



**Letter and report submitted to
*Commission indépendante
sur les caribous forestiers et montagnards***

by



Cree First Nation of
WASWANIP

Waswanipi, May 31, 2022

To:

Honorable Commissioners

Commission indépendante sur les caribous forestiers et montagnards

Commissioners,

Within the framework of the *Commission indépendante sur les caribous forestiers et montagnards*, the Cree First Nation of Waswanipi (CFNW) wishes to submit this letter with high hope that it will be taken with all the consideration it requires. Note that our participation in this process must not be understood as an acknowledgment that it is sufficient to meet the consultation and accommodation obligations of your government towards our First Nation.

Due to the traditional and cultural importance of woodland caribou, the state of the herds in the face of rapidly changing habitats has been of great concern to land users in Waswanipi and even throughout Eeyou Istchee for several years now (Cree Regional Administration, 2010¹). Although the *Ministère des Forêts, de la Faune et des Parcs* (MFFP) has developed two theoretical management scenarios presented in the appendix of the Consultation Document, we will not base our discussion on these scenarios. We do not consider them viable, and several of our partners and allies had or will file documents underline this fact. Rather, we want to lead the commissioners to a few lines of thought that we consider to be priorities in the protection of the species, its habitat and all living beings that share connections with it.

Since the tabling in 2016 of a caribou habitat management action plan, and to this day, the Government of Quebec has never taken into account nor respected the rights and decision-making role of First Nations concerning this species. Over the years, even though they have agreed to participate openly, the First Nations have deplored the setting up of inappropriate tables and forums that do not allow them

¹ Cree Regional Authority, 2010. Woodland caribou (boreal population): A portrait of Cree knowledge in Eeyou Istchee. Prepared for Environment Canada for the development of the Woodland Caribou National Recovery Strategy.

The portrait of knowledge on the Woodland Caribou reflects much of the past and present relationship with the animal and thus informs us on elements such as its traits, habitat, diet, health, threats and traditional uses. It is hoped that the general portrait of knowledge will contribute to a good recovery strategy for the endangered Woodland Caribou, an animal much valued by the people.

to be adequately consulted and accommodated and, more generally, to discuss their ancestral rights, including their ancestral title and other interests.

The CFNW's point of consideration

Indigenous and scientific knowledge as management tools

First, we would like to draw your attention to a study that we commissioned from an independent consultant², presented in Appendix 1. Please note that this study has been presented to tallymen and that they all agreed with the conclusions and recommendations. Support for these conclusions therefore comes as well from both indigenous knowledge and scientific knowledge, which further reinforces these findings. We consider it our duty as Guardians of the territory to document the situation as it arises on our lands. This report documents precisely the situation on our territory, which the responsible authorities must consider carefully and with all due respect in the framework of territory management. Moreover, as pointed out by a few organizations that have filed a brief, increased participation by Aboriginal peoples is required.

Cultural and ecosystemic value

The cultural importance of caribou in the traditional way of life of many Aboriginal communities is well established. A deep connection exists between the caribou and the communities that share the same territory. A study has shown this at the level of the Cree nation (Cree Regional Administration, 2010³). In February 2010, a series of interviews were conducted in six Cree communities with the objective of gathering a Portrait of Cree Knowledge on Woodland Caribou in Eeyou Itschee. These communities include Waswanipi, Mistissini, Ouje-Bougoumou, Nemaska, Waskaganish, and Eastmain. The information was gathered from 35 knowledgeable hunters and elders and revealed that the people of Eeyou Itschee have long ago maintained a close relationship with the Caribou, owing much of their survival to them.

Other nations have demonstrated the same connection with the species, notably the Innus⁴. Moreover, in honour of their ancestors and their teachings on the

² Giroux-Bougard, X., 2022. Status of Boreal Woodland Caribou (*Rangifer tarandus caribou*) Critical Calving Habitat within the Traditional Territory of Waswanipi. Submitted to the Cree First Nation of Waswanipi. Waswanipi, Québec. 55 pp. Mr. Xavien Giroux-Bougard is an environmental data scientist and Ph.D candidate. His thesis focuses on barren-ground caribou movement and the ice phenology of freshwater in Canada's rapidly changing North.

³ Cree Regional Authority, 2010. Woodland caribou (boreal population): A portrait of Cree knowledge in Eeyou Itschee. Prepared for Environment Canada for the development of the Woodland Caribou National Recovery Strategy

⁴ At a recent conference, on May 10, as part of a panel discussion for the 2022 *Journée Nordique* of the *Institut Nordique* du Québec. Discussion panel : « Quel avenir pour le caribou ? ». *Portrait biologique des trois écotypes de caribou présents au Québec ; mise en lumière des enjeux de conservation les concernant et des pratiques mises en place à l'échelle nationale pour les préserver ; retour analytique sur les expériences de cogestion du Caribou au Canada ; les coulisses de l'entente historique sur la chasse au Caribou entre les nations Innus et Cris et la singularité de la relation entre la culture innue et le Caribou*

By 'André Michel, Biologist, Ashkuatshikunnu Experts-conseil
<https://www.inq.ulaval.ca/fr>

sacred values of sharing and respecting the resource, the Cree Nation of Eeyou Istchee and the Innu Nation negotiated the *MAAMUU NISITUHTIMUWIN / MATINUEU-MASHINAIKAN ATIKU E UAUINAKANIT* which translates as “mutual understanding”. This agreement is the result of years of effort and collaboration on the part of the Cree Nation of Chisasibi, the Cree Nation of Eeyou Istchee and the Innu Nations to achieve common objectives aimed at maintaining the health of their caribou populations and the continuation of their respective cultural relationships and connection with the caribou and the land. Also, the *Forum Atik*, a meeting organized by the Abitibiwinni First Nation Council since last year, is a good example of a relatively large-scale event. It highlights the importance of the specie for its participants and the significant expenses they are willing to make progress regarding the caribou protection.

At the ecosystem level, it is well known that caribou is an umbrella specie. The caribou's needs include those of several other species that coexist with it. By protecting vast areas undisturbed for caribou, we also ensure that we conserve other sensitive wildlife species.

Provincial and Federal Legislation

The two main laws aimed at protecting endangered species are the Quebec's *Act respecting threatened or vulnerable species*⁵ and Canada's *Species at Risk Act*⁶. In the Consultation Document, the MFFP suggests that it is an option to sacrifice isolated populations. The suggestion is surprising from a ministry whose legal obligations include the establishment of “programs to promote the survival of designated threatened or vulnerable species”.⁷ The *Sustainable Forest Development Act*⁸ states that sustainable forest development must contribute to “the preservation of biological diversity” and take into consideration “the values and needs expressed by the populations concerned”.⁹ Specifically, the “interests, values and needs of the Native communities” such as the community of Waswanipi are “an integral part of sustainable forest development”.¹⁰

Given these legal and moral duties, voluntarily sacrificing populations of caribou is completely unacceptable to us. The provincial government ought to follow its own laws and put forward its best efforts to promote the survival of caribou instead of willfully abandoning biodiversity in the name of short-sighted economic interests.

Aboriginal and Treaty Rights

The process proposed by the *Commission indépendante sur les caribous forestiers et montagnards* falls short of meeting your government's consultation

⁵ CQLR c E-12.01.

⁶ SC 2002, c 29.

⁷ Act respecting threatened or vulnerable species, *supra*, s. 7(2).

⁸ CQLR c A-18.1.

⁹ *Ibid*, s. 2(1) and (6).

¹⁰ *Ibid*, s. 6.

and accommodation obligations towards our Nation. Waswanipi, as a Cree community, has recognized Aboriginal and treaty rights.

Our treaty rights include that forestry activities applied by Québec must allow “participation, in the form of consultation, of the Crees in the various planning and management processes”.¹¹

Our treaty rights specifically afford additional protections for very important wildlife species such as the caribou:

*3.10.1 Special intervention modalities shall be applied to maintain or improve that habitat of very important wildlife species (moose, marten, beaver, hare, fish, caribou, partridge) and portions of each trapline shall benefit from special protection to improve the level of harmonization between forest management activities and traditional activities, including hunting, fishing and trapping activities.*¹²

According to Québec Government own laws respecting conservation and development of wildlife, “Government shall consult the Native communities separately if the circumstances so warrant”.¹³ The *Guide intérimaire en matière de consultation des communautés autochtones* (2008)¹⁴ include similar language with respect to developing consultation processes that are distinct from broad public consultation processes. This requirement is in line with our Nation-to-Nation relationship and respectful of the particular nature of the rights and interests we, as First Nations, have on our lands.

The process currently put forward by the Commission does not respect our constitutional right to be consulted and accommodated.¹⁵ Given the very important cultural significance of caribou for the maintenance of our Cree way of life, and given the potential impact of these important strategic-level conversations about the protection of caribou on our land, a stronger consultation and accommodation process is required¹⁶ and has not yet been fulfilled.

¹¹ Paix des Braves, Amendment No 6, s. 3.1.

¹² Paix des Braves, Amendment No 6, s. 3.10.1.

¹³ Act respecting the conservation and development of wildlife, CQLR, c C-61.1, s. 24.0.2.

¹⁴ https://cdn-contenu.quebec.ca/cdn-contenu/adm/min/conseil-executif/publications-adm/saa/administratives/orientations/fr/guide_inter_2008.pdf?1605704677 at p 11.

¹⁵ Mikisew Cree First Nation v. Canada (Minister of Canadian Heritage), 2005 SCC 69.

¹⁶ Rio Tinto Alcan Inc v. Carrier Sekani Tribal Council, 2010 SCC 43 at para 44.

Socio-economic

The socio-economic issue is omnipresent in the interventions of the MFFP and certain users of the territory. We understand this and attach importance to it. We are aware that some of our people and many of our fellow Jamesians are involved at different levels in the forest industry and understand their reluctance in the face of the likelihood of a slowdown in this economic activity. However, wood harvesting is the main cause of caribou habitat alteration¹⁷. Several other economic consequences associated with other sectors, however, seem obliterated from the current discourse.

It is possible to perform a monetary and sociocultural assessment of the woodland caribou habitat in Eeyou Itchee. This assessment would allow the identification, qualification, quantification and monetarization of the benefits generated by these ecosystems' biodiversity, i.e. the ecosystem services from which the Crees and other individuals can enjoy. These benefits include procurement services for goods such as wood, materials, food, etc. These ecosystem services also serve the purpose of regulating the Crees' environment, so it remains stable, safe and resilient to climate changes. Finally, the woodland caribou habitat has positive impacts socially, culturally and on the health. Global health (*miyupimaatsiium*) is part of it¹⁸.

All that being said, the economic argument presented here does not constitute a stamp of approval of the CFNW on the monetization of the territory. At the ethical level, our relationship with the living world and the territory is not monetizable and should not be the subject of a transaction. Rather, we would like to demonstrate that if the economic exercise were carried out properly, considering all the factors listed above, the balance of the benefits of economic activities considered until now by the MFFP would not necessarily outweigh the disadvantages associated with habitat alteration and all the associated consequences.

¹⁷ Northward expansion of commercially harvested forests and resource extraction industries in the past decades has resulted in rapid loss of old-growth forests and caused important declines in many boreal woodland caribou herds of Canada (Festa-Bianchet et al., 2011)

¹⁸ These ecological services were studied in Bois-Charlebois Master's essay (2018) and are the subject of *Plan de compensation pour la perte de milieux humides d'Éléonore* (Eleonore Wetland Loss Compensation Plan). This compensation plan, which is underway under Newmont's supervision, aims the increase of these ecological services and the benefits for the Crees through rehabilitation plantations. This type of assessment was performed for several ecosystems in the province of Quebec, including during the study *Les valeurs socioculturelles et monétaires des services écologiques rendus par les parcs nationaux du Québec* (Limoges, 2017: Ecological services sociocultural and monetary values in Quebec's National Parks). Its main advantage would be to assess the monetary and sociocultural benefits of the woodland caribou habitat, if it is maintained. Once this comparison is done with comparable units, for example dollars, a cost-benefit analysis could be performed in full knowledge of the facts.

References :

Bois-Charlebois (2018) : <https://depositum.uqat.ca/id/eprint/796/>;
Eleonore compensation plan : <https://comexqc.ca/wp-content/uploads/Eleonore-Plan-de-compensation-MHH-FR.pdf>;
Limoges 2017 : <https://www.erudit.org/en/journals/natcan/2018-v142-n1-natcan03265/1042012ar/>

Conclusions and Acknowledgements

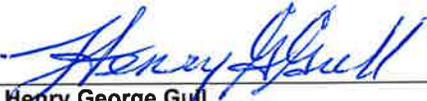
Our approach over the past few weeks has been to share our position with partners and organizations with similar concerns. We were able to confirm that we have many allies across the province. This underlines the importance of considering the highlighted priorities listed above. They for us are fundamental and unavoidable.

Although we consider the consultation process as presented to be far from ideal, we thank you for allowing us to express ourselves. Please consider our suggestions with all the respect and good care they deserve.

Accept our warmest regards,



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Attached :

Giroux-Bougard, X., 2022. Status of Boreal Woodland Caribou (*Rangifer tarandus caribou*) Critical Calving Habitat within the Traditional Territory of Waswanipi. Submitted to the Cree First Nation of Waswanipi. Waswanipi, Québec. 55 pp.

Status of woodland caribou (*Rangifer tarandus caribou*) critical calving habitat in the traditional territory of Waswanipi

Submitted to

The Cree First Nation of Waswanipi

by

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January 2022

Cite:

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1. Introduction

Caribou and reindeer herds (*Rangifer tarandus*) throughout North America and Eurasia have undergone important declines (Vors and Boyce, 2009) in the wake of rapidly changing environments. In Canada, boreal woodland caribou (*Rangifer tarandus caribou*) are particularly vulnerable given that the perennity of their populations depends on large areas of undisturbed old-growth boreal forest which are also prized for their tremendous value to forestry and forestry-related industries. Northward expansion of commercially harvested forests and resource extraction industries in the past decades has resulted in rapid loss of old-growth forests and caused important declines in many boreal woodland caribou herds of Canada (Festa-Bianchet et al., 2011).

In response to rapidly decreasing populations of several boreal woodland caribou herds, the Government of Canada's Committee on the Status of Endangered Wildlife in Canada (COSEWIC) listed it as a "Threatened" species under the *Species at Risk Act* in the year 2000 (COSEWIC, 2014, 2002), prompting the creation of a recovery strategy by Environment and Climate Change Canada (EC, 2012; ECCC, 2020). The Government of Québec also designated boreal woodland caribou as a "Vulnerable" species in 2005 and has since created its own recovery strategy (MFFP, 2013; MRNF, 2008). However, implementation of landscape planning and management strategies that reconcile forestry-based economies with the habitat requirements of species with large individual and herd ranges like boreal woodland caribou remains a challenge, and woodland caribou populations continue to decline throughout their boreal range to the present day (ECCC, 2020).

Unlike their migratory counterparts, boreal woodland caribou ("woodland caribou" or "caribou" hereafter) disperse prior to calving, selecting isolated areas characterised by mature open coniferous forests, wetlands, and peatlands (Bergeron, 2012; ECCC, 2020; Rudolph et al., 2012). This spacing-out strategy requires large areas of undisturbed habitat (Lesmerises et al., 2013) and helps reduce the risk of predation by reducing population densities during calving. However, forestry-impacted landscapes disrupt this strategy through several interacting mechanisms: habitat loss and transformation, apparent competition, and increased predator mobility. Logging

invariably leads to loss of old growth forests. Loss of such habitats reduces forage availability in winter (Smith et al., 2000), which exacerbates what is already a period of nutritional and energetic stress for parturient females. Cutblocks and forestry-managed landscapes also promote the growth of younger forests and shrublands, a process that has led to an increase in moose (*Alces alces*) populations adjacent to woodland caribou habitats (Bergerud et al., 2008). In turn, higher moose density leads to increased predator density and increased predation pressure on caribou (Serrouya et al., 2017), a process called apparent competition. Finally, the problem of habitat loss and increased predator density is further compounded by logging roads and other linear disturbances (e.g. hydro lines, seismic lines), which facilitate predator mobility and access into core calving areas (Whittington et al., 2011). The cumulative effects of anthropogenic disturbances on caribou ranges has resulted in lower caribou population recruitment rates and, as a consequence, the persistence of several populations is threatened (EC, 2009).

In the Eeyou Istchee and James Bay territory there are three herds of woodland caribou: the Assinica, the Nottaway, and the Témiscamie herds. Their populations face mounting pressure from habitat disturbances, especially in the southern part of their ranges where forestry is more prevalent. As of 2013, it is estimated that disturbances impact 51%, 33%, and 47% of the ranges of the Assinica, the Nottaway, and the Témiscamie herds, respectively (Rudolph, 2017; Rudolph et al., 2017). The most severely impacted range is that of the Assinica herd, which overlaps significantly with the traditional territory of the Cree First Nation of Waswanipi (CFNW). Due to the traditional importance of woodland caribou, the status of these herds in the face of rapidly changing habitats is of great concern to land users in Waswanipi and indeed throughout Eeyou Istchee (Cree Regional Authority, 2010).

2. Objectives

Previous studies on herds in Waswanipi (and Eeyou Istchee) confirm that the winter, spring, calving, and post-calving seasons are the periods of the year with the greatest mortality due to predation (Rudolph et al., 2012). It is during this critical period of the year that habitat selection can have the greatest consequence on demographic parameters such as female survival and calf recruitment (Pinard et al., 2012). Given the vulnerability of calves to predation in the days following birth, calving ranges constitute the most sensitive areas of a population's overall critical habitat (EC, 2011). As mandated by the Cree First Nation of Waswanipi, this study aims to identify and describe critical calving habitats within the Waswanipi territory (see Figure 1) between 2004 and 2020. Specifically, the primary objectives of this study are to:

- 1) *Identify individual calving ranges within Waswanipi.***
- 2) *Identify the habitat characteristics of calving ranges using habitat selection analysis.***
- 3) *Identify critical calving habitats within Waswanipi and describe their status (quantity and quality) over the course of study period.***
- 4) *Provide recommendations on the protection of existing calving habitats.***

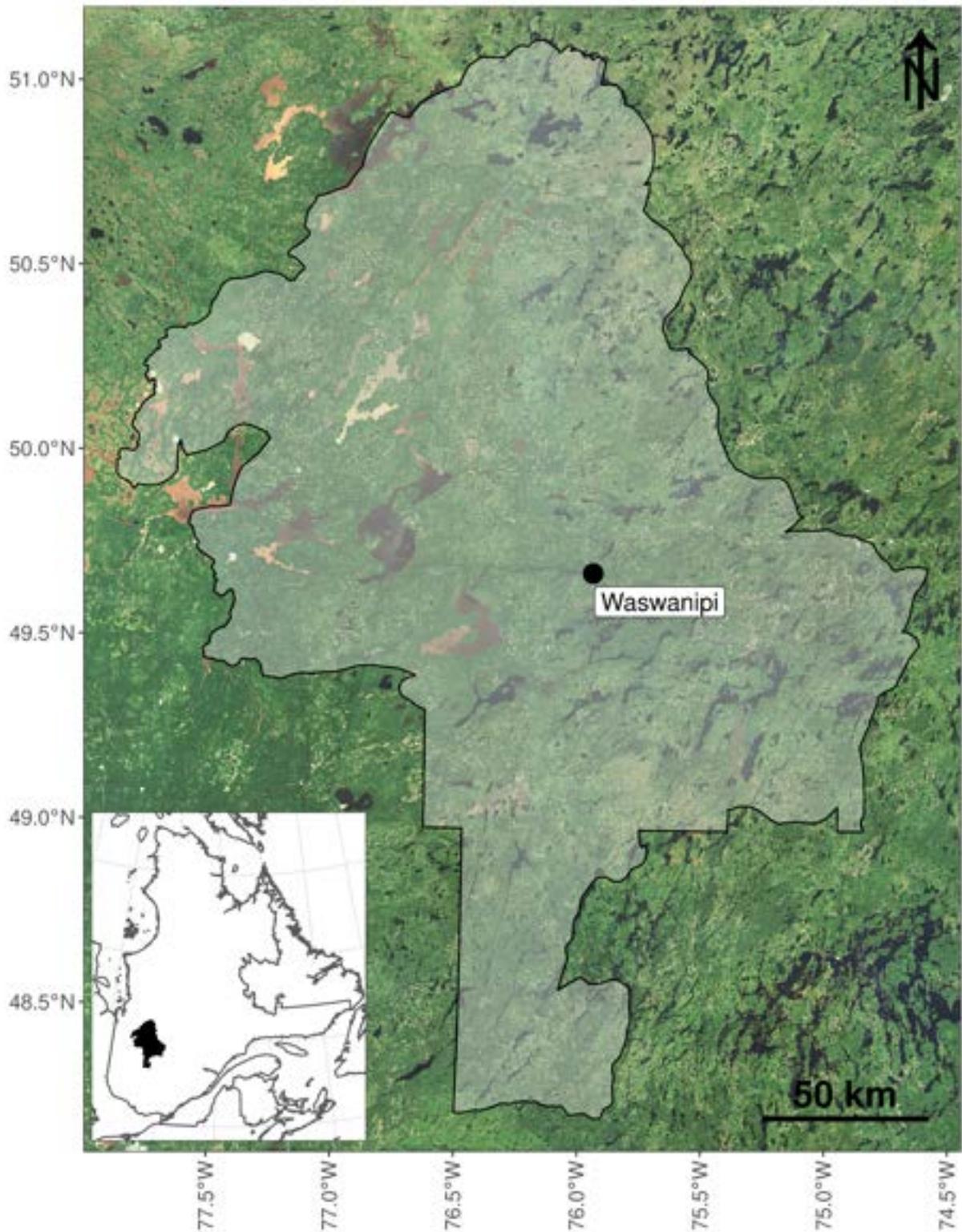


Figure 1. Map of study area encompassing the traditional territory of the Cree First Nation of Waswanipi. The inset shows the location of the region within the province of Quebec. Basemap is a Sentinel-2 RGB annual median composite.

3. Methodology

3.1 Caribou Telemetry Data

Telemetry data collected from female woodland caribou between 2004 and 2020 was used to (i) identify calving events and (ii) estimate the calving range associated to each calving event.

Through an ongoing GPS collar program, the Ministère des Forêts, de la Faune et des Parcs (MFFP) has been monitoring the GPS locations (*i.e.* relocations) of individuals from several herds, including three herds in the boreal forests of Quebec within the Eeyou Istchee territory: the Assinica, the Nottaway, and the Témiscamie herds. A subset of these data, collected within the Waswanipi region, was released to the Cree First Nation of Waswanipi (CFNW) by the MFFP. For the purposes of this study, only relocation data from female caribou during calving were retained for subsequent analysis. To ensure data quality, duplicate observations and extreme outliers were censored. Extreme outliers were determined based on thresholds in the distribution of speeds between two successive relocations (>4 km/h) and the distribution of net square displacement (NSD) since initial capture (>15000 sq km).

Calving events were identified by inspecting each female's annual relocation data using (i) maps of trajectories, (ii) time series of movement speed, and (iii) time series of NSD. Given the high temporal variability of seasonal cycles and behaviours, the beginning and end of individual calving events were identified through exhaustive inspection of individual collar data. The period of interest was limited to the spring, calving, and post-calving seasons which were selected using dates identified by previous studies for these caribou herds (Rudolph et al., 2012; Rudolph and Drapeau, 2012), from approximately the 95th to the 210th day of each year. To further reduce the influence of outlier observations during this period, the speed between successive relocations and the NSD since the first observation of spring was estimated using a moving average in a 48-hour sliding window. A female was considered to be calving if her trajectory exhibited temporary residency in a small area, very low mean movement speeds (almost zero km/h), and stable mean NSD. Using the time series of relocations

associated with each calving event, a female's calving range was estimated using a minimum convex polygon (MCP) containing 95% of relocations. All data cleaning operations and computations were performed in R (R Development Core Team, 2020) and the MCP was estimated using the method implemented in the *adehabitatHR* package (Calenge, 2006).

3.2 Environmental Covariates

3.2.1 Land Cover

The Earth Observation for Sustainable Forests' (EOSD) land cover classification map (Wulder and Nelson, 2003) was used as a habitat map and was updated each year of the study period with natural and anthropogenic disturbance data from digital forest inventory maps (Inventaire écoforestier du Québec) produced by the Ministère des Forêts, de la Faune et des Parcs (MFFP).

The EOSD land cover classification map, produced in 2002 by the Canadian Forest Service using Landsat imagery, was used as a baseline of available habitats at the beginning of the study period. Habitat classes were further aggregated based on ecological attributes previously shown to be relevant to woodland caribou during calving (ECCC, 2020; Rudolph et al., 2012). A detailed list of EOSD land cover classes and the corresponding habitats classes used for subsequent analyses in this study is available in *Supplementary Table 2*.

Digital maps from Québec's 3rd (MRNF, 2009), 4th (MFFP, 2015), and 5th (MFFP, 2021) forest inventories were utilised to characterise habitat disturbances that occurred within the Waswanipi region during the study period. Forestry-related disturbance polygons were classified as "cutblocks" while natural disturbance polygons were classified as "burns". A complete list of forest inventory disturbance classes and the corresponding disturbance classes used in this study is available in *Supplementary Table 3*.

Using the year each disturbance occurred, "cutblocks" and "burns" were further classified into "recent" (0 to 5 years old) and "old" (6 to 50 years old) to produce annual categorical maps for each year of the study period (2004 to 2020). An automated change detection algorithm based on satellite imagery was used to validate the year of

disturbance associated with each polygon in the MFFP's forest inventory maps. Satellite images captured during calving season by medium resolution (30-metre) sensors from the Landsat 5, 7, and 8 (EROS, 2018a, 2018b) missions were used to build a time series of Normalised Burn Ratio (NBR) from 1984 to 2020. The LandTrendr change detection algorithm (Kennedy et al., 2018, 2010) was then used to detect the years when significant drops in NBR, indicating a forest disturbance, were observed in each 30-metre pixel of the study area. Within each disturbance polygon, the disturbance year that was most frequently detected (*i.e.* mode) by the LandTrendr algorithm was recorded and subsequently compared to the year recorded in the forest inventory. In case of a disagreement between both years, the earliest year was selected. One exception was if LandTrendr detected a change one year after the year recorded in the forest inventory map, which would suggest that the disturbance occurred after the calving season. In this situation, the year detected by LandTrendr was retained for subsequent analyses. All satellite imagery data was accessed with and remote sensing analyses were conducted in Google Earth Engine (Gorelick et al., 2017) using the JavaScript API.

Finally, a categorical land cover raster map incorporating habitat classes and disturbances was produced for each study year. The raster map of habitat classes based on the EOSD land cover classification map (circa 2002) was updated each year (2004 to 2020 inclusively) with the disturbances that occurred up to and during the current study year's calving season.

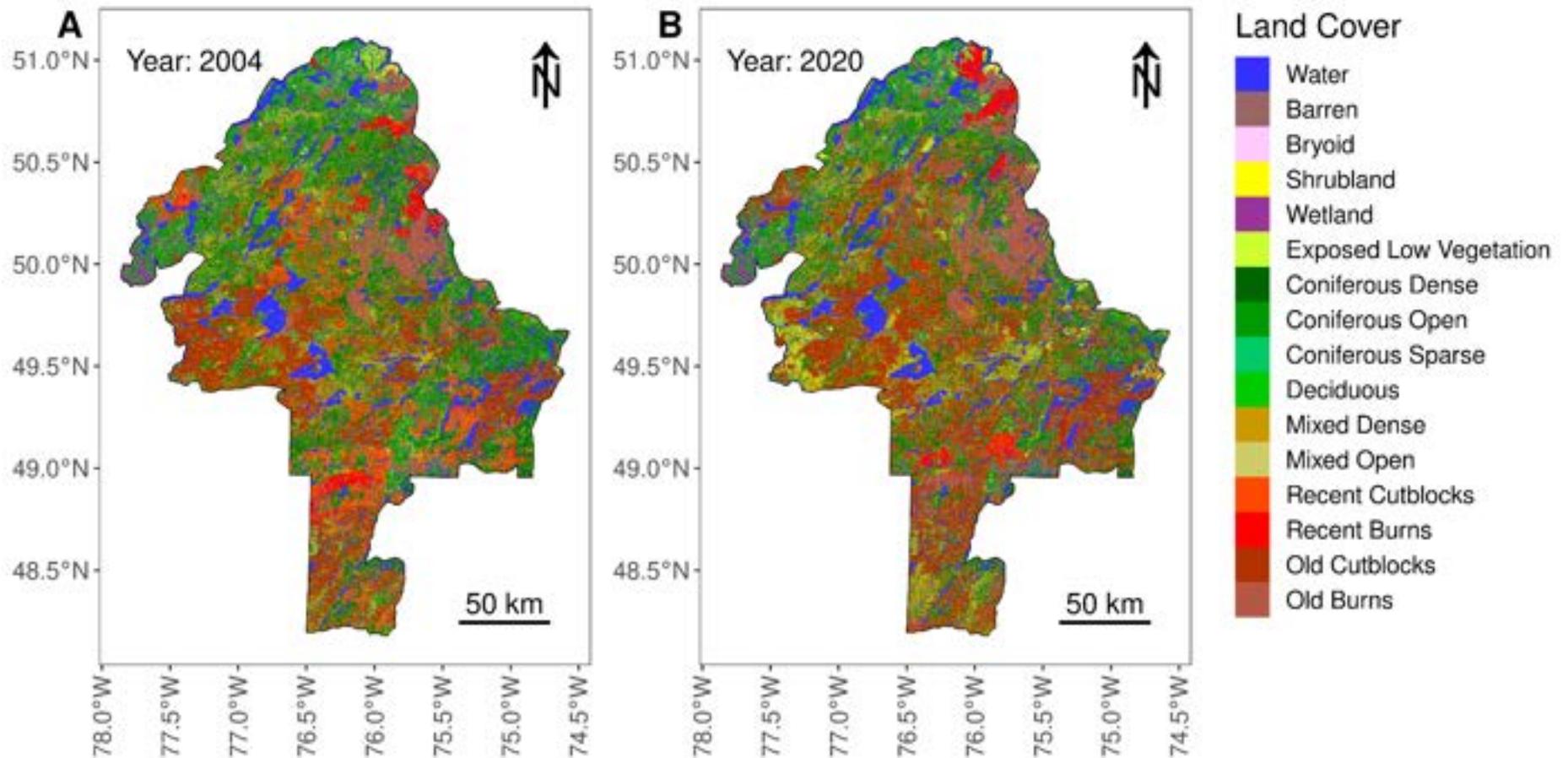


Figure 2. Map of land cover in the Waswanipi region at (A) the beginning (2004) and at (B) the end (2020) of the study period. Habitat classes are based on EOSD land cover classifications while natural and anthropogenic disturbances (burns and cutblocks) are based on MFFP forest inventories.

3.2.2 Road Density

Maps of road density within the Waswanipi region were produced for each study year using the road network spatial database available via the AQRéseau product (MERN, 2021). The year of construction of each road was pinpointed by using a change detection algorithm based on Landsat imagery. Using the LandTrendr algorithm as detailed above, a time-series of NBR derived from images captured by Landsat 5, 7, and 8 sensors during calving season was examined to detect significant changes to forests in areas adjacent to roads. For each road polyline in AQRéseau's database, the year of construction was assumed to be the earliest year of disturbance detected by LandTrendr in all the 30-metre pixels within a 60-metre buffer around that road. All satellite imagery data was accessed with and remote sensing analyses were conducted in Google Earth Engine (Gorelick et al., 2017) using the JavaScript API.

Previous studies investigating the spatial scales of habitat selection in Quebec have shown that calving woodland caribou avoid areas within 8 kilometres of roads (Leblond et al., 2011). To capture the effects of roads at a similar landscape scale, density raster maps were produced by computing, for each 500-metre cell, the density of all roads and railways (e.g. logging, municipal, provincial, federal) contained within an 8-kilometre radius from the cell's centre. Road density maps were recomputed every year of the study (2004 to 2020 inclusively) to incorporate new roads built since the previous study year's calving season. All road density raster maps were produced using R (R Development Core Team, 2020).

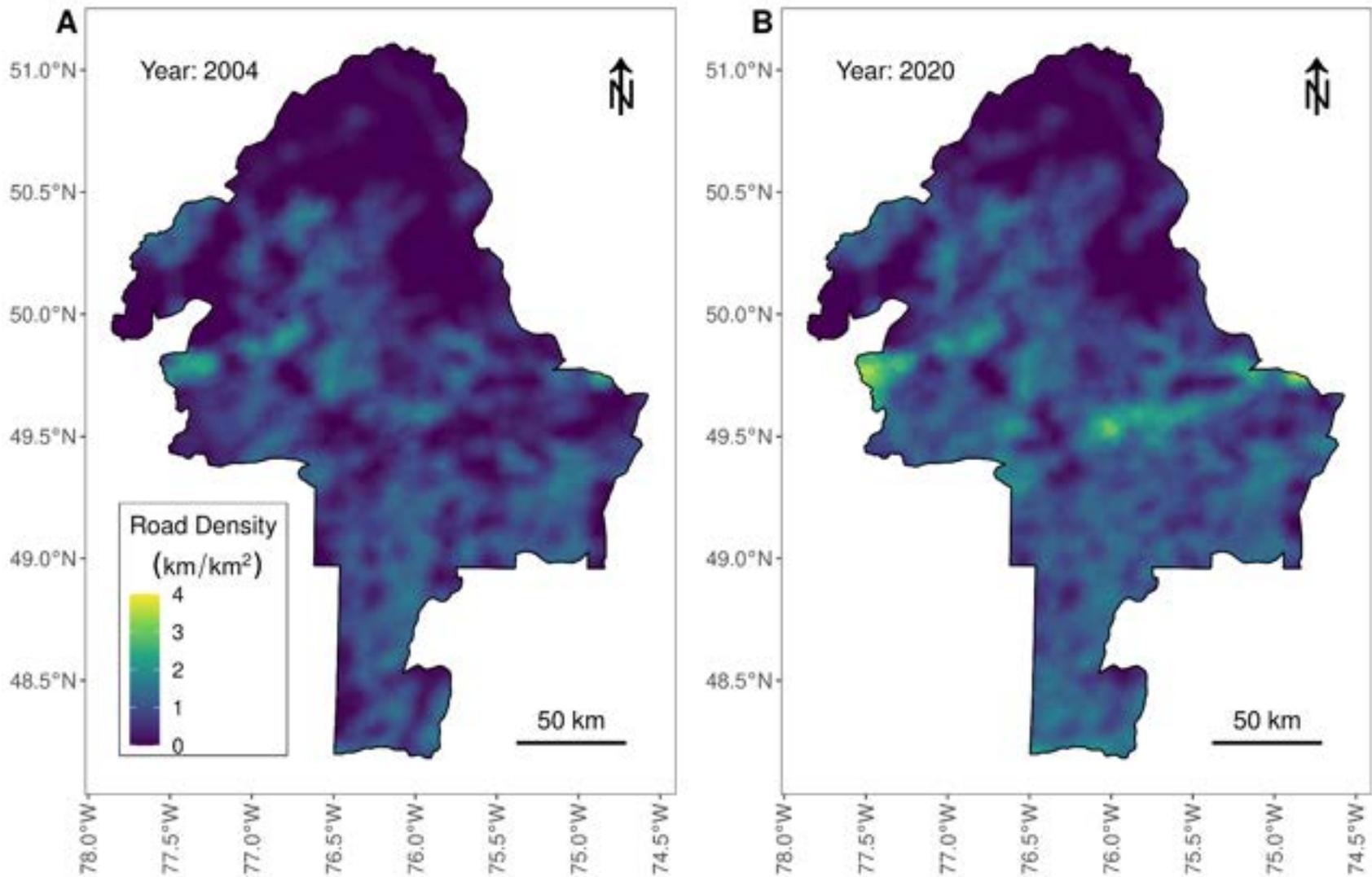


Figure 3. Maps of road density (km/km^2) in the Waswanipi region. Each panel illustrates road density (A) in 2004 and (B) in 2020 to highlight increased road density during the study period. Road density was derived from road network data available from the AQRéseau database (MERN, 2021).

3.2.3 Distance to Water

A single raster map of the distance to the nearest water body was produced for the Waswanipi region during the study period. Woodland caribou are known to select calving habitats adjacent to water bodies, such as islands and peninsulas (ECCC, 2020). The 30-metre resolution raster map of distance to water was produced by computing the Euclidean distance to the nearest water pixel found in the EOSD land cover classification map. The distance to water map was assumed to remain unchanged throughout the study period and was produced using R (R Development Core Team, 2020).

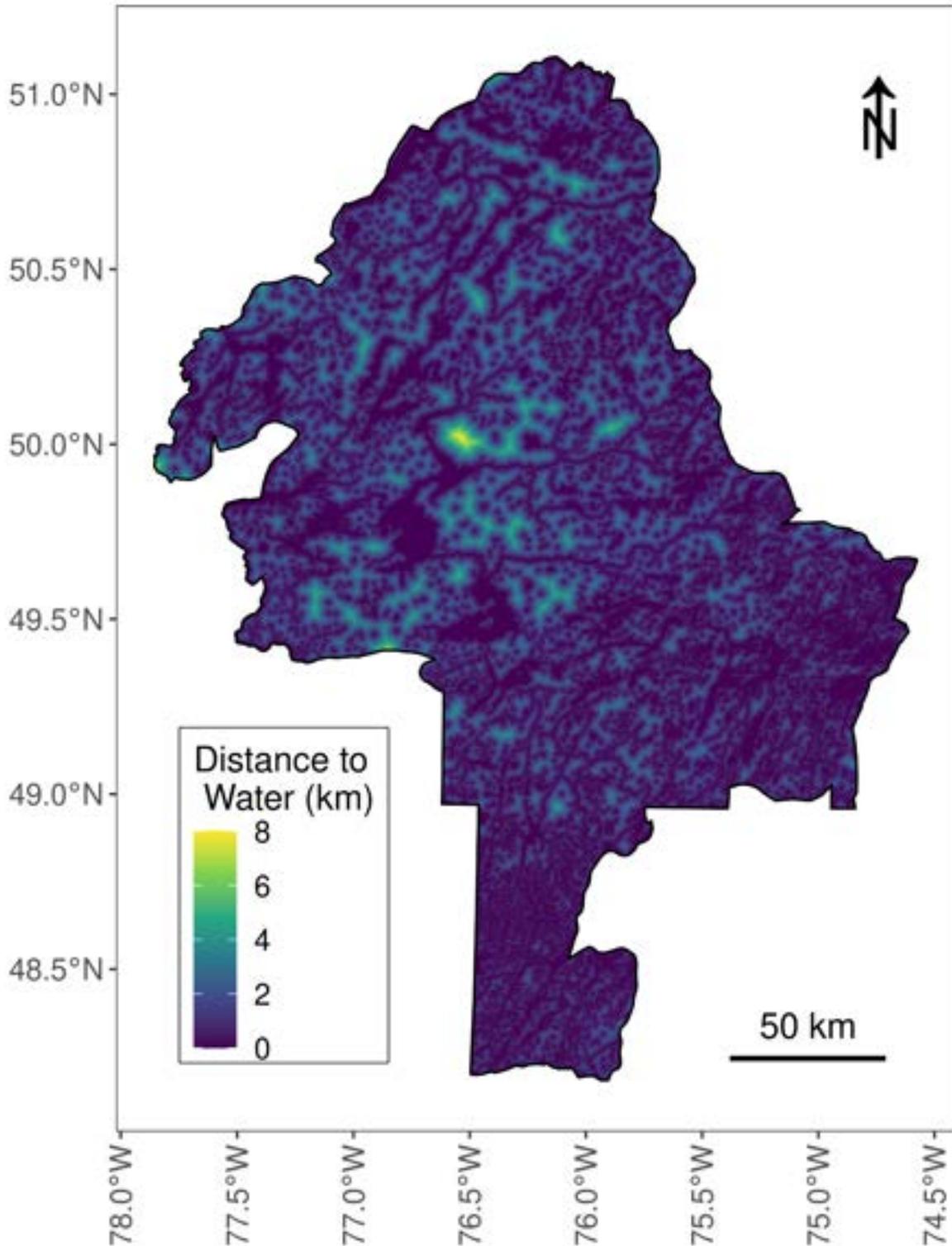


Figure 4. Map of distance to water (in kilometres) in the Waswanipi region. Distance to water was calculated as the Euclidean distance to the nearest water pixel in the EOSD land cover map (see Figure 2) and was assumed to be constant throughout the study period.

3.3 Calving Habitat Selection

3.3.1 Sampling Habitat Use-Availability

For each distinct calving event identified in *Section 3.1*, land cover classes, road density, and distance to water maps were sampled in used (*i.e.* observed) and available (*i.e.* random) locations. Available locations associated with a given calving event were randomly sampled in terrestrial habitats within a 51-kilometre buffer of the given calving range, excluding areas outside the Waswanipi region. To capture the breadth of possible calving ranges to select at the spatial scale of caribou movement, the buffer distance was calculated as the mean total distance that calving females travelled during spring, calving, and post-calving seasons. For each used location within a calving range, 100 corresponding available locations were randomly sampled in the surrounding buffer (see Figure 5). Rapid forestry-related landscape change during the study period was accounted for by sampling environmental covariates from annually updated maps reflecting the cumulative changes that occurred in prior years up to the calving season of the year a given calving event took place.

● Random Locations (Available) ● Observed Locations (Used)

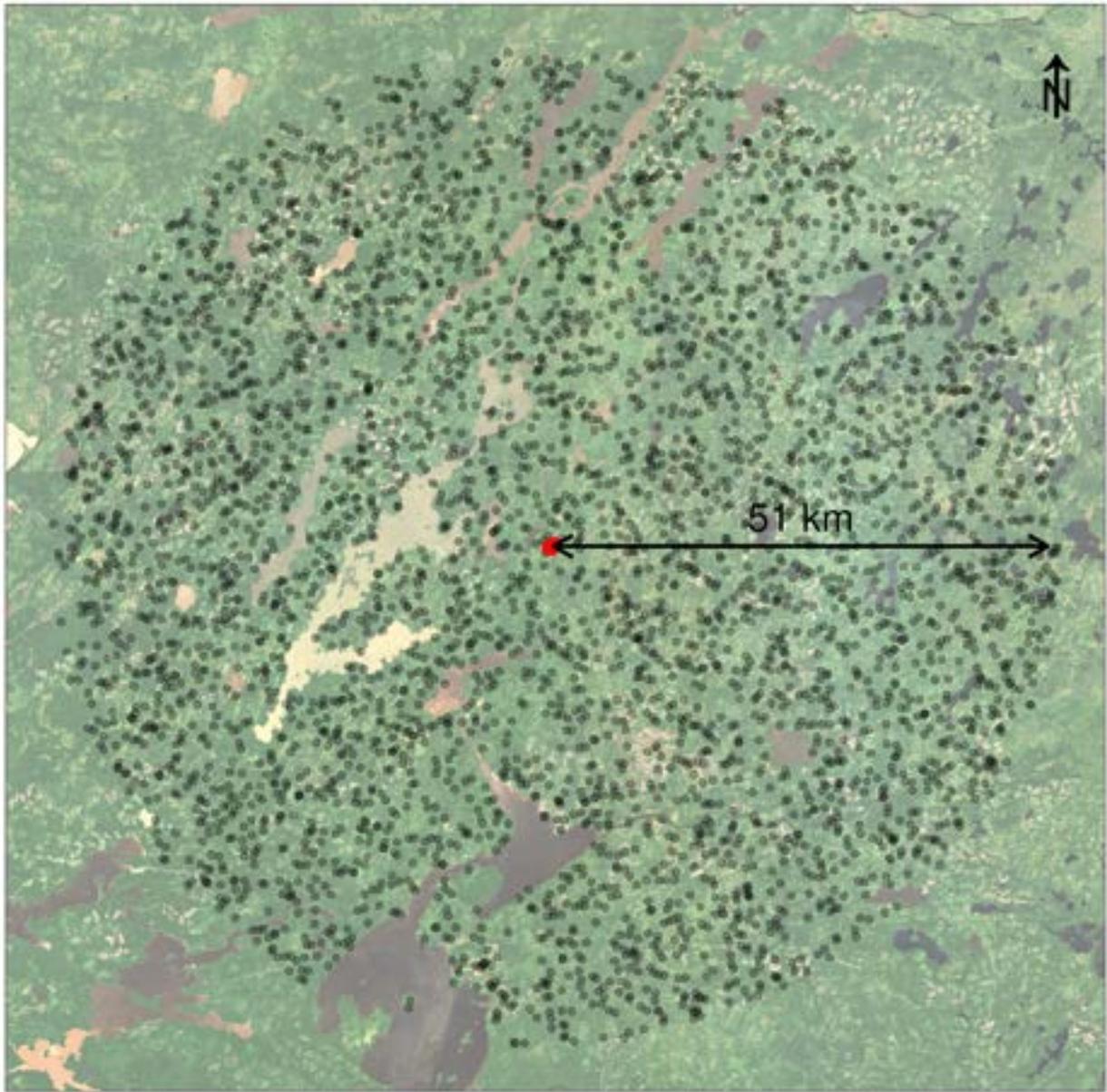


Figure 5. Example of the random sampling strategy employed to estimate Manly’s global selection ratios and resource selection functions. Red points represent the observed locations (“used”) of a fictitious female during calving. Black points represent random locations (“available”) in the surrounding landscape. Random locations were sampled from terrestrial habitats in Waswanipi within a 51-kilometre radius of each female’s calving range. Basemap is a Sentinel-2 RGB annual composite.

3.3.2 Selection Ratio

Selection or avoidance of each habitat was evaluated by computing Manly's global selection ratio (Manly et al., 2004) across all calving events. Specifically, this is calculated as the ratio of the proportion of use of a given habitat to that habitat's relative prevalence in the available landscape across all calving events. A ratio of 1 thus indicates that a given habitat is used as frequently as it is found in the landscape, while above or below a ratio of 1 suggests selection and avoidance, respectively. Selection ratios were computed using the *widesIII* function in the *adehabitatHR* package (Calenge, 2006) implemented in R (R Development Core Team, 2020).

3.3.3 Resource Selection Function

Probability of habitat use by female caribou during calving season was modelled using a resource selection function (RSF) fit with a hierarchical (*i.e.* mixed-effects) logistic regression. Using a use-availability design (Johnson et al., 2006), the RSF was fit assuming the exponential form:

$$\omega(x) = \exp(\beta_0 + x_1\beta_{1ij} + \dots + x_k\beta_{kij} + \gamma_{kj}x_{kj} + \gamma_{0j})$$

where $x_1 \dots x_k$ are environmental covariates; β_0 is the population level intercept; $\beta_1 \dots \beta_k$ are coefficients to be estimated; and γ_{kj} and γ_{0j} are the random coefficients fitted to environmental covariate x_k and the random intercept within group j (Gillies et al., 2006).

Based on environmental covariates previously identified as important to selection of calving habitats (ECCC, 2020), three explanatory variables were included in the model: (i) annually updated land cover (categorical variable), (ii) annually updated road density (continuous variable), and (iii) distance to water (continuous variable). Land cover classified as "Water" and "Exposed Low Vegetation" were removed prior to modelling because they were not usable calving habitats or were too rare for meaningful inference. Since use-availability observations associated with each calving event are not independent observations, observations for each calving event were grouped using

a factor accounting for “individual-year” and included as a random effect in the model, effectively allowing the coefficients to vary within each group.

Because habitat availability is only an estimation of the true composition of the surrounding landscape, the hierarchical logistic regression was fit using an arbitrarily large weight of 5000 for “available” locations and a weight of 1 for “used” locations (Fithian and Hastie, 2013). To further ensure the interpretability and stability (*i.e.*, reproducibility) of model coefficients, 100 available locations were included in the model for each used location (Fieberg et al., 2021; Warton and Shepherd, 2010). Selection or avoidance of habitat covariates was estimated using relative selection strength (RSS; Avgar et al., 2017) using “Open Coniferous Forest” as a reference level. Coefficients for the hierarchical logistic regression were estimated using the *lme4* package (Bates et al., 2015) implemented in R (R Development Core Team, 2020).

To monitor potential calving habitats over the course of the study period, RSF maps were created to inspect probability of use in Waswanipi between 2004 and 2010. Using the raster maps of environmental covariates for each year as inputs, the fitted RSF model was used to produce annual maps of the predicted probability of use as calving habitat. The predicted probability of use for each habitat pixel was pooled across all years and separated into 10 equal-interval bins (Morris et al., 2016). The equal-interval bins were then used to classify each annual habitat map into 10 classes ranging from “low” to “high” probability of use for calving. Proportions of habitats in each probability of use class were then computed to monitor declines in potential calving habitats during the study period. All modelling, statistics, and spatial analyses were computed in R (R Development Core Team, 2020).

4. Results

4.1 Calving Ranges

The inspection of GPS location time series helped identify 55 distinct calving events by 19 female woodland caribou in Waswanipi between 2004 and 2020. The majority of calving ranges were located in the region northwest and north of the community of Waswanipi (see Figure 6) in undisturbed coniferous forests with low road density. With the exception of 2013 and 2014, calving events were identified every year of the study period (see Figure 6). Between 1 to 5 calving events were typically identified for each female included in this study, though 1 female did display typical calving movement behaviours for 8 seasons (see Suppl. Table 1). During confirmed calving events, most collars collected GPS fixes approximately every 8 to 12 hours, and the total GPS locations collected during each distinct event typically varied from 20 to 50 recorded locations (see Suppl. Table 1). Calving females were predominantly from the Assinica herd, though one individual was from the Nottaway and another had no assigned herd (see Suppl. Table 1).

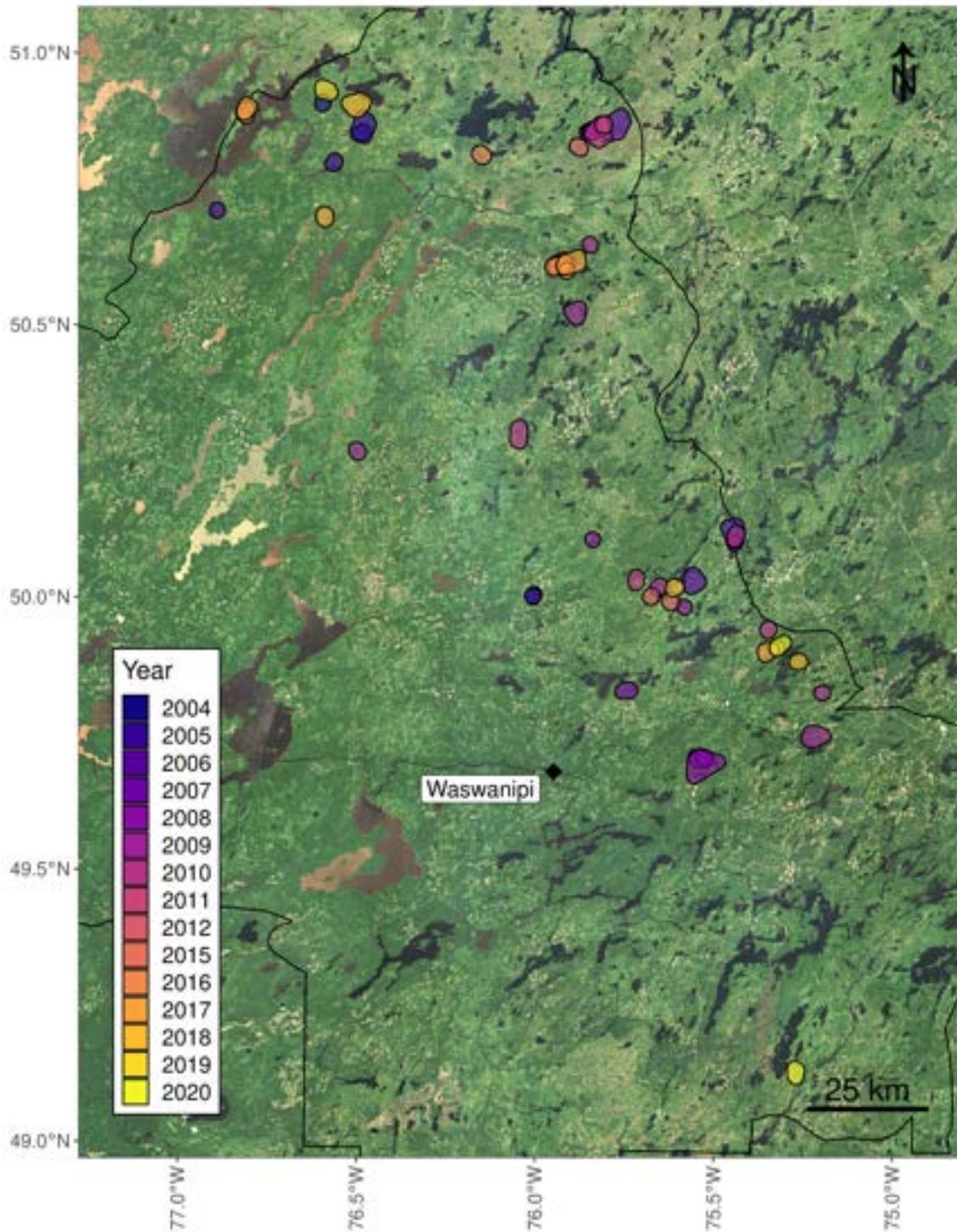


Figure 6. Map of 55 calving ranges used by 19 female woodland caribou within the Waswanipi region between 2004 and 2020, inclusively. Calving ranges were estimated using a minimum convex polygon (MCP) encompassing 95% of relocations collected via GPS-fitted collars during calving events. An additional buffer of 1500 metres was added to MCPs to facilitate visualisation. Basemap is a Sentinel-2 RGB annual median composite.

4.2 Calving Habitat Selection

4.2.1 Habitat Composition and Selection Ratios

Amongst the undisturbed habitats available throughout the study period in the Waswanipi region, calving woodland caribou typically selected coniferous forest habitats. Open coniferous forest habitats were especially prized by calving females. While they only covered 25.8% of potentially available habitats, 48.5% of all locations recorded during calving were observed in open coniferous forest (see Figure 7a). Manly's selection ratio for open coniferous forest habitats was 1.7 and statistically significant, indicating that this habitat was used at almost double the rate of its relative availability in the landscapes surrounding calving ranges. Sparse and dense coniferous habitats were also heavily utilised during calving, together accounting for 23.8% of habitats used during calving while only representing 16.7% of all available habitats. Wetlands, open mixed forests, and dense mixed forests account for most of the remaining habitat use (24.1%) during calving, though they are each used at approximately the same rate as they are available as demonstrated by selection ratios of around 1 (see Figure 7b). Barren, shrubland, deciduous forests, and exposed low vegetation habitats, though uncommon, were nonetheless avoided by females during calving season (see Figure 7).

All disturbed habitats available throughout the study period were strongly avoided by calving females. Selection ratios for recent and old cutblocks were both 0 (see Figure 7b), showing strong avoidance of forestry impacted areas. Together these areas accounted for 11.2% of available habitats and only 0.1% of used habitats (see Figure 7a). Recent burns and old burns were more abundant, accounting for 4.5% and 14.5% of available habitats, respectively. While selection ratios for burns demonstrated strong avoidance, old burn habitats were nonetheless used most frequently amongst disturbed habitats, with 3.8% of locations observed in old burns during calving.

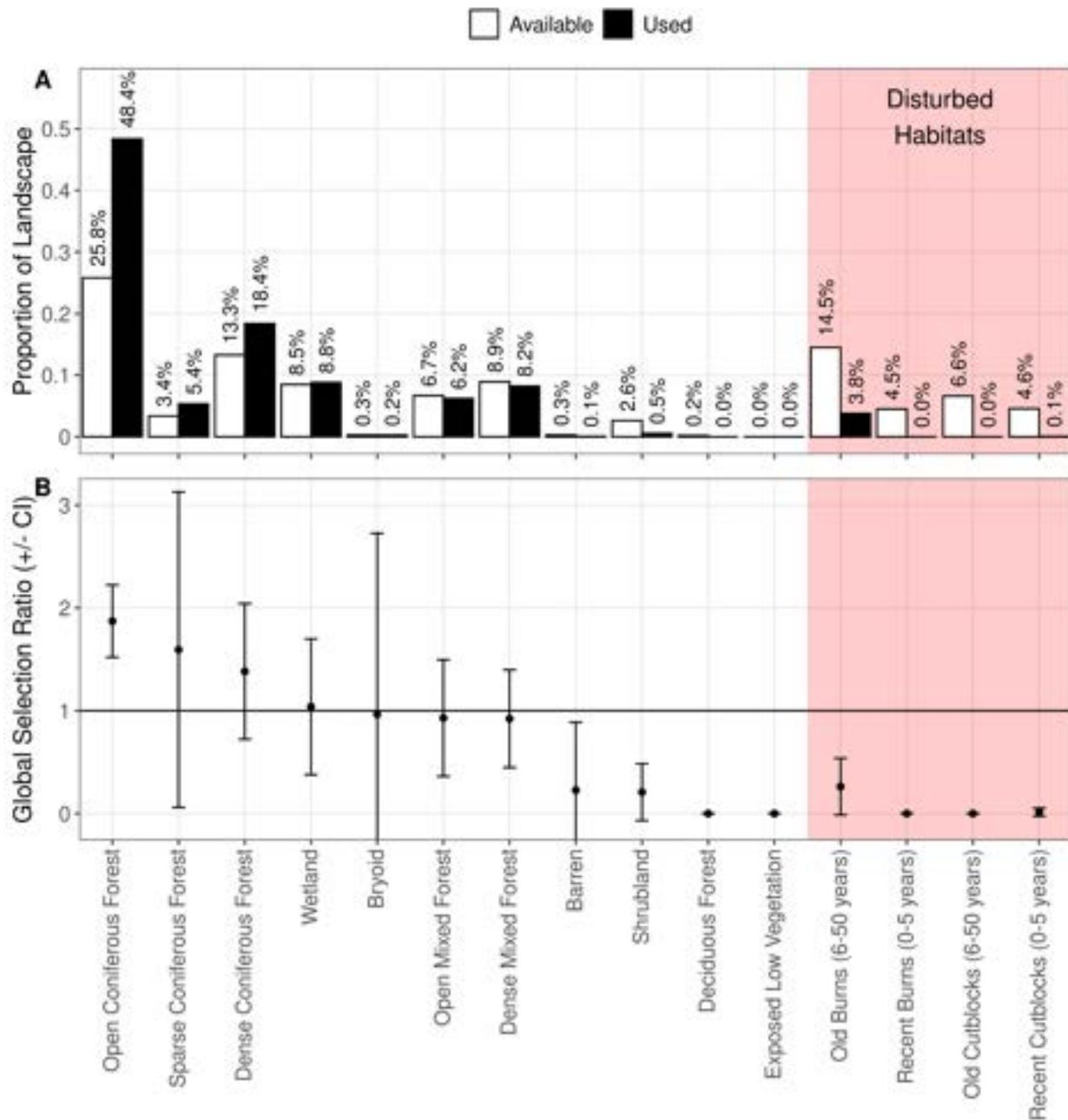


Figure 7. Use, availability, and selection-avoidance of land cover classes across all calving events in the Waswanipi region between 2004 and 2020. (A) Proportion of used (*i.e.* observed) and available (*i.e.* random) land cover classes are presented with distinction between undisturbed habitats (in white) and disturbed habitats (in red). (B) Selection or avoidance of each habitat class is indicated by Manly's global selection ratios (\pm 95% confidence intervals), where statistically significant selection or avoidance correspond to ratios with confidence intervals entirely above or below 1, respectively.

4.2.2 Selection of Land Cover Classes

All the natural (*i.e.* undisturbed) habitats included in the land cover classification had statistically significant effects on calving habitat selection by female woodland caribou in Waswanipi between 2004 and 2020 (see Figure 8 & Suppl. Table 4). Open coniferous forest, the habitat most prized by calving females, was used as a reference level to assess the relative selection strength (RSS) of other habitat covariates. RSS values indicate that, after open coniferous forests, calving females preferred sparse and dense coniferous forests, open and dense mixed forests, and wetlands (see Figure 8). The RSS values for these habitats ranged from 0.3366 to 0.1665 (see Suppl. Table 4), indicating that they were selected by calving females roughly 3 to 6 times less frequently than open coniferous forests. Other undisturbed habitats, such as shrublands, deciduous forests, and barren habitats were selected approximately 100 times less frequently than open coniferous forest (see Figure 8), with RSS values of 0.0251, 0.0121, and 0.0052, respectively.

All the disturbed habitats included in the land cover classification were significantly avoided by calving female woodland caribou in Waswanipi between 2004 and 2020 (see Figure 8 & Suppl. Table 4). Relative to open coniferous, both recent and old cutblocks were more than 1000 times less likely to be used by calving females, with RSS values of 0.0006 and 0.0008, respectively (see Suppl. Table 4). Burns were also avoided during calving, though old burns were avoided at a lesser rate than recent burns, with RSS values of 0.0123 and 0.0005, respectively (see Suppl. Table 4).

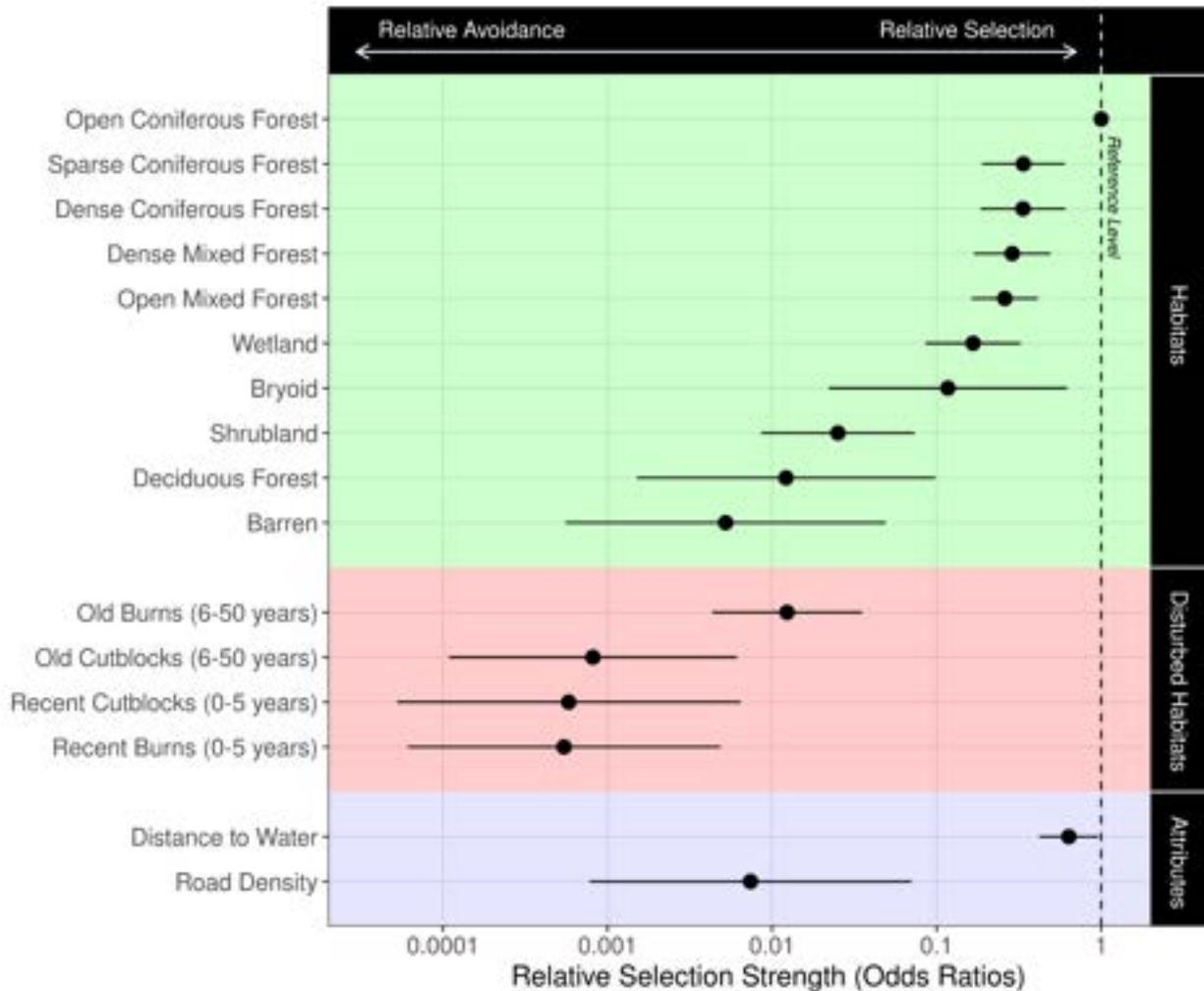


Figure 8. Selection or avoidance of habitats by female woodland caribou during calving season in Waswanipi between 2004 and 2020. Relative selection strength (\pm 95% confidence intervals) was estimated with the resource selection function described in *Section 3.3.3*, and describes selection or avoidance relative to the “Open Coniferous Forest” reference level. Land cover classes are presented as “Habitats” (in green) and “Disturbed Habitats” (in red), while the two continuous environmental covariates are presented as “Attributes” (in blue). All variables were statistically significant (see Suppl. Table 4).

4.2.3 Road Density and Distance to Water

Both continuous environmental covariates had significant effects on calving habitat selection by female woodland caribou over the course of the study period.

Habitats with high road density were avoided by calving females ($\beta = -4.9066$, P -value = 0.00002; see Figure 8 and Suppl. Table 4). Female woodland caribou almost exclusively selected calving habitats in areas where road density was less than 0.5 km/km². All else being constant, the RSF predicted that in habitats where road density was higher than 0.5 km/km², the relative probability of use dropped to 0 (see Figure 9A).

In contrast, calving females showed slight preference for habitats close to water bodies ($\beta = -0.4534$, P -value = 0.03211; see Figure 8 and Suppl. Table 4). All else being constant, the RSF predicted a very gradual increase in relative probability of use when habitats were closer to water, with probability of use almost doubling in habitats adjacent to water relative to habitats 4 km away (see Figure 9B).

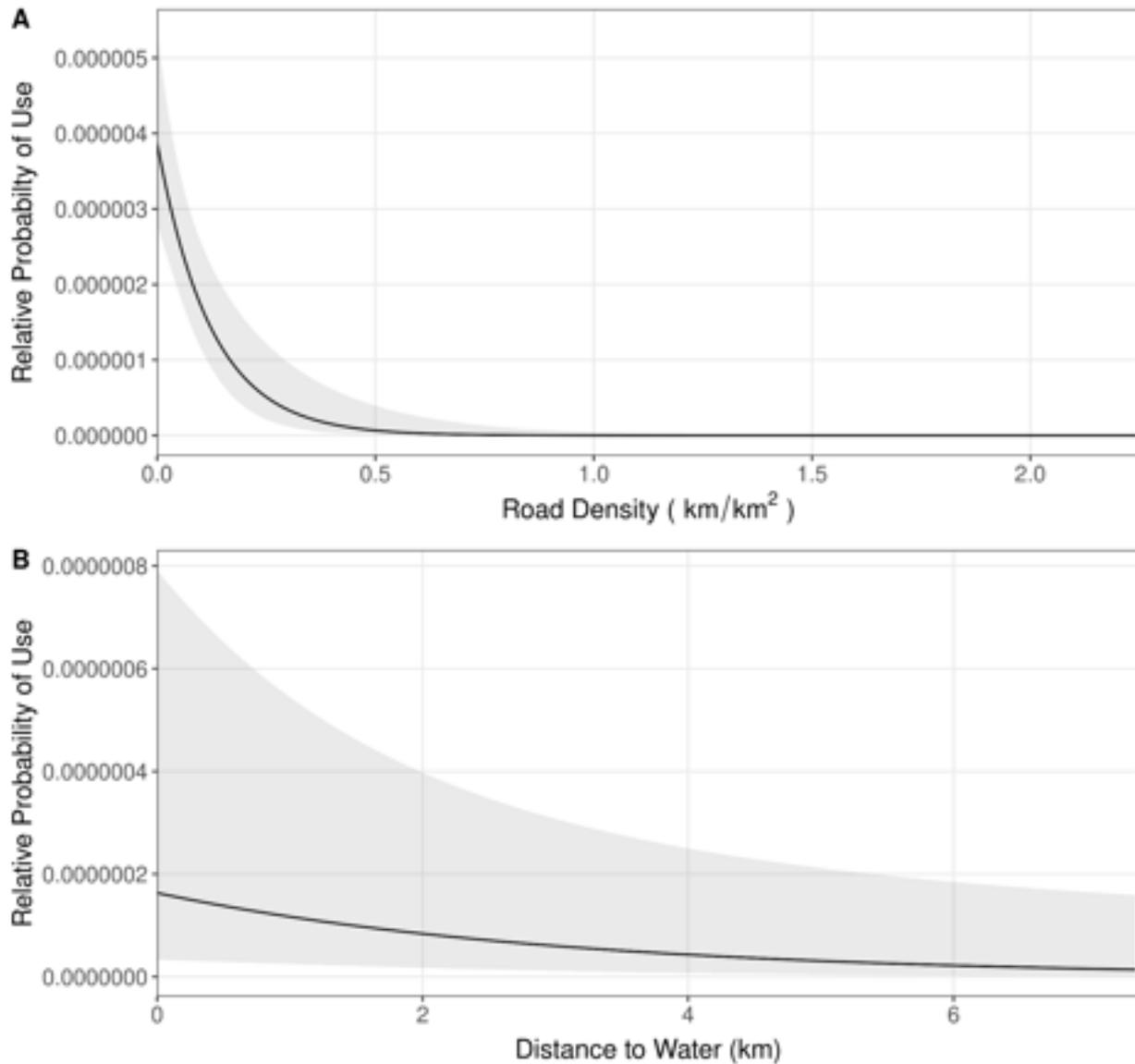


Figure 9. Effects of (A) road density (km/km²) and (B) distance to water (km) on the relative probability of use as calving habitat by woodland caribou in Waswanipi between 2004 and 2020. The solid line depicts the relative probability of use predicted by the resource selection function (RSF) described in *Section 3.3.3*, while the grey shading depicts the 95% confidence intervals. RSF predictions for a single continuous variable are estimated while holding all other variables constant.

4.3 Decline of Calving Habitats

The availability of potential calving habitats identified through habitat selection analyses within the Waswanipi region has undergone steady declines between 2004 and 2020 (see Figure 10 & Suppl. Figures 1 to 17).

The overall proportion of habitats suitable for calving within Waswanipi has steadily declined between 2004 and 2020 (see Figure 10C). Habitats classified as having the lowest probability of use for calving (the lowest equal-interval bin amongst 10 bins) occupied just over 85% of Waswanipi's territory in 2004. This proportion increased to 92% by 2020. Habitats ranked in the top 5 (of 10) equal-interval bins with the highest probability of use for calving occupied 3.4% of Waswanipi's landscape in 2004. However, these high quality calving habitats only occupied 1.9% of Waswanipi's landscape by the year 2020 (see Figure 10C), representing a 45% loss. Habitats classified as having the highest probability of use for calving (the highest equal-interval bin amongst 10 bins), occupied 0.35% of the landscape in 2004, but only 0.23% by 2020, a loss of 33% over the course of the study period.

At the beginning of the study period, there were small relatively undisturbed areas immediately south as well as east of the Waswanipi community where probability of use as calving habitat was higher, but these have disappeared following logging activity. In 2004, the areas surrounding Lac Matagami in the westernmost part of the Waswanipi region, were predicted to have a high probability of use as they were dominated by wetlands and open coniferous forests (see Figure 2). Following logging activity, notable declines in potential calving habitats occurred in the area north-east of Lac Matagami began around 2009 (see Suppl. Figures 5 to 12).

The most important calving habitats within Waswanipi are located in the northern part of the traditional territory where both natural and anthropogenic disturbances have had increasing impacts on the landscape between 2004 and 2020. Most calving ranges were located in the region east of Lac Evans, as well as the areas surrounding the Broadback river, especially between Lac Théodat and the Lac Salamandre and Lac Quénonisca areas (see Figure 6), which are all characterised by high quality calving habitats (see Figure 10). The areas west of Lac Assinica and Lac Comencho falling

within the Waswanipi traditional territory were also identified as important calving habitats. Due to the prevalence of coniferous forest habitats (see Figure 2) and low road density in all these areas (see Figure 3), the RSF model predicted high probabilities of use by calving females. However, the most important declines in calving habitat quality during the study period occurred in these areas (see Figures 10A & 10B, Suppl. Figures 1 to 17). Specifically, the calving habitats south of the Broadback river around Lac Quénonisca and Lac Roger underwent important declines in the past 15 years following important expansion of logging roads and forestry activity in the area. The calving habitats west of Lac Assinica and Lac Comencho falling within the Waswanipi traditional territory have undergone important declines for the same reasons. The calving habitats north and east of Lac Théodat, however, underwent important declines following large forest fires. Additional maps illustrating these changes in greater detail are available in Supplementary Figures 1 to 17.

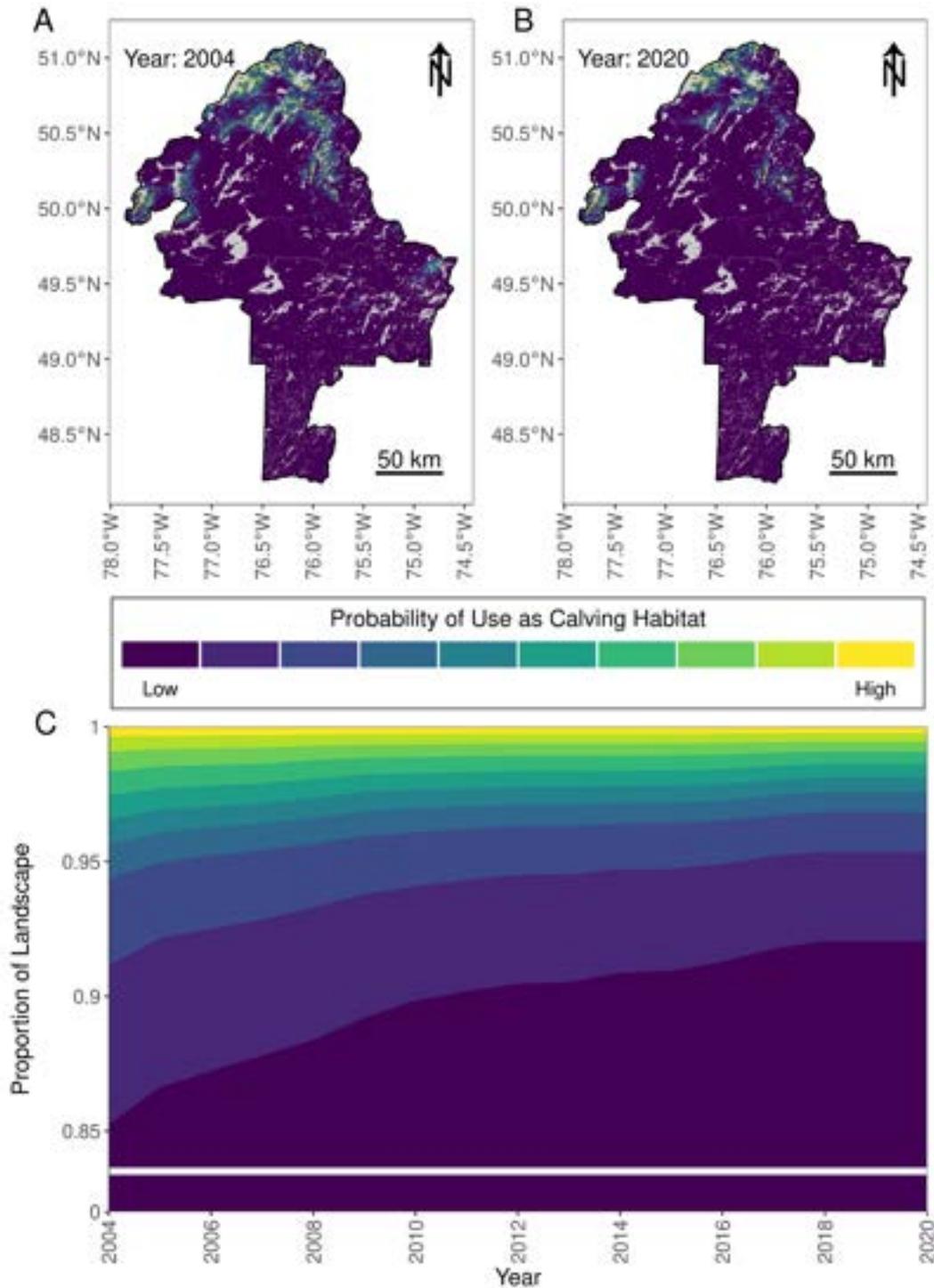


Figure 10. Probability of use as calving habitat in the Waswanipi region between 2004 and 2020. Maps display probability of use as calving habitat at (A) the beginning and (B) the end of the study period. (C) Time series of landscape composition shows proportion of all Waswanipi habitats within bins ranging from low to high probability of selection. Note the insertion of an axis break between 0 and 85% to maximise visualisation of bins with higher probability of use. Probability of use as calving habitat was predicted using a resource selection function, and grouped into 10 equal-interval bins. Water bodies are displayed in grey.

5. Recommendations

Because the productivity of boreal forests is relatively low, natural restoration of habitats to suitable caribou habitats can take several decades. The effects of disturbances that have occurred since 2004 are likely to persist for many years, and continued declines in calving habitats will undoubtedly have important effects on population health.

Consequently, to prevent further degradation of woodland caribou calving habitats in the Waswanipi regions, this study proposes the following:

1) An immediate moratorium on anthropogenic disturbances, especially exploitation of coniferous forests, in the northern region of Waswanipi.

The calving habitats identified in the northern part of Waswanipi are critical to the Assinica herd. The areas around Lac Evans, Lac Théodat, and the Broadback River, are especially important habitats and have been previously identified as such by traditional land users (Cree Regional Authority, 2010). If logging must continue, it should be limited to areas with preexisting forestry impacts adjacent to existing logging roads and prioritise the protection of large intact areas of undisturbed habitat (Courtois et al., 2007). Any new logging of areas within 10 to 15 kilometres of current calving habitats will likely lead to extirpation of caribou from that area within the next two decades (Vors et al., 2007).

2) An immediate moratorium on construction of logging roads and other linear anthropogenic disturbances, especially in areas adjacent to calving habitats.

Numerous studies in Quebec and Canada have confirmed that increased predation pressures near logging roads (and other linear disturbances) are likely the most important factor in calving habitat selection and calf survival (Courtois et al., 2007; Fortin et al., 2017; James and Stuart-Smith, 2000; Pinard et al., 2012; Whittington et al., 2011). Road avoidance has been detected in movement and habitat selection behaviours up to distances of 8 to 10 kilometres (Leblond et al., 2011; Rudolph, 2011).

Protecting existing calving habitats requires, at a bare minimum, the halting of all new road construction within this range of distances.

3) *The reclamation of logging roads within Waswanipi to hinder predator access to remote calving areas.*

This approach was proposed as a recovery strategy by the Quebec government as early as 2008 (MRNF, 2008), but preliminary trials only began in Côte-Nord in 2017 (Pernot et al., 2020). It will take decades for natural succession to restore these linear disturbances. Reclamation of roads could accelerate this process, especially if efforts are targeted in areas adjacent to critical habitats in the Waswanipi territory.

4) *A continued moratorium on all harvesting of woodland caribou.*

A continued moratorium on caribou harvest by traditional land users of the CFNW will aid adult female survival and, consequently, promote population recruitment.

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7. Supplementary Materials

Supplementary Table 1. Female woodland caribou included in this study along with their respective assigned herds, year of confirmed calving events, and number of GPS observations collected during each calving event.

| Herd | Caribou ID | Calving Event Year | GPS Observations |
|------------|------------|--------------------|------------------|
| Assinica | [REDACTED] | 2004 | 28 |
| | | 2005 | 19 |
| | | 2006 | 48 |
| | | 2007 | 22 |
| | | 2008 | 25 |
| | [REDACTED] | 2004 | 34 |
| | | 2005 | 35 |
| | | 2006 | 37 |
| | | 2007 | 25 |
| | | 2009 | 20 |
| | | 2010 | 30 |
| | | 2011 | 32 |
| | | 2012 | 113 |
| | [REDACTED] | 2004 | 44 |
| | | 2005 | 21 |
| | | 2006 | 45 |
| | | 2007 | 25 |
| | | 2008 | 27 |
| | [REDACTED] | 2005 | 44 |
| | [REDACTED] | 2006 | 41 |
| | [REDACTED] | 2008 | 33 |
| | | 2009 | 37 |
| | | 2010 | 29 |
| | | 2012 | 96 |
| | [REDACTED] | 2008 | 22 |
| | | 2009 | 15 |
| | | 2015 | 22 |
| | | 2016 | 32 |
| | | 2017 | 18 |
| | | 2018 | 19 |
| [REDACTED] | 2008 | 14 | |
| | 2009 | 21 | |
| | 2010 | 18 | |
| [REDACTED] | 2010 | 49 | |
| [REDACTED] | 2009 | 38 | |
| | 2010 | 19 | |

| | | | |
|----------------------|----------|------|----|
| | | 2012 | 49 |
| | ████████ | 2009 | 22 |
| | | 2010 | 40 |
| | ████████ | 2009 | 24 |
| | ████████ | 2015 | 21 |
| | | 2017 | 29 |
| | | 2018 | 19 |
| | ████████ | 2015 | 20 |
| | | 2016 | 28 |
| | | 2017 | 14 |
| | ████████ | 2017 | 34 |
| | ████████ | 2016 | 11 |
| | | 2017 | 37 |
| | | 2018 | 21 |
| | | 2019 | 12 |
| | ████████ | 2020 | 19 |
| Nottaway | ████████ | 2004 | 30 |
| | | 2005 | 57 |
| Currently Unassigned | ████████ | 2020 | 26 |

Supplementary Table 2. Classification scheme used to classify EOSD landscape classes into corresponding caribou habitat classes used in this study. Additional information on EOSD landscape classes are detailed in Wulder and Nelson (2003).

| EOSD Codes | EOSD Landscape Classes | Habitat Classes |
|----------------------|---|------------------------|
| 0 | No Data | No Data |
| 10 | Unclassified | No Data |
| 11 | Cloud | No Data |
| 12 | Shadow | No Data |
| 20 | Water | Water |
| 31 32 33 34 | Snow/Ice Rock/Rubble Exposed / Barren Land Developed | Barren |
| 40 | Bryoids | Bryoid |
| 51 52 | Shrubland Tall Shrubland Low | Shrubland |
| 81 82 83 | Wetland-Treed Wetland-Shrub Wetland-Herb | Wetland |
| 110 120 | Grassland Agriculture | Exposed Low Vegetation |
| 211 | Coniferous Dense | Coniferous Dense |
| 212 | Coniferous Open | Coniferous Open |
| 213 | Coniferous Sparse | Coniferous Sparse |
| 221 222 223 | Broadleaf Dense Broadleaf Open Broadleaf Sparse | Deciduous |
| 231 | Mixedwood Dense | Mixed Dense |
| 232 | Mixedwood Open | Mixed Dense |

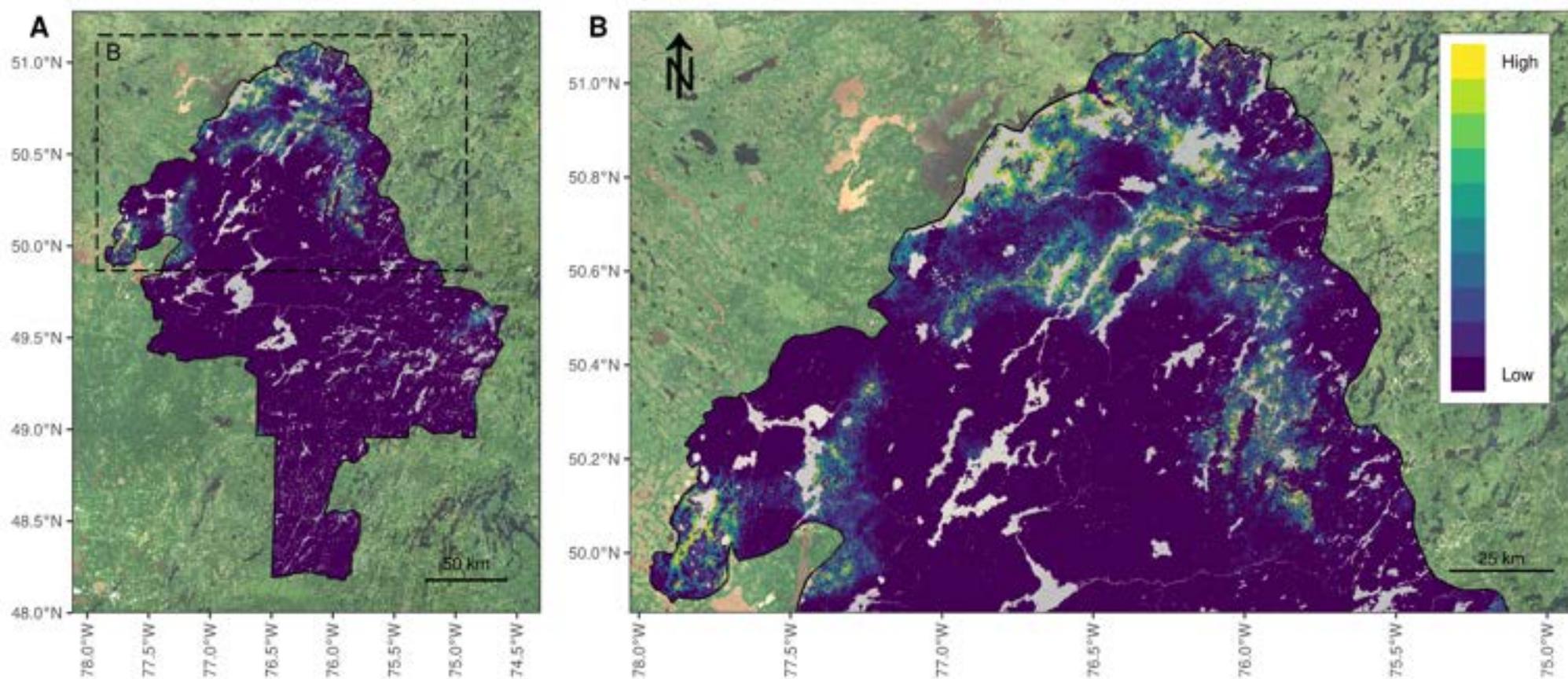
Supplementary Table 3. Classification scheme used to classify disturbances from MFFP's forest inventory maps into the habitat disturbance categories used in the current study. Disturbance codes and corresponding database fields are presented for all three forest inventories used. Additional information on disturbance codes is available in MRNF (2009) and MFFP (2021, 2015).

| Inventory | Field (Description) | Disturbance Code | Habitat Disturbance |
|------------------|--------------------------------------|--|----------------------------|
| 3rd | PER_CO_ORI (Severe disturbance) | BR, CHT, DT, ES, FR | Burns |
| | | CBT, CPR, CT, ENM, ENS, P, PLN, PLR | Cutblocks |
| | PER_CO_MOY (Moderate disturbance) | CHP, BRP, EL | Burns |
| | | CB, CP, EPC, DRM, DR | Cutblocks |
| 4th | ORIGINE (Severe disturbance) | BR, ES, CHT, DT | Burns |
| | | CT, PRR, CPR, P, RPS, CBA, REA, ENS, CEF, CRR, CPH, ETR, CPT, CRB | Cutblocks |
| | PERTURB (Moderate disturbance) | CHP, EL, DP, BRP | Burns |
| | | CP, DEG, RR, RRG, EPC, EC, ECL, EPR, CPC, CA | Cutblocks |
| 5th (MAJ) | ORIGINE (Severe disturbance) | BR, CHT, DT, ES | Burns |
| | | CBA, CBT, CEF, CPH, CPHRS, CPI_RL_F, CPPTM_DIS, CPPTM_U, CPR, CPRS_BA, CPRS_U, CPT, CRB, CRR, CRS, CT, ENS, ETR, P, PL, PLR, PRR, REA, RPS | Cutblocks |
| | PERTURB (Moderate disturbance) | BRP, CHP, DP, EL | Burns |
| | | CA, CP, CPC, CPI_CP, CPI_RL, CPI_TA, CPR_T, CPS, DEG, EC, ECL, ENP, EPC, EPC_SYS, NET, PL_REG, RPLB, RR, RRR | Cutblocks |

Supplementary Table 4. Results from the hierarchical logistic regression used to fit the resource selection function (RSF). Coefficients (β), relative selection strength with 95% confidence levels, and significance levels (P -value) are presented for fixed-effect variables. Land cover classes are grouped into habitats and disturbed habitats, displayed in green and red, respectively. Environmental attributes are displayed in blue.

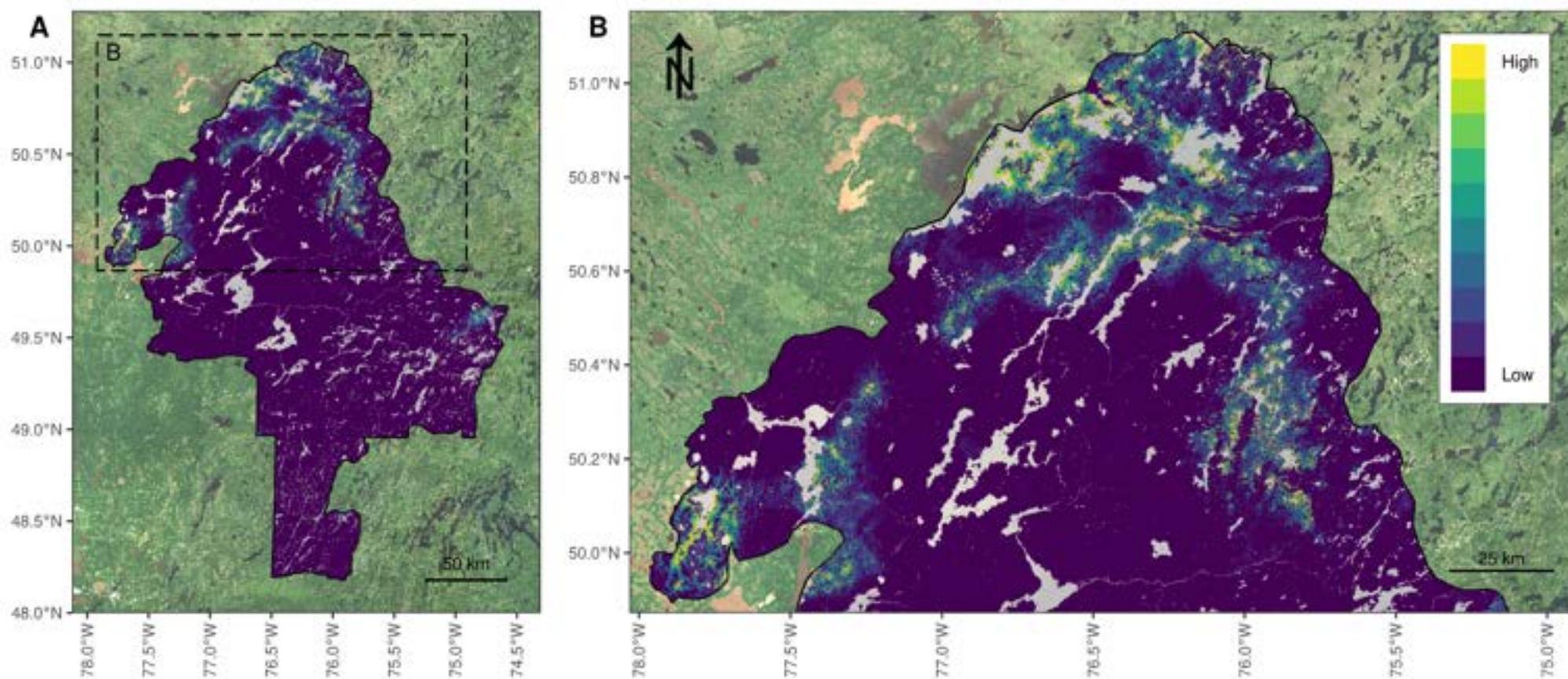
| Fixed-Effect Variables | Coefficient (β) | Relative Selection Strength (\pm 95% CI) | Significance $P(> z)$ |
|-------------------------------|---|--|---|
| Sparse Coniferous Forest | -1.0888 | 0.3366 (\pm 0.2949) | 0.00022 |
| Dense Coniferous Forest | -1.0946 | 0.3347 (\pm 0.3036) | 0.00031 |
| Dense Mixed Forest | -1.2448 | 0.2880 (\pm 0.2743) | <0.00001 |
| Open Mixed Forest | -1.3490 | 0.2595 (\pm 0.2375) | <0.00001 |
| Wetland | -1.7926 | 0.1665 (\pm 0.3397) | <0.00001 |
| Bryoid | -2.1452 | 0.1170 (\pm 0.8501) | 0.01162 |
| Shrubland | -3.6842 | 0.0251 (\pm 0.5477) | <0.00001 |
| Deciduous Forest | -4.4106 | 0.0121 (\pm 1.0648) | <0.00001 |
| Barren | -5.2556 | 0.0052 (\pm 1.1423) | <0.00001 |
| Old Burns (6-50 years) | -4.3956 | 0.0123 (\pm 0.5336) | <0.00001 |
| Old Cutblocks (6-50 years) | -7.1121 | 0.0008 (\pm 1.0276) | <0.00001 |
| Recent Cutblocks (0-5 years) | -7.4513 | 0.0006 (\pm 1.2251) | <0.00001 |
| Recent Burns (0-5 years) | -7.5159 | 0.0005 (\pm 1.1168) | <0.00001 |
| Distance to Water | -0.4534 | 0.6355 (\pm 0.2116) | 0.03211 |
| Road Density | -4.9066 | 0.0074 (\pm 1.1501) | 0.00002 |

Probability of Use as Calving Habitat by Woodland Caribou in Waswanipi – 2004



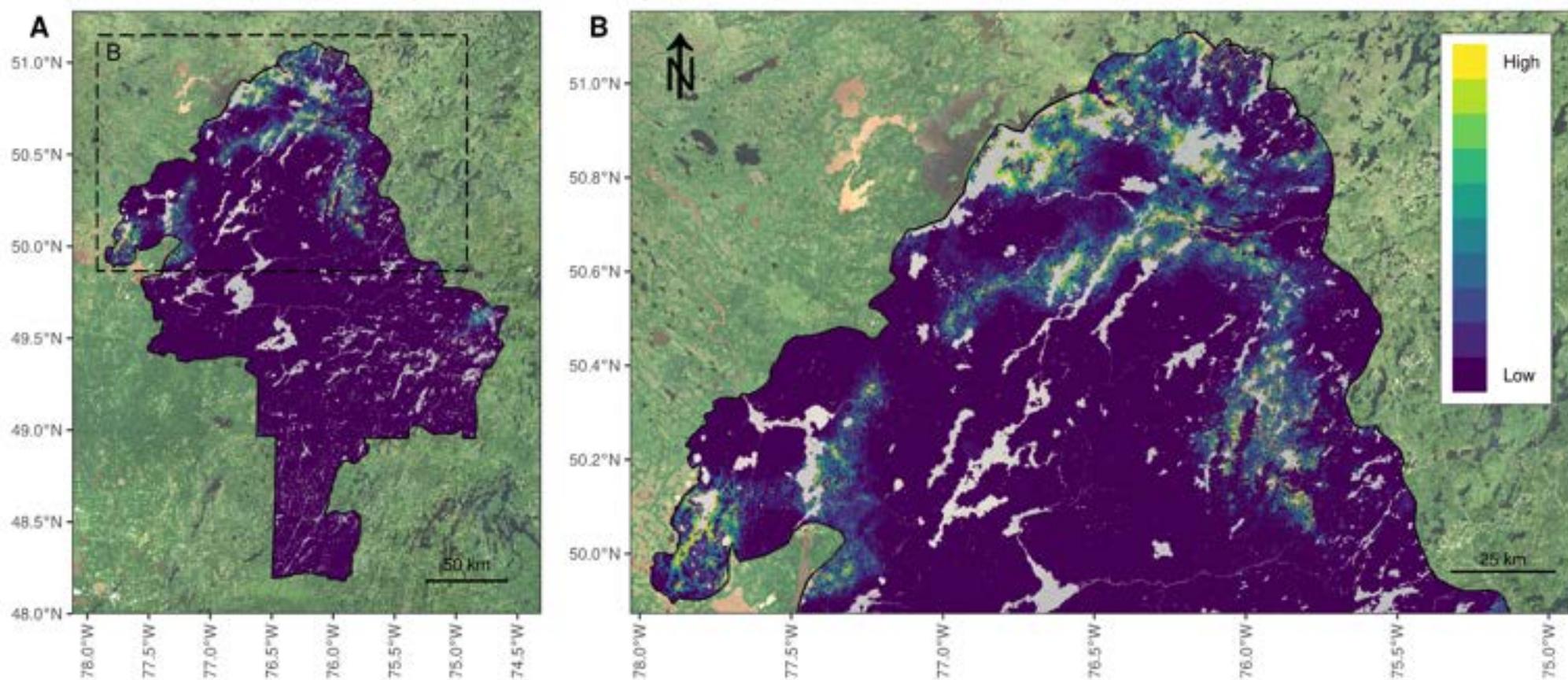
Supplementary Figure 1. Maps of probability of use as calving habitat in 2004 (A) over the entire Waswanipi region and (B) in the northern part of the Waswanipi region. Probability of use as calving habitat was predicted using a resource selection function, and grouped into 10 equal-interval bins. Water bodies within Waswanipi are illustrated in grey. Basemap is a Sentinel-2 RGB annual median composite.

Probability of Use as Calving Habitat by Woodland Caribou in Waswanipi – 2005



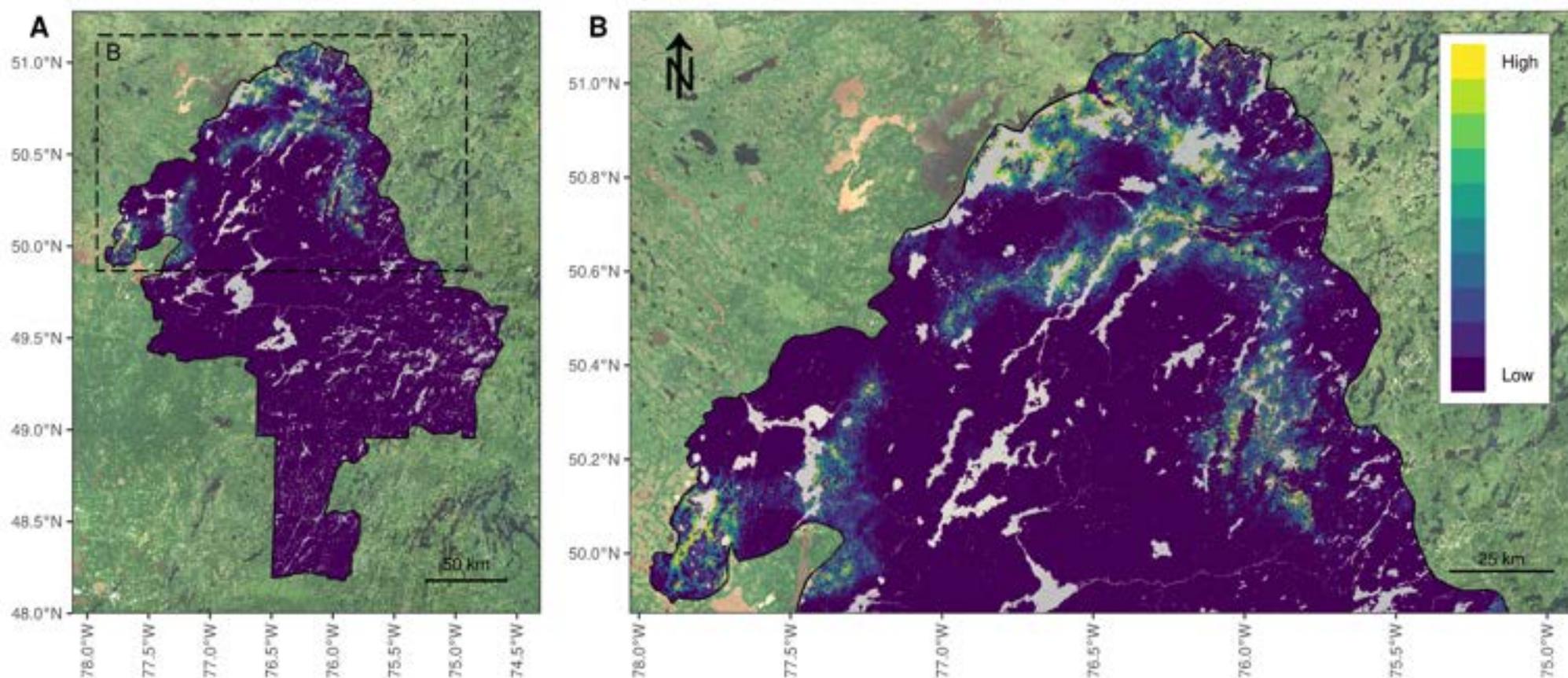
Supplementary Figure 2. Maps of probability of use as calving habitat in 2005 (A) over the entire Waswanipi region and (B) in the northern part of the Waswanipi region. Probability of use as calving habitat was predicted using a resource selection function, and grouped into 10 equal-interval bins. Water bodies within Waswanipi are illustrated in grey. Basemap is a Sentinel-2 RGB annual median composite.

Probability of Use as Calving Habitat by Woodland Caribou in Waswanipi – 2006



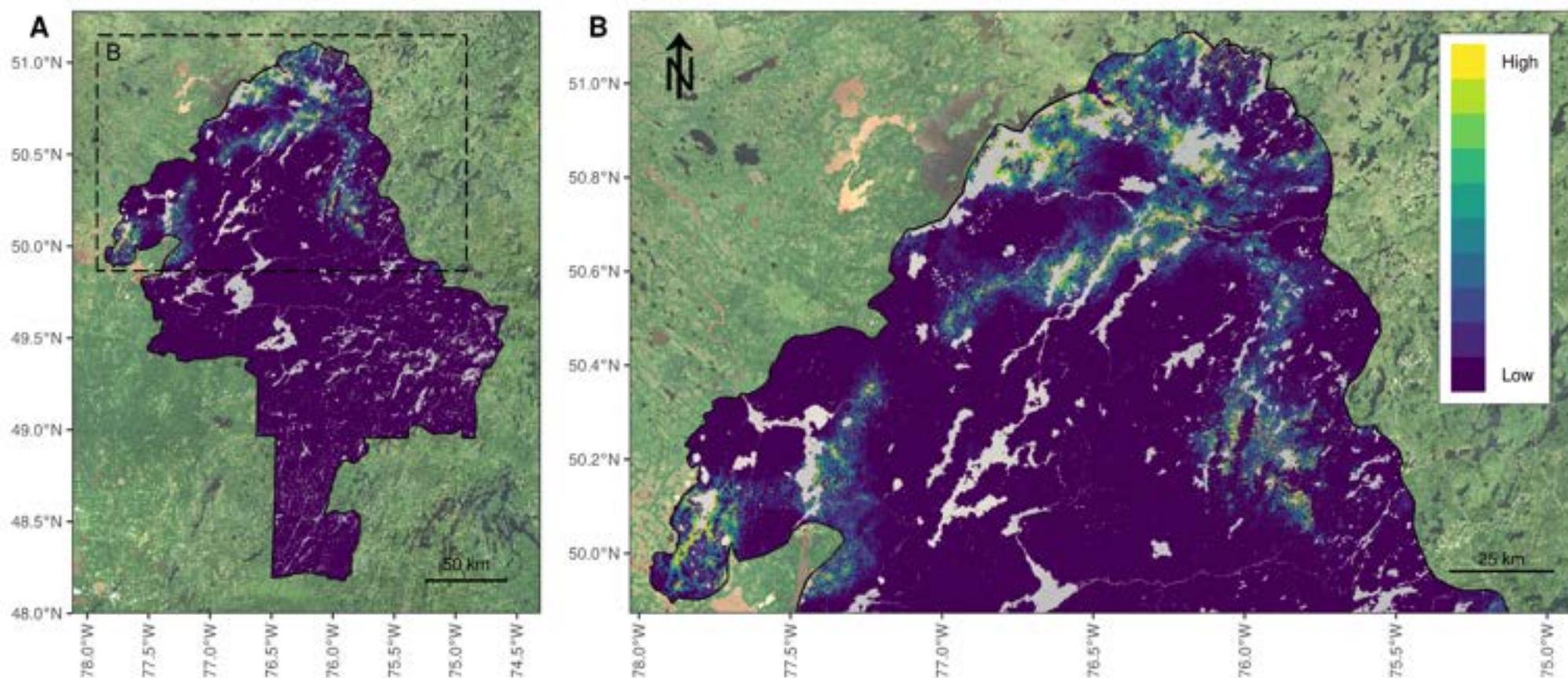
Supplementary Figure 3. Maps of probability of use as calving habitat in 2006 (A) over the entire Waswanipi region and (B) in the northern part of the Waswanipi region. Probability of use as calving habitat was predicted using a resource selection function, and grouped into 10 equal-interval bins. Water bodies within Waswanipi are illustrated in grey. Basemap is a Sentinel-2 RGB annual median composite.

Probability of Use as Calving Habitat by Woodland Caribou in Waswanipi – 2007



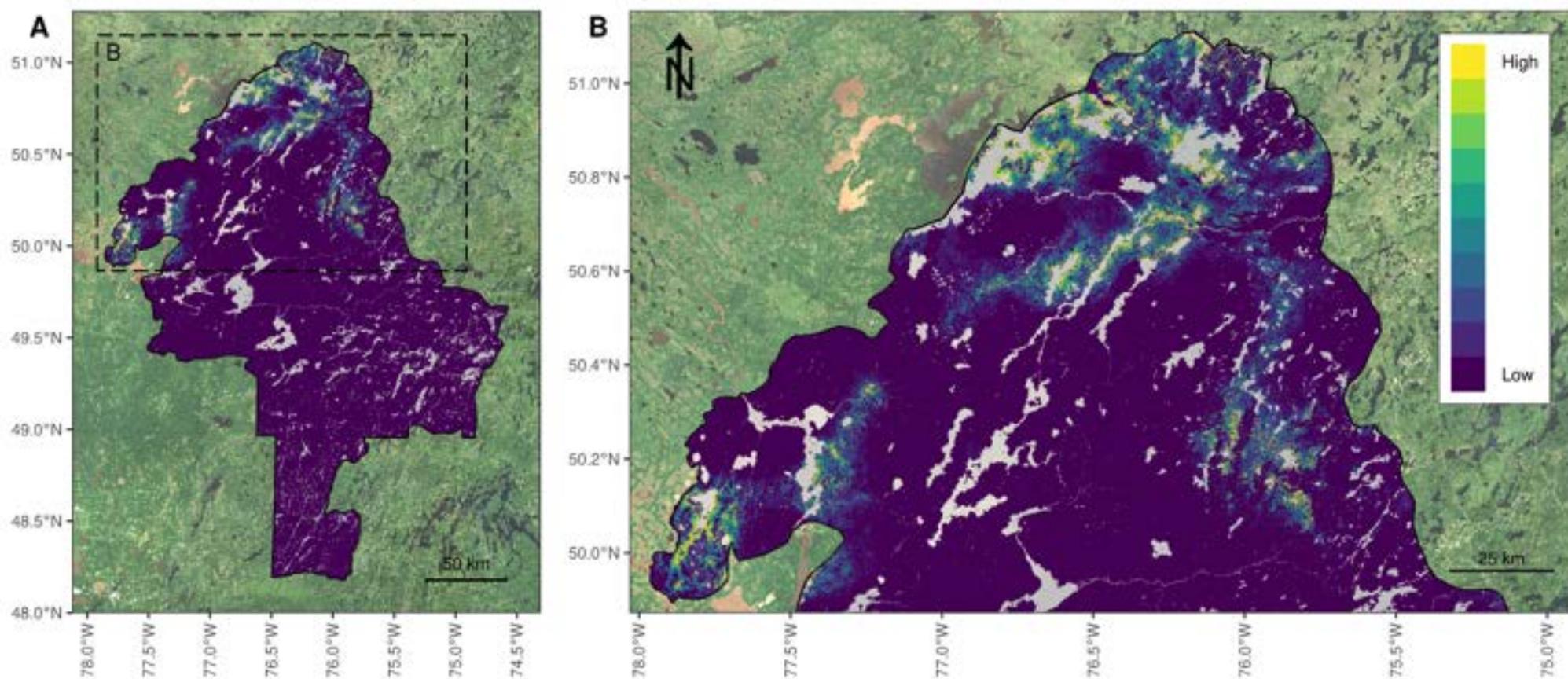
Supplementary Figure 4. Maps of probability of use as calving habitat in 2007 (A) over the entire Waswanipi region and (B) in the northern part of the Waswanipi region. Probability of use as calving habitat was predicted using a resource selection function, and grouped into 10 equal-interval bins. Water bodies within Waswanipi are illustrated in grey. Basemap is a Sentinel-2 RGB annual median composite.

Probability of Use as Calving Habitat by Woodland Caribou in Waswanipi – 2008



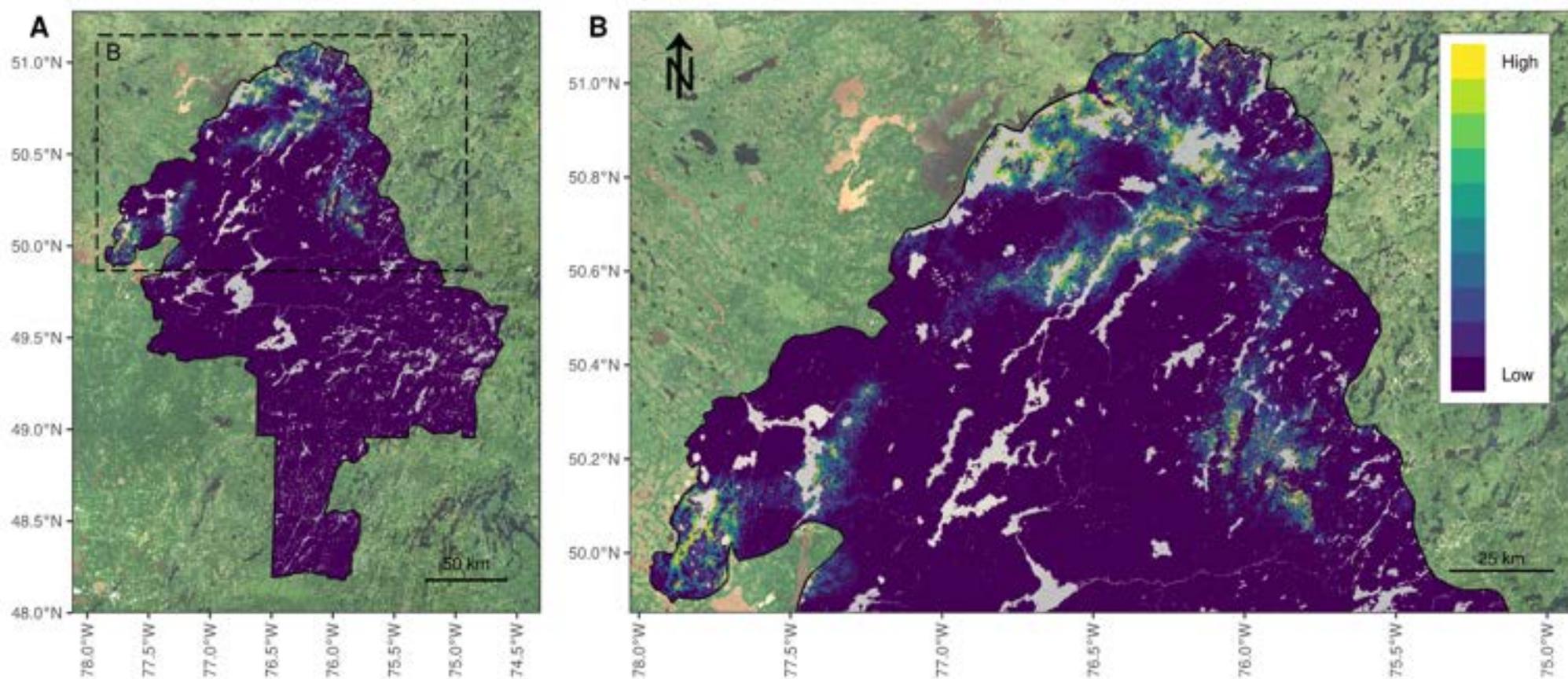
Supplementary Figure 5. Maps of probability of use as calving habitat in 2008 (A) over the entire Waswanipi region and (B) in the northern part of the Waswanipi region. Probability of use as calving habitat was predicted using a resource selection function, and grouped into 10 equal-interval bins. Water bodies within Waswanipi are illustrated in grey. Basemap is a Sentinel-2 RGB annual median composite.

Probability of Use as Calving Habitat by Woodland Caribou in Waswanipi – 2009



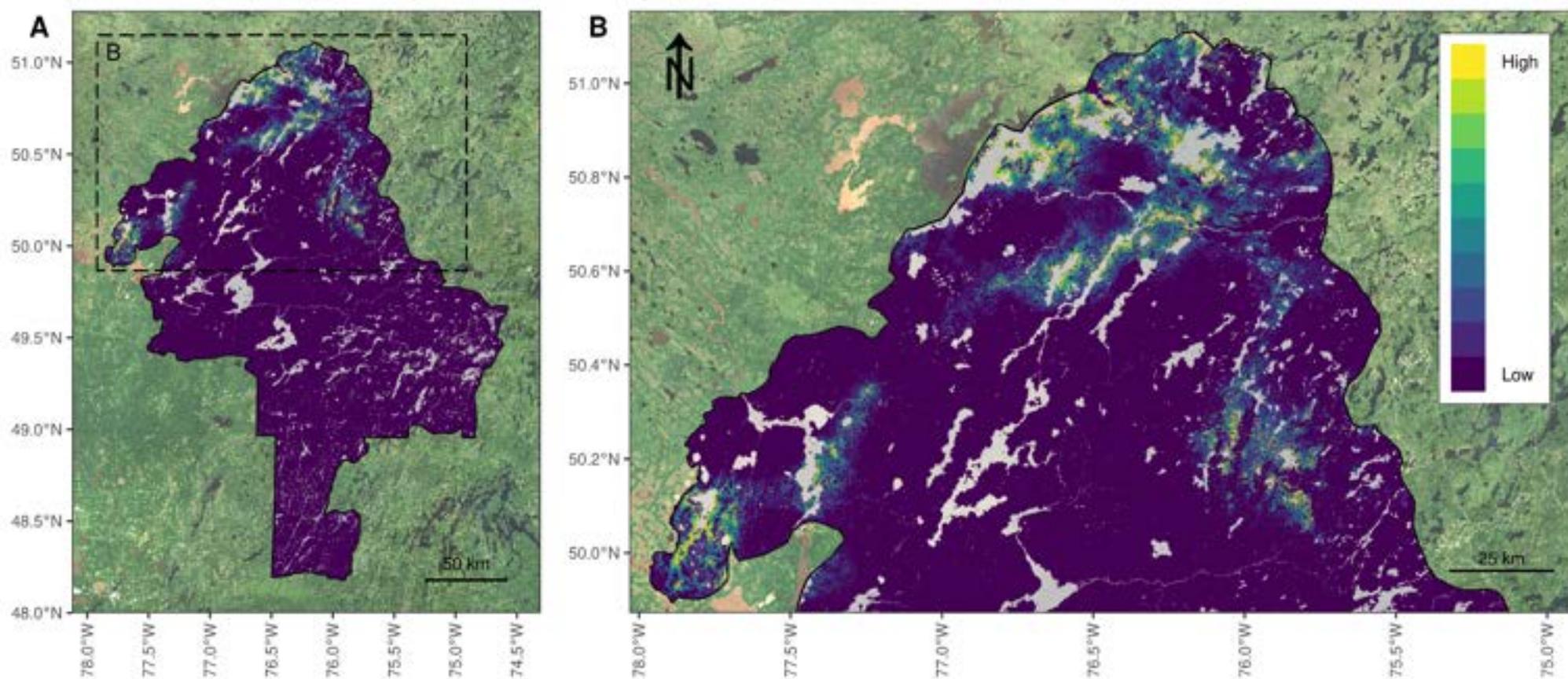
Supplementary Figure 6. Maps of probability of use as calving habitat in 2009 (A) over the entire Waswanipi region and (B) in the northern part of the Waswanipi region. Probability of use as calving habitat was predicted using a resource selection function, and grouped into 10 equal-interval bins. Water bodies within Waswanipi are illustrated in grey. Basemap is a Sentinel-2 RGB annual median composite.

Probability of Use as Calving Habitat by Woodland Caribou in Waswanipi – 2010



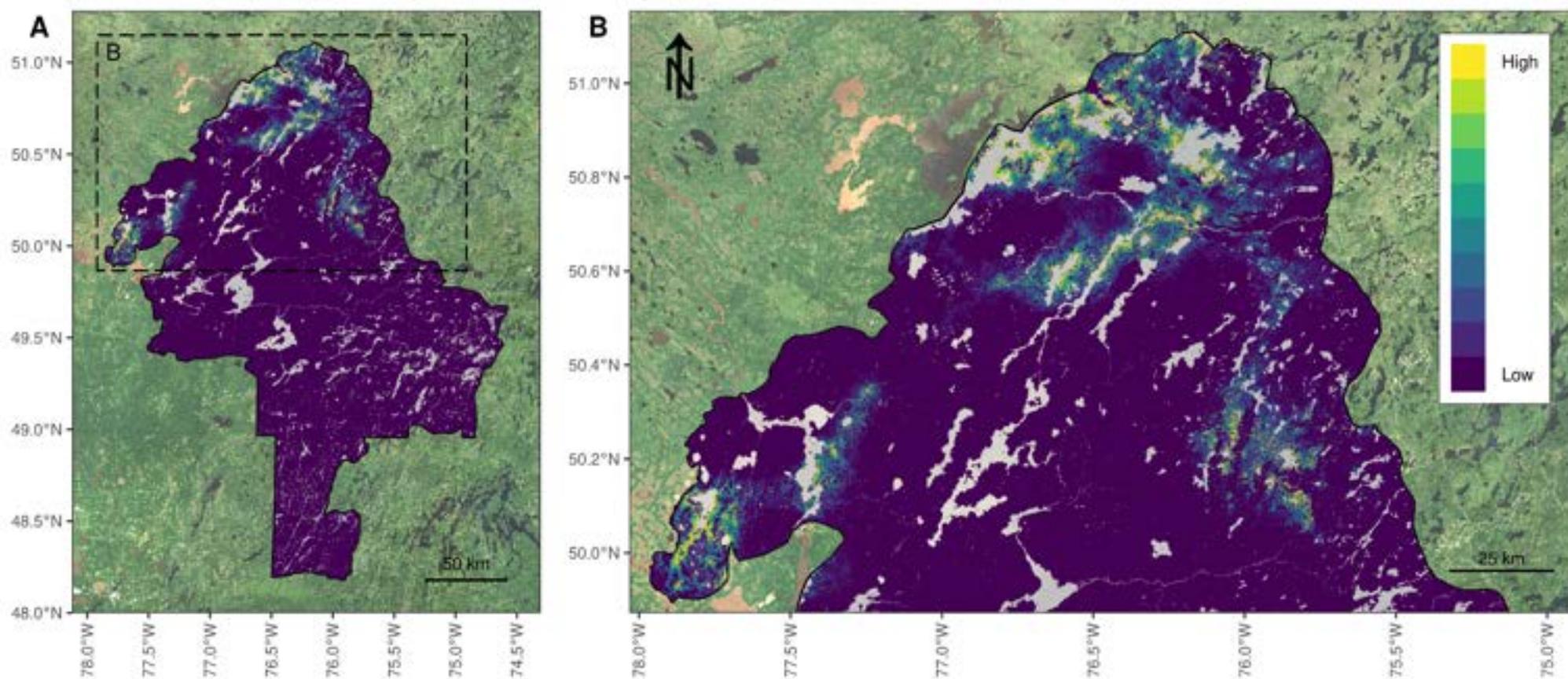
Supplementary Figure 7. Maps of probability of use as calving habitat in 2010 (A) over the entire Waswanipi region and (B) in the northern part of the Waswanipi region. Probability of use as calving habitat was predicted using a resource selection function, and grouped into 10 equal-interval bins. Water bodies within Waswanipi are illustrated in grey. Basemap is a Sentinel-2 RGB annual median composite.

Probability of Use as Calving Habitat by Woodland Caribou in Waswanipi – 2011



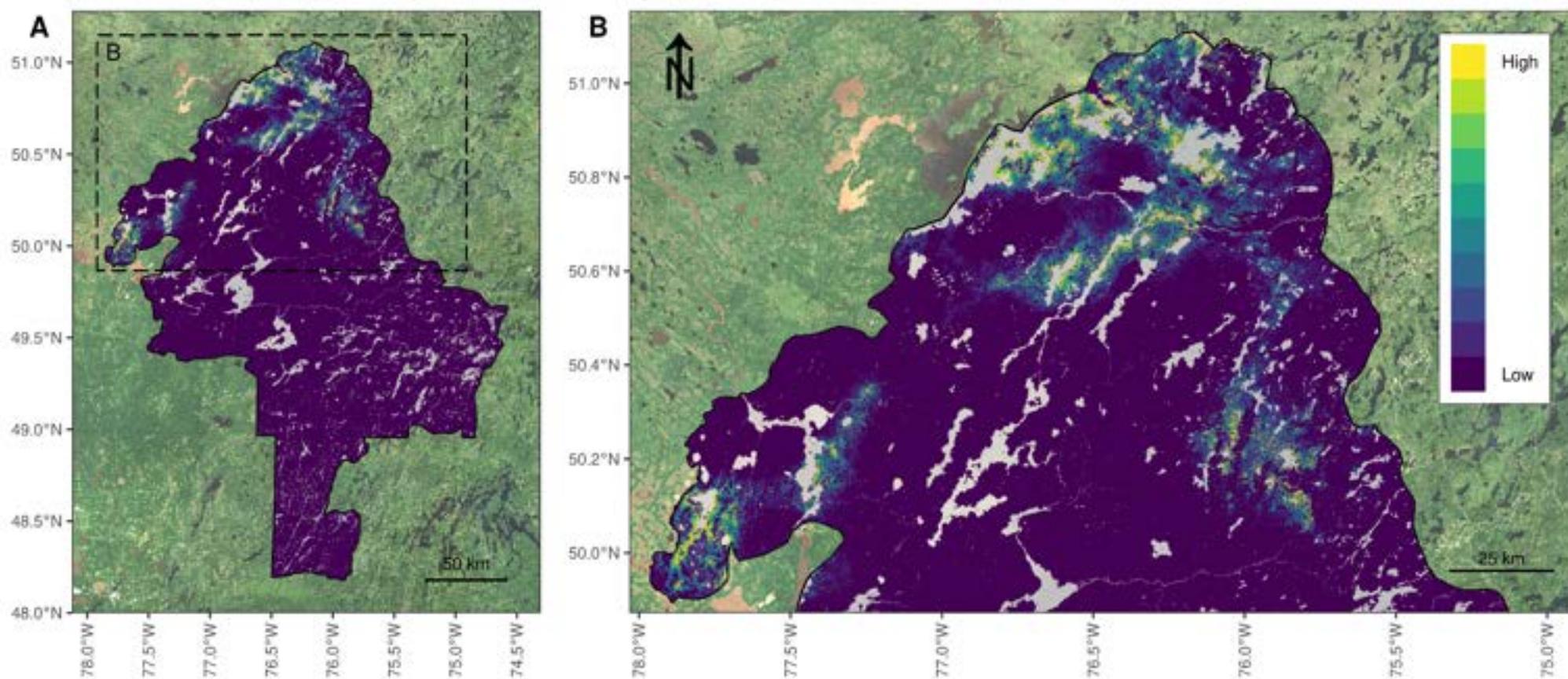
Supplementary Figure 8. Maps of probability of use as calving habitat in 2011 (A) over the entire Waswanipi region and (B) in the northern part of the Waswanipi region. Probability of use as calving habitat was predicted using a resource selection function, and grouped into 10 equal-interval bins. Water bodies within Waswanipi are illustrated in grey. Basemap is a Sentinel-2 RGB annual median composite.

Probability of Use as Calving Habitat by Woodland Caribou in Waswanipi – 2012



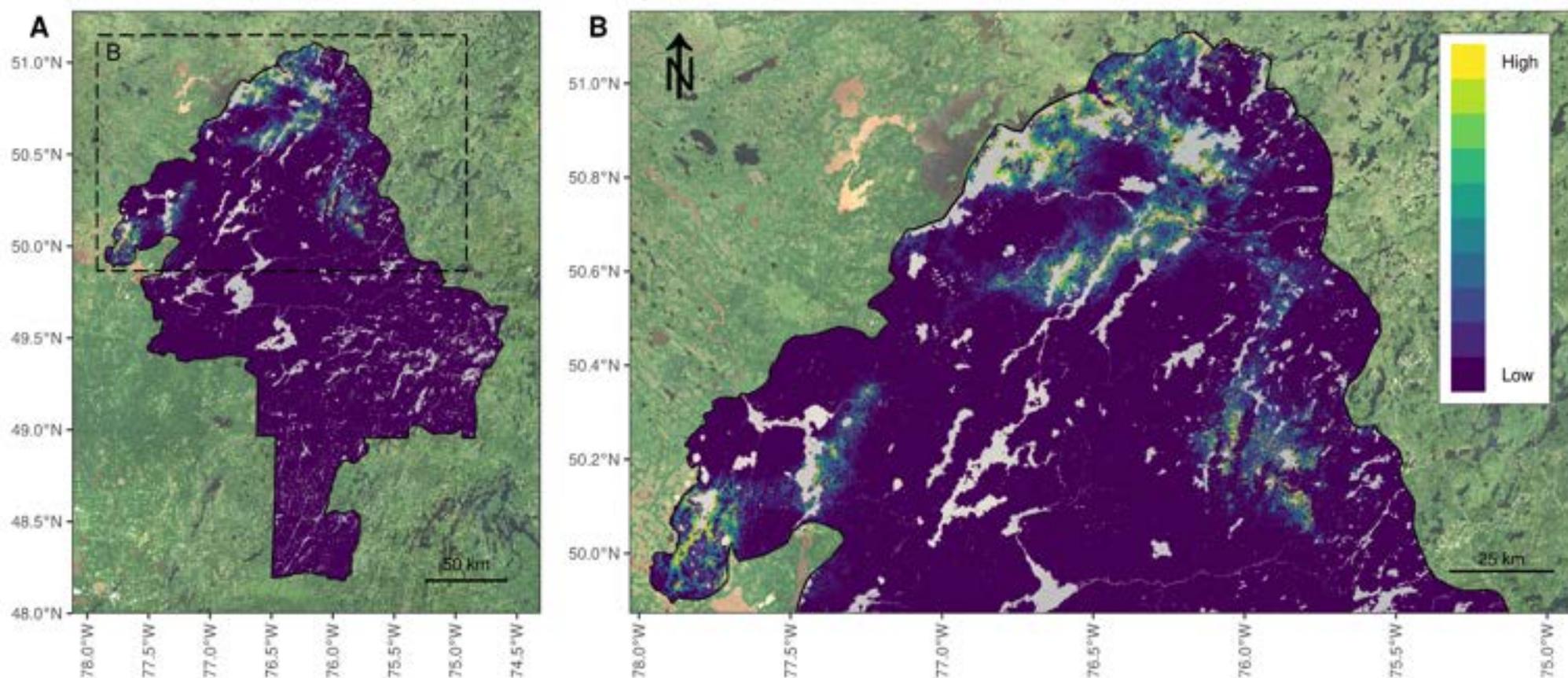
Supplementary Figure 9. Maps of probability of use as calving habitat in 2012 (A) over the entire Waswanipi region and (B) in the northern part of the Waswanipi region. Probability of use as calving habitat was predicted using a resource selection function, and grouped into 10 equal-interval bins. Water bodies within Waswanipi are illustrated in grey. Basemap is a Sentinel-2 RGB annual median composite.

Probability of Use as Calving Habitat by Woodland Caribou in Waswanipi – 2013



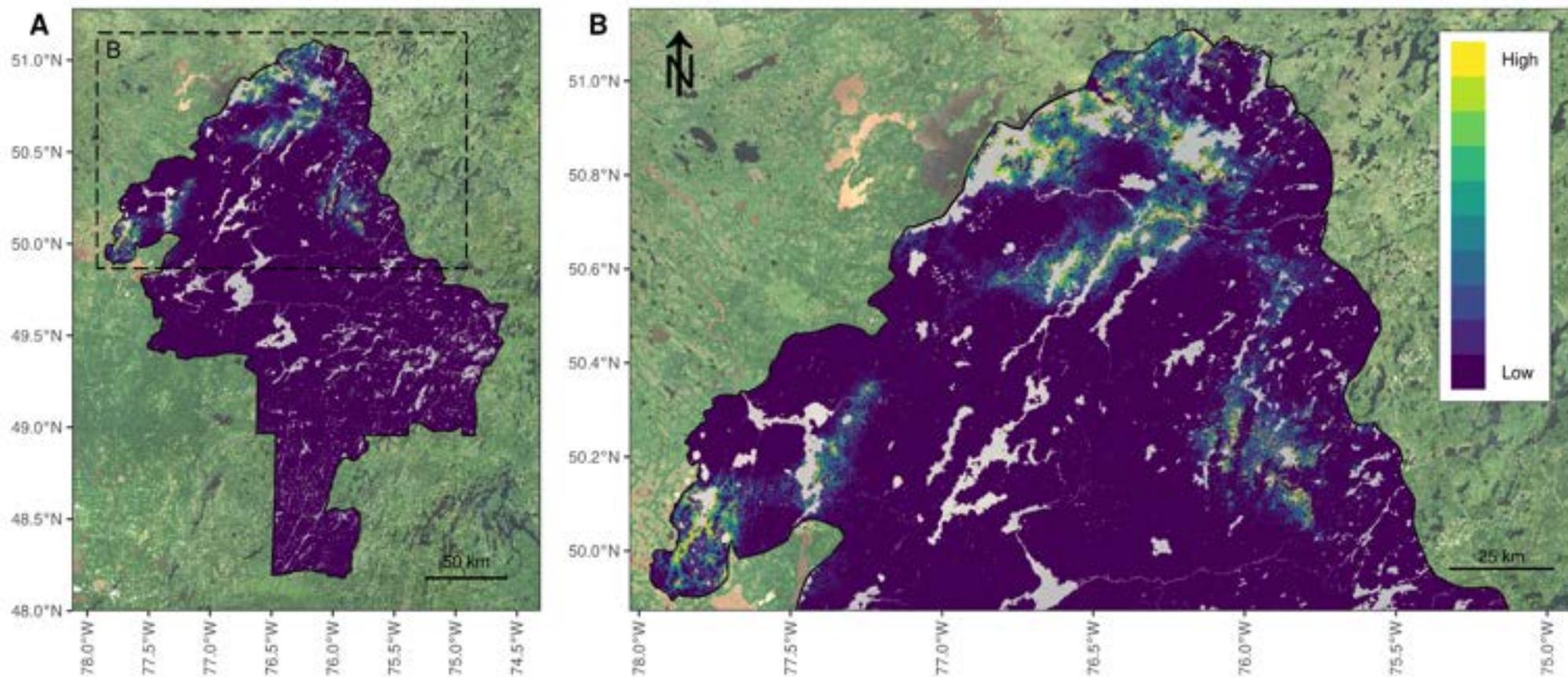
Supplementary Figure 10. Maps of probability of use as calving habitat in 2013 (A) over the entire Waswanipi region and (B) in the northern part of the Waswanipi region. Probability of use as calving habitat was predicted using a resource selection function, and grouped into 10 equal-interval bins. Water bodies within Waswanipi are illustrated in grey. Basemap is a Sentinel-2 RGB annual median composite.

Probability of Use as Calving Habitat by Woodland Caribou in Waswanipi – 2014



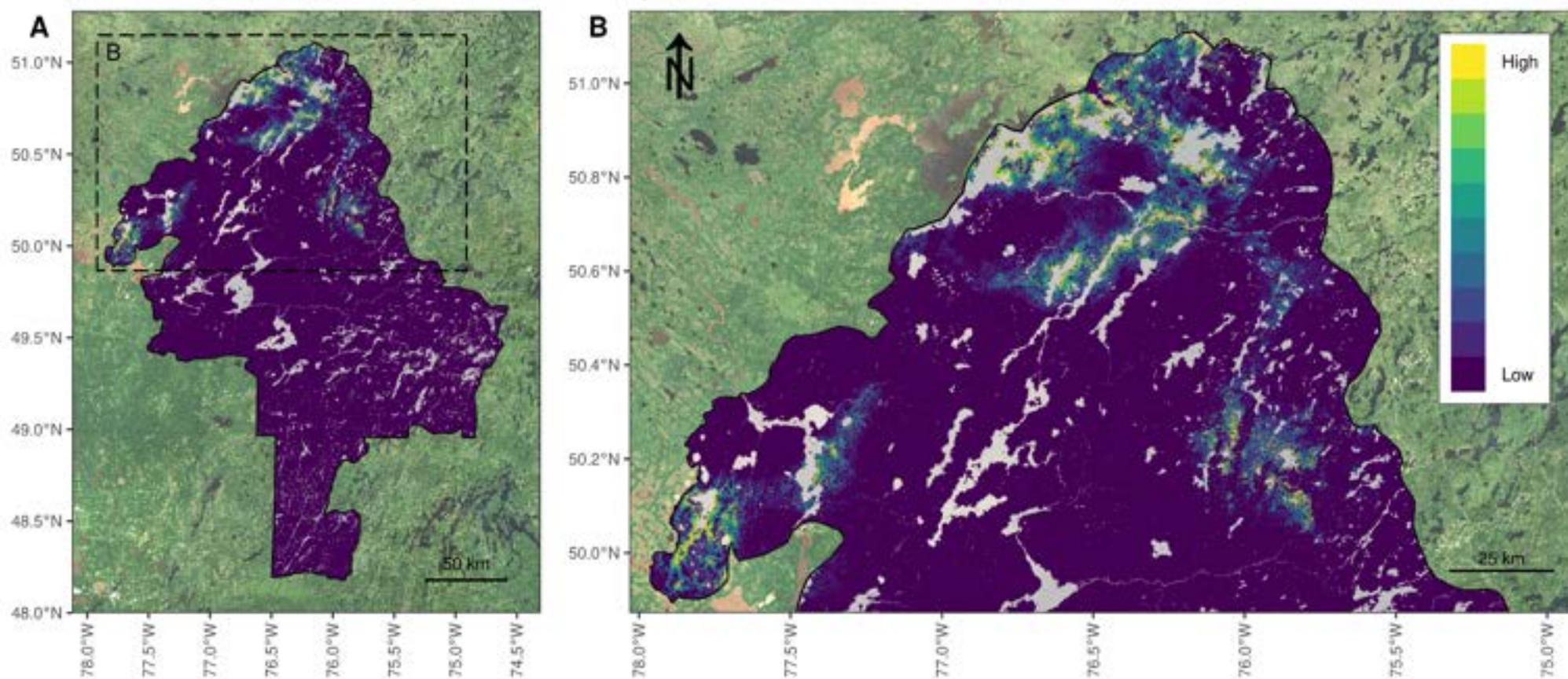
Supplementary Figure 11. Maps of probability of use as calving habitat in 2014 (A) over the entire Waswanipi region and (B) in the northern part of the Waswanipi region. Probability of use as calving habitat was predicted using a resource selection function, and grouped into 10 equal-interval bins. Water bodies within Waswanipi are illustrated in grey. Basemap is a Sentinel-2 RGB annual median composite.

Probability of Use as Calving Habitat by Woodland Caribou in Waswanipi – 2015



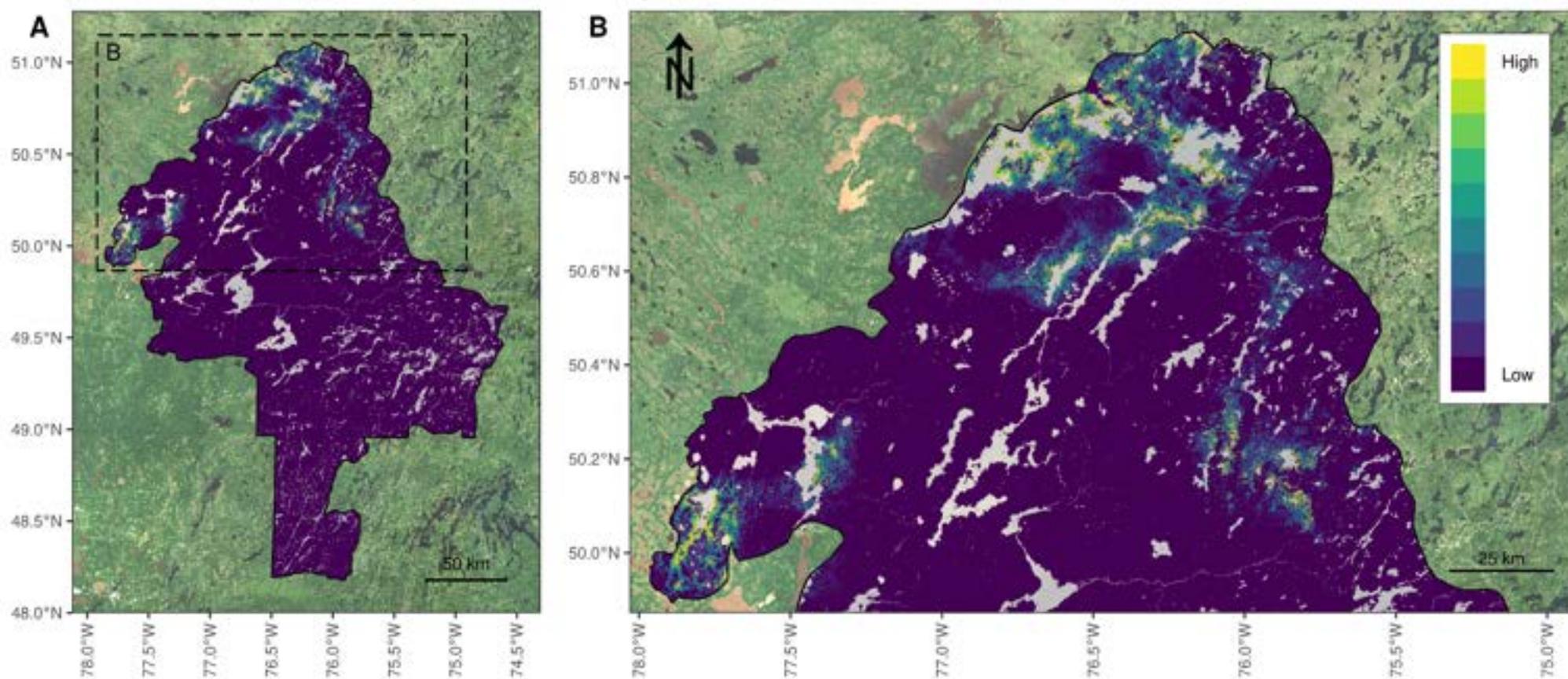
Supplementary Figure 12. Maps of probability of use as calving habitat in 2015 (A) over the entire Waswanipi region and (B) in the northern part of the Waswanipi region. Probability of use as calving habitat was predicted using a resource selection function, and grouped into 10 equal-interval bins. Water bodies within Waswanipi are illustrated in grey. Basemap is a Sentinel-2 RGB annual median composite.

Probability of Use as Calving Habitat by Woodland Caribou in Waswanipi – 2016



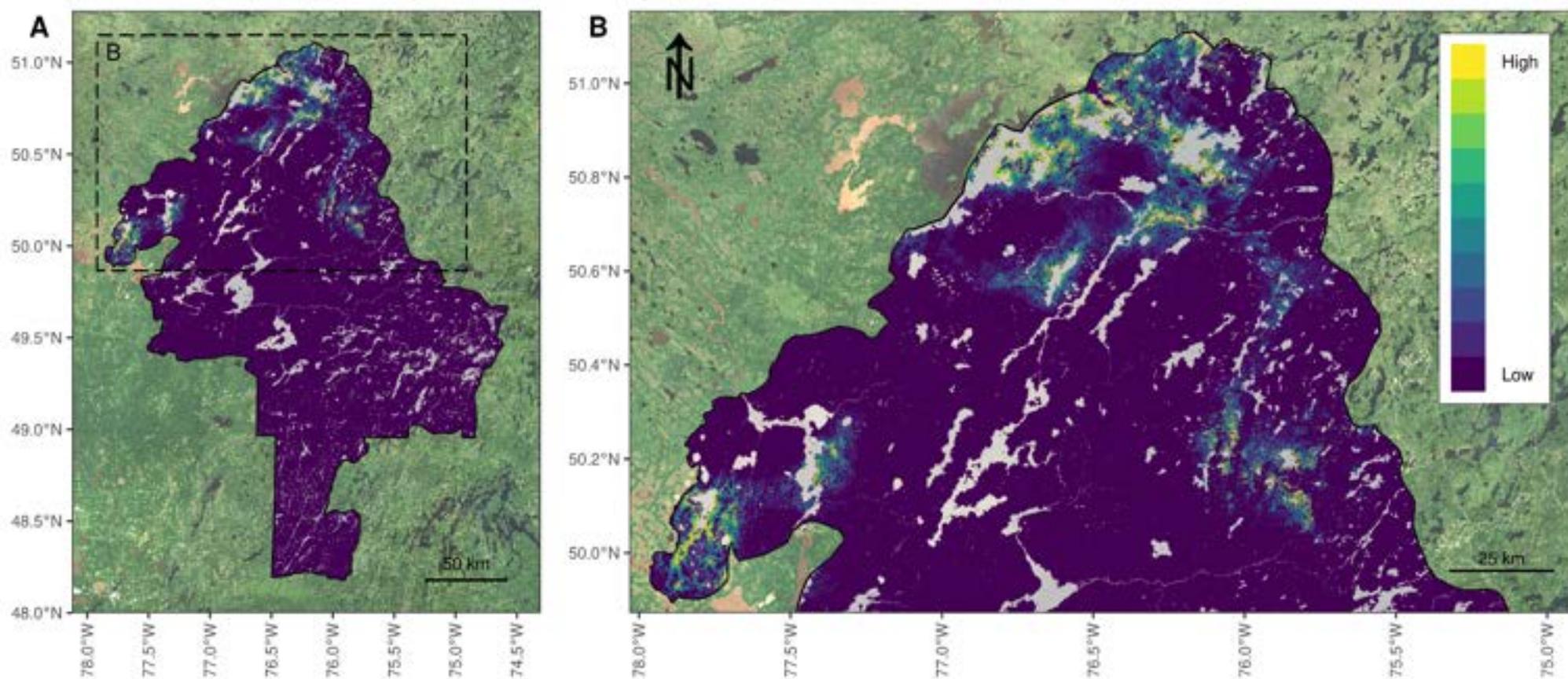
Supplementary Figure 13. Maps of probability of use as calving habitat in 2016 (A) over the entire Waswanipi region and (B) in the northern part of the Waswanipi region. Probability of use as calving habitat was predicted using a resource selection function, and grouped into 10 equal-interval bins. Water bodies within Waswanipi are illustrated in grey. Basemap is a Sentinel-2 RGB annual median composite.

Probability of Use as Calving Habitat by Woodland Caribou in Waswanipi – 2017



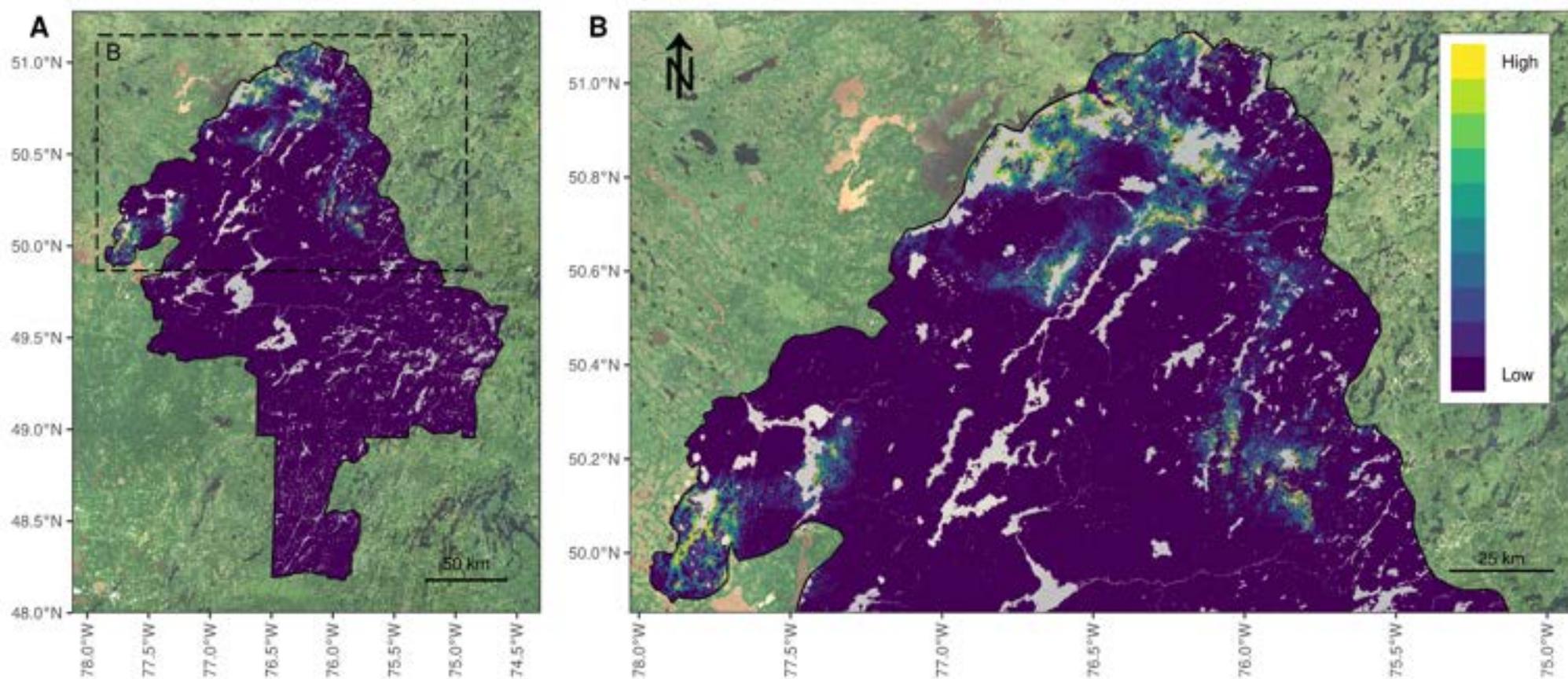
Supplementary Figure 14. Maps of probability of use as calving habitat in 2017 (A) over the entire Waswanipi region and (B) in the northern part of the Waswanipi region. Probability of use as calving habitat was predicted using a resource selection function, and grouped into 10 equal-interval bins. Water bodies within Waswanipi are illustrated in grey. Basemap is a Sentinel-2 RGB annual median composite.

Probability of Use as Calving Habitat by Woodland Caribou in Waswanipi – 2018



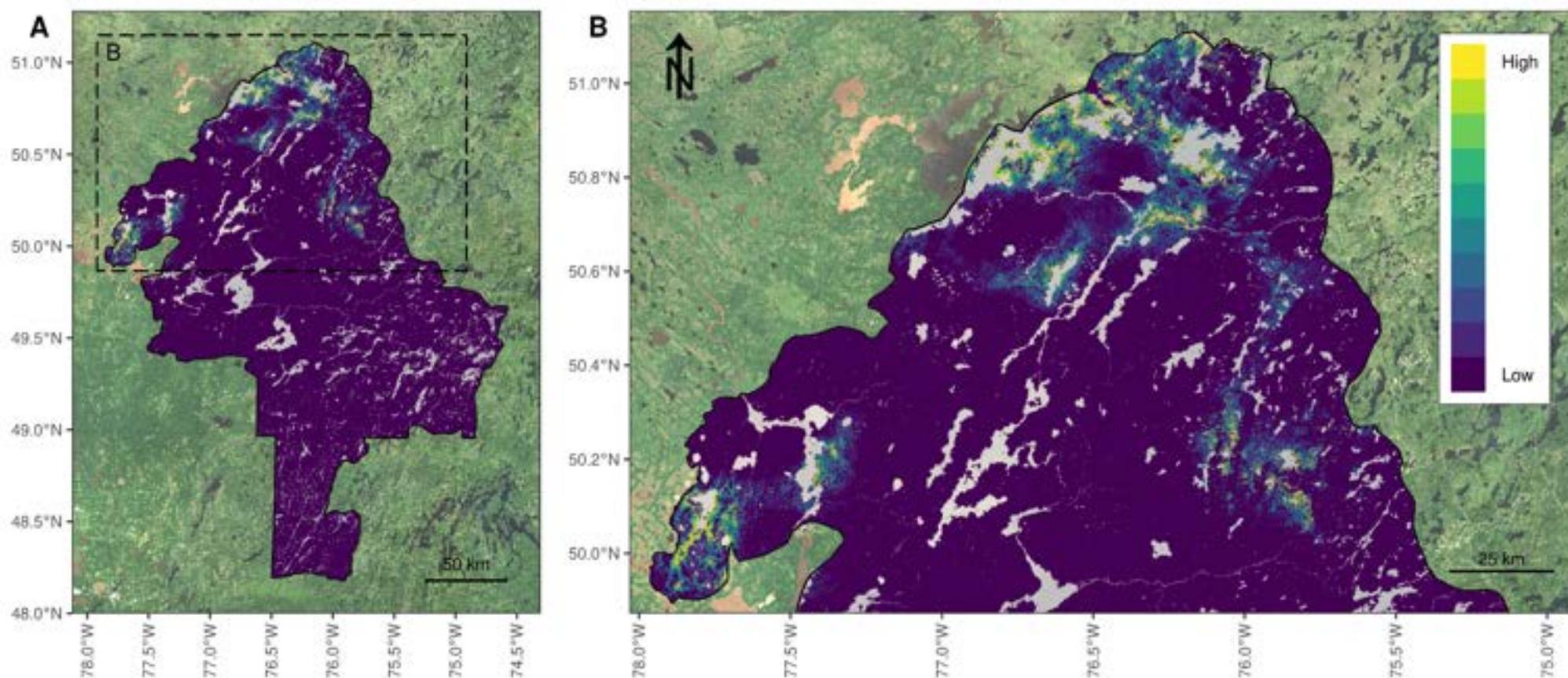
Supplementary Figure 15. Maps of probability of use as calving habitat in 2018 (A) over the entire Waswanipi region and (B) in the northern part of the Waswanipi region. Probability of use as calving habitat was predicted using a resource selection function, and grouped into 10 equal-interval bins. Water bodies within Waswanipi are illustrated in grey. Basemap is a Sentinel-2 RGB annual median composite.

Probability of Use as Calving Habitat by Woodland Caribou in Waswanipi – 2019



Supplementary Figure 16. Maps of probability of use as calving habitat in 2019 (A) over the entire Waswanipi region and (B) in the northern part of the Waswanipi region. Probability of use as calving habitat was predicted using a resource selection function, and grouped into 10 equal-interval bins. Water bodies within Waswanipi are illustrated in grey. Basemap is a Sentinel-2 RGB annual median composite.

Probability of Use as Calving Habitat by Woodland Caribou in Waswanipi – 2020



Supplementary Figure 17. Maps of probability of use as calving habitat in 2020 (A) over the entire Waswanipi region and (B) in the northern part of the Waswanipi region. Probability of use as calving habitat was predicted using a resource selection function, and grouped into 10 equal-interval bins. Water bodies within Waswanipi are illustrated in grey. Basemap is a Sentinel-2 RGB annual median composite.