

**FUTURE TESTING OF A WOODLAND CARIBOU HABITAT
SUITABILITY INDEX MODEL**

FOREST MANAGEMENT DISTRICT 15

DRAFT

By

Kristin Powell, MSc.

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Introduction

A woodland caribou habitat suitability index (HSI) model was developed for forest management district 15 in western Newfoundland in 2004 (Côté and Doyon 2004). This model was developed as part of the Western Newfoundland Model Forest's (WNMF) *Biodiversity Assessment Project*; an initiative started in 1999 to develop a suite of tools to predict the influence of forest harvesting on biodiversity (Dolter 2004). The first three species selected for habitat modeling by the WNMF were chosen as indicator species due to their specific life history requirements or conservation status: Boreal Owl (obligatory secondary cavity nester), Newfoundland Marten (*Martes americana atrata*, listed as endangered in insular Newfoundland (Lemon 1996)) and Woodland Caribou (*Rangifer tarandus caribou*, old-growth forest dependent). These species are all likely to be influenced by forest harvesting in Newfoundland.

This document outlines procedures that will be used to test the woodland caribou HSI model for district 15. It outlines problems encountered during the initial phase of model testing and provides a brief description of other caribou herds in the province to which the HSI model can potentially be applied.

Habitat Suitability Index Model Overview

Habitat suitability index models provide a “numerical assessment of the capacity of a given area to support a particular species” (Brooks and Temple 1990). They combine habitat attributes and species life history and demographic information to produce a map ranking habitat in a given region from least to most suitable. HSI models were first developed by the US Fish and Wildlife Service in 1980 although the use of quantitative techniques of habitat evaluation began in the 1960s (Rickers *et al.* 1995). Since that time modifications of HSI models have been used in a host of studies to model the distribution of a variety of species (Brooks and Temple 1990, Rickers *et al.* 1995, Akçakaya and Atwood 1997, Mladenoff *et al.* 1999, Storch 2002).

The woodland caribou HSI model was developed using expert information and local demographic and location data obtained on the Corner Brook Lakes caribou herd from 1994-1997 (Mahoney and Virgl 2003). These same data will be used to test the model.

It should be noted that because the HSI model was created based on knowledge obtained from the same data being used to test the model, the model should fit the data perfectly. The testing of a model with the same data it was created from is not a valid method of testing a HSI model and is only done in this case to confirm that the model is running properly. In order to truly test the HSI model it should be tested with new data from the Corner Brook Lakes herd (not possible at this time) or applied to herds in other areas (see “*Model Application in Other Areas*”, below).

Forest Management District 15

Forest management district 15 includes most of the WNMF and extends from the southern boundary of Gros Morne National Park south to Gallants and across from the Bay of Islands to east of Grand Lake. Most of the study area is part of the Corner Brook subregion of the Western Newfoundland ecoregion (Meades and Moores 1994). It is characterized by hilly to undulating terrain, a humid climate, and relatively long frost-free period compared to other areas of the island. Fires are very infrequent in this area and balsam fir (*Abies balsamea*) is the dominant tree species. Red maple (*Acer rubrum*) and yellow birch (*Betula alleghaniensis*) are also common in the region. The area is underlain by slate and limestone till and has some of the most favourable sites for forest growth on the island (Meades and Moores 1994).

Corner Brook Lakes Herd

The Corner Brook Lakes (CBL) herd is a non-migratory woodland caribou herd whose entire home range is within forest management district 15. There is little or no immigration into this herd from other areas and hunting of the herd is not permitted. Based on data from 1994-1997, the herd is estimated to number approximately 584 animals (0.6 caribou/km²) although there is much uncertainty associated with this estimate (Mahoney and Virgl 2003). The CBL herd occupies a 1016 km² area of district 15 and their range extends from Grand Lake west to the Trans Canada highway (Mahoney and Virgl 2003). Mahoney and Virgl (2003) report that 38% of the CBL home range is made up of non-forested land including softwood scrub, bogs and barrens; 26% is secondary-growth forest stands, 7% is young recently harvested stands and 26% is mature forest.

Beginning in 1994, adult caribou were captured and collared with very high frequency (VHF) radio collars. In total, 24 adults and 48 calves were captured over a four-year period (until 1997). Detailed information on capture techniques are provided in Mahoney and Virgl (2003).

Future Model Testing Methods

As stated above, the HSI model will be tested on the CBL herd to ensure that it is functioning properly and will then be applied to other herds in the province. However, a brief description of the Mahoney and Virgl (2003) study of habitat selection is required to understand why the statistical analyses outlined below, which will be used to test the HSI model, were performed. Mahoney and Virgl (2003) examined habitat use of CBL caribou by comparing the proportion of each of the 17 habitat types within a seasonal (spring, summer, fall, winter) caribou home range to the proportion of each habitat type available to caribou (entire CBL study area encompassing all seasonal home ranges).

This method is based on the method of Manly et al. (1993). They used 95% minimum convex polygons to delineate home ranges and found that all home ranges overlapped extensively within the study area. Habitat selection did not differ by sex or year but did differ by season (α level of 0.10). Caribou were found to use rock and heath barrens and mature forest stands more than other habitat types during all seasons although barrens were used less in winter than in spring and fall and non-commercially harvested forest was used more in winter than in all other seasons.

The habitat selection information obtained from this study was used to develop the current Woodland Caribou HSI model. Therefore, to test the model with these data the same home range estimation methods were used. Home ranges were calculated only for spring (calving) and winter as the model generates separate HSI values for these periods.

Statistical Analyses

Home ranges (95% minimum convex polygons) were determined for individual adult caribou for each year (1994-1997) and for two seasons: spring (calving, 1 May to 30 June) and winter (1 December to 30 April) using the program Range Manager (Data Solutions, MapInfo 5.5 extension, Figures 1 and 2). Home ranges were only calculated for caribou with 10 or more radiolocations for each season-year period following the methods of Mahoney and Virgl (2003). This resulted in a total of 11 spring-year home ranges and 32 winter-year home ranges. As the polygon method only provides the extent of area used by each animal, core home ranges (60% cross validated fixed kernel, Animal Movement extension of ArcView 3.1) will also be determined to indicate areas used most intensively by each caribou.

The model will be tested by comparing caribou use of HSI classes for each year to total availability of HSI classes for that year using the method of Manly *et al.* (1993). This is analogous to comparing habitat use to availability but substituting HSI classes for habitat types. A similar method has been used to test the results of a HSI model developed for wolves in the upper Midwest, U.S. (see Mladenoff *et al.* 1999) and is a valid method of determining model performance. HSI values will be calculated separately for each year so that habitat changes (harvesting, disturbance) can be accounted for and their impact on the HSI values can be incorporated into the model.

The proportion of each HSI class within each caribou home range (95% MCP) will be determined and compared to the proportion of each HSI class within the CBL herd study area. This will indicate whether or not caribou are selecting areas with high HSI values. All analyses will be done in R 2.1.1 (The R Development Core Team, 2005). The significance level for all statistical tests will be 0.05.

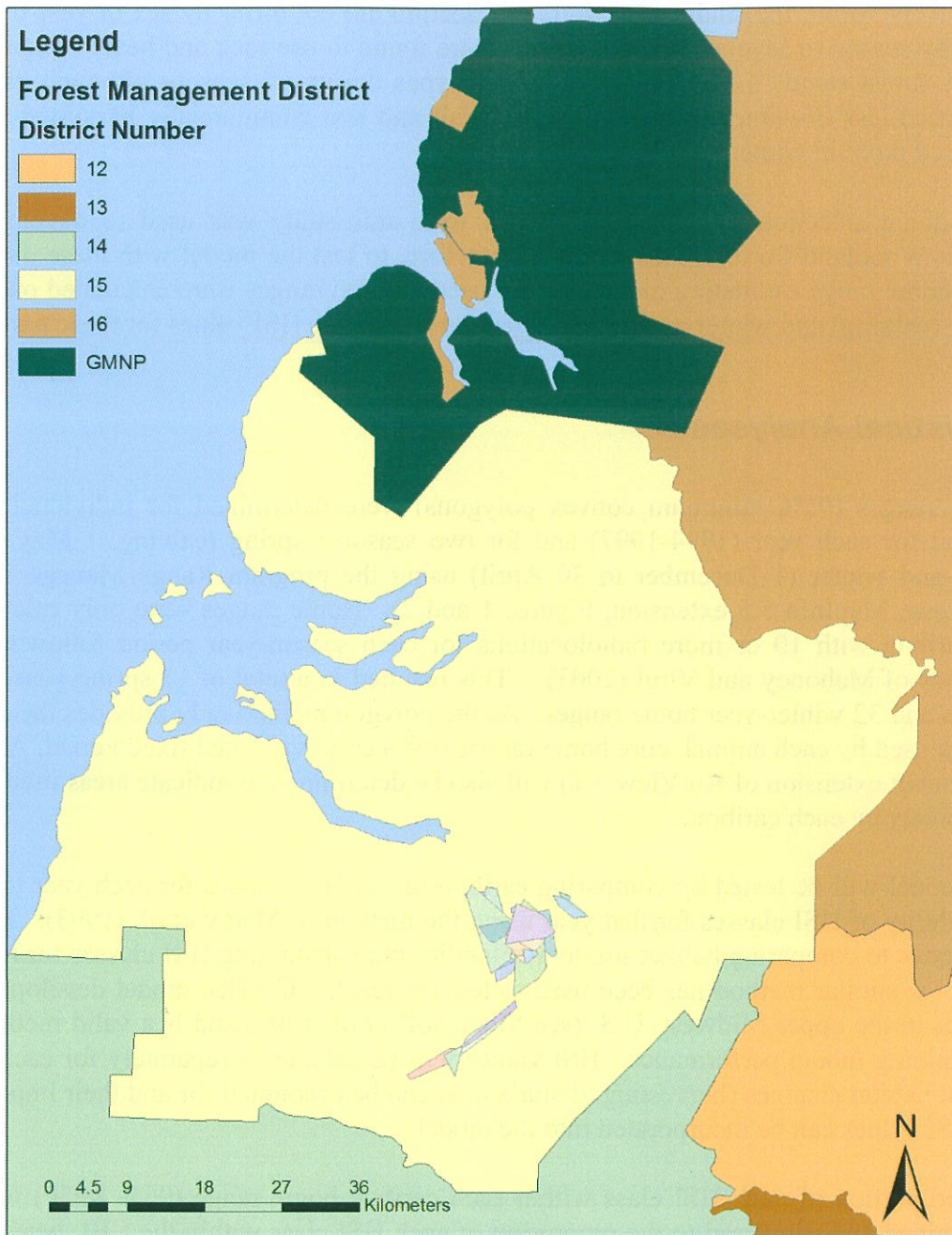


Figure 1. Map of western Newfoundland showing individual spring (calving) home ranges (coloured polygons) of Corner Brook Lakes caribou with 10 or more radiolocations.

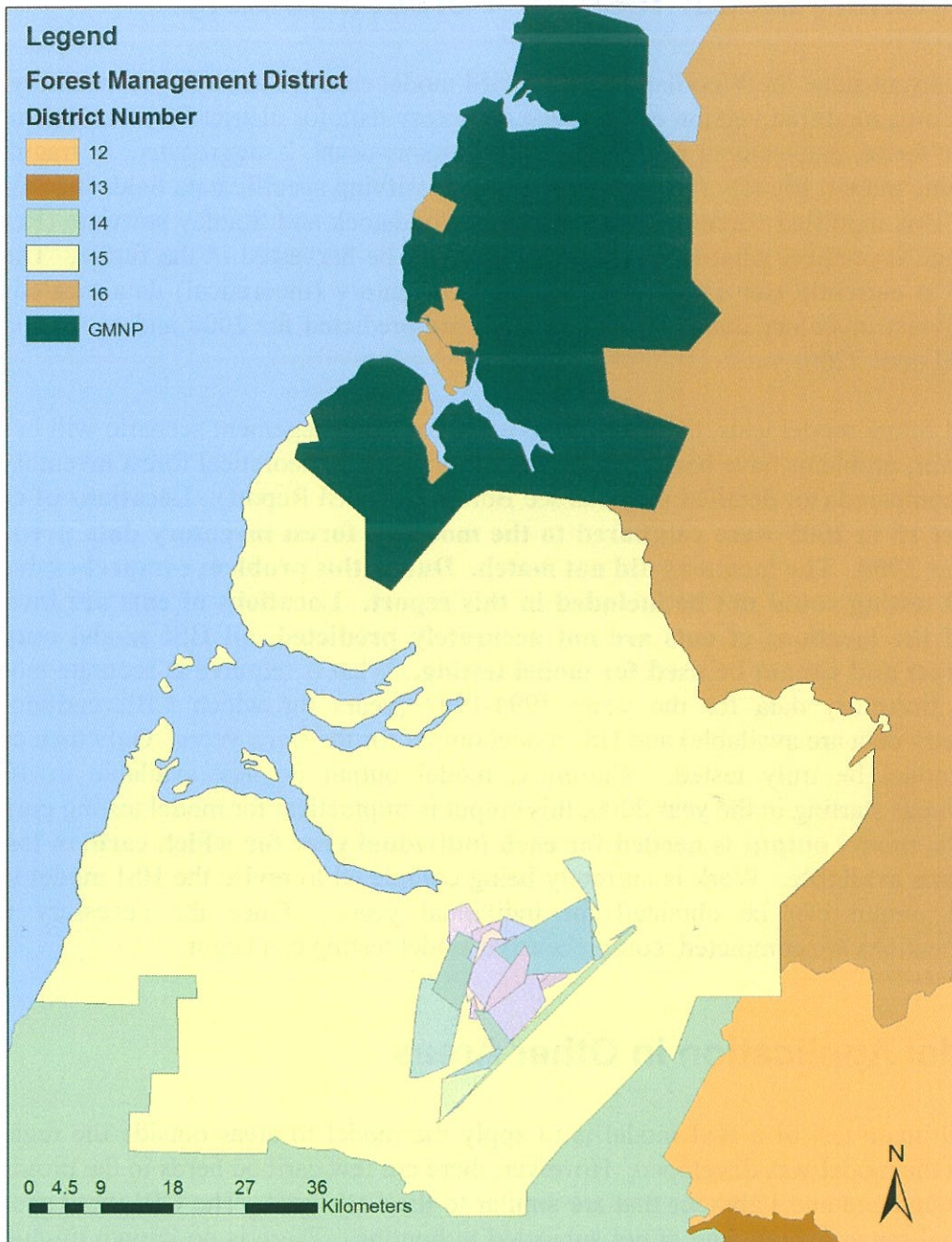


Figure 2. Map of western Newfoundland showing individual winter home ranges (coloured polygons) of Corner Brook Lakes caribou with 10 or more radiolocations.

Preliminary Model Testing: Forest Inventory

In its current state, the Woodland Caribou HSI model cannot run on forest inventory data. It runs on a modified version of the forest inventory data for district 15 created using one of four forest management scenarios (1. business-as-usual, 2. aggregated, 3. fragmented or 4. pine marten friendly (see Pond 2004). Reclassifying specific data fields modifies the data. This modified version is created using Woodstock and Stanley software (Remsoft Inc.) and it predicts what areas of the district will be harvested in the future. The HSI model is currently run using modified forest inventory (theoretical) data created from 1999 forest inventory data. Habitat changes are predicted for 2000 and every 10 years onward until 2200.

For all future model tests, the business as usual forest management scenario will be used. However, problems have been found when the actual and theoretical forest inventory data were compared (for detailed methods see Boreal Owl HSI Report). **Locations of cuts in district 15 in 2005 were compared to the modified forest inventory data predicting cuts for 2000. The locations did not match. Due to this problem comprehensive HSI model testing could not be included in this report. Locations of cuts are incorrect and if the locations of cuts are not accurately predicted, all HSI model output is incorrect and cannot be used for model testing.** What is required is accurate modified forest inventory data for the years 1994-1997 (years for which CBL caribou herd telemetry data are available) and HSI model output for the same years. Only then can the HSI model be truly tested. Currently, model output is only available in 10-year increments starting in the year 2000; this output is impractical for model testing purposes. **Ideally, model output is needed for each individual year for which caribou location data are available.** Work is currently being completed to revise the HSI model so that model output can be obtained for individual years. Once the necessary model modifications are completed, comprehensive model testing can begin.

Model Application in Other Areas

The ultimate test of a HSI model is to apply the model to areas outside the region for which the model was developed. However, there are few caribou herds in the province of Newfoundland and Labrador that are similar to the CBL herd. The CBL herd shows no seasonal range overlap and is not subjected to hunting. There is no known immigration of caribou from other herds into the CBL herd and the herd does not make annual migratory movements (Mahoney and Virgl 2003). Despite this, the Gros Morne (GM) herd was chosen as the herd most similar to the CBL herd and will be used to test the model. Location data obtained from GPS, Argos and VHF collars is available on the GM herd from 1993-1998. The GM herd is similar to the CBL herd as resident animals (within Gros Morne National Park (GMNP) boundaries) are not subjected to hunting and do not make long migratory movements.

Gros Morne Herd

Capture and collaring of GM caribou began in 1992. Details on capture techniques and collaring procedures can be found in Mahoney *et al.* (2001). Caribou were outfitted with Argos units, VHF units or GPS units. A total of 38 adults were collared from 1992-1996.

The range of the GM caribou herd is centred on GMNP located on the northern peninsula although the annual herd home range, determined by combining all radiolocations of all collared caribou, includes portions of forest management districts 15, 16, and 17 (Figure 3). The herd was estimated to number approximately 2877 animals in the spring of 1997 and is thought to be stable with high annual adult survival of 91-100% (Mahoney *et al.* 2001).

Habitat analyses of collared GM caribou indicated that Big Level was an important calving area. The most highly used habitats by resident (within GMNP) animals during the spring included soil barren followed by soil barren shrub, water and softwood. In the winter, habitat selection was highly diverse and included the use of 16 different habitat types (Mahoney *et al.* 2001).

Seasonal (spring and winter) home ranges will be determined for each year for all adult caribou with 10 or more radiolocations. Argos, GPS and VHF collared caribou will be analysed separately due to differences in the accuracy of the three collar types. Based on GPS data, it is possible to calculate home ranges for 4 caribou in the spring of 1997 and 4 in the spring of 1998. For Argos data, 23 individual caribou home ranges can be calculated for the spring including 10 in 1993, 10 in 1994 and 3 in 1995. For the winter, there are enough data available to calculate home ranges for 31 caribou, 17 with Argos units and 14 with GPS units. There was not enough data collected on caribou with VHF units to allow for any season-year home range estimates.

Before HSI model testing for the GM herd can continue, modified forest inventory data for use in the model must be obtained for the years 1992-1998 for GMNP and districts 16 and 17. These data can then be used to obtain HSI model output for the entire GM herd home range.

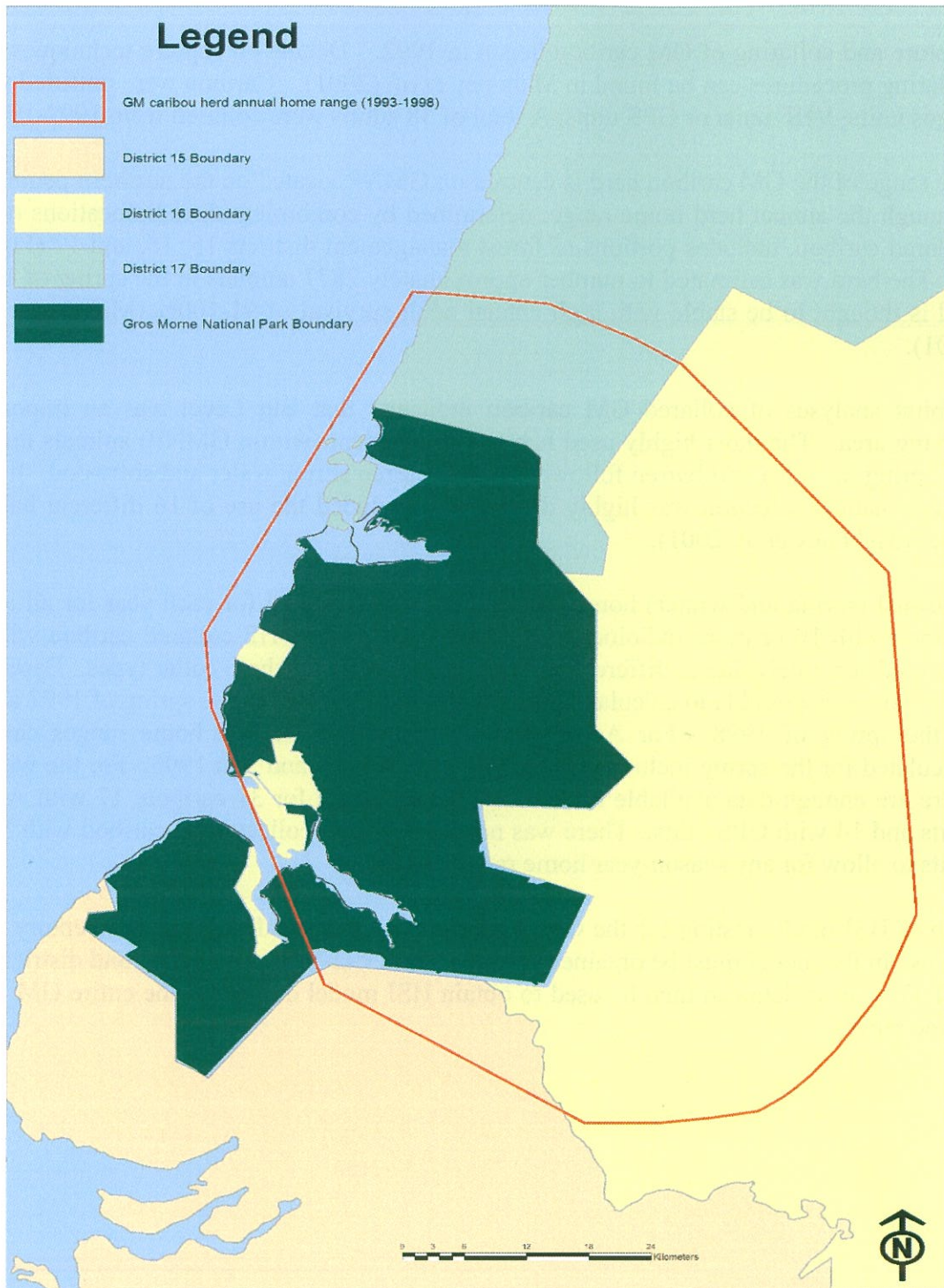


Figure 3. Map of western Newfoundland showing the annual home range of all collared GM caribou (including GPS, Argos, and VHF collars) from 1993-1998. Home range shape was determined using Range Manager (Data Solutions, MapInfo 5.5 extension).

Buchans Plateau and Middle Ridge Herds

The Woodland caribou HSI model will be applied to a third herd within the province of Newfoundland and Labrador. There are location data available for many herds within the province however, there are no herds, with the exception of GM and CBL, for which sufficient location data are available AND are located in areas where complete forest inventory data are also available. Work is currently being done to determine how the model can be applied to other herds where forest inventory information is not complete. This may require truncating the ranges of individual caribou and applying the model only to those parts of the home range for which forest inventory data are available.

Two caribou herds being considered in this situation are the Middle Ridge and Buchans Plateau herds.

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Appendix I

Woodland Caribou Habitat Suitability Index Model

HSI Model Assumptions

Model assumptions are well-supported by information found in the literature and data from district 15 but other considerations are mentioned for some assumptions; mostly based on information available after the model was completed.

Calving and wintering habitats are the most important limiting factors for the woodland caribou and these factors do not spatially interact.

CBL herd occupies a small area thus caribou are likely able to travel easily between different seasonal habitats (Mahoney and Virgl 2003).

CALVING

HSI_{calving} value calculated using a radius of 3241 m corresponding to a neighbourhood window of 3300 ha (value based on home range requirements during the calving season).

Mahoney and Virgl (2003) report Corner Brook Lakes caribou spring home range to be 33.2 +/- 7.6 km² (n=17) corresponding to a range of 2560 to 4080 ha.

Calving habitat quality increases linearly with stand age and highest quality habitat is in mature forest and in bogs and scrub.

Mahoney and Virgl (2003) found that adult caribou selected mature forest stands (80+), non-commercially harvested timber, and rock and heath barrens more than all other habitats during all seasons indicating that these areas are the highest quality habitats. Caribou used scrub habitat more in the spring, summer and autumn than in the winter.

Predator foraging habitat quality is based on habitat selection of black bear (young stands and recently disturbed areas) and lynx (dense juvenile stands).

Both black bear and lynx are known to prey on caribou calves but another potential predator in this district is the eastern coyote (*Canis latrans*). In the last several years, coyote numbers have increased in the province and their effect on caribou is not known. Coyotes are known to prey upon both calves and adult caribou (P. Saunders, *pers comm.*) but there is currently no available information on coyote predation rates on caribou for Newfoundland.

A high amount of edge habitat is detrimental for woodland caribou.

Mahoney and Virgl (2003) report that disturbed and cleared areas were used significantly less by caribou than other natural habitats in the Corner Brook Lakes region. Several other studies have shown that caribou avoid roads (Dyer *et al.* 2002) and fragmented

areas (Smith *et al.* 2000) when possible, both of which have high amounts of edge habitat.

WINTERING

HSI_{wintering} value calculated using a radius of 3613 m corresponding to a neighbourhood window of 4100 ha (value based on home range requirements during the winter).

Mahoney and Virgl (2003) report that Corner Brook Lakes caribou have a home range size during the winter of 40.7 +/- 6.6 km² (n=20) corresponding to a range of 3410 to 4730 ha. The value of 4100 ha falls within this range.

Habitat selection during the winter (when food availability is assumed to be low) is based on stand age, composition and density; variables, which affect lichen biomass.

This assumption that stand age, composition and density affect lichen biomass is supported by several different studies (Adams and Risser 1971, Arseneau *et al.* 1998).

The assumption that food availability is the major factor influencing habitat selection in winter is supported by studies showing that caribou in winter most often use habitat in areas with high lichen abundance (Martinez 1998, Duelling 1999).

