou – 2022



## Webequie Supply Road

Caribou Annual Range Estimates for Collared Caribou in Relation to the Caribou Regional Study Area – 2022

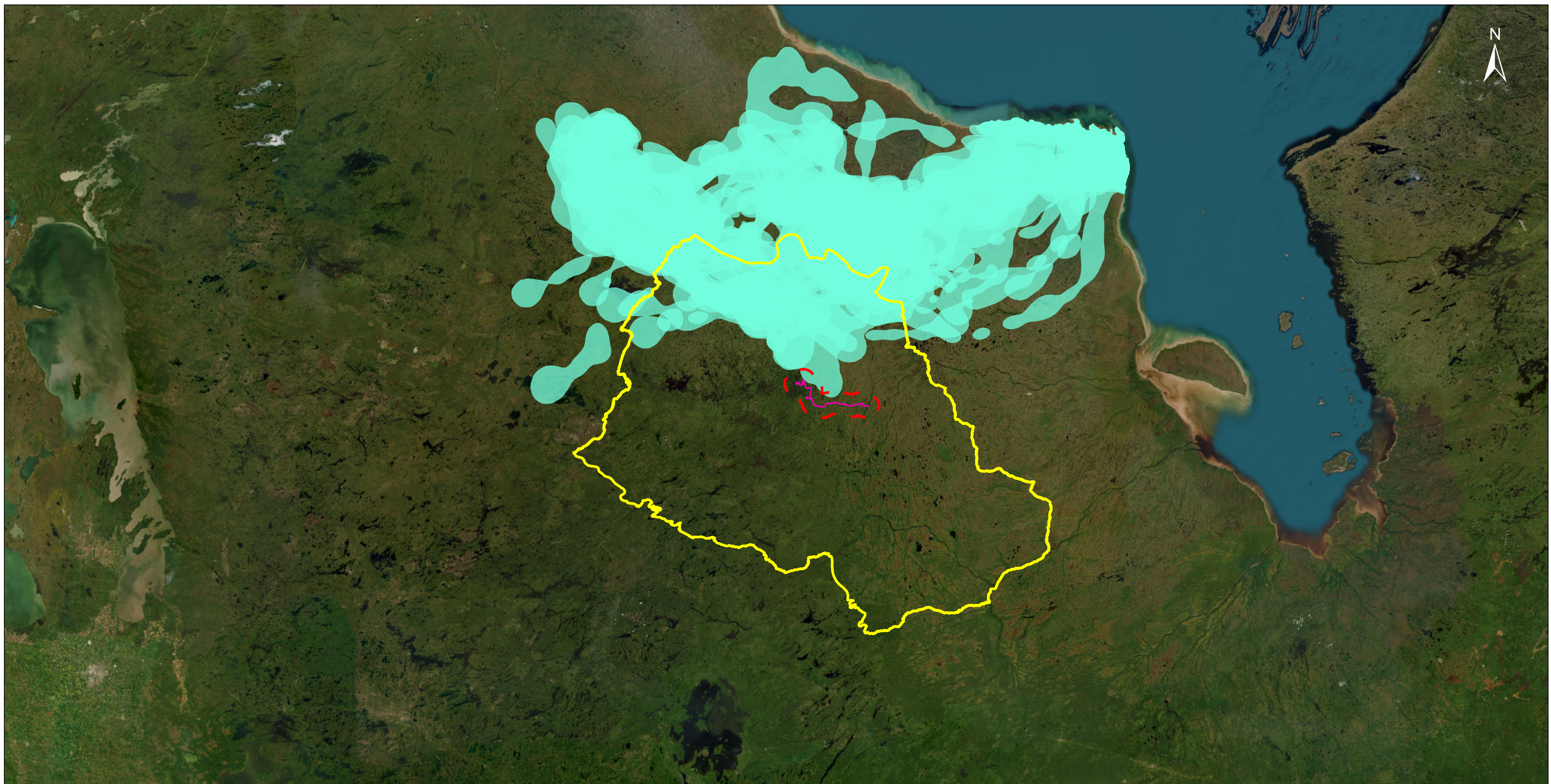
**NOTES**

1. Coordinate System: NAD 1983 UTM Zone 18N.
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DSC		DRN	CHK	APP
		TE	GS	GS



- Legend:**
- Project Footprint
  - Caribou LSA
  - Caribou RSA (Ozhiski and Missisa Ranges)
  - Caribou Annual Range Estimates for Collared Caribou – 2023

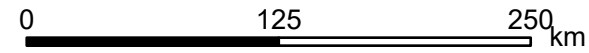


**NOTES**

1. Coordinate System: NAD 1983 UTM Zone 18N.
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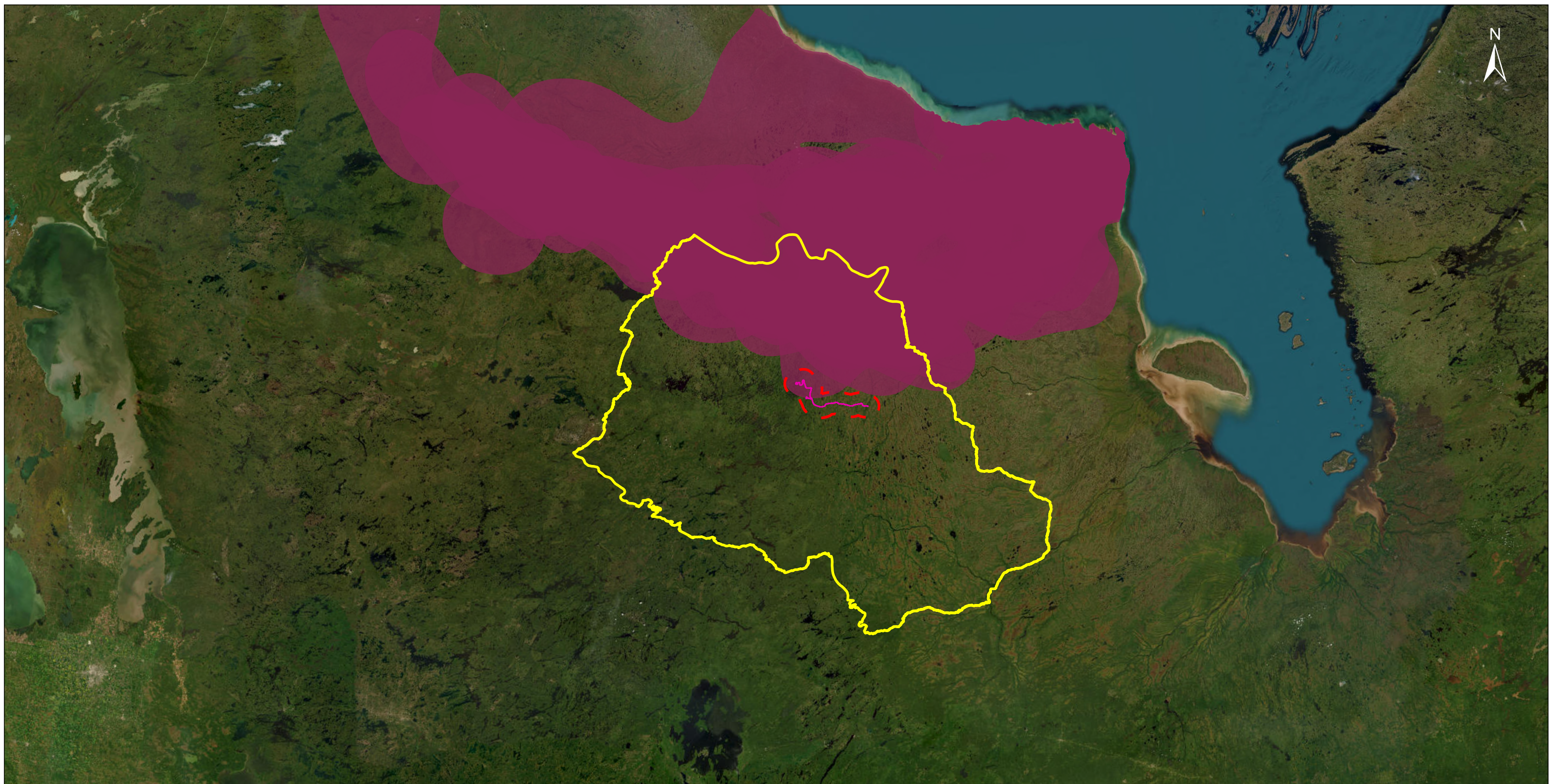
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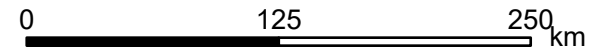
## Webequie Supply Road

Caribou Annual Range Estimates for Collared Caribou in Relation to the Caribou Regional Study Area – 2023

<b>Figure Number:</b> 2-31		<b>REV:</b> PA		
<b>Client:</b> Webequie First Nation	<b>Project Number:</b> 661910	<b>Date:</b> 3/27/2026		
DSC		DRN	CHK	APP
		TE	GS	GS



- Legend:**
- Project Footprint
  - - - Caribou LSA
  - Caribou RSA (Ozhiski and Missisa Ranges)
  - Caribou Annual Range Estimates for Collared Caribou – 2024



## Webequie Supply Road

Caribou Annual Range Estimates for Collared Caribou in Relation to the Caribou Regional Study Area – 2024

**NOTES**  
 1. Coordinate System: NAD 1983 UTM Zone 18N.  
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<b>Figure Number:</b> 2-32		<b>REV:</b> PA		
<b>Client:</b> Webequie First Nation	<b>Project Number:</b> 661910	<b>Date:</b> 3/27/2026		
DSC		DRN	CHK	APP
		TE	GS	GS

## 2.8 Provincial General Habitat Description

### 2.8.1 Methods

To delineate potential new Category 1 nursery and winter use areas, a Resource Selection Function (RSF) approach was used. The approach used GPS collaring data to model seasonal RSFs based on collaring data collected for the WSR, NRL, and MFCAR studies, along with data collected by MNR. This data includes the most recent collections of GPS collar data from the studies as of May 2025; data from MNR within the Missisa and Ozhiski ranges was also included. Individual home ranges were estimated using kernel utilization distributions, within which available points were sampled. Environmental covariates describing land cover, disturbance, linear features, and range identity were linked to all points. RSFs were estimated using XGBoost, a machine-learning approach capable of modeling nonlinear habitat relationships (Chen et al., 2024). Detailed methodology is described in **Appendix A7-3**.

Based on the MECP approach, Category 2 habitat mapping was done using resource selection probability functions (RSPFs). The methodology is described in State of the Woodland Caribou Resource Report: Part 3 (MNRF, 2019) and maps potential habitat value based on modelling associations of observed caribou use with land cover, linear features, and other environmental variables. More detail is available in **Appendix A7-4**.

### 2.8.2 Results

Model performance was acceptable for both seasonal periods, with the winter model demonstrating higher predictive skill and lower variance than the calving season model. Variable importance metrics and partial dependence plots indicated clear seasonal differences in habitat selection.

During the winter period, treed peatlands were the most influential predictor of habitat use. In contrast, during the calving season, open peatlands and conifer forest cover were the most important predictors. These differences highlight seasonal variation in habitat selection across the caribou ranges.

Final seasonal models were applied across the full extent of the caribou ranges to generate spatially continuous probability-of-use surfaces. These surfaces were classified into Category 1 (high use), Category 2 (moderate use), and Category 3 (low use) habitat using optimal threshold values. Predicted Category 1 Nursery and Winter Use areas are shown in **Figure 2.33**. The amount of Category 1, 2, and 3 habitats within the caribou LSA and the caribou RSA is summarized in **Table 2-6**. Potential and known caribou habitat identified across the Ozhiski and Missisa ranges are summarized in **Table 2-7**.

Within the RSA, known Category 1 nursery areas account for 2.6% of the total area, while potential nursery areas account for 29.4%, for a combined total of 31.7%, with an overlap of 0.3%. Known Category 1 winter use areas represent 4.5% of the RSA, while potential winter use areas account for 27.7%, resulting in a combined total of 31.0%, with an overlap of 1.2% of the RSA.

Within the LSA, known Category 1 nursery areas account for 0.3% of the area, while potential nursery areas account for 13.9%, for a combined total of 14.2%, with no overlap. No known winter use areas occur within the LSA; however, potential winter use areas account for 27.7% of the LSA. The large difference between known and potential habitat areas likely reflects limited data availability at the time the Missisa and Ozhiski ranges were initially delineated.



Some differences in Category 1 habitat availability were observed between the two (02) ranges comprising the RSA. Combined known and potential nursery habitat were at similar levels in both ranges accounting for 29.1% of the Ozhiski range and 31.7% of the Missisa range. In contrast, potential winter use habitat was substantially more common in the Missisa range, comprising 32.5% of the range, compared to 19.1% in the Ozhiski range.

The lower proportion of winter use habitat in the Ozhiski range resulted in a higher proportion of Category 3 habitat, which comprised 26.7% of the range, compared to 5.7% in the Missisa range. These values are substantially lower than existing General Habitat Description (GHD) estimates, with modeled Category 3 habitat predicted to be 30.4% lower for the Ozhiski range and 61.0% lower for the Missisa range. Modeled Category 2 habitat was also lower than GHD estimates, with reductions of 35.6% for the Ozhiski range and 47.9% for the Missisa range. Overall, modeling results predict substantially higher availability of Category 1 habitat across both ranges, with corresponding reductions in Category 2 and Category 3 habitat.



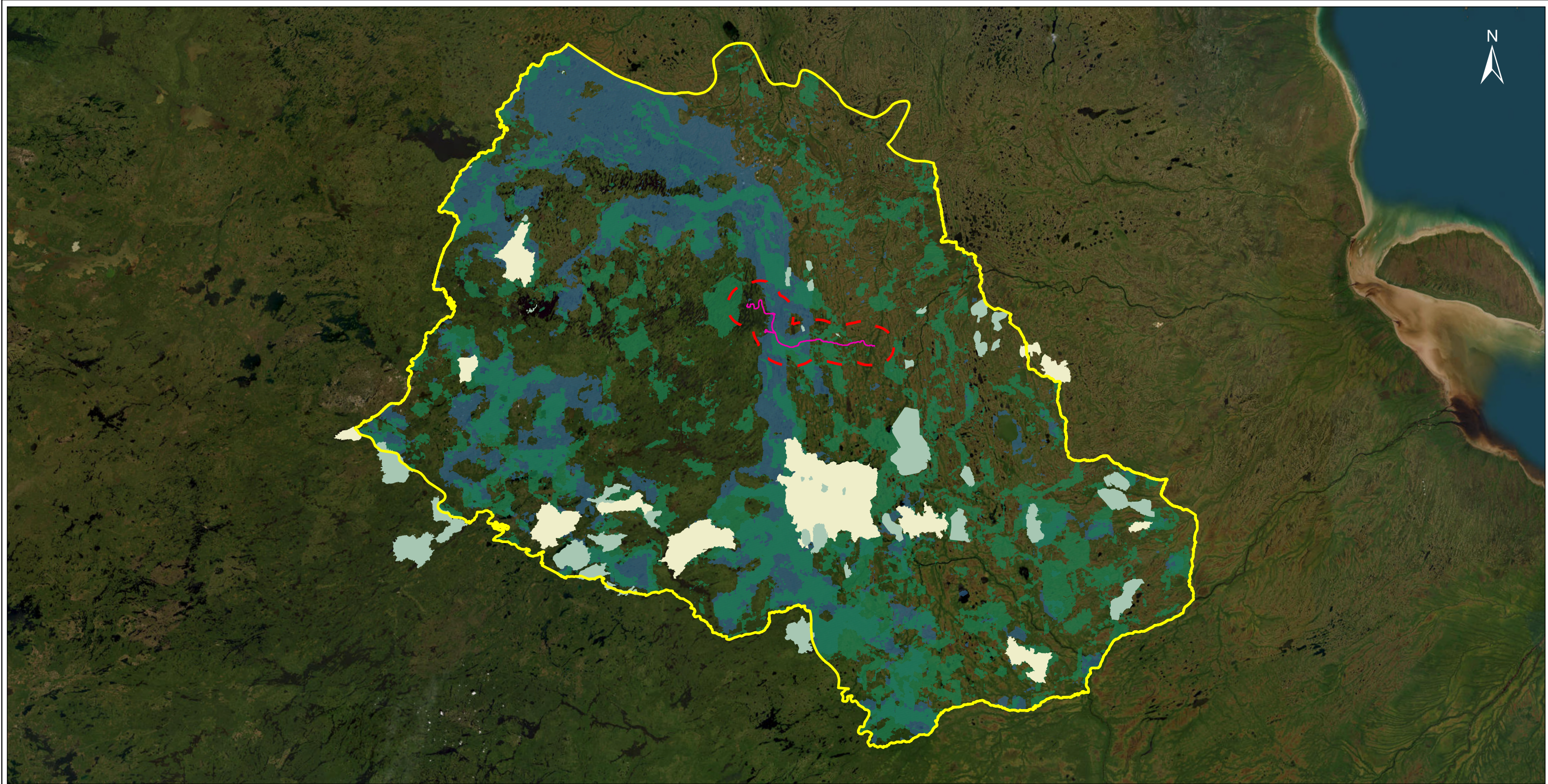
**Table 2-6: Potential and Known Caribou Habitat in the Caribou LSA and Caribou RSA**

Habitat Category	Caribou RSA						Caribou LSA					
	Potential Areas		Known Areas		Total		Potential Areas		Known Areas		Total	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Category 1 - Nursery	3,188,272	29.4	283,726	2.6	3,347,147	30.8	36,302	14.8	759	0.3	37,056	15.1
Category 1 - Winter Use	3,013,434	27.7	486,857	4.5	3,342,270	30.8	101,827	41.6	0	0.0	101,827	41.6
Category 2	4,226,361	38.9	7,605,886	70.0	4,005,988	36.9	94,514	38.6	198,742	81.1	94,293	38.5
Category 3	1,432,672	13.2	2,504,990	23.1	1,390,418	12.8	23,818	9.7	45,338	18.5	23,818	9.7

**Table 2-7: Potential and Known Caribou Habitat in the Ozhiski and Missisa Ranges**

Habitat Category	Ozhiski Range						Missisa Range					
	Potential Areas		Known Areas		Total		Potential Areas		Known Areas		Total	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Category 1 - Nursery	1,086,691	28.0	72,772	1.9	1,132,383.8	29.2	2,101,581	30.1	210,954	3.0	2,214,762.7	31.7
Category 1 - Winter Use	741,343	19.1	182,535	4.7	844,139.0	21.8	2,272,091	32.5	304,322	4.4	2,498,131.5	35.8
Category 2	1,375,408	35.4	2,137,058	55.1	1,305,774.4	33.6	2,850,953	40.8	5,468,828	78.3	2,700,213.8	38.7
Category 3	1,036,684	26.7	1,490,309	38.4	1,007,980.4	26.0	395,988	5.7	1,014,681	14.5	382,438.0	5.5



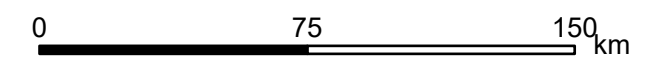


- Legend:**
- Project Footprint
  - - - Caribou LSA
  - Caribou RSA (Ozhiski and Missisa Ranges)
  - MECP - Nursery Areas GHD
  - MECP - Winter Use GHD
  - Caribou Modelling - Nursery Areas
  - Caribou Modelling - Winter Areas



**NOTES**  
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## Webeque Supply Road

Known and Potential Category 1 Habitats in the Caribou Regional Study Area

<b>Figure Number:</b> 2-33		<b>REV:</b> PA		
<b>Client:</b> Webeque First Nation	<b>Project Number:</b> 661910	<b>Date:</b> 3/27/2026		
DSC		DRN	CHK	APP
		TE	GS	GS

## 2.9 Cumulative Disturbance

In their response MECP requests further information about cumulative disturbance. Given the strong negative relationship between range disturbance and calf recruitment, cumulative disturbance levels provide insight into range condition.

Current disturbance levels as determined by Federal Range Assessment (ECCC, 2020) and the province discussed in Section 13.1.2.2.1 of Assessment of Effects on Species at Risk. A summary of these disturbance assessments is shown in **Table 2-8**.

**Table 2-8: Cumulative disturbance estimates for the Provincial Integrated Range Assessment and the Federal Assessment**

Provincial Integrated Range Assessment (2014)				Provincial Update (2022)	Federal Assessment (2020)			
Range	Natural	Anthropogenic	Total	Total	Range	Natural	Anthropogenic	Total
Missisa	5	9.4	14.4	8.4	ON9 includes Missisa, Ozhiski, Swan, Spirit, Kinloch and James Bay Ranges	15	1	16
Ozhiski	20	7.6	27.6	20.5				
RSA	10.4	8.8	19.1	12.7				

In order to assess the impact of the WSR Project the Project Team used the updated federal anthropogenic disturbance footprint (ECCC, 2020) as a starting point to update disturbance in the caribou RSA. This layer was updated to include more detailed disturbance using provincial datasets including the Ontario Road Network (LIO), MNRF road segments (LIO) and Fire Disturbance Area (LIO) Utility Lines (LIO), Abandoned Mines (Geology Ontario) and the Ontario Drill Hole Database (Geology Ontario). Other disturbances sources were checked but not used as they were either covered by other Anthropogenic footprints, did not exist in the caribou RSA, were not visible on satellite imagery or followed water features. In the case where the federal anthropogenic footprint and the provincial road layers did not align for the same road sections, the roads were compared manually and the source that better matched the satellite imagery was chosen and the other source removed.

As per the federal recovery strategy, anthropogenic linear and polygonal disturbances were buffered by a 500 m radius, to represent their zone of impact upon boreal caribou (EC, 2011). Point sources including boreholes were also buffered 500 m. Where the 500 m buffer overlapped natural disturbances or undisturbed areas the area was categorized as an anthropogenic disturbance. Natural disturbances were not buffered and fire disturbances within the last 40 years (1986-2025) were included. The resulting calculations are different from the federal and provincial assessments due to landcover changes, disturbance sources and range area differences in the case of the federal assessment which doesn't completely cover the Missisa range.

Existing natural disturbances and anthropogenic disturbances in the caribou RSA are shown in **Figure 2.34**. Approximately 22% of the Ozhiski Range and 5% of the Missisa Range were classified as Natural Disturbances, all of which was attributable to fire over the last 40 years (1986-2025). The difference between the two ranges is



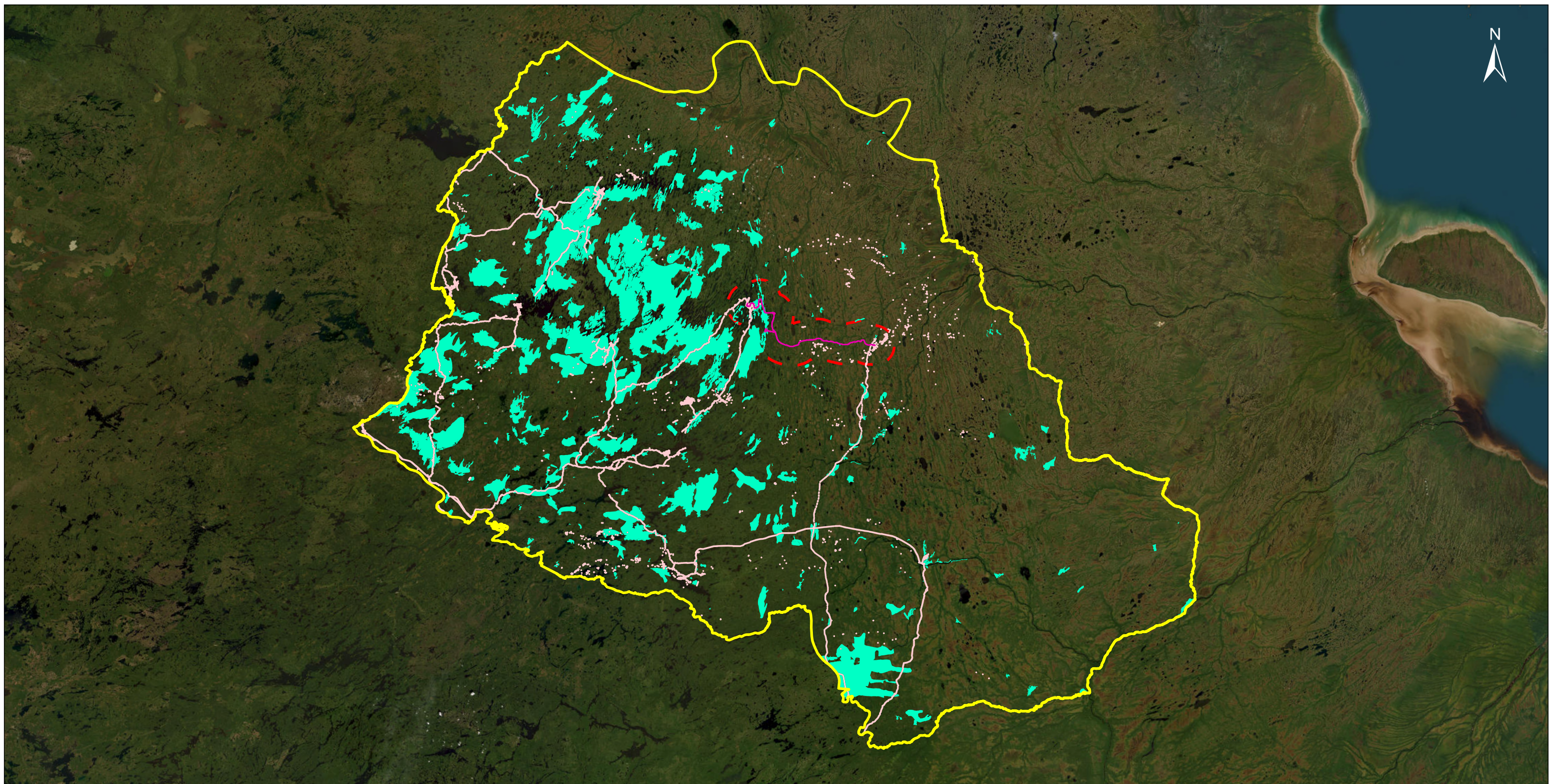
largely attributable to differences in fire regime. The LSA is almost exclusively within the Missisa Range and has a natural disturbance level similar to the Missisa Range at 6%.

Existing anthropogenic disturbances are low in number across the RSA. Anthropogenic disturbances are 4.5% in the Ozhiski Range, 1.4% in the Missisa Range and 2.5% in the RSA. Anthropogenic disturbances in the LSA are higher at 6%, primarily because the community of Webequie is within the LSA. The total existing disturbance in the caribou RSA, LSA and the Missisa and Ozhiski ranges are summarized in **Table 2-9**.

The existing disturbance was then updated with the project footprint buffered to 500 m. The updated disturbance levels are summarized in **Table 2-10**. The Project is expected to result in direct habitat loss during the construction and operations phase. The Project will increase disturbance in the LSA and RSA 8,835 ha. Anthropogenic disturbance would increase 10,408 ha while natural disturbance would decrease 1,573 ha as the road is built through existing natural disturbance areas. All of the disturbance increase is located in the Missisa Range where anthropogenic disturbance increases 10.5% while natural disturbance decreases 0.4%. Total anthropogenic disturbance in the range increases 1.9%, or 0.6% within the RSA. Within the LSA, anthropogenic disturbance increased 70.9% while natural disturbance decreased 10.7%. Overall disturbance in the LSA increased 30.2%.

The federal government identifies 65% undisturbed habitat in a range as the critical disturbance management threshold to provide a measurable probability (60%) for a local population to be self-sustaining (ECCC, 2020). The Missisa Range increases from 6.7% total disturbance to 6.8% total disturbance which is still well below the disturbance threshold identified in the federal recovery strategy. The Ozhiski Range remains at 26.1% disturbed, also below the disturbance threshold.





- Legend:**
- Project Footprint
  - Caribou LSA
  - Caribou RSA (Ozhiski and Missisa Ranges)
- Caribou Disturbance**
- Anthropogenic
  - Natural

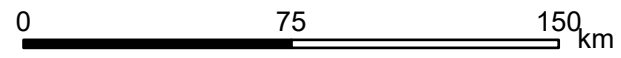


**NOTES**

1. Coordinate System: NAD 1983 UTM Zone 18N.
2. Cadastral boundaries are for informational purposes only and should not be considered suitable for legal, engineering, or surveying purposes.
3. Topographic/landcover features obtained from CanVec v12.0 dataset, Natural Resources Canada Earth and Sciences Sector Centre for Topographic Information, and Land Information Ontario (LIO) Warehouse Open Data (<https://geohub.lio.gov.on.ca/>), Ontario Ministry of Natural Resources and Forestry (OMNRF)
4. Service Layer Credits: Earthstar Geographics

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## Webequie Supply Road

Existing Anthropogenic and Natural Disturbance in the Caribou Regional Study Area

<b>Figure Number:</b> 2-34		<b>REV:</b> PA		
<b>Client:</b> Webequie First Nation	<b>Project Number:</b> 661910	<b>Date:</b> 3/27/2026		
DSC		DRN	CHK	APP
		TE	GS	GS

**Table 2-9: Existing disturbance Levels in the Ozhiski, Missisa, Caribou RSA and LSA**

Area	Disturbance Type									
	Anthropogenic <sup>(a)</sup>	%	Natural Disturbance <sup>(b)</sup>	%	Total Disturbed	%	Water <sup>(c)</sup>	%	Undisturbed	%
Ozhiski	175,354	4.5	838,658	21.6	1,014,012	26.1	477,954	12.3	2,388,951	61.6
Missisa	99,035	1.4	368,884	5.3	467,919	6.7	572,540	8.2	5,941,373	85.1
RSA	274,311	2.5	1,207,620	11.1	1,481,931	13.6	1,050,494	9.7	8,330,324	76.7
LSA	14,688	6.0	14,616	6.0	29,304	12.0	34,537	14.1	181,091	73.9

**Note:**

- a) Anthropogenic disturbances were buffered 500 m outside of their footprint
- b) Based on a fire history period between 1986 and 2025.
- c) Area based on water coverage in the Far North Landcover dataset

**Table 2-10: Changes to Disturbance Levels in the Ozhiski, Missisa, Caribou RSA and LSA Considering the Project Footprint**

Area	Disturbance Type									
	Anthropogenic <sup>(a)</sup>	%	Natural Disturbance <sup>(b)</sup>	%	Total Disturbed	%	Water <sup>(c)</sup>	%	Undisturbed	%
Ozhiski	175,354	4.5	838,658	21.6	1,014,012	26.1	477,954	12.3	2,388,951	61.6
Missisa	109,443	1.6	367,311	5.3	476,754	6.8	571,704	8.2	5,933,374	85.0
RSA	284,719	2.6	1,206,047	11.1	1,490,766	13.7	1,196,385	11.0	8,322,325	76.6
LSA	25,095	10.2	13,045	5.3	38,140	15.6	33,701	13.8	173,091	70.7

**Note:**

- d) Anthropogenic disturbances were buffered 500 m outside of their footprint
- e) Based on a fire history period between 1986 and 2025.
- f) Area based on water coverage in the Far North Landcover dataset



## 2.10 Net Effects Assessment for Eastern Migratory Caribou

**Sections 2.2** Eastern Migratory Caribou Background Review, **2.3** Classification of Female Caribou into Ecotype, **2.4** Seasonal Movement Periods, and **2.5** Migration Corridors were to specifically address questions related to eastern migratory caribou although other sections also inform the determination of Net Effects for eastern migratory caribou.

**Table 2-11** provides summary for predicted net effects for eastern migratory caribou during the construction phase and operations. The table takes into consideration the background information, additional data and analysis presented in **Sections 2** and **3**. The table has been modified slightly from the tables used in the EAR/IS in order to meet the requirements of the Addendum. The following changes have been made:

- The context column has been moved and expanded to “Ecological Context and Rational”.
- Net Effects that are assessed the same for both the construction and operations phase have been combined into one assessment with any differences discussed in the Ecological Context and Rational column.
- The timing column has been removed as the assessed result was the same for all effects with the net effect occurring in all seasons.
- A significance column has been added to the end of the table.
- An uncertainty column has been added to the end of the table.

For this Species at Risk VC assessment, the net effects that are characterized as having a likelihood of occurrence of “Probable and “Certain” and a “Moderate” to “High” magnitude have been carried forward to the cumulative effects assessment. Net effects with this characterization are most likely to interact with other RFD and activities.



**Table 2-11: Summary Table of the Predicted Net Effects for Eastern Migratory Caribou During the Construction and Operations Phase**

Predicted Net effect	Phase	Ecological Context and Rational	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood of Occurrence	Significance	Uncertainty
Habitat loss due to clearance activities	Construction and Operations	<p>Low amount of existing human disturbance are present in the caribou Regional Study Area. Based on the latest provincial estimates 20.5% of the Ozhiski is disturbed and 8.4% of the Missisa both numbers are below the federal critical disturbance management threshold (ECCC,2020).</p> <p>In the Southern Hudson Bay subpopulation area of the eastern migratory caribou disturbance levels have not been mapped. In general, the number of anthropogenic disturbance features are low, but not but a winter road exists between Fort Severn and Manitoba.</p>	Negative	<p>A <b>negligible</b> magnitude effect in terms of habitat loss through clearance activities is expected for eastern migratory caribou.</p> <p>Habitat loss from the Project will solely occur within the Missisa range, with anthropogenic disturbance increasing increase 10,408 ha a 10.5% increase from existing levels.</p> <p>Anthropogenic disturbance in the Missisa range is predicted to increase to 1.6%, or 2.6% within the RSA.</p> <p>The Construction of the Project will remove 5,837 ha of known and potential new winter use habitat. As the eastern migratory caribou does not calve in the caribou RSA nursery area losses are not considered.</p> <p>The Missisa range is a small area of the habitat utilized by eastern migratory caribou and outside their broad migratory pathways. The Project itself is generally south of areas used by the population.</p>	LSA	Permanent	Continuous	Irreversible	Certain	Not Significant	Moderate
Habitat degradation through structural change	Construction and Operations	<p>The Woodland Caribou Recovery Strategy (Woodland Caribou Recovery Team, 2008) identified alteration of vegetative cover as an activity that may result in adult female caribou selecting higher risk environments for calving. Conversion of mature forests into early seral forests may force female caribou into riskier environments.</p>	Negative	<p>A <b>negligible</b> magnitude effect in terms of habitat degradation through structural change is expected for eastern migratory caribou. Cleared areas associated with the road are relatively small in comparison to areas farther south where managed forests occur. Eastern migratory caribou will not be located in or near these areas during the calving period.</p>	LSA	Long-term	Continuous	Irreversible for WSR ROW Reversible for access roads and laydowns	Certain	Not Significant	Low
Habitat alteration or degradation through sensory disturbance	Construction	<p>Sensory disturbance includes noise, vibration, lights, odours, and human activity, all of which can alter caribou behaviour, habitat use, movement patterns, and connectivity. Caribou are known to respond to these disturbances through avoidance with naïve populations responding more strongly.</p> <p>The eastern migratory Population is suspected to have altered its distribution along the coast of Hudsons Bay due to sensory disturbance by ATVs.</p> <p>Few sources of sensory disturbance are currently present in the project study areas.</p>	Negative	<p>A <b>negligible</b> magnitude effect in terms of habitat degradation through sensory disturbance is expected for eastern migratory caribou as the Project Footprint is south of most of their range, in some years use of the caribou RSA is negligible, and their calving area is not within the caribou RSA.</p>	LSA	Permanent	Continuous	Irreversible	Probable – given that EMC may not use the area during the construction phase	Not Significant	Moderate
	Operations	See Construction phase.	Negative	<p>A <b>negligible</b> magnitude effect in terms of habitat degradation through sensory disturbance is expected for eastern migratory caribou as the Project Footprint is south of most of their range, in some years use of the caribou RSA is negligible and their calving areas are not within the caribou RSA.</p>	LSA	Permanent	Continuous	Irreversible	Certain	Not Significant	Low

Predicted Net effect	Phase	Ecological Context and Rational	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood of Occurrence	Significance	Uncertainty
Habitat Alteration/Degradation through hydrological Changes	Construction and Alteration	Nursery Areas include wetland complexes dominated by fens and bogs interspersed with peninsulas and upland islands Hydrological changes during road construction from activities such as grading, installation of drainage features, and construction of the roadbed could alter soil moisture regime, and shift or alter Nursery Areas and Seasonal Ranges.	Negative	A <b>negligible</b> magnitude effect in terms of habitat degradation through is expected for eastern migratory caribou as the Project Footprint is south of most of their range, effects are localized to the area around the Project Footprint, and their calving area is not within the caribou RSA.	LSA	Permanent	Continuous	Irreversible	Probable	Not Significant	Low
Alterations in movement through loss of connectivity (barrier)	Construction	Sensory disturbance includes noise, vibration, lights, odours, and human activity, all of which can alter caribou behaviour, habitat use, movement patterns, and connectivity. Caribou encountering roads are known to change their movement patterns including delayed crossing, faster movements near the road, moving parallel to the road and bouncing back. Few linear features are currently present in the project study areas suggesting caribou have limited exposure to roads and traffic.	Negative	A <b>negligible</b> magnitude effect in terms of alterations in movement through loss of connectivity is expected. The caribou LSA is not part of their migratory corridors for either the Spring or Fall Migration and it represents a minor component of their range with some years of no use. During construction mitigations including road closures when caribou present near the road are expected to be effective.	RSA	Permanent	Continuous	Reversible	Possible	Not Significant	Moderate
	Operations	See Construction phase.	Negative	A <b>low</b> magnitude effect in terms of Alterations in movement through loss of connectivity is expected. The caribou LSA is not part of their migratory corridors for either the Spring or Fall Migration and it represents a minor component of their range with some years of no use. During operations fewer mitigation measures are practical and are less enforceable.	RSA	Permanent	Continuous	Reversible	Possible	Not Significant	Moderate
Alterations in movement due to sensory disturbance (avoidance)	Construction	Caribou are reported to consistently avoid human disturbances such as road, human settlements and mines. Caribou are most sensitive to disturbance during the calving period and it is generally understood that adult female caribou may avoid suitable locations when selecting Nursery Areas due to sensory disturbances from development or recreational activities. Conversely, caribou may decrease avoidance behaviour or even increased their use of disturbances during periods of higher energy requirements. Under existing conditions cumulative disturbance of anthropogenic features in the Ozhiski Range is low (4.5%) and the Missisa range even lower (1.4%). Few linear features are in the Southern Hudson Bay subpopulation area of the eastern migratory caribou but a winter road exist between Fort Severn and Manitoba.	Negative	A <b>negligible</b> magnitude effect in terms of alterations in movement through sensory disturbance is expected. The caribou LSA represents a minor component of their range with some years of no use. Additionally, eastern migratory caribou calving areas are not within the caribou RSA situated near Cape Henrietta-Maria. During construction mitigations including road closures when caribou present near the road are expected to be effective.	RSA	Long-term	Continuous	Irreversible	Possible	Not Significant	Moderate

Predicted Net effect	Phase	Ecological Context and Rational	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood of Occurrence	Significance	Uncertainty
	Operations	See Construction phase.	Negative	A <b>low</b> magnitude effect in terms of alterations in movement through sensory disturbance is expected. The caribou LSA represents a minor component of their range with some years of no use. Additionally, eastern migratory caribou calving areas are not within the caribou RSA situated near Cape Henrietta-Maria. As access to the road will not be controlled mitigative measures are expected to be less effective less effective.	RSA	Long-term	Continuous	Irreversible	Possible	Not Significant	Moderate
Injury/Death – Collisions with Vehicles	Construction	In the range of the Ontario population of the eastern migratory caribou permanent roads are extremely rare outside of communities. Numerous winter roads do exist within the range, Generally, caribou are known to avoid human disturbance, including roads, making them lower risk for road mortality; however, caribou mortality due to collision with vehicles or trains, often involving groups of live animals, has been documented in several Canadian provinces, including Ontario.	Negative	A <b>negligible</b> magnitude in terms of injury or death due collisions as there will be a limited number of eastern migratory caribou that may encounter the road and the effectiveness of mitigations during the construction phase are expected to be high.	LSA	Long-term	Frequent	Irreversible	Possible	Not Significant	Moderate
	Operations	See Construction Phase.	Negative	A <b>negligible</b> magnitude in terms of injury or death due collisions is predicted as there will be a limited number of eastern migratory caribou that may encounter the road despite mitigative measures being less effective.	LSA	Long-term	Continuous	Irreversible	Probable	Not Significant	Moderate
Injury/Death – Increased Access	Construction	Hunting of caribou is known to exist within the communities that are part of the eastern migratory caribou range. As there is no mandatory reporting mechanism for indigenous harvest estimates are difficult to obtain. While recreational hunting is banded there is the potential for poaching if access is increased.	Negative	A <b>negligible</b> magnitude in terms of injury or death due to increased access exists as there will be a limited number of eastern migratory caribou that may be encountered during construction and access will be controlled during this phase.	LSA	Permanent	Infrequent	Irreversible	Possible	Not Significant	Low
	Operations	See Construction Phase.	Negative	A <b>low</b> magnitude in terms of injury or death due increased access is predicted. While there will be a limited number of eastern migratory caribou using the caribou RSA in the vicinity of the road there will be opportunities for legal and illegal harvest. While controls over access will not be present like the construction phase, the isolated location and lack of additional linear features will limit access.	LSA	Permanent	Infrequent	Irreversible	Probable	Not Significant	High

Predicted Net effect	Phase	Ecological Context and Rational	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood of Occurrence	Significance	Uncertainty
Injury/Death – Changes to Predator-Prey Dynamics	Construction	The primary cause of caribou decline in Ontario is widely recognized as habitat disturbance that indirectly results in changes to predator-prey dynamics and increased predation rates. Wolf and Moose densities are low in the caribou RSA, especially in the northern part of the RSA where EMC would be present. This is important as disturbance-mediated apparent competition has been found to decouple in northern boreal caribou ranges with low populations of predators and other ungulate species.	Negative	A <b>negligible</b> magnitude in terms of injury or death due increased predation is predicted. The road is at the southern limit of EMC range use. Nursery areas are outside the caribou RSA and low levels of predators and moose along with a lack of deer are expected to limit disturbance-mediated apparent competition. Construction Activities are expected to deter predator use.	LSA	Permanent	Frequent	Irreversible	Possible	Not Significant	Moderate
	Operations	See Construction Phase.	Negative	A <b>low</b> magnitude in terms of injury or death due increased predation is predicted. The road is at the southern limit of EMC range use. Nursery areas are outside the caribou RSA and low levels of predators and moose along with a lack of deer are expected to limit disturbance-mediated apparent competition.	LSA	Permanent	Frequent	Irreversible	Possible	Not Significant	Moderate
Injury/Death – Increased Energy Expenditure	Construction and Operations	Roads including winter roads are known to cause changes in caribou movement behavior the road may act as a barrier to some caribou, alter movement speed and or movement trajectory as has been demonstrated in a number of studies (Dyer et al., 2002; Wilson et al., 2016; Plante et al., 2018).	Negative	A <b>negligible</b> magnitude in terms of injury or death due energy expenditure as the area is not part of their migratory corridor and it represents a minor component of their range with some years of no use.	LSA	Long-term	Frequent	Reversible	Possible	Not Significant	Moderate

# 3 Habitat Loss and Degradation

## 3.1 Comments Addressed

In their comments, MNR and MECP made a number of comments and requests for additional data in regard to habitat loss and degradation, this section is meant to address the following requests:

- Determine habitat lost or degraded for both existing and potential Category 1 habitats (for MECP-SAR-054).
- Additional information on the amount of habitat likely to be altered or degraded as a result of construction activities (for MECP-SAR-056, 057).
- The amount of caribou habitat (Category 1,2, and 3) likely to be lost using a 500 m buffer (for MECP-SAR-053, 118).
- The amount of caribou habitat (Category 1,2, and 3) likely to be altered or degraded using a 10 km buffer (for MECP-SAR-058, 118).
- General request for all items (for MECP-SAR-033).
- The number of known and potential new Nursery Areas and Winter Use Areas that could be lost and habitat alteration and degradation (for MECP-SAR-052).

## 3.2 Response

### 3.2.1 Known Caribou Habitat Destroyed or Degraded

Estimated direct habitat loss within the Project Footprint is summarized in **Table 3-1**. Based on using a conservative approach, the entire Project Footprint is assumed to be cleared during construction. Based on the Ontario GHD, no Category 1 habitat occurs within the Project Footprint. However, approximately 360 ha of Category 2 habitat and 180 ha of Category 3 habitat will be lost, a total of approximately 550 ha. All identified habitat loss occurs within the Missisa range; no known habitat associated with the Ozhiski range overlaps the Project Footprint. The predicted loss represents approximately 0.008% of the total Missisa range, approximately 0.007% of Category 2 habitat and 0.018% of its Category 3 habitat.

**Table 3-1: Known and Potential Caribou Habitat Features within the Project Footprint**

Habitat Category	Ozhiski				Missisa			
	Potential Areas		Known Areas		Potential Areas		Known Areas	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Category 1 - Nursery	0	0.0	0	0.0	41.44	7.5	0	0.0
Category 1 - Winter Use	0	0.0	0	0.0	329.83	59.8	0	0.0
Category 2	0	0.0	0	0.0	150.9	27.4	366.85	3.0
Category 3	0	0.0	0	0.0	58.7	10.6	184.45	1.5



In addition to direct habitat loss due to construction disturbance, functional habitat loss was assessed within the Project Footprint plus a 500 m buffer as per the federal recovery strategy (ECCC, 2020). As summarized in **Table 3-2**, the Ontario GHD model indicates that no Category 1 habitat occurs within 500 m of the Project Footprint. Functional habitat loss is estimated to include 9,487 ha of Category 2 habitat and 2,637 ha of Category 3 habitat, for a total of 12,125.2 ha. All habitat loss is located within the Missisa range as the Ozhiski range is not within the 500 m buffer. Overall, this represents approximately 0.002% of the Missisa range. Specifically, the Missisa range is expected to lose approximately 0.002% of its Category 2 habitat and 0.003% of its Category 3 habitat.

**Table 3-2: Known and Potential Caribou Habitat Features within the Project Footprint and 500 m Buffer**

Habitat Category	Ozhiski				Missisa			
	Potential Areas		Known Areas		Potential Areas		Known Areas	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Category 1 - Nursery	0	0.0	0	0.0	1,191.5	9.8	0	0.0
Category 1 - Winter Use	0	0.0	0	0.0	5,836.6	48.1	0	0.0
Category 2	0	0.0	0	0.0	4,227.6	34.9	9,487.9	78.2
Category 3	0	0.0	0	0.0	1,718.5	14.2	2,637.3	21.8

The potential for the Project to degrade caribou habitat through sensory disturbance was assessed by establishing a 10 km buffer around the Project footprint. As summarized in **Table 3-3**, the Project is expected to affect 759 ha of Ontario GHD Category 1 habitat within 10 km. All Category 1 habitat consists of nursery areas; no winter use areas are within the 10 km buffer. In addition, approximately 200,000 ha of Category 2 habitat and 50,000 ha of Category 3 habitat within the LSA are expected to be affected.

Most of the 10 km buffer is located within the Missisa caribou range. Approximately 759 ha of known Missisa Category 1 habitat, entirely comprised of nursery areas, intersects the buffer or 0.4% of known nursery habitat in the range. The 10 km buffer also overlaps approximately 175,000 ha of Missisa Category 2 habitat, representing approximately 3.2% of the ranges total Category 2 habitat.

Less than 4% of the 10 km buffer overlaps the Ozhiski range. No Ozhiski Category 1 habitat intersects the 10 km buffer; however, approximately 10,000 ha of Ozhiski Category 2 habitat occurs within the 10 km buffer. This overlap represents approximately 0.5% of Category 2 habitat within the Ozhiski range.

**Table 3-3: Known and Potential Caribou Habitat Features within the Project Footprint and 10 km Buffer**

Habitat Category	Ozhiski Range				Missisa Range				Total			
	Potential Areas		Known Areas		Potential Areas		Known Areas		Potential Areas		Known Areas	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Category 1 – Nursery Areas	4,144.6	38.2	0	0.0	26,401	12.2	759	0.4	30,546	13.5	759	0.3
Category 1 - Winter Use Areas	3.1	0.0	0	0.0	94,717	43.9	0	0.0	94,720	41.8	0	0.0
Category 2	6,703	61.8	10,650	98.2	82,249	38.1	174,231	80.5	88,952	39.2	184,881	81.4
Category 3	0	0.0	190	1.8	23,418	10.8	41,431	19.1	23,418	10.3	41,621	18.3



### 3.2.2 Potential Caribou Habitat Destroyed or Degraded

Updated caribou habitat range models were developed using a combination of GPS-collar data and habitat information. The categories used are consistent with the Ontario GHD. More Information on the modeling approach is found in **Section 2.8**.

Estimated habitat loss within the Project Footprint is summarized in **Table 3-1**. The Project Footprint overlaps with 41.44 ha of potential Category 1 – Nursery Area habitat and 329.83 ha of potential Category 1 – Winter Use Area habitat, for a total of 341.68 ha of potential Category 1 habitat expected to be lost as a result of the Project. It also indicates the Project Footprint includes 150.91 ha of potential Category 2 caribou habitat. All identified habitat loss occurs within the Missisa population range; no known habitat associated with the Ozhiski population overlaps the Project Footprint. Based on the predictive model the Missisa range is expected to lose 0.002 % of the total potential Nursery habitat and 0.015 % of the total potential Winter Use habitat. It also indicates the Missisa population is expected to lose 0.009 % of total potential Category 2 habitat.

For functional habitat loss (Project Footprint plus a 500 m buffer) the Project Footprint and 500 meter buffer overlaps with approximately 1,200 ha of Category 1 – Nursery Area habitat and 5,800 ha of Category 1 – Winter Use Area habitat (**Table 3-2**). Together this comprises an expected functional loss of approximately 6,200 ha of Category 1 habitat. Additionally, 4,200 ha of Category 2 caribou habitat intersects with the Project Footprint and 500-meter buffer and is therefore expected to be functionally lost. All of the Project Footprint and 500-meter buffer is situated within the Missisa range. The Ozhiski caribou range does not overlap with Project Footprint or its 500-meter buffer.

Based on the predictive model, the Missisa range is expected to functionally lose 0.06% of its potential Nursery Area habitat, and 0.26% of its potential Winter Use habitat, together representing 0.17% of the total Category 1 habitat in the range. The Missisa Range is also predicted to lose 0.15% of its total Category 2 habitat.

For the 10 km buffer around the Project footprint representing the area where habitat degradation may take place, the Project is expected to affect 759 ha of Ontario GHD Category 1 habitat within 10km (**Table 3-3**). All Category 1 habitat consists of nursery areas; no winter use areas are within the 10 km buffer. In addition, approximately 200,000 ha of Category 2 habitat and 50,000 ha of Category 3 habitat within the LSA are expected to be affected.

For the Missisa range, approximately 26,400 ha of known Missisa nursery habitat intersects the buffer, representing approximately 1.26% of the ranges' nursery habitat. In terms of winter use areas 94,717 ha are within the 10 km buffer, this represents 4.17% of the winter use habitat in the range. The 10 km buffer also overlaps approximately 82,000 ha of Missisa Category 2 habitat, representing approximately 2.89% of the ranges Category 2 habitat.

Approximately 4,145 ha of known Ozhiski nursery habitat intersects the buffer, representing approximately 0.38% of the ranges' nursery habitat. A single three hectare winter use area is also located within the buffer, which is less than 0.001% of the winter use habitat in the range. Approximately 6,700 ha of Category 2 habitat occurs within the 10 km buffer. This overlap represents approximately 0.48% of Category 2 habitat within the Ozhiski Range.



### 3.2.3 Number of Nursery and Winter Use Areas Affected

The number of potential and known Category 1 nursery and winter use areas are shown in **Table 3-4**. For the Ozhiski range, in terms of known areas, no nursery or winter use areas are within any of the buffers.

In terms of potential Category 1 areas, four (04) nursery areas are within the 10 km buffer and none within the smaller buffer and footprint; this is out of 668 nursery areas available within the range. There is one (01) small Winter Use area in the 10 km buffer.

For the Missisa, in terms of known areas, only two (02) nursery areas are within the 10 km buffer, with no Category 1 areas potentially damaged or destroyed by the smaller 500 m buffer or the Project footprint, and no winter use areas affected by Project activities. In terms of potential Category 1 areas, three (03) nursery areas may potentially be damaged by the Project Footprint, six (06) nursery areas are within the 500 m buffer, and 45 nursery areas are within the 10 km buffer; this is out of 1,334 nursery areas available within the range.

In terms of potential winter use areas, three (03) nursery areas may potentially be damaged by the Project Footprint, four (04) winter use areas are within the 500 m buffer and five (05) winter use areas are within the 10 km buffer. It must be noted that there is large variability in the size of the potential Category 1 areas affected (1.95 – 1,600,746 ha) and the percent of the area affected (1-100%).

**Table 3-4: Number of Nursery and Winter Use Areas Affected by the Project Footprint, a 500 m Buffer Around the Footprint and a 10 km Buffer Around the Footprint in the Missisa and Ozhiski Ranges**

Category 1 Class	Disturbance Area	Potential Areas		Known Areas	
		Number	Size Range (ha)	Number	Size Range (ha)
Ozhiski Nursery Areas	Footprint	0	-	0	-
	Footprint + 500 m	0	-	0	-
	Footprint + 10 km	4	3.1-27,379.0	0	-
Ozhiski Winter Use Areas	Footprint	0	-	0	-
	Footprint + 500 m	0	-	0	-
	Footprint + 10 km	1	1.95	0	-
Missisa Nursery Areas	Footprint	3	406.7-29,168.2	0	-
	Footprint + 500 m	6	12.4-29,168.2	0	-
	Footprint + 10 km	45	3.1-29,168.2	2	232.0-525.9
Missisa Winter Use Areas	Footprint	3	6.2-1,600,746	0	-
	Footprint + 500 m	4	6.2-1,600,746	0	-
	Footprint + 10 km	5	6.2-1,600,746	0	-

### 3.2.4 Changes to Habitat availability and Landscape Function

Taken all together, the loss of caribou habitat is contained to the Missisa range as the Ozhiski range is not within the 500-m buffer, with both potential nursery and winter use areas affected. In terms of habitat altered or degraded where caribou utilization can expect to be lower due to sensory disturbance both the Missisa and Ozhiski are affected.



The Ozhiski only has a small number of potential nursery areas and a single (01) winter area within the 10 km buffer which suggest the Ozhiski Range will not be heavily impacted by habitat loss or habitat alteration and degradation.

The Missisa has a larger number of nursery areas and winter use areas impacted but they still only reflect a small percentage of the total area available in the range.

Overall, some individual caribou are likely to be affected by the loss or degradation of known or potential nursery areas or winter use areas. From an assessment perspective, neither the Ozhiski range nor the Missisa Range is heavily impacted by habitat loss.

## 4 Individual Responses

### 4.1 Comments Previously Resolved in Final EAR/IS

The following comments were resolved in the Final EAR/IS and will not be addressed further in this addendum.

**Table 4-1: Comments not discussed in Addendum**

Comment ID	Action	Response
MNR-219	Please provide a “probability of use” figure for the summer season, within the Final EA.	A probability of use figure for caribou during the summer season is found as Figure 13.7 in Section 13.2.2.1.3 of the Final EAR/IS.
MECP-SAR-034	Please update this section of the Final EAR/IS Report, and all other relevant locations within the EAR/IS Report and associated Appendices (e.g., Appendix F) as appropriate, to include a figure of the probability of use by caribou for the summer season.	A probability of use figure for caribou during the summer season is found as Figure 13.7 in Section 13.2.2.1.3 of the Final EAR/IS.
MECP-SAR-179	Please update Appendix 10-B of Appendix F to include the relevant information associated with caribou Nursery Habitat Surveyed in 2018.	Information regarding caribou nursery habitat is found as Appendix 11-C of Appendix F Natural Environment Existing Conditions Report

### 4.2 Individual Comments

#### 4.2.1 MECP-SAR-035

##### Comment, Rationale, and/or Proposed Action/Solution relating to Section 13.2.2.1.3

In their comment, the MNR requests the report on caribou seasonal patterns of habitat use that was missing from the EAR/IS be provided.

*Please update this section of the Final EAR/IS Report, and all other relevant locations within the EAR/IS Report and associated Appendices (e.g., Appendix F) as appropriate, to include the details associated with the seasonal pattern of habitat use.*



## Response

The Report on caribou Seasonal Patterns of Habitat Use in the NRL and WSR Study Areas has been appended to this addendum as **Appendix A7-6**.

### 4.2.2 MECP-SAR-060

#### Comment, Rationale, and/or Proposed Action/Solution relating to Section 13.3.3.2

In their comment, MECP requested additional information about the amount of caribou habitat within 20 m, 60 m, and 250 m of the Project footprint through the creation of a table.

*Please update this section of the Final EAR/IS Report, and all other relevant locations within the EAR/IS Report and associated Appendices (e.g., Appendix F) as appropriate, to include a table summarizing the amount of Caribou habitat within 20m, 60 m, and 250 m of the Project components.*

## Response

The Project Team clarifies that the distances used to calculate the areas of caribou habitat affected by changes to hydrology are those discussed in Section 11.3.2.3.7 of the Final EAR/IS and shown in **Table 4-2** for known habitat and **Table 4-3** for Potential habitat based on modeling. High magnitude effects may occur within 20 m of the road edge, moderate to high effects up to 40 m, moderate effects at 60 m, and minimal effects up to 250 m. The following table shows the areas of caribou habitat within these zones. Based on these zones, habitat loss is most likely to occur within the zones located adjacent to the roadway and project components with the potential for degradation within the outermost zone.

For known areas there are no Category 1 habitat affected by hydrological changes. For Category 2 habitat, 1,111.8 ha would have high to moderate effects which represents 0.56% of the known Category 2 habitat in the caribou LSA. For Category 3 habitat, 296.6 ha would have high to moderate effects which represents 0.65% of the known Category 3 habitat in the caribou LSA.

Hydrological changes could affect both nursery and winter use potential Category 1 habitat. For nursery habitat, 142.9 ha would have high to moderate effects which represents 0.39% of the potential nursery habitat in the caribou LSA. For winter use habitat, 689 ha would have high to moderate effects which represents 0.68% of the potential nursery habitat in the caribou LSA. For Category 2 habitat, 486 ha would have high to moderate effects which represents 0.51% of the potential Category 2 habitat in the caribou LSA. For Category 3 habitat, 188.5 ha would have high to moderate effects which represents 0.79% of the potential Category 3 habitat in the caribou LSA.

**Table 4-2: Known Areas of Category 1, 2 And 3 Habitat Within the 4 Hydrological Zones Extending from the Project Footprint**

Distance from Project Footprint	Known Areas (ha)				
	Category 1 - Nursery	Category 1 - Winter Use	Category 1 - Total(b)	Category 2 - Seasonal Range	Category 3 - Remaining Areas within the Range
0-20m	0.0	0.0	0.0	372.1	98.9
20-40m	0.0	0.0	0.0	370.5	98.8
40-60m	0.0	0.0	0.0	369.3	98.9
60-250m	0.0	0.0	0.0	3470.8	939.2



**Table 4-3: Potential Areas of Category 1, 2 And 3 Habitat Within the 4 Hydrological Zones Extending from the Project Footprint**

Distance from Project Footprint	Potential Areas (ha)				
	Category 1 - Nursery Areas	Category 1 - Winter Use	Category 1 - Total(b)	Category 2 - Seasonal Range	Category 3 - Remaining Areas within the Range
0-20m	47.3	228.5	240.4	156.1	68.6
20-40m	47.6	231.2	244.9	165.0	59.4
40-60m	48.0	229.2	242.8	164.9	60.4
60-250m	437.1	2103.8	2233.1	1566.0	610.8

Overall given the updated information on the amount of potential and existing caribou habitat affected by hydrological changes the assessment has been revised for both the construction and operations phase. Overall, the net effect is expected to be negative, with a low magnitude localized effect. Given that a number of changes to the evaluation of Habitat Alteration or Degradation - Hydrological Changes have taken place as part of this addendum please see **Section 5, Table 5-1** for the updated assessment for both Construction and Operations phases.

### 4.2.3 MECP-SAR-061

#### Comment, Rationale, and/or Proposed Action/Solution relating to Section 13.3.3.4

In their comment, the MNR requests,

*Please update this section of the Final EAR/IS Report, and all other relevant locations within the EAR/IS Report and associated Appendices (e.g., Appendix F) as appropriate, to clarify the years in which each collared Caribou died and the results of each mortality investigation associated with the WSR Caribou Collaring Study, as well as all other Caribou collaring studies (i.e., NRL, MFCAR, MNR).*

#### Response

See response to **MECP-SAR-175 & 176**.

### 4.2.4 MECP-SAR-062

#### Comment, Rationale, and/or Proposed Action/Solution relating to Section 13.3.3.4

In their comment, the MNR requests,

*Please update this section of the Final EAR/IS Report, and all other relevant locations within the EAR/IS Report and associated Appendices (e.g., Appendix F) as appropriate, to expand on the potential for the Project to increase access beyond the Project itself by providing greater access for predators through snowmobile trails.*

#### Response

It is acknowledged in the Final EAR/IS Report that construction and operation of the road will lead to increased human access and changes to predator-prey dynamics relating to caribou. As such, it can be hypothesized that increased human access will lead to the creation of formal or informal recreational trails, such as snowmobile trails, which can in turn provide greater access to caribou habitat by predators.



As noted in the Final EAR/IS Report, creation of roads in previously inaccessible areas can often lead to increased use by hunters (Crichton et al., 2004; Boston, 2016). In the winter, particularly in remote landscapes such as the boreal and Hudson Bay Lowlands regions in Northern Ontario, snowmobile is a common method of off-road travel, including for recreational purposes. Snowmobiling in Ontario is governed by the *Highway Traffic Act, 1990* and the *Motorized Snow Vehicles Act, 1990*. Under these laws, snowmobile drivers are required to be licenced by their home province, state or country, and a permit is required to use trails operated by the Ontario Federation of Snowmobile Clubs. Snowmobiles are permitted on private property with the owner's permission; on private trails of organizations to which the snowmobile driver belongs; and in permitted public parks and conservation areas. Snowmobiling is also permitted on Crown land if the activity is not restricted by planning or placement of a sign. As the proposed route would traverse unpatented Crown land, it is possible that humans may select sites along the constructed road for snowmobile access.

As noted in the Final EAR/IS Report, Grey Wolves and other predators use linear corridors to facilitate movement, which also increases hunting efficiency by these species as a result (Dickie et al., 2020, 2022; McKay et al., 2021; Pigeon et al., 2016). Paquet et al. (2010) found that wolves used “modified trails of compacted snow” (i.e., snowmobile trails) more often than natural trails, which allowed wolves to travel through areas where deep snow would likely impede movements. While travel on modified trails was unrelated to ungulate densities, rates of ungulate (including caribou) kill by wolves on modified trails were significantly higher than on natural trails (Paquet et al. 2010).

In Section 16.2.2.4.1 of the Final EAR/IS Report, snowmobiling (Ski-doo) was identified by Webequie First Nation community members as a recreational opportunity both on and off-reserve. Marten Falls First Nation community members also identified snowmobiling as an outdoor recreational activity. While there are no formal trail networks in the standard RSA snowmobiling ranks as a popular activity for Weenusk First Nation community members as well. Barriers to travel in Webequie, including snowmobile use, included the cost of gas and inflation. Observations of trails created by snowmobiles and snowmobile use in the caribou LSA and RSA were not tracked during baseline biological field investigations. It is unknown with what frequency or likelihood local community members or visitors to the area will choose to disembark with snowmobiles from the roadside or designated rest or maintenance areas.

Relating largely to Moose (*Alces alces*) but considering effects to other ungulates including caribou, Harris et al. (2013) determined that winter recreation is potentially detrimental to ungulates when: unpredictable; spanning large areas; long in duration; large in spatial footprint; non-motorized; and when animals are displaced to poor quality habitats. In Ontario, Conservation Reserves can be established under the *Provincial Parks and Conservation Reserves Act, 2006* to permanently protect biodiversity and limit snowmobile use entirely or on authorized trails only. To protect caribou from indirect effects causing injury or death from increased access, snowmobile use and changes to predator-prey dynamics, restrictions can be put in place limiting the use of snowmobiles in certain areas, such as within Category 1 or Category 2 caribou habitat accessible from the proposed road, potentially associated with protecting such locations as part of new Conservation Reserves. Additionally, signage can be posted along the road prohibiting parking and in rest and maintenance areas prohibiting long-term parking or vehicle abandonment.

Refer to the response to comment MECP-SAR-127 below for the characterization of net effects and determination of significance as it relates to injury or death to caribou from changes to predator-prey dynamics.



## 4.2.5 MECP-SAR-063

### Comment, Rationale, and/or Proposed Action/Solution relating to Section 13.3.3.5 / Table 13-17 (Final EAR/IS Table 13-23)

In their comment, the MNR requests,

*Please update this section of the Final EAR/IS Report, and all other relevant locations within the EAR/IS Report and associated Appendices (e.g., Appendix F) as appropriate, to include a detailed description of rationale and justification to support the conclusions for each threat assessment criteria associated with each individual threat.*

#### Response

Threats or effects assessment (TISG - Section 13; Section 13.3.1) for species at risk involves a staged approach in which the initial assessment of potential effects of the Project or “Threat Assessment” is completed without any consideration of mitigation. This assessment is followed by an assessment of predicted net effects after the application of the mitigative measures in Section 13.4. These two assessments differ in that the initial Threat Assessment is limited to the physical direct removals or alteration of species at risk habitat, while the predicted net effects assessment incorporates a qualitative and quantitative description of the effects using criteria to assess adverse effects, taking into account any important contextual factors and mitigation.

For species at risk the VC, the potential effects for the threats assessment used the following defined criteria (Section 13.3.1):

- Scope;
- Severity;
- Irreversibility (or permanence);
- Magnitude; and
- Degree of effect.

The summary of the Threats Assessment is included at the end of the potential effects assessment for each of the SAR species. The evaluation criteria within the net effects section (Section 13.5) uses additional evaluation criteria, but the criteria used in the threats assessment are accounted for through the use of magnitude and irreversibility within the net effects evaluation. Similarly, the degree of effect found in the threat assessment is a component of the evaluation of significance completed in Section 13.6. Section 13.3.1 outlines some potential issues related to spatial scale and sensitive features when using this new method.

The loss of caribou Habitat will be used to illustrate how the Threats Assessment method has been applied throughout the EAR/IS. In Section 13.3.3.1 Habitat Loss Due To Clearing Activities and the area impacted by the Project is placed in context with the area impacted (scope), value of habitat (severity) and re-growth (permanence). The info is summarized in Section 13.3.3.5 in the first row of Table 13-23 where Habitat Loss – Clearance Activities rated Scope (small), severity (slight), magnitude (low), irreversibility (very high) degree of effect (medium) based on IUCN-CMP unified threat classification system.

In Section 13.4.3, a summary of the potential effects, mitigation measures, and predicted net effects for caribou are in Table 13-44. Numerous mitigations were developed in consideration of provincial guidance documents including Best Management Practices for Renewable Energy, Energy Infrastructure and Energy Transmission Activities and Woodland Caribou in Ontario (MNR, 2013) and presented in Table 13-44 for Habitat Loss Clearance Activities. A Predicted Net Effect is still expected to occur.



In Section 13.5, the predicted net effects assessment incorporates a qualitative and quantitative description of the effects using criteria to assess adverse effects, taking into account any important contextual factors and mitigation. Table 13-49: Net Effects Assessment Criteria Definitions presents the predicted net effects assessment criteria definition. Based Table 13-49 definitions, Table 13-50: Criteria Results for Loss of Caribou Habitat – Construction and Table 13-51: Criteria Results for Loss of Caribou Habitat – Operations, the characterization criteria are rated and a rationale provided. These are used to determine significance of an adverse environmental effect. The predicted net effects criteria are presented on the first line of the summary tables, Table 13-70 (Construction) and Table 13.71 (Operations).

Section 13.6 Determination of Significance - as presented in Section 5.2.6 (Environmental Assessment/Impact Assessment Approach: Determination of Significance), is a qualitative aggregation method that is used to determine significance based on the sequential interaction among the magnitude, geographic extent, duration, frequency, reversibility, and likelihood of occurrence criteria for effects. Consideration is also given to potential management concerns, and concerns expressed by Indigenous communities and groups, the public, government agencies and stakeholders raised during engagement and consultation activities conducted for the Project.

The following sequential interactions form the basis for determination of significance of adverse net effects for the Caribou VC:

A predict net effects is considered not significant if the effect is:

- Low to negligible in magnitude, Project Footprint in extent, short-term to medium in duration, infrequent to continuous occurrence, reversible to irreversible in nature, and unlikely to certain to occur.

A predict net effects is considered significant if the effect is:

- Moderate to high in magnitude, regional in extent, long-term to permanent in duration, continuous in occurrence, irreversible in nature, and probable (likely) or certain to occur.

In Section 13.6.1.1 Habitat Loss to caribou applies the criteria above and with the predicted net effects presented in Tables 13-70 and 13-71 that overall habitat loss is predicted to be not significant.

## 4.2.6 MECP-SAR-099

### Comment, Rationale, and/or Proposed Action/Solution relating to Section 13.4.3.2.1

In their response MECP requests that the project team clarify the statement on how the creation of browse may benefit caribou.

*Please update this section of the Final EAR/IS Report, and all other relevant locations within the Report and associated Appendices (e.g., Appendix E) as appropriate, to clarify the statement.*

### Response

The Project team recognizes that the statement requires clarity. The statement was made in isolation of the concept of disturbance-mediated apparent competition where browse-rich early seral habitats are attractive to other ungulate species, moose in the case of WSR, and in turn their predators. This can result in increase predation risk to caribou depending on the predator response. While the creation of browse may benefit caribou in isolation as caribou require high quality browse, especially in summer (Denryter et al., 2017) overall it is like a net negative due to increased predation, although disturbance-mediated apparent competition has been found to



decouple in northern boreal caribou ranges with low populations of predators and other ungulate species (Neufeld et al., 2020; Superbie et al. 2022).

#### 4.2.7 MECP-SAR-100

##### Comment, Rationale, and/or Proposed Action/Solution relating to Sections 13.4.3.2.1 and 13.4.3.3.1

In their comment, the MNR requests,

*Please consider updating the Final EAR/IS Report, and all other relevant locations within the Report and associated Appendices (e.g., Appendix E) as appropriate, to reconsider the mitigation measures and their effectiveness in avoiding sensory disturbances to Boreal Caribou and carry forward the topic of sensory disturbances to Section 12.5 (Characterization of Net Effects).*

##### Response

MECP SARB's recommendation is noted. However, it is noted that while Section 13.4.3.2.1 states Habitat Alteration or Degradation from Sensory Disturbance was not carried forward, sensory disturbance was assessed as part of net effects in Section 13.5.2.1.2.

The Project team also accepts the MECP assertion that mitigation measures will not fully mitigate the impacts of sensory disturbance for both the construction and operations phase. Given that a number of changes to the evaluation of Habitat Alteration or Degradation from Sensory Disturbance have taken place as part of this addendum please see **Section 5, Table 5-1** for the updated assessment for both construction and operations phases.

#### 4.2.8 MECP-SAR-102

##### Comment, Rationale, and/or Proposed Action/Solution relating to Section 13.4.3.4.1

In their comment MECP requests that the Project Team clarify when road maintenance activities will take place.

*Please update this section of the Final EAR/IS Report, and all other relevant locations within the Report and associated Appendices (e.g., Appendix E) as appropriate, to clarify the statement and modify, as necessary.*

##### Response

The Project Team clarifies that scheduled road maintenance activities will not take place will not occur during sensitive life cycle periods, such as calving season. If unexpected maintenance activities are required, the situation will be evaluated to determine if the repair must be completed due to health and safety concerns. If the repair must be completed within a sensitive period, the repair will be completed while implementing mitigation measures to minimize disturbance (See Section 13.4.3).

#### 4.2.9 MECP-SAR-119

##### Comment, Rationale, and/or Proposed Action/Solution relating to Section 13.5.2.1.1 / Table 13-43 (Final EAR/IS Table 13-50)

In their comment MECP requests that the Project Team provide additional rationale for magnitude of caribou habitat loss



*Please update this section of the Final EAR/IS Report, and all other relevant locations within the Report and associated Appendices, as appropriate, to provide additional rationale to support the Project Team's conclusions, or reconsider the assessment of magnitude as it relates to Caribou habitat loss.*

## Response

Based on the results of Section 2 the Project team agrees to revise the magnitude from negligible to low. The Project team does not agree with MECP-SAR assessment of moderate for habitat loss for the caribou RSA.

Given that the MECP suggests the effects should be assessed at the range level the Project team considered the following.

In terms of direct and indirect habitat loss (Project Footprint + 500 m). The Missisa range is expected to lose approximately 0.002% of its known Category 2 habitat. For potential habitat its loss is 0.06 % of its potential Nursery Area habitat, and 0.26 % of its potential Winter Use habitat along with 0.15% of its total Category 2 habitat (**Section 3.2**).

All habitat loss is located within the Missisa range as the Ozhiski range is not within the 500 m buffer.

In terms of cumulative disturbance, the Missisa Range increases from 6.7% total disturbance to 6.8% total disturbance while the Ozhiski Range remains at 26.1% disturbed as all of the disturbance increase is located in the Missisa Range.

Two definitions of magnitude are given in the EA.

- The definition provided in the threats assessment (Section 13.3.1) was provided as part of the TISG and states magnitude is determined by crossing scope (defined spatially as the proportion of the valued component's occurrence or population within the study areas that can reasonably be expected to be affected by the predicted effect) by severity (within the scope, the level of damage to the valued component from the effect that can reasonably be expected).

Given this definition for the Ozhiski the magnitude is negligible as the project cause no habitat loss or increase in cumulative disturbance.

Given this definition for the Missisa the magnitude is low as the project causes small in scope loss or increase in cumulative disturbance.

However, the EAR/IS also uses the definition provided in Section 13.5.2, with the following two definitions for low and moderate magnitude.

- Low – A measurable change that is not expected to cause significant losses of wildlife species and the net effect will be unlikely to affect the overall population but is above negligible.
- Moderate – A measurable change that could cause impacts to a wildlife species within the area but likely can be managed. This effect would cause an observable effect to the wildlife species but would be within the adaptive capability of the species.

Please note that both definitions describe a measurable change; they vary in degree. The Project team will accept based on a conservative approach the Missisa magnitude could be considered moderate. Combined into the caribou RSA, the magnitude would be low.

The Project team agrees that there is some inconsistency with the EAR/IS. Within Section 13.6.1.1, it is stated that the net effects of habitat loss during the construction phase is Moderate; this should be taken as the



assessment for the Missisa range. It is also noted that Habitat Loss – Clearance Activities (Construction Phase) was carried forward to the Cumulative Effects Assessment in Section 21.4.8.1 of the Final EAR/IS Report but was not correspondingly listed as being carried forward Section 13.7 Given that a number of changes to the evaluation of Loss of Caribou Habitat – Construction and Operations have taken place as part of this addendum please see **Section 5** for the updated assessment for both construction and operations phases.

#### 4.2.10 MECP-SAR-120

##### **Comment, Rationale, and/or Proposed Action/Solution relating to xxx**

In their comment MECP requests that the Project Team provide additional rational that the duration of sensory disturbances associated with habitat alteration or degradation and alteration of caribou movement are medium-term.

*Please update this section of the Final EAR/IS Report, and all other relevant locations within the Report and associated Appendices, as appropriate, to provide additional rationale to support the Project Team’s conclusions or reconsider the assessment of duration as it relates to Caribou habitat alteration or degradation and alteration of Caribou movement from Sensory Disturbance during operations.*

##### **Response**

MECP SARB’s recommendation is noted and the Project Team has increased the duration from Medium Term to Permanent. While the initial duration of the net effects was made on the assumed 75 years period for operations of the Project the project team acknowledges that the road will likely be maintained in some capacity and therefor acknowledges that the duration should be regarded as permanent. Given that a number of changes to the evaluation of Injury/Death – Collisions with Vehicles have taken place as part of this addendum please see **Section 5** for the updated assessment for both construction and operations phases.

#### 4.2.11 MECP-SAR-121

##### **Comment, Rationale, and/or Proposed Action/Solution relating to 13.5.2.1.1 / Table 13-43 (Final EAR/IS Table 13-50)**

In their comment MECP requests that the Project Team provide additional rational for geographic extent being LSA of caribou habitat loss.

*Please update this section of the Final EAR/IS Report, and all other relevant locations within the Report and associated Appendices, as appropriate, to provide additional rationale to support the Project Team’s conclusions or reconsider the assessment of geographic extent associated with the loss of Caribou habitat during construction.*

##### **Response**

The Project Team considers the geographic extent for habitat loss correctly evaluated. Habitat loss is confined to the LSA based on the assessment conducted in the response to comment MECP-SAR 119 (**Section 4.2.10**). When assessing habitat loss through clearance activities the Project Footprint + 500 m should be regarded as habitat loss. This is consistent with the Federal recovery strategy (ECCC, 2020) and with the Integrated Range Assessment for the Far North 2013 (MNR, 2014b) which states anthropogenic disturbances are buffered 500 m and are “intended to reflect the loss or conversion of functional habitat”. The action of vegetation removal in of itself is considered a local impact.



This is not to say the at the Project Team does not agree that impacts would be felt at further distances (the Project Footprint + 10 km) through sensory disturbance, predator avoidance and changes to caribou seasonal movement however these would be assessed as part of other indicators, namely Wildlife Habitat Alteration/Degradation, and Alteration in Wildlife Movement.

As described in Section 13.1.6.1, Table 13-9, the specific LSA for caribou extends 11 km from the centerline of the preferred route and supportive infrastructure. The 11 km buffer used for the LSA is consistent with the General Habitat Description for the Forest-dwelling Woodland Caribou and critical thresholds for disturbance in Category 1 areas. Direct habitat loss will occur within the Project footprint the effect will extend into the LSA.

However, as the RSA is defined as being inclusive of the LSA case of caribou Section 13.1.6.1 it is understood that the geographic extent of the effect of habitat loss includes losses to the RSA where it overlaps the LSA. Table 13-50 has been updated to reflect this (see response to comment MECP SAR-119).

## 4.2.12 MECP-SAR-122

### Comment, Rationale, and/or Proposed Action/Solution relating to Section 13.4.5.2.2

In their comment, the MNR requests,

*Please update this section of the Final EAR/IS Report, and all other relevant locations within the Report and associated Appendices, as appropriate, to provide additional rationale to support the Project Team's conclusions or reconsider the assessment of geographic extent associated with the alteration in Caribou movement due to sensory disturbance during construction and operations.*

### Response

MECP SARB's recommendation is noted and the Project Team has increased the geographic extent to regional. The project team notes that movement effects would be concentrated within the local study area but regional effects result as the road may act as a barrier to some caribou, alter movement speed and or movement trajectory as has been demonstrated in a number of studies (Dyer et al., 2002; Wilson et al., 2016; Plante et al., 2018). However, as the magnitude was previously assessed at the LSA, the magnitude has been reassessed as moderate due to reduced severity at the RSA scale.

Given that a number of changes to the evaluation of Alterations in movement – Sensory Disturbance have taken place as part of this addendum please see Section 5 for the updated assessment for both construction and operations phases. Please see Section 2.10 for the net effects and significance assessment for eastern migratory caribou.

## 4.2.13 MECP-SAR-123

### Comment, Rationale, and/or Proposed Action/Solution relating to Section 13.5.2.1.3

In their comment, the MECP requests,

*Please update this section of the Final EAR/IS Report, and all other relevant locations within the Report and associated Appendices, as appropriate, to provide additional rationale to support the Project Team's conclusions, or reconsider the assessment of magnitude associated with the alteration in Caribou movement due to loss of connectivity during operations.*



## Response

MECP SARB's recommendation is noted and the Project Team has increased the Magnitude from Low to Moderate for boreal (sedentary) caribou. The Project Team notes that based on 178 caribou spring migration seasons only 6.2% of sedentary caribou crossed the WSR project footprint and 9% entered the caribou LSA for fall migration the numbers were lower with 4.2% of 214 fall migration seasons crossing the footprint and 6.5% entering the LSA (See Section 2.5.3). Additionally, the Project team notes that for eastern migratory caribou the use of the caribou LSA, where they would be exposed to sensory impacts, is extremely low. Given that a number of changes to the evaluation of Alteration in Movement – Loss of Connectivity have taken place as part of this addendum please see **Section 5** for the updated assessment for both construction and operations phases. Please see **Section 2.10** for the net effects and significance assessment for eastern migratory caribou.

### 4.2.14 MECP-SAR-124

#### Comment, Rationale, and/or Proposed Action/Solution relating to Section 13.5.2.1.3

In their comment MECP requests that the Project Team provide additional rationale that the duration associated with alteration in movement due to changes in connectivity is medium-term.

*Please update this section of the Final EAR/IS Report, and all other relevant locations within the Report and associated Appendices, as appropriate, to provide additional rationale to support the Project Team's conclusions, or reconsider the assessment of duration associated with the alteration in Caribou movement due to loss of connectivity during operations.*

## Response

MECP SARB's recommendation is noted and the Project Team has increased the duration from Medium Term to Permanent. While the initial duration of the net effects was made on the assumed 75 years period for operations of WSR, the Project Team acknowledges that the road will likely be maintained in some capacity and therefor acknowledges that the duration should be regarded as permanent. Given that a number of changes to the evaluation of Alterations in movement – loss of connectivity have taken place as part of this addendum please see **Section 5** for the updated assessment for both construction and operations phases. Please see **Section 2.10** for the net effects and significance assessment for eastern migratory caribou.

### 4.2.15 MECP-SAR-125

#### Comment, Rationale, and/or Proposed Action/Solution relating to Section 13.5.2.1.3 / Table 13-56 (Final EAR/IS Table 13-63)

In their comment, MECP requests,

*Please update this section of the Final EAR/IS Report, and all other relevant locations within the Report and associated Appendices, as appropriate, to provide additional rationale to support the Project Team's conclusions or reconsider the assessment of magnitude associated with injuries or death due to collisions with vehicles during operations.*

## Response

MECP SARB's recommendation is noted and the Project Team has increased the magnitude from Negligible to Low in Table 13-63 in Result and Rationale columns. The Project Team notes that vehicle collisions of reindeer in Finland was considered low but recommends species-specific mitigation measures for reindeer (Niemi et al.,



2024). These measures include use of wildlife detection systems on high risks road sections and short-term temporal warning signs. Similarly in the Yukon, EDI (2015) suggested possible mitigation measures including modifying human behaviour and animal behaviour.

Mitigations currently used in the Yukon, include public awareness campaigns, wildlife warning signs, vegetation management, escape ramps, and wildlife underpass. When evaluating caribou collisions high frequency areas were noted. Wildlife warning signs were deemed effective, particularly, if they incorporate a wildlife detection system and flashing lights. Vegetation management, vehicle speed limits and monitoring were also recommended. Most collisions occurred during the fall and late winter reflecting seasonal wildlife habitat use and typically poor driving conditions.

Given that a number of changes to the evaluation of Injury/Death – Collisions with Vehicles have taken place as part of this addendum please see **Section 5** for the updated assessment for both construction and operations phases. Please see **Section 2.10** for the net effects and significance assessment for eastern migratory caribou.

## 4.2.16 MECP-SAR-126

### Comment, Rationale, and/or Proposed Action/Solution relating to Section 13.5.2.1.4 / Table 13-58 (Final EAR/IS Table 13-65)

In their comment, MNR requests,

*Please update this section of the Final EAR/IS Report, and all other relevant locations within the Report and associated Appendices, as appropriate, to provide additional rationale to support the Project Team's conclusions, or reconsider the assessment of magnitude and likelihood of occurrence associated with injuries or death due to increased access during operations.*

#### Response

Data on caribou harvest by indigenous communities within or near the study area is limited, and do not provide numbers of caribou harvested. Indigenous knowledge existing conditions reports indicate that in Marten Falls First Nation caribou holds an important cultural significance to the community; and therefore, is not harvested as readily as moose. Fewer Webequie First Nation community members hunt caribou relative to moose because caribou are only present for a short time each year. The Country Foods Assessment for Webequie (Appendix O, Table D) indicates that 29.5 % of surveyed community members consumed caribou meat over an average of 16.03 days per year compared to 99.1% of members consuming moose meat over an average of 35.33 days per year.

The isolation of the project from urban centres, distance and lack of connectivity from other indigenous communities in the study area, and the general lack of trails within the LSA are likely to limit the increase in public access. Traffic along roads and increased human presence causing sensory disturbance in the Project Development area may result in avoidance by caribou of the accessible parts of the LSA, which would decrease the potential effect of hunters if caribou alter their distribution to more remote areas. At low population density, animals could display higher habitat selectivity due to reduced intraspecific competition and stronger avoidance of human disturbances (Plante et al. 2018). Mitigations to injury or death due to increased access for SAR during the operations phase are included in Section 13.4.2.3.2. These include limiting the number of rest areas and pull-off areas along the road, fencing maintenance turnaround areas to restrict public access, and fencing/gating access roads to aggregate areas and other operational infrastructure.

In consideration of these factors increase in opportunistic roadside harvest is expected to be rare and magnitude is predicted to be Low. However, given concerns expressed by indigenous communities the magnitude will be



classified as moderate. Given that a number of changes to the evaluation of Injury/Death – Increased access have taken place as part of this addendum please see **Section 5** for the updated assessment for both construction and operations phases. Please see **Section 2.10** for the net effects and significance assessment for eastern migratory caribou.

MECP-SAR-127

#### **Comment, Rationale, and/or Proposed Action/Solution relating to Section 13.5.2.1.4**

In their comment, MNR requests,

*Please update this section of the Final EAR/IS Report, and all other relevant locations within the Report and associated Appendices, as appropriate, to provide additional rationale to support the Project Team's conclusions, or reconsider the assessment of likelihood of occurrence associated with injuries or death due to changes in predator-prey dynamics during construction and operations.*

#### **Response**

The characterization of net effects to caribou from changes to predator-prey dynamics (Section 13.5.2.1.4) have been reassessed and predict that it is certain there will be a net negative effect on caribou survival in the RSA due to increased predation as a result of road construction and that it is certain there will be a net negative effect on caribou survival in the RSA as a result of road operation due to increased predation. Given that a number of changes to the evaluation of Injury/Death – Changes to Predator-Prey Dynamics have taken place as part of this addendum please see **Section 5, Table 5-1** for the updated assessment for both construction and operations phases.

### **4.2.17 MECP-SAR-129**

#### **Comment, Rationale, and/or Proposed Action/Solution relating to Section 13.5.2.1.4**

In their comment, MNR requests,

*Please update this section of the Final EAR/IS Report, and all other relevant locations within the Report and associated Appendices, as appropriate, to provide additional rationale to support the Project Team's conclusions, or reconsider the assessment of magnitude and likelihood of occurrence associated with injuries or death due to increased energy expenditures during construction and operations.*

#### **Response**

MECP SARB's recommendation is noted, however the Project Team has maintained the magnitude at Low. Roads may act as a barrier to some caribou, alter movement speed and or movement trajectory as has been demonstrated in a number of studies (Dyer et al., 2002; Wilson et al., 2016; Plante et al., 2018). Altered movements, delays in migration, or loss of habitat access related to altered movements could have energetic consequences that could affect survivorship and reproduction. Joly et al. (2025) found that 19 of 98 caribou that encountered a solitary mine road did not cross and had significantly higher mortality than those that did (42.1% vs 21.5%). However, like many examinations of caribou movement and roads it was done with migratory caribou which have more distinct movement corridors and move in large groups through these corridors. While some caribou who use areas around the WSR Project are likely to be affected, they represent a small number of individuals within the caribou RSA, for the collared sedentary caribou it was ~ 5% of individuals. Additionally, while site fidelity to nursery locations is high for boreal caribou there is some behavioral plasticity when it comes to winter use areas and pathways between high use locations. Given that a number of changes to the evaluation



of Alteration in Movement – Sensory Disturbance have taken place as part of this addendum please see **Section 5** for the updated assessment for both construction and operations phases. Please see **Section 2.10** for the net effects and significance assessment for eastern migratory caribou.

#### 4.2.18 MECP-SAR-172

##### **Comment, Rationale, and/or Proposed Action/Solution relating to Appendix F Natural Environment Existing Conditions Report, 11.3.2.4**

In their comment, MNR requests,

*Please update this section of Appendix F, and all other relevant locations within the EAR/IS Report and other Appendices as appropriate, to include additional information on the capture work, including maps showing areas searched and/or tracklogs of the capture crew, all relevant information associated with the individuals captures (e.g., group size, group composition, etc.).*

##### **Response**

The 2021 Winter Aerial Survey was initiated as a scouting exercise in support of caribou capture for the collaring study and took place between February 24 and March 1. Section 10.2.5.1.1 of the Natural Environment Existing Conditions Report details winter aerial survey methods and references Figure 10.5 (2021 Winter Aerial Survey Transects), which shows tracklogs of the scouting crew for respective survey dates. Results of the 2021 Aerial survey are presented in Figure 11.13 of the Natural Environment Existing Conditions Report and includes caribou sign observed as number of individuals observed in live sightings. Tracklogs of capture crew are not available.

Information for captured individuals is presented in **Table 4-4**, which has been revised below to include age and group size as well as minor corrections to the appendix title and UTM zone.

Clustered deployment in the western half of the LSA is most likely the result of prioritization of capturing in earliest surveyed eastern transects to prevent loss of caribou sign to snowfall or wind events and restrictive weather conditions preventing helicopter access to the western portion of the LSA.



**Table 4-4: Caribou Capture Details for the 2021 WSR Collaring Program**

Caribou ID	Date (M/D/Y)	Time	Sex	Estimated Age (Y)	Group Size	UTM Zone	Easting	Northing	VHF Freq	GPS Collar SN	Blood Sample Taken	Feces Sample Taken	Hair Sample 1 Taken	Hair Sample 2 Taken	Health Notes
WSR-049135	2/25/2021	1230	F	3	18	16U	0494425	5836836	154.140	049135	Y	Y	Y	Y	Healthy upon capture and release.
WSR-049125	2/25/2021	1330	F	6	18	16U	0493135	5838313	154.040	049125	Y	Y	Y	Y	Healthy upon capture and release.
WSR-049136	2/25/2021	1459	F	5	?	16U	0488120	5835454	154.150	049136	Y	Y	Y	Y	Healthy upon capture and release.
WSR-049128	2/27/2021	1208	F	5	6	16U	0486581	5832192	154.070	049128	Y	Y	Y	Y	Healthy upon capture and release.
WSR-049145	2/28/2021	1030	F	5	12	16U	0488518	5849369	154.240	049145	N	Y	Y	Y	Healthy upon capture and release.
WSR-049143	2/28/2021	1137	F	6.5	22	16U	0496074	5861109	154.220	049143	Y	Y	Y	Y	Healthy upon capture and release.
WSR-049141	2/28/2021	1219	F	7	5-6	16U	0496014	5861470	154.200	049141	Y	Y	Y	Y	Healthy upon capture and release.
WSR-049134	2/28/2021	1254	F	6	>20	16U	0494820	5859700	154.130	049134	Y	Y	Y	Y	Healthy upon capture and release.
WSR-049127	2/28/2021	1428	F	10	12	16U	0486397	5863138	154.060	049127	Y	Y	Y	Y	Healthy upon capture and release.
WSR-049139	2/28/2021	1510	F	6	8	16U	0487588	5861794	154.180	049139	Y	Y	Y	Y	Animal was slow to depart with potential confusion Animal will be monitored.
WSR-049126	3/4/2021	1000	F	10	4	16U	0488533	5849214	154.050	049126	Y	Y	Y	Y	Healthy upon capture and release.
WSR-049142	3/4/2021	1100	F	6	5	16U	0489229	5849993	154.210	049142	Y	Y	Y	Y	Healthy upon capture and release.
WSR-049146A	3/4/2021	1125	F	6	5	16U	0490978	585060	154.250	049146	Y	Y	Y	Y	Caribou injured and was euthanized. Collar was removed.
WSR-049146B	3/4/2021	1320	F	4	5	16U	0490524	5854895	154.250	049146	Y	Y	Y	Y	Healthy upon capture and release.
WSR-049140	3/4/2021	1515	F	3	30	16U	0490959	5865829	154.190	049140	Y	Y	Y	Y	Healthy upon capture and release.
WSR-049131	3/4/2021	1535	F	6	30	16U	0491050	5865976	154.100	049131		Y	Y	Y	Healthy upon capture and release.
WSR-049304	3/4/2021	1621	F	5	12	16U	0491054	5865253	154.320	049304	Y	Y	Y	Y	Healthy upon capture and release.
WSR-049137	3/5/2021	10115	F	4	1	16U	0491416	5861953	154.160	049137	Y	Y	Y	Y	Healthy upon capture and release.
WSR-049133	3/5/2021	1100	F	5	6	16U	0490079	5865662	154.120	049133	Y	Y	Y	Y	Healthy upon capture and release.
WSR-049305	3/5/2021	1145	F	3	23	16U	0498176	5852189	154.330	049305	Y	Y	Y	Y	Healthy upon capture and release.
WSR-049130	3/5/2021	1420	F	2.5	30	16U	0502198	5861079	154.090	049130	Y	Y	Y	Y	Healthy upon capture and release.
WSR-049132	3/5/2021	1515	F	7	16	16U	0500719	5860355	154.110	049132	Y	Y	Y	Y	Healthy upon capture and release.
WSR-049123	3/5/2021	1555	F	3	33	16U	0508484	5862037	154.020	049123	Y	Y	Y	Y	Healthy upon capture and release.
WSR-049144	3/6/2021	0907	F	4	5	16U	0483963	5840038	154.230	049144	Y	Y	Y	Y	Healthy upon capture and release.
WSR-049302	3/6/2021	0949	F	3	7	16U	0484254	5841526	154.300	049302	Y	Y	Y	Y	Healthy upon capture and release.
WSR-049124	3/6/2021	1055	F	3	9	16U	0501093	5852767	154.030	049124	Y	Y	Y	Y	Healthy upon capture and release.
WSR-049303	3/6/2021	1138	F	3	29	16U	0509945	5863292	154.310	049303	Y	Y	Y	Y	Healthy upon capture and release.
WSR-049138	3/6/2021	1218	F	5	8	16U	0510979	5865012	154.170	049138	Y	Y	Y	Y	Healthy upon capture and release.
WSR-049306	3/6/2021	1411	F	4	5	16U	0513293	5860987	154.340	049306	Y	Y	Y	Y	Healthy upon capture and release.
WSR-049129	3/6/2021	1545	F	7	15-20	16U	0049865	5863251	154.080	049129	Y	Y	Y	Y	Healthy upon capture and release.



## 4.2.19 MECP-SAR-175 and MECP-SAR-176

### Comment, Rationale, and/or Proposed Action/Solution relating to Appendix F Natural Environment Existing Conditions Report- Section 11.3.2.4.4

In their comment, MNR requests,

*Please update this section of Appendix F, and all other relevant locations within the EAR/IS Report and other Appendices as appropriate, to incorporate all Caribou collaring data collected by the WSR, NRL, MFCAR, and MNR Projects in the analysis of mortalities.*

*Please update this section of Appendix F, and all other relevant locations within the EAR/IS Report and other Appendices as appropriate, to provide additional details on the mortalities.*

#### Response

Additional details are provided for mortalities on WSR, NRL, and MCFAR. MNR mortality data was not analyzed as it was not available at the time of publication.

#### *Webequie Supply Road :*

Across four years of collar monitoring, which ended on March 1, 2025, a total of 10 mortalities of collared caribou were confirmed. In addition, four (04) collars released prematurely out of the 29 adult female caribou initially collared.

One mortality event is considered likely capture-related, based on the limited movement observed from the capture location during the approximately 15-day period between release and activation of the mortality signal. The remaining nine mortalities were attributed to predation, most often by wolves, or an undetermined cause. There is no evidence to suggest that incidental mortality occurred as a result of anthropogenic activities.

Annual mortality rates during the first three years of monitoring were 7.4%, 17.4%, and 21.3%, respectively, with an average annual mortality rate of 14.5% over that period. No mortalities were confirmed during the fourth year of monitoring. The overall average annual mortality rate for the four-year study period was 12.5%. Signal loss associated with collar malfunction were excluded from mortality rate calculations.

Detailed information on each mortality event is provided in **Table 4-5**. A photographic log documenting caribou mortality investigation during the study is included as **Appendix A7-7**.

**Table 4-5: Summary of WSR Collared Caribou Mortalities Between 2021 and 2023**

Collar ID	Date Mortality Alert Received	Date Collar Retrieved	Location	Likely Cause of Mortality	Mortality supporting evidence
49126	2021-03-19	2021-07-26	Within Caribou LSA; 24 km SW of Webequie	Delayed capture mortality	Location data/capture observations
49131	2021-06-27	2021-07-27	80 km N of Caribou LSA; 85 km NW of Webequie	Undetermined - likely wolf	Chewed scapula & collar
49303	2022-03-03	2022-03-20	157 km NW of Caribou LSA; 49 km NE of Angling Lake	Predation - Wolf kill	Wolf tracks & kill site
49130	2022-04-11	Not retrieved - Inaccessible	87 km N of Caribou LSA; 95 km N of Webequie	Undetermined	n/a



Collar ID	Date Mortality Alert Received	Date Collar Retrieved	Location	Likely Cause of Mortality	Mortality supporting evidence
49137	2022-05-21	Not retrieved - Inaccessible	> 300 km NE of Caribou LSA; Near Hudson Bay	Undetermined	n/a
49133	2022-06-13	2022-09-12	> 300 km NE of Caribou LSA; Near Hudson Bay	Undetermined - natural	n/a
49132	2023-02-03	2023-03-03	70 km N of Caribou LSA; 77 km N of Webequie	Predation - wolf	Wolf tracks; blood
49127	2023-05-21	2023-09-14	> 300 km NE of Caribou LSA; Near Hudson Bay	Predation - wolf	Skeleton disarticulation
49138	2023-07-25	2023-09-14	> 300 km NE of Caribou LSA; Near Hudson Bay	Predation - wolf	Skeleton disarticulation
49146	2023-12-12	Not retrieved	153 km N of Caribou LSA; 180 km NW of Webequie	Undetermined	n/a

*Northern Road Link:*

As of January 2026, following three (03) years of monitoring for the NRL caribou collaring program, two (02) mortalities of collared caribou have been confirmed, along with seven (07) undetermined outcomes consisting of either unresolved mortalities or premature collar releases, and one (01) suspected collar battery malfunction, out of 14 adult female caribou initially collared.

Of the confirmed mortalities, one (01) was attributed to wolf predation, and one (01) is suspected to have resulted from human harvest. For the purposes of calculating average mortality rates, the seven (07) undetermined collar outcomes were conservatively treated as natural mortalities, most likely due to predation, based on the remote locations of stationary collar signals (i.e., greater than approximately 43 km from the nearest community). The collar confirmed to have malfunctioned due to battery failure was excluded from all mortality calculations.

Annual mortality rates during Years 1 through 3 of the study were 7.1%, 15.4%, and 50.0%, respectively, resulting in an average annual mortality rate of 21.4% over the first three years of monitoring. As of March 2026, four (04) collared caribou remain active in the study. Detailed information on each mortality event is provided in **Table 4-6**.

**Table 4-6: Summary of NRL Collared Caribou Mortalities Between 2023 and 2026**

Collar ID	Date Mortality Alert Received	Date Collar Retrieved	Location	Likely Cause of Mortality	Mortality Supporting Evidence
151312	2023-08-11	2023-08-13	278 km NW of NRL LSA	Predation; wolf	Skeleton disarticulation
151313	2024-04-17	Not assessed	Within NRL LSA; 43 km NW of MFFN	Undetermined (mortality or dropped)	n/a
151307	2024-10-22	Not assessed	64 km E of NRL LSA; 100 km NE of MFFN	Undetermined (mortality or dropped)	n/a



Collar ID	Date Mortality Alert Received	Date Collar Retrieved	Location	Likely Cause of Mortality	Mortality Supporting Evidence
151309	2025-01-03	Not assessed	116 km E of NRL LSA; 140 km NE of MFFN	Undetermined (mortality or dropped)	n/a
151311	2025-05-26	Not assessed	23 km E of NRL LSA; 82 km N of MFFN	Undetermined (mortality or dropped)	n/a
151310	2025-06-27	Not assessed	9 km W of NRL LSA; 61 km E of Lansdowne House	Undetermined (mortality or dropped)	n/a
151319	2025-09-11	Not assessed	1 km E of NRL LSA; 80 km NW of MFFN	Undetermined (mortality or dropped)	n/a
151306	2025-10-27	Not assessed	-	Undetermined (mortality or dropped)	n/a
151308	2026-02-24	2026-03-01	12 km NW of Angling Lake; 236 km NW of NRL LSA	Human	Release mechanism intact; no carcass

*Martin Falls Community Access Road :*

For the MFCAR, following three years of monitoring for the Northern Road Link caribou collaring program that ended February 2025, 13 mortalities of collared caribou were confirmed. In addition, two (02) collars malfunctioned out of the 30 adult female caribou initially collared. Six (06) mortalities were the result of predation by wolves, one (01) by an unknown predator, one (01) suspected as caused by a human hunter, one (01) by other natural causes, and four (04) were undetermined (MFCAR 2026a). Annual mortality rates in years 1 to 3 of the collaring program were 10%, 19% and 20%, respectively. Across all years, the mortality rate averaged 17% (MFCAR, 2026b). See **Table 4-7** below for mortality details.



**Table 4-7: Summary of MFCAR Collared Caribou Mortalities Between 2021 and 2025**

Animal ID	Collar ID	Collar Frequency	Date Mortality Alert Received	Date Collar Retrieved	General Location Relative to Project Study Areas	Habitat Type at Mortality Site	Likely Cause of Mortality	Samples Collected
MFCAR 11	88107	140.500	June 29, 2021	September 22, 2021	In ungulate LSA, near Albany River	Conifer swamp	Unknown	Collar, hair, bone
MFCAR 04	88109	149.150	August 6, 2021	September 21, 2021	4 km north of ungulate LSA, in caribou RSA	Conifer swamp	Predation; wolf	Collar, hair, bone
MFCAR 22	88188	149.075	August 11, 2021	November 2021	300 km north of ungulate LSA, outside caribou RSA	Black spruce forest	Unknown	Collar, jaw, bone
MFCAR 03	88099	140.100	January 12, 2022	June 14, 2022	45 km north of ungulate LSA, in caribou RSA	Black spruce bog	Predation; wolf	Collar, bone
MFCAR 20	88116	149.950	April 19, 2022	May 3, 2022	In ungulate LSA, near Ogoki River	Black spruce forest	Predation; wolf	Collar, hair, bone
MFCAR 05	88101	149.200	July 19, 2022	September 8, 2022	400 km north of ungulate LSA, outside caribou RSA	Treeless fen	Unknown	Collar
MFCAR 25	88191	149.225	July 23, 2022	August 9, 2022	In ungulate LSA, 65 km west of Ogoki	Conifer swamp	Predation; likely bear	Collar, hair, bone, unknown scat
MFCAR 17	88113	149.800	December 16, 2022	March 5, 2023	230 km northwest of ungulate LSA, in caribou RSA	Black spruce bog	Predation; wolf	Collar
MFCAR 01	88097	149.000	March 14, 2023	March 23, 2023	10 km west of Ogoki; outside ungulate LSA	Waterbody / shoreline	Human	Collar, intact head
MFCAR 29	88195	149.425	July 4, 2023	August 20, 2023	170 km north of Ogoki; outside ungulate LSA	Bog / wetland	Predation; wolf	Collar
MFCAR 18	88114	149.850	July 6, 2023	September 26, 2023	45 km southwest of Ogoki, in ungulate LSA, in Caribou RSA	Black spruce	Natural causes	Collar, jawbone
MFCAR13	88109	149.600	November 28, 2023	April 22, 2024	70 km NE of Ogoki; outside ungulate LSA	Black spruce	Unknown	Collar, partial jaw
MFCAR 28	88194	149.375	No signals as of early 2025	February 11, 2025	20 km north of ungulate LSA, in caribou RSA	Frozen lake	Predation; wolf	Collar



## 4.2.20 MNR-224

### Comment, Rationale, and/or Proposed Action/Solution relating to Section 13.4.3.2

In their comment, MNR requests,

*Please describe the trade-off regarding moose attractant and predation risk, either in Sections 13.4.3.2.1, 13.4.2.4.1, and/or in Section 13.5 (Characterization of Net Effects).*

### Response

This was considered as part of the predicted effects to caribou injury and death. In Section 13.3.3.4, it states “Habitat disturbance may also create movement corridors and suitable habitat for alternate ungulate prey species (Cumming, 1992), which in turn results in increased wolf numbers (Ballard et al., 2000).” In Section 13.5.2.1.4, it states “While reclamation and restoration have been shown to reduce predator and prey use of anthropogenic features (Dickie et al., 2021; Dickie et al., 2022; Keim et al. 2021; Tattersall et al., 2020), the effects of increased predation cannot be completely eliminated.” In Section 13.6.1, it states “The two main reasons for this species’ decline are increased predation and habitat loss, the latter resulting from both natural disturbances like fires and anthropogenic activities such as natural resource extraction, which together fragment the landscape, benefit predator and alternate prey species, and ultimately increase predation risk for caribou (COSEWIC, 2014).” While the creation of browse may benefit caribou in isolation as caribou require high quality browse, especially in summer (Denryter et al., 2017) overall it is like a net negative due to increased predation, although disturbance-mediated apparent competition has been found to decouple in northern boreal caribou ranges with low populations of predators and other ungulate species (Neufeld et al., 2020; Superbie et al. 2022).

## 4.2.21 MNR-225

### Comment, Rationale, and/or Proposed Action/Solution relating to Section 13.4.3.2.1 and 13.4.3.4.1

In their comment, MNR requests,

*Please reconcile the inconsistency between Sections 13.4.3.2.1 and 13.4.3.4.1 regarding forage habitat for caribou. This can also be noted within similar statements in Table 13-37.*

### Response

Please refer to the response to MECP-SAR-099 (**Section 4.2.6**), above.

To reduce forage attractive to caribou and other ungulates, an effective mitigation measure recommended is to cut brush early in the growing season rather than in the middle of the growing season (Rea, 2003).



## 4.2.22 MNR-228

**Comment, Rationale, and/or Proposed Action/Solution relating to Section 13.5.2.1.2/ Table 13-52 (Final EAR/IS Table 13-57); Section 13.5.2.1.4/ Table 13-64 (Final EAR/IS Table 13-71); Section 13.6.1.3; Section 21.4.8.1.5/ Table 21-53 (Final EAR/IS Table 21-52)**

In their comment, MNR requests,

*Within the Final EAR/IS, please indicate how sensory disturbance can be mitigated/reversed during the operations phase and/or provide evidence/references within Table 13-52, 13-64, Table 21-53 (and/or in the associated text), and Section 13.6.1.3.*

*Describe the continued significance of the effects during the operations phase, as it's currently unclear how the effects during operations differ from the effects during construction, as well as how mitigation will result in a different significance outcome. If evidence of successful mitigation approaches cannot be described, it is recommended that the significance rating be revised.*

### Response

In response to MNR comment the Project Team notes that while sensory disturbance contributes to effective habitat loss during both construction and operation phases, the construction phase is the most intense but shorter period of sensory stimuli. While the effects of the actual construction activities would be reversible at the end of construction, the constructed road remains with areas that need to be remediated over time (e.g., temporary camps, RoW).

Whereas the operation phase has lower effect levels, but they are sustained over the long-term. Both phases can be mitigated to some degree. **Table 4-8** compares the effects during the construction and operation phases illustrating a short-term, higher intensity during construction compared to the long-term, chronic effects of operations. This is followed by the possible mitigation measures for each phase.

**Table 4-8: Comparison of Impacts between Construction and Operation Phases**

Impact	Construction Phase	Operation Phase
Noise	Highest (blasting, clearing, heavy equipment)	Moderate (traffic, engine brakes)
Light	High during any night work	Chronic – related to installed infrastructure
Human Presence	High in numbers and duration, mobile in distribution	Low (<500 cars/day) with predictable timing
Visual Stimuli	Heavy equipment operation with an open RoW.	Regular vehicles with open RoW
Animal Displacement	High risk during calving season	Reduced but at a chronic long-term level

Construction phase mitigation (ARCKP, n.d.) includes:

- Seasonal timing restrictions;
  - Avoid disruptive activities during late gestation, calving and post-calving to reduce disturbance to calving and neonates.
- Noise management;
  - Use quieter equipment or mufflers where feasible.



- Impose noise caps near key habitat areas (during calving periods).
- Schedule loudest work in mid-day periods, avoiding dusk or dawn when caribou are most active.
- Controlled visual exposure and movement;
  - Maintain vegetative buffers to reduce line of site exposure.
  - Limit number of machines working at one time.
- Managing humans;
  - Restrict workers to designated areas.
  - Implement no attraction and no harassment rule with strict waste management to avoid attracting predators.
  - Prohibit off-road vehicle use outside of approved corridors.
- Light management;
  - Use down-shielded, directional lighting.
  - Avoid white/blue light by using warmer tones.
  - Limit nighttime construction whenever possible.
  - Install timers or motion sensors to reduce constant illumination.
- Temporary closures or stoppages.
  - Temporarily halt heavy construction until the caribou pass.
  - Apply slow-drive zones for construction vehicles near refugia.

Operation phase mitigation (ARCKP, n.d.) includes:

- Traffic management;
  - Reduced speed limits (50 km/h or less) in caribou zones.
  - Convoy during migration to reduce repeated events.
  - Temporarily close roads if telemetry indicates aggregation at corridor preparing to cross.
  - Avoid placing pullouts in modelled nursery areas (design phase issue).
- Long-term lighting controls;
  - Down-shield all permanent lighting.
  - Only illuminate RoW where it is absolutely necessary.
  - Minimize lighting near water crossings. Peatlands and any known movement pinch-points.
- Chronic human activity;
  - Consider a permit-based access system.
  - Limit/control recreational use unless approved.
  - Manage waste, fuel and attractants (plan and manage pullouts).
- Noise and vibration reduction;
  - Limit use of engine brakes.
  - Maintain road surface to reduce vibration and shock from vehicles.
  - Consider vegetated berms or other natural screens.
- Habitat and visual restoration (RoW); and
- Reducing visual openness and sight lines also reduces predator speed and visibility as noted in response to MNR-231 comment:
  - Encourage rapid revegetation, especially coniferous cover, along the shoulders.



- Avoid aggressive brush-cutting that opens sight lines or stimulates browse (which could increase moose/deer presence).
- Use coarse woody debris (CWD) placements to visually break up the road margin and reduce line-of-sight stimuli.
- Sensory disturbance monitoring.
  - Use camera traps and telemetry to detect avoidance, delays, or altered use of habitat. As well, to track migration periods for road closures or convoying.
  - Include noise and light monitoring at fixed stations near sensitive zones.
  - Adapt operational restrictions if disturbance thresholds are exceeded.

If appropriate mitigations are implemented, then effects can be reduced during both phases. The potential effects sensory disturbance are outlined for the construction and operation phases in Section 13.3.3.3 Alteration in Movement. The suggested mitigations address many of the issues raised in this section. The sensory disturbance monitoring will assess the effectiveness of the mitigations and add to the knowledge base on construction and operational impacts to caribou. Overall, alteration in movement due to sensory disturbances from the construction and operations phases is not deemed significant as local in extent.

The Project team also notes the following:

- Table 13-59 (alteration in movement from sensory disturbance – operations) should be regarded as irreversible.
- Table 13-71 (summary table) should also be regarded as irreversible to be consistent with Table 13-57.

## 4.2.23 MNR-231

### **Comment, Rationale, and/or Proposed Action/Solution relating to Section 13.5.2.1.4, Table 13-63; Section 13.5.2.1.4, Table 13-64; Section 13.6.1.4; Section 21.4.8.1.5, Table 21-53**

In their comment, MNR requests,

*Provide reference(s) to substantiate this claim (regarding negative effects of predator-prey dynamics during construction being reversible), within Tables 13-63 and 13-64 (actually Tables 13-66 and 13-67) and/or in the text.*

*Provide evidence that access by predators can be reversed/mitigated during the operations phase, including reference(s), and describe the continued significance of the effects during the operations phase, as it's currently unclear how the effects during operations differ from the effects during construction, as well as how mitigation will result in a different significance outcome. If evidence of successful mitigation approaches cannot be described, it is recommended that the significance rating be revised.*

*Add a row to Table 21-53 indicating the cumulative effects of changes to predator-prey dynamics during the operations phase, including that they are irreversible.*

### **Response**

The Project Team evaluated the negative effects of predator-prey dynamics during construction in Table 13-66 and determined that they are somewhat irreversible with revegetation efforts along the ROW to reduce predator access from the road, in particular the temporary construction areas is reduced but not eliminated. Construction



impacts like avoidance to noise and construction activity are eliminated upon road completion, and the road is subject to a lower level of activity during operations.

New linear access (e.g., clear ROWs, temporary roads and camps) instantly expanded wolf travel corridors (Latham et al., 2011; Finnegan et al., 2018). This access is reduced by revegetation efforts over time but can be enhanced by adding physical barriers like felled tree fences or other barriers (like earthen mounds) to block off revegetated temporary roads (Finnegan et al., 2018). Road access through refugia (e.g., peatlands) should be avoided to the extent possible (ARCKP, n.d.; DeMars and Boutin, 2026). Given that predator-prey relationships respond to linear features in complex ways that alter individual space-use of the landscape and likely influence predation risk (Mumma et al., 2019), construction and post-construction monitoring is important.

While access by predators can be mitigated during the operations phase, it cannot be eliminated and the effectiveness of the revegetation is still being evaluated (e.g., required vegetative height to reduce predator access - Finnegan et al., 2018). Permanent linear access will be selected by wolves particularly in peatlands and encounter rates and calf vulnerability rise where operational roads pass through calving/summer ranges (Mumma et al., 2019; DeMars and Boutin, 2026). The updated assessment for Injury or Death - Changes to Predator-Prey Dynamics, both Construction and Operations Phase, can be found in **Section 5, Table 5-1**.

## 5 Characterization of Net Effects and Determination of Significance for Boreal Caribou

The following table is an update summary table for predicted net effects for caribou during the construction phase and operations phase and replace Tables 13-70 and Table 13-71 in the Final EAR/IS. The table takes into consideration the additional data and analysis presented in **Sections 2** and **3** as well as supporting some of the answers given in **Section 4**. The table has been modified slightly in order to meet the requirements of the Addendum. The following changes have been made:

- Where the assessment of the net effect in this table differs from the tables in the EAR/IS those results are italicised.
- The context column has been moved and expanded to “Ecological Context and Rational”.
- Net Effects that are assessed the same for both the construction and operations phase have been combined into one assessment with any differences discussed in the Ecological Context and Rational column.
- The timing column has been removed as the assessed result was the same for all effects with the net effect occurring in all seasons.
- A significance column has been added to the end of the table.

The conclusions in **Table 5-1** are based on the information contained in this addendum in addition to the information available in the EAR/IS.



**Table 5-1: Conclusion revised based on Addendum**

Predicted Net effect	Phase	Ecological Context and Rationale	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood of Occurrence	Significance	Uncertainty
Habitat loss due to clearance activities. Revised based on comment response to MECP-SAR-119	Construction and Operations	The Missisa Caribou Range is approximately 70,000 km <sup>2</sup> in size while the Ozhiski Caribou Range covers 38,700 km <sup>2</sup> (MNRF, 2014a; 2014b; 2014c). In the LSA, road construction will remove 232.40 ha (30.6%) of Category 1 Nursery Areas and 98,483 (48.5%) of Category 2 Seasonal Ranges. Those areas are effectively converted to Category 3 Remaining Areas in the Range, increasing that sub-range habitat by 98,797.34 ha (202.6%) in the RSA. The 232.40 ha of Category 1 High Use Habitat estimated to be removed as a result of construction activities represents 0.07% of the known Category 1 features in the Missisa and Ozhiski Caribou Ranges.	Negative	A <b>Low</b> magnitude effect in terms of habitat loss is expected for boreal caribou. A small loss of 0.07% Category 1 High Use Habitat from the Missisa and Ozhiski Caribou Ranges is a measurable change but is not expected to cause significant losses of boreal caribou. The magnitude for the Ozhiski range is predicted to be negligible, while the magnitude for the Missisa range is moderate.	LSA	Permanent	Continuous	Irreversible	Certain	Not Significant	Moderate
Habitat degradation through structural change.	Construction	The Woodland Caribou Recovery Strategy (Woodland Caribou Recovery Team, 2008) identified alteration of vegetative cover as an activity that may result in adult female caribou selecting higher risk environments for calving. While caribou tend to avoid disturbed areas caribou may use disturbed areas in some periods as caribou require high quality browse, especially in summer.	Negative	A <b>Low</b> magnitude effect in terms of habitat alteration or degradation through habitat structural change from construction is expected as the amount of habitat structural change is expected to have a minimal effect on the population compared to other factors influencing caribou habitat use such as sensory disturbance and predators. Cleared areas associated with the road are relatively small in comparison to areas farther south where managed forests occur.	LSA	Long-term	Continuous	Irreversible for WSR ROW Reversible for access roads and laydowns	Certain	Not Significant	Low
	Operations	See Construction Phase	Neutral	A <b>Negligible</b> magnitude effect in terms of habitat alteration or degradation through habitat structural change from operations is expected as no new effects are expected to be generated from occasional vegetation maintenance related to road operation.	LSA	Short-term	Infrequent	Reversible	Unlikely	Not Significant	Low
Habitat alteration or degradation through sensory disturbance Revised based on comment response to MECP-SAR-120	Construction	Sensory disturbance includes noise, vibration, lights, odours, and human activity, all of which can cause habitat to become less suitable and therefore used less frequently by caribou. Caribou are known to respond to these disturbances through avoidance with naïve populations responding more strongly. Anthropogenic disturbance in the Missisa Range is prevalent compared to the other Far North ranges and is primarily associated with high levels of mineral exploration activity (MNRF, 2014d). However these disturbance levels are inflated due to using mine claims as disturbance footprints. Few sources of sensory disturbance are currently present in the project study areas. Existing anthropogenic disturbances are low in number across the RSA. Anthropogenic disturbances are 4.5% in the Ozhiski Range, 1.4% in the Missisa Range and 2.5% in the RSA. Anthropogenic disturbances in the LSA are higher at 6%, primarily because the community of Webequie is within the LSA.	Negative	A <b>Moderate</b> magnitude effect in terms of habitat alteration or degradation through sensory disturbance from construction is expected, with approximately 4.68% of existing Category 2 Seasonal Ranges altered in the LSA, and 5.41% of Category 3 habitat; in the RSA from disturbances such as blasting, earth hauling, and vegetation clearing, as well as use of construction lighting.	LSA	Short-term for activities associated with construction. Sensory disturbance will continue during Operations where it is considered permanent.	Frequent	Reversible	Certain	Not Significant	Low

Predicted Net effect	Phase	Ecological Context and Rationale	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood of Occurrence	Significance	Uncertainty
	Operations	Sustained or repeated disturbance, such as regular road use by vehicles, can result in the reduction in use of suitable habitat (Sapolsky, 1992; Creel et al., 2002). Several studies have demonstrated that caribou do not use suitable habitat in the vicinity of industrial activities and other human developments (Dyer et al., 2001; Mahoney and Schaefer, 2001; Dyer et al., 2002) indicating sensory disturbances such as noise, light, and odour may contribute to alteration or degradation of habitat.	Negative	A <b>Moderate</b> magnitude effect in terms of habitat alteration or degradation through sensory disturbance from operation is expected in the LSA due to noise, light, odour, and visual disturbances from vehicles travelling on the road and supportive infrastructure that will reduce habitat suitability within 500 metres of the road.	LSA	Permanent	Continuous	Reversible	Certain	Not Significant	Low
Habitat alteration or degradation through hydrological changes Revised based on comment response to MECP-SAR-060	Construction and Operations	Hydrological changes during road construction from activities such as grading, installation of drainage features, and construction of the roadbed could alter soil moisture regime, and shift or alter Nursery Areas and Seasonal Ranges There is no known Category 1 Nursery or Winter Use Habitat within areas predicted to undergo hydrological changes extending 250m from the Project Footprint.	Negative	A <b>Low</b> magnitude effect in terms of habitat alteration or degradation from hydrological changes as the majority of effects occur within 60 m from the road edge, with minimal effects up to 250 m from the road edge. Approximately 95 ha of potential nursery habitat and 460 ha of winter use habitat will potential experience high to medium impacts.	LSA	Permanent	Continuous	Irreversible	Certain	Not Significant	Low
Alterations in movement through loss of connectivity (barrier) Revised based on comment response to MECP-SAR-123 and MECP-SAR-124	Construction	Boreal caribou move between high use areas and seasonal ranges depending on their needs throughout the year, with individual mean annual home ranges of 4,000 km <sup>2</sup> (Brown et al., 2003) A study tracking 53 GPS-collared boreal caribou in the Laurentides Wildlife Reserve (7250 km <sup>2</sup> ), Quebec, before, during and after a highway expansion project found that 77% of the caribou did not cross the highway during the 6-year study period, and the presence of active construction sites (up to 7 km in length) elicited strong behavioural reactions by caribou (Leblond et al., 2013). The road corridor will extend approximately 70 km east-west across the Missisa Range, creating a disturbance that stretches across 45% of the east-west distance near the middle of the range. Given their reluctance to move across roads, including moving parallel to the road prior to crossing (Leblond et al., 2013), this potentially may cause boreal caribou to move large distances east (into the Ozhiski Range) or west to avoid or prior to crossing the road, which may be through sub-optimal habitat.	Negative	A <b>Moderate</b> magnitude effect in terms of alterations in movement through loss of connectivity Based collar data spring migration seasons only 6.2% of sedentary caribou crossed the WSR project footprint and 9% entered the caribou LSA for fall migration the numbers were lower with 4.2% of 214 fall migration seasons crossing the footprint and 6.5% entering the LSA. During construction mitigations including road closures when caribou present near the road are expected to be effective. The barrier effect will generally increase over time as the construction footprint increases.	RSA	Short-term for activities associated with construction. The barrier effect will continue during Operations where it is considered permanent.	Continuous	Reversible	Probable	Significant	Moderate
	Operations	Dyer et al. (2002) found boreal caribou in Alberta crossed actual roads six (6) times less frequently in late winter than control roads in their study, and also less frequently compared to other seasons (calving, summer, rut), although road use was higher in the winter than the other seasons. The level of traffic may create the barrier effect, which was the result of a similar study conducted by Smith and Johnson (2023).	Negative	A <b>Moderate</b> magnitude effect in terms of Alterations in movement through loss of connectivity is expected. During operations fewer mitigation measures are practical and are less enforceable.	RSA	Permanent	Frequent	Irreversible	Probable	Not Significant	Moderate

Predicted Net effect	Phase	Ecological Context and Rationale	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood of Occurrence	Significance	Uncertainty
Alterations in movement due to sensory disturbance (avoidance)	Construction	Adult female caribou avoid suitable locations when selecting Nursery Areas due to sensory disturbances from development or recreational activities (Carr et al., 2007; Schaefer and Mahoney, 2007; Vors et al., 2007; Vistnes and Nellmann, 2008), with a potential critical threshold for pregnant cows identified as 10 to 15 km from the disturbance (Carr et al., 2011; MECP, 2020). In disturbed landscapes, boreal caribou have been found to increase the size of their home ranges and reduce fidelity to seasonal and annual home ranges, likely to avoid disturbed habitat (Courtois et al., 2007).	Negative	A <b>Moderate</b> magnitude effect in terms alterations in movement through sensory disturbance is expected. Avoidance of suitable areas by some caribou can be expected, with level of avoidance highest in sensitive periods. During construction mitigations including road closures when caribou present near the road are expected to be effective. Zones of avoidance will also shift during constructions as construction zones move.	RSA	Short-term for activities associated with construction. Sensory disturbance will continue during Operations where it is considered permanent.	Continuous	Reversible	Probable	Not Significant	Moderate
	Operations	See Construction phase. Additionally, sensory disturbances generated by road operations may also elicit anti-predator behaviour in caribou. The risk-disturbance hypothesis suggests displacement of wildlife by roads is because wildlife perceive roads, and associated human activity, as a predation risk (Frid and Dill 2002). Boreal caribou also move more quickly when near roads with increased traffic density (Leblond et al., 2013).	Negative	A <b>moderate</b> magnitude effect in terms of alterations in movement due to sensory disturbance is expected. During operations fewer mitigation measures are practical and are less enforceable.	RSA	Permanent	Continuous	Irreversible	Probable	Not Significant	Moderate
Injury/Death – Collisions with Vehicles Revised based on comment response to MECP-125	Construction	Generally, caribou are known to avoid human disturbance, including roads, making them lower risk for road mortality; however, caribou mortality due to collision with vehicles or trains, often involving groups of live animals, has been documented in several Canadian provinces, including Ontario.	Negative	A <b>Negligible</b> magnitude effect in terms of injury or death due collisions from the construction phase as there will be a limited number of boreal caribou that may encounter the road and the effectiveness of mitigations during the construction phase are expected to be high	LSA	Short-term for activities associated with construction.	Frequent	Irreversible	Possible	Not Significant	Low
	Operations	See Construction Phase	Negative	A <b>Low</b> magnitude effect in terms of injury or death due collisions from the operations phase is predicted as there will be a limited number of boreal caribou that may encounter the road but fewer effective mitigation measures are available.	LSA	Long-term	Continuous	Irreversible	Probable	Not Significant	Low
Injury/Death – Increased Access Revised based on comment response to MECP-126	Construction	Boreal caribou have not been legally harvested in Ontario, except by First Nation Peoples, since 1929 (MECP, 2020). Creation of roads in previously inaccessible areas can often lead to increased use by hunters (Crichton et al., 2004; Boston 2016), which may also include increased harvesting by First Nation Peoples.	Neutral	A <b>Low</b> magnitude effect in terms of injury or death due increased access exists as there will be a limited number of boreal caribou that may be encountered during construction and access will be controlled during this phase.	LSA	Short-term for activities associated with construction.	Infrequent	Irreversible	Possible	Not Significant	Low
	Operations	The potential for harvest is assumed to be greater during the operations phase as it will operate over a long period of time with complete public access and provide new areas for hunters and harvesters to access habitat.	Negative	A <b>Moderate</b> magnitude effect in terms of injury or death due increased access is predicted. While controls over access will not be present like the construction phase, the isolated location and lack of additional linear features will limit access as it relates to legal and illegal harvest. A limited number of boreal caribou may be encountered.	LSA	Permanent	Infrequent	Irreversible	Probable	Not Significant	Low
Injury/Death – Changes to Predator-Prey Dynamics	Construction	The primary cause of caribou decline in Ontario is widely recognized as habitat disturbance that indirectly results in changes to predator-prey dynamics and increased predation rates.	Negative	A <b>Moderate</b> magnitude effect in terms of injury or death due to changes to predator-prey dynamics is predicted from construction of the road.	LSA	Permanent	Frequent	Irreversible	Certain	Not Significant	Moderate

Predicted Net effect	Phase	Ecological Context and Rationale	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood of Occurrence	Significance	Uncertainty
Revised based on comment response to MECP-SAR-062, MECP-127 and MNR-231		During the winter months, wolves have difficulty moving in snow deeper than 40 to 50 cm (Formozov, 1946) which typically prevents them from accessing low-density caribou populations (Jung et al., 2019) such as those in the Missisa and Ozhiski ranges. Grey Wolves and other predators use linear corridors to facilitate movement, which also increases hunting efficiency by these species as a result (Dickie et al., 2020, 2022; McKay et al., 2021; Pigeon et al., 2016). Wolf and Moose densities are low in the caribou RSA. This is important as disturbance-mediated apparent competition has been found to decouple in northern boreal caribou ranges with low populations of predators and other ungulate species.		Low levels of predators and moose along with a lack of deer are expected to limit disturbance-mediated apparent competition. While providing access for predators, access will be concentrated in the vicinity of the road.							
	Operations	See Construction Phase, Additionally: Paquet et al. (2010) found that wolves used "modified trails of compacted snow" (i.e., snowmobile trails, plowed roads) more often than natural trails, which allowed wolves to travel through areas where deep snow would likely impede movements. While travel on modified trails was unrelated to ungulate densities, rates of ungulate (including caribou) kill by wolves on modified trails were significantly higher than on natural trails (Paquet et al. 2010).	Negative	A <b>Moderate</b> magnitude effect in terms of terms of injury or death due increased predation is predicted. The linear features created during construction will remain during the Operations Phase. Given the long-term operation of the road there is a strong likelihood that informal trails may be developed that enter into the RSA.	RSA	Permanent	Frequent	Irreversible	Certain	Significant	Moderate
Injury/Death – Increased Energy Expenditure Revised based on comment response to MECP-129	Construction and Operations	Roads, including winter roads, are known to cause changes in caribou movement behavior. The road may act as a barrier to some caribou, alter movement speed and or movement trajectory as has been demonstrated in a number of studies Murphy and Curatolo (1987) found that, near roads, caribou reduce their food acquisition and increase their energy expenditure, and they tend to have higher movement rates and increased vigilance. Leblond et al. (2013) also found caribou exhibited higher movement rates within 5 km of roads, especially when traffic density was high. The sensory disturbances generated by road traffic may lead to increased vigilance behaviour and movement, which can compromise fitness (Frid and Dill, 2002; Cameron et al., 2005). Modelling by Plante et al. (2020) on boreal caribou in Quebec and Labrador suggest that cumulative effects of non-industrial (roads, villages) and industrial (mines, mining exploration) human disturbances impact early life (1 to 7 years) mortality risk during the winter for caribou using warmer areas, with the mortality risk increasing by a factor of 6.5 for each 1°C increase but on its own disturbance effects on survival, although detectable, were limited.	Negative	A <b>Moderate</b> magnitude effect in terms of terms of injury or death due energy expenditure is predicted. The road is likely to act as a barrier to some caribou, alter their movement speed and or movement trajectory. The response can vary considerably between individuals. Caribou who use areas around the WSR Project are likely to be affected, for the collared sedentary caribou it was ~ 5% of individuals. While site fidelity to nursery locations is high for boreal caribou there is some behavioral plasticity when it comes to winter use areas and pathways between high use locations.	LSA	Permanent	Frequent	Reversible	Probable	Not Significant	Moderate

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# APPENDIX A

## A7-1: Report on Migration Corridors and Parturition Dates



# Migration Corridor and Parturition Date Analysis for the WSR and NRL: Comparison of Eastern Migratory and Boreal Woodland Sedentary Caribou \_V2

(Draft March 29<sup>th</sup>, 2026)

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# 1 INTRODUCTION

Identifying, mapping and comparing seasonal migration patterns and parturition phenology for eastern migratory caribou versus sedentary boreal woodland caribou is an important component of the environmental assessment for the Webequie Supply Road (WSR) and Northern Road Link (NRL) projects. Eastern migratory caribou undertake large-scale seasonal movements between inland wintering areas and coastal calving and summer habitats along Hudson Bay and James Bay. These migrations occur across broad landscapes and connect multiple caribou ranges, including the Missisa, Ozhiski, Swan, and neighbouring ranges in the vicinity of the proposed projects. Sedentary caribou occupy the same area for parts of the year, so analysis requires classification of the two behavioural types.

Linear infrastructure such as all-season roads has the potential to influence caribou movement through several mechanisms, including disturbance during migration, behavioural avoidance of infrastructure, increased human access, and habitat fragmentation. Because migration represents a critical life-history process linking seasonal habitats, disruption or alteration of migration pathways could affect the ability of animals to reach calving grounds, access seasonal foraging areas, or maintain connectivity among range components. Consequently, identifying the spatial distribution of migration pathways and evaluating how proposed infrastructure overlaps with these movements is necessary to assess potential project effects and inform mitigation strategies.

For the WSR and NRL environmental assessments, migration corridor analysis provides several key insights. First, it helps determine whether project corridors intersect areas of concentrated migratory movement or narrow migration bottlenecks where disturbance could have disproportionate effects. Second, it identifies whether migration occurs across broad landscapes with multiple alternative pathways, which may reduce the likelihood of migration obstruction. Finally, mapping recurrent movement pathways provides spatial context for evaluating potential cumulative effects of infrastructure within the regional migration system.

The phenology of parturition (calving) may have important implications for the project and mitigation, and there may be differences in the timing of these events between migratory and sedentary populations. Classifying individual caribou by year in the movement categories, followed by identification of sharp declines in movement, allows determination of reproductive phenology and comparison parturition timing between the two populations.

The analytical approach used for classifying movement categories in this study builds on the seasonal framework described by Pond et al., which provides ecologically meaningful seasonal definitions for eastern migratory caribou in the Hudson Bay–James Bay region. Pond et al. (2016) defined seasonal periods based on long-term observations of caribou behaviour and movement ecology, including early winter, late winter, calving, summer, and breeding periods. These seasonal windows correspond to major phases of the caribou annual cycle and have been widely used in regional analyses of caribou habitat use and movement.

The Pond et al. (2016) seasonal framework provided a consistent ecological basis for organizing telemetry data and interpreting seasonal movement patterns. In particular, the calving period defined by Pond et al. (2016) corresponds closely to the period when females aggregate in coastal lowland habitats, while the winter and summer periods represent phases when movements are generally more localized. By comparing observed step-length patterns and migration behaviour relative to these seasonal windows, it was possible to identify periods of elevated movement associated with spring and fall migration and to distinguish them from periods of residency.

This approach also facilitates comparison with previous studies and regional monitoring programs that use similar seasonal definitions. While the analysis incorporated empirically derived movement windows based on telemetry step-length patterns, the Pond et al. (2016) framework provided an ecologically grounded reference for interpreting these movements within the broader annual cycle of eastern migratory caribou. Once classified, timing of the parturition events and comparison of timing between the movement types is possible.

## 2 METHODS

### 2.1 Classification female caribou ecotype

We classified female caribou collar-years as eastern migratory caribou (EMC) or sedentary boreal caribou using a two-stage workflow based on calving-season distribution and seasonal movement behaviour, following the general logic of Pond et al. (2016). The analysis was conducted at the level of the individual-year (hereafter, female-year), and final classifications were subsequently joined back to all GPS locations from the corresponding female-year.

The analyses were all conducted in R, and the full suite of packages used were:

#### 2.1.1 Telemetry data preparation

GPS telemetry data were compiled from multiple collar data sources (MNR data for Ozhiski and Mississ Range surveys, and AtkinsRéal data from WSR and NRL caribou surveys) and standardized into a common format containing animal ID, timestamp, and projected coordinates (Figure 1C). Collar records from all datasets were merged and ordered by individual and datetime. Only female collar data were included in the analysis.

All spatial data were analyzed in Ontario MNR Lambert projection (EPSG:3161). Telemetry records were converted to sf point objects, and year, month, and date fields were derived from the timestamp where needed. Prior to classification, obvious spatial or temporal anomalies were removed. Specifically, locations with x-coordinates greater than 11,360,000 were excluded, and a short interval of suspect locations for collar 49138 between 7 October 2023 and 10 October 2023 was removed. After filtering 203 unique female caribou, with 478 caribou-year observations were used for analysis.

## 2.1.2 Spatial reference layers

Classification was informed by three spatial layers: (1) a treeline boundary representing the taiga–tundra ecotone, (2) a polygon representing the area north of treeline, and (3) ecoregion polygons used to identify Hudson Bay Lowland and related lowland regions. All layers were transformed to the same projected coordinate reference system as the telemetry data before analysis.

For each GPS fix, we calculated signed distance to treeline as the minimum Euclidean distance to the treeline boundary, with distances assigned as negative for locations north of treeline and positive for locations south of treeline (Figure 1A). Each location was also spatially joined to ecoregion polygons and classified according to whether it occurred in Hudson Bay Lowland, Coastal Hudson Bay Lowland, or the broader Hudson Bay–James Bay lowland region (Figure 1B).

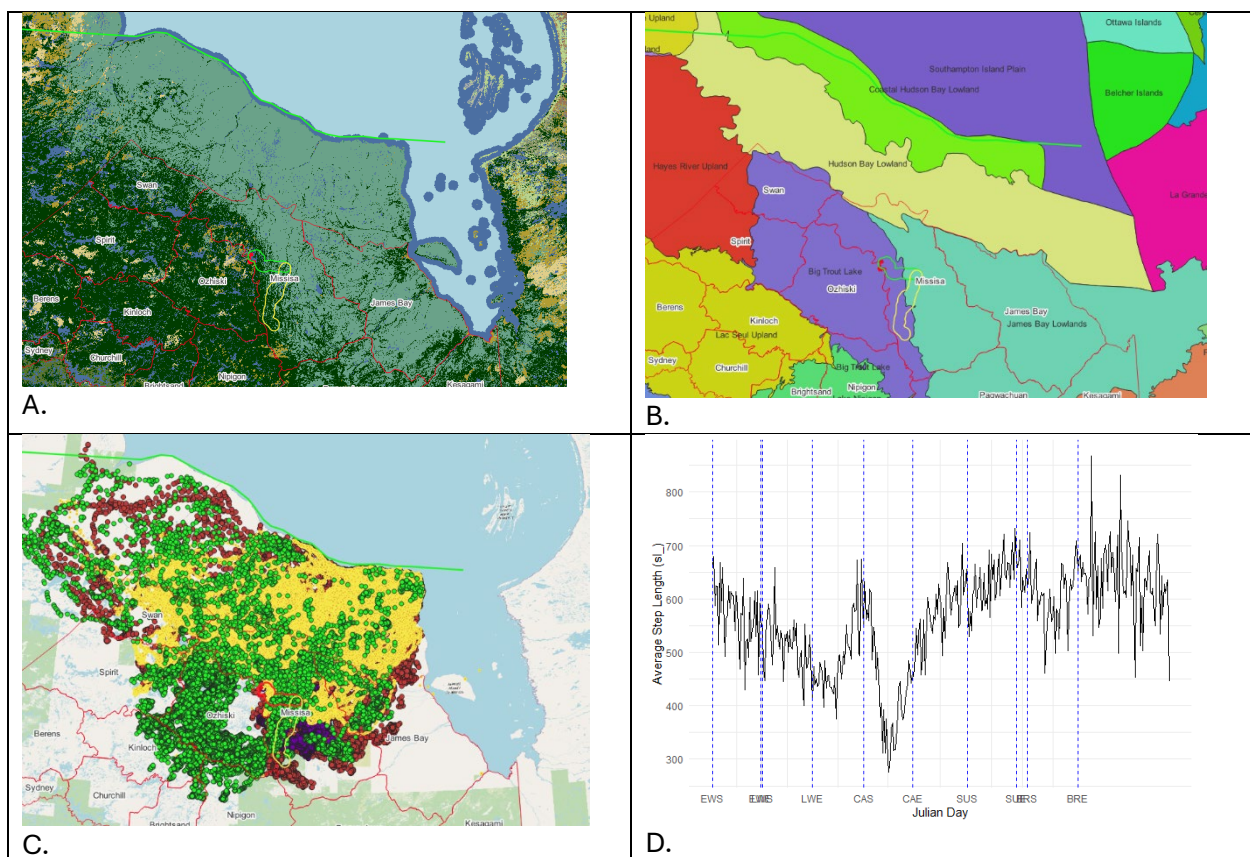


Figure 7. A; Landcover.8686 with location of WSR and NRL study areas. (RSA is combined Ozhiski and Mississa range) and treeline (light green line). B; Ecoregions of Canada. C; Caribou GPS collar locations (post-classification). D; global movement rates by day of year (Julian day) with season start and end indicated by vertical dotted lines;

### 2.1.3 Calving-season metrics

Female-years were first characterized using calving-season location metrics intended to distinguish migratory and sedentary ecotypes. Although a June 1–30 calving window was initially defined in the script header, the implemented analysis used the Pond-style calving period of 1 May to 9 June. GPS fixes within this window were extracted for each female-year.

For each female-year, we summarized calving-season space use using the following metrics:

- number of calving-season fixes;
- mean, median, and minimum signed distance to treeline;
- proportion of calving locations in Hudson Bay Lowland;
- proportion of calving locations in Coastal Hudson Bay Lowland;
- proportion of calving locations in the broader Hudson Bay–James Bay lowland region;
- total calving-season path length (km), calculated as the sum of step lengths between successive projected locations;
- 100% minimum convex polygon (MCP) area during calving;
- mean x- and y-coordinates of calving locations, used as a calving centroid;
- mean and maximum net squared displacement (NSD) during the calving season, calculated relative to the first calving-season fix.

These metrics were intended to capture the expectation that EMC females calve farther north and/or in lowland environments, whereas sedentary boreal females remain farther inland and south of treeline.

### 2.1.4 Stage 1: Ecotype classification from calving distribution

The first stage of classification used a two-component Gaussian finite mixture model (Scrucca et al. 2016) fit to female-year calving metrics. The implemented model used two predictors: proportion of calving fixes in Hudson Bay Lowland and mean signed distance to treeline.

Only female-years with complete data for both variables were included in the mixture analysis. Two clusters were fit, and the cluster interpreted as EMC-like was identified as the one with the higher mean proportion of calving fixes in Hudson Bay Lowland and the smaller, more northerly mean distance to treeline. The other cluster was interpreted as sedentary-like.

Each female-year was assigned to the cluster with the highest posterior probability. To avoid overconfident assignment of borderline cases, cluster assignments were converted into three ecotype categories using a posterior probability threshold of 0.80:

- EMC: assigned to the EMC-like cluster with posterior probability  $\geq 0.80$ ;
- Sedentary: assigned to the sedentary-like cluster with posterior probability  $\geq 0.80$ ; and
- Ambiguous: assigned to either cluster with posterior probability  $< 0.80$ .

As a diagnostic, simple rule-based classifications were also calculated using thresholds of 50% of calving fixes in Hudson Bay Lowland and 75 km mean distance to treeline, but the mixture-model classification was retained as the primary stage-1 ecotype assignment.

After stage-1 classification, female-years with extreme mean distance-to-treeline values were removed using a filter of  $\text{mean\_dist\_treeline\_km} \leq 800000$  in the implemented code. Because distance had already been converted to kilometres, this filter effectively served as a very permissive screen for extreme outliers rather than a biologically restrictive threshold.

### 2.1.5 Stage 2: Seasonal movement classification

A second stage classified female-years according to annual movement behaviour. Seasonal movement metrics were derived using simplified summer and winter windows intended to represent relatively stationary periods: summer: August–September and winter: February–March

For each female-year, GPS fixes from these seasonal windows were extracted. Female-years with fewer than 10 summer fixes or fewer than 10 winter fixes were excluded from movement classification.

Two movement metrics were calculated for each female-year: summer–winter centroid distance (km), computed as the Euclidean distance between centroids of the summer and winter point clouds, and seasonal utilization distribution overlap, estimated using kernel utilization distributions (kernelUD) and volume intersection overlap (kerneloverlap, method = "VI") (Calenge 2023).

Kernel overlap was only calculated where each seasonal subset contained at least 20 fixes and at least 5 unique coordinates. Female-years with centroid distances greater than 800 km were treated as outliers and their centroid-distance values were set to missing prior to classification.

Movement strategy was then assigned using empirical thresholds: Migratory: utilization distribution overlap  $\leq 0.05$  and centroid distance  $\geq 50$  km; Sedentary: utilization distribution overlap  $> 0.05$  and centroid distance  $< 50$  km; and Intermediate: all other cases. Female-years lacking sufficient data for either metric were left unclassified at this stage.

The female-year classification combined stage-1 ecotype assignment and stage-2 movement strategy. Female-years were assigned to the following classes:

- EMC\_core: ecotype = EMC and movement strategy = Migratory;
- Sedentary\_core: ecotype = Sedentary and movement strategy = Sedentary;
- Contact\_zone: ecotype = Ambiguous or movement strategy = Intermediate;
- EMC\_like\_nonmigrant\_year: ecotype = EMC and movement strategy = Sedentary probable;
- Sedentary\_like\_migrant\_year: ecotype = Sedentary and movement strategy = Migratory probable;
- Uncertain: insufficient information for classification.

Core and probable classes were aggregated, and to propagate female-year classifications back to the point level, the final classification table was joined to the full GPS dataset by animal ID and year. The classified GPS dataset was exported as a GeoPackage for subsequent mapping and analysis.

## 8;7i07 Visual.diagnostics

Several graphical diagnostics were used to assess the plausibility of classification results. These included histograms and density plots of the proportion of calving fixes in Hudson Bay Lowland and mean calving distance to treeline, bivariate plots of distance to treeline versus Hudson Bay Lowland use, plots of seasonal movement metrics by movement strategy, and maps of calving centroids and classified GPS locations. These diagnostic plots were used to confirm that the telemetry data showed the expected separation between migratory and sedentary female-years before final interpretation.

## 2.2 Identification and visualization of seasonal movement periods

Seasonal movement periods were identified from GPS telemetry using daily summaries of step length and then visualized relative to seasonal windows adapted from Pond et al.

### 2.2.1 Step-length calculation

Step lengths were calculated from successive GPS fixes for each collared female caribou after ordering records by individual and timestamp. For each relocation, the previous x- and y-coordinates were obtained using a lag operation within animal ID, and Euclidean distance between consecutive fixes was calculated in projected coordinates and converted to kilometres. The elapsed time between consecutive fixes was also calculated in hours, and day of year (DOY) was extracted from each timestamp. Records with missing or non-finite step lengths, missing time intervals, or non-positive time intervals were excluded from subsequent summaries. In the final workflow, step lengths were not standardized by elapsed time, although elapsed time was retained as a quality-control variable and could be used to filter unusually long fix intervals if needed.

### 2.2.2 Daily step-length summaries

To characterize annual movement patterns, step lengths were summarized by day of year across all available collars (Figure 1D). For each DOY, the median step length was calculated, along with the 25th and 75th percentiles and the number of contributing steps. Median step length was used as the primary measure of seasonal movement intensity to reduce sensitivity to extreme values. For some plots, only DOYs with at least 10 observations were retained to avoid displaying unstable daily summaries. In the cleaner workflow used for final visualization, the daily median step-length series was additionally smoothed within movement class using a 15-day centered rolling mean, and a nonparametric smoother was overlaid for display.

### 2.2.3 Seasonal reference windows

Seasonal reference periods were defined from Pond et al. using day-of-year windows. These included early winter (DOY 1–40), late winter (DOY 41–81), calving, summer, and breeding. Although the original Pond calving window corresponded to 1 May–9 June, the implemented plots used an adjusted calving period of DOY 132–172. Summer and breeding were defined as DOY 205–244 and DOY 253–293, respectively. These reference windows were used as ecological context for interpreting the seasonal movement curves and were displayed as lightly shaded bands in the figures.

## 2.2.4 Empirical identification of high-movement periods

Movement periods were identified empirically from the seasonal pattern in daily median step length. In the exploratory workflow, days were classified as “travel days” when their median step length was greater than or equal to the 75th percentile of the annual distribution of daily median step lengths. Consecutive travel days were grouped into contiguous blocks, and each block was summarized by start day, end day, peak median step length, mean median step length, and duration in days. This step was used to identify periods of sustained elevated movement rather than isolated daily peaks.

Based on inspection of these empirical high-movement periods and the smoothed annual step-length curves, three broad travel windows were delineated for visualization and interpretation: a pre-calving movement period, a post-calving movement period, and a fall migration period. In the final plotting workflow, these were represented as DOY 85–135, DOY 155–215, and DOY 275–335, respectively. These windows were treated as empirically derived periods of elevated movement intensity rather than fixed biological seasons.

## 2.2.5 Comparison by movement class

To compare seasonal travel patterns between migratory and sedentary animals, step lengths were recalculated from the GPS dataset after joining female-year movement classifications back to individual locations. GPS points classified as “Migratory” or “Sedentary” were retained, and daily summaries were calculated separately for each movement class. For each class-by-DOY combination, the median step length, interquartile range, and sample size were computed. DOYs with fewer than 10 observations were omitted from the final class-specific plots.

Class-specific annual curves were plotted with median step length as the response, interquartile range shown as a ribbon, and smoothed seasonal trends overlaid. Seasonal windows from Pond et al. (2016) were displayed as lightly shaded background bands, while empirically derived travel periods were shown as darker bands along the top of the plotting area. Final figures were faceted by movement class to allow visual comparison of the timing and magnitude of seasonal movement between migratory and sedentary caribou.

## 2.2.6 Assignment of points to seasonal and travel periods

For downstream mapping and spatial analysis, each GPS point (and corresponding step record) was assigned to both a Pond et al. (2016) seasonal category and an empirically derived travel-period category based on day of year. Pond et al. (2016) seasonal classes were defined as Early winter (DOY 1–40), Late winter (DOY 41–81), Calving (DOY 132–172), Summer (DOY 205–244), Breeding (DOY 253–293), and Other for all dates outside these windows. Travel-period classes were defined as Pre-calving migration (DOY 85–135), Post-calving movement (DOY 155–215), Fall migration (DOY 295–340), and Other for all remaining dates.

The classified step table was then converted back to an sf object using projected x and y coordinates. Movement-class information was joined from the classified GPS dataset, and subsets of migratory and sedentary points were exported as GeoPackages for subsequent mapping and analysis.

## 8;8;27 Visualization

Seasonal movement patterns were visualized using `ggplot2`. Initial exploratory plots showed raw daily median step-length curves and smoothed trends. Final figures displayed median daily step length by day of year, interquartile ribbons, seasonal background shading, and labeled empirical travel windows. Month labels were used on the x-axis for interpretability, and the y-axis was constrained to a common range across panels to facilitate comparison among movement classes. These visualizations were used to identify the principal annual periods of elevated movement and to interpret them relative to calving, summer, and breeding seasons.

### 2.3 Reproductive phenology analysis (parturition dates)

Parturition events were inferred from GPS telemetry by identifying abrupt and sustained reductions in movement rate during the calving period (1 May–15 June). Daily movement rates were calculated as mean step length per hour and smoothed using a 3-day rolling mean. For each individual-year, the date of minimum movement within the calving window was identified as the candidate parturition date. Individuals were classified as having calved if movement rates declined to less than 40% of pre-calving baseline levels and remained suppressed for at least three consecutive days. Annual calving rates (% of individuals with evidence of parturition) and parturition timing were summarized by year and by movement class (migratory vs sedentary). Differences in timing were evaluated using linear models and pairwise comparisons.

### 2.4 Identification and mapping of movement corridors

Movement corridors used by eastern migratory caribou were identified from GPS telemetry using dynamic Brownian bridge movement models (dBBMMs). The analysis was restricted to GPS locations previously classified as belonging to migratory animals, and separate corridor surfaces were developed for spring and fall migration periods.

#### 2.4.1 Input telemetry data and migration windows

The corridor analysis used the classified GPS telemetry dataset (`gps_classified`), provided as an `sf` point layer with animal ID, timestamp, projected coordinates, and movement-class assignment. Only locations assigned to the Migratory class were retained for corridor modelling. All data were required to be in a projected coordinate reference system with units in metres; analyses were not conducted in geographic coordinates.

Migration periods were defined using empirically derived day-of-year windows based on the seasonal step-length analysis. Spring migration was defined as day of year (DOY) 85–135, and fall migration was defined as DOY 275–335. Each GPS point was assigned to one of these migration phases according to its DOY, and points outside these windows were excluded from corridor modelling.

## 2.4.2 Preparation of migration episodes

GPS points within the spring and fall migration windows were first grouped into migration episodes at the level of individual, year, and migration phase. Within each individual, records were ordered chronologically and basic movement quality-control fields were calculated, including time lag between successive fixes (dt\_hours) and step length between consecutive projected locations.

To avoid modelling across major gaps in the telemetry record, a new migration burst was initiated whenever the elapsed time between successive fixes exceeded 24 hours, or when a record represented the first fix in a sequence. Each continuous burst was assigned a unique episode identifier composed of animal ID, year, migration phase, and burst number.

Episode-level quality control was then applied. For each episode, the number of fixes, number of unique timestamps, start and end time, duration in days, median fix interval, and spatial extent were summarized. Spatial extent was quantified as the diagonal length of the episode bounding box. Episodes were retained for dBBMM analysis only if they met all of the following criteria:

- at least 12 fixes;
- at least 12 unique timestamps;
- duration of at least 2 days; and
- bounding-box diagonal of at least 5 km.

This filtering step ensured that corridor models were fit only to episodes with sufficient temporal and spatial information to characterize directed migratory movement.

## 2.4.3 Dynamic Brownian bridge movement modelling

A separate dBBMM was fit to each valid migration episode using the move package (Kranstauber et al. 2023). Prior to fitting, episode records were ordered by time, duplicate timestamps were removed, and records with missing coordinates or timestamps were excluded. Episodes with fewer than 8 valid fixes after screening were not modelled.

For each episode, a move object was created using projected x- and y-coordinates, timestamps, and the projected CRS of the telemetry dataset. Dynamic Brownian bridge movement models were then fit using the following settings:

- location error = 100 m;
- behavioral variance window size = 31 fixes;
- margin size = 11 fixes;
- output raster cell size = 5,000 m; and
- extent expansion factor = 0.20 around the track.

These models estimate the utilization distribution (UD) associated with each migration episode while allowing movement variance to change dynamically along the path. Model outputs that failed to run, returned empty rasters, or produced only missing values were flagged and excluded from subsequent averaging.

#### 2.4.4 Standardization and averaging of episode utilization distributions

For each successful episode, the resulting dBBMM utilization distribution raster was normalized so that cell values summed to 1. Normalized episode UDs were then grouped by migration phase (spring or fall).

To create composite corridor surfaces for each migration phase, phase-specific raster templates were first defined to encompass all migration points for that phase at the selected raster resolution. Individual normalized UDs were resampled to the appropriate phase template and then averaged cell-by-cell across all successful episodes. The resulting mean spring and fall UDs were re-normalized so that each phase-specific surface summed to 1.

In addition to phase-specific surfaces, a combined annual corridor surface was created by aligning the spring and fall mean UDs to a common template spanning all migration points, averaging the two rasters, and re-normalizing the result.

#### 2.4.5 Conversion to cumulative-volume surfaces and corridor isopleths

Mean utilization distributions were converted to cumulative-volume rasters to facilitate delineation of corridor polygons. For each mean UD, raster cells were ranked from highest to lowest utilization value, and cumulative proportional volume was calculated across cells. In this representation, low cumulative-volume values correspond to the most intensively used portions of the corridor.

Corridor polygons were then extracted from cumulative-volume rasters using isopleth thresholds. Two corridor extents were delineated for each migration phase and for the combined annual surface: 50% isopleth, interpreted as the core corridor, and 95% isopleth, interpreted as the broad corridor.

Binary rasters representing cells with cumulative volume less than or equal to the specified threshold were converted to polygons and dissolved into corridor features. Corridor polygons were attributed with migration phase and isopleth level for subsequent mapping and interpretation.

#### 8;0;17 Output.products

The workflow produced both raster and vector outputs. Raster outputs included normalized mean utilization distributions and cumulative-volume rasters for spring migration, fall migration, and the combined annual corridor surface. Vector outputs included 50% and 95% corridor polygons for each migration phase and the combined annual corridor. All corridor polygons were also merged into a single geospatial layer for convenience.

In addition, a summary table of migration episodes and a status table documenting dBBMM model success or failure were written to file. Episode track lines were also created by connecting sequential fixes within each valid migration episode and exporting them as line features for diagnostic and mapping purposes.

#### 8;0;18 Visualization.and.diagnostics

Diagnostic maps were generated for spring, fall, and combined corridor surfaces. These plots displayed the normalized mean dBBMM utilization distribution raster with overlaid corridor polygons, including the 95% broad corridor and 50% core corridor. Additional exploratory plots

examined the distribution of raster values, including log-transformed utilization surfaces, to assess the spatial concentration of use and support interpretation of corridor structure.

These outputs were used to identify recurrent migration pathways, distinguish core versus peripheral movement areas, and provide mapped corridor products for subsequent ecological interpretation and spatial planning.

A couple of implementation details are worth noting for transparency. First, the workflow depends on helper functions (`make_phase_template`, `normalize_ud`, and `resample_to_template`), which standardize raster extent, resolution, and scaling before averaging. Second, the final corridor maps represent population-level average use surfaces across retained migration episodes, not single-animal paths or route-centerline corridors.

## 3 RESULTS

### 3.1 Classification into migratory and sedentary ecotypes

The two-stage classification workflow separated the 478 female caribou collar-years (203 unique caribou) into eastern migratory and sedentary ecotypes based on calving-season distribution and seasonal movement behaviour. Calving-season metrics showed clear separation between groups, with animals classified as migratory exhibiting a greater proportion of calving locations in the Hudson Bay Lowland region and smaller (more northerly) mean distances to the treeline boundary compared with sedentary animals (Figure 2A, Figure 2B). Gaussian mixture modelling of these variables produced two distinct clusters corresponding to migratory and sedentary ecotypes, with a smaller number of female-years assigned as ambiguous when posterior classification probabilities were low.

Seasonal movement metrics further distinguished these ecotypes. Female-years classified as migratory typically exhibited large centroid displacements between winter and summer ranges and low overlap between seasonal utilization distributions, whereas sedentary female-years showed shorter seasonal displacements and higher seasonal overlap (Figure 2C). Integration of the ecotype and movement classifications produced two dominant groups: EMC core animals exhibiting both northern calving distributions and migratory seasonal movements, and sedentary core animals exhibiting southern calving distributions and localized seasonal movements. A smaller number of female-years were classified as contact-zone or probable categories when ecotype and movement metrics were partially inconsistent or when seasonal movement data were limited (Figure 2D).

Individuals classified as ‘contact zone’ exhibited intermediate calving distributions and spatial behaviour consistent with use of the ecotonal region between northern migratory and southern sedentary ranges, and are interpreted as representing transitional or facultative movement strategies. In contrast, ‘uncertain’ classifications were assigned where model-based probabilities or movement metrics did not support confident assignment to a behavioural class, reflecting either limited data or conflicting indicators rather than a distinct ecological strategy.

When classifications were aggregated into the migratory and sedentary categories, the telemetry dataset separated into distinct groups of migratory and sedentary animals, providing a basis for subsequent analyses of seasonal movement patterns and migration corridors. The spatial patterns of seasonal locations reveal clear differences in movement behaviour between migratory and sedentary caribou, with additional insight provided by individuals classified within the contact zone (mixed classification).

Migratory caribou exhibit pronounced seasonal redistribution across a broad north–south gradient (Figure 3). During the spring calving period, locations are concentrated along the northern coastal region, consistent with use of coastal calving grounds associated with the Hudson Bay Lowlands. This coastal distribution persists into summer, although animals disperse more broadly along the coastline following calving. In the fall, there is a distinct inland shift, with individuals moving southward into transitional forested areas. By winter, migratory caribou occupy extensive inland ranges, indicating long-distance seasonal movements linking coastal calving areas with interior winter habitat. The WSR and NRL LSAs overlap primarily with these inland fall and winter ranges, as well as portions of migration corridors, but do not intersect core coastal calving areas.

In contrast, sedentary caribou display relatively restricted and localized movements throughout the year (Figure 4). Calving occurs inland, largely within or adjacent to the LSAs, and seasonal distributions remain broadly similar through summer and fall, indicating limited post-calving dispersal. Although there is some expansion of space use during winter, locations remain centered within the same general region. This pattern reflects strong site fidelity and small home ranges, with all seasonal habitats overlapping substantially with the WSR and NRL LSAs.

Caribou classified within the contact zone (mixed classification) exhibit spatial patterns that are intermediate between these two strategies. These individuals tend to occupy inland areas during calving, similar to sedentary caribou, but may show partial seasonal movements or broader spatial distributions in summer, fall, or winter. Their locations often occur near the transition between northern coastal and southern inland ranges, consistent with use of ecotonal regions near the treeline. This suggests that contact zone individuals may represent facultative or transitional movement strategies, with variable degrees of seasonal displacement.

Overall, these patterns demonstrate a continuum of movement behaviour, from long-distance migration to localized residency, with contact zone individuals occupying an intermediate position. From a management perspective, migratory caribou are most likely to be affected by disturbances to migration pathways and winter ranges, whereas sedentary caribou are exposed to year-round habitat disturbance within the LSAs. Contact zone individuals may be particularly sensitive to changes that affect connectivity between northern and southern habitats, given their reliance on transitional landscapes.

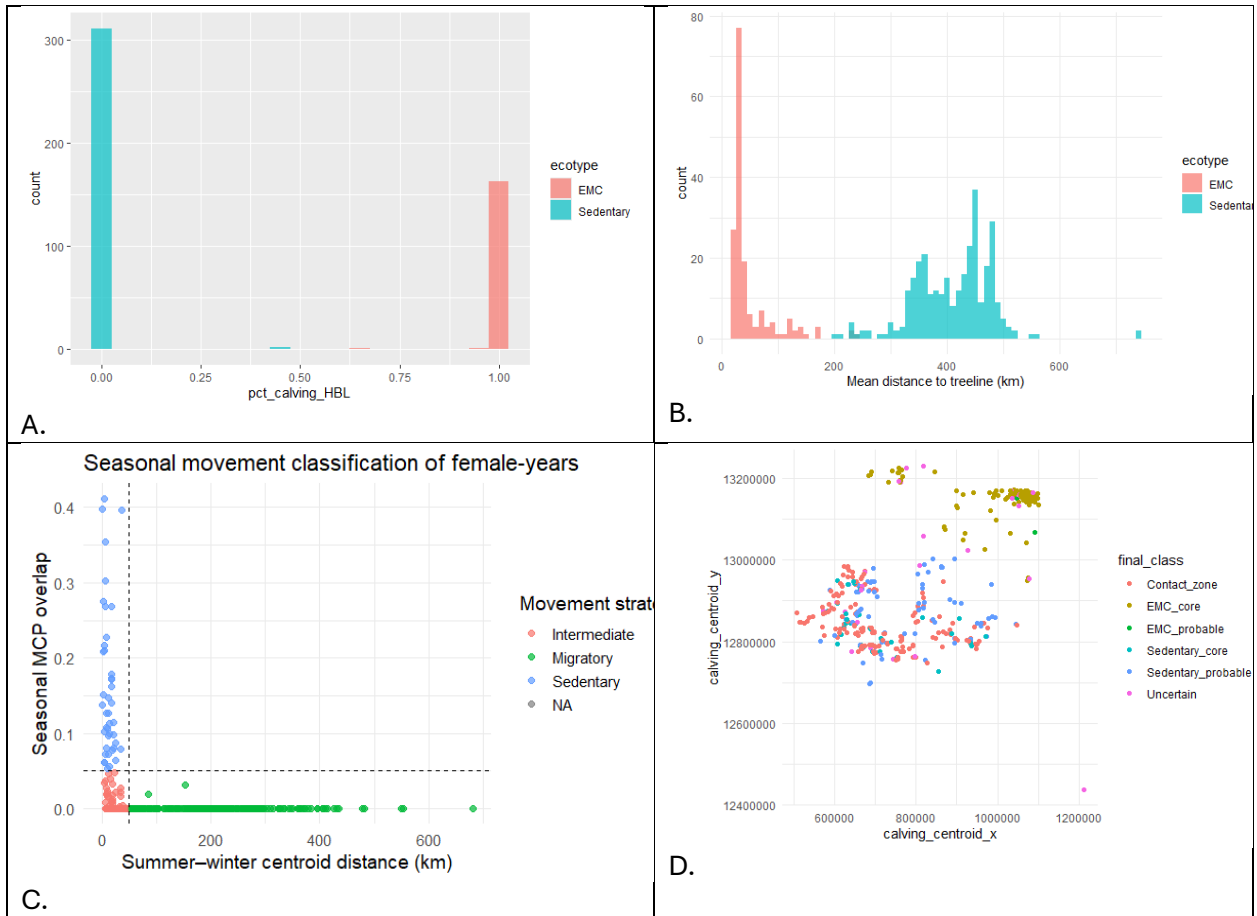


Figure.8: Analysis stages for classification of individual caribou into migratory versus sedentary classes;

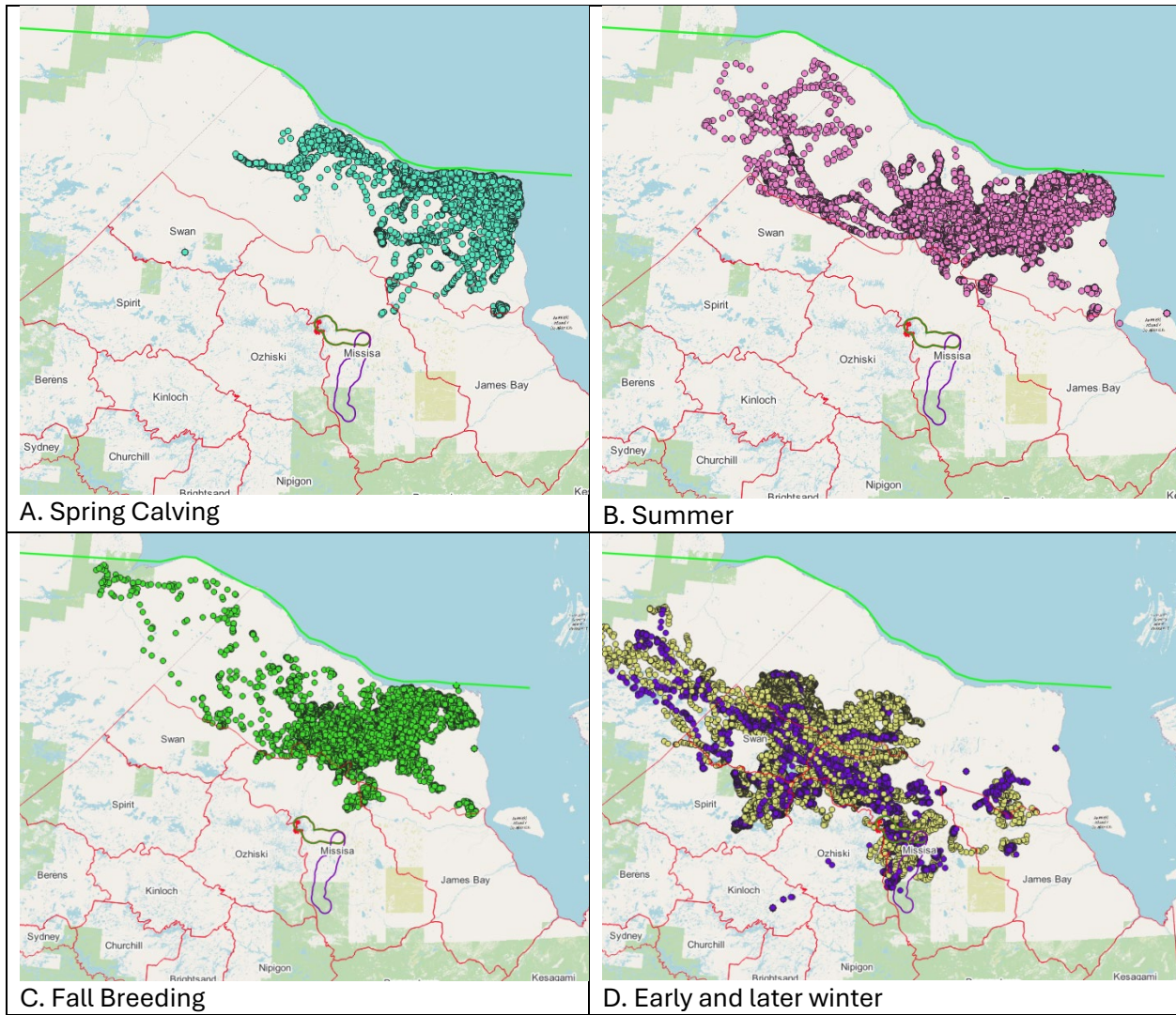


Figure.9; Seasonal locations for eastern migratory caribou (with overlay of WSR and NRL caribou LSAs);

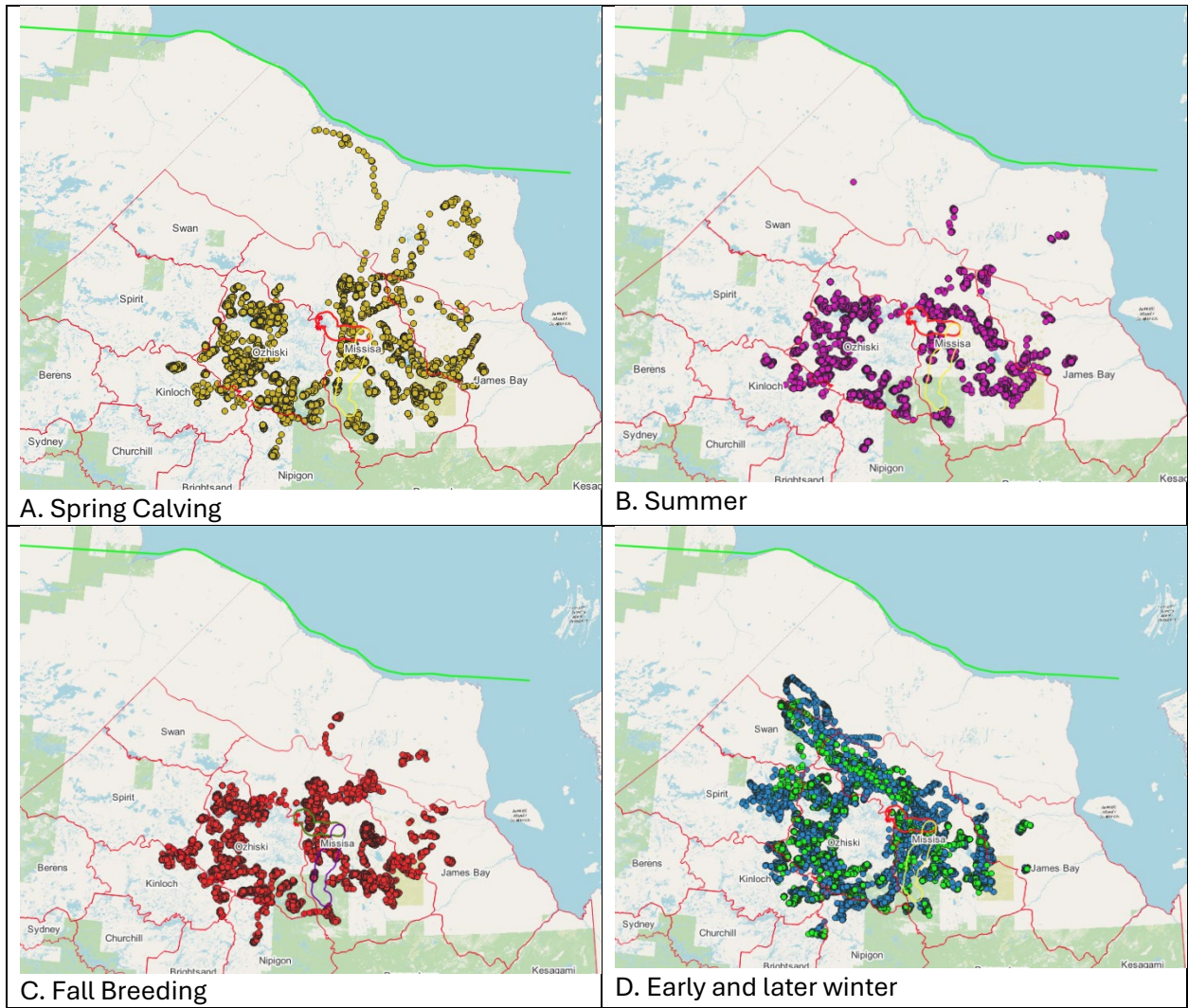


Figure 0: Seasonal locations for boreal woodland (sedentary) caribou (with overlay of WSR and NRL caribou LSAs)

### 3.2 Seasonal movement periods

Analysis of GPS step lengths revealed three distinct periods of elevated movement during the annual cycle of eastern migratory caribou. Median daily step lengths increased sharply during late winter and early spring, producing a pronounced peak between approximately day of year (DOY) 85 and 135 (Figure 5). This period corresponded to pre-calving migration, when animals moved from winter ranges toward calving areas. Following the calving period, movement rates increased again between approximately DOY 155 and 215, forming a second period of elevated step length interpreted as post-calving movement or dispersal. During this period, animals moved away from calving areas toward summer habitats. A third major movement peak occurred during late autumn, approximately DOY 275–335, representing fall migration as animals moved toward rutting and wintering areas. Between these high-movement periods, step lengths declined markedly, particularly during the calving season and during mid-winter, indicating periods of relatively localized movement. When step lengths were summarized separately for migratory and sedentary animals, the seasonal peaks were pronounced in the migratory class but much weaker or absent in sedentary caribou, supporting the interpretation that these periods represent large-scale seasonal migrations characteristic of eastern migratory caribou.

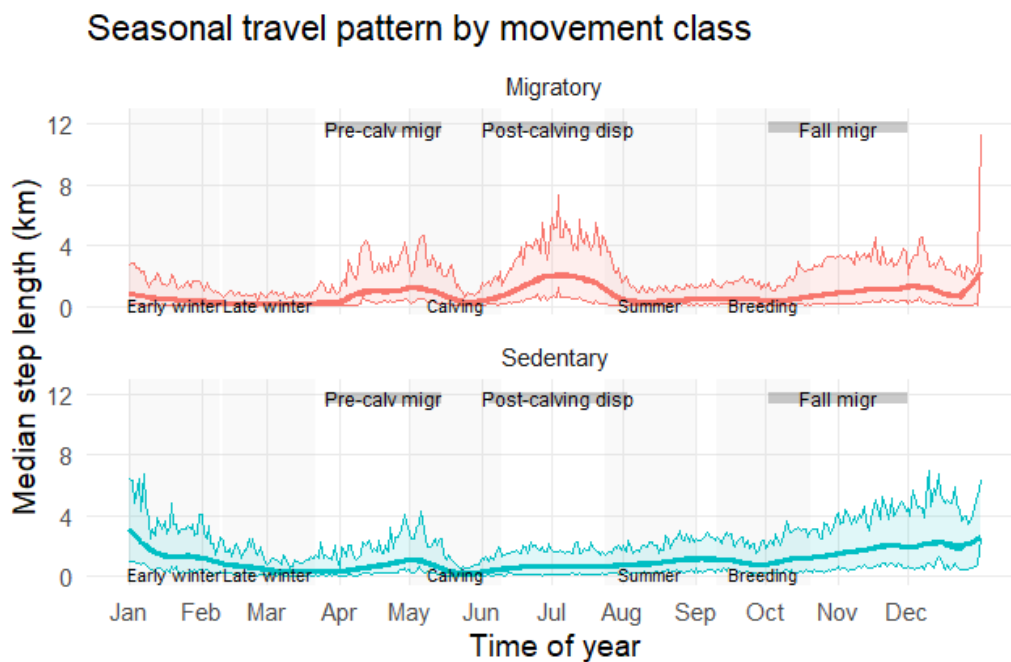


Figure 5. Seasonal median step length (km) by day of year for migratory and sedentary eastern migratory caribou. Light grey shading indicates seasonal windows defined by Pond et al. with the calving period adjusted for this analysis. Dark grey bands show empirically derived high-movement periods identified from seasonal step length patterns.

Seasonal step length patterns differed markedly between migratory and sedentary individuals. Migratory caribou exhibited a pronounced peak in movement during late spring, corresponding to migration toward calving areas. Movement declined sharply during the calving period, reflecting localized use of calving grounds. A secondary increase in movement occurred during late summer and autumn as animals redistributed toward winter ranges. In contrast, sedentary individuals exhibited relatively stable movement rates throughout the year with no distinct spring migration peak, although movements increased moderately during winter months, likely reflecting local shifts in winter foraging areas.

Table.7; Seasonal.and.Movement.Period.Definitions;

DOY Start	DOY End	Approx. Date Range	Pond et al. Season	Movement Period
1	40	Jan 1 – Feb 9	Early winter	Winter residency
41	81	Feb 10 – Mar 21	Late winter	Winter residency
85	135	Mar 26 – May 15	Late winter Pre-calving	Pre-calving migration
122	161	May 01– Jun 09	Calving	Calving
155	215	Jun 4 – Aug 3	Calving Early summer	Post-calving movement / dispersal
205	244	Jul 24 – Sep 1	Summer	Summer residency
253	293	Sep 10 – Oct 20	Breeding (rut)	Autumn residency
275	335	Oct 2 – Dec 1	Breeding Early winter	Fall migration

Table.8; Number.of.classified.caribou.by.movement.class.(0-34 caribou\_years.based.on.869.unique.caribou);

Classification	Count of final class
Contact zone	179
EMC core	146
EMC probable	3
Sedentary core	39
Sedentary probable	79
Uncertain	32

### 3.3 Reproductive Phenological Analysis

#### Parturition Rates and Interannual Variation

Across all years, the proportion of monitored females inferred to have calved was consistently high, ranging from 85.5% to 99.1% (Table 3). The highest calving rate occurred in 2021 (99.1%), while 2020 showed the lowest (85.5%). Overall, these results indicate strong reproductive output and high detectability of parturition events using the movement-based method.

Mean parturition dates were relatively consistent among years, occurring between 19 May and 25 May (DOY 140.2–146.2), with standard deviations of approximately 6–9 days, indicating a moderately synchronized calving period (Table 3). The earliest mean parturition occurred in 2024 (19 May), while the latest occurred in 2020 and 2023 (25 May). Interannual variability in timing was modest ( $\approx$ 6-day range in mean DOY), suggesting that annual environmental variation had limited influence on overall calving phenology during the study period. These patterns are reflected in Figure 6, which shows overlapping distributions among years with only minor shifts in central tendency, and Table 3, which illustrates consistently high reproductive rates.

Parturition rates differed slightly among movement classes but remained high across all groups (Table 4). Sedentary individuals exhibited the highest inferred calving rate (94.1%), followed by Mixed (92.7%) and Migratory (87.9%) animals. Note that parturition rates and dates for sedentary individuals represents calving period in the WSR and NRL RSAs. Clear differences were observed in parturition timing among movement classes: migratory mean DOY = 145.4 ( $\sim$ 25 May); sedentary mean DOY = 143.3 ( $\sim$ 23 May), and mixed mean DOY = 142.4 ( $\sim$ 22 May). These results indicate that migratory individuals calved approximately 2–3 days later than sedentary and mixed individuals. Variation in timing was slightly lower for migratory individuals (SD = 6.6 days) compared to mixed (8.3 days) and sedentary (8.6 days), suggesting greater synchrony in calving among migratory animals. These differences are evident in Figure 7 and Figure 8, where migratory individuals show a right-shifted (later) distribution relative to sedentary and mixed groups.

The movement-based detection of parturition was supported by clear seasonal patterns in relative movement rates. All movement classes exhibited a pronounced decline in movement during the calving period (Figure 9), with values falling below the defined threshold (40% of baseline movement). This decline was sharp and synchronous for migratory individuals, while more gradual and variable for sedentary and mixed individuals (Figure 8). These patterns are consistent with expected behavioural differences, where migratory caribou undertake long-distance movements prior to calving and then rapidly reduce movement upon reaching calving areas.

Table.9 Summary of parturition metrics by year

Year	N monitored	N inferred calved	% inferred calved	Mean parturition DOY	SD parturition DOY	Mean parturition date
2019	42	39	92.9	141.1	7.7	2019-05-21
2020	83	71	85.5	146.2	8.6	2020-05-25
2021	117	116	99.1	142.0	7.4	2021-05-21
2022	103	92	89.3	144.2	7.9	2022-05-24
2023	73	64	87.7	145.8	7.7	2023-05-25
2024	28	26	92.9	140.2	6.4	2024-05-19

Table.0¿ Summary.of.parturition.metrics.by.movement.class¿

Movement class	N monitored	N inferred calved	% inferred calved	Mean parturition DOY	SD parturition DOY
Migratory	149	131	87.9	145.4	6.6
Mixed	179	166	92.7	142.4	8.3
Sedentary	118	111	94.1	143.3	8.6

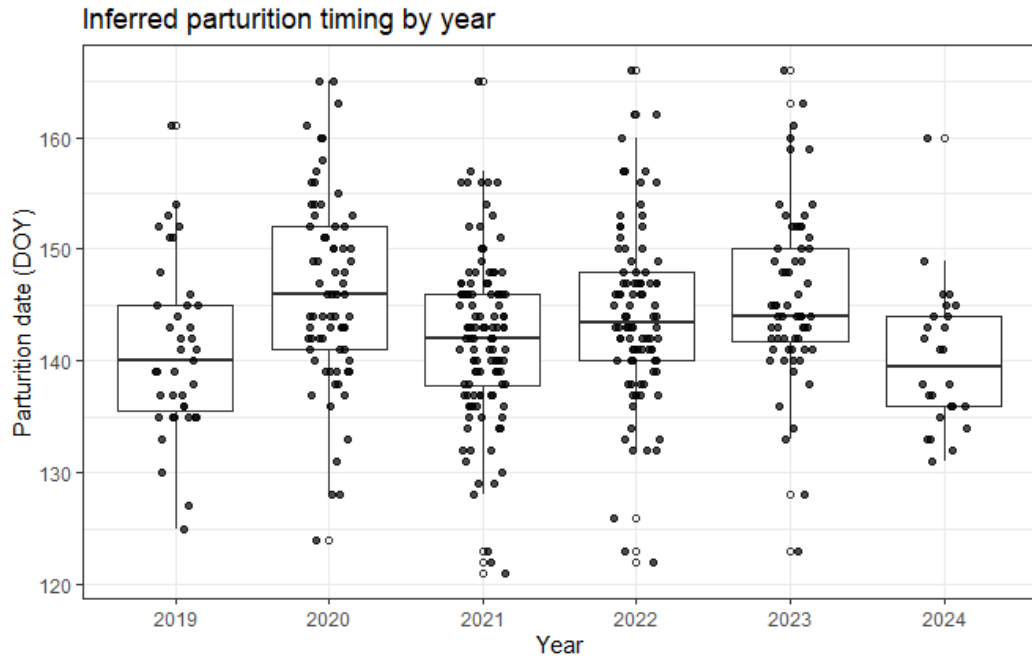


Figure.0¿ Parturition.DOY.by.year

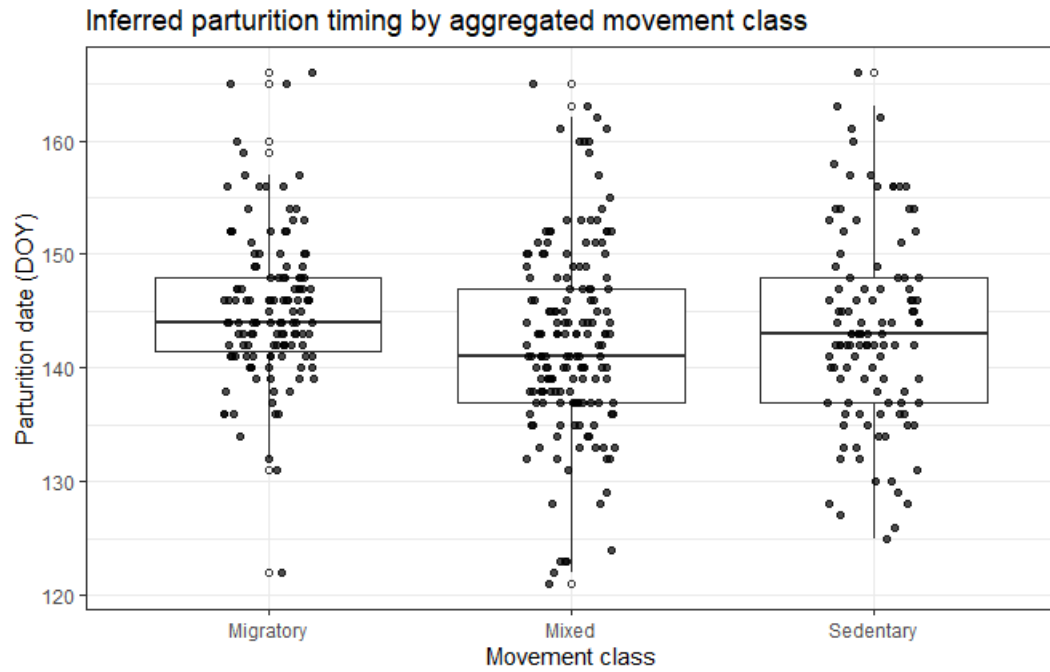


Figure 3. Parturition.DOY.by.movement.class;

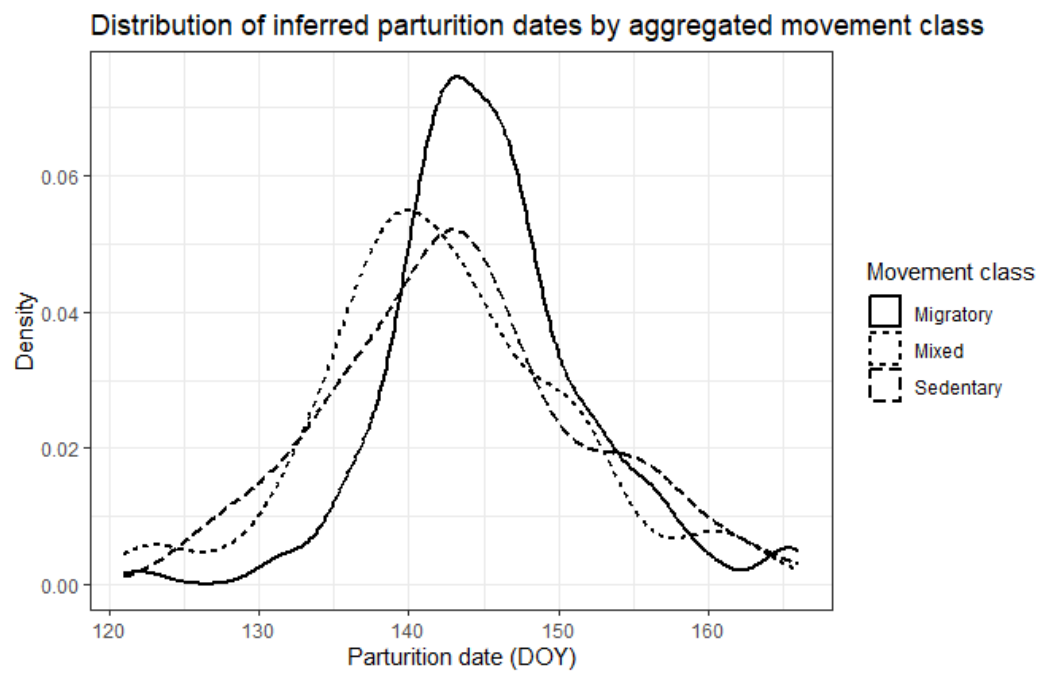


Figure 4. Density.of.parturition.timing.by.movement.class;

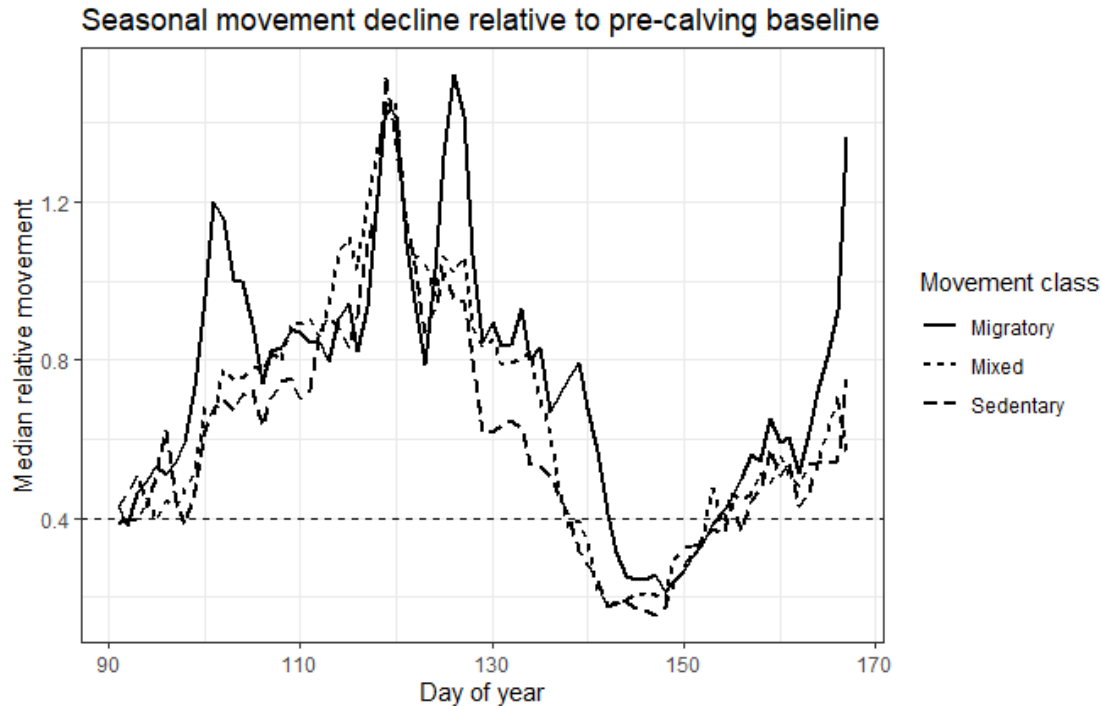


Figure 9. Relative movement rates through calving period;

### 3.4 Movement Corridors:

Dynamic Brownian bridge modelling of migratory caribou identified coherent movement corridors for both spring and fall migration periods and yielded a combined annual corridor surface representing recurrent migratory use (Figure 10A, Figure 11A). Phase-specific utilization distributions showed spatially concentrated movement pathways, from which 95% isopleths defined broad seasonal corridors and 50% isopleths defined core areas of repeated use. The spring corridor analysis captured movements associated with northward pre-calving travel, while the fall corridor product described southward or post-summer return movements. The combined annual corridor integrated these seasonal surfaces into a single spatial product that emphasized areas of overlap and repeated use, thereby identifying the principal migratory corridor network used by eastern migratory caribou across the annual cycle.

#### 3.4.1 Spring migration

Spring migration of eastern migratory caribou (EMC) is characterized by directed northward movement from inland winter ranges toward coastal calving areas, with strong convergence onto the Hudson Bay Lowlands (Figure 10B). The movement paths show that individuals initiate migration from dispersed wintering areas within and surrounding the southern ranges, including the Mississa range and adjacent portions of the Ozhiski range. Early in migration, trajectories are relatively diffuse, reflecting a broad departure front across inland habitats. As animals move northward, paths become increasingly aligned and directional, indicating coordinated movement toward a common destination. A pronounced convergence of movement tracks occurs as animals

approach the northern coastal region, where the density of locations increases sharply. The green calving locations (Figure 10D) confirm that calving is concentrated along the coast and near-coastal peatland complexes, consistent with typical EMC use of the Hudson Bay Lowlands for parturition. This spatial pattern indicates strong fidelity to northern calving grounds and a high degree of synchrony in migration timing.

The WSR and NRL regional study areas (RSAs) are defined by the combined Ozhiski and Mississa caribou ranges. The caribou local study areas (LSAs) are 11 km buffers around the project footprint and represent areas where more direct impacts of the project may affect caribou. They are situated within the southern portion of the RSAs, primarily within the Mississa range and near the boundary with the Ozhiski range. Movement paths clearly pass through and around these LSAs during spring migration, demonstrating that both areas overlap with active migration corridors rather than calving habitat. The density of tracks in this region indicates repeated use across individuals, suggesting that these corridors are important for facilitating movement between winter ranges and coastal calving areas.

Notably, there is no evidence of concentrated calving activity within either LSA, as indicated by the absence of green calving locations in these areas. Instead, both LSAs function as transit zones during spring migration. This distinction is important, as it implies that potential direct effects within the WSR and NRL areas are more likely to influence movement behaviour, connectivity, and migration efficiency, rather than directly affecting calving sites.

Overall, spring migration is characterized by broad inland departure, directional northward travel through the Mississa and Ozhiski ranges, convergence into well-defined pathways, and eventual concentration on coastal calving grounds, with the WSR and NRL LSAs intersecting key migration corridors along this route.

### 3.4.2 Fall migration

The fall migration patterns of eastern migratory caribou (EMC) show a clear and structured southward movement from northern summer ranges toward inland breeding grounds and wintering areas (Figure 11B). Movement paths are widely distributed across the northern portion of the range, reflecting dispersed summer use along the Hudson Bay coastal region. As migration progresses, these paths begin to converge into more defined travel corridors, indicating coordinated directional movement rather than random displacement.

A pronounced funneling effect is evident as animals move southward, with many trajectories concentrating toward a narrower zone in the central portion of the range. This convergence suggests the presence of preferred migration routes or landscape features that guide movement, such as terrain, vegetation structure, or avoidance of unsuitable habitats. The density of tracks increases markedly in this central corridor, indicating repeated use by multiple individuals and years. Approaching the southern extent of migration, movement paths transition from long, directional trajectories into more localized and looping patterns, consistent with arrival on breeding ranges. The clustering of locations and reduced linearity of movement is consistent with animals entering the rutting period.

The WSR and NRL LSAs are situated within this zone of convergence and fall rutting and early winter settlement. As a result, these areas overlap with high-use migration corridors and staging areas, rather than peripheral or low-use portions of the migratory pathway. This positioning suggests that fall migration represents a period of elevated sensitivity to disturbance, as large numbers of individuals are funneled through relatively constrained areas during a critical seasonal transition.

Overall, the fall migration of EMC is characterized by broad-scale dispersal in the north, directional southward movement, convergence into key corridors, and eventual concentration on breeding ranges, highlighting the importance of maintaining connectivity across this landscape. Virtually all the breeding area is north of the WSR and NRL LSAs.

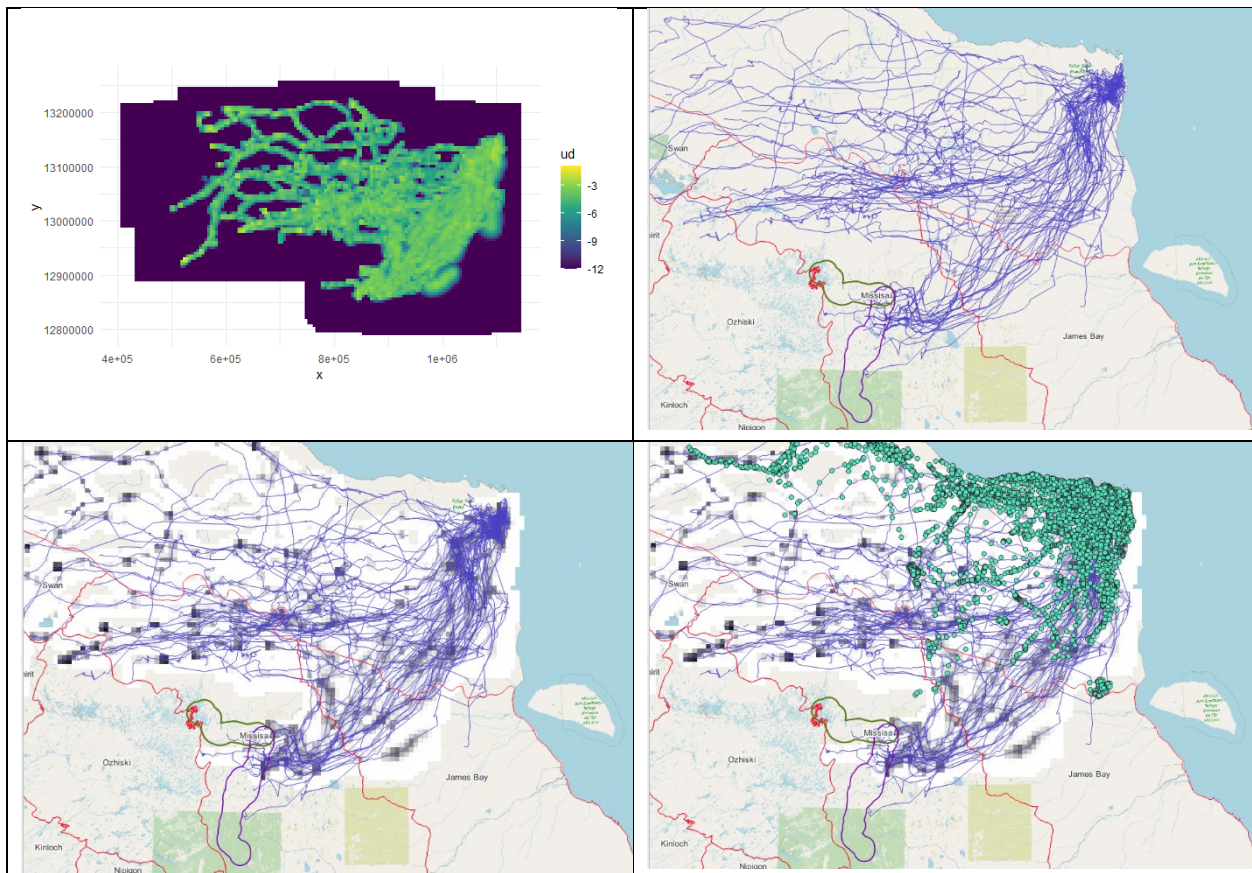


Figure.76; Spring.migration.Brownian.UDs?tracks?and.Calving.period.locations.(parturition?with overlay.of.WSR.and.NRL.caribou.LSAs);..EMC.only;

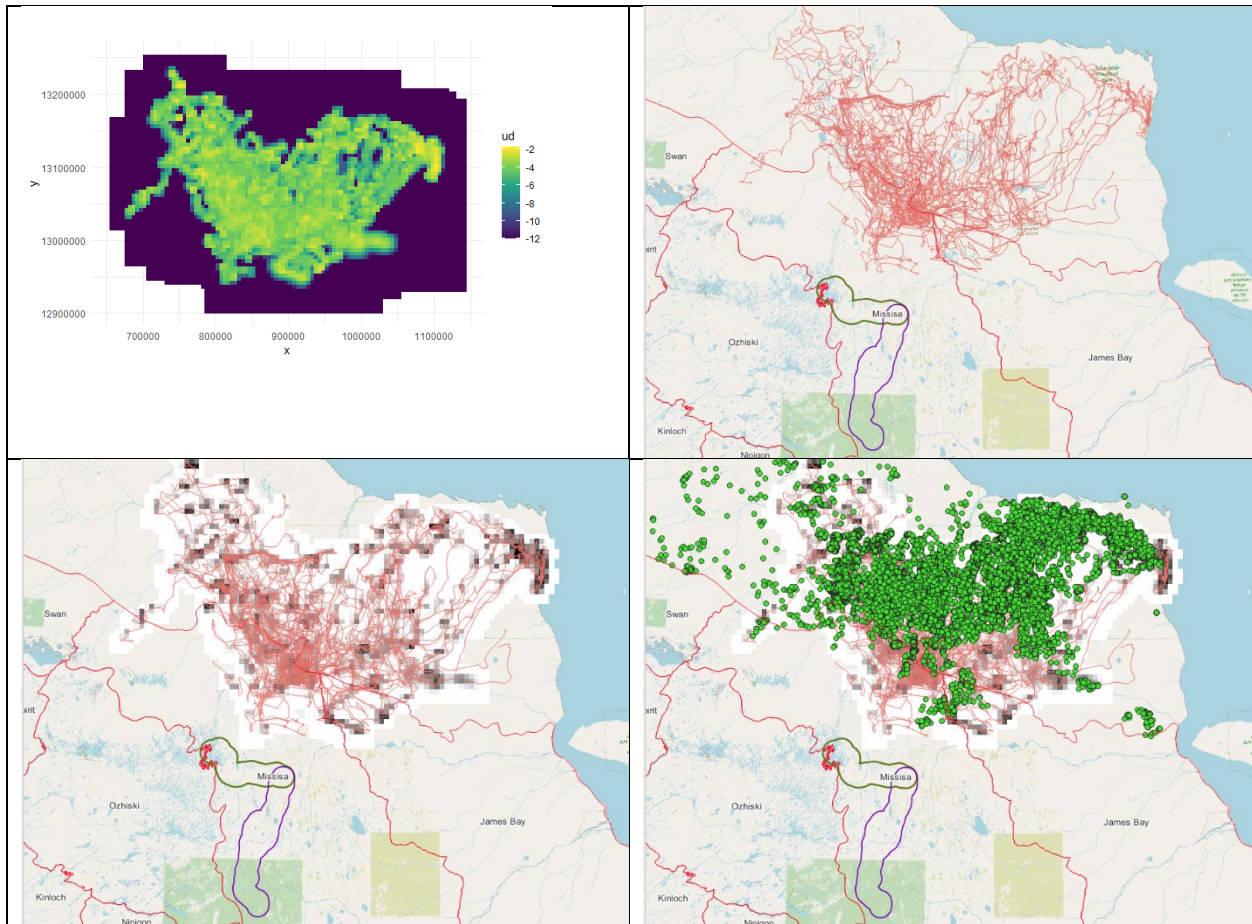


Figure.77; Fall migration Brownian UDs (A); migration tracks (B and C); and breeding (rut) period locations (D) for EMC only with overlay of WSR and NRL caribou LSAs;

## 4 DISCUSSION

### 4.1 Interpretation of Project Effects on Caribou Migration

Telemetry data from collared eastern migratory caribou were used to examine seasonal migration pathways relative to the proposed Northern Road Link (NRL) and Webequie Supply Road (WSR) project areas. Figure 10 and Figure 11 illustrate spring and fall migration tracks, respectively. Taken together, the spring and fall telemetry patterns indicate that the project area occurs within a regional migration landscape characterized by broad movement fronts rather than discrete migration corridors. This pattern suggests that caribou have the capacity to adjust migration routes locally if disturbances occur. Potential project interactions with migration therefore include localized disturbance or temporary avoidance of infrastructure during migration, minor shifts in migration pathways around the road corridor, and increased sensitivity during peak migration periods, particularly during spring migration when movements are more directional.

Neither the spring nor fall migration patterns indicate the presence of a single critical migration bottleneck within the project footprints. Instead, migration appears to occur across a broad network of pathways extending across multiple caribou ranges. As a result, the primary potential effect of the proposed infrastructure is expected to be localized disturbance or route displacement rather than complete obstruction of migration. Maintaining permeability across the migration landscape—particularly during peak migration periods—will therefore be important for minimizing potential project effects on caribou movement.

## 4.2 Interpretation of parturition phenology

The distribution of inferred parturition dates shows clear but modest differences among movement classes, with important implications for the environmental assessment. Migratory caribou exhibit a later and more tightly clustered peak in parturition, centered around approximately DOY 144–147 (late May). The narrower distribution indicates greater synchrony in calving, consistent with coordinated arrival on northern calving grounds following spring migration. This reflects a strategy where timing is closely linked to migration phenology and coastal habitat conditions.

In contrast, sedentary and mixed (contact zone) individuals show slightly earlier and more dispersed parturition timing, with broader distributions extending both earlier and later than migratory animals. The mixed class closely overlaps with sedentary caribou but tends to exhibit the widest spread in dates, indicating greater variability in reproductive timing. This is consistent with their intermediate behavioural strategy and use of more variable inland environments.

Overall, the differences among classes are relatively small (on the order of a few days), but the degree of synchrony differs substantially, with migratory caribou showing the most compressed calving period and mixed individuals the least. From an environmental assessment perspective, these patterns indicate that timing and sensitivity to disturbance vary by movement strategy. Migratory caribou may be particularly vulnerable to disturbance during a short, well-defined calving window, where disruption could affect a large proportion of individuals simultaneously. However, because their calving occurs in coastal areas outside the WSR and NRL LSAs, direct effects on calving sites are unlikely; instead, impacts would be more relevant during migration periods that precede this tightly synchronized calving event.

Sedentary and mixed (contact zone) caribou, which calve earlier and over a broader time window, are more likely to be exposed to prolonged periods of potential disturbance within or near the LSAs. Their extended and less synchronized calving period increases the likelihood that some individuals will overlap temporally with project-related activities, particularly given that their ranges overlap spatially with the WSR and NRL regions. The broader spread in parturition timing for mixed (contact zone) individuals further suggests greater variability and potentially reduced predictability in reproductive behaviour, which may complicate mitigation timing and increase uncertainty in assessing effects.

In summary, while differences in mean parturition timing are modest, the contrast in synchrony and temporal spread among movement classes is ecologically meaningful, indicating that migratory caribou are sensitive to short-duration, high-intensity disturbance events tied to migration timing, whereas sedentary and contact zone caribou may be more affected by longer-duration or poorly timed disturbances within inland habitats, including those associated with the WSR and NRL LSAs.

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# APPENDIX A (CONT'D)

## A7-2: Ecotype Classification of Collared Caribou



**Appendix A7-2:** Ecotype Classification of Collared Caribou from WSR, NRL and MNR programs between 2019 and 2024.

Project	Collar ID	Movement Class	Years
MNR	CMS001	Migratory	2020-2022
MNR	CMS001	Migratory	2020-2022
MNR	CMS002	Migratory	2020
MNR	CMS003	Migratory	2020-2022
MNR	CMS004	Migratory	2020-2022
MNR	CMS005	Migratory	2020-2022
MNR	CMS006	Migratory	2020-2022
MNR	CMS007	Migratory	2020-2021
MNR	CMS008	Unknown	2020
MNR	CMS009	Migratory	2020
MNR	CMS010	Migratory	2020-2022
MNR	CMS011	Migratory	2020-2021
MNR	CMS011	Unknown	2022
MNR	CMS012	Migratory	2020
MNR	CMS013	Sedentary	2020
MNR	CMS013	Mixed	2021-2022
MNR	CMS014	Migratory	2020-2022
MNR	CMS015	Migratory	2020-2021
MNR	CMS016	Migratory	2020-2022
MNR	CMS017	Migratory	2020-2022
MNR	CMS018	Migratory	2020-2022
MNR	CMS019	Migratory	2020-2021
MNR	CMS019	Unknown	2022
MNR	CMS020	Migratory	2020-2021
MNR	CMS020	Unknown	2022
MNR	CMS021	Migratory	2020
MNR	CMS022	Migratory	2020
MNR	CMS022	Unknown	2021
MNR	CMS023	Migratory	2020-2022
MNR	CMS024	Migratory	2020-2022
MNR	CMS025	Migratory	2020-2022
MNR	CMS026	Migratory	2020-2021
MNR	CMS027	Sedentary	2020
MNR	CMS027	Unknown	2021
MNR	CMS028	Migratory	2020-2022
MNR	CMS029	Sedentary	2020-2022
MNR	CMS030	Migratory	2020-2022
MNR	CMS031	Mixed	2020

Project	Collar ID	Movement Class	Years
MNR	CMS031	Sedentary	2021-2022
MNR	CMS032	Mixed	2020
MNR	CMS032	Sedentary	2021
MNR	CMS033	Mixed	2020-2022
MNR	CMS034	Mixed	2020-2022
MNR	CMS035	Mixed	2020-2021
MNR	CMS035	Unknown	2022
MNR	CMS036	Mixed	2020-2022
MNR	CMS036	Sedentary	2021
MNR	CMS037	Mixed	2020-2022
MNR	CMS038	Mixed	2020-2022
MNR	CMS039	Sedentary	2020-2021
MNR	CMS039	Mixed	2022
MNR	CMS040	Mixed	2020-2022
MNR	CMS041	Mixed	2020
MNR	CMS042	Mixed	2020
MNR	CMS042	Sedentary	2021
MNR	CMS043	Mixed	2020
MNR	CMS043	Sedentary	2021
MNR	CMS045	Mixed	2020
MNR	CMS045	Sedentary	2021
MNR	CMS046	Mixed	2020
MNR	CMS046	Sedentary	2021
MNR	CMS047	Mixed	2020
MNR	CMS048	Mixed	2020
MNR	CMS048	Sedentary	2021-2022
MNR	CMS049	Mixed	2020
MNR	CMS050	Mixed	2020
MNR	CMS050	Sedentary	2021-2022
MNR	CMS051	Migratory	2020
MNR	CMS052	Sedentary	2021
MNR	CMS052	Mixed	2022
MNR	CMS053	Migratory	2021-2023
MNR	CMS054	Mixed	2021
MNR	CMS054	Sedentary	2022
MNR	CMS055	Mixed	2021
MNR	CMS055	Sedentary	2022-2023
MNR	CMS056	Unknown	2021
MNR	CMS057	Sedentary	2021
MNR	CMS057	Mixed	2022

Project	Collar ID	Movement Class	Years
MNR	CMS058	Migratory	2021
MNR	CMS058	Unknown	2022
MNR	COZ001	Mixed	2020
MNR	COZ001	Sedentary	2021
MNR	COZ002	Mixed	2019-2021
MNR	COZ003	Sedentary	2019-2020
MNR	COZ003	Mixed	2021-2022
MNR	COZ004	Mixed	2019, 2021
MNR	COZ004	Sedentary	2020
MNR	COZ005	Migratory	2019
MNR	COZ005	Unknown	2020
MNR	COZ006	Unknown	2019
MNR	COZ007	Sedentary	2019-2022
MNR	COZ008	Migratory	2019-2020
MNR	COZ008	Unknown	2021
MNR	COZ009	Mixed	2019-2021
MNR	COZ010	Sedentary	2019
MNR	COZ011	Sedentary	2019
MNR	COZ011	Migratory	2020-2023
MNR	COZ012	Sedentary	2019, 2021
MNR	COZ012	Mixed	2020
MNR	COZ013	Mixed	2019-2021
MNR	COZ014	Mixed	2019
MNR	COZ014	Sedentary	2020
MNR	COZ014	Unknown	2021
MNR	COZ015	Mixed	2019
MNR	COZ015	Unknown	2020
MNR	COZ016	Sedentary	2019
MNR	COZ016	Mixed	2020-2021
MNR	COZ017	Mixed	2019
MNR	COZ018	Sedentary	2019, 2021, 2022
MNR	COZ018	Mixed	2020
MNR	COZ019	Mixed	2019
MNR	COZ020	Sedentary	2019-2021
MNR	COZ020	Mixed	2020
MNR	COZ021	Unknown	2019
MNR	COZ022	Mixed	2019
MNR	COZ023	Sedentary	2019-2021
MNR	COZ024	Mixed	2019-2020
MNR	COZ024	Sedentary	2021

Project	Collar ID	Movement Class	Years
MNR	COZ025	Mixed	2019-2021
MNR	COZ026	Mixed	2019-2020
MNR	COZ027	Mixed	2019
MNR	COZ027	Sedentary	2020
MNR	COZ028	Sedentary	2019-2020
MNR	COZ029	Mixed	2019-2020
MNR	COZ029	Sedentary	2021
MNR	COZ030	Mixed	2019-2021
MNR	COZ031	Sedentary	2019, 2021
MNR	COZ031	Mixed	2020
MNR	COZ032	Sedentary	2020
MNR	COZ034	Mixed	2019-2020
MNR	COZ035	Sedentary	2019
MNR	COZ035	Mixed	2020-2021
MNR	COZ036	Unknown	2019
MNR	COZ037	Mixed	2019-2020
MNR	COZ037	Sedentary	2021
MNR	COZ038	Sedentary	2019-2020
MNR	COZ039	Mixed	2019
MNR	COZ039	Sedentary	2020-2021
MNR	COZ040	Mixed	2019
MNR	COZ040	Unknown	2020
MNR	COZ041	Mixed	2019
MNR	COZ042	Mixed	2019-2021
MNR	COZ045	Unknown	2019
MNR	COZ046	Mixed	2019-2020
MNR	COZ047	Mixed	2019-2020
MNR	COZ047	Sedentary	2021
MNR	COZ048	Mixed	2019
MNR	COZ049	Sedentary	2019-2021
MNR	COZ050	Mixed	2019, 2021
MNR	COZ050	Sedentary	2020
MNR	COZ051	Mixed	2019
MNR	COZ052	Sedentary	2021
MNR	COZ052	Mixed	2022-2023
MNR	COZ053	Sedentary	2021-2023
MNR	COZ054	Sedentary	2021
MNR	COZ054	Mixed	2022
MNR	COZ054	Unknown	2023
MNR	COZ055	Mixed	2021-2023

Project	Collar ID	Movement Class	Years
MNR	COZ056	Sedentary	2021-2022
MNR	COZ056	Mixed	2023
MNR	COZ057	Sedentary	2021
MNR	COZ057	Mixed	2022
MNR	COZ058	Sedentary	2021-2023
MNR	COZ059	Sedentary	2021
MNR	COZ059	Unknown	2022
MNR	COZ060	Sedentary	2021
MNR	COZ060	Mixed	2022-2023
MNR	COZ061	Migratory	2021-2023
MNR	COZ062	Mixed	2021, 2023
MNR	COZ062	Sedentary	2022
MNR	COZ063	Mixed	2021-2023
MNR	COZ064	Mixed	2021
MNR	COZ064	Sedentary	2022-2023
MNR	COZ065	Sedentary	2021-2022
MNR	COZ066	Sedentary	2021
MNR	COZ066	Mixed	2022
MNR	COZ067	Sedentary	2021
MNR	COZ067	Mixed	2022
MNR	COZ068	Sedentary	2021
MNR	COZ068	Mixed	2022-2023
MNR	COZ069	Sedentary	2021, 2023
MNR	COZ069	Mixed	2022
MNR	COZ070	Mixed	2021-2022
MNR	COZ071	Mixed	2021
MNR	COZ071	Sedentary	2022-2023
MNR	COZ072	Mixed	2022, 2024
MNR	COZ072	Sedentary	2023
MNR	COZ073	Mixed	2022-2023
MNR	COZ074	Mixed	2022, 2024
MNR	COZ074	Sedentary	2023
MNR	COZ075	Unknown	2022
MNR	COZ076	Mixed	2022
MNR	COZ077	Mixed	2022-2024
MNR	COZ078	Sedentary	2022-2023
MNR	COZ079	Mixed	2022-2024
MNR	COZ080	Mixed	2022-2023
MNR	COZ081	Sedentary	2022
MNR	COZ082	Mixed	2022-2024

Project	Collar ID	Movement Class	Years
MNR	COZ083	Mixed	2022-2024
MNR	COZ084	Mixed	2022
MNR	COZ085	Mixed	2022-2023
MNR	COZ085	Sedentary	2024
MNR	COZ086	Mixed	2022, 2024
MNR	COZ086	Sedentary	2023
MNR	COZ087	Mixed	2022-2024
MNR	COZ088	Mixed	2022-2024
MNR	COZ089	Sedentary	2022, 2024
MNR	COZ089	Mixed	2023
MNR	COZ090	Sedentary	2022
MNR	COZ090	Mixed	2023-2024
MNR	COZ091	Mixed	2022-2024
MNR	COZ092	Mixed	2022-2024
MNR	COZ093	Mixed	2022-2023
MNR	COZ1301	Sedentary	2022
MNR	COZ1301	Mixed	2023
MNR	COZ1301	Unknown	2024
MNR	COZ2401	Sedentary	2022-2024
MNR	COZ3001	Unknown	2022
MNR	COZ3101	Sedentary	2022
MNR	COZ3101	Mixed	2023-2024
MNR	COZ3701	Sedentary	2022-2023
MNR	COZ3701	Mixed	2024
MNR	COZ4201	Mixed	2022-2024
MNR	COZ4901	Mixed	2022
MNR	COZ4901	Sedentary	2023
NRL	151306	Mixed	2023
NRL	151307	Sedentary	2023
NRL	151308	Mixed	2023
NRL	151309	Sedentary	2023
NRL	151310	Mixed	2023
NRL	151311	Mixed	2023
NRL	151312	Migratory	2023
NRL	151313	Mixed	2023
NRL	151314	Sedentary	2023
NRL	151315	Sedentary	2023
NRL	151316	Mixed	2023
NRL	151317	Mixed	2023
NRL	151318	Mixed	2023

Project	Collar ID	Movement Class	Years
NRL	151319	Sedentary	2023
WSR	49123	Unknown	2021
WSR	49124	Migratory	2021-2024
WSR	49125	Migratory	2021
WSR	49127	Migratory	2021-2023
WSR	49127	Unknown	2024
WSR	49128	Mixed	2021
WSR	49128	Sedentary	2022-2023
WSR	49128	Unknown	2024
WSR	49129	Migratory	2021-2024
WSR	49130	Migratory	2021
WSR	49131	Sedentary	2021
WSR	49132	Sedentary	2021-2022
WSR	49133	Migratory	2021
WSR	49133	Unknown	2022
WSR	49134	Migratory	2021
WSR	49134	Unknown	2022
WSR	49135	Migratory	2021-2024
WSR	49136	Migratory	2021-2024
WSR	49137	Migratory	2021-2023
WSR	49138	Migratory	2021-2023
WSR	49138	Unknown	2024
WSR	49139	Migratory	2021-2024
WSR	49140	Migratory	2021-2024
WSR	49141	Migratory	2021-2024
WSR	49142	Migratory	2021-2024
WSR	49143	Migratory	2021-2023
WSR	49144	Migratory	2021-2024
WSR	49145	Migratory	2021-2024
WSR	49146	Migratory	2021-2023
WSR	49146	Unknown	2024
WSR	49302	Migratory	2021-2023
WSR	49303	Migratory	2021
WSR	49304	Migratory	2021-2022
WSR	49305	Migratory	2021-2023
WSR	49305	Unknown	2024
WSR	49306	Migratory	2021-2023
WSR	49306	Unknown	2024

# APPENDIX A (CONT'D)

A7-3: Caribou Category 1 Modelling  
Report-V3



# Predictive Mapping and Development of an RSF for GHD Category 1 (Nursery and High Use Winter) Habitat for the WSR and NRL Environmental Assessment Projects.

September 24<sup>th</sup>, 2025

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# 1 Background:

GHD Category 1 habitat represents important habitat critical for the persistence of caribou, and includes 1) Calving and Nursery Areas, and 2) High use winter areas. In this report I present results from two modelling approaches to map Category 1 habitat. The 1<sup>st</sup> approach uses a mixed-effects model developed recently with MECP to identify the probability of areas belonging to Nursery and High Use Winter areas. A report on the development of the model is available from MECP (Report on Predictive Modelling of Nursery and High Use Winter Areas for Caribou, April 2025). The 2<sup>nd</sup> approach uses GPS collaring data to model seasonal resource selection (RSF) based on collaring data collected for the WSR, NRL, and MFCAR studies, along with data collected by MNR. This data includes the most recent collections of GPS collar data from the studies, and data from MNR within the Missisa and Ozhiski ranges was also included. Together, these mapping efforts provide a robust perspective on predicted occurrence of Category 1 habitat within the WSR and NRL study areas.

## 2 Methods:

### 2.1 Development of GHD Category 1 Habitat Probability Model

A full description of the MECP Category 1 models is available in the report, Report on Predictive Modelling of Nursery and High Use Winter Areas for Caribou, April 2025, and a brief summary is provided here.

**Source Data:** To build the Category 1 habitat models for caribou nursery and winter areas, researchers first drew on the 2019 GHD mapping of existing Category 1 polygons. They treated each polygon as a “case” and paired it with a 10-km buffer “control” ring, creating a matched-design sample frame that captured nearby landscape conditions without excessive overlap among neighboring polygons. Using the GRTS algorithm, they randomly placed about 1 000 points inside the polygons and 10 000 in the surrounding buffers (the ratio varied slightly among polygons) and reserved roughly one-third of the polygons—carefully stratified by size class and spatial distribution—for out-of-sample testing.

Because most original polygon delineations were based on 2012-2013 surveys, land-cover data were “back-cast” in the GMap/LSL system to reflect the disturbance pattern that existed in 2013: all disturbance newer than 2013 was suppressed, disturbance between 1974 and 2013 was frozen, and anything older than 1973 was rolled forward to mature forest. Comparison with independent burn data confirmed the accuracy of this reconstruction.

#### 2.1.1 Candidate Variables:

The full set of candidate predictors—water, harvest, anthropogenic disturbance, high- and low-use linear features, and seasonal use probabilities at several spatial scales—was examined for multicollinearity with variance-inflation factors. One highly correlated interaction term (harvest × high-use linear features) was removed, after which all remaining VIFs were below two. Variables were normalized where necessary, and exploratory analyses indicated that landscape effects were strongest at 5 000–10 000 ha scales.

### 2.1.2 Modelling Methods:

Model building proceeded with stepwise AIC selection (forward–backward) for six separate datasets: nursery and winter areas in each of three range groups. Final models were fitted as generalized linear mixed-effects models with polygon ID as a random term, which best addressed the matched-pair structure and avoided the convergence problems encountered with conditional logistic or Bayesian alternatives. Tests with an unmatched sampling scheme covering entire range boundaries produced similar coefficients, but the matched design provided a cleaner statistical fit.

The selected nursery models associated suitable habitat with greater distance from linear features, higher spring-use probability and open-water proportion, and lower anthropogenic disturbance and harvest. Winter models likewise penalized disturbance and harvest but tended to occur in areas with less open water.

Unlike the GPS-based Category 2 models that estimate seasonal-use probability directly, the Nursery and Winter logistic-regression models were built chiefly as planning tools: they show how likely any location is to serve as a Nursery or high-use Winter Area. Consequently, output is presented as continuous probability surfaces rather than preset Category 1 classes. Together with other information, planners import these probability layers into GIS, combine them with supporting evidence such as field survey data, and then decide whether a site should be formally delineated as Category 1 habitat.

## 2.2 Development of Seasonal RSF Model for Nursery and High-Use Winter Seasons

### 2.2.1 Source data:

The analysis began by assembling and screening the GPS collar data. All relocations were read as an sf object and the animal identifier (AnimID) was converted to a factor. Spatial references for every layer were set to NAD 83 / Ontario MNR Map Zone 10 (EPSG 3161) so that subsequent overlays were exact. Locations falling outside a custom polygon that delimited the current range extent were discarded, ensuring that only movements within the study area were analysed. The filtered dataset was then divided by the recorded Season attribute to create separate Spring and Winter point sets.

All GPS-collar fixes were first read into R as spatial features and the working directory was set to the project's data folder. A shortlist of core attributes—animal identifier (AnimID), date, season flag, planar coordinates (x, y), and timestamp (t)—was declared so that only fields required for subsequent analyses were propagated through the workflow.

### 2.2.2 Delineation of Seasons:

Seasonal membership was assigned using the custom **getSeason** function. For every record the function compared the fix date to calendar boundaries that were chosen to identify seasons based strictly on GHD definitions: Dec 1<sup>st</sup> to March 31<sup>st</sup> for High-Use Winter Habitat, and May 1<sup>st</sup> to July 14<sup>th</sup> for Calving/Nursery Habitat

### 2.2.3 Movement metrics:

Movement metrics of individual caribou were derived with the **getTrackData** function, which relies on the *amt* package. The routine converted the point data to formal track objects referenced to NAD 83 / Ontario MNR Map Zone 10 (EPSG 3161) and preserved ancillary fields such as data source and capture location. Because collar duty cycles sometimes drifted from their nominal schedule, tracks were resampled to an evenly spaced interval supplied by the `sampleRate` argument (expressed in hours). A 20-minute tolerance allowed minor deviations without breaking temporal continuity. The resampling produced bursts of sequential fixes that met the regularity criterion; for each burst the function calculated step vectors (distance and turn angle) with `steps_by_burst()`. Resulting tracks were unpacked back into a flat table and filtered to retain biologically relevant movements only—steps shorter than 50 m, which can indicate collar error or bedding behaviour, and steps longer than 1.2 km, which can indicate GPS outliers, were both excluded.

The final output of these preprocessing steps is a season-tagged, regularly sampled set of movement steps for every collared animal, ready for downstream habitat-selection or movement-behaviour modelling.

### 2.2.4 Separation of Used and Available Points:

To construct the resource-selection design matrix, the script applied a helper function, `make_rsf_data`, to each seasonal subset. Within that function, relocations were first split by animal and individuals with fewer than twenty fixes were removed. Only one point per day per collar was used to reduce pseudo-replication, and to standardize data collection rates across programs (e.g., MNR and project specific data). A 95 % home-range envelope was calculated for every remaining animal using a kernel utilisation distribution (`kernelUD` with the reference bandwidth and an extent factor of 1.5). If the kernel estimator failed—an occasional outcome when fixes were sparse—the code fell back to a minimum-convex polygon buffered by five kilometres. Once the envelope was defined, random “available” points were drawn inside it at a five-to-one ratio relative to the number of observed fixes. All observed fixes were labelled as `status = 1` and assigned a weight of one, whereas the sampled points were labelled `status = 0` and given a design weight equal to the sampling ratio (5) so that the weighted likelihood would remain unbiased. The function returned a single `sf` object that merged used and available points for each season.

### 2.2.5 Environmental covariates:

Environmental covariates were linked to the use and availability points by intersecting them with 3-ha land-system–land-cover polygons for the Missisa and Ozhiski caribou ranges. The initial list of candidate covariates was based on all the biophysical variables used in the original spring and winter Category 2 models, plus two additional variables used in the MECP Category 1 model (distance to high and low use linear features) (Table 1). This initial list was then evaluated for collinearity by assessing variance inflation factor (VIF) and redundant variables `RDIST` (which was correlated with the `HULFDIST` and `LULFDIST`) was removed and this resolved the collinearity issue.

Table 1. Candidate Variable List

Variable Name	Description
ESK_S6	Eskers
TDENLF_S6	Linear Feature Density
DTN_S6	Natural Disturbance
ANT_S6	Anthropogenic Disturbance
CON_S6	Mature Conifer
DEC_S6	Mature Deciduous
MIX_S6	Mature Mixed Wood
LGW_S6	Open Water
LGOP_S6	Open Peatland
LGTP_S6	Treed Peatland
HULFDIST	High-Use Linear Feature Distance
LULFDIST	Low-Use Linear Feature Distance
Range	Factor for caribou range (Ozhiski/Missisa)

### 2.2.6 ML Approach for RSF:

XGBoost (Extreme Gradient Boosting) was used for estimating the RSF, and this is consistent with an earlier report on estimating patterns of seasons use. XGBoost is a supervised machine learning algorithm that implements an efficient and scalable form of gradient boosting for predictive modeling. In this study, XGBoost was used to develop a Resource Selection Function (RSF) model for caribou habitat selection based on environmental covariates. The method builds an ensemble of decision trees in a sequential manner, where each new tree is trained to correct the residual errors of the previous ensemble by minimizing a specified loss function. Model optimization is achieved through gradient descent, which updates predictions based on the gradient of the loss.

Unlike traditional boosting approaches, XGBoost incorporates both L1 and L2 regularization to reduce model complexity and prevent overfitting, which is particularly important when working with high-dimensional ecological data. The algorithm also handles missing values natively and can automatically learn the best direction to take when data are incomplete. Its implementation supports parallelized tree construction and efficient memory usage, making it well-suited for large spatial datasets.

Model was developed and performance evaluated using five-fold cross-validation that respected individual animals as blocks. I used `group_vfold_cv` to group individual animals (defined by AnimalID) rather than random individual points across all animals, preventing information leakage between training and testing partitions and producing a more realistic assessment of predictive skill. Thus, entire sets of point data for a subset of individual animals were used to test model performance. This approach helps assess model generalizability to new individuals and reduces the risk of over-optimism caused by spatial or temporal autocorrelation. This was especially important because a mixed-effect model that would define individual AnimalID as a factor could not be used in the XGBoost analysis.

The dataset was partitioned into five folds, with each fold serving once as the assessment set while the remaining folds were used for model fitting. This resulted in approximately 28% of the data in any fold set aside as assessment data. This approach allowed for the calculation of average performance metrics across folds, such as the area under the receiver operating characteristic curve (AUC), which quantifies the model's ability to discriminate between used and available locations.

Because every row of metrics\_df came from a cv split that used a mutually exclusive set of animals, the spread of AUC values across the five rows provides a direct measure of between-animal variance in predictive skill. Large differences among folds would signal that the model generalises poorly to unseen individuals, whereas a tight cluster of AUC values implies robust transferability across the population.

Of the 5 (fold) models generated for each season, the model that performed the best with the test data was selected as the final model, although the performance of that model is best estimated as the average performance and variability across the 5 model estimates.

## 3 Results

### 3.1 MECP Category 1 Probability Model.

The MECP Category 1 models for Nursery/Calving Areas and High Use Wintering Areas were applied to the Mississa and Ozhiski hexagon-based data layers (Fig. 1) and reveal patterns where landscape conditions are similar to those found in manually mapped Category1 areas. Areas most similar to mapped Category 1 areas are darker red in the figures. The NRL and WSR study areas overlap with areas of moderately high predicted High-Use Winter use, and relatively high predicted Calving/Nursery area use.

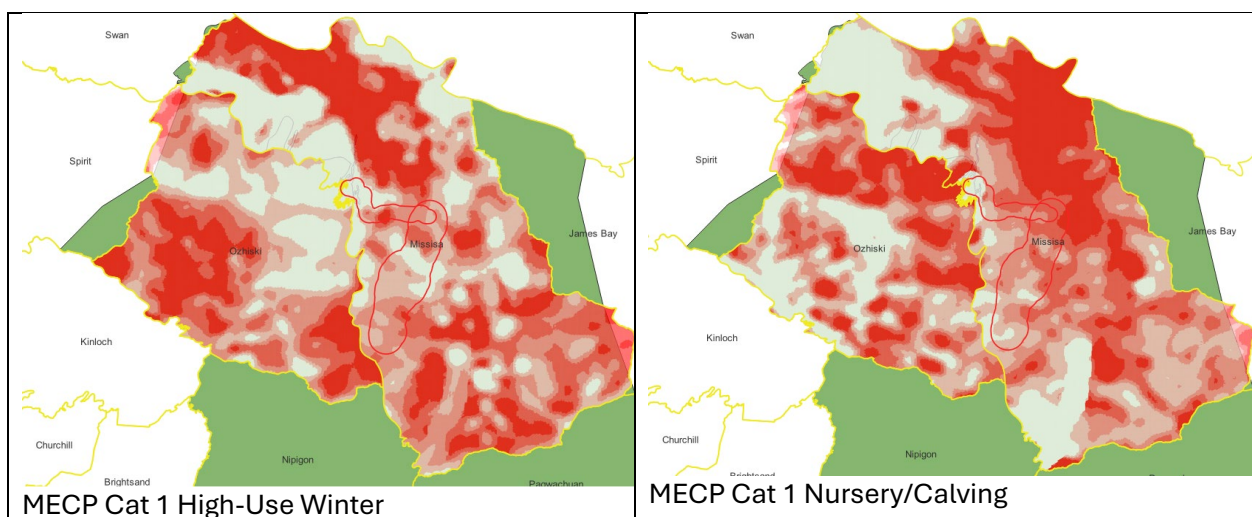


Figure 1: MECP Category 1 High-Use Winter and Nursery/Calving probability

### 3.2 Collar-based RSF Analysis:

GHD seasonal definitions were overlaid on daily movement patterns (Fig. 2) and reveal strong differences in movement activity among seasons. For Calving/Nursery period, the chart suggests this period might better be defined as starting in mid-May, rather than May 1<sup>st</sup>. Both dates were evaluated in terms of RSF models, and there was little difference, so the formal May 1<sup>st</sup> date was retained for selecting points for the Calving/Nursery RSF analysis.

Output from the XGBoost decision tree models included strength of variable influence on the models (Fig. 3), and partial dependence plots (Fig. 4) to reveal the direction and nature of the influence of the variables on the model. For example, percent treed peatland (LGTP) was the most important variable for the winter model and exerted a negative influence for lower values of treed peatland. The sharp increase for the highest percentage should be viewed with caution, as it may be somewhat of an artifact as the high order polynomial curves may be trying to fit sparse data too tightly. For the spring calving model, percent open peatland was the most important variable and also exerted a generally negative influence on the model, while conifer had a positive influence.

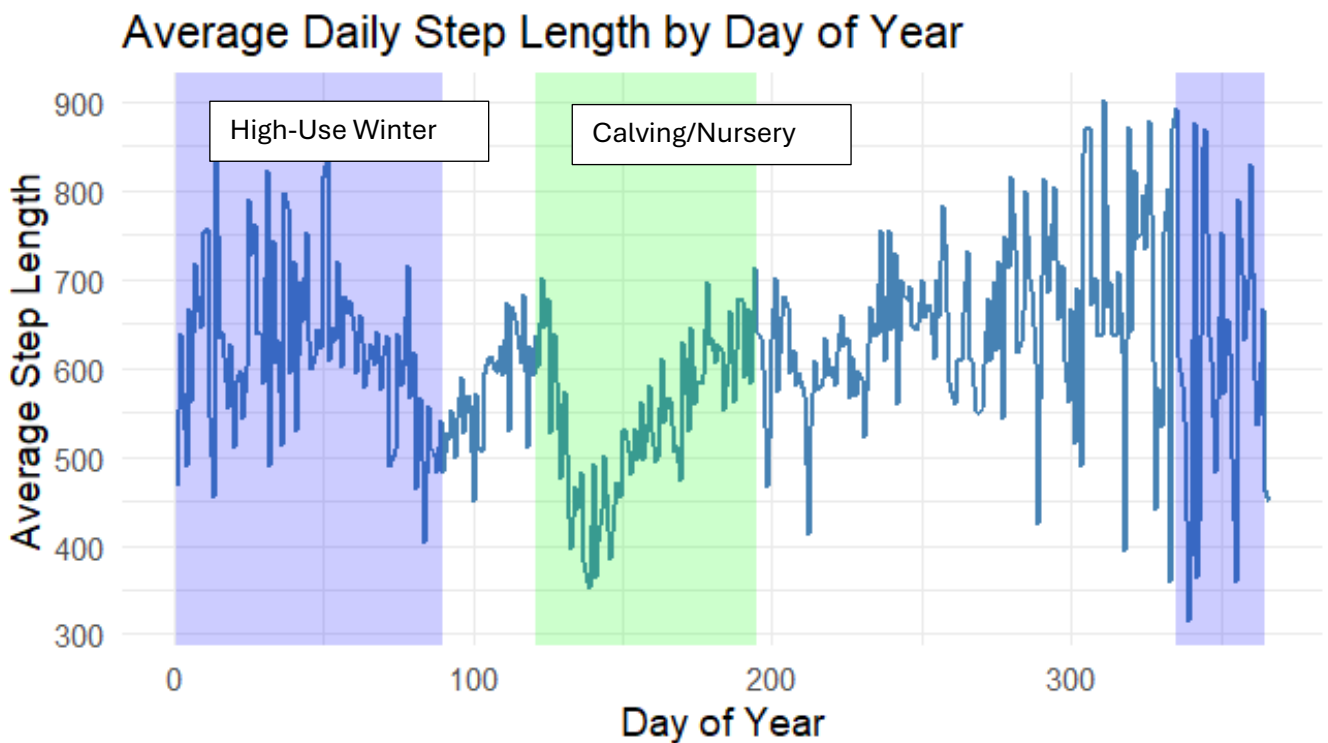


Figure 2: Variance in daily movement rates (step length) among GHD Category 1 periods. Blue shade represents High-Use Winter period, and green shade is Calving/Nursery.

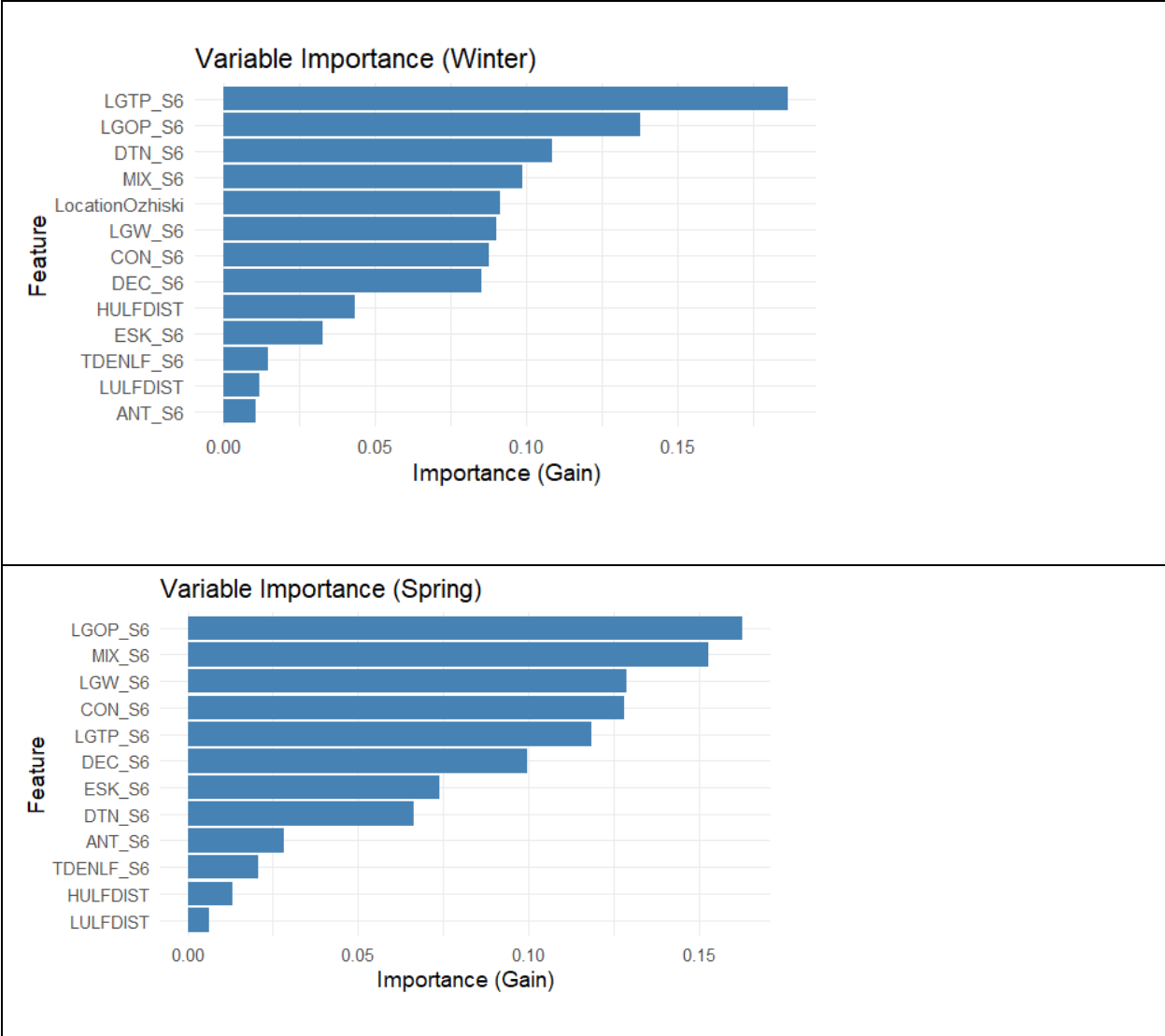


Figure 3: Variable Importance for the XGBoost regression model for High-Use Winter (winter) and Nursery/Calving (spring) models.

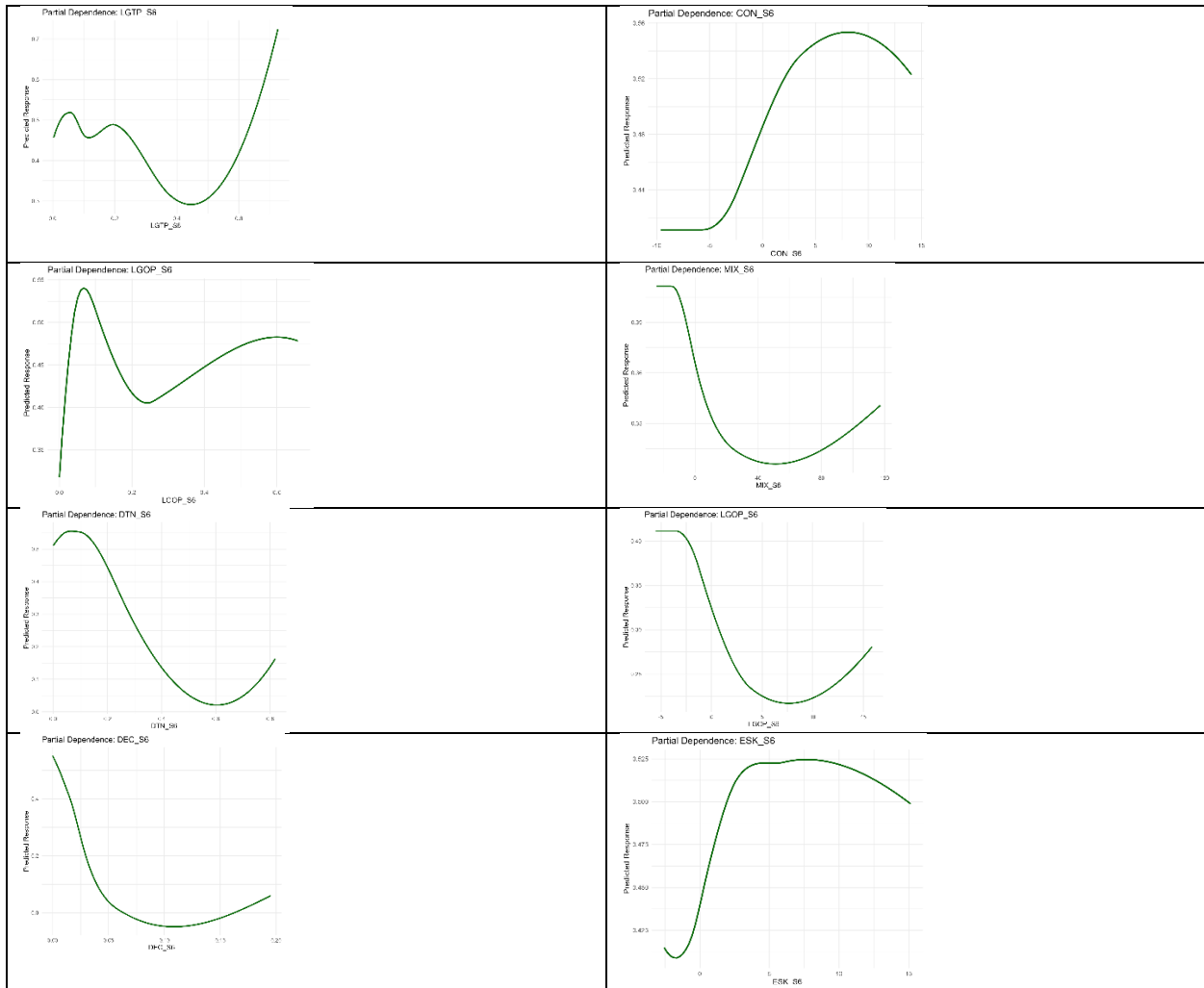


Figure 4: Partial dependence plots for a sub-set of model variables.

Model development and performance was based on 5-fold divisions of the data, with ROC curves (Fig. 5) for each fold representing an important metric of performance. Area under the ROC curves (AUC) was derived by applying the model to a withheld folds of data that was not used in model development. Both models produced acceptable performance, but in general, the winter model performed better than the spring model, with average AUC of 0.747 for the Winter High Use model, and 0.638 for the Spring Calving and Nursery Area model (Tables 2 and 3). For both models, sensitivity and specificity were acceptable, and relatively well balanced. The Winter model had less variance among folds than the Spring model, indicating better extensibility in terms of predicting habitat use to unseen caribou.

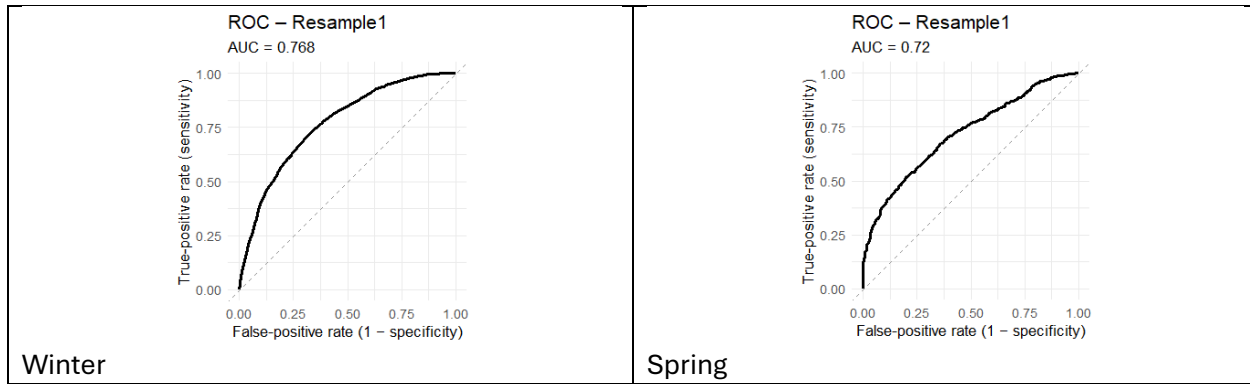


Figure 5: ROC curves for final xgBoost models, with AUC, balanced threshold, sensitivity and specificity.

Table 2. Spring (Nursery) Test Data Metrics

Spring	auc	threshold	sensitivity	specificity
Resample1	0.720	0.035	0.669	0.646
Resample2	0.687	0.039	0.567	0.713
Resample3	0.649	0.038	0.601	0.620
Resample4	0.583	0.034	0.518	0.609
Resample5	0.553	0.036	0.541	0.546
Average	0.638	0.036	0.579	0.627
SD	0.081		0.054	0.062

Table 3. High Winter Use Test Data

Winter	auc	threshold	sensitivity	specificity
Resample1	0.768	0.044	0.705	0.692
Resample2	0.704	0.041	0.654	0.648
Resample3	0.758	0.040	0.722	0.639
Resample4	0.770	0.047	0.706	0.690
Resample5	0.734	0.041	0.679	0.660
Average	0.747	0.043	0.693	0.666
Stand Dev	0.028		0.027	0.024

Maps of predicted use were created by applying the model to a data layer for the entire Ozhiski and Mississa ranges (Figs.6 and 7). These maps based on collar-based models revealed patterns somewhat different than the MECP Category 1 maps, but there were some similarities. For High Use Winter Areas, the NRL study areas overlays predicted high value areas, while NRL is more to the east of this habitat class (Fig. 6). For Spring Calving areas, both WSR and NRL overlap predicted high value areas (Fig. 7).

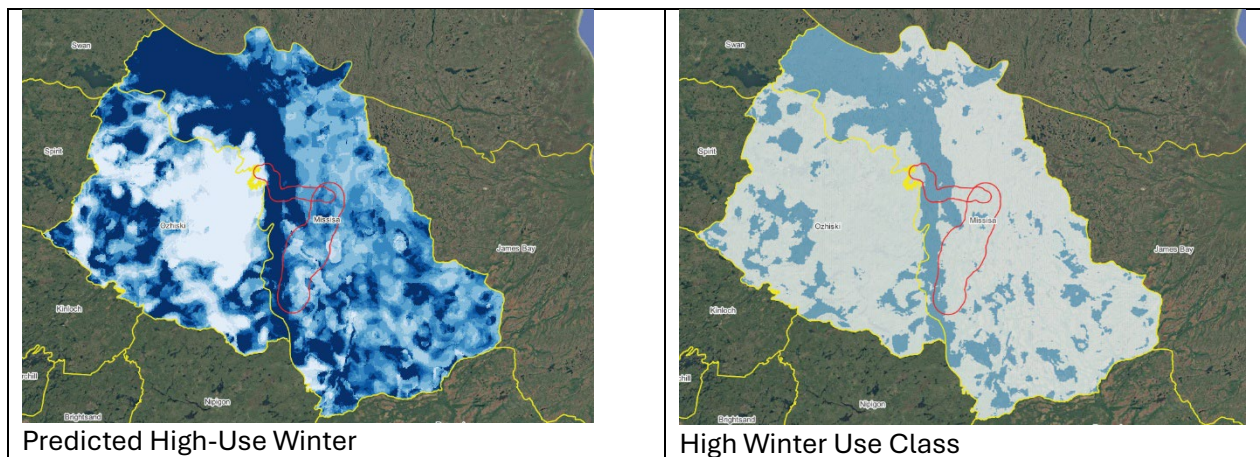


Figure 6: Predicted probability of use for High-Use winter period, and associated classification map for predicted High-Use class, where predicted probability of use exceeds the classification threshold value.

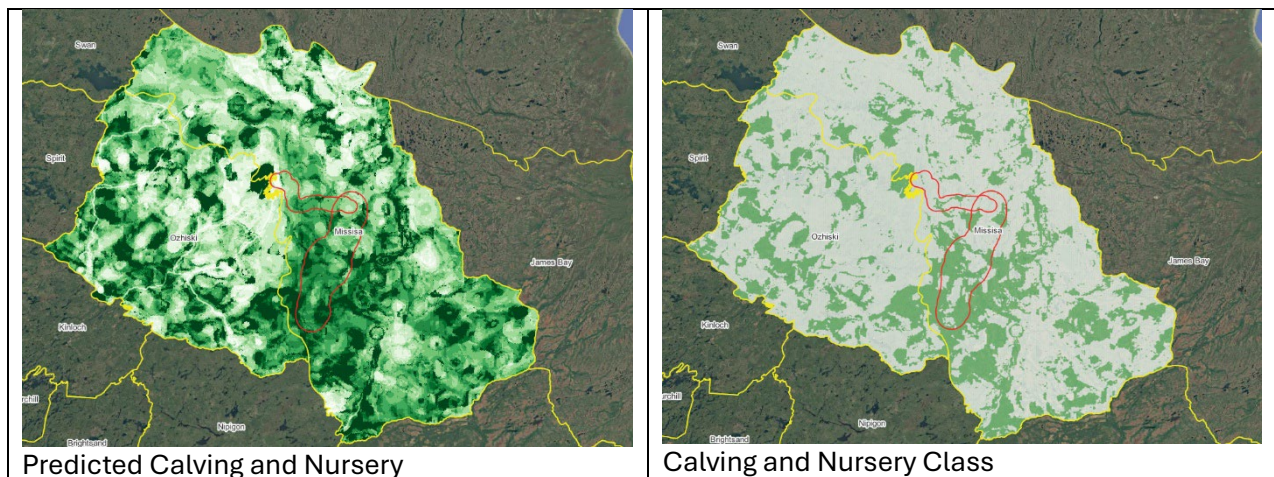


Figure 7: Predicted probability of use for Calving/Nursery spring period, and associated classification map for predicted Calving/Nursery class, where predicted probability of use exceeds the classification threshold value.

### 3.3 Patterns of Use in Relationship to Predicted Habitat Quality

The predicted RSF maps for High-Winter Use and Calving/Nursery Use provide a useful, coarse-filter summary of which areas are predicted to have highest habitat value or quality across multiple years of data collection. However, evaluating the movement patterns of individual caribou, or small groups of caribou over time can help make the maps less abstract, telling a story to help the reader better understand patterns of habitat use relative to both seasonal changes, and variability among years. To facilitate this, movement animations using heat maps, where clusters of individual caribou are tracked spatially overtime, and overlaying these movement patterns on RSF maps for

High-Use Winter and Calving/Nursery periods, were created and saved as video .MP4 animations. Four videos were created to emphasize different aspects of the movement patterns.

Video 1 (General Use) is a broad overview that shows clear differences in the biophysical features of the Ozhiski and Missisa ranges, and the consequences of this on movement behaviour. The Ozhiski range is located firmly in the Canadian shield, and the video reveals that the boreal woodland caribou using this range are non-migratory, with strong fidelity to the range. In contrast, the Missisa range is associated within the Hudson's Bay lowland ecoregion, with a lowland landscape of sparse and stunted spruce that blends into the neighboring James Bay Range, as well as the habitat to the north used by the Southern Hudson Bay Caribou subpopulation of the Eastern Migratory Caribou (COSSARO 2017). The video reveals that many of the caribou using the Missisa Range have much lower fidelity to the range, likely belonging to the Southern Hudson Bay subpopulation, with animals migrating as a group to areas both to the northeast (including Polar Bear Park region), and to the northwest of the woodland ranges, at different times of the year (see figure 6 in COSSARO report).

Video 2 (Spring use) focuses on the relationship between the predicted Calving/Nursery GHD habitat and movement patterns. Clear differences in behaviour are revealed between the two ranges. Of importance for this study is the pattern of use associated with the WSR/NRL regional study areas. Although apparent use of this area differs among years, the area is clearly of importance over the long-term.

Video 3 (Winter use) focuses on the relationship between the predicted High-Use Winter GHD habitat and movement patterns. Again, clear differences in behaviour are revealed between the two ranges, and there is strong use of the WSR/NRL areas across years.

Videos 4 and 5 zoom into the WSR/NRL area to allow the user of the video to explore in more detail patterns of use in the study areas, across seasons and among years, with focus on Winter and Spring Use.

## 4 Appendix 1. Files (Dropbox Folders)

- Saved XGBoost Models and Graphic output (Cat1\_Models\_and\_Plots)
- GIS vector and raster layers for RSF predictions (Cat1\_Prediction\_Maps)
- Videos and point file of caribou movement in relation to RSFs (Caribou\_Movement\_Videos)
- R programs and data files used in RSF modelling (R)

Table A. Category 1 fields in Prediction maps

Field Name	Description
PNA_Use_S	MECP Prediction for Calving/Nursery Area habitat
PWA_Use_S	MECP Prediction for High-Use Winter Area habitat
PredSpr	RSF probability of use for Calving/Nursery Area
Spr_cls	RSF classification for Calving/Nursery Area
PredWin	RSF probability of use for High-Use Winter Area
Win_cls	RSF classification for High-Use Winter Area

## 5 References

CASSARO (2017). Ontario Species at Risk Evaluation Report for Caribou (*Rangifer tarandus*) Eastern Migratory Population

# APPENDIX A (CONT'D)

A7-4: Category 2 and 3 Report for  
Ozhiski and Missasa Ranges



# GHD Category 2 and 3 Mapping Report for Baseline Condition in Ozhiski and Missisa Caribou Ranges (2024)

FERIT Environmental Consulting (Jan 30, 2024)

<https://www.ferit.ca>



## Background

Under the General Habitat Description, Category 2 habitat represents seasonal ranges for caribou, while category 3 is the remaining habitat that may still be used, but has lower value to caribou ([General habitat description for the Forest-dwelling Woodland Caribou | ontario.ca](#)). MECP has taken an RSPF approach to mapping category 2 habitat by mapping each of the 4 seasonal ranges, and is briefly described in methods for State of the Woodland Caribou Resource reports ([State of the Woodland Caribou Resource Report: Part 3 | ontario.ca](#)). More detail is available in Hornseth and Rempel (2016) and Rempel and Hornseth (2017). This method maps potential habitat value based on modelling associations of observed caribou use with land cover, linear features, and other environmental variables.

## Methods

The Category 2 (RSPF) model was based on 7 classes from the Landsat based Provincial Forest Classification (PLC) plus esker lines, mapped forest fires, and anthropogenic linear features (Table 1). Maps of the variables are provided in Appendix - Cat 2 Input Variable Maps, along with PLC class definitions. Calculations are conducted in the specialized GIS program, Landscape Scripting Language (LSL) (Kushneriuk and Rempel 2011), which allows for multiple scale modeling using spatial averaging of hexagons. For caribou Category 2 maps, an intersection of 3-ha hexagons with

landscape variables is conducted first, and then spatial averages generated at the 5,000-ha scale are used for the RSPF analysis. This scale was used because it resulted in the highest performance relative to all other scales that were assessed (Hornseth and Rempel 2016).

Table 1. Variables used in the Category 2 RSPF model.

Variable	Source	Calculation
Dense Deciduous	PLC	Proportion within hexagon
Dense Mixed Forest	PLC	Proportion within hexagon
Dense Conifer	PLC	Proportion within hexagon
Sparse Treed	PLC	Proportion within hexagon
Treed Peatland	PLC	Proportion within hexagon
Open Peatland	PLC	Proportion within hexagon
Water	PLC	Proportion within hexagon
Natural Disturbance	Disturbance mapping	Majority with hexagon
Eskers lines	Topographic map	Density (m/ha)
Linear features – roads, railways, and transmission lines	Anthropogenic disturbance mapping	Density (m/ha)

Forest harvest, aging, and succession change the landcover over time, especially forest cover. Wetlands and other variables remain stable. Of the original PLC model variables, deciduous, mixed forest, and conifer in the PLC were updated in LSL by overlaying disturbance layers and reassigning existing PLC classes to the appropriate disturbance classes.

Within the WSR area, two groups of disturbance under current condition were processed in LSL to update the PLC 2000 map: burns and infrastructure. There was no forest harvest, so this layer was not relevant for the WSR area. The burn layer was from LIO, and disturbance age calculated as current year – burn year. A settlement layer was created from the LIO settlements layer and MNM mines layer by creating a 1 km buffer around existing mines and settlements. If a 3-ha hexagon intersected a burn or harvest disturbance  $\leq 40$  years or a settlement, and proportion was  $> 10\%$  of the hexagon, then mature forest in the hexagon was reclassified to either PLC classes 7 (Burn), 8 (Harvest), or 3 (Settlement). In addition, construction of roads, hydro lines, communication lines and pipelines also remove mature forest. To model this the PLC landcover was updated in LSL to change any mature forest classes in the 3.1 ha hexagon cell (100 m radius) that intersected an anthropogenic linear feature to the Settlement class. The collective effect of this disturbance on the PLC 2000 landcover is shown output as the original PLC updated landcover maps. When net effects are being considered, future condition, proposed mine infrastructure, including project footprint and laydown areas, were added to the appropriate layers, and processed in LSL as a separate scenario.

Linear features have an additional effect on caribou in that they facilitate movement and effectiveness of predators. Vector lines from LIO for roads, railways, and hydro-lines were imported into LSL, and density of these features calculated.

## Results

GHD category 2 and 3 regional range caribou habitat is based on the selective use of landscape features across all 4 seasons. The RSPF models probability of use for each season, and a threshold value for the continuous probability of use is determined above which the habitat is categorized as high use, and therefore contributes to category 2 habitat. A location that has predicted high use for any season is labelled category 2, otherwise in is labelled category 3. The report output includes season specific maps for probability of use, high- and low-use threshold maps, and GHD category 2 and 3 maps. In addition to the category 2 modelling maps, a few of the critical model variable input maps are included, but the full set of variable maps are in the Appendix. Summarized values for across the landscape are provided in Table 2.

Table2. Average probability of use and GHD Category 2 for the Ozhiski and Missisa Caribou Ranges under current conditions (2024).

Variable	Scenario	Range	Season	Mean
<b>Category 2</b>	<b>Current_Condition</b>	<b>Ozhiski</b>	<b>All Seasons</b>	<b>0.6878</b>
Prob High Use	Current_Condition	Ozhiski	Spring	0.2712
Prob High Use	Current_Condition	Ozhiski	Summer	0.4027
Prob High Use	Current_Condition	Ozhiski	Fall	0.4833
Prob High Use	Current_Condition	Ozhiski	Winter	0.3304
Prob of Use	Current_Condition	Ozhiski	Spring	0.1101
Prob of Use	Current_Condition	Ozhiski	Summer	0.0897
Prob of Use	Current_Condition	Ozhiski	Fall	0.1689
Prob of Use	Current_Condition	Ozhiski	Winter	0.1021
<b>Category 2</b>	<b>Current_Condition</b>	<b>Missisa</b>	<b>All Seasons</b>	<b>0.8621</b>
Prob High Use	Current_Condition	Missisa	Spring	0.7195
Prob High Use	Current_Condition	Missisa	Summer	0.5024
Prob High Use	Current_Condition	Missisa	Fall	0.5885
Prob High Use	Current_Condition	Missisa	Winter	0.2814
Prob of Use	Current_Condition	Missisa	Spring	0.1529
Prob of Use	Current_Condition	Missisa	Summer	0.1926
Prob of Use	Current_Condition	Missisa	Fall	0.0338
Prob of Use	Current_Condition	Missisa	Winter	0.1628

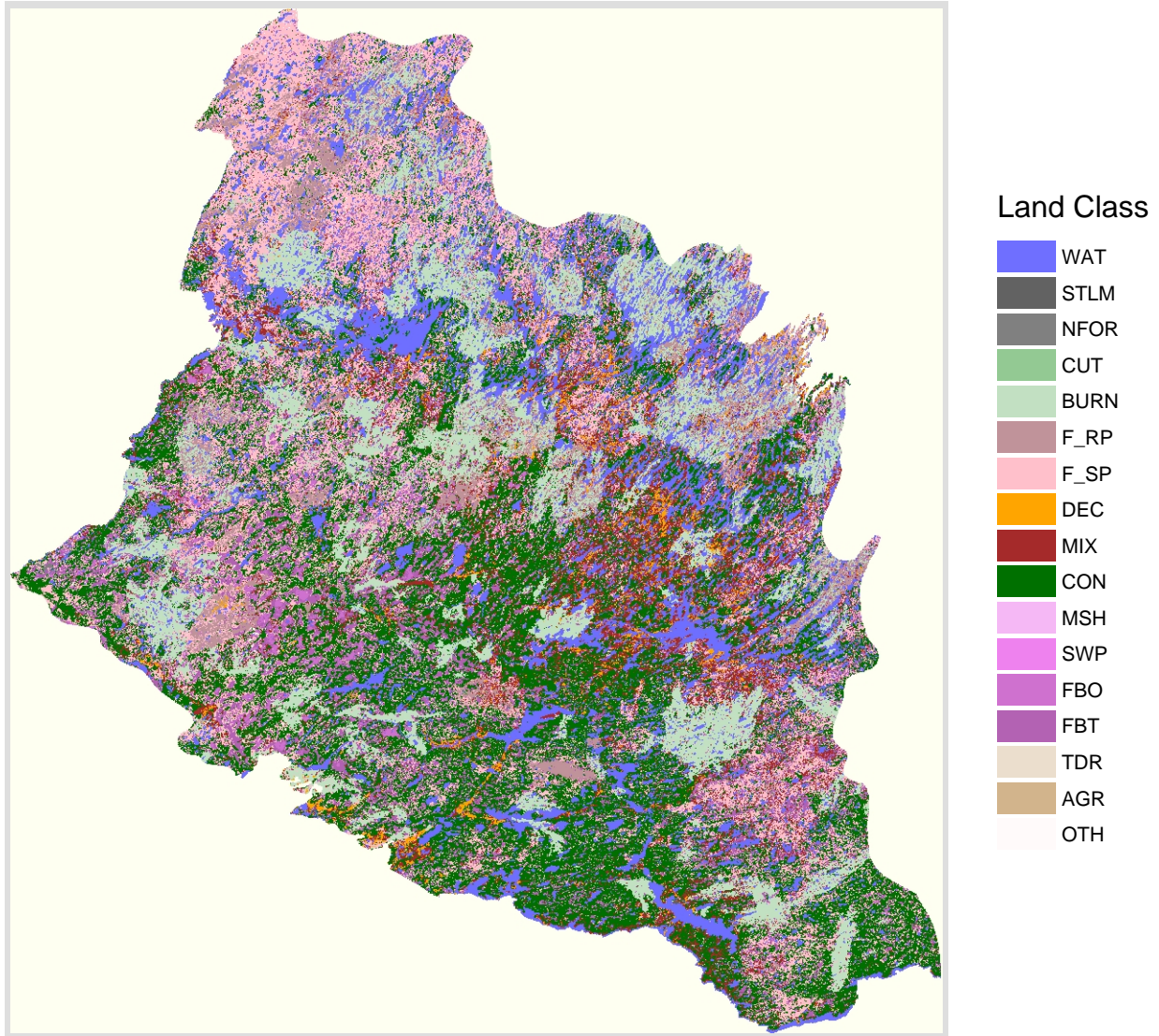
## References

1. <https://www.ontario.ca/page/general-habitat-description-forest-dwelling-woodland-caribou>
2. <https://www.ontario.ca/page/state-woodland-caribou-resource-report-part-3>
3. Kushneriuk, R. S., and R. S. Rempel. 2011. LSL- Landscape Scripting Language Ontario Ministry of Natural Resources, Centre for Northern Forest Ecosystem Research, Thunder Bay, Ontario.
4. Hornseth, M. L., and R. S. Rempel. 2016. Seasonal resource selection of woodland caribou (*Rangifer tarandus caribou*) across a gradient of anthropogenic disturbance. *Canadian Journal of Zoology* 94:79-93. Kushneriuk, R. S., and R. S.
5. Rempel, R. and M. Hornseth. 2018. Range-specific seasonal resource selection probability functions for 13 caribou ranges in Northern Ontario. Ontario Ministry of Natural Resources and Forestry

3.1

### Category 2 Mapping for Ozhiski Range - Current\_Condition

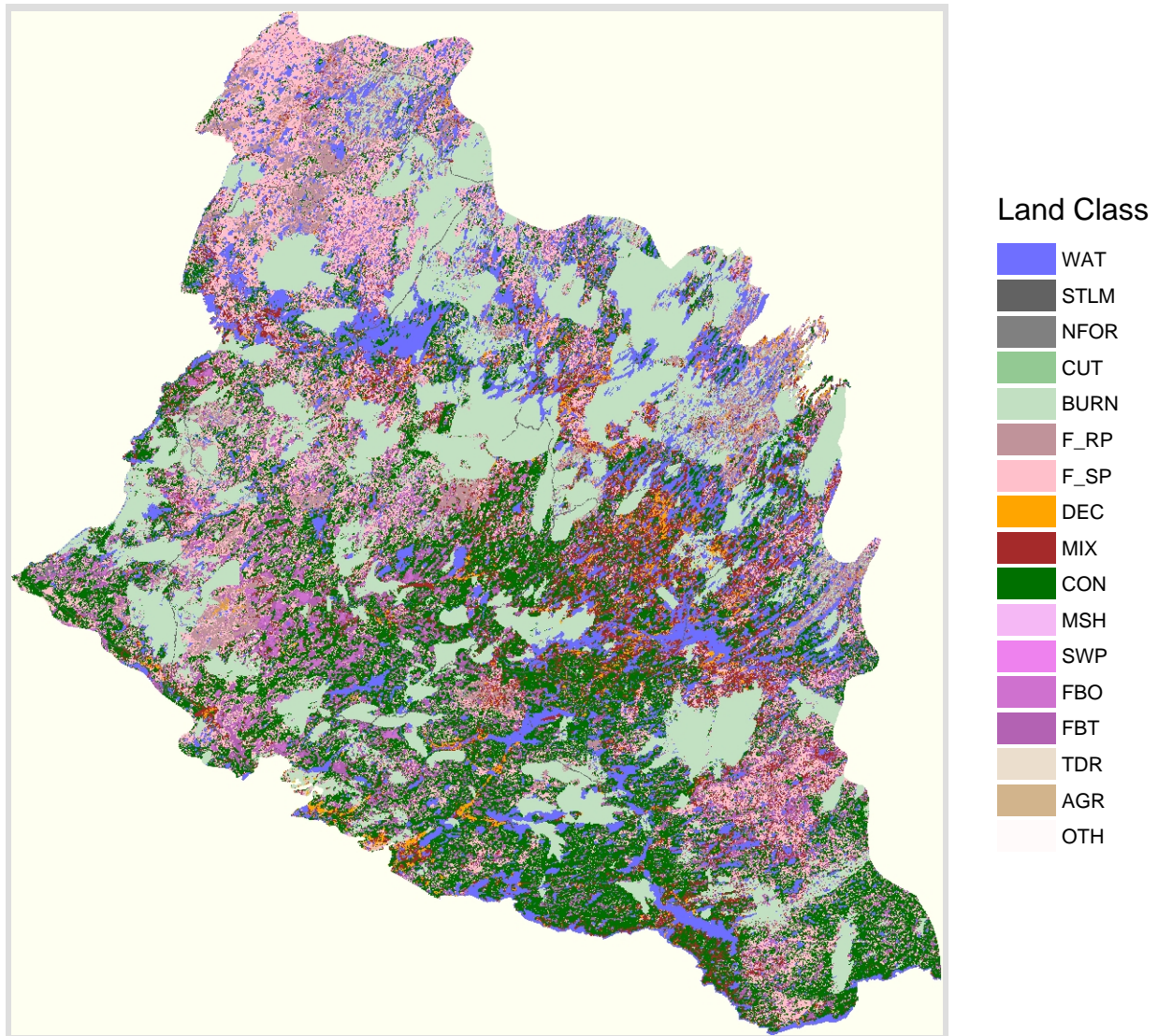
Original Land Cover Class (2000) within the Ozhiski Caribou Range



3.1

### Category 2 Mapping for Ozhiski Range - Current\_Condition

Updated Land Cover Class within the Ozhiski Caribou Range

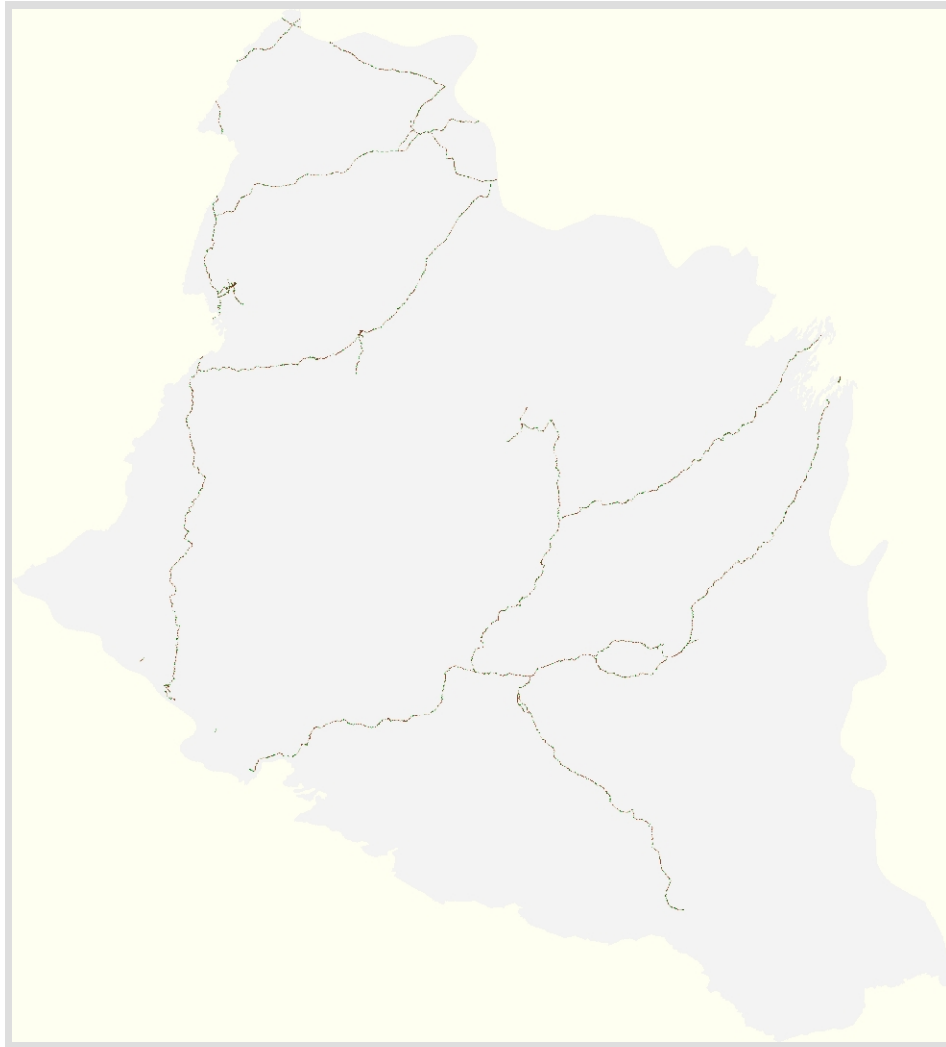


0 50 100 km

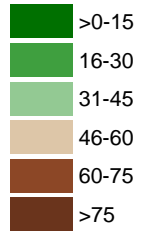
3.1

### Category 2 Mapping for Ozhiski Range - Current\_Condition

#### Roads within the Ozhiski Caribou Range



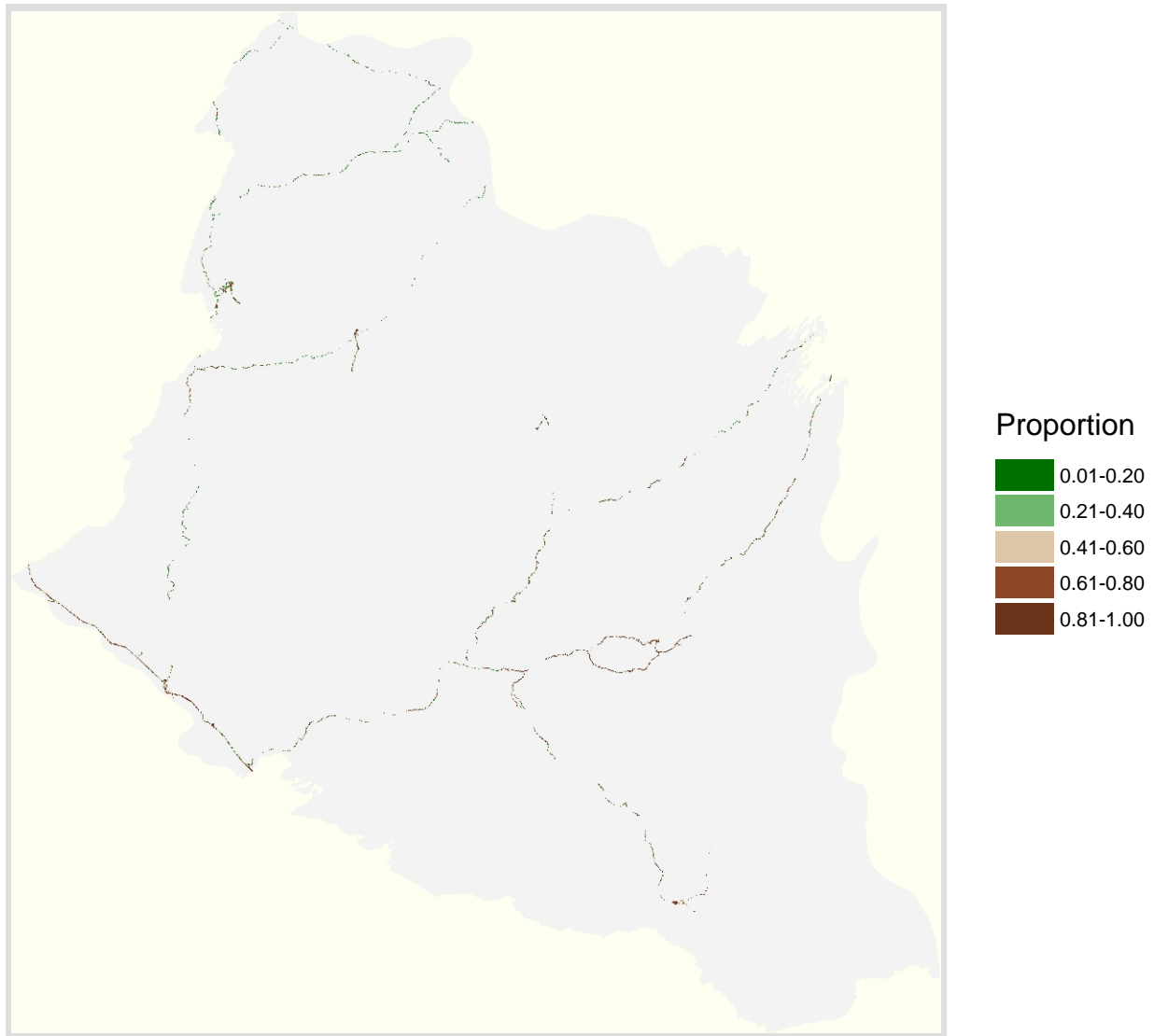
Density m/ha



3.1

### Category 2 Mapping for Ozhiski Range - Current\_Condition

Settlements and Infrastructure (PLC Updated) within the Ozhiski Caribou Range

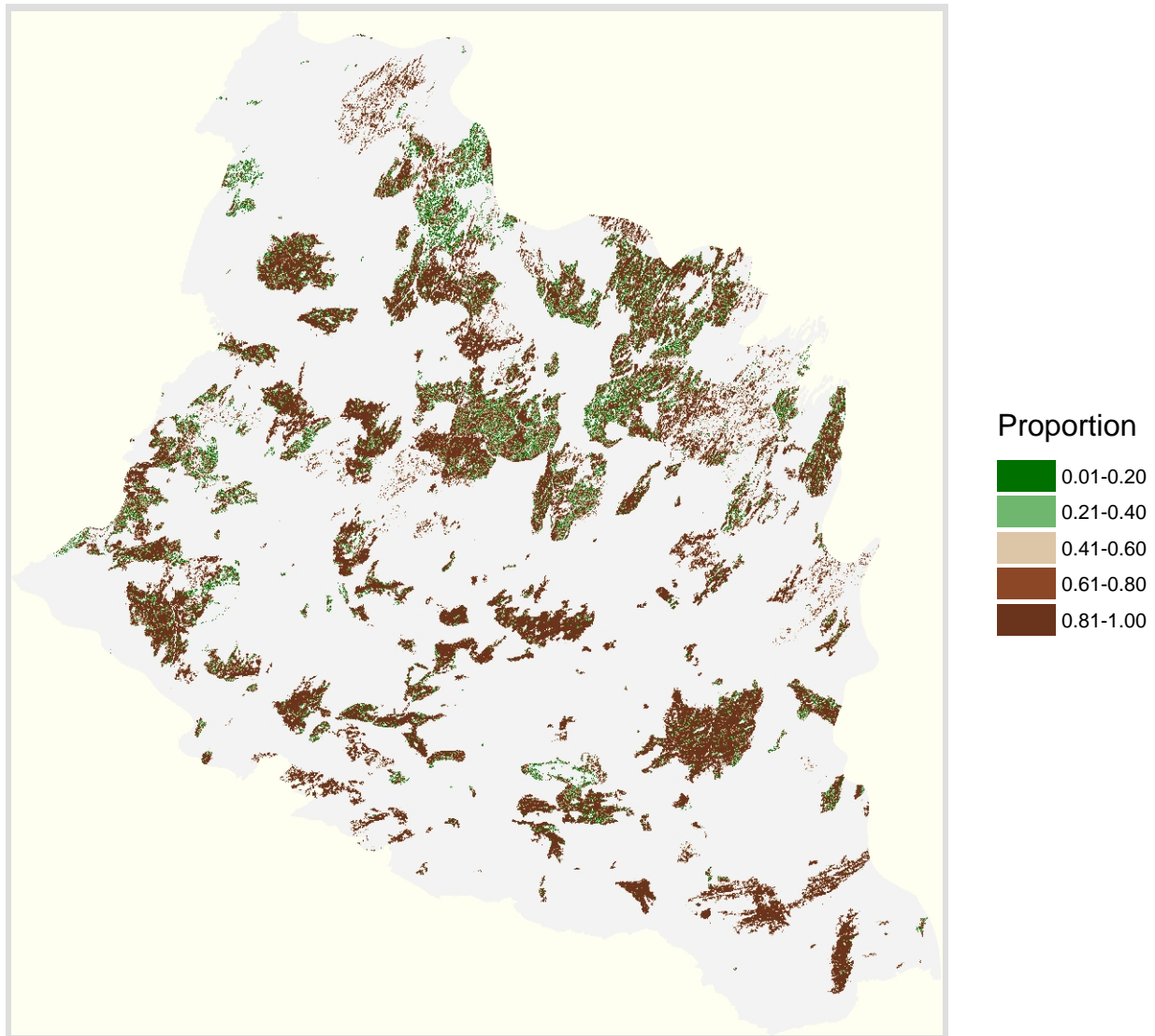


0 50 100 150 km

3.1

## Category 2 Mapping for Ozhiski Range - Current\_Condition

Natural Disturbance (PLC Updated) within the Ozhiski Caribou Range

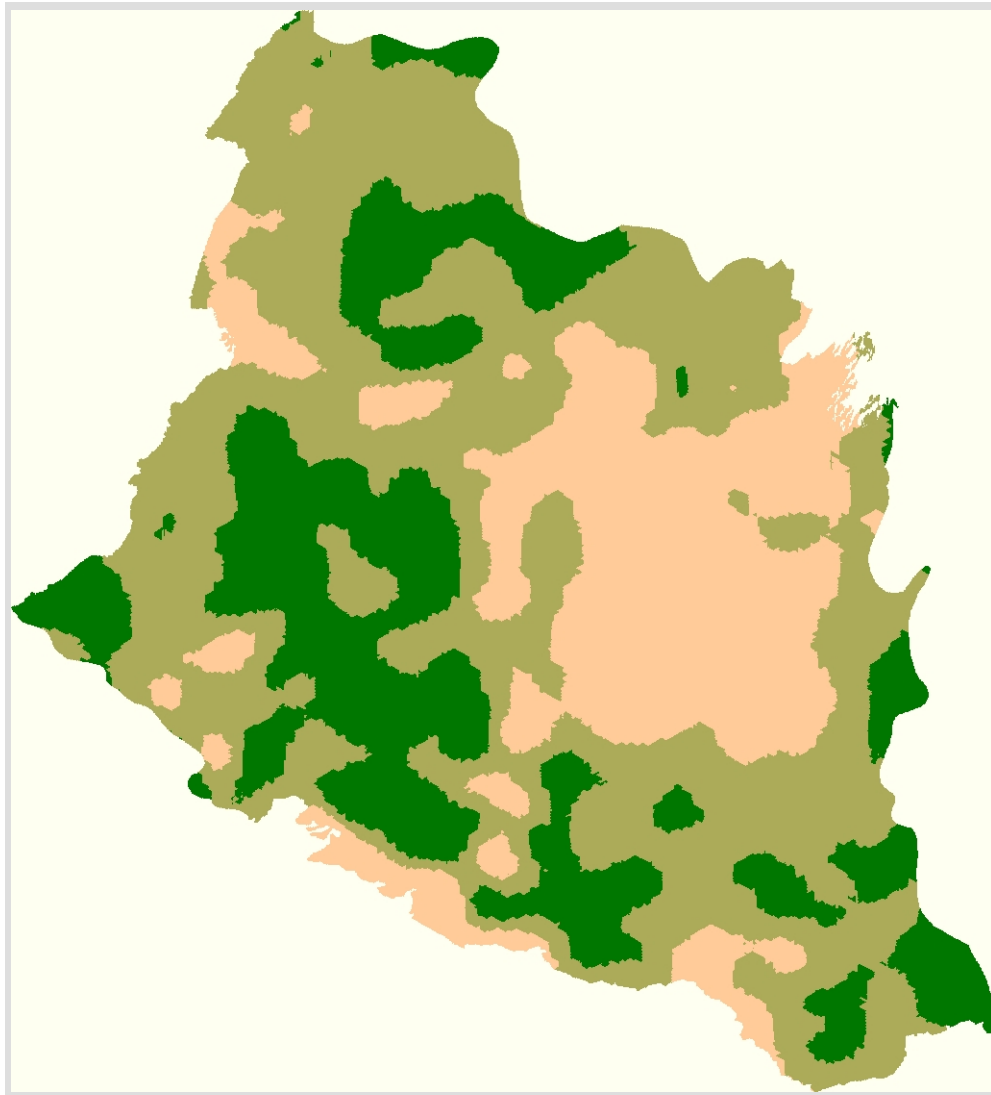


0 50 100 150 km

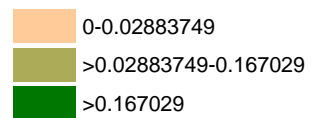
3.1

### Category 2 Mapping for Ozhiski Range - Current\_Condition

Probability of Spring Use within the Ozhiski Caribou Range



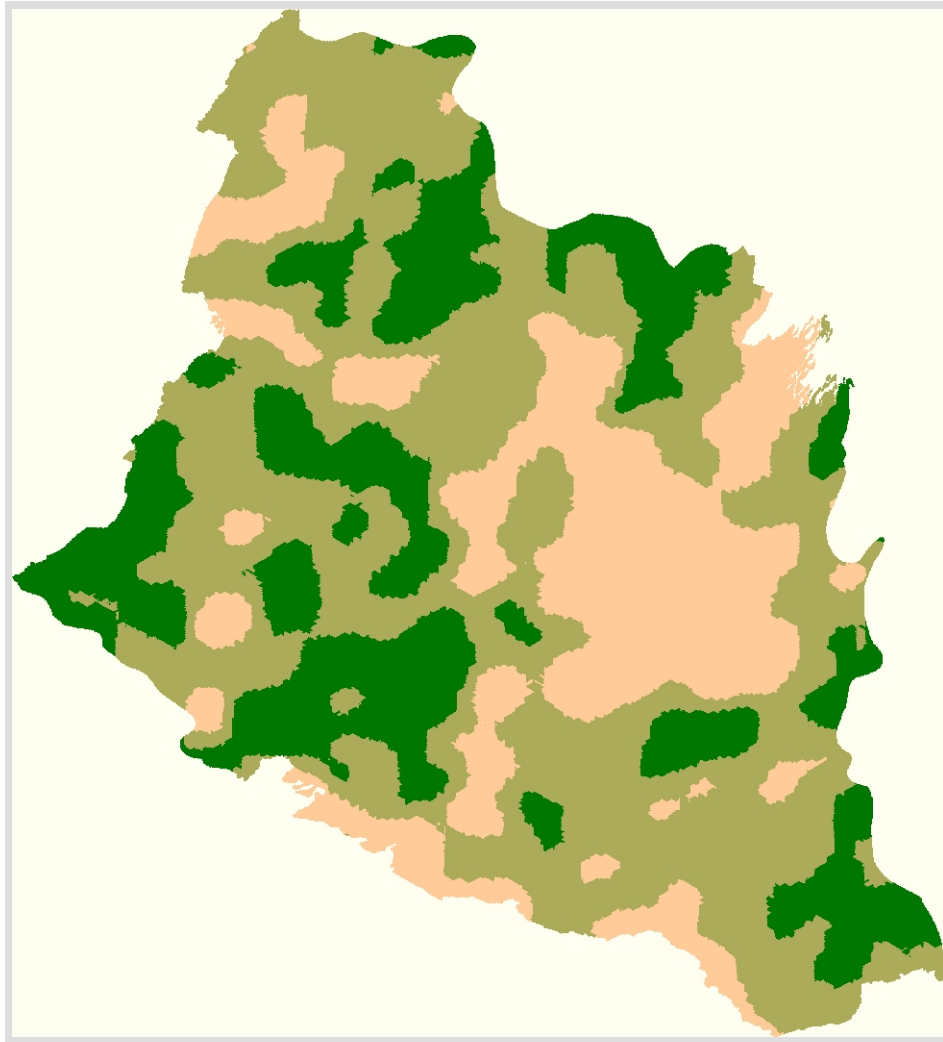
Probability of Spring Use



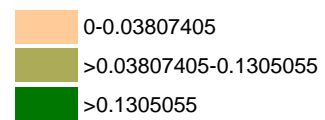
3.1

### Category 2 Mapping for Ozhiski Range - Current\_Condition

Probability of Summer Use within the Ozhiski Caribou Range



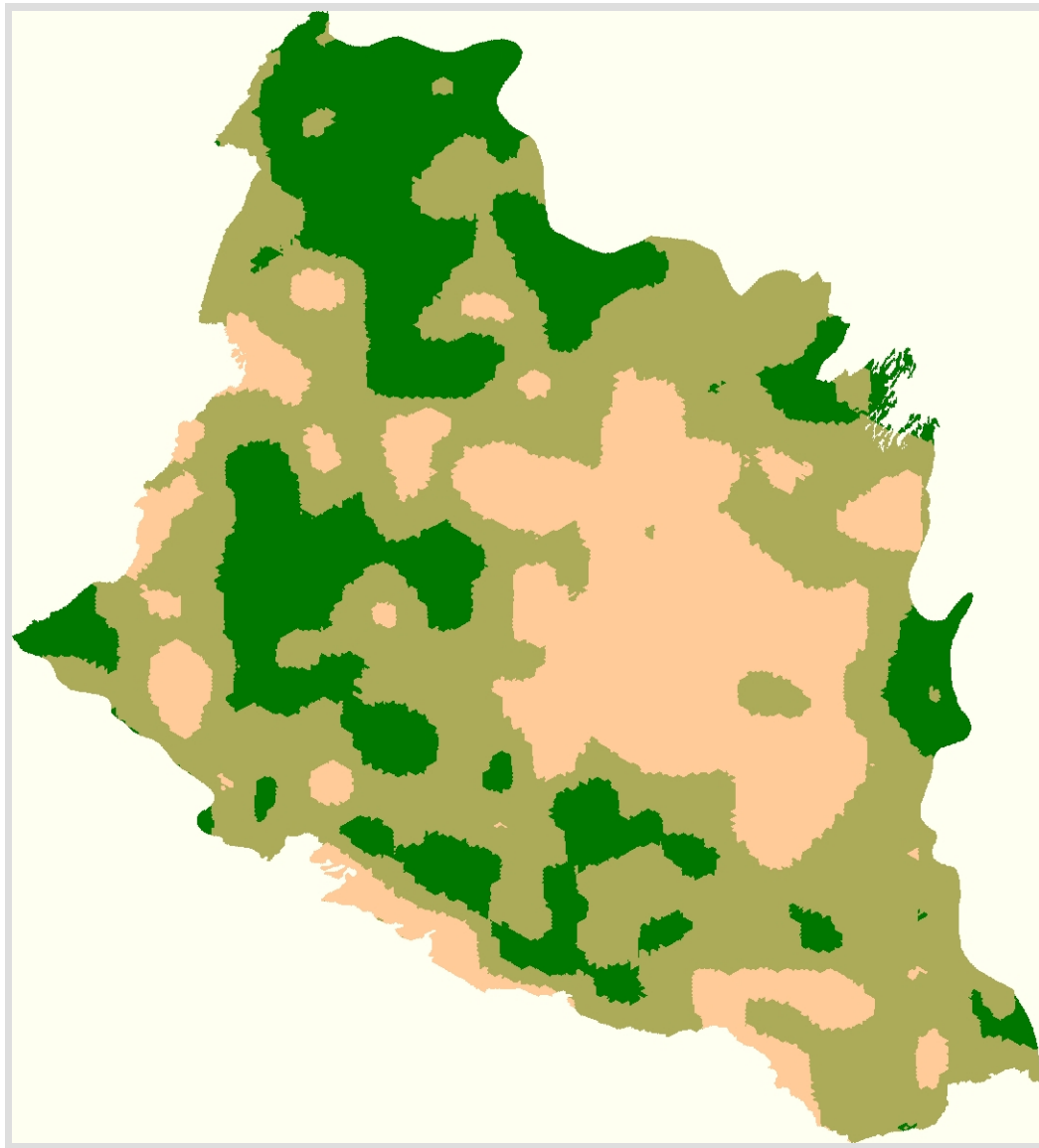
Probability of Summer Use



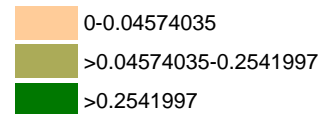
3.1

### Category 2 Mapping for Ozhiski Range - Current\_Condition

Probability of Fall Use within the Ozhiski Caribou Range



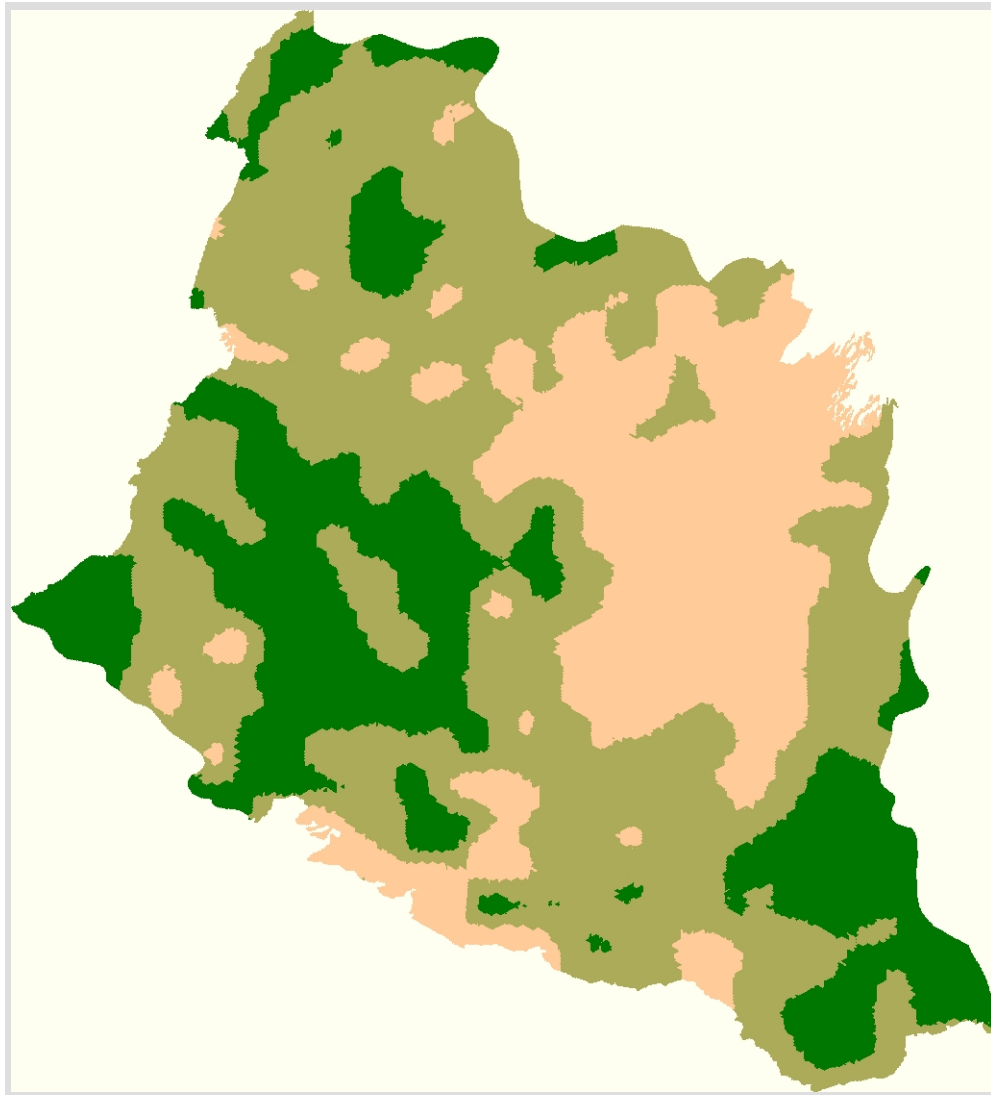
Probability of Fall Use



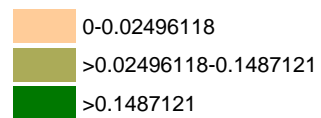
3.1

### Category 2 Mapping for Ozhiski Range - Current\_Condition

Probability of Winter Use within the Ozhiski Caribou Range



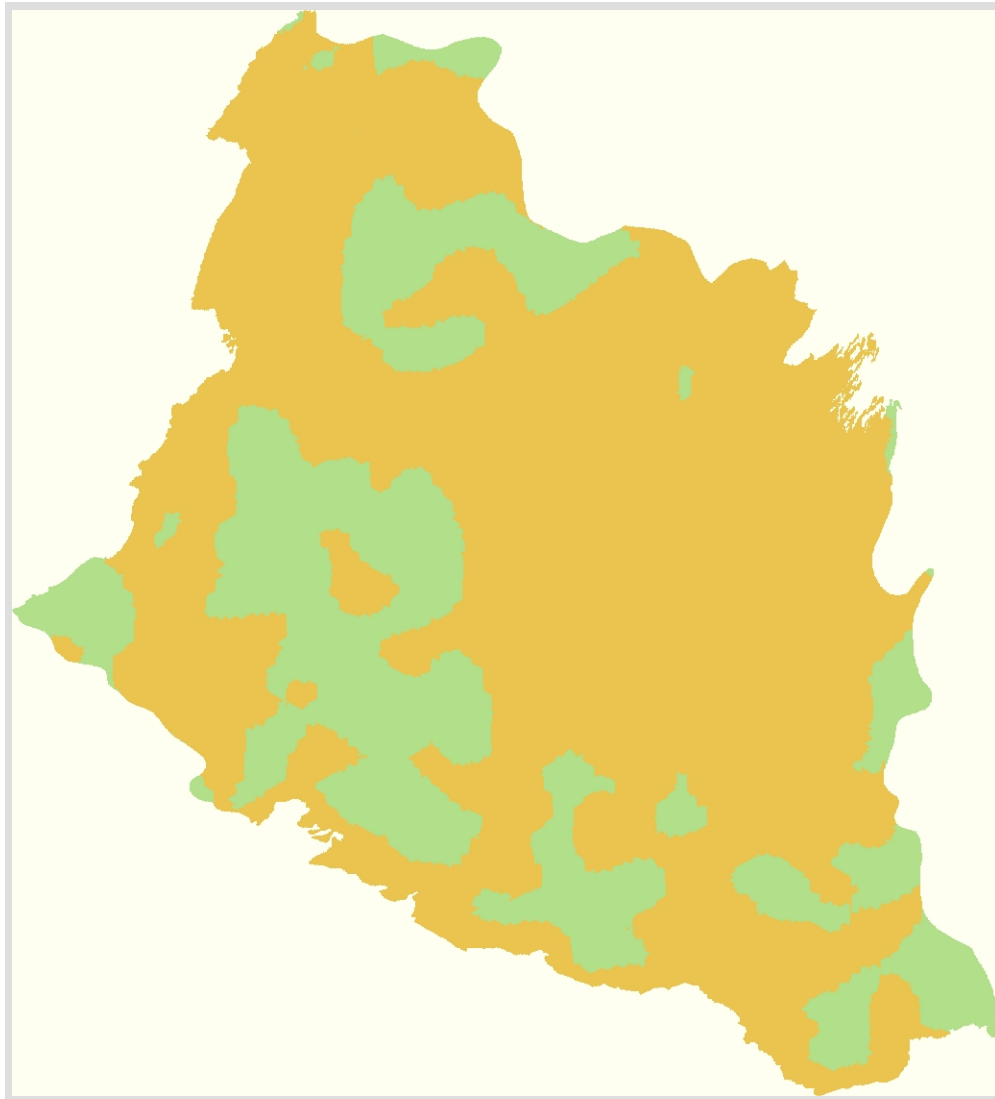
Probability of Winter Use



3.1

### Category 2 Mapping for Ozhiski Range - Current\_Condition

Categorized: Spring Use within the Ozhiski Caribou Range



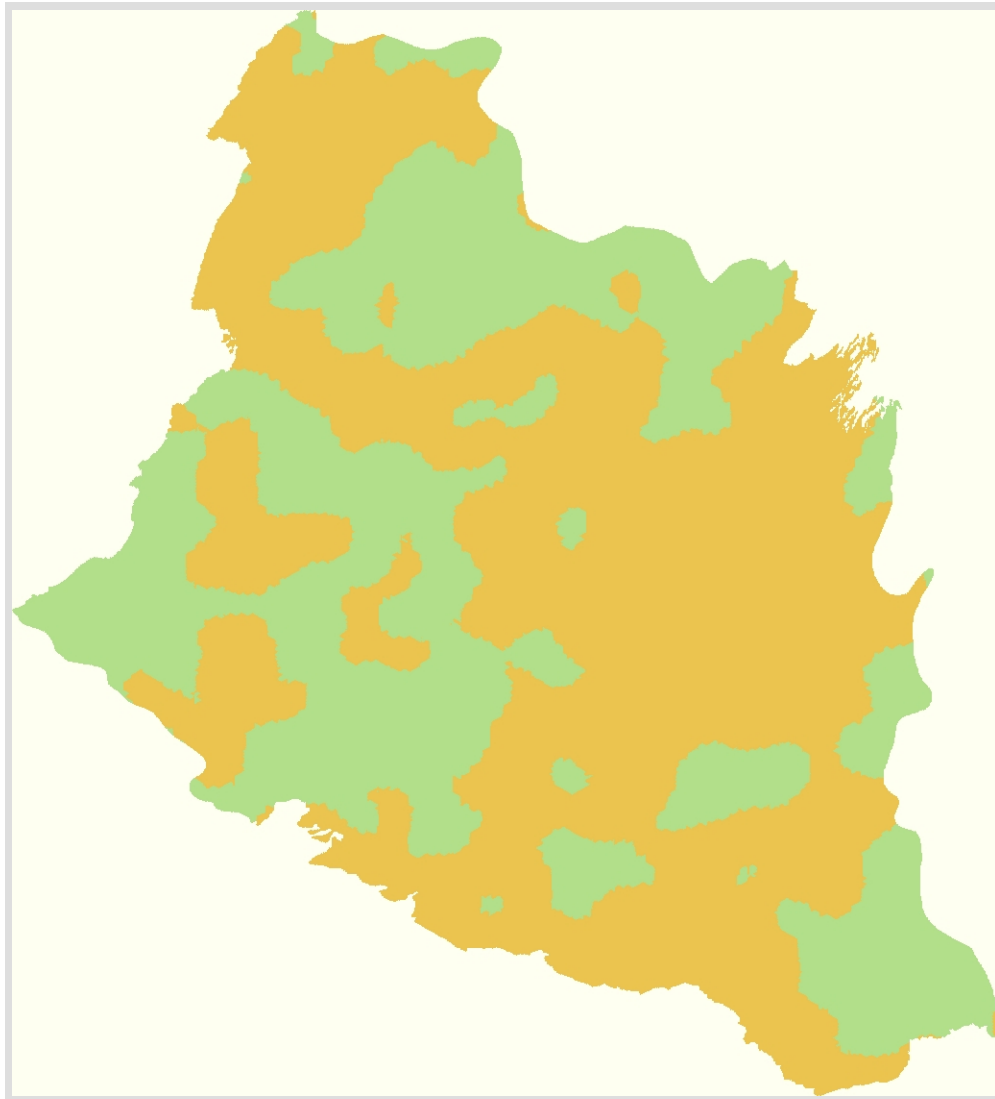
Prob. Class Spring Use



3.1

### Category 2 Mapping for Ozhiski Range - Current\_Condition

Categorized: Summer Use within the Ozhiski Caribou Range



Prob. Class Summer Use

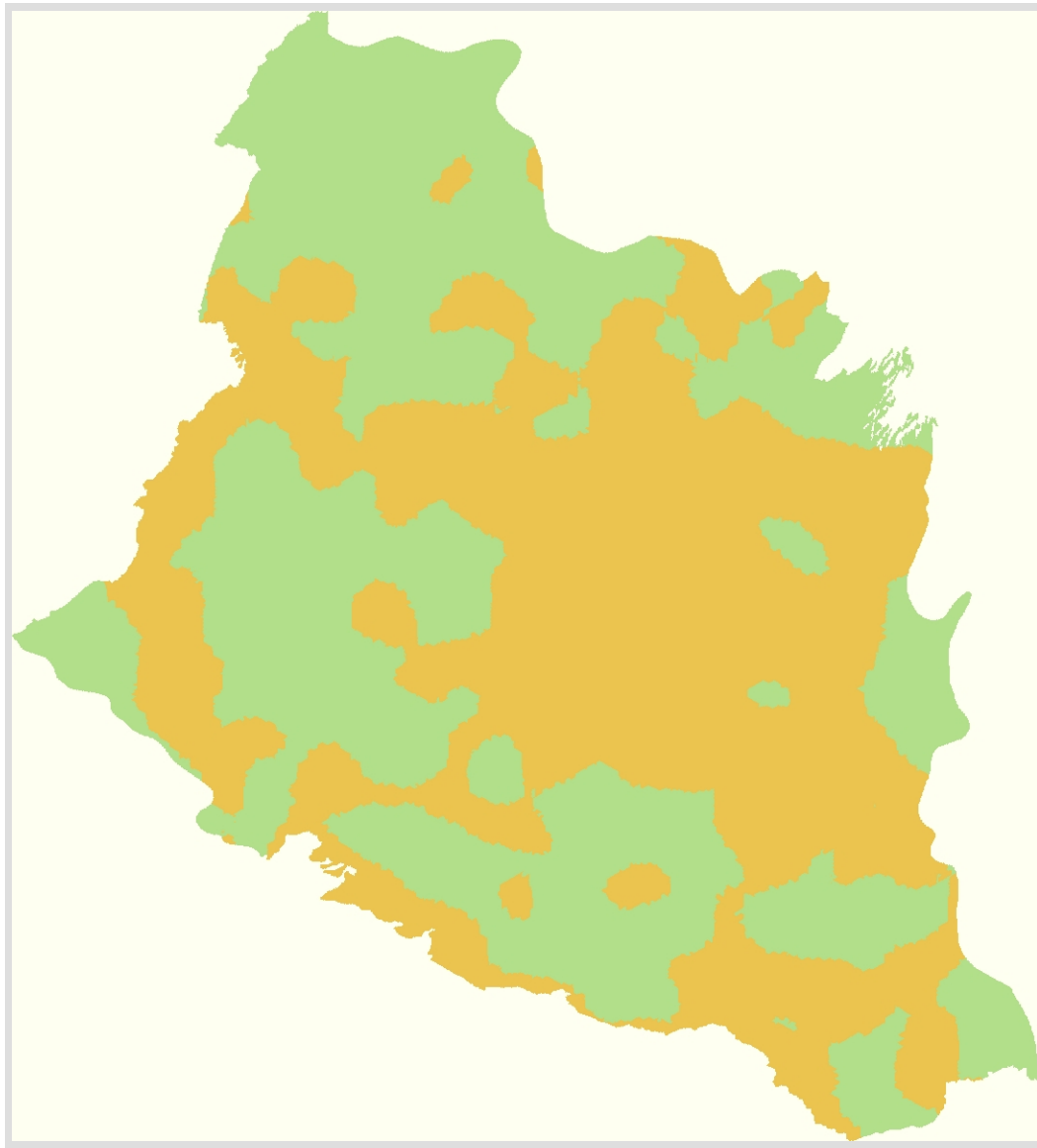
- Low
- High



3.1

### Category 2 Mapping for Ozhiski Range - Current\_Condition

Categorized: Fall Use within the Ozhiski Caribou Range



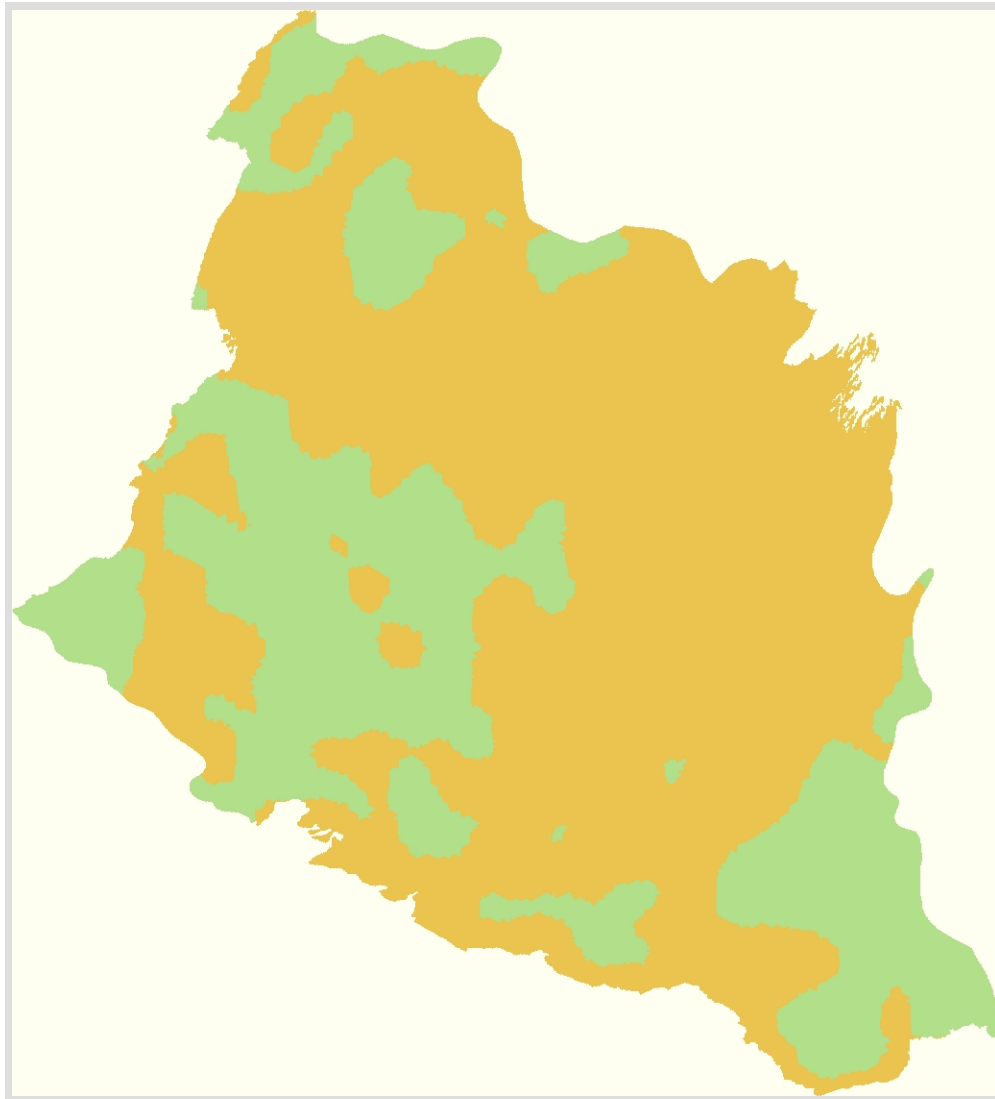
Prob. Class Fall Use



3.1

### Category 2 Mapping for Ozhiski Range - Current\_Condition

Categorized: Winter Use within the Ozhiski Caribou Range



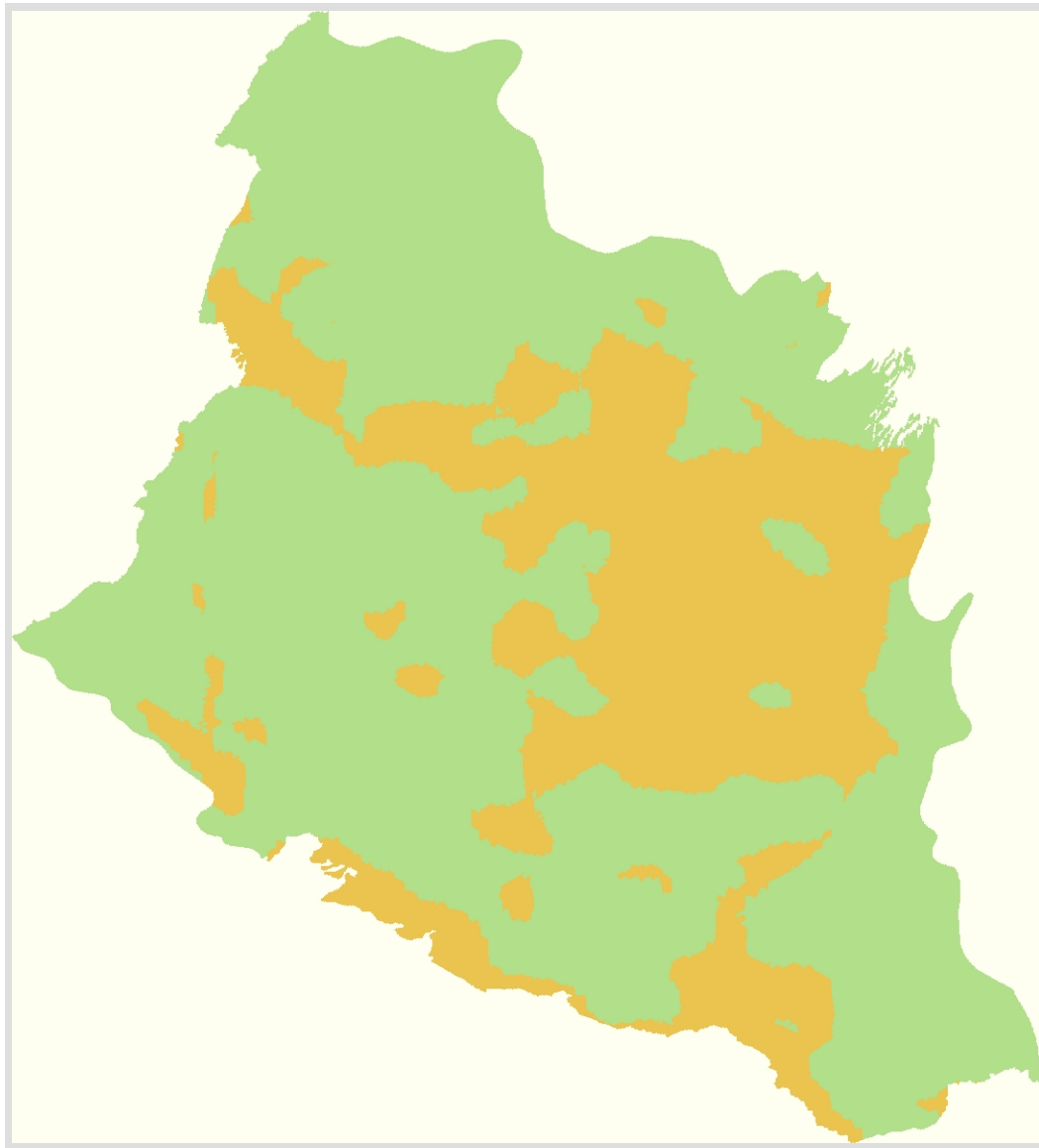
Prob. Class Winter Use



3.1

### Category 2 Mapping for Ozhiski Range - Current\_Condition

GHD Category 2 and 3 within the Ozhiski Caribou Range



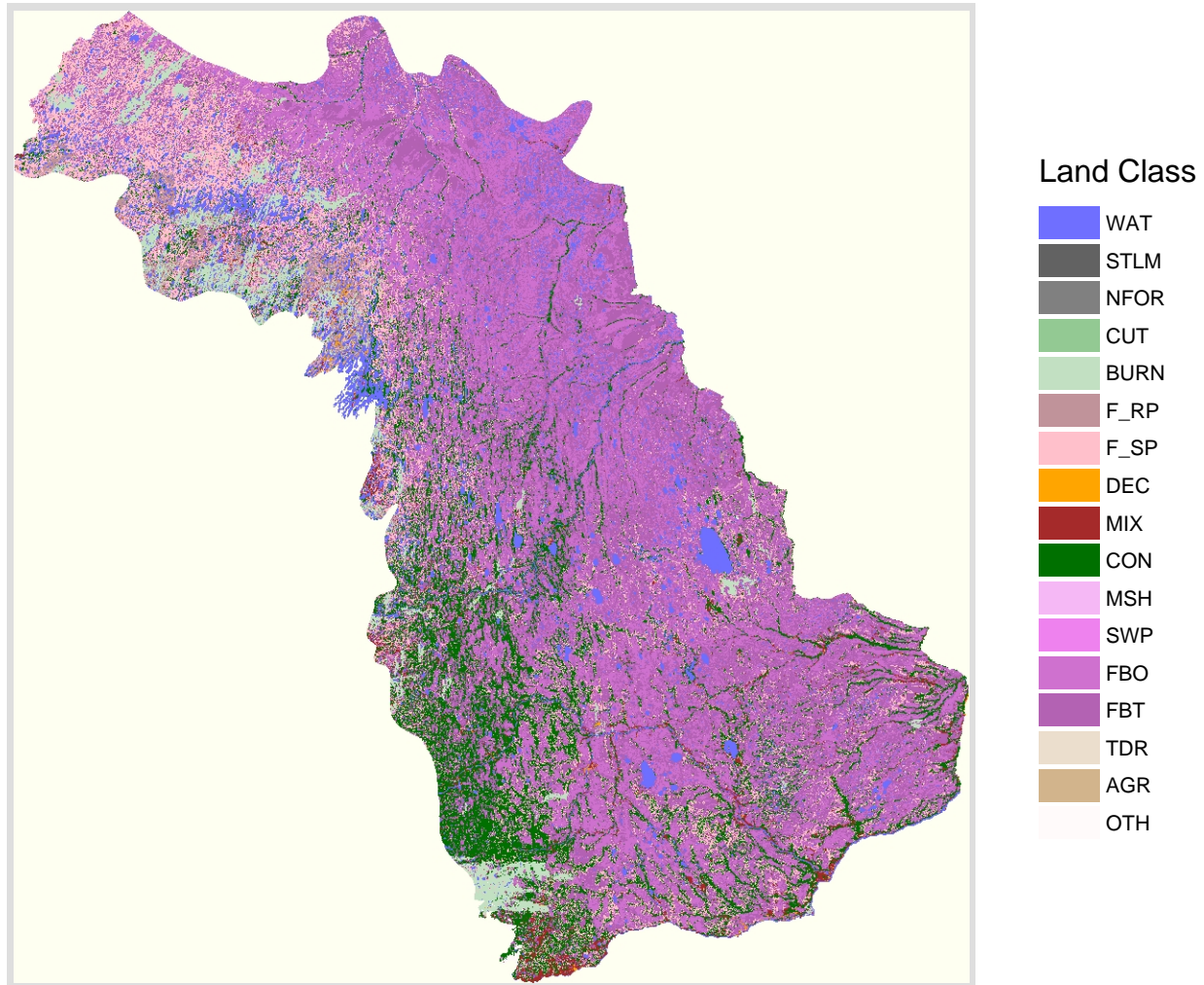
GHD Category



3.1

### Category 2 Mapping for Missisa Range - Current\_Condition

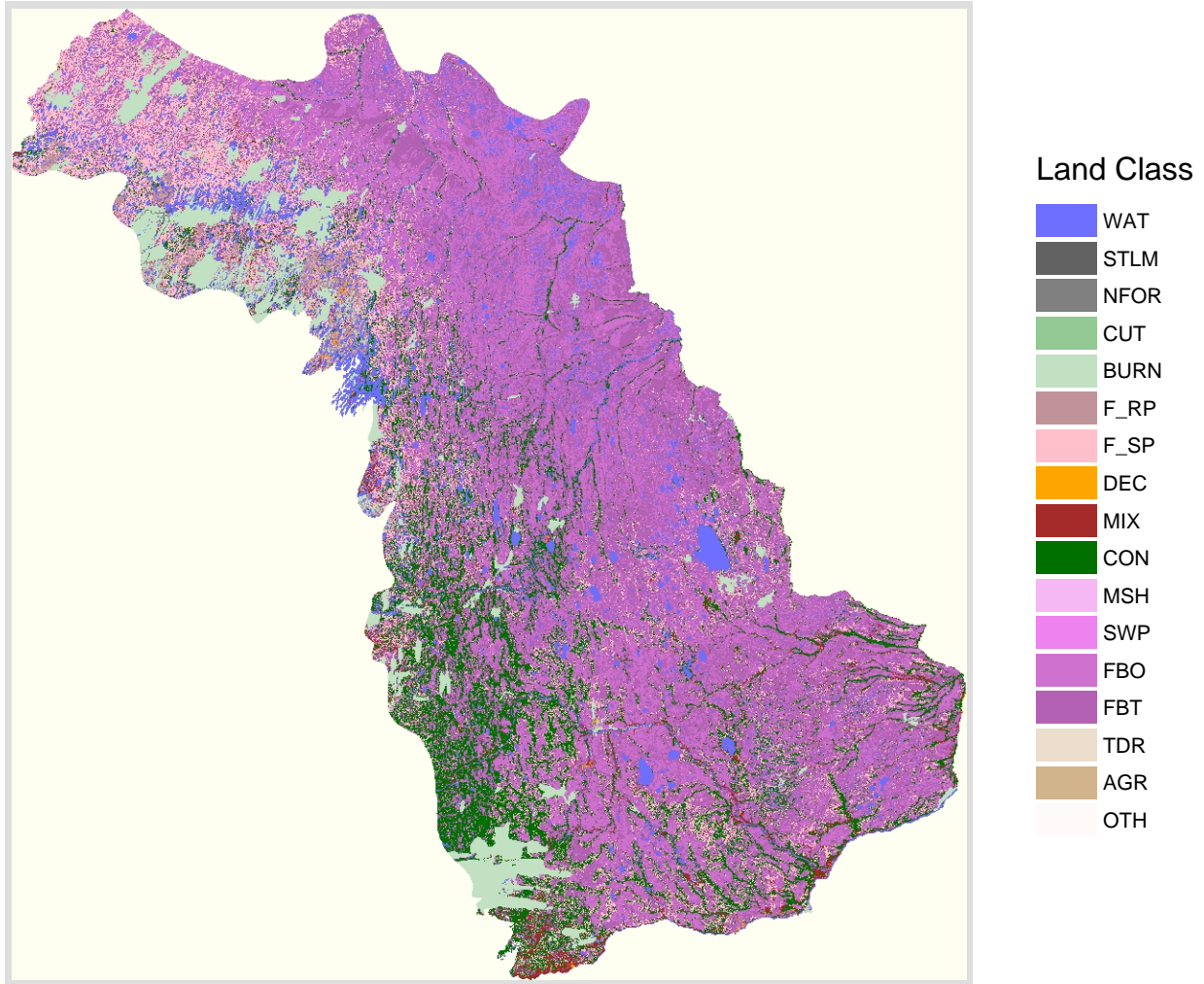
Original Land Cover Class (2000) within the Missisa Caribou Range



3.1

# Category 2 Mapping for Missisa Range - Current\_Condition

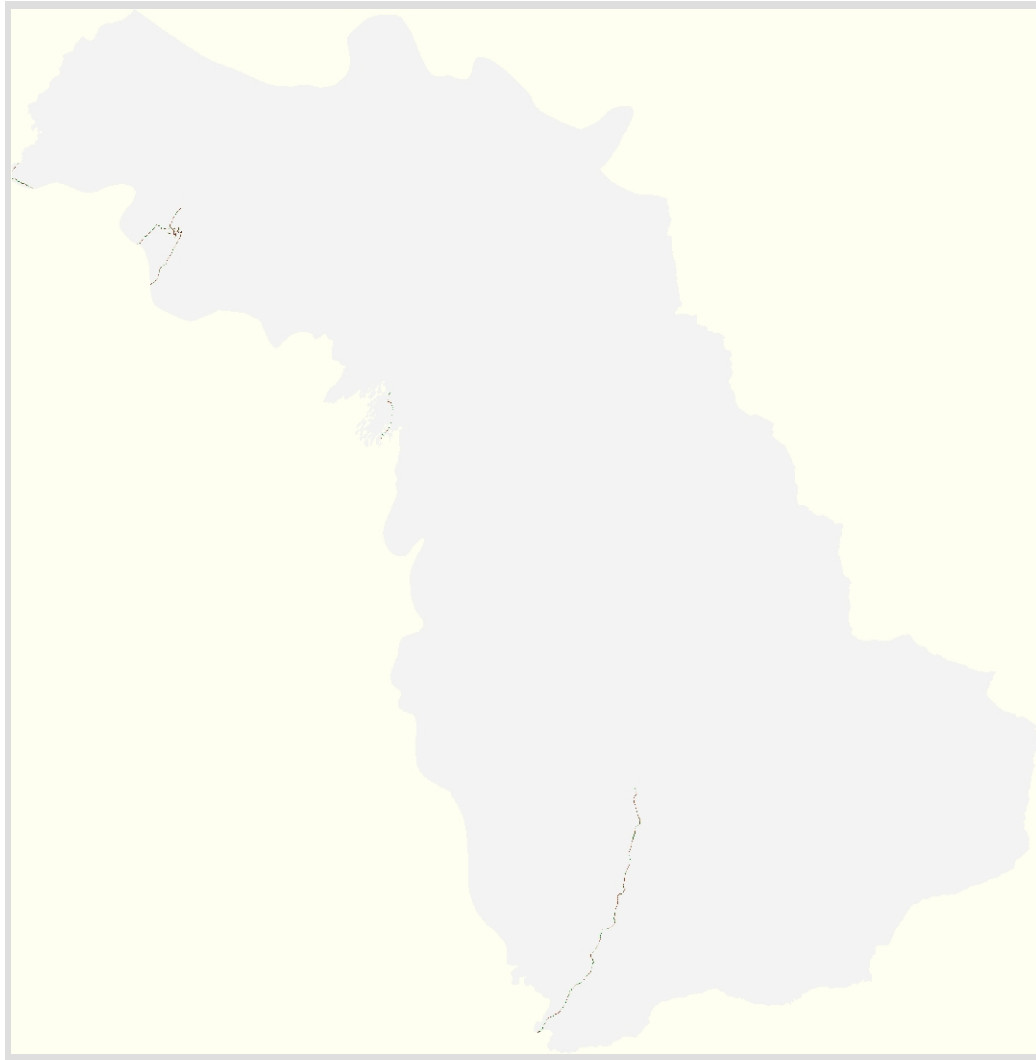
Updated Land Cover Class within the Missisa Caribou Range



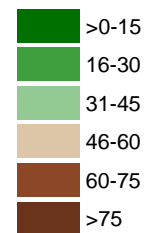
3.1

## Category 2 Mapping for Missisa Range - Current\_Condition

Roads within the Missisa Caribou Range



Density m/ha



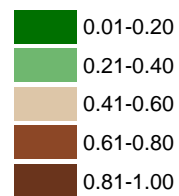
3.1

### Category 2 Mapping for Missisa Range - Current\_Condition

Settlements and Infrastructure (PLC Updated) within the Missisa Caribou Range



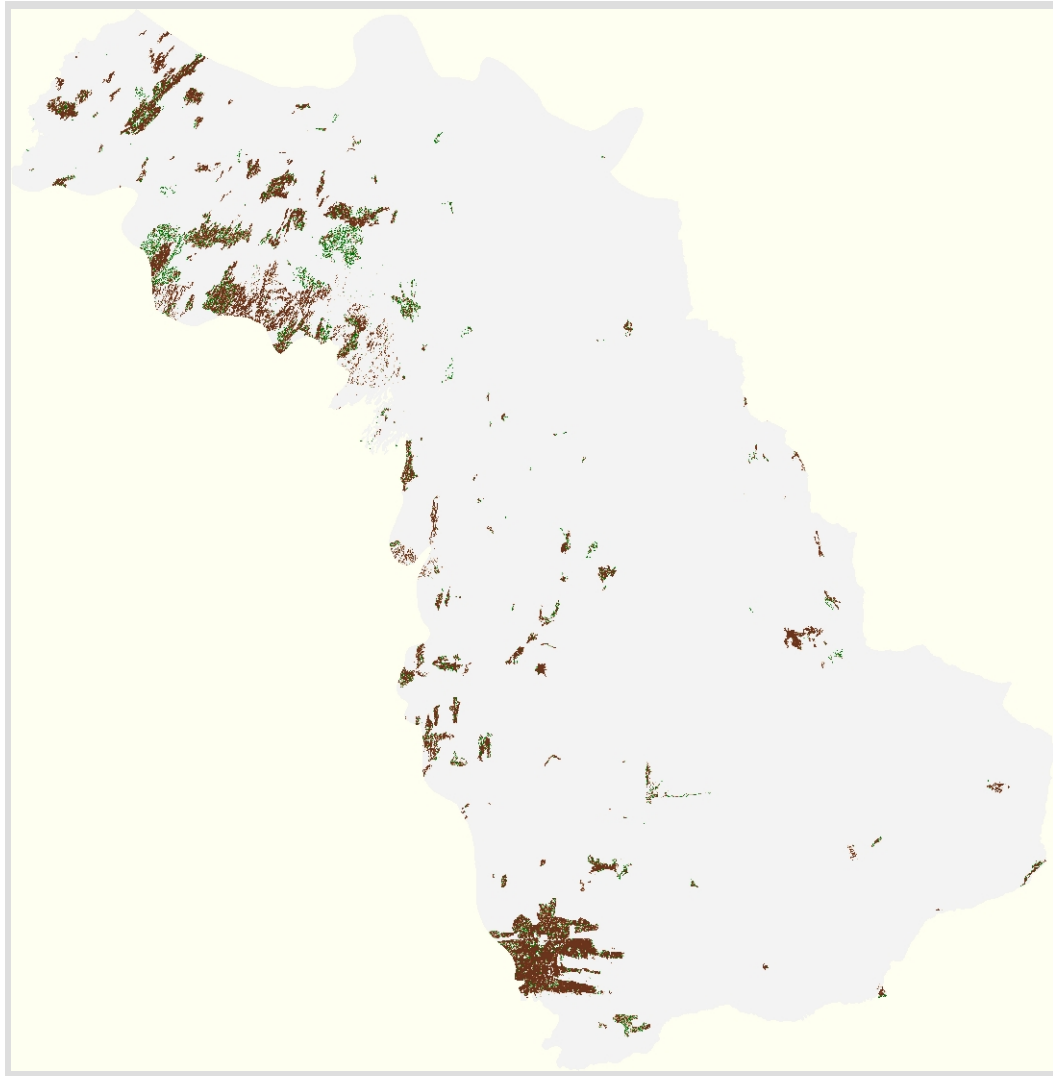
Proportion



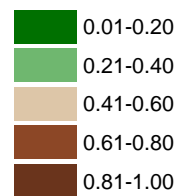
3.1

### Category 2 Mapping for Missisa Range - Current\_Condition

Natural Disturbance (PLC Updated) within the Missisa Caribou Range



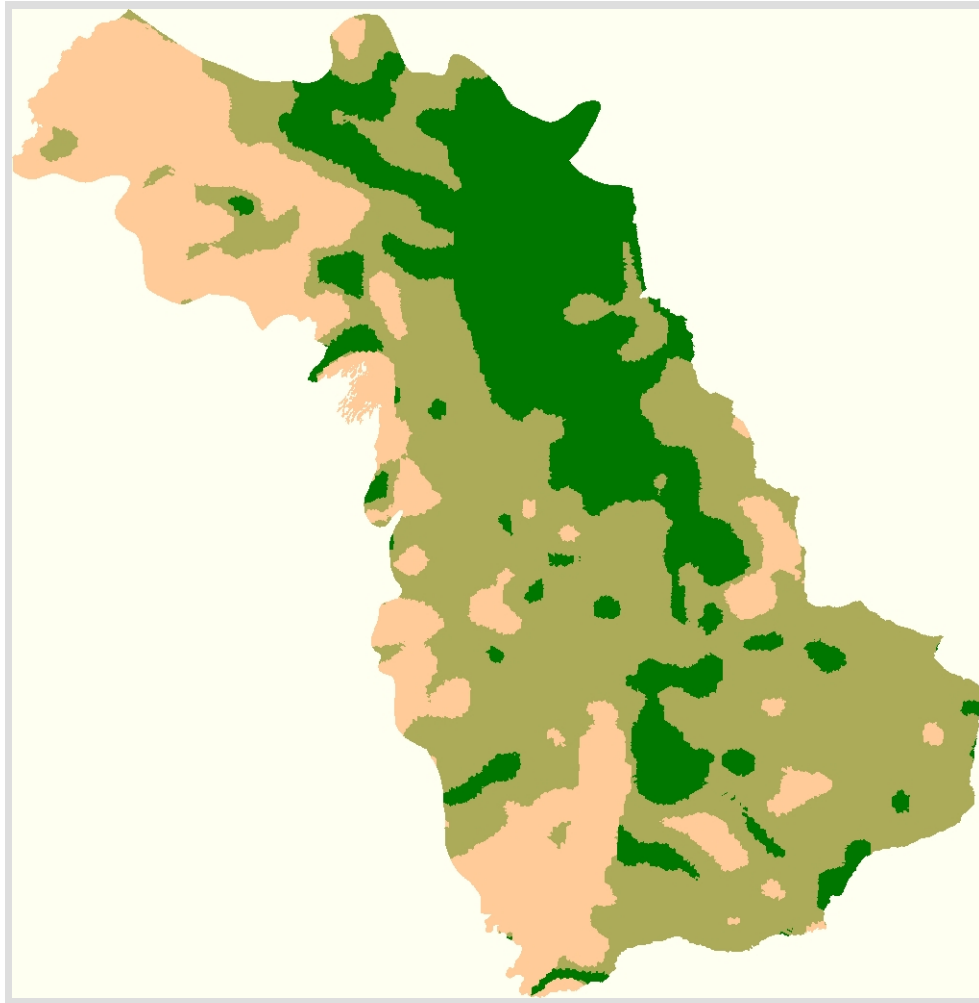
#### Proportion



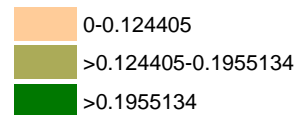
3.1

### Category 2 Mapping for Missisa Range - Current\_Condition

Probability of Spring Use within the Missisa Caribou Range



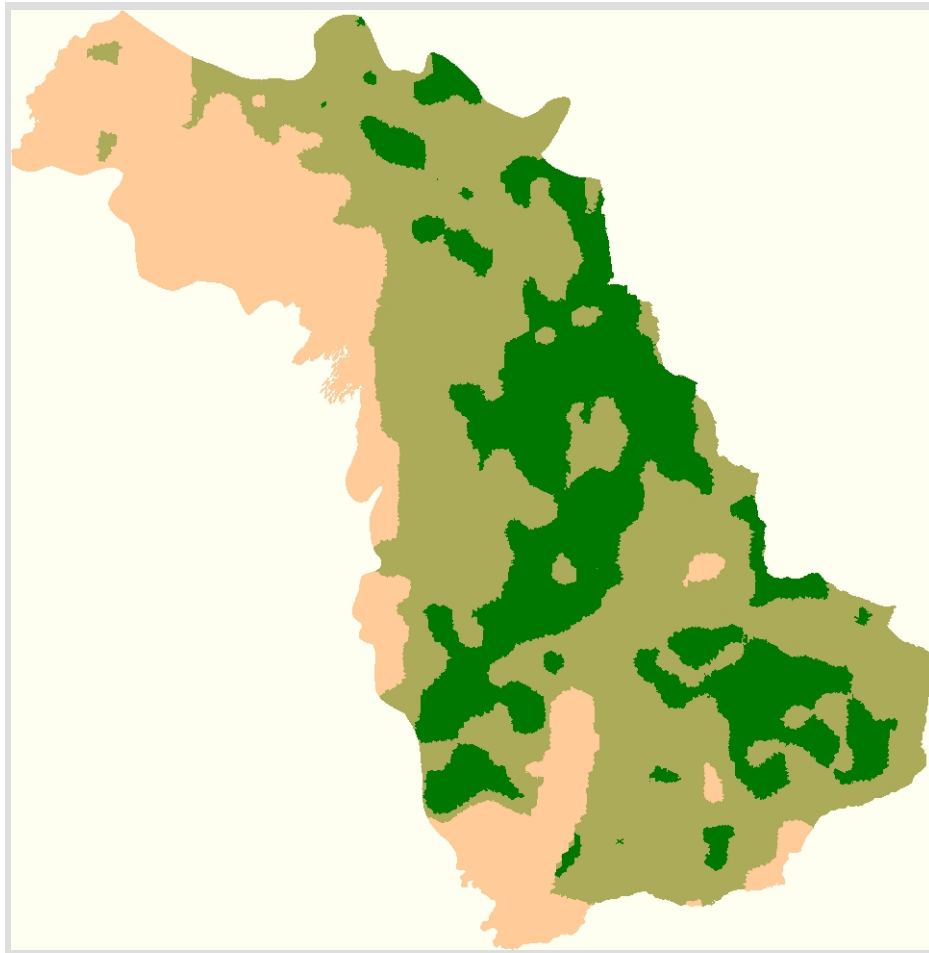
Probability of Spring Use



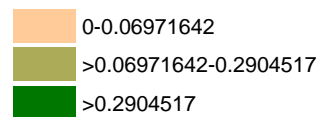
3.1

### Category 2 Mapping for Missisa Range - Current\_Condition

Probability of Summer Use within the Missisa Caribou Range



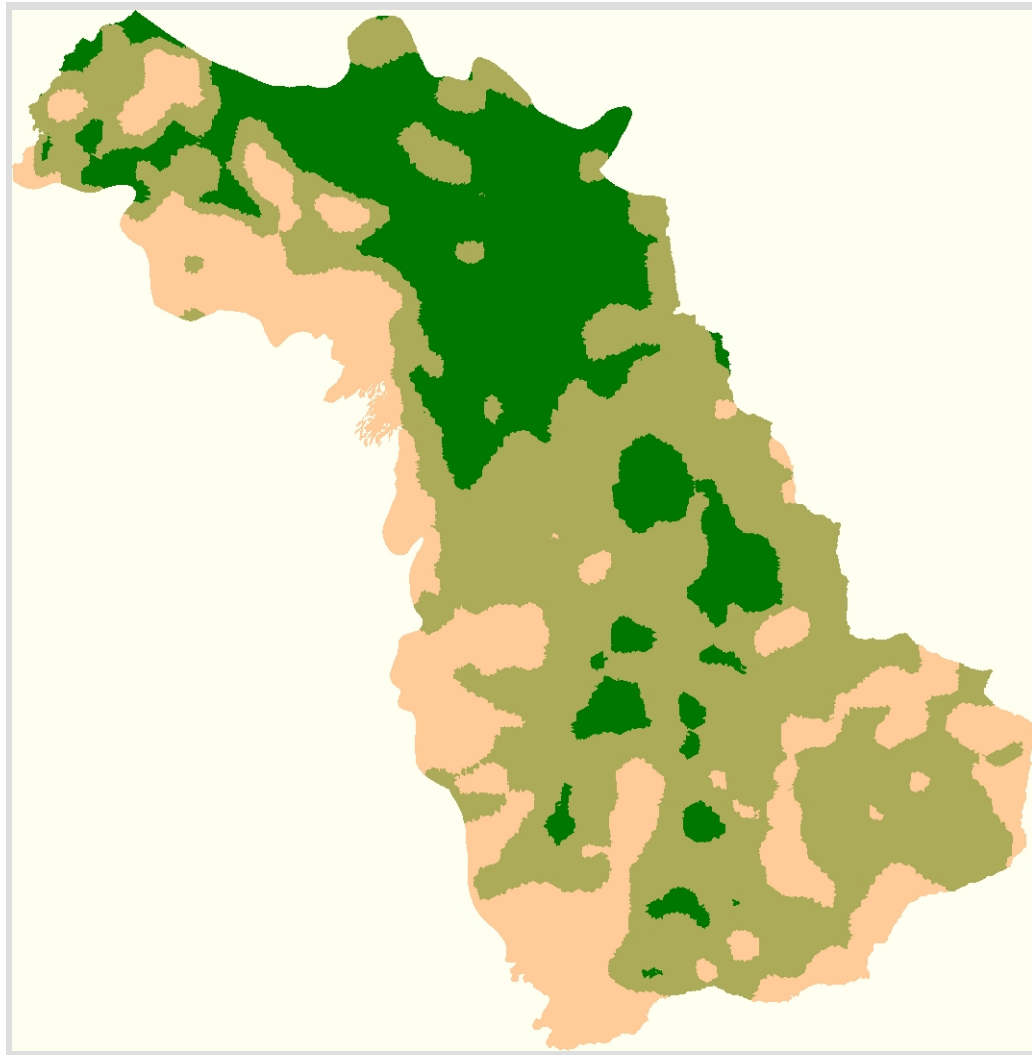
Probability of Summer Use



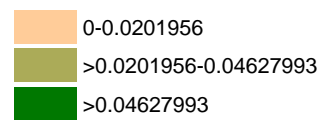
3.1

### Category 2 Mapping for Missisa Range - Current\_Condition

Probability of Fall Use within the Missisa Caribou Range



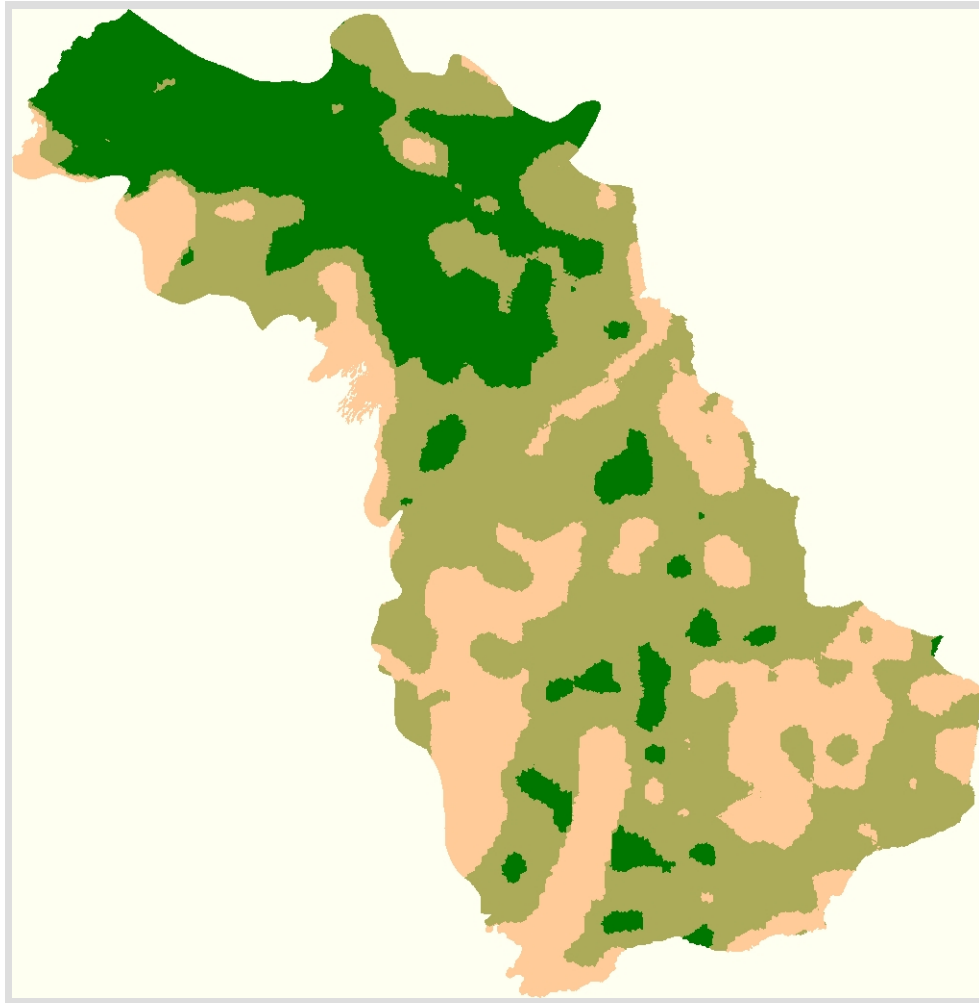
Probability of Fall Use



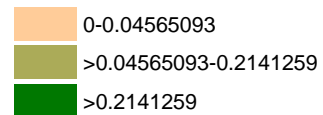
3.1

### Category 2 Mapping for Missisa Range - Current\_Condition

Probability of Winter Use within the Missisa Caribou Range



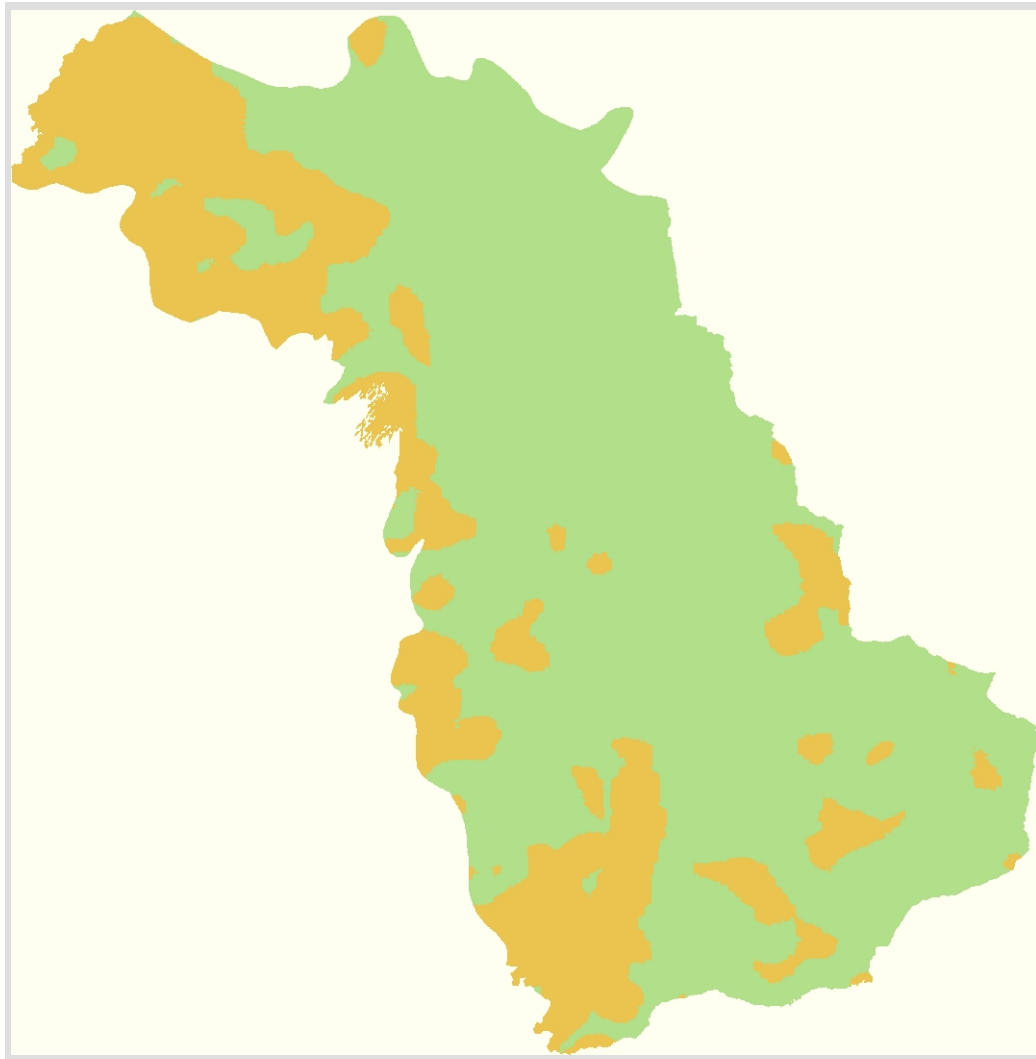
Probability of Winter Use



3.1

### Category 2 Mapping for Missisa Range - Current\_Condition

Categorized: Spring Use within the Missisa Caribou Range



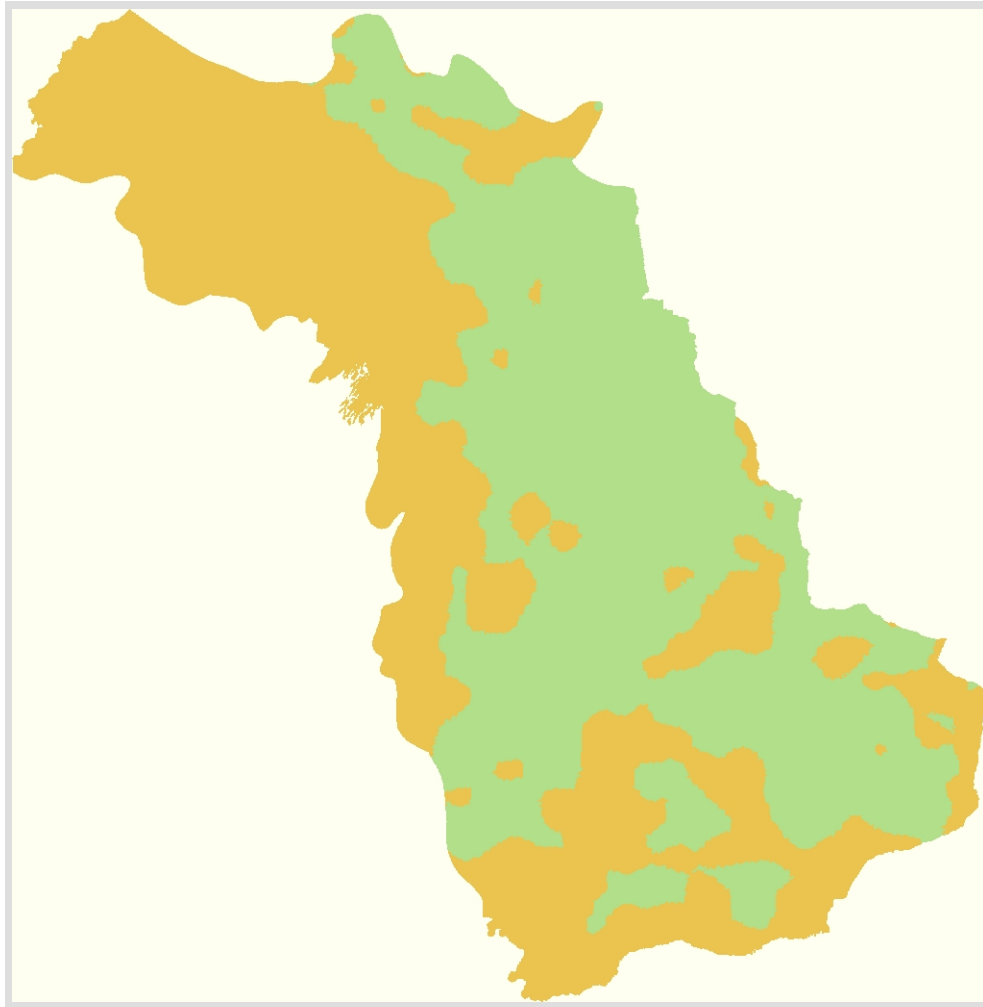
Prob. Class Spring Use



3.1

### Category 2 Mapping for Missisa Range - Current\_Condition

Categorized: Summer Use within the Missisa Caribou Range



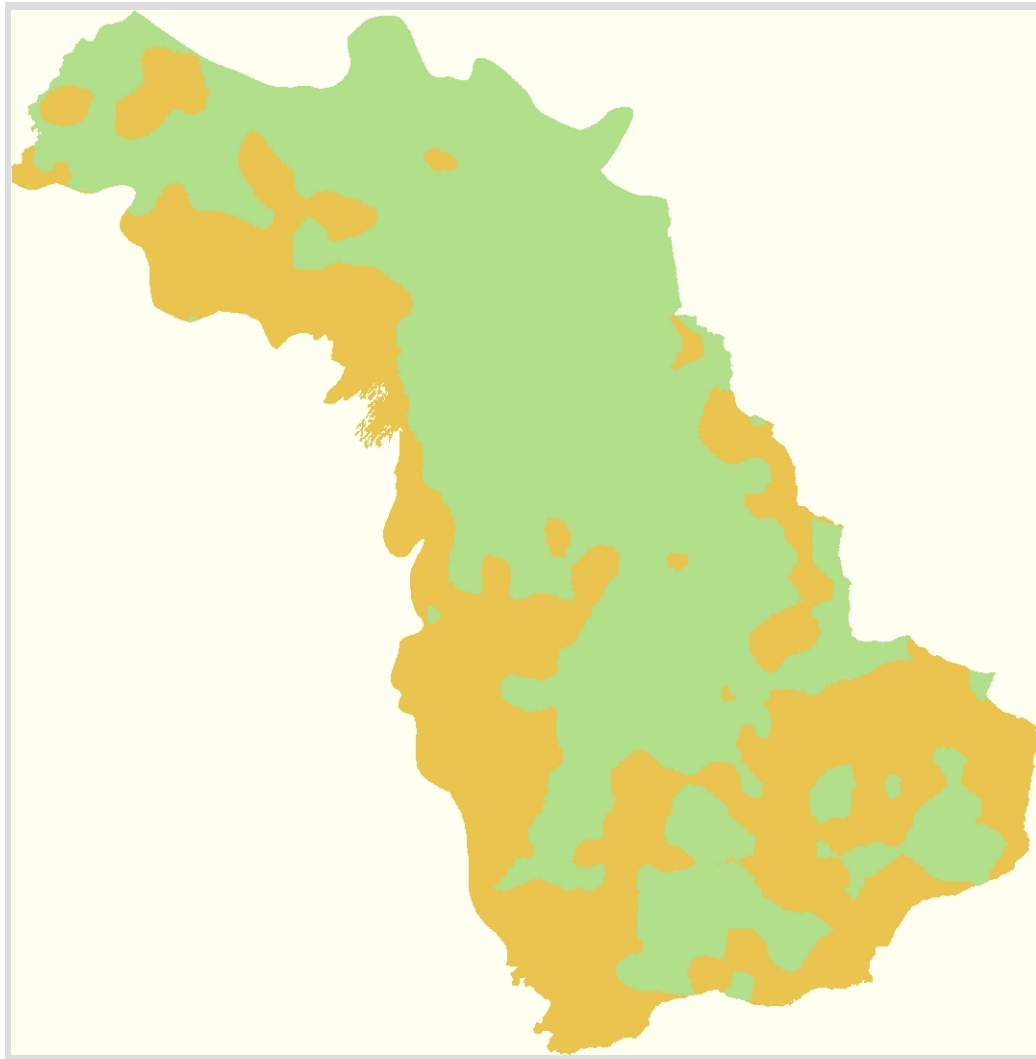
Prob. Class Summer Use



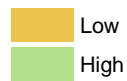
3.1

### Category 2 Mapping for Missisa Range - Current\_Condition

Categorized: Fall Use within the Missisa Caribou Range



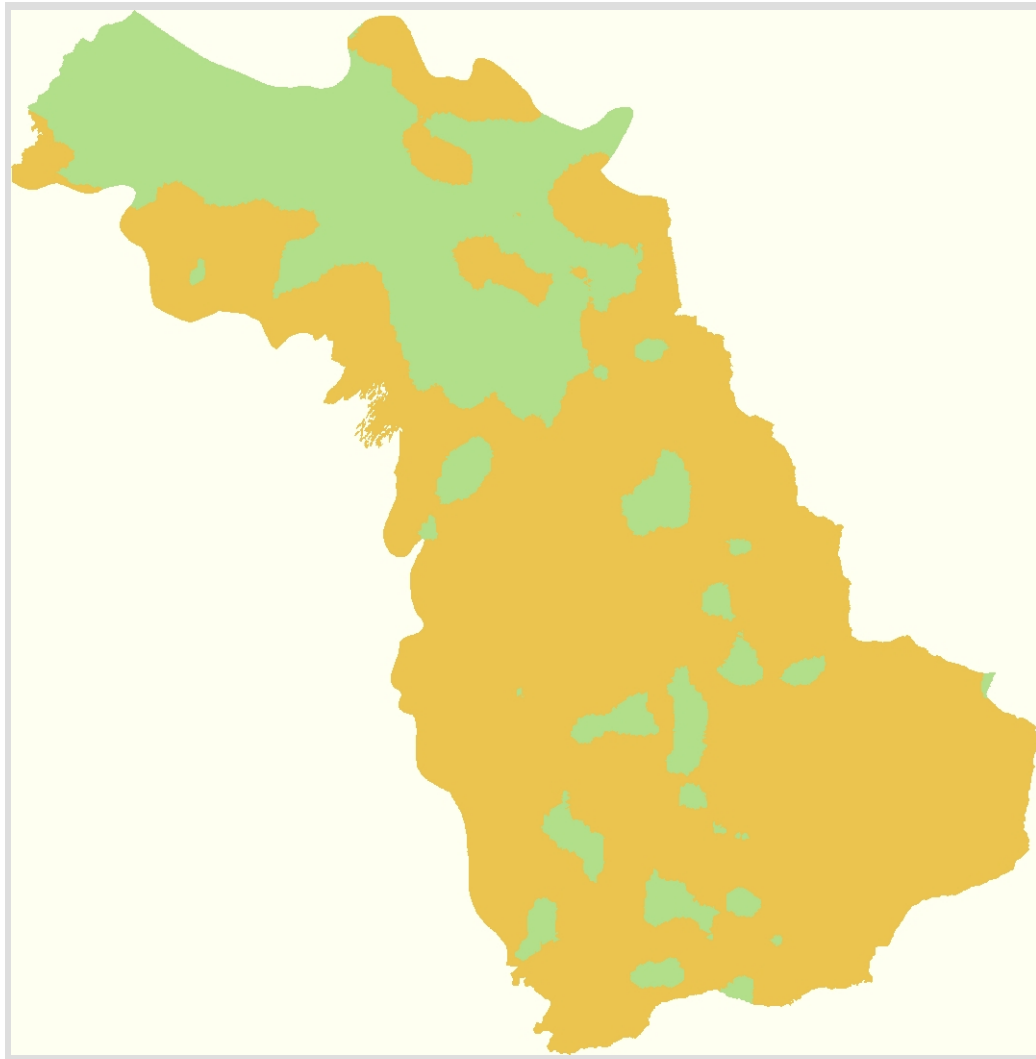
Prob. Class Fall Use



3.1

### Category 2 Mapping for Missisa Range - Current\_Condition

Categorized: Winter Use within the Missisa Caribou Range



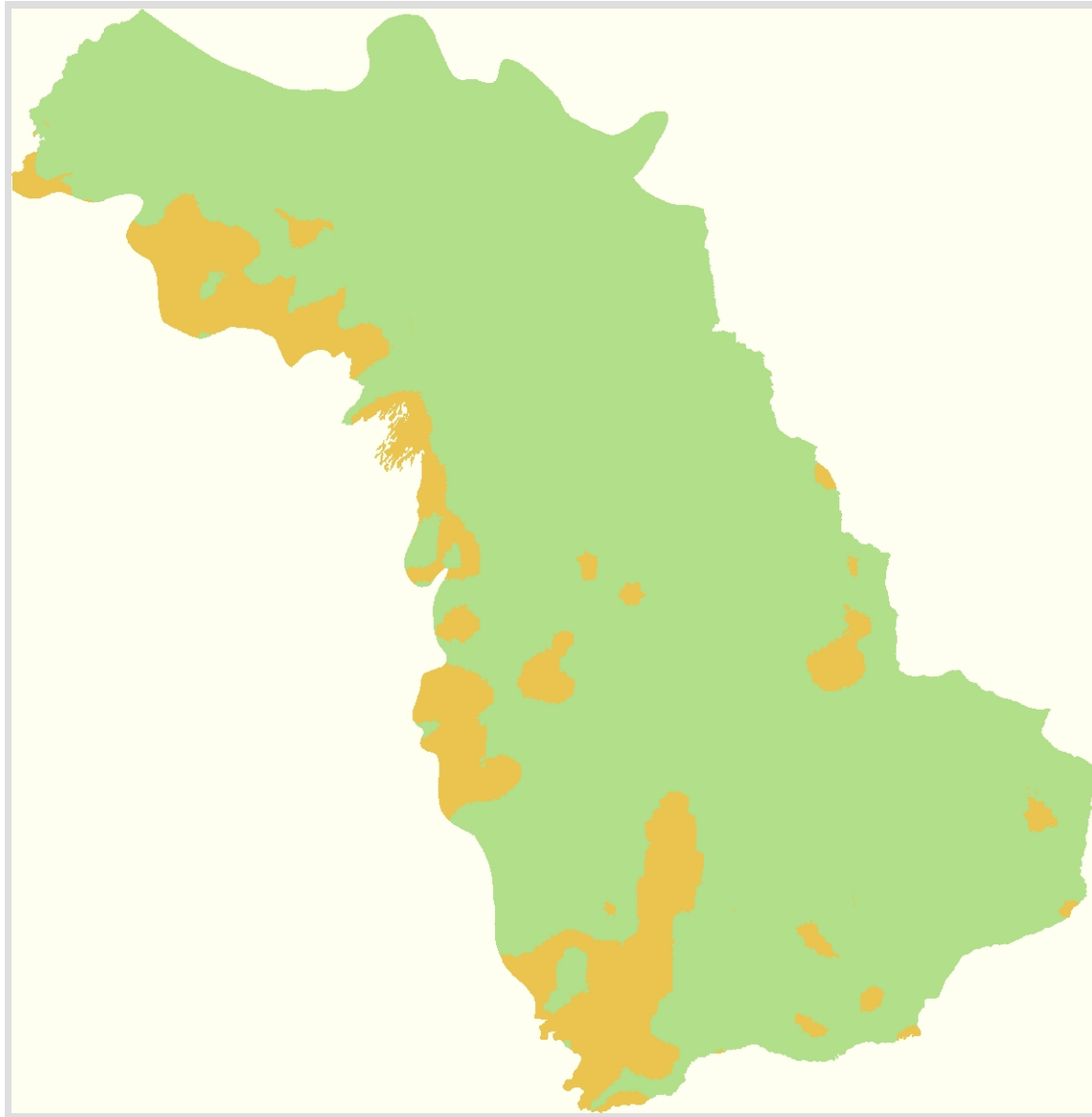
Prob. Class Winter Use



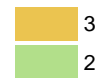
3.1

### Category 2 Mapping for Missisa Range - Current\_Condition

GHD Category 2 and 3 within the Missisa Caribou Range



GHD Category



# APPENDIX A (CONT'D)

A7-5: Individual Annual Home  
Ranges for WSR and NRL Caribou



**Appendix A7-5: Individual Annual Home Ranges for WSR and NRL Caribou**

**WSR:**

**Table 1: Annual Home Ranges for WSR Collared Caribou during 2021**

Collar ID	Annual Range	Range Area within RSA	Percent of Home-range	Range Area within Missisa	Percent of Home-range	Range Area within Ozhiski	Percent of Home-range
49124	2177602	272899	12.5	272899	12.5	0	0.0
49127	2837945	78126	2.8	78126	2.8	0	0.0
49128	939692	807957	86.0	791213	84.2	16744	1.8
49129	2730187	280350	10.3	280350	10.3	0	0.0
49130	3146545	530024	16.8	530024	16.8	0	0.0
49132	839955	791931	94.3	791931	94.3	0	0.0
49133	2221860	879599	39.6	879599	39.6	0	0.0
49134	2341793	89816	3.8	89816	3.8	0	0.0
49135	1402636	722300	51.5	714300	50.9	8000	0.6
49136	3058432	661351	21.6	661351	21.6	0	0.0
49137	2593439	1155898	44.6	1154166	44.5	1732	0.1
49138	2954945	528762	17.9	528762	17.9	0	0.0
49139	2460155	89400	3.6	89400	3.6	0	0.0
49140	3703684	647790	17.5	647790	17.5	0	0.0
49141	2730289	1195887	43.8	1181239	43.3	14648	0.5
49142	2309666	823050	35.6	779995	33.8	43055	1.9
49143	2156438	688509	31.9	668989	31.0	19521	0.9
49144	880800	368406	41.8	368406	41.8	0	0.0
49145	2975868	273466	9.2	273466	9.2	0	0.0
49146	1779664	698046	39.2	697603	39.2	443	0.0
49302	2689956	1042272	38.7	954076	35.5	88196	3.3
49303	2619381	6665	0.3	6665	0.3	0	0.0
49304	3828324	892356	23.3	892356	23.3	0	0.0
49305	1941642	123690	6.4	123690	6.4	0	0.0

**Table 2: Annual Home Ranges for WSR Collared Caribou during 2022**

Collar ID	Annual Range	Range Area within RSA	Percent of Home-range	Range Area within Missisa	Percent of Home-range	Range Area within Ozhiski	Percent of Home-range
49124	3393781	805594	23.7	596434.0	17.6	209160	6.2
49127	3433650	773825	22.5	487842.0	14.2	285983	8.3
49128	548779	471359	85.9	342952.0	62.5	128407	23.4
49129	3275003	639674	19.5	639674.0	19.5	0	0.0
49132	586526	419570	71.5	419570.0	71.5	0	0.0
49135	2512869	786962	31.3	786962.0	31.3	0	0.0
49136	3874134	752153	19.4	687702.0	17.8	64450	1.7
49138	4987223	1387143	27.8	1387143.0	27.8	0	0.0
49139	3781027	824269	21.8	645696.0	17.1	178573	4.7
49140	3133280	686975	21.9	556870.0	17.8	130104	4.2
49141	4076877	728608	17.9	728608.0	17.9	0	0.0
49142	3793108	1386018	36.5	1214433.0	32.0	171586	4.5
49143	3391114	1190283	35.1	847943.0	25.0	342339	10.1
49144	1582229	650498	41.1	592437.0	37.4	58061	3.7
49145	3605748	931192	25.8	783637.0	21.7	147555	4.1
49146	3509915	919743	26.2	919743.0	26.2	0	0.0
49302	2613227	1068281	40.9	684936.0	26.2	383346	14.7
49305	3067853	749260	24.4	749260.0	24.4	0	0.0
49306	3580143	913645	25.5	910191.0	25.4	3454	0.1

**Table 3: Annual Home Ranges for WSR Collared Caribou during 2023**

Collar ID	Annual Range	Range Area within RSA	Percent of Home-range	Range Area within Missisa	Percent of Home-range	Range Area within Ozhiski	Percent of Home-range
49124	3658140	369129	10.1	269124	7.4	100004	2.7
49128	1373088	868372	63.2	821192	59.8	47180	3.4
49129	2644929	341718	12.9	329680	12.5	12038	0.5
49135	3644717	585843	16.1	585843	16.1	0	0.0
49136	4495760	1282954	28.5	1271006	28.3	11948	0.3
49139	2671306	74768	2.8	74768	2.8	0	0.0
49140	4111148	890113	21.7	780869	19.0	109244	2.7
49141	3718727	340460	9.2	340460	9.2	0	0.0
49142	3843922	816649	21.2	816421	21.2	228	0.0
49144	1223475	577419	47.2	574251	46.9	3168	0.3
49145	3375080	446996	13.2	446996	13.2	0	0.0
49305	3284551	457366	13.9	457366	13.9	0	0.0
49306	3027992	1112169	36.7	1112169	36.7	0	0.0

**Table 4: Annual Home Ranges for WSR Collared Caribou during 2024**

Collar ID	Annual Range	Range Area within RSA	Percent of Home-range	Range Area within Missisa	Percent of Home-range	Range Area within Ozhiski	Percent of Home-range
49124	7684324	1174741	15.3	1174741	15.3	0	0.0
49135	5833236	1464205	25.1	1457167	25.0	7038	0.1
49141	7087319	1499345	21.2	1499345	21.2	0	0.0
49129	13066140	1965222	15.0	1855559	14.2	109663	0.8
49142	7392697	2136539	28.9	2121462	28.7	15077	0.2
49140	6331391	1049677	16.6	1049677	16.6	0	0.0
49145	9168845	1755032	19.1	1755032	19.1	0	0.0
49144	2241123	658692	29.4	658692	29.4	0	0.0
49136	5833792	945378	16.2	945378	16.2	0	0.0

**NRL:**

**Table 5: Annual Home Ranges for NRL Collared Caribou during 2023**

Collar ID	Annual Range	Range Area within RSA	Percent of Home-range	Range Area within Missisa	Percent of Home-range	Range Area within Ozhiski	Percent of Home-range
151318	189378	189378	100.0	189378	100.0	0	0.0
151315	150372	150372	100.0	150372	100.0	0	0.0
151314	170198	130748	76.8	130748	76.8	0	0.0
151309	112904	112904	100.0	112904	100.0	0	0.0
151316	152329	152329	100.0	152329	100.0	0	0.0
151313	21406	21406	100.0	21406	100.0	0	0.0
151319	113817	113817	100.0	111434	97.9	2383	2.1
151308	724163	530859	73.3	492101	68.0	38758	5.4
151310	82262	82262	100.0	79338	96.4	2925	3.6
151306	60150	60150	100.0	60150	100.0	0	0.0
151317	210743	210743	100.0	210743	100.0	0	0.0
151311	123917	123917	100.0	123917	100.0	0	0.0
151307	201429	201429	100.0	201429	100.0	0	0.0

**Table 6: Annual Home Ranges for NRL Collared Caribou during 2024**

Collar ID	Annual Range	Range Area within RSA	Percent of Home-range	Range Area within Missisa	Percent of Home-range	Range Area within Ozhiski	Percent of Home-range
151318	87403	87403	100.0	87403	100.0	0	0.0
151315	210977	133726	63.4	133726	63.4	0	0.0
151314	1076405	575876	53.5	575876	53.5	0	0.0
151316	571623	376272	65.8	376272	65.8	0	0.0
151319	99027	99027	100.0	99027	100.0	0	0.0
151308	1681461	682748	40.6	678026	40.3	4721	0.3
151310	615089	329036	53.5	326030	53.0	3005	0.5

**Table 6 (Cont'd): Annual Home Ranges for NRL Collared Caribou during 2024**

Collar ID	Annual Range	Range Area within RSA	Percent of Home-range	Range Area within Missisa	Percent of Home-range	Range Area within Ozhiski	Percent of Home-range
151306	118113	118113	100.0	118113	100.0	0	0.0
151317	150831	150831	100.0	150831	100.0	0	0.0
151311	29844	29844	100.0	29844	100.0	0	0.0

**Table 7: Annual Home Ranges for NRL Collared Caribou during 2025**

Collar ID	Annual Range	Range Area within RSA	Percent of Home-range	Range Area within Missisa	Percent of Home-range	Range Area within Ozhiski	Percent of Home-range
151318	103583	103583	100.0	103583	100.0	0	0.0
151315	115943	100066	86.3	100066	86.3	0	0.0
151314	106835	106835	100.0	106835	100.0	0	0.0
151308	377204	318886	84.5	318886	84.5	0	0.0
151306	6865	6865	100.0	6865	100.0	0	0.0
151317	76249	76249	100.0	76249	100.0	0	0.0

# APPENDIX A (CONT'D)

A7-6: Caribou Seasonal Patterns of  
Habitat Use in the NRL and WSR  
Study Areas



# Report on Caribou Seasonal Patterns of Habitat Use in the NRL and WSR Study Areas

FERIT Environmental Consulting (Feb 28<sup>th</sup>, 2024)



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# 1 Background

The seasonal patterns in habitat use are an important piece of background information for both the WSR and NRL assessments. Although the report on GHD category 2 critical habitat provides helpful information on assessing the prevalence of important caribou habitat [1], those models are based on an RSF (resource selection function) using older collaring data, and an inadequate number of locations in the Ozhiski range. An additional issue is that neither the Missisa nor Ozhiski range have permanent disturbance, so an RSF developed from data only in these locations would not be able to predict changes in patterns of use based on new development proposals. New GPS collaring data has been collected by both Atkins Réalis and MNRF in both the NRL and WSR study areas. This data transverses the Ozhiski and Missisa caribou ranges, and together with data obtained from previous MNRF projects in the more southern ranges, was used to develop a new RSF suitable for describing seasonal patterns of habitat use. The RSF models will be useful for evaluating the net effects of future development proposals. The RSF developed here uses biophysical attributes reported on earlier [2], although additional scales of analysis were considered in developing the RSF.

In addition to the statistical RSF model, animated graphics of seasonal animal movements were generated to depict and better understand movement patterns within seasons in the NRL and WSR study area.

## 2 Methods

### 2.1 Study Areas

Missisa and Ozhiski were the primary ranges of interest for the NRL and WSR projects. However, neither of these ranges had any permanent roads, and other anthropogenic disturbances were minimal. To create an RSF that would be responsive to anthropogenic disturbance it was necessary to include in the data other ranges that have significant areas of disturbance. The Nipigon and Pagwachuan ranges were selected because they were contiguous with the northern ranges, the southern parts of these ranges have significant anthropogenic disturbance, and the ranges also encompass the Marten Falls Community Access Road project.

### 2.2 Biophysical Attributes:

Resource variables used in developing the RSF were based on the same variables used in the GHD category 2 mapping, and as described in the biophysical attributes report [1,2]. The GHD category 2 mapping uses the Provincial Landcover Classification map (PLC 2000) rather than the Far North Landcover Classification (FNLC v1.4) map because the PLC2000 encompasses the southern ranges, while the FNLC does not. Landcover variables derived from the PLC are indicated by the \_PLC suffix in Table 1 and were created for all 6 spatial scales.

Table 1: *Biophysical variable definitions. Full set of all 55 variables across all scales given in Appendix A.*

Field	Description	Units
ANTHRO	Settlements and Infrastructure	Proportion (of hexagon)
CON_PLC	Dense Conifer	Proportion (of hexagon)
CUT_PLC	Forest Harvest	Proportion (of hexagon)
DEC_PLC	Dense Deciduous	Proportion (of hexagon)
Eskers	Eskers	Density (m/ha)
HARV	Forest Harvest	Proportion (of hexagon)
LGOP_PLC	Open Peatland (Fen and Bog)	Proportion (of hexagon)
LGTP_PLC	Treed peatland (swamp, fen, and bog)	Proportion (of hexagon)
LGW_PLC	Deep and Shallow (turbid) Water	Proportion (of hexagon)
MIX_PLC	Mixed wood Forest	Proportion (of hexagon)
NATDIST	Natural Disturbance	Proportion (of hexagon)
R_dist	Distance to the nearest road (meters)	Proportion (of hexagon)
ST_PLC	Sparse Treed Forest	Proportion (of hexagon)
TDen_LF	Density of roads, railways, and linear features	Density (m/ha)

## 2.3 Caribou Location Data - Sources and Processing:

Caribou collaring data was obtained from two organizations, Atkins Réalis and MNRF, collected under 5 separate projects (Table 2). The initial processing of location data was conducted in R and begins with assigning approximate seasonal dates to each location point. The data includes multiple ranges with different seasonal dates, so an initial season was assigned as Winter (December 22<sup>nd</sup> to April 14), Spring (April 15<sup>th</sup> to June 21<sup>st</sup>), Summer (June 22<sup>nd</sup> to September 21<sup>st</sup>), and Fall (September 22<sup>nd</sup> to December 21<sup>st</sup>).

The next step is the removal of duplicate records by collar ID and date/time. The software package "amt" (animal movement tool) was then used to create movement tracks for filtering location data. Rather than using simple random sampling, tracks by bursts were created and selected to ensure that each collar with different sampling rates contributed equally. Using track bursts - periods of sequential movement - I could adjust sampling optimized for each data source, as different data sources had different fix rates (3, 6, 10, or 24 hours). Sample rates of 6, 10, and 24 were selected as optimal for Atkins Réalis, NHIC, and MNRF data sources, respectively. Note that MNRF data in Ozhiski and Missisa had a fairly high fix rate, but only daily location data was provided for this project.

Step lengths between sequential location fixes were created to help with filtering - selecting a step length greater than 150m avoids sleeping animals, dead animals, or dropped collars (note: GPS error of immobile device can vary up to 100m between positions). Selecting a step length of less than 1200m avoids fixes on days animals were highly mobile, thus focusing analysis on local habitat use within a seasonal home range. Note that even during periods of migration animals stop to feed and rest, and these locations are captured in the data.

Average daily step lengths are depicted in Fig. 1 and reveal large differences in activity among seasons. Seasonal definitions vary, and the ones used here are based on the Category 2 RSF [1,3], with demarcations are identified by the blue the blue vertical lines (Fig. 1A). These biological seasons are calving (Spring), foraging (Summer), rut and migration (Fall), and winter survival (Winter) seasons. These periods could be adjusted to better reflect movement patterns (Fig.1B), or to define more detailed seasons used in other studies [4,5,6]. For this work I decided to use the Category 2 seasonal delineations to maintain consistency with the critical habitat analysis.

*Table 2: Sources1 for GPS collar data, including fix rates and date ranges.*

<b>Source</b>	<b>Location</b>	<b>Device</b>	<b>Collar IDs</b>	<b>Fix Freq</b>	<b>Date Range</b>
AtkinsRéalis	WSR	ATS	30	3 hours	Feb 24th, 2021 to Dec 7th, 2023
AtkinsRéalis	NRL	Lotek	14	3 hours	Feb 22, 2023 to Dec 8th, 2023
MNRF	Missisa	Lotek	101	24 hours	March 18, 2019 to March 31st, 2023
MNRF	Ozhiski	Lotek	58	24 hours	Feb 25th, 2020 to March 31st, 2023
FNCC (NHIC)	Missisa, Oz, Nipigon, Pag	Lotek	166	Variable	2009 - 2012 (FNP);
CPCR (NHIC)	Nipigon, Pag	Lotek		Variable	2010-2015 (CRP)

1. FNCC = Far North Caribou Collaring; CPCR = Collaborative Provincial Caribou Research Program, NHIC = Natural Heritage Information Centre, MNRF = Ministry of Natural Resources and Forestry

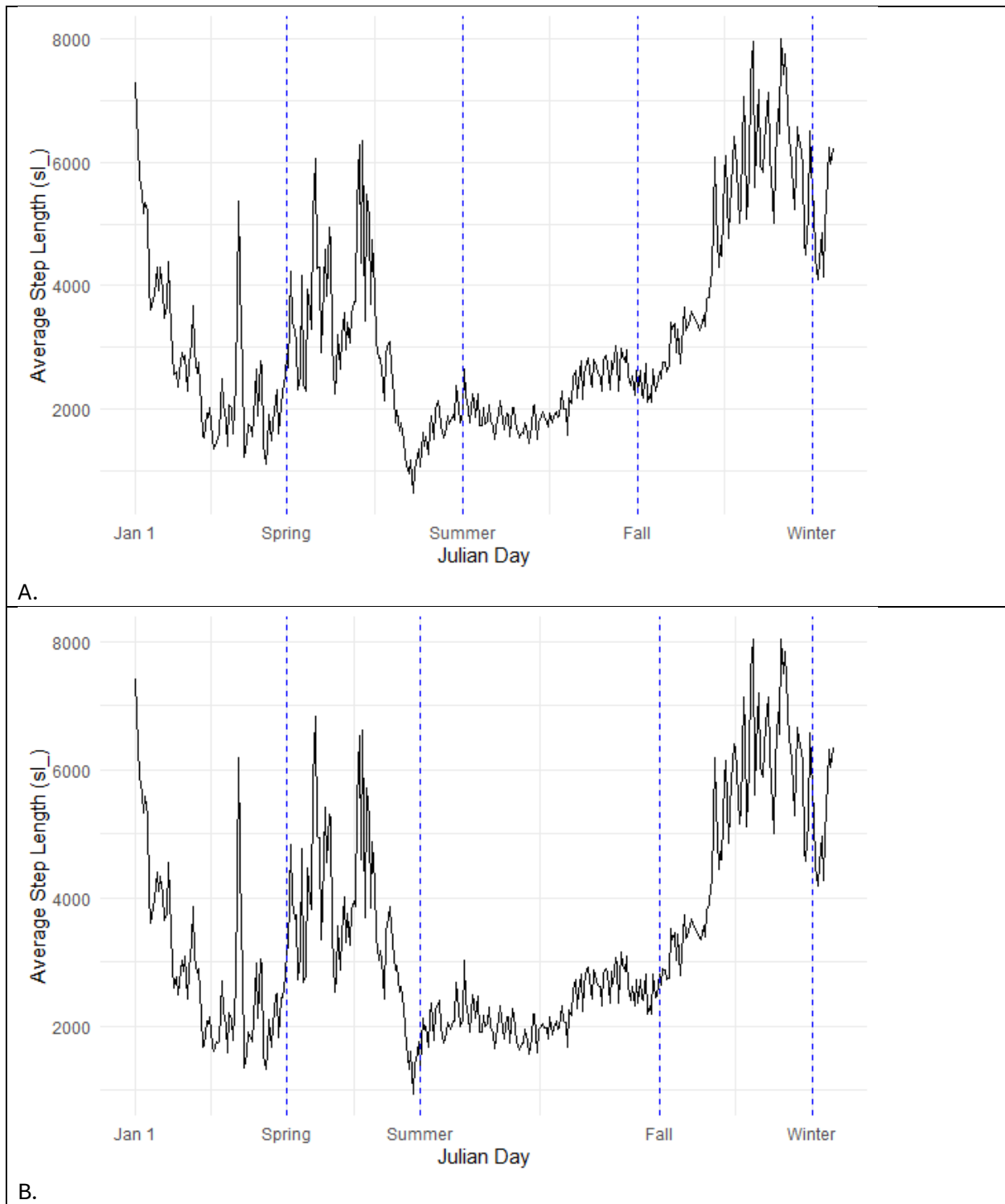


Figure 1: Seasons defined in A. by Julian Days 80, 172, 264, and 355, and modified in B. to 80, 150, 275, and 355, for Spring (calving), Summer (foraging), Fall (rut and migration), and Winter (survival) seasons, respectively. Step Lengths are daily averages.

Track data from caribou collars represents “used” habitat, whereas available habitat is defined by random points. To define a spatial domain that the population is aware of, a population-level seasonal home range was defined using the kernel density approach in `amt` from the individual animal tracks. For each seasonal home range (95% level) a random set of points was generated using the `amt random_points` function where the number of random “available” points equals 5 times the number of “used” points within the collective seasonal home range. The used and available data were joined to create full sets of sample points for each season.

The full data sets were then split into training and test data sets, where the train data comprised 80% of the full data set. Code was written to keep points from individual animals (collar IDs) together, and to ensure that the same proportion of used and available points were selected as occurred in the full data sets. Geographic coordinates were retained throughout so a simple feature (sf) shapefile for each of the seasonal train and test data sets could be created and saved.

These spatial datasets were then linked to multiple-scale biophysical attributes using the specialized GIS program LSL. Hexagons (3.1) ha were overlaid on the Provincial Landcover raster map, anthropogenic features, and eskers, and then spatially averaged at scales of 3.1, 27.1, 524, 1026, 5137, and 9824 ha. Details of this process are described in the Biophysical Attributes report [2]. For each 3-ha hexagon (100m radius), attributes of the point file (season and train/test label) were retained, plus the count of points that fell within the hexagon. Most hexagons had a single point (caribou collar location), but because more than one point can fall within a hexagon the count of points is used as a weight in the regression models. The seasonal train and test data sets were then imported back into R for RSF model building.

## 2.4 RSF modelling

The gradient-boosted regression tree (BRT) approach was used for modeling resource selection. Initial exploration revealed this approach performed very well and is particularly appropriate for this project where multiple predictive variables exist across 6 spatial scales, and where there is limited *a priori* knowledge of which variables, or interactions of variables, will predict presence/absence best. The R package `gbm` was used to estimate the BRT, which is a potentially complex model, and like all complex models, subject to overfitting. The number of location points with the LSL habitat hexagon was set as a model weight.

My general objective of model-fitting and hyper-parameter tuning was to develop a strong model, but not the strongest model, that performed well with both the training and the independent, unseen testing data. The strategy was to first separate the original full data set into a training and testing data set (described above), and then tune the hyper-parameters to develop the model on the training data.

This approach involved using 10-fold cross-validation, where training data was partitioned into ten sets or folds with the model trained on one of the folds, and then performance evaluated on the other 9 folds using a measure of how much variance was accounted for by the model (Bernoulli deviance). This is repeated 10 times. As model complexity increases the performance of the model continuously increases on the full data set, but plateaus when cross-validation predictions are made on the 9 folds of data not used for that iteration. This indicates where overfitting begins to occur (i.e., the number of trees), i.e., where the model stops performing well on out-of-sample data.

The number of trees tended to plateau at about 750, so 750 was set as the maximum number of trees, and this helps to reduce the risk of overfitting by not letting the number of trees grow excessively.

The model is capable of evaluating interactions among variables, for example, 2, 3, 4, or 5 levels of interactions between multiple variables. Although higher levels of interaction can result in better performance with the training data, the risk is overfitting, resulting in poor performance with the unseen testing data. I set the maximum interaction depth hyper-parameter to 2 (i.e., restricting interactions to between a maximum of 2 variables).

The model learning rate is another hyperparameter that affects model performance. In a GBM model, trees are added sequentially to the model, where each new tree attempts to correct the errors made by the ensemble of previously built trees. Shrinkage is applied to each tree when it is added to the model, effectively scaling down the contribution of each tree by a factor called the learning rate. By slowing down the learning process (i.e., making smaller adjustments), shrinkage helps in reducing overfitting. This slower learning rate requires more trees to be added to the model to achieve similar levels of model complexity and fit the training data, allowing for a more gradual and controlled improvement in model performance. The learning rate varies between 0 and 1, and based on initial exploration, I set the learning rate to a fairly low level of 0.1 to help reduce overfitting.

Once the model hyperparameters were set, the model was estimated, predictions applied to the unseen test data set, and performance evaluated. It is important to note that the test data used locations from individual caribou, defined by caribou collar ID, that were not included in the model training data, thus representing a truly independent set of data. If the model performs well on this independent, unseen set of data, then there is no evidence of overfitting.

Model performance was evaluated on both the train and test data sets, however, evaluation on the test data is most important from a user's perspective. I calculated 11 performance measures using the *confusionMatrix* function in the **caret** package, and selected sensitivity, specificity, and AUC under the ROC as the measures to report. ROC curves were created using the function *ROC* in the *Epi* package. These metrics require a threshold value above which the probability of use is classified as indicating predicted caribou presence. This value was calculated using a balanced approach where false-positives and false-negatives were treated as equally bad. The function *optimal.thresholds* in the package **PresenceAbsence** was used, with an option that maximizes both sensitivity and specificity selected.

To understand the model, and how it is making predictions for probability of use, variable influence and response diagrams were created. The response diagrams are particularly useful, in that they plot how the probability of use responds to the habitat variables. I created plots for the top 8 variables indicated by the variable influence analysis. Plots were created using the *gbm.plot* function in the package **dismo**.

The final step is to apply the seasonal models to the entire study area (Missisa, Ozhiski, Nipigon, and Pagwachuan Ranges). This requires one additional processing step. The model is based on presence-only observations, with availability defined by a random set of variables. This changes the model from being a normal logistic regression type model, as the arbitrary number of random

locations will affect the estimated intercept for the model, and hence the absolute value of the predictions. Consequently, the model is only valid as an estimate of the relative probability of use, not the absolute probability of use. To correct for this, the model predictions are scaled by the maximum predicted value (i.e., predicted use/maximum predicted use). If any of the predicted use values approach one, then the change to relative value will be relatively small.

## 2.5 Movement Visualization

Caribou patterns of movement across seasons were visualized by creating temporal variables in QGIS. Data tracks from both Atkins Réalis and MNR sources for Ozhisiki and Missisa were first resampled at the individual caribou level using the *track\_resample* function in **amt**, with a sample rate of 1 week. These were imported into QGIS, and the date field from the tracks was assigned as the temporal variable. Heat maps were created to identify clusters of individual animals with higher density clusters having a brighter signature. These heat map clusters were then animated at a bi-weekly rate, with the date field visible, and saved as mp4 videos. Visualizing with the mp4 allows the user to view and closely inspect patterns of activity within seasons, as well as migration patterns between seasons.

# 3 Results

## 3.1 RSF Modelling

The seasonal models performed well, with AUC model performance (overall model accuracy) on the train data ranging from 0.810 to 0.874, and 0.709 to 0.745 on the unseen model test data (Table 3). As expected, model performance was higher for the training data, but overall the performance was good, and the model was useful for projecting spatial patterns of use. In general, model sensitivity was higher than model specificity, thus the model is more successful at predicting where caribou are likely to be found than predicting where they are likely to be absent. Among the seasons, the model performed better for the Spring, Summer, and Fall than for Winter.

Table 3: RSF model (BRT) performance metrics for training and unseen testing data.

Season	Sensitivity (Training)	Specificity (Training)	Sensitivity (Testing)	Specificity (Testing)	AUC (Training)	AUC (Testing)
Winter	0.680	0.778	0.678	0.710	0.810	0.770
Spring	0.813	0.708	0.805	0.484	0.845	0.709
Summer	0.792	0.787	0.788	0.514	0.874	0.745
Fall	0.776	0.756	0.775	0.566	0.849	0.738

Note that sensitivity measures the proportion of actual positive cases (i.e., caribou habitat use) that are correctly identified by the model as positive. In contrast, specificity measures the proportion of actual negative cases that are correctly identified by the model as negative. The area under the receiver operating characteristic (ROC) curve (AUC) is a metric that quantifies the overall performance of the model across various decision thresholds. The ROC curve plots the true positive rate (sensitivity) against the false positive rate for different threshold values. A higher AUC

value indicates better discrimination ability of the model, i.e., the model is better at distinguishing between positive and negative cases. A higher AUC suggests that the model is better at ranking areas according to their likelihood of being used by caribou. For summer, the area under the curve was 0.874, and sensitivity and specificity 79.1% and 78.95, respectively (Fig. 2; Appendix A).

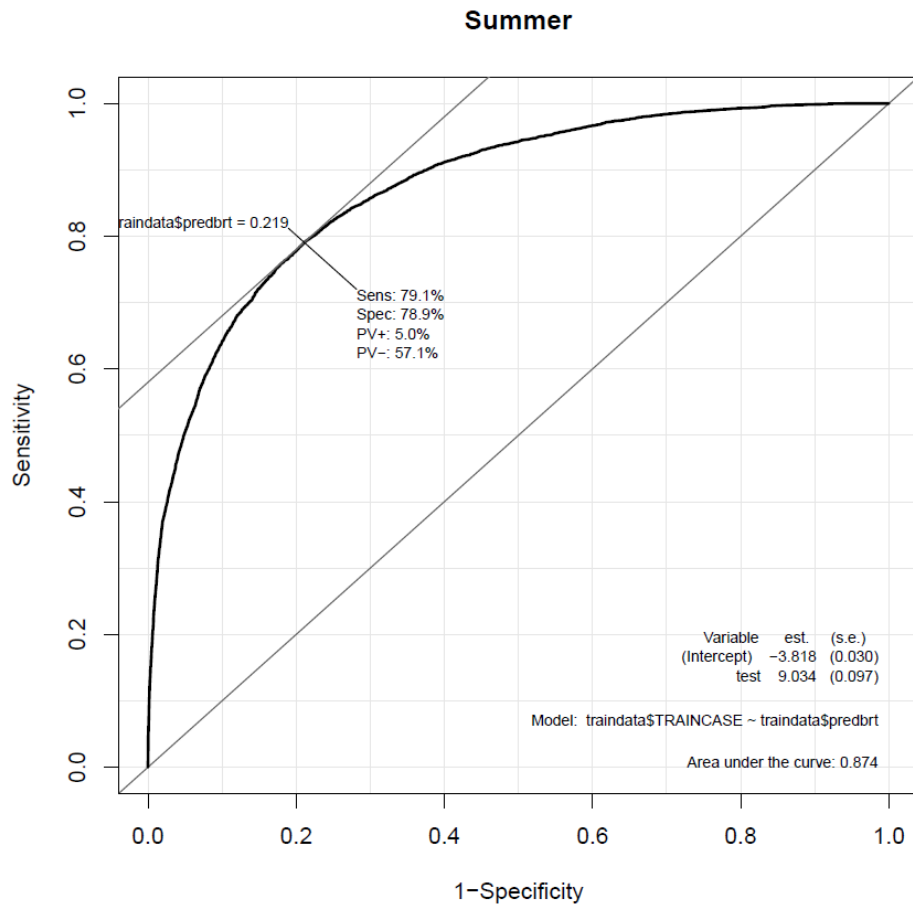


Figure 2: Area under the curve (AUC) for resource operating characteristic (ROC) graph.

The importance of variables differed among seasons, with importance identified in the variable influence diagrams and table of all variables with influence > 1 (Fig. 3; Appendix A). For summer, water, conifer, open peatland, mixed wood, natural disturbance, and eskers are some of the most important variables, and all of these were at the 10,000-ha scale. The total density of linear features was included in the top variable list. The response of caribou to these variables is estimated by plotting the response of a single variable while holding all other variables constant, and these plots reveal that caribou respond positively to conifer, water, and open peatland, but negatively to natural disturbance (Fig. 4; Appendix A). These diagrams are helpful but remember that they do not account for interactions or other complexities, so should only be used as a rough guide to interpret how the model responds to individual variables.

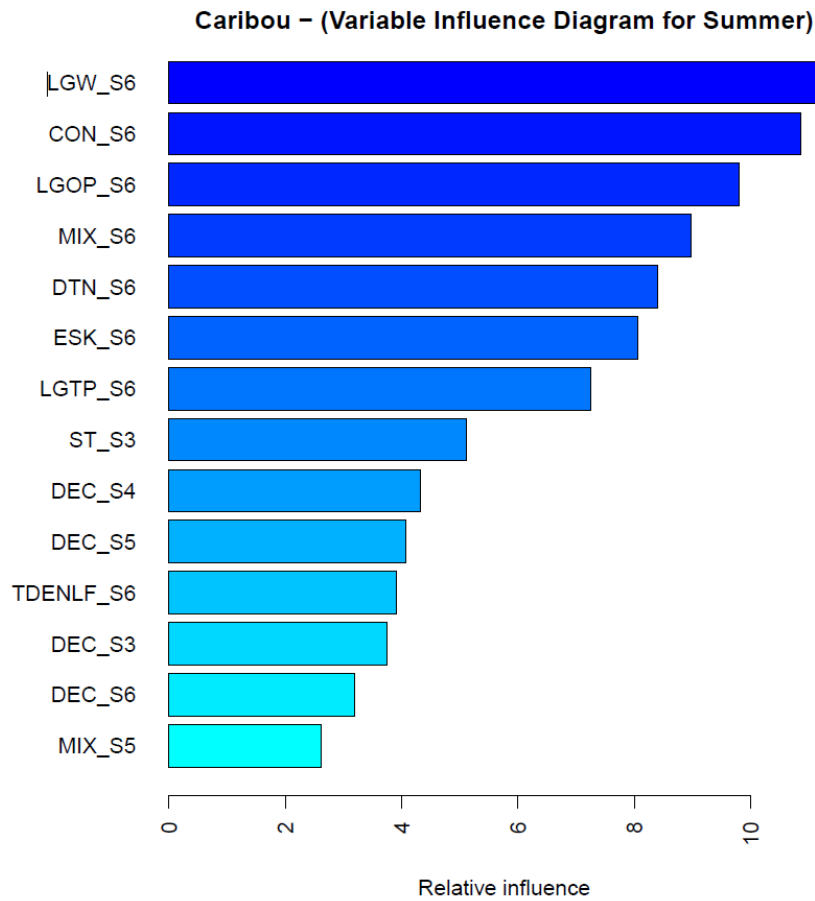


Figure 3: Variable influence diagram from the boosted-regression tree (BRT) model

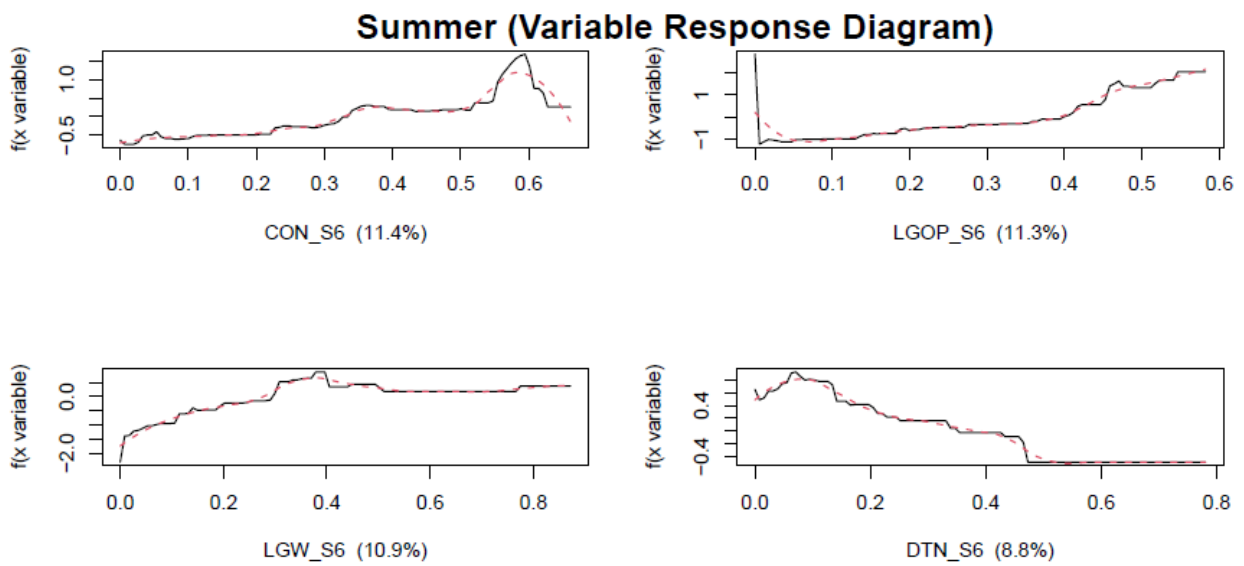


Figure 4: BRT model responses to Conifer (CON), Open Peatland (LGOP), Water (LGW), and Natural Disturbance (DTN) at the 10,000 ha spatial scale (\_S6).

The seasonal models were applied to the full landscape to visualize the relative probability of use across the landscape. This can also be interpreted as spatial patterns in relative carrying capacity or habitat quality among seasons. Patterns for probability of use differ among seasons, but in general, the Missisa range is used more heavily than the Ozhiski range and is more strongly associated with both the WSR and NRL study areas (Fig. 5). Probability of use for all seasons, including the southern Nipigon and Pagwachuan ranges, are given in Figs. 6-9.

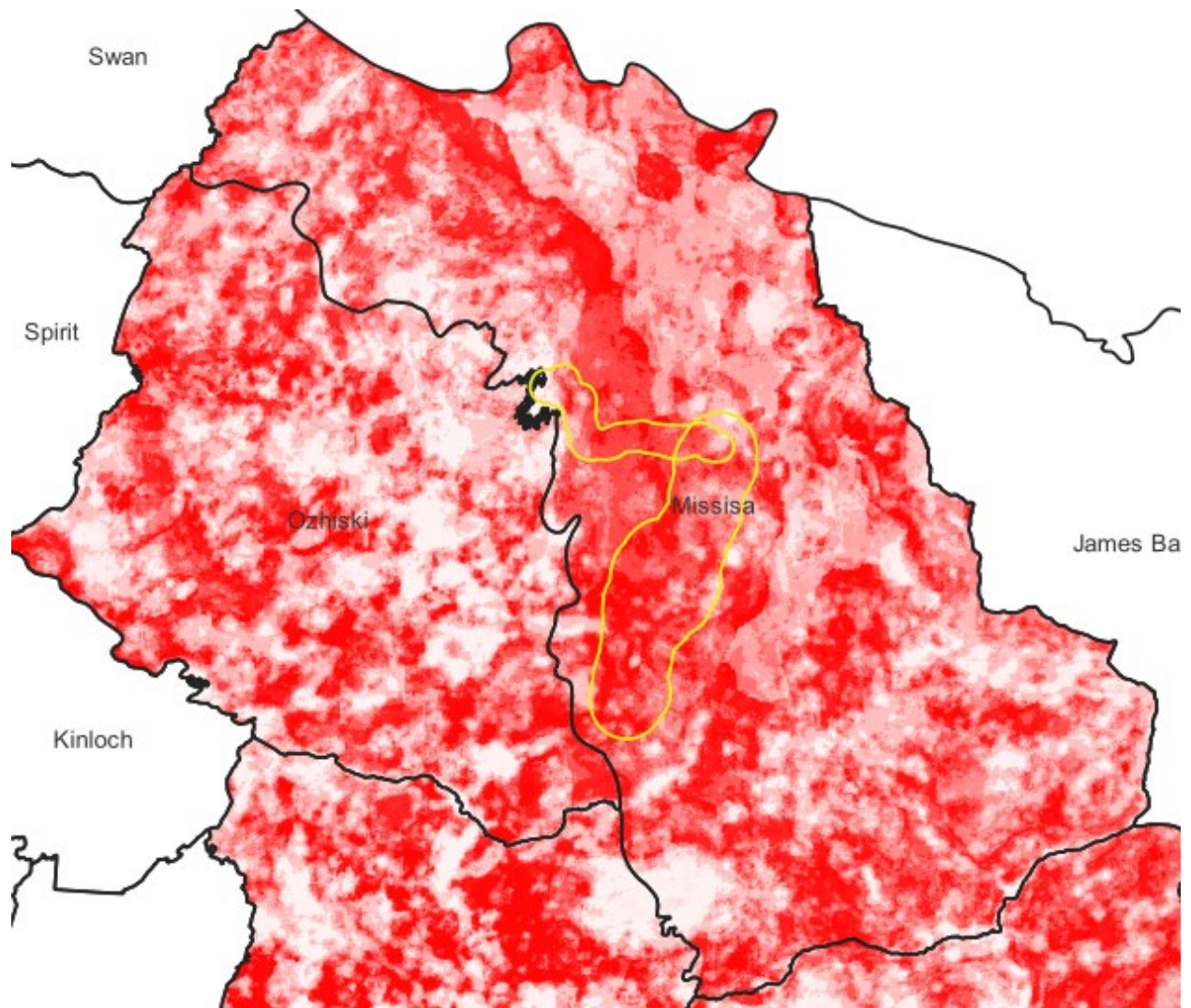


Figure 5: Probability of use by caribou for the Summer season in the ranges overlaying and adjacent to the WSR and NRL study areas.

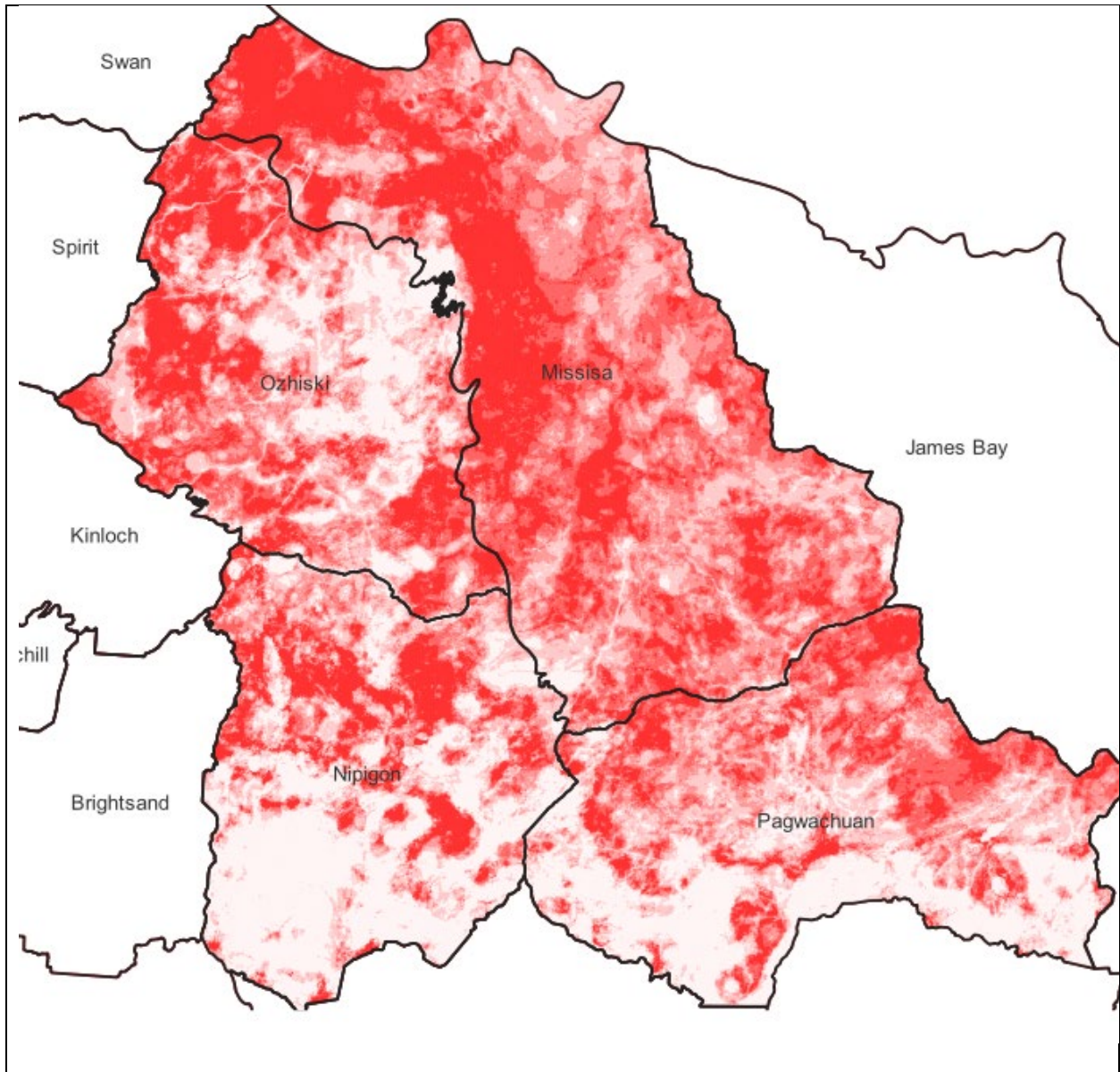


Figure 6: Probability of Use – Winter for the four ranges of Ozhiski, Missisa, Nipigon, and Pagwachuan.

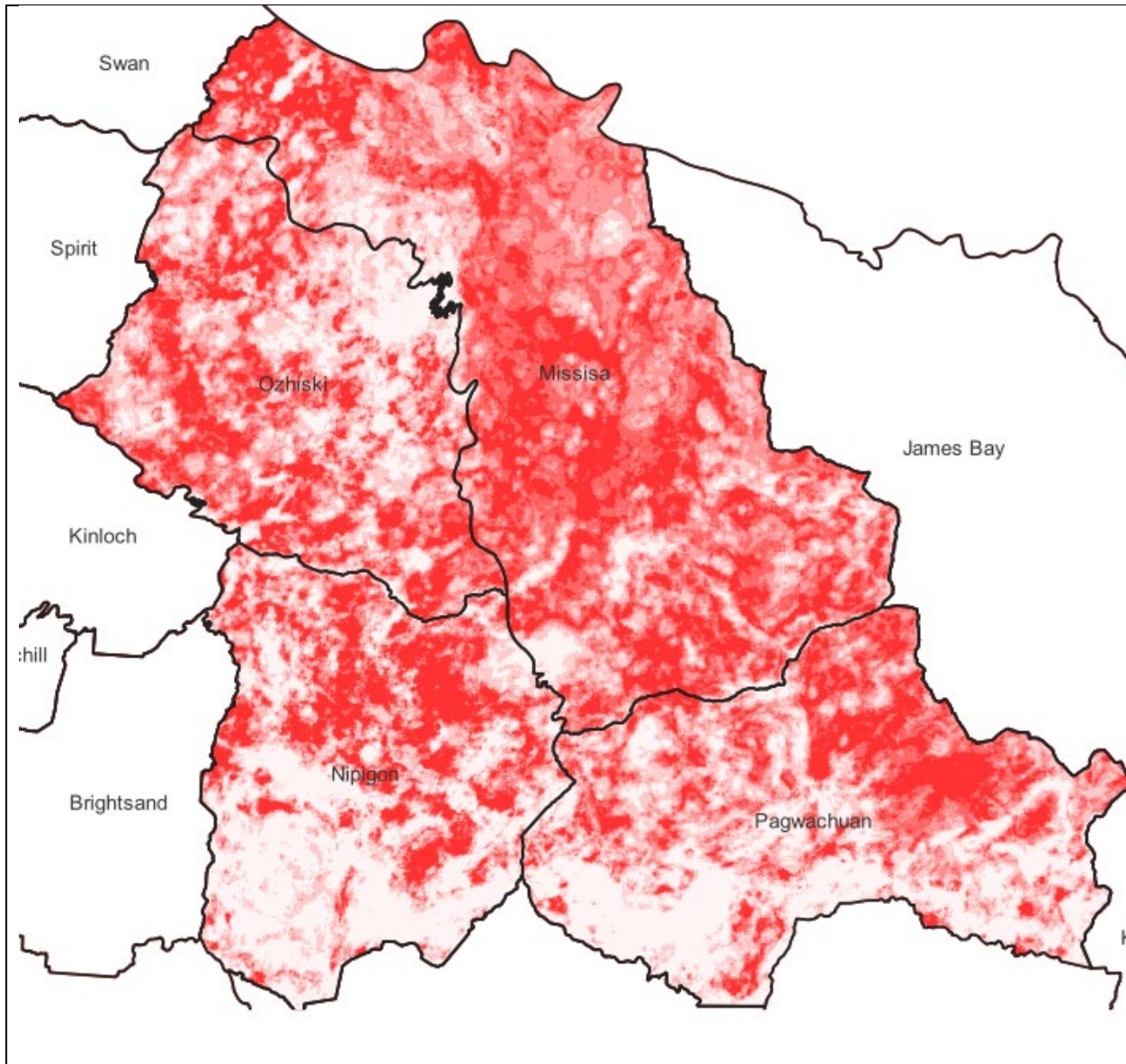


Figure 7: Probability of Use – Spring for the four ranges of Ozhiski, Missisa, Nipigon, and Pagwachuan. Darker red indicates higher probability of use.

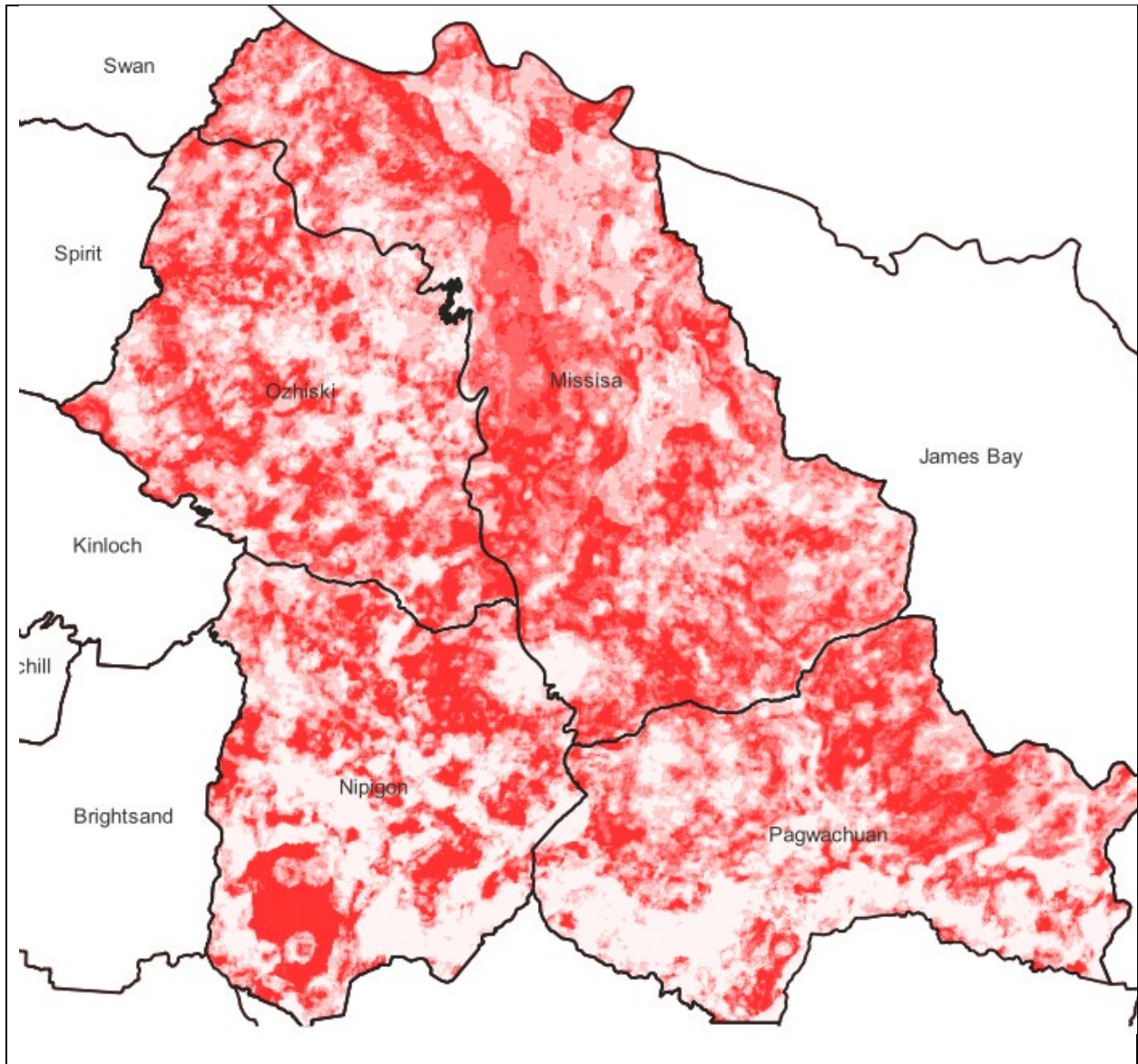


Figure 8: Probability of Use – Summer for the four ranges of Ozhiski, Missisa, Nipigon, and Pagwachuan. Darker red indicates higher probability of use.

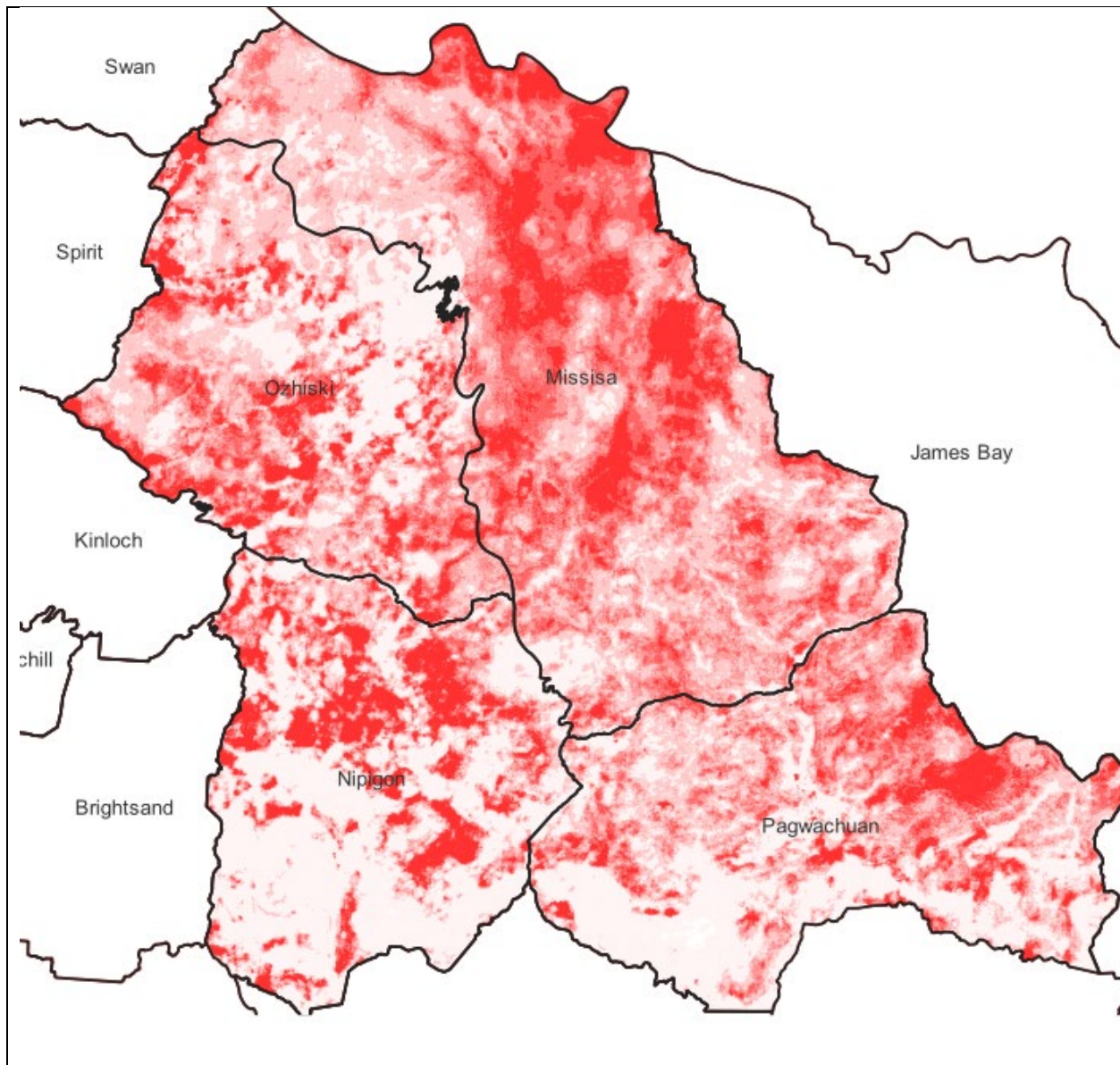


Figure 9: *Probability of Use – Fall for the four ranges of Ozhiski, Missisa, Nipigon, and Pagwachuan. Darker red indicates higher probability of use.*

### 3.2 Movement Animations Within and Between Seasons

Caribou movement animations reveal patterns of movement within a home range, across seasons, and among years. Although statistical summaries, such as step length and turn angle metrics can be useful in some analyses, movement animations provide insight not easily obtained from statistical analysis. For example, periods of relatively sedentary behavior, sudden starts to migrations between seasons, and herd splitting into barren-land versus wood-land habitats with subsequent aggregation can all be viewed from the animations. Snapshots from the motion videos are given in Fig. 10, and in general, the maps reveal patterns of use with Ozhiski and Missisa that

reflect the probability-of-use maps from the RSF. For example, very little use is seen in the eastern quadrat of the Ozhiski range that borders on the WSR study area, but fairly heavy use is seen throughout Ozhiski in both WSR and NRL study areas [animation link 1]. Animations over broader extents reveal patterns showing the herd splitting into sub-groups, with some animals heading to the barren grounds, only to return later in the year [animation link 2].

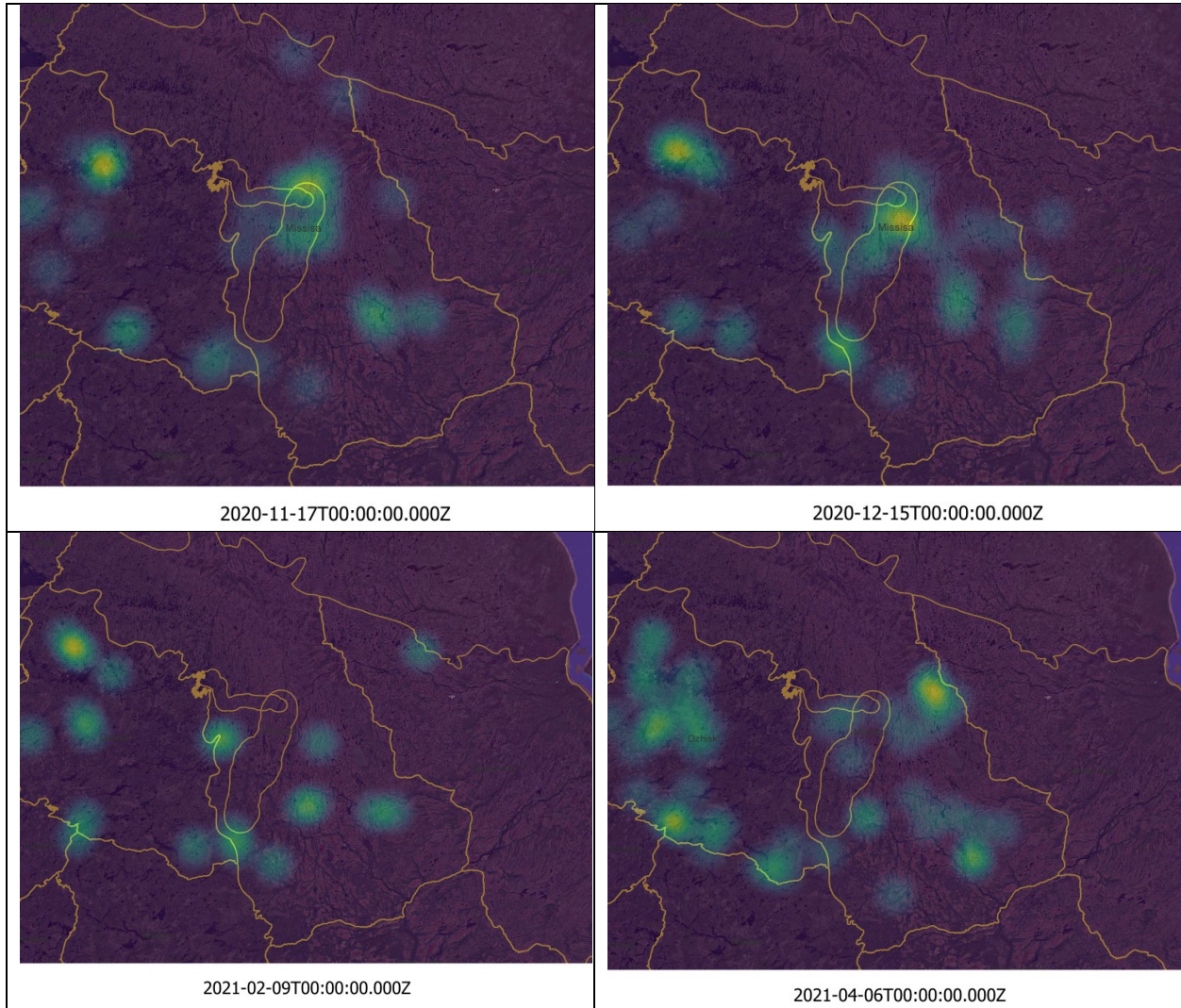


Figure 10: Snapshots from heat map motion animation (mp4) for caribou movement between Nov 2020 and April 2021. Hot spots represent location clusters over 1 week for of 1 or more caribou.

## 4 Links

Movements videos. Bi-weekly movement patterns. Jan 2019 to Dec 2023.

Link 1: [AR ATS and Lotek plus MNRF collars.](#)

Link 2: [AR ATS only collars.](#)

Link 3: [AR Lotek only collars.](#)

Link 4: Appendix A. *Appendix A\_SeasonalHabitatandMovementPatterns.pdf*

Link 5: RSF Prediction maps in geopackage format (ESRI compatible, CRS 3161); caribouRSF.gpkg

## 5 References

GHD Category 2 and 3 Mapping Report for Baseline Condition in Ozhiski and Missisa Caribou Ranges (FERIT, January 30<sup>th</sup>, 2024)

Report on Caribou Biophysical Attributes (FERIT, Feb 7<sup>th</sup>, 2024)

Hornseth, M. L., and R. S. Rempel. 2016. Seasonal resource selection of woodland caribou (*Rangifer tarandus caribou*) across a gradient of anthropogenic disturbance. *Canadian Journal of Zoology* **94**:79-93.

Ferguson, S. H., and P. C. Elkie. 2004. Seasonal movement patterns of woodland caribou (*Rangifer tarandus caribou*). *Journal of Zoology* **262**:125-134.

Walker, P. D., A. R. Rodgers, J. L. Shuter, I. D. Thompson, J. M. Fryxell, J. G. Cook, R. C. Cook, and E. H. Merrill. 2021. Comparison of woodland caribou calving areas determined by movement patterns across northern Ontario. *The Journal of Wildlife Management* **85**:169-182.

Pond, B. A., G. S. Brown, K. S. Wilson, and J. A. Schaefer. 2016. Drawing lines: Spatial behaviours reveal two ecotypes of woodland caribou. *Biological Conservation* **194**:139-148.

# APPENDIX A (CONT'D)

## A7-7: WSR Photo Log of Mortality Investigations

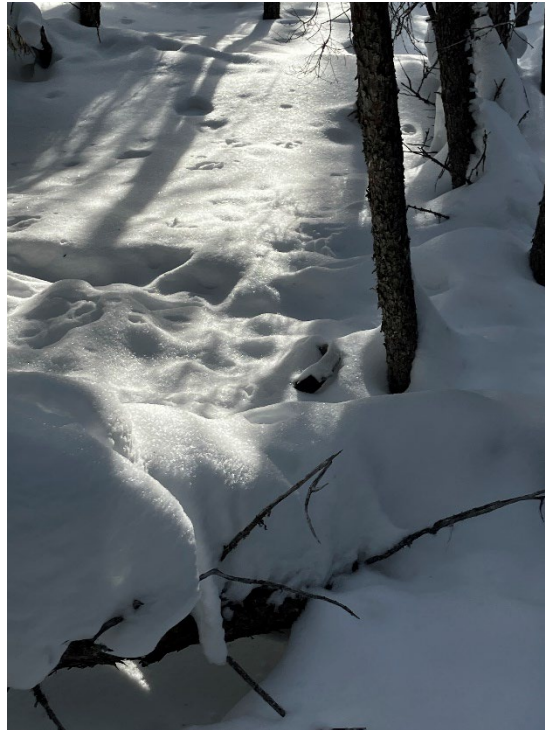




Photograph 1: Scapula at mortality site of Collar ID 049131



Photograph 2: Collar at mortality site of Collar ID 049131



Photograph 3: Collar and mortality site of Collar ID 049132.



Photograph 4: Mortality site of Collar ID 049303.

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