CALVING GROUND HABITAT SELECTION OF BOREAL WOODLAND CARIBOU (*RANGIFER TARANDUS CARIBOU*) IN THE OWL-FLINTSTONE RANGE

BY

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ABSTRACT

Due to declines in populations, boreal woodland caribou have been listed as Threatened in both Manitoba and Canada. Although there are many factors affecting boreal woodland caribou (*Rangifer tarandus caribou*) populations in Canada, it is recognized that protecting critical caribou habitat is required for the conservation of the species. The Owl-Flintstone range, the most southern range of boreal woodland caribou in Manitoba, is among the most at risk in the province. In order to better understand critical habitat use of the Owl-Flintstone range, this study's objectives were to characterize calving habitat at a fine scale, determine whether large mammal species other than caribou utilize caribou calving areas and examine if a calving habitat model (Dyke 2008) correctly identified high quality calving habitat.

A series of transects and plots were established within known calving sites, predicted high quality calving habitat and predicted low quality calving habitat in the Owl-Flintstone range in southeastern Manitoba during the months of May to August 2009/2010. Data for the following categories were collected: ground vegetation, shrub, tree canopy, downed woody debris and animal signs.

Parturient females utilized islands and peninsulas on lakes as well as islands and peninsulas in bogs. Ground vegetation consisted predominantly of bryophytes, lichens, ericaceans species and rock. The shrub and tree canopy layer consisted mostly of black spruce (*Picea mariana*). Downed woody debris was not abundant. Calving sites were characterized by gentle topography with gradual sloping shorelines or stand edge.

Based on animal signs observed, moose utilized predicted low quality sites significantly more than both known calving sites and predicted high quality sites. Bears did not appear to

utilize a type of site more than another. The probability of wolves utilizing predicted low quality sites was significantly higher than predicted high quality sites.

Black spruce and lichen cover were significantly greater within known calving sites compared to predicted low quality habitat. Model parameters such as the distance to cutblocks, linear features, fires and hardwoods were significantly greater, while the distance to treed muskeg and intermediate black spruce were significantly shorter to known calving sites compared to predicted low quality habitat. The only differences between known calving sites and predicted high quality sites were the lower abundance of downed woody debris and the lower forb and herb cover within known calving sites.

The calving habitat model correctly identified both high quality and low quality calving habitat in the Owl-Flintstone range. Management recommendations include refining the calving habitat model by adding parameters reflecting the use of islands and peninsulas on lakes and the selection of calving sites with lower forbs, herbs and downed woody debris values.

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- For Grandpère et Pépère -

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CHAPTER 1.

INTRODUCTION

1.0. BACKGROUND

Woodland caribou are one of four caribou subspecies found in Canada (Banfield 1974). Within the woodland caribou subspecies, the boreal population is among the six geographically distinct woodland caribou populations in Canada (Environment Canada 2012*a*).

During the last few decades, there has been growing concern with the state of boreal woodland caribou (*Rangifer tarandus caribou*) populations in Canada. In 2002, by recommendation of the Committee on the Status of Endangered Wildlife in Canada, the federal government listed boreal woodland caribou as Threatened under the *Species at Risk Act* (Thomas and Gray 2002). In 2006, Manitoba followed suit and listed boreal woodland caribou populations as Threatened under the *Endangered Species and Ecosystems Act* (Manitoba Conservation 2005). Boreal woodland caribou has been identified as threatened in Canada on the basis of declines in population throughout most of its range, habitat loss and increased predation, facilitated by increased human activity (Thomas and Gray 2002).

Historically, caribou were found throughout much of Canada and the northern parts of the United States. (Seton 1909, U.S. Fish and Wildlife Service 1993, Callaghan et al. 2011) (Fig 1-1). In Manitoba, caribou ranged from the Manitoba-Minnesota border in the southeast part of the province, extending north and northwest (Seton 1909, MB Conservation 2005, Callaghan et al. 2011). Since the early 1900s, the southern edge of the continuous distribution of boreal woodland caribou has gradually moved northward (Bergerud 1974, Thomas and Gray 2002). Today, boreal woodland caribou can be found from the Yukon to Labrador and as far south as Lake Superior in Ontario (Thomas and Gray 2002, Environment Canada 2012*a*). The southern extent of boreal woodland caribou occupation in eastern Manitoba is found north of the Whiteshell Provincial Park (Eastern Manitoba Woodland Caribou Advisory Committee 2005).

Thirty boreal caribou local populations occur in the Boreal Shield Ecozone. Of these local populations, two are increasing, four are declining, fourteen are stable, and the status of ten is unknown (Callaghan et al. 2011). Among the ten boreal woodland caribou ranges found in Manitoba, the Owl-Flintstone is the most southern range (Martinez 1998, Manitoba Conservation 2005). Although the population is thought to be currently stable at an estimated size of 78 animals (Thomas and Gray 2002, Environment Canada 2012*a*), it is classified as a high conservation concern by the Government of Manitoba due to habitat loss, fragmentation or degradation and other indirect impacts as a result of anthropogenic disturbances (Manitoba Conservation 2005).

1.1. ISSUE STATEMENT

Due to declines in populations, boreal woodland caribou have been listed as Threatened in both Manitoba and Canada (Thomas and Gray 2002, Manitoba Conservation 2005). There has been a gradual decline of boreal woodland caribou populations in North America (Scotter 1964, Bergerud 1974, Edmonds 1991, Thomas and Gray 2002, Manitoba Conservation 2005, Vors et al. 2007, Vors and Boyce 2009). Many factors have been attributed to the decline in caribou populations, such as: increased natural predation and increased hunting mortality (Bergerud 1974, Jordan et al. 1998, Manitoba Conservation 2005), parasites (Jordan et al. 1998, Manitoba Conservation 2005), habitat alteration (Vors et al. 2007, Vors and Boyce 2009), apparent competition (Wittmer et al. 2005, Latham et al. 2011), and climate change (Grayson and Delpech 2005, Vors and Boyce 2009, Joly et al. 2011). Although there are many factors affecting boreal woodland caribou populations in Canada, it is recognized that protecting critical caribou habitat is required for the conservation of boreal woodland caribou on the Canadian landscape.

As specified in the Scientific Review for the Identification of Critical Habitat for Boreal Caribou, critical habitat is identified by determining "the quantity, quality and spatial configuration of habitat required for the persistence of boreal woodland caribou populations throughout their current distribution" (Environment Canada 2008). Caribou calving and nursing habitat is essential for the persistence of boreal woodland caribou and therefore is considered critical habitat (Manitoba Conservation 2005, Environment Canada 2012*a*, *b*).

The Owl-Flintstone range, the most southern range of boreal woodland caribou in Manitoba (Martinez 1998), is among the most at risk in the province (Manitoba Conservation 2005). As the Owl-Flintstone range is at the southern extent of current boreal woodland caribou occupation, is isolated from other ranges and is surrounded by human activities, it is important to gather baseline data to further understand critical habitat use. Most of the research done with the Owl-Flintstone range has focused on winter habitat use (Martinez 1998). The primary goal of this study was to evaluate the calving habitat use in a southern boreal woodland caribou range and examine if a calving habitat model (Dyke 2008) correctly identified high quality calving habitat.

1.2.OBJECTIVES

The purpose of this study was to characterize calving areas in the Owl-Flintstone boreal woodland caribou range in southeastern Manitoba. The specific objectives were:

- to identify vegetation composition of calving habitat at a fine scale,
- to identify large mammal species other than caribou utilizing caribou calving habitat,

- to examine whether variables used within a predictive calving habitat model (Dyke 2008) for the Owl-Flintstone range correctly predict low quality and high quality calving habitat, as determined through field studies
- to provide management recommendation for boreal woodland caribou calving habitat in the Owl-Flintstone range in southeastern Manitoba.

1.3. SCOPE

In Manitoba, there are ten boreal woodland caribou ranges, occurring from southeastern Manitoba to west-central Manitoba. Caribou populations in three of these ranges are of a high conservation concern, which includes the Owl-Flintstone range in southeastern Manitoba (Manitoba Conservation 2005). These ranges occur within peat bog complexes with rock outcrops intermixed with rivers and lakes. The geographical positioning of the Owl-Flintstone range provides an opportunity to characterize ecological needs of a southern boreal woodland caribou population and provide management recommendations.

There have been a variety of studies conducted in Manitoba regarding boreal woodland caribou. In 1977, a study conducted in southeastern Manitoba examined the winter ecology of boreal woodland caribou (Stardom 1977), while in 1998, a similar study in the Owl-Flintstone area examined winter habitat use of boreal caribou (Martinez 1998). In 1998, calving habitat of the Wabowden boreal caribou range was assessed in relation to timber resource value (Hirai 1998), while Shoesmith examined the social organization of boreal woodland caribou in western Manitoba and briefly discussed calving habitat (Shoesmith 1978). Furthermore, a study with a primary focus of describing seasonal movements, habitat utilization and population ecology of boreal woodland caribou was conducted in southeastern Manitoba (Darby 1979). While the aforementioned studies may have examined different temporal and spatial aspects of boreal woodland caribou habitat use and ecology in Manitoba, none have specifically examined both fine and broad scale calving habitat of a boreal woodland caribou population, while at the same time examining the use of caribou calving areas by other large mammal species.

This study looks at characterizing calving sites utilized by caribou in the Owl-Flintstone boreal woodland caribou range of southeastern Manitoba. Specifically, this study examines features characterizing calving areas, whether large mammals other than caribou utilize caribou calving areas and whether a caribou calving habitat model (Dyke 2008) correctly identified high quality calving habitat and low quality calving habitat. The following three predictions were tested: 1) Parturient female utilize calving areas dominated by black spruce, terrestrial lichen and associated ground vegetation, 2) caribou calving sites are not utilized by moose, bears and wolves, 3) parturient females utilize predicted high quality calving habitat and do not utilize predicted low quality calving habitat as predicted by a calving habitat model (Dyke 2008).

1.3.1.STUDY AREA

The study was conducted in southeastern Manitoba in the Lac Seul Upland Ecoregion, which is part of the Boreal Shield Ecozone (Ecological Stratification Working Group 1995). The area is located approximately 150 km northeast of the City of Winnipeg. The study area encompasses approximately 3600 km^2 of boreal forest, most of which is crown land. It is bordered by Lake Winnipeg to the west and the Manitoba-Ontario border to the east (Fig. 1-1).

This part of southeastern Manitoba is characterized by broad sloping uplands and lowlands with an interspersion of creeks, rivers and lakes. The eastern and western part of the study area lie at 335 and 218 metres above sea level respectively (Smith et al. 1998).

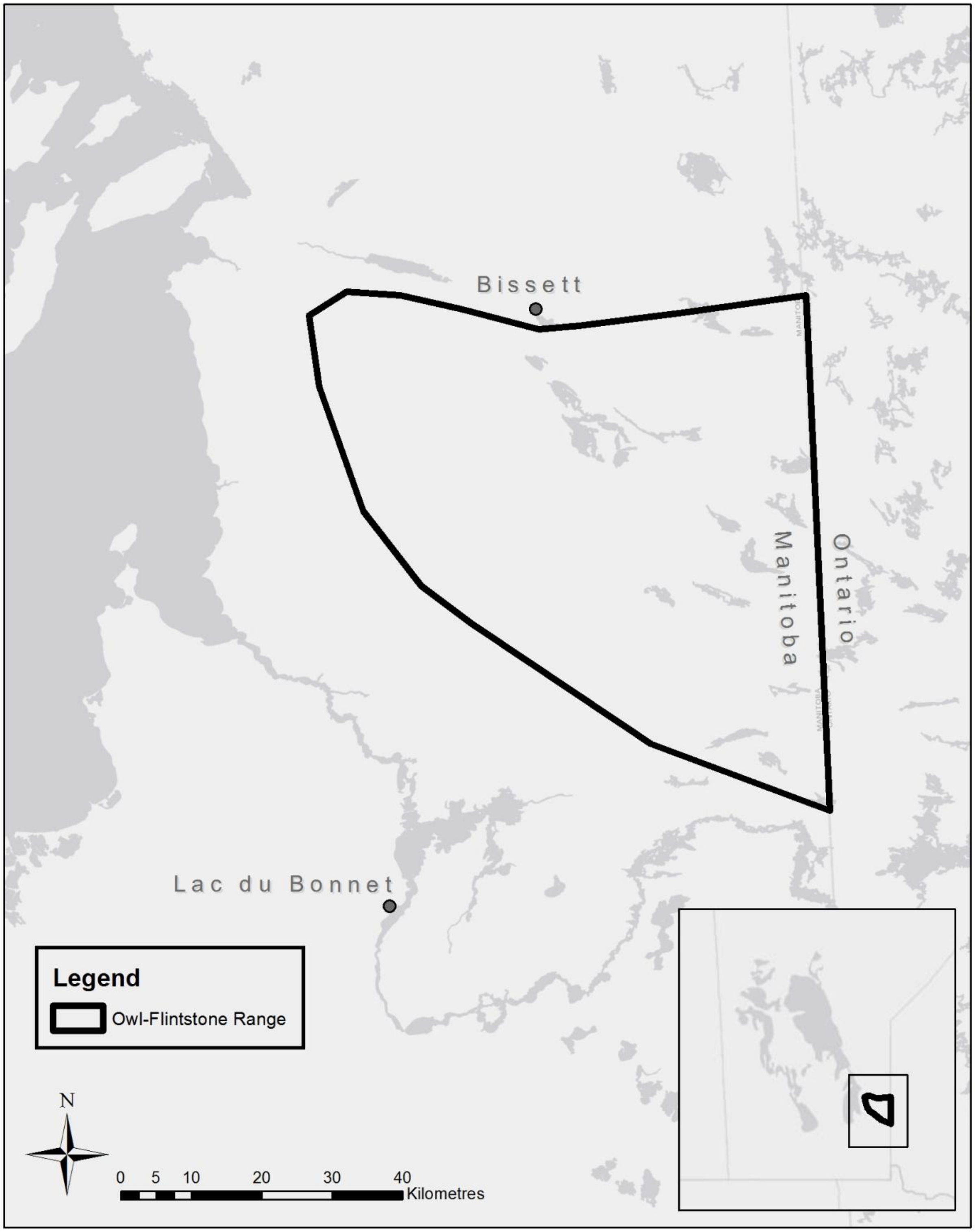

Fig. 1-1. Owl-Flintstone range in southeastern Manitoba. Owl-Flintstone range file provided by Manitoba Conservation.

The study area is situated within the transition between bedrock dominated habitat to the east and the peat-covered lowland to the northwest. The eastern part of the study area is composed of outcrops of Precambrian bedrock thinly covered by glacial drift deposits; to the west, the bedrock is increasingly covered by clay and silty glaciolacustrine sediments. There are small, medium and large lakes throughout the area, with most of the latter found in the eastern portion (Smith et al. 1998).

Forest stands in the area contain a mosaic of softwood species including black spruce (*Picea mariana*), white spruce (*Picea glauca*), tamarack larch (*Larix laricina*), balsam fir (*Abies balsamea*), and jack pine (*Pinus banksiana*). Broad leaf hardwoods in the area include trembling aspen (*Populus tremuloides*), paper birch (Betula *papyrifera*), black ash (*Fraxinus nigra*), and balsam poplar (*Populus balsamifera*) (Palidwor and Schindler 1995).

Southeastern Manitoba is part of the humid continental climate zone, where there are short warm summers and cold winters (Ecological Stratification Working Group 1995, Peel et al. 2007). Precipitation varies greatly from year to year. Most of the precipitation falls from spring through summer (Smith et al. 1998). Total annual precipitation in the area is 536.8 mm, a third of which falls as snow. Mean temperature in January and June are -17.5°C and 15.9°C respectively (Environment Canada 2013).

There are two provincial parks in the area, Nopiming Provincial Park and Manigotagan River Provincial Park. The study area is used by many different user groups for both recreational purposes and resource development such as forestry and mining. There are several communities in proximity of the study area, including three First Nation communities. The local economy is predominantly based on resource development.

1.3.2.METHODS

Caribou calving habitat use was documented by surveying calving areas based on a Global Positioning System (GPS) (current calving areas), historical records (historical calving areas) and a predictive model (predicted calving areas). Field work was conducted during the months of May through August in 2009 and 2010. Throughout the survey area, a series of transects were established within historic, current and predicted calving areas to record both vegetation communities and animal presence. A database was established to enable analysis with a Geographic Information System (ArcGIS version 9.x, ESRI Inc.) and the statistical program R (Version R-3.0.1).

1.4. ORGANIZATION

This thesis is presented in six chapters. Chapter 2 describes methods used throughout the study. Chapter 3 examines the fine scale characteristics of caribou calving habitat, while chapter 4 focuses on predator avoidance and its effects on caribou calving habitat selection. Chapter 5 examines which features are selected for calving habitat and whether a calving habitat model (Dyke 2008) correctly predicted low quality and high quality calving habitat. Chapter 6 is comprised of management recommendations based on the data analysis and field observation during this research.

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CHAPTER 2.

METHODS

2.0. INTRODUCTION

Methods described in this Chapter are common to the studies in Chapter 3, 4 and 5.

2.1. CALVING HABITAT MODEL

Development of the calving habitat model – Dyke (2008*b*) produced a model predicting high quality calving habitat based on GPS data from parturient female caribou within three different ranges; one in central Saskatchewan and two in northwestern Manitoba. Once calving locations were identified for each individual, the distance from these calving locations to various landscape features were determined to produce a model using resource selection function analysis. Using the same methods to produce the calving habitat model for the three ranges in Manitoba and Saskatchewan, Dyke produced a calving habitat model for the Owl-Flintstone range (Dyke 2008*a*). For the Owl-Flintstone range, parameters used within the calving habitat model included distance to:

- Intermediate Black Spruce (40-100 years)
- Mature Black Spruce (>100 years),
- Hardwoods
- Tamarack, Cedar and Balsam Fir
- Treed Muskeg
- Cutblocks (<40 years)
- Fire (<40 years)
- Linear Features

Testing the calving habitat model – In order to examine whether the calving habitat model produced by Dyke (2008*a*) for the Owl-Flintstone range correctly predicted high quality and low quality calving habitat, a series of transects were established within both predicted high quality calving habitat and predicted low quality calving habitat. The survey methods used are described in the next methods section.

2.2. FIELD TECHNIQUES

Spatial Data of Boreal Woodland Caribou - Manitoba Conservation and the Eastern Manitoba Woodland Caribou Advisory Committee collared female caribou from 1995 to 2009 as part of various projects. Individuals were captured and fitted with Lotek Very High Frequency (VHF) collars and Lotek 3300L series Global Positioning System (GPS) collars. VHF locations were gathered using 2 H antennae on board a De Havilland Otter float plane and a Bell 206 Jet Ranger helicopter. When funding permitted, flights to retrieve location data were performed every two weeks during the months of May and June, whereas flights were performed every month for the remainder of summer. GPS units were programmed to collect both temporal and spatial information at one or three hour intervals. Twenty five females within the Owl-Flintstone population were fitted with either a VHF or GPS collar. Of the 25 collared females, 18 were fitted with VHF collars, while the remaining 7 females were equipped with GPS collars.

Calving sites – GPS and VHF collar data for the months of May and June, months which are commonly considered to represent the calving season in southeastern Manitoba (Shoesmith 1978, Darby 1979, Hirai 1998, Dyke 2008*a*) were imported into ArcGIS (version 9.x, ESRI Inc.). Calving sites were determined by examining movement rates of collared animals. Calving events were defined as having movement rates of less than 50 m/h for a minimum of a week. Calving sites were determined by using a 95% Kernel and least square cross-validation (Dyke 2008*b*).

Sampling Design – In an effort to examine as many calving areas as possible, the survey area examined three different temporal scales: 1) historical calving areas, 2) current calving areas

3) and predicted calving areas. Historical calving areas were defined as areas known to have been used for calving by caribou prior to GPS and VHF information being available. Historical areas were identified through interviews with local biologists. Current calving areas were defined as GPS and telemetry locations of collared female displaying calving behaviour dating from 1995 to 2009. Predicted locations were defined as locations of high or low calving habitat value as indicated by a calving habitat model produced by Dyke (2008a). The calving habitat model utilized GPS data of parturient females to model distances from various landscape features (ex: distance to cutblocks, black spruce stands, roads) using resource selection function (RSF) analysis (Dyke 2008*b*). A series of 100 m survey transects were established within areas representing each temporal scale between the months of May and August 2009 and 2010. A total of 803 established transects were separated into three categories: predicted low quality sites, predicted high quality sites, and known calving sites (Table 2-1).

Table 2-1. The number of transects established within each category

Category	**Number of Transects**
Predicted Low Quality Sites	**201**
Predicted High Quality Sites	**541**
Known Calving Sites	**61**
Total	**803**

Historical calving areas consisted of relatively large lakes in the eastern part of the study area, ranging between 1.1 km^2 and 10.1 km^2 in size. All islands and peninsulas 100 m or greater in length within historical calving areas were surveyed. The majority of islands were relatively small in size (a few hundred metres long), and two transects were established on most islands and peninsulas. However, on one larger island approximately 2 km long and 1 km wide, ten transects were established. Islands smaller than 100 m in length were examined for caribou sign, but vegetation data was not recorded.

For both current and predicted calving areas, ten transects were randomly established within two km^2 survey blocks. The location of survey blocks were established at aggregations of GPS locations dating from 1995 to 2009 for current calving areas. To survey predicted calving areas, the location of survey blocks were established in both predicted high quality calving habitat and predicted low quality calving habitat according to Dyke's model. Survey blocks were positioned throughout caribou range (Fig. 2-1). In addition to the ten transects established per sample block, there were transects established within calving sites determined from GPS locations. Previously unknown calving sites were encountered and classified as such only when evidence of presence of a calf (visual of the calf or calf pellets) was found at the site. Sites at which there were features consistent with other calving sites but no calf sign found, were not classified as a calving site and not included as such in the analysis.

Transects – The cover and composition of ground vegetation species and abiotic components were assessed using the line intercept method (Canfield 1941), similarly to the method used by Gustine (Gustine et al. 2006). The lineal distance to the nearest metre was recorded for each species or a group of species intersecting the transect. If the stem, leaves or thalli of a species intersected the transect, it was recorded. In the case of multiple species intersecting the transect at the same location, the most abundant species was recorded first, followed by the second most abundant and so forth. Species with a height of one metre or less were considered ground vegetation (Roberts-Pichette and Gillespie 1999). Down woody debris intersecting the transect were recorded and classified according to the Ecological Monitoring and Assessment Network (EMAN) Terrestrial Vegetation Biodiversity Monitoring Protocols (Roberts-Pichette and Gillespie 1999). Incidental observations of animal signs and animal signs found along the transect were also recorded (See chapter 3). Additional qualitative characteristics of calving sites, such as topography and other general descriptions were recorded.

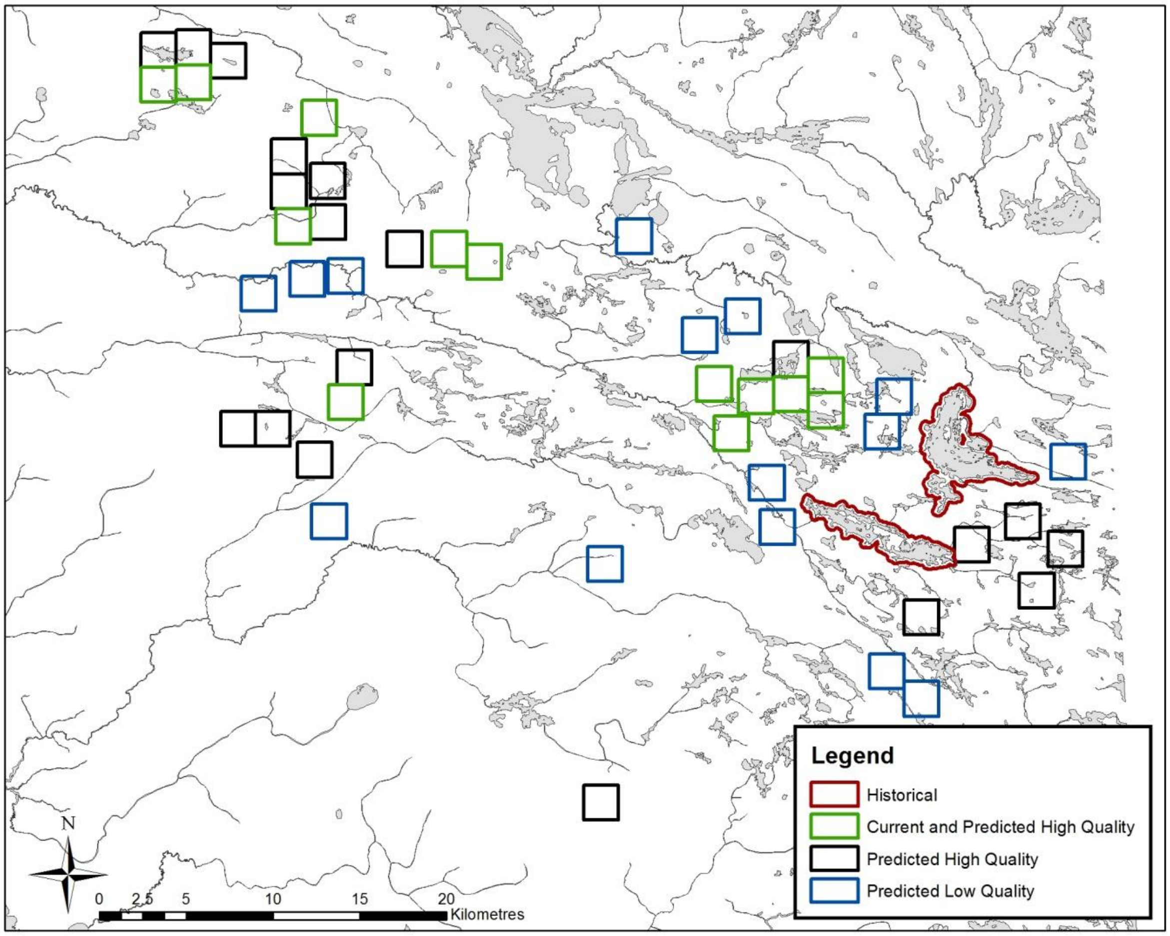

Fig. 2-1. Survey blocks established throughout the survey area in southeastern Manitoba, 2009-2010.

In addition to vegetation data, animal signs within two metres of both sides of the transect were recorded. Signs of the following large mammal species were recorded: caribou, moose, wolf and black bear. Signs included tracks, pellet/scat, sheds, hair, trails, bed sites and sightings. GPS locations of incidental observations of animal signs were also recorded when travelling throughout the survey area.

Plots – The shape and size of shrub and tree canopy plots as described by the EMAN Terrestrial Vegetation Biodiversity Monitoring Protocols (Roberts-Pichette and Gillespie 1999) were modified in an effort to establish as many transects and plots as possible. At both the beginning (0 m) and the end of each transect (100 m), shrub and tree canopy species were identified within a 5 m radius. An individual was classified as a tree canopy species if it had a diameter at breast height (DBH) greater or equal to four centimetres and a shrub or sapling if it had a DBH smaller than four centimetres. The condition (alive/dead; standing/leaning/fallen; alive/dead top/broken top) and DBH were recorded for all tree canopy species individuals within the 5 m radius using protocols described by Roberts-Pichette and Gillespie (1999). Tree canopy closure was determined by ocular estimation of the percentage of tree canopy closure. At the end of each transect, the age of three individuals of the dominant tree canopy species was determined using an increment borer. The percentage cover of all shrub and sapling species within the plot was recorded. The absolute shrub cover was determined by ocular estimation of the percentage of area covered by shrubs or saplings.

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CHAPTER 3.

FINE SCALE CHARACTERIZATION OF CARIBOU CALVING HABITAT

Abstract: Fine scale characteristics of calving sites utilized by boreal woodland caribou (*Rangifer tarandus caribou*) in the Owl-Flintstone range in southeastern Manitoba were identified during the months of May to August 2009/2010. Through a series of transects (n=61) and plots established within 26 calving sites, ground vegetation species, shrubs species, tree canopy species and downed woody debris were recorded. Parturient females utilized islands and peninsulas on lakes as well as islands and peninsulas in bogs. Ground vegetation consisted predominantly of bryophytes, lichens, ericacean species and rock. The shrub layer consisted mostly of black spruce (*Picea mariana*), while the tree canopy layer consisted mostly of black spruce and to a lesser extent jack pine (*Pinus banksiana*). Downed woody debris was not abundant. Calving sites were characterized by gentle topography with gradual sloping shorelines (islands and shorelines on lake) or stand edge (islands or peninsulas in bog). At the fine scale, parturient females in the Owl-Flintstone range selected calving sites with sufficient forage within calving areas with reduced predation risk.

3.0. INTRODUCTION

Boreal woodland caribou were listed as Threatened under the *Species at Risk Act* in 2002 (Thomas and Gray 2002) and by the Province of Manitoba under the *Endangered Species and Ecosystems Act* in 2006 (Manitoba Conservation 2005). The southern distribution of boreal woodland caribou has gradually receded northwards (Bergerud 1974, Thomas and Gray 2002) and populations have been gradually declining (Scotter 1964, Bergerud 1974, Edmonds 1991, Thomas and Gray 2002, Manitoba Conservation 2005, Vors et al. 2007, Vors and Boyce 2009).

Many factors have been attributed to the decline in caribou populations such as: increased natural predation and increased hunting mortality (Bergerud 1974, Jordan et al. 1998, Manitoba Conservation 2005), parasites (Jordan et al. 1998, Manitoba Conservation 2005), habitat alterations (Vors et al. 2007, Vors and Boyce 2009), apparent competition (an indirect relationship between prey species sharing a common predator) (Wittmer et al. 2005, Latham et al. 2011), and climate change (Grayson and Delpech 2005, Vors and Boyce 2009, Joly et al. 2011). In light of the effects of such factors on boreal woodland caribou populations, critical habitat has become increasingly important for the survival of boreal woodland caribou in North America.

Calving habitat selection involves weighing predation risks with forage necessities in an effort to maximize the probability of a successful calving event. Although studies have shown predator avoidance plays an important role in the decision-making process of calving habitat selection (Shoesmith 1978, Bergerud 1985, Cumming and Beange 1987, Bergerud et al. 1990, Barten et al. 2001, Wittmer et al. 2006, Gustine et al. 2006, Carr et al. 2007, Metsaranta and Mallory 2007, DeMars et al. 2011, Pinard et al. 2012), only a few have looked at evaluating detailed fine scale vegetative characteristics of boreal woodland caribou calving habitat and its influence on calving habitat selection (Gustine et al. 2006, Carr et al. 2007, Lantin et al. 2011).

Boreal woodland caribou find food and shelter in the boreal forest, where they prefer older coniferous forest between 40 and 100 years of age (Stardom 1977, Johnson 1993, Rettie and Messier 2000). In early successional stages of forest, caribou are less abundant, while moose tend to be more abundant. As the forest matures, the forage available becomes more favorable to caribou and less favorable to moose (Fisher and Wilkinson 2005).

Caribou calving habitat is essential for the persistence of boreal woodland caribou and therefore is considered critical habitat (Racey and Arsenault 2006, Environment Canada 2008, 2012*a*, *b*). Studies have shown that caribou calving habitat throughout the continent have similarities, as well as differences. Parturient females often selected for stands consisting of treed bog (Darby 1979, Fuller and Keith 1981, Stuart-Smith et al. 1997, Hirai 1998, Anderson 1999, Dyer 1999, James and Stuart-Smith 2000, Brown 2001, James et al. 2004, DeMars et al. 2011), mature conifer forest (Edmonds 1988, Lander 2006, Courbin et al. 2009, Hins et al. 2009, Lantin et al. 2011, Moreau et al. 2012, Pinard et al. 2012) or islands and shorelines (Shoesmith 1978, Darby 1979, Carr et al. 2007). Ground vegetation and shrubs present in calving habitat appear to be varied both among boreal woodland caribou populations and within boreal woodland caribou range. Nevertheless, an abundance of lichen seems to be a reoccurring vegetation condition selected for by parturient females (Barten et al. 2001, Carr et al. 2007, Lantin et al. 2011).

Darby (1979) indicated that the abundance of upland mature coniferous forest, tamarack bog and black spruce bog in southeastern Manitoba suggests food supply is not a limiting factor to the growth of boreal woodland caribou population. Based on forage availability, the area could support a larger population of boreal woodland caribou (Darby 1979). While this may be true, it is important to fully characterize calving habitat in southeastern Manitoba to verify whether there are specific vegetation conditions needed within habitat identified by Darby and others to support a greater population of boreal woodland caribou in southeastern Manitoba.

The objectives of this study were to characterize calving habitat for the Owl-Flintstone range in southeastern Manitoba. Specific objectives were to: 1) find the location of calving sites 2) identify ground vegetation, shrub and tree canopy species present in caribou calving sites, 3) identify downed woody debris present in calving areas, 4) and identify the age of calving habitat tree stands.

3.1. STUDY AREA

A description of the study area is provided in chapter 1.

3.2. METHODS

3.2.1. FIELD TECHNIQUES

A description of the field techniques is provided in chapter 2.

3.2.2. DATA ANALYSIS

The data recorded along transects and within plots was organized in a flat file format into Microsoft Excel (2010 version). The database was then imported in the statistical program R (Version R-3.0.1).

Analysis - The data was separated into four major sections: Ground vegetation, shrubs, tree canopy and downed woody debris. Ground vegetation species and abiotic components (rock, leaves/needles and water) observed along transects were further classified into eight groups: Bryophytes, lichens, shrubs, forbs, graminoids, rock, leaves/needles and water. Data was also separated based on the landform in which the transect occurred. Landforms were determined using both Manitoba Forest Resource Inventory (FRI) shape files in ArcGIS and imagery from Google Earth. The frequency, abundance, density and relative density were calculated for appropriate variables using methods described by Roberts-Pichette and Gillespie (1999).

Using the statistical program R (Version R-3.0.1), the data were analyzed for normal distribution using box plots. Environmental data is often not normally distributed; therefore a logarithmic transformation was completed for data. In order to account for data with zeroes, 1 was added to all values (McCune and Grace 2002). The logarithmic transform was completed using the following formula:

$b = \log(x+1)$ where x = original value and b = adjusted value

The data were then analyzed using box plots. Variables were omitted from further analysis when there was not enough data for that particular variable to produce a box plot.

Using program R, a Principal Component Analysis was conducted for variables in each vegetation layer (ground vegetation, shrubs, tree canopy and downed woody debris). The scores for the first two components were then displayed using a biplot.

2.3. RESULTS

2.3.1. GROUND VEGETATION

A total of 59 different ground vegetation species were recorded within known calving sites along with four abiotic components (rock, water, mud, leaves/needles). Of the 59 ground vegetation species, there were six moss species, five lichen species, twelve shrub species, thirty forb species, three fern or horsetail species and three graminoid species (See Appendix A). A total of 61 transects were established within 26 known calving sites.

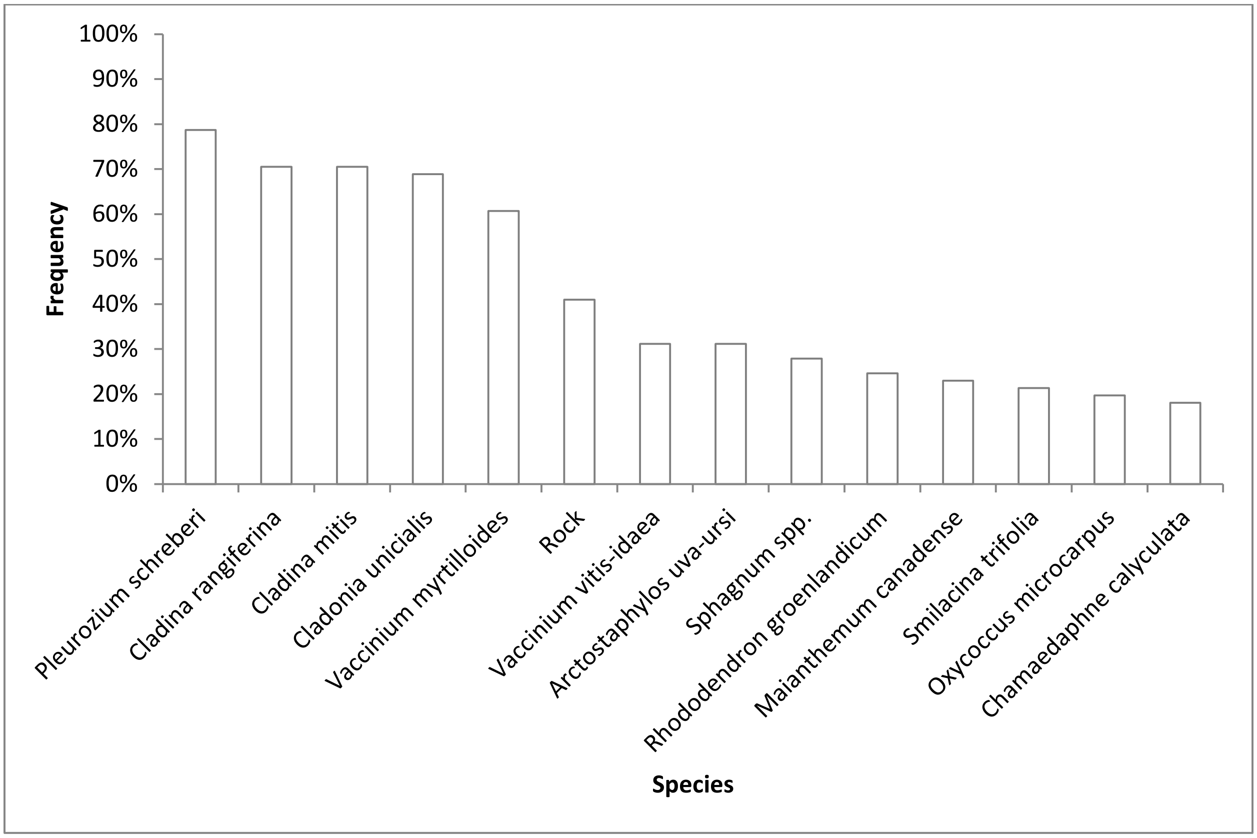

Fig. 3-1. Frequency of ground vegetation species and abiotic components at known calving sites in southeastern Manitoba, 2009-2010. Species with a frequency greater than 10% are shown.

There were thirteen different species or an abiotic component with a frequency greater than 10%. The species with the greatest frequency throughout sites were feather moss (*Pleurozium schreberi*), followed closely by reindeer lichens (*Cladina rangiferina*, *Cladina mitis* and *Cladonia unicialis*) and blueberry (*Vaccinium myrtilloides*), all of which were present at more than 60% of calving sites (Fig. 3-1).

Figure 3-2 displays the distribution of data for species with enough data to produce a box plot. There was the least amount of variance among feather moss values, while sphagnum moss (*Sphagnum* spp.), rock, bog cranberry (*Vaccinium vitis-idaea*) and bear berry (*Arctostaphylos uva-ursi*) data were skewed towards zero.

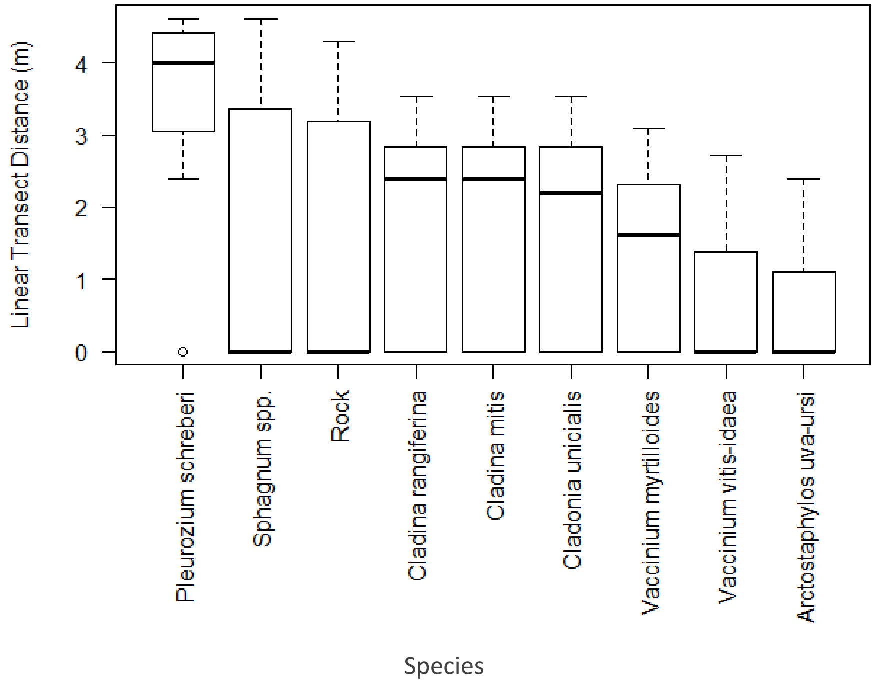

Fig. 3-2. Box plot of the logarithmic transformation of the linear distance of ground vegetation species and abiotic components along transects at calving sites in southeastern Manitoba, 2009-2010. Only species with sufficient data to produce a box plot were included.

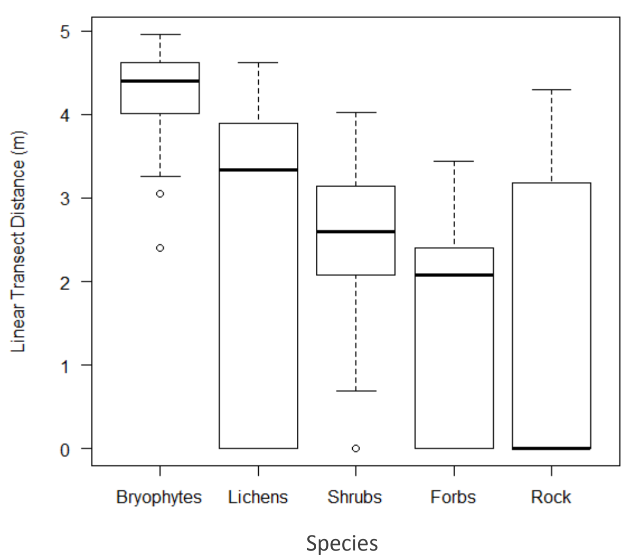

Fig. 3-3. Box plot of the logarithmic transformation of the linear distance of ground vegetation groupings along transects at calving sites in southeastern Manitoba, 2009-2010. Only groupings with sufficient data to produce a box plot were included.

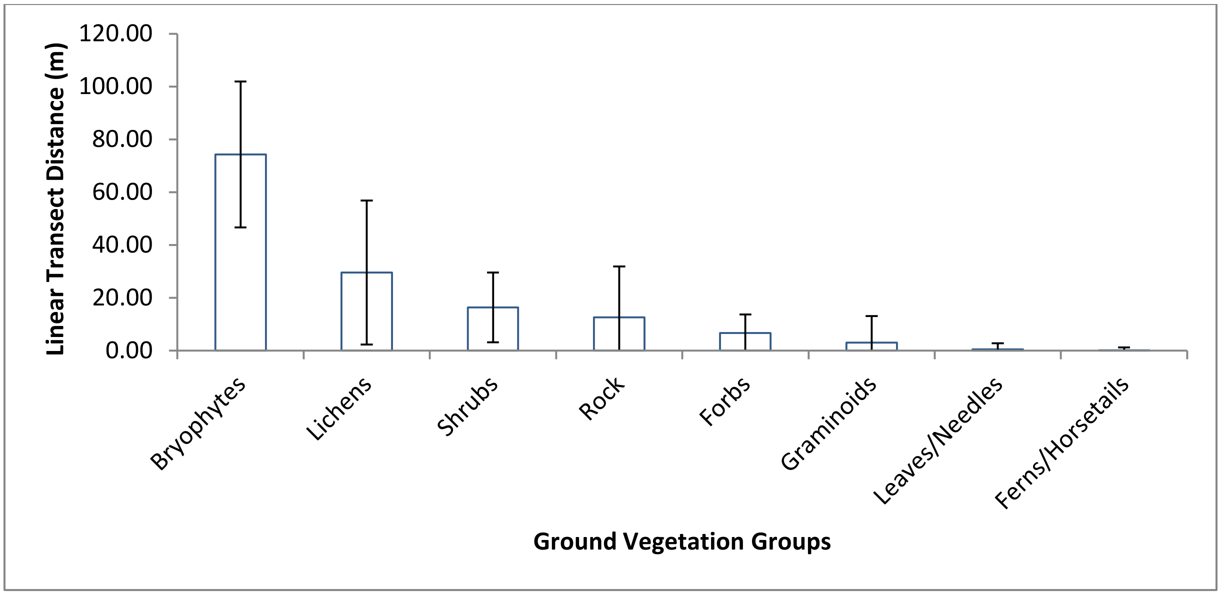

Fig. 3-4. Mean linear distance and standard deviation of ground vegetation groupings along transects at calving sites in southeastern Manitoba, 2009-2010. Only species with sufficient data to produce a box plot were included.

As there were many ground vegetation species identified at calving sites, species and abiotic components were classified into the following eight different groups: Bryophytes, lichens, shrubs (with a height less than 1 metre), rock, forbs, graminoids, leaves/needles and ferns/horsetails. Figure 3-3 shows the distribution of different ground vegetation groupings; while figure 3-4 shows the mean linear transect distance of each ground vegetation grouping. Despite the considerable variation among species and among species composition (Fig. 3-3), transects were composed mostly of byrophytes, lichens, shrubs and rock (Fig. 3-4).

Figure 3-5 illustrates the PCA scores of the logarithmic transformation of the linear distance of ground vegetation groupings along transects for the first two components. The first component accounts for 46.3% of the variance and the second component accounts for 30.0% of the variance for a total of 76.3%. Bryophytes (log(G_Total_B+1)), lichens (log(G_Total_Li+1)), shrubs (log(G_Total_S+1)), rock (log(G_Total_R+1)) and forbs (log(G_Total_F+1)) appeared to account for a relatively similar portion of the variance. Lichens and rock were positively correlated, but negatively correlated with bryophytes. Shrubs and forbs were positively correlated, but there was no correlation with other variables.

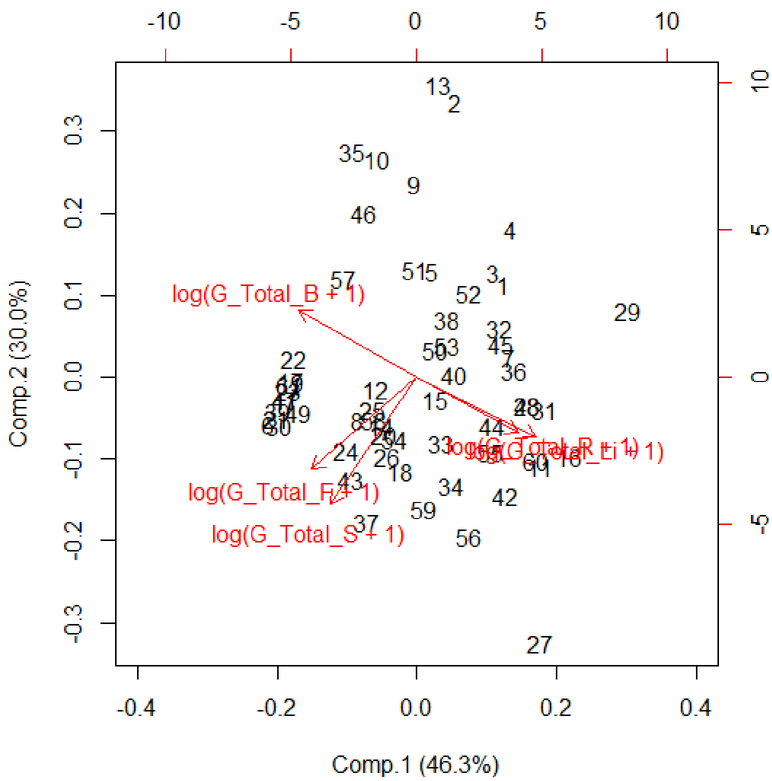

Fig. 3-5. Biplot for the first 2 axes of the Principle Components Analysis (PCA) of the logarithmic transformation of the linear distance of ground vegetation groupings along transects at calving sites in southeastern Manitoba, 2009-2010. Only groupings with sufficient data to produce a box plot were included.

Table 3-1 illustrates frequencies and mean linear distances of each grouping at different landforms. Although bryophytes, shrubs, lichens and forbs displayed high frequencies across all landforms, the mean linear distance of lichens and especially bryophytes were significantly higher than other groupings.

Table 3-1. Frequency and mean linear distance of ground vegetation species and abiotic components grouped by landform at calving sites in southeastern Manitoba, 2009-2010

	Landform													
	Island in Bog (n=4)		**Island on Lake (n=11)**		**Peninsula on Lake (n=5)**		**Peninsul a in Bog (n=26)**		**Bog (n=14)**		**Forest (n=1)**			
Frequency													**Total Mean**	
Bryophytes	100%		100%		100%		100%		100%		100%		**100%**	
Shrubs	100%		82%		100%		92%		93%		100%		**92%**	
Lichens	100%		82%		80%		88%		14%		100%		**70%**	
Forbs	75%		27%		80%		54%		93%		100%		**62%**	
Rock	25%		9%		80%		65%		14%		0%		**41%**	
Graminoids	0%		27%		0%		8%		43%		0%		**18%**	
Leaves/Needles	0%		27%		0%		0%		0%		0%		**5%**	
Ferns/Horsetails	25%		0%		0%		4%		0%		0%		**3%**	
Mean Linear Distance (m)		**SD**		**SD**		**SD**		**SD**		**SD**		**SD**	**Total Mean**	**SD**
Bryophytes	45	35.91	72	22.04	80	39.91	66	26.19	98	7.39	72	NA	**74**	27.68
Lichens	60	32.02	33	25.35	32	39.55	37	21.17	1	3.47	63	NA	**30**	27.26
Shrubs	12	8.34	6	7.35	17	9.64	11	6.02	35	12.22	16	NA	**16**	13.24
Rock	7	13.50	3	11.46	8	7.50	25	22.67	1	3.63	0	NA	**13**	19.23
Forbs	7	7.19	2	3.63	14	11.17	5	6.65	11	4.21	9	NA	**7**	6.99
Graminoids	0	0.00	10	21.97	0	0.00	0	1.43	5	5.59	0	NA	**3**	10.11
Leaves/Needles	0	0.00	3	5.07	0	0.00	0	0.00	0	0.00	0	NA	**0**	2.31
Ferns/Horsetails	1	1.50	0	0.00	0	0.00	0	1.45	0	0.00	0	NA	**0**	1.02
Total	**130**		**129**		**151**		**145**		**150**		**160**			

3.3.2. SHRUBS

Among shrub species, black spruce (*Picea mariana*) had the greatest frequency (88%) and percentage cover (12%) at calving sites (Fig. 3-6 and Fig. 3-7). The values for black spruce frequency and percentage cover were nearly double the values of common juniper (*Juniperus communis*), the species with the second highest frequency and percentage cover. Four species other than black spruce and juniper were recorded with a frequency greater than five percent: white birch (*Betula papyrifera*), pin cherry (*Prunus pensylvanica*), river alder (*Alnus rugosa*) and willow (*Salix* spp.) (Fig. 3-6 and Fig. 3-7). Black spruce data were evenly distributed, while juniper data were skewed towards zero (Fig. 3-8).

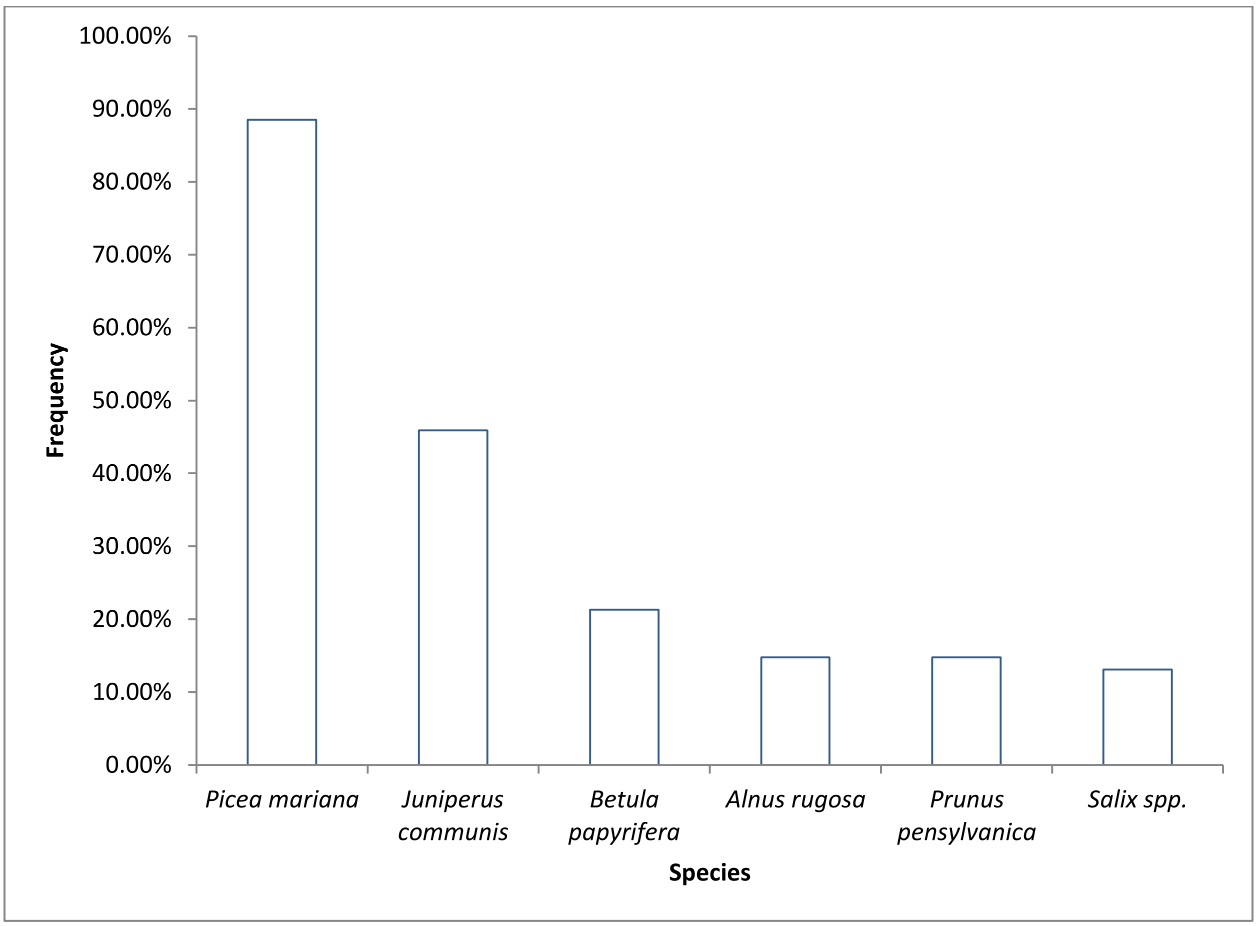

Fig. 3-6. Frequency of shrub species at calving sites in southeastern Manitoba, 2009-2010. Species with a frequency greater than 5% are shown.

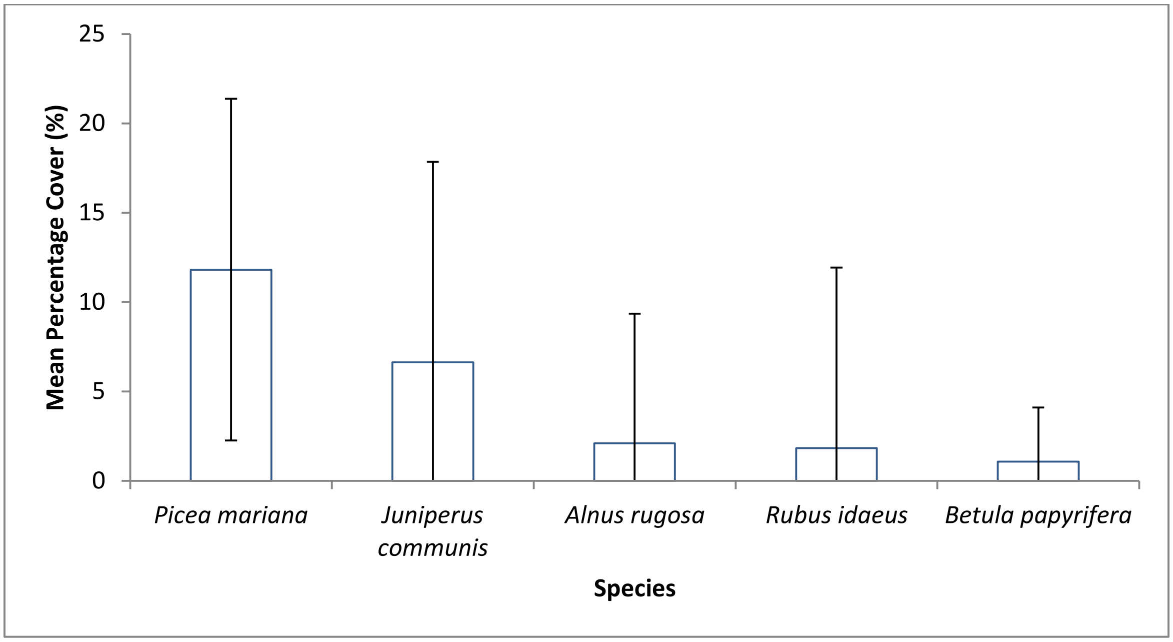

Fig. 3-7. Mean cover and standard deviation of shrub species at calving sites in southeastern Manitoba, 2009-2010. Species with a mean cover greater than 1% are shown.

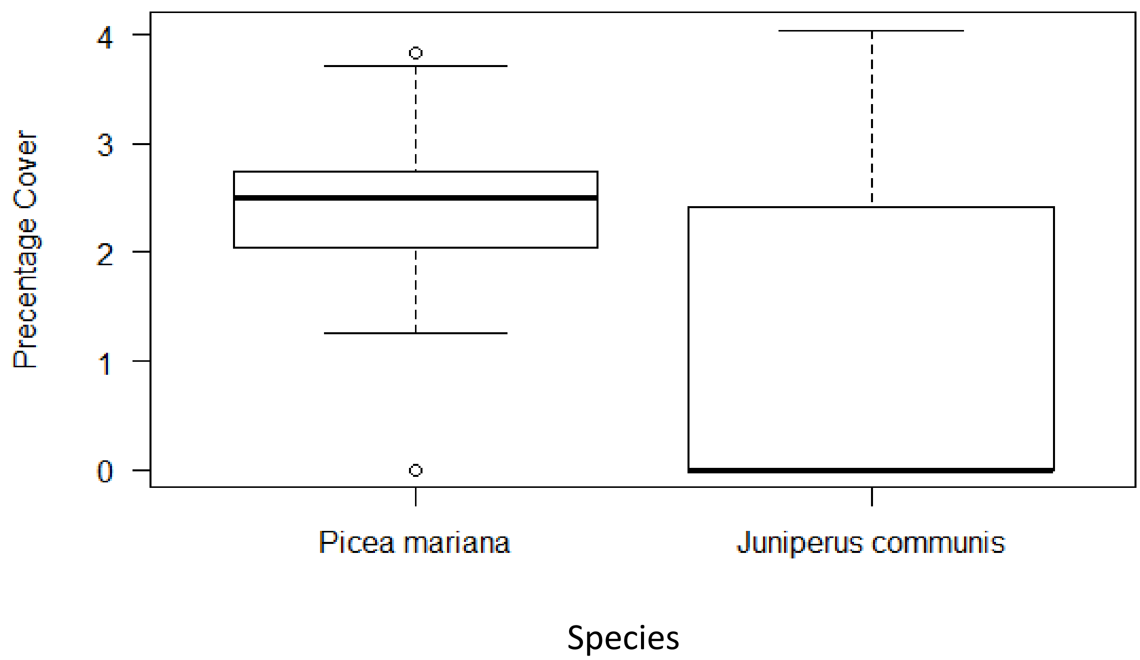

Fig. 3-8. Logarithmic transformation of the percentage cover of shrubs at calving sites in southeastern Manitoba, 2009-2010. Only species with sufficient data to produce a box plot were included.

Figure 3-9 illustrates the PCA scores of the logarithmic transformation of shrub species cover for the first two components. The first component accounts for 22.0% of the variance and the second component accounts for 20.3% of the variance for a total of 42.3%. Black spruce (log(S_Picem+1)), white birch (log(S_Betpa+1)), river alder (log(S_Alnur+1)) and willow (log(S_Salis+1)) accounted for the most variance, while pin cherry (log(S_Prunp+1)) and common juniper (log(S_Junic+1)) accounted for a smaller portion of the variance. Black spruce was negatively correlated with willow. Pin cherry and river alder were positively correlated, but negatively correlated with both white birch and common juniper.

There was little variation among species frequency and percentage cover in different landforms. Table 3-2 illustrates that shrub composition throughout different landforms was dominated by black spruce with a mix of other species with lesser frequency and percentage cover values. The forest landform was different than other landforms given that it did not have any other species present other than black spruce.

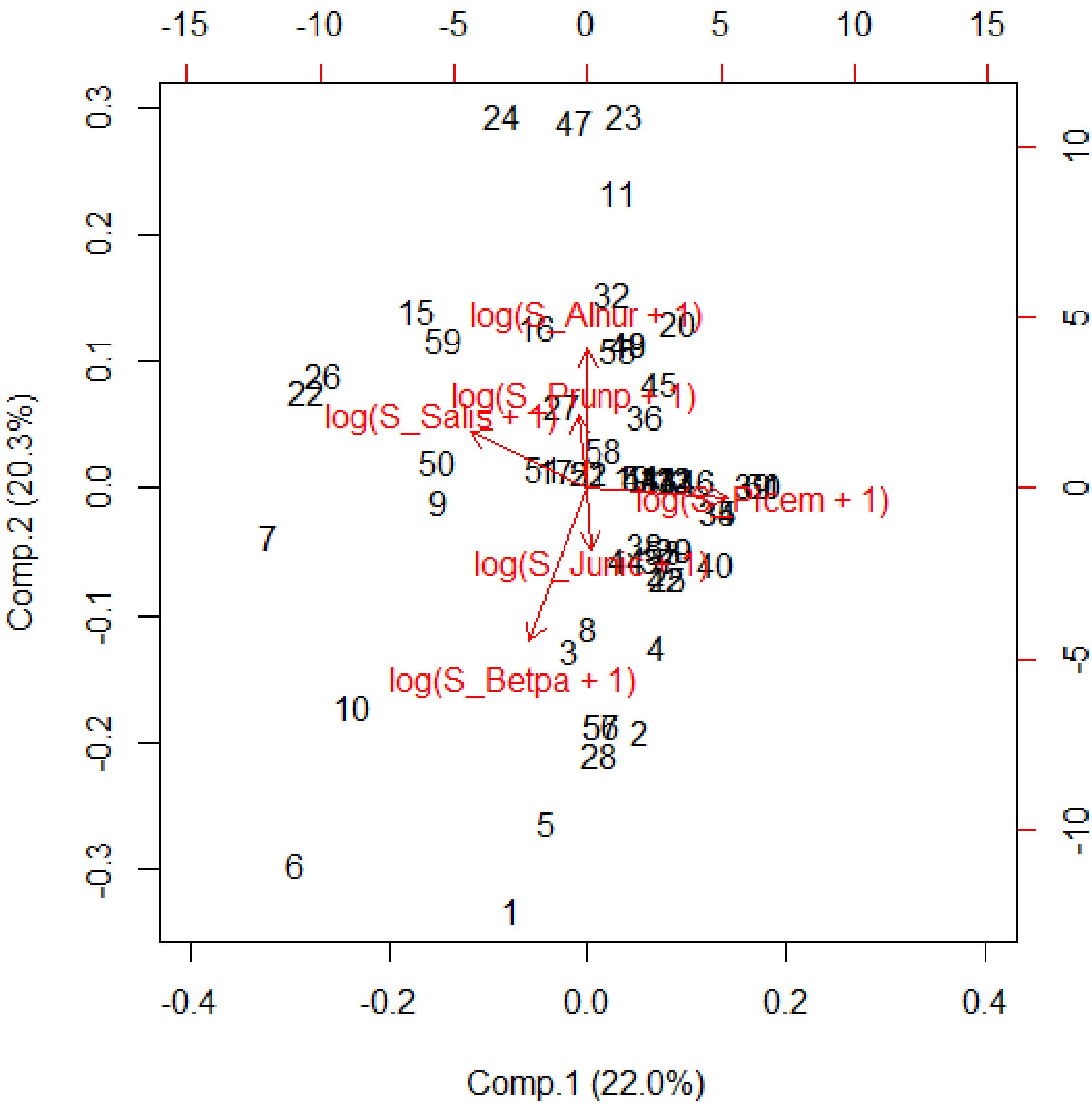

Fig. 3-9. Biplot for the first 2 axes of the Principle Components Analysis (PCA) of the logarithmic transformation of shrub species cover at calving sites in southeastern Manitoba, 2009-2010. Only species with a frequency greater than 5% were included.

Table 3-2. Frequency and percentage cover of shrub species grouped by landform at calving sites in southeastern Manitoba, 2009-2010. Species with a frequency greater than 5% and an absolute cover greater than 1% are shown.

	Landform													
	Island in Bog (n=4)		**Island on Lake (n=11)**		**Peninsula on Lake (n=5)**		**Peninsula in Bog (n=26)**		**Bog (n=14)**		**Forest (n=1)**			
Frequency													**Total Mean**	
Picea mariana	100%		64%		80%		92%		100%		100%		**89%**	
Juniperus communis	0%		45%		60%		58%		36%		0%		**46%**	
Betula papyrifera	25%		73%		20%		8%		7%		0%		**21%**	
Prunus pensylvanica	75%		0%		20%		19%		0%		0%		**15%**	
Alnus rugosa	75%		0%		0%		12%		21%		0%		**15%**	
Salix spp.	50%		18%		20%		12%		0%		0%		**13%**	
Pinus banksiana	25%		18%		0%		8%		0%		0%		**8%**	
Amelanchier alnifolia	25%		9%		20%		8%		0%		0%		**8%**	
Absolute Cover		**SD**		**SD**		**SD**		**SD**		**SD**		**SD**	**Total Mean**	**SD**
Picea mariana	7.38	3.46	7.95	8.07	6.65	5.37	13.47	8.72	15.00	12.96	10.00	NA	**11.81**	9.56
Juniperus communis	0.00	0.00	6.43	12.90	11.95	12.91	8.98	12.94	2.86	4.95	0.00	NA	**6.62**	11.21
Alnus rugosa	6.81	7.54	0.00	0.00	0.00	0.00	0.72	2.15	5.86	13.73	0.00	NA	**2.10**	7.24
Betula papyrifera	0.50	1.00	3.23	3.88	3.60	8.05	0.25	0.89	0.21	0.80	0.00	NA	**1.07**	3.04
Rubus idaeus	0.00	0.00	10.09	22.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA	**1.82**	10.12
Mean	**2.94**		**5.54**		**4.44**		**4.68**		**4.79**		**2.00**			

3.3.3. TREE CANOPY

Five tree canopy species were observed at calving sites: black spruce, jack pine (*Pinus banksiana*), tamarack larch (*Larix laricina*), balsam fir (*Abies balsamea*) and white birch. Both black spruce and jack pine were found at most sites, while other species occurred considerably less (Fig. 3-10).

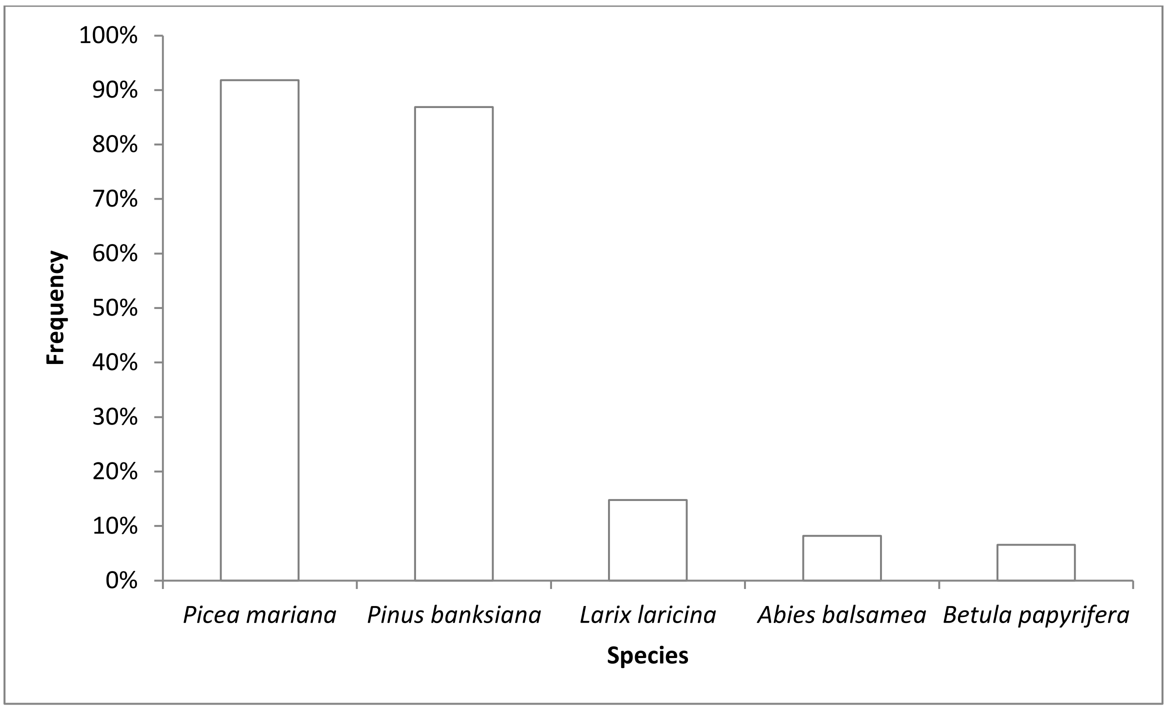

Fig. 3-10. Frequency of tree canopy species at calving sites in southeastern Manitoba, 2009-2010.

Figure 3-10, 3-11 and 3-12 shows a significant amount of variation between calving sites and species composition when looking at both abundance and density of tree canopy species. Black spruce and jack pine abundance and density were considerably greater than other species. However, black spruce abundance and density values were approximately double the respective values for jack pine (Fig. 3-11 and Fig. 3-12).

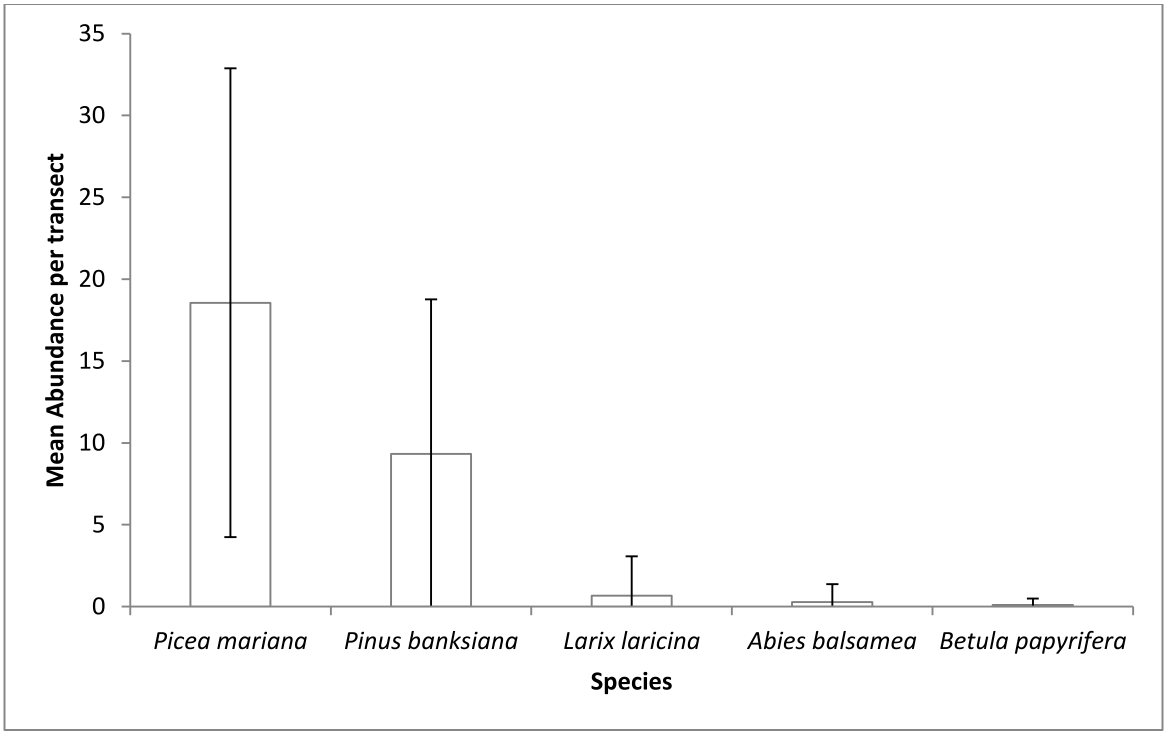

Fig. 3-11. Mean abundance and standard deviation of tree canopy species at calving sites in southeastern Manitoba, 2009-2010.

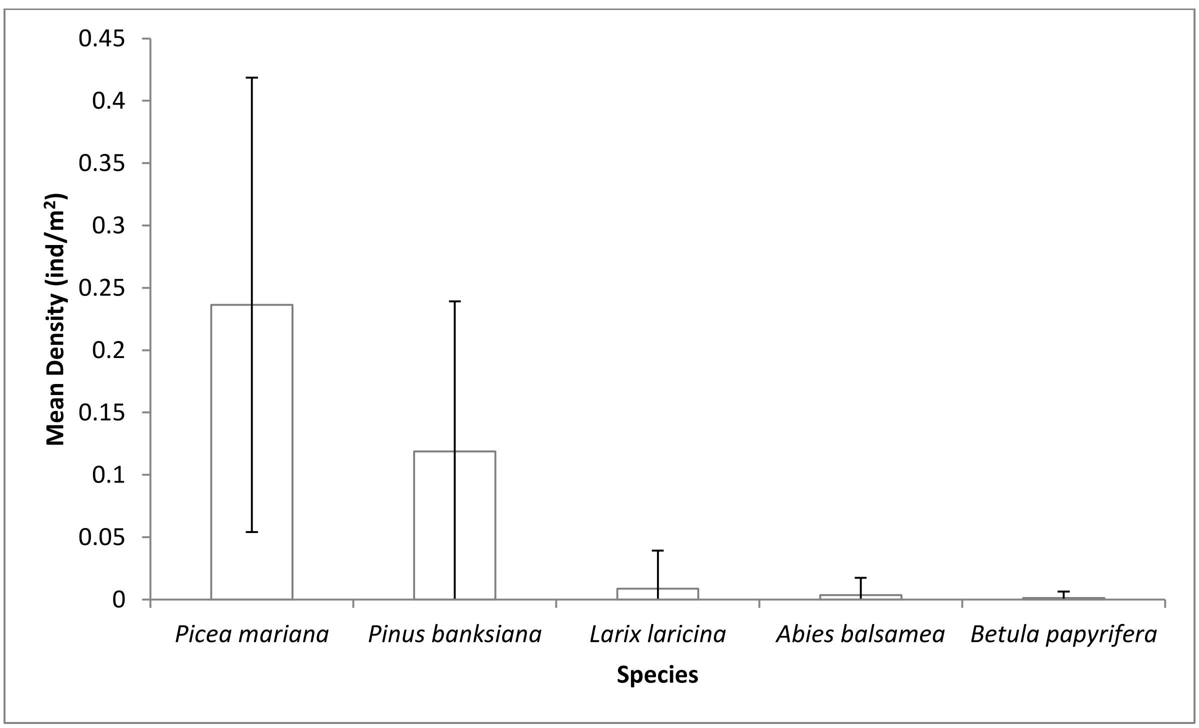

Fig. 3-12. Mean density and standard deviation of tree canopy species at calving sites in southeastern Manitoba, 2009-2010.

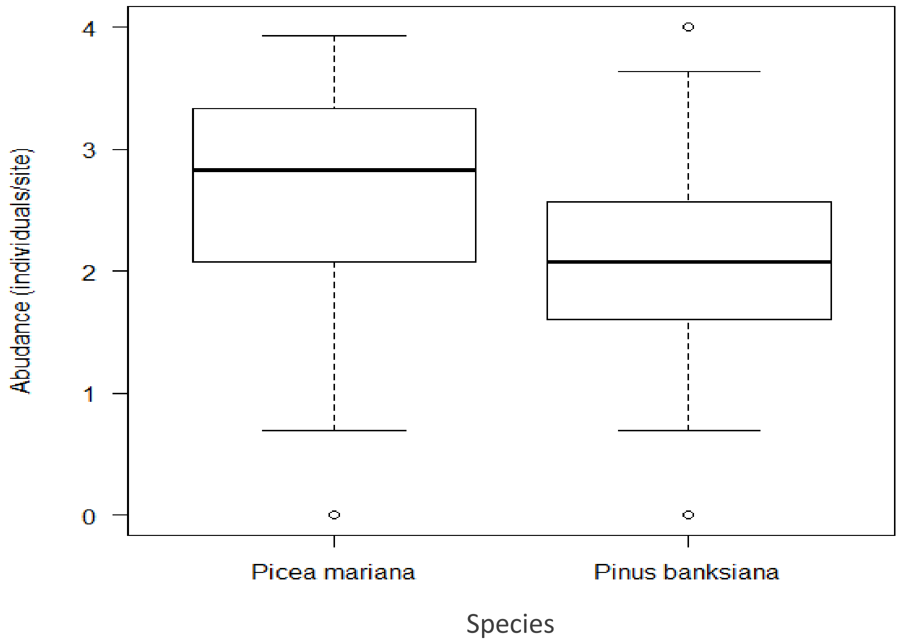

Fig. 3-13. Logarithmic transformation of the abundance of tree canopy species at calving sites in southeastern Manitoba, 2009-2010. Only species with sufficient data to produce a box plot were included.

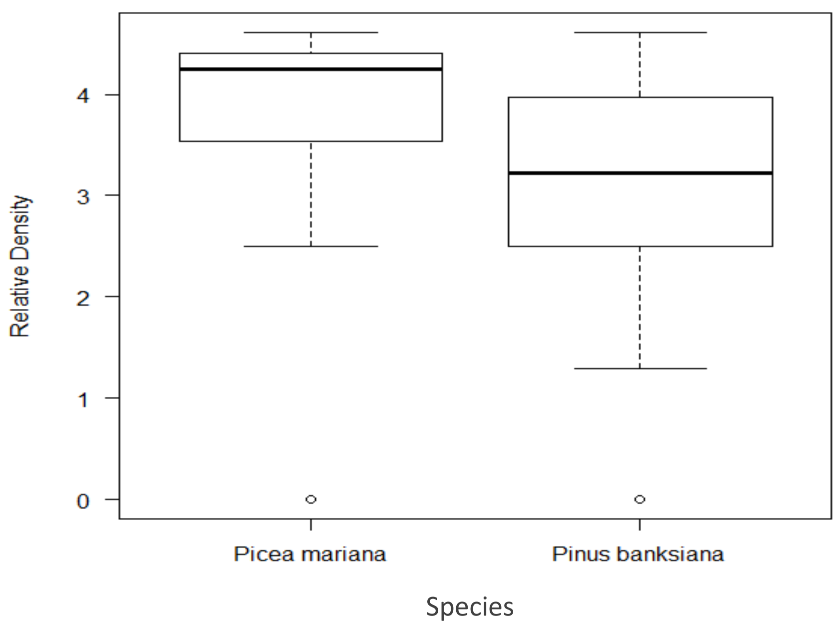

Fig. 3-14. Logarithmic transformation of the relative density of tree canopy species at calving sites in southeastern Manitoba, 2009-2010. Only species with sufficient data to produce a box plot were included.

Figure 3-13 and 3-14 show the abundance and relative density of black spruce and jack pine were normally distributed once the logarithmic transformation performed. There was more variation among values in the lower quartile of the relative density of black spruce than its upper quartile.

Figure 3-15 shows the percentage of tree canopy closure at calving sites. The highest value was 80% tree canopy closure and the lowest value being 7.5% tree canopy closure. All sites had some degree of tree canopy closure; however no sites had a complete tree canopy closure. Most values ranged between 30% and 50% tree canopy closure with a mean tree canopy closure of 36.22%.

Tree stand age at calving sites ranged from 27 to 155 years of age. Only a few sites were younger than 60 years of age (Fig. 3-16). The mean stand age of calving sites was 83 years. The three landforms associated with bog (island in bog, peninsula in bog and bog) had the highest mean age (Table 3-3).

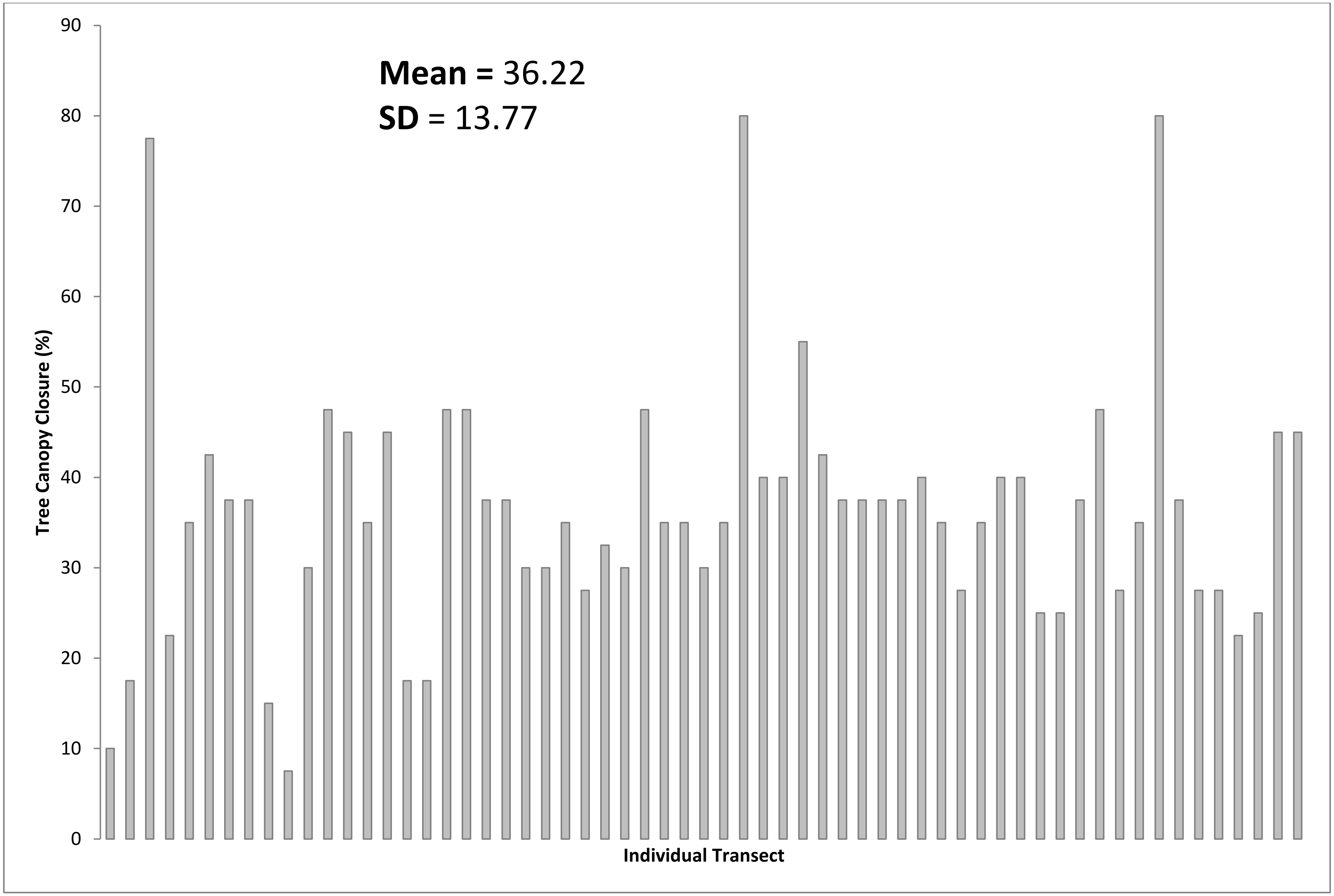

Fig. 3-15. Tree canopy closure of tree canopy species at each calving sites in southeastern Manitoba, 2009-2010 (n=61).

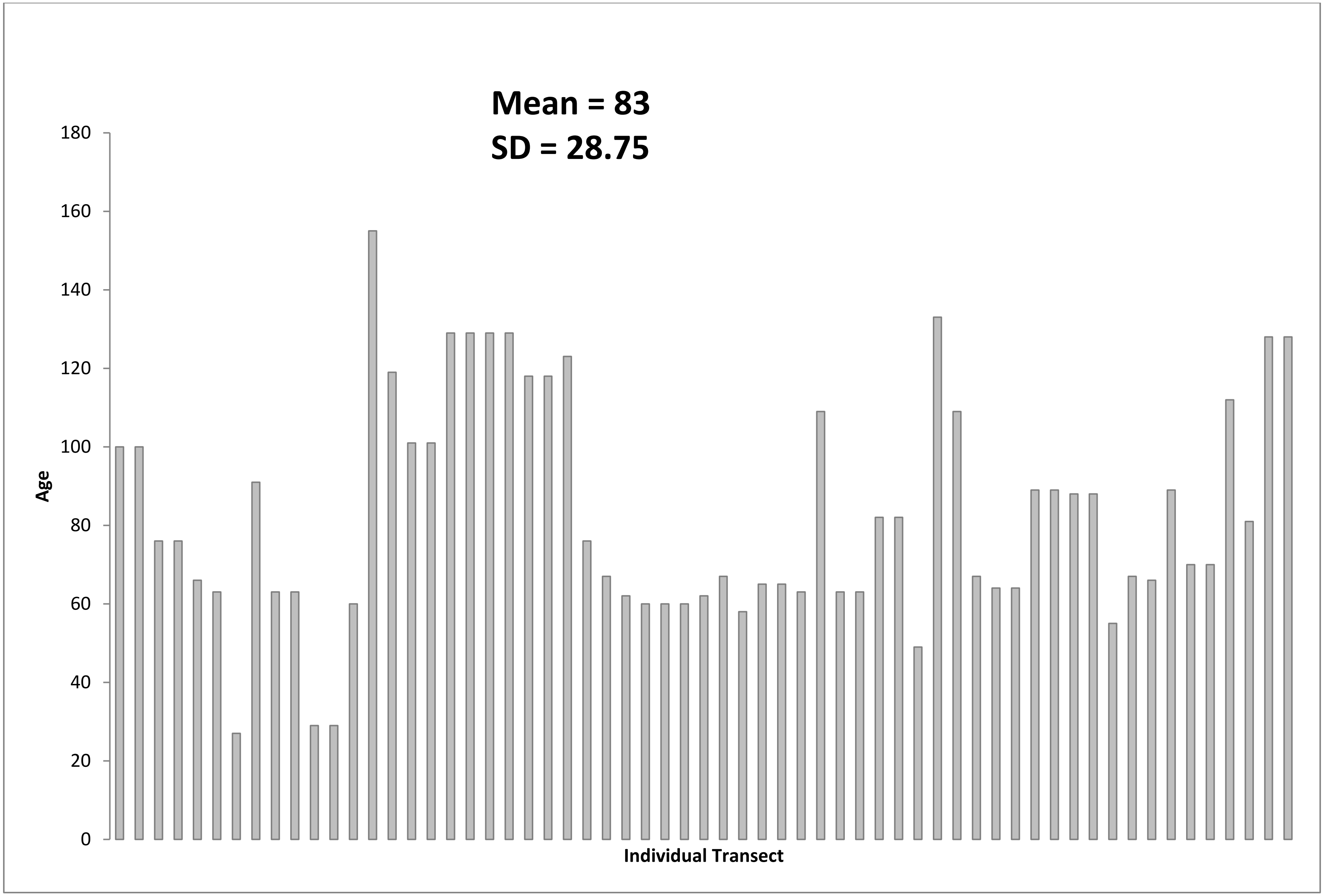

Fig. 3-16. Age of tree canopy species at each calving sites in southeastern Manitoba, 2009-2010 (n=61).

Figure 3-17 illustrates the PCA scores of the logarithmic transformation of the relative density of tree canopy species for the first two components. The first component accounts for 38.3% of the variance and the second component accounts for 25.8% of the variance for a total of 64.1%. The species accounting for the most variance to the least variance were as follows: black spruce (log(C_Picema_RD+1)), jack pine (log(C_Pinuba_RD+1)), tamarack larch (log(C_Larila_RD+1)), white birch (log(C_Betupa_RD+1)) and balsam fir (log(C_Abieba_RD+1)). Black spruce was negatively correlated with jack pine and white birch and positively correlated with tamarack larch. However, the correlation was not strong, seeing the angles separating variables were almost evenly spaced out. There was a strong negative correlation between tamarack larch and white birch.

In table 3-3, frequencies for different species did not vary much between landforms, with the exception of islands on lakes. Black spruce and jack pine frequencies were lower and balsam fir and white birch frequencies were higher for the islands on lakes landform compared to other landforms. Density values for black spruce and jack pine were consistently higher than other species across all landforms. Black spruce and jack pine densities were similar for both islands in bogs and islands on lakes landforms. Black spruce densities were higher than jack pine densities for peninsulas in bogs, bog and forest landforms. However, jack pine densities were higher than black spruce densities for the peninsulas on lakes landform (Table 3-3).

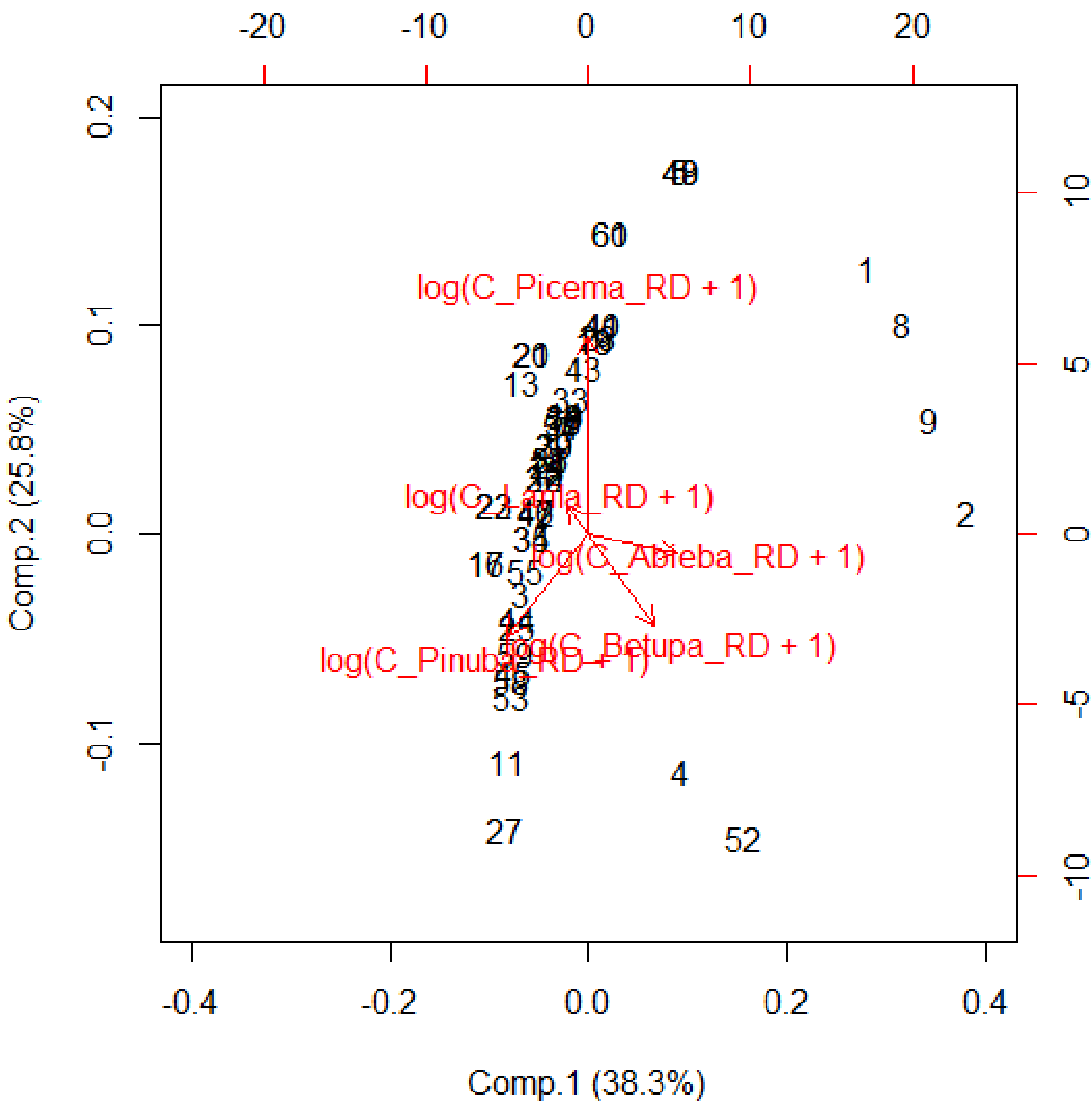

Fig. 3-17. Biplot for the first 2 axes of the Principle Components Analysis (PCA) of the logarithmic transformation of the relative density of tree canopy species at calving sites in southeastern Manitoba, 2009-2010.

Table 3-3. Frequency, density and age of tree canopy species grouped by landform at calving sites in southeastern Manitoba, 2009-2010.

	Landform													
	Island in Bog (n=4)		**Island on Lake (n=11)**		**Peninsula on Lake (n=5)**		**Peninsula in Bog (n=26)**		**Bog (n=14)**		**Forest (n=1)**			
Frequency													**Total Mean**	
Picea mariana	100%		64%		80%		100%		100%		100%		92%	
Pinus banksiana	100%		45%		100%		96%		93%		100%		87%	
Larix laricina	25%		0%		0%		15%		29%		0%		15%	
Abies balsamea	0%		45%		0%		0%		0%		0%		8%	
Betula papyrifera	0%		27%		20%		0%		0%		0%		7%	
Density		**SD**		**SD**		**SD**		**SD**		**SD**		**SD**	**Total Mean**	**SD**
Picea mariana	0.18	0.11	0.11	0.13	0.04	0.04	0.28	0.17	0.32	0.17	0.60	NA	**0.24**	0.24
Pinus banksiana	0.18	0.13	0.16	0.23	0.12	0.12	0.11	0.07	0.08	0.05	0.15	NA	**0.12**	0.12
Larix laricina	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.03	0.02	0.04	0.00	NA	**0.01**	0.01
Abies balsamea	0.00	0.00	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA	**0.00**	0.00
Betula papyrifera	0.00	0.00	0.01	0.01	0.003	0.006	0.00	0.00	0.00	0.00	0.00	NA	**0.00**	0.00
Mean	**0.07**		**0.06**		**0.03**		**0.08**		**0.08**		**0.15**			
Age													**Total Mean**	**SD**
Dominant species	93.00		76.18		64.60		81.73		95.71		66.00		83.02	28.75

3.3.4. DOWNED WOODY DEBRIS

The two most abundant species of downed woody debris were jack pine and black spruce, with mean values of 5.11 individuals and 2.08 individuals per transect respectively. Trembling aspen (*Populus tremuloides*), balsam fir, white birch and white spruce (*Picea glauca*) had mean values less than one (Fig. 3-18). There was little variation of abundance between landforms. The landform with the greatest abundance of downed woody debris was islands in bogs (Table 3-4).

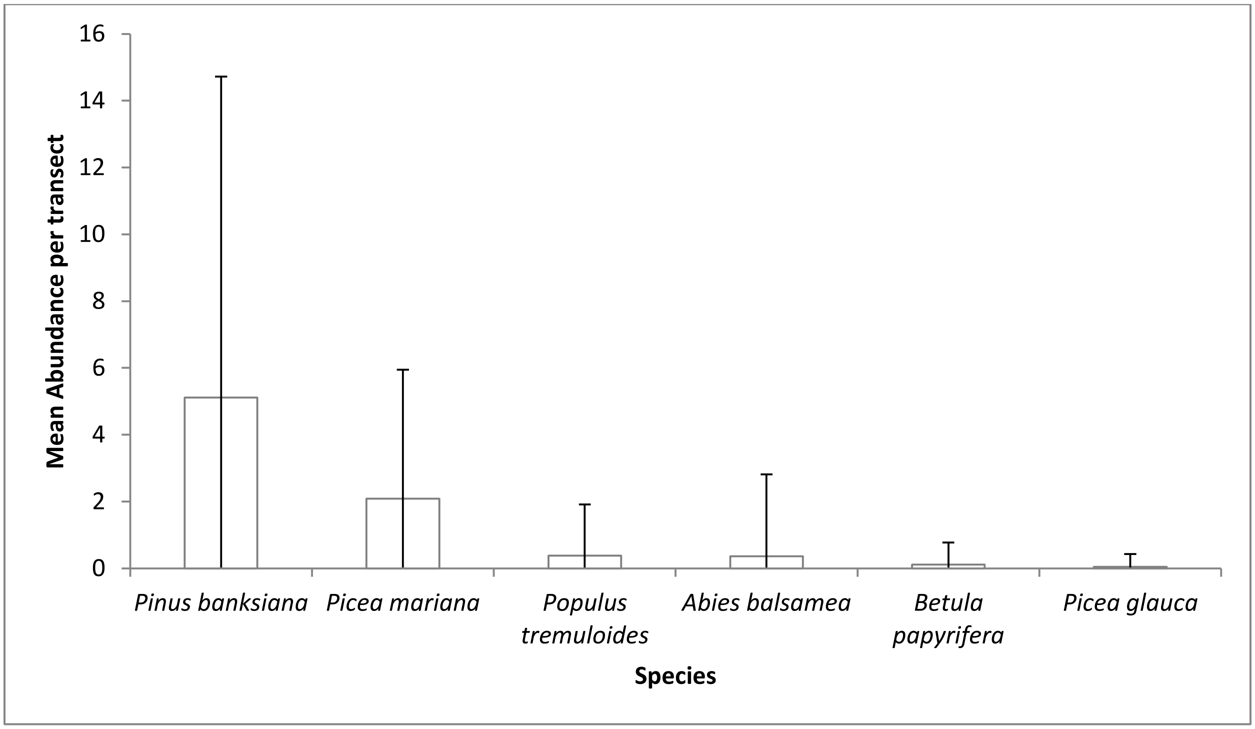

Fig. 3-18. Mean abundance and standard deviation of downed woody debris species at calving sites in southeastern Manitoba, 2009-2010.

Figure 3-19 shows the distribution of abundance values for black spruce, jack pine and the total of all species. There appears to be considerable variation of abundance for black spruce, jack pine and the total of all species.

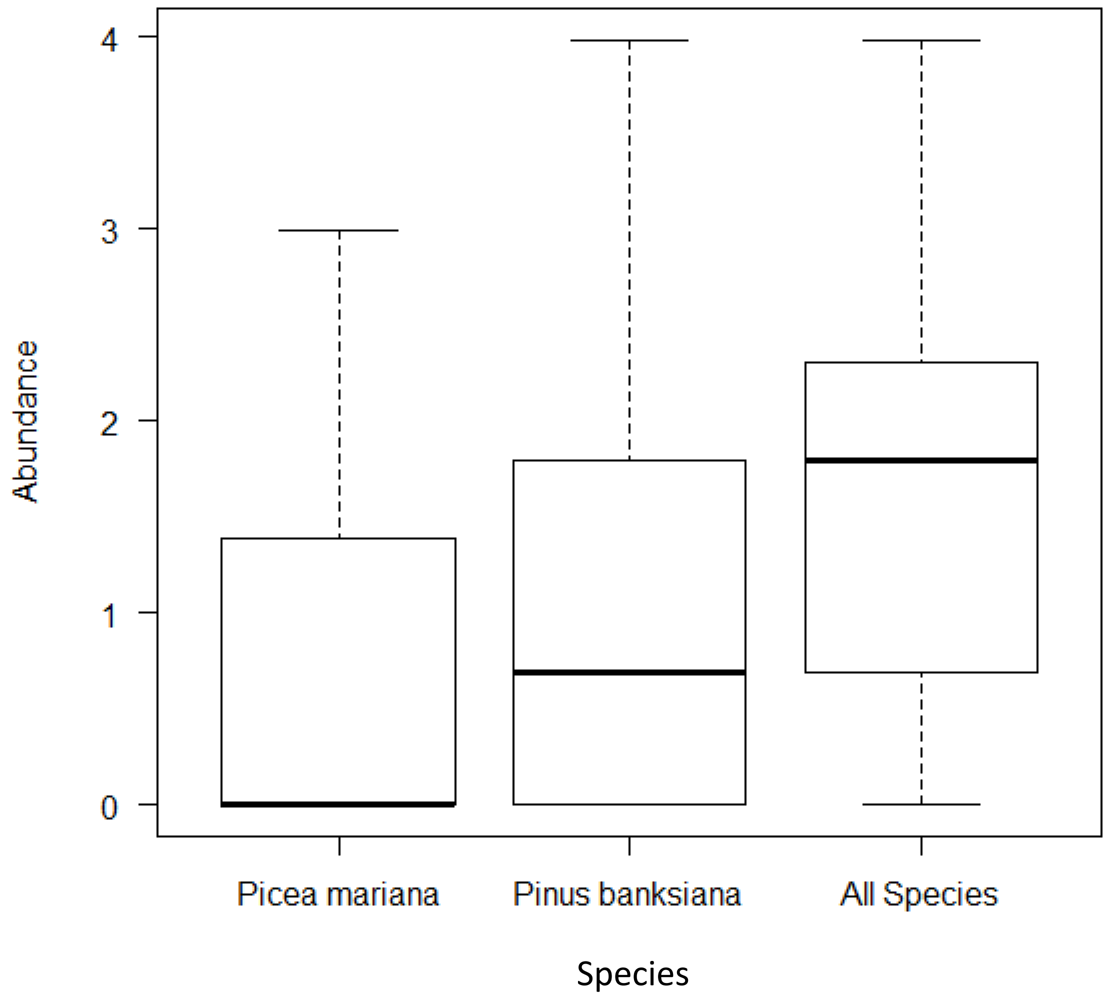

Fig. 3-19. Logarithmic transformation of the abundance of downed woody debris species at calving sites in southeastern Manitoba, 2009-2010. Only species with sufficient data to produce a box plot were included.

Figure 3-20 illustrates the PCA scores of the logarithmic transformation of the abundance of downed woody debris species for the first two components. The first component accounts for 37.2% of the variance and the second component accounts for 22.9% of the variance for a total of 60.1%. Black spruce (log(D_Picemar_A+1)) and jack pine (log(D_Pinuban_A+1)) accounted for a smaller proportion of the variance when compared to white birch (log(D_Betupap_A+1)), balsam fir (log(D_Abiebal_A+1)), white spruce (log(D_Picegla_A+1)), trembling aspen (log(D_Poputre_A+1)). Black spruce was negatively correlated with jack pine. There was a strong correlation between balsam fir and white birch, as well as between white spruce and trembling aspen.

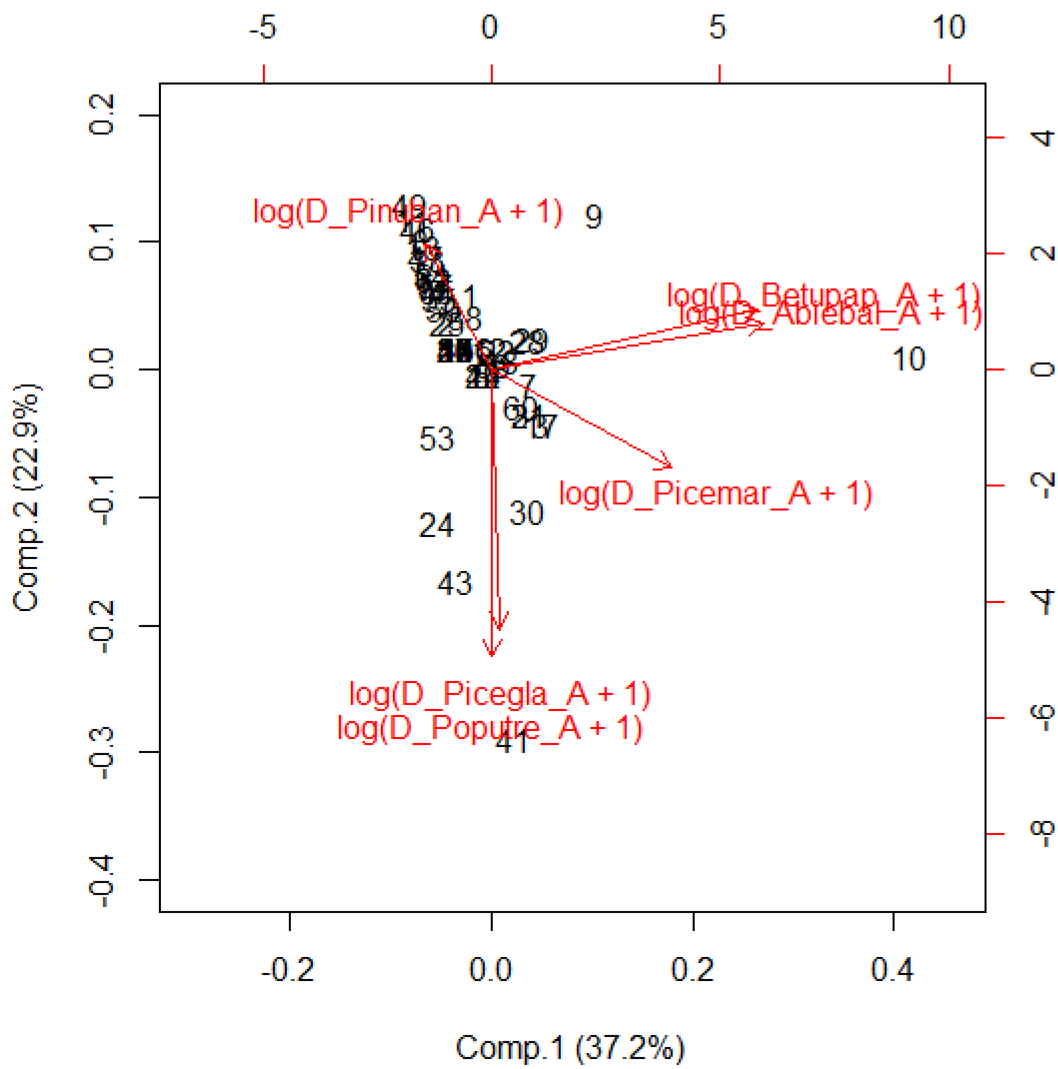

Fig. 3-20. Biplot for the first 2 axes of the Principle Components Analysis (PCA) of the logarithmic transformation of the abundance of downed woody debris species at calving sites in southeastern Manitoba, 2009-2010.

Table 3-4. Frequency and abundance of downed woody debris species grouped by landform at calving sites in southeastern Manitoba, 2009-2010.

	Landform													
	Island in Bog (n=4)		**Island on Lake (n=11)**		**Peninsul a on Lake (n=5)**		**Peninsula in Bog (n=26)**		**Bog (n=14)**		**Forest (n=1)**			
Frequency													**Total Mean**	
Pinus banksiana	50%		73%		20%		62%		36%		100%		54%	
Picea mariana	0%		55%		20%		58%		29%		0%		43%	
Populus tremuloides	25%		0%		0%		12%		21%		0%		11%	
Betula papyrifera	0%		18%		20%		0%		0%		0%		5%	
Abies balsamea	0%		9%		20%		0%		0%		0%		3%	
Picea glauca	0%		0%		0%		4%		0%		0%		2%	
Abundance		**SD**		**SD**		**SD**		**SD**		**SD**		**SD**	**Total Mean**	**SD**
Pinus banksiana	10.00	17.44	5.82	7.48	0.20	0.45	4.58	7.10	5.77	14.06	7.00	NA	**5.11**	9.61
Picea mariana	0.00	0.00	3.36	5.84	2.60	5.81	2.08	3.27	1.77	2.90	0.00	NA	**2.08**	3.87
Populus tremuloides	0.50	1.00	0.00	0.00	0.00	0.00	0.54	2.18	0.54	1.16	0.00	NA	**0.38**	1.54
Abies balsamea	0.00	0.00	0.27	0.90	3.80	8.50	0.00	0.00	0.00	0.00	0.00	NA	**0.36**	2.46
Betula papyrifera	0.00	0.00	0.18	0.40	1.00	2.24	0.00	0.00	0.00	0.00	0.00	NA	**0.11**	0.66
Picea glauca	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.59	0.00	0.00	0.00	NA	**0.05**	0.38
Mean	**1.75**		**1.61**		**1.27**		**1.22**		**1.35**		**1.17**			

3.3.5. OTHER CHARACTERISTICS

At each calving site, notes were taken describing topography and other features not recorded with established transects and plots.

Calving sites occurred almost exclusively at the edge of forest stands. The stand in which the calving site occurred was always adjacent to a relatively large body of water or a bog (Fig.3-21 and Fig. 3-22). All sites were characterized by gentle topography with gradual sloping shorelines or stand edge. A network of trails was interspersed throughout the calving site following the edge of the stand and into either the bog or water. Calving sites were predominantly situated in small areas with a localized open tree canopy, but within a larger conifer stand with an overall greater tree canopy closure.

Fig. 3-21. Calving site on a peninsula of an unnamed lake between Black and Flintstone Lake

Fig. 3-22. Calving sites surrounded by bog in the Seagrim Lake area

3.4. DISCUSSION

Ground Vegetation – There were many different species identified in the ground vegetation layer, most of which occurred infrequently and with a small linear distance value. This was especially true for herbaceous species. Among the species with the greatest frequency and cover, there were reindeer lichens (*Cladina rangiferina*, *Cladina mitis* and *Cladonia unicialis*), bryophytes (*Sphagnum* spp. and *Pleurozium schreberi*) and shrubs (*Vaccinium myrtilloides*, *Vaccinium vitis-idaea* and *Arctostaphylos uva-ursi*). Bryophytes had the greatest percentage of cover, followed by both the lichen and shrub grouping.

This study found a considerable amount of reindeer lichens and certain shrubs, especially ericacean species. Lantin et al. (2011) indicated that both terrestrial lichens and ericacean species were important sources of forage for parturient females with increased nutritional demands. Ericacean species were abundant throughout most calving sites (Hirai 1998). Carr (2007) found that calving sites had a greater abundance of lichens than sites with no evidence of calving. Calving sites had considerable amounts of terrestrial lichens, arboreal lichens, deciduous shrubs and forbs (Bergerud 1972, Darby 1979). Similarly to the aforementioned studies, a substantial amount of lichen and ericacean species were found within calving sites which could help sustain parturient females with the required nutritional demands when lactating and therefore can play an important role in the decision making process of calving site selection at the fine scale. Lantin et al. (2011) proposed that greater attention should be given to forage conditions when assessing caribou calving habitat.

Parturient females take a certain amount of predation risk in order to access a sufficient quantity of quality forage (Bowyer et al. 1999, Gustine et al. 2006). This behaviour was also found with moose (*Alces alces*) (Barten et al. 2001) and elk (*Cervus canadensus*) (Rearden et al. 2011, Van Beest et al. 2013). At the fine scale, it appears as though parturient caribou in the Owl-Flintstone range select calving sites within calving areas with sufficient forage, such as lichens and ericacean species.

Shrubs – Black spruce was the shrub species with the greatest percentage cover and frequency. In addition to black spruce, the following species were also present but with a lesser percentage cover: common juniper, wild red raspberry, white birch, pin cherry, river alder and willow.

Percent cover of all shrub species was relatively low within calving sites in the Owl-Flintstone range. Carr et al. (2007) found similar results, indicating caribou choose calving sites with lower shrub density than sites not used. Parturient female choose calving sites where they could detect approaching predators (Pinard et al. 2012). In an effort to reduce predation risk, elk choose calving sites with greater visibility (Rearden et al. 2011). Comparably to what Pinard et al. (2012) and Rearden et al. (2011) found, female caribou in the Owl-Flintstone range choose calving sites with good visibility due to little shrub cover at calving sites. The relatively low shrub cover would help parturient females detect approaching predators by maximizing visibility while maintaining a required amount of cover.

Tree canopy – Habitat utilized by parturient female caribou was dominated by black spruce and to a lesser extent, jack pine. Tamarack larch, balsam fir and white birch were also found at a small number of sites, but their densities were relatively low when compared to jack pine and especially black spruce. Black spruce had the greatest abundance, frequency, density and relative density of all five species. The islands and peninsulas on lake were the only two landforms for which jack pine had a greater density than black spruce.

Parturient females selected for stands consisting of treed bog (Darby 1979, Fuller and Keith 1981, Stuart-Smith et al. 1997, Hirai 1998, Anderson 1999, Dyer 1999, James and Stuart-Smith 2000, Brown 2001, James et al. 2004, DeMars et al. 2011). In some cases, parturient females chose stands described as mature conifer (Edmonds 1988, Rettie 1998, Lander 2006, Courbin et al. 2009, Hins et al. 2009, Lantin et al. 2011, Moreau et al. 2012, Pinard et al. 2012). Much like the aforementioned studies, parturient females in the Owl-Flintstone range choose both black spruce dominated treed bogs and mature conifer dominated islands/peninsulas on lakes. The selection of stands dominated by black spruce within bog complexes offers spatial separation from alternate prey such as moose who utilize well-drained habitat and by doing so, parturient caribou ultimately separate themselves from predators such as wolves (Bergerud and Page 1987, James et al. 2004, McCutchen 2007). This anti-predator tactic along with the presence of quality forage for parturient females could explain the strong selection of black spruce dominated habitat.

Tree canopy closure varied between sites, but for the most part ranged between 30% and 50%, with a mean tree canopy closure of 36.22%. Some studies have shown that caribou select for closed tree canopy stands (Edmonds 1988, Hirai 1998, Courbin et al. 2009), while others found that caribou select for open tree canopy stands (Carr et al. 2007, DeMars et al. 2011). Parturient caribou in this study selected for partially closed tree canopy stands. The selection of partially closed tree canopy could potentially be explained by the greater abundance of terrestrial lichens found these in open and partially open tree canopy stands.

The age of tree canopy species at selected sites were consistently above 60 years with the exception of a few sites. The mean age was 83 years of age. It is not surprising to find caribou utilizing mature stands seeing as caribou have adapted to old growth forest between 40 and 100 years old (Stardom 1977, Johnson 1993, Rettie and Messier 2000). As the forest matures, the forage and tree canopy available becomes more favorable to caribou and less favorable to moose (Fisher and Wilkinson 2005). The spatial seperation of caribou and moose helps minimize predation on caribou populations.

Downed Woody Debris – The abundance of downed woody debris varied between calving sites. However, the majority of calving sites in the Owl-Flintstone range had only a few individuals of down woody debris present. Hirai (1998) indicated that deadfall was common at calving sites, but rarely exceeded levels hindering human movement. Carr (2009) found there was little downed woody debris at calving sites. Results of this study concur with the aforementioned studies. The low abundance of downed woody debris could be a characteristic selected for at a fine scale by parturient females in an effort to reduce obstructive features at calving sites. A minimal amount of downed woody debris at calving sites would most likely improve predator detection by female caribou and improve the probability of an escape from a predator.

Other Characteristics – Calving sites in the Owl-Flintstone range occurred almost exclusively at the edge of stands as well as on adjacent to a relatively large body of water or a bog. Islands and peninsulas provide separation from predators during calving (Shoesmith 1978, Darby 1979, Bergerud 1985, Cumming and Beange 1987, Bergerud et al. 1990, Carr et al. 2007, Metsaranta and Mallory 2007). The spatial separation of parturient caribou and predator is an important factor in the selection of calving sites.

All sites were characterized by gentle topography with gradual sloping shorelines or stand edge, as Darby (1979) also found in Wallace-Aikens Lake region of southeastern Manitoba. A network of trails was interspersed throughout the calving site following the edge of the stand and into either the bog or water. These calving site characteristics could help parturient caribou escape in the event of an intrusion by a predator.

3.5. CONCLUSIONS

The objectives of this study were to find calving sites and characterize calving habitat for the Owl-Flintstone range in southeastern Manitoba. Parturient females utilized islands and peninsulas on lakes as well as islands and peninsulas in bogs. Ground vegetation consisted predominantly of bryophytes, lichens, ericacean species and rock. The shrub layer consisted mostly of black spruce, while the tree canopy layer consisted mostly of black spruce and to a lesser extent jack pine. Downed woody debris was not abundant. Calving sites were characterized by gentle topography with gradual sloping shorelines (islands and shorelines on lake) or stand edge (islands or peninsulas in bog).

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CHAPTER 4.

USE OF CARIBOU CALVING SITES BY PREDATOR AND PREY

Abstract: The use of boreal woodland caribou (*Rangifer tarandus caribou*) calving sites by other large mammal species such as moose (*Alces alces*), bears (*Ursus americanus*) and wolves (*Canis lupus*) in the Owl-Flintstone range in southeastern Manitoba was examined during the months of May to August 2009/2010. Through a series of transects (n=803) and incidental observations (n=728), the location of each animal sign was recorded in order to calculate its distance to the closest known boreal woodland caribou calving site and to determine whether the animal sign was within predicted low quality or predicted high quality calving habitat as identified by a calving habitat model produced by Dyke (2008). Based on animals signs found, the probability of caribou utilizing known calving sites and predicted high quality sites was significantly higher than predicted low quality sites (P = <0.001). Moose utilized predicted low quality sites significantly more than both predicted high quality sites (P = 0.002) and known calving sites (P = 0.01). Bears did not appear to utilize a type of site more than another (P ranged from 0.058 to 0.715). The probability of wolves utilizing predicted low quality sites was significantly higher than predicted high quality sites (P = <0.001). However, wolves did not appear to utilize known calving sites or both predicted low quality and predicted high quality sites more than the other (P = 0.742 & P = 0.403). Results do not suggest bear are actively searching for calving sites. However, bears occurred throughout the landscape, including high quality calving habitat and has the potential to affect caribou calf populations. Further research is needed to identify if predation and apparent competition has a significant impact on the Owl-Flintstone range.

4.0. INTRODUCTION

Calving ground habitat selection is a process which involves weighing the risks of predation against foraging requirements. A variety of studies have shown that predator avoidance plays a significant role in the decision-making process of caribou calving ground habitat selection (Shoesmith 1978, Bergerud 1985, Cumming and Beange 1987, Bergerud et al. 1990, Barten et al. 2001, Wittmer et al. 2006, Gustine et al. 2006, Carr et al. 2007, Metsaranta and Mallory 2007, DeMars et al. 2011, Pinard et al. 2012). However, the way in which predator avoidance is incorporated within calving habitat selection appears to vary within different parts of woodland caribou (*Rangifer tarandus caribou*) range.

Many factors have been attributed to the decline of caribou populations throughout North America. Nevertheless, increased natural predation is often one of the proposed causes of caribou declines (Bergerud 1974, Jordan et al. 1998, Manitoba Conservation 2005). Although in most cases, wolves (*Canis lupus*) are considered to be a main predator of caribou populations (Crisler 1956, Bergerud 1974, Couturier et al. 1990, Gasaway et al. 1992), there are a growing number of studies demonstrating the effects of other predators.

Black bear (*Ursus americanus*) may have a greater impact on caribou populations than reported (Edmonds 1991, Latham et al. 2011*a*). Based on the literature, Ballard (1994) suggested that a proposed reintroduction of boreal woodland caribou in north-central Minnesota could experience black bear predation accounting for 6-30% of caribou calf mortality, while Pitt and Jordan (1996) indicated black bear predation was the main factor for the failure of a caribou reintroduction in Maine. Black bears were responsible for a third of calf mortalities in Newfoundland (Mahoney and Virgl 2003) and 57% of calf mortalities in Québec (Pinard et al. 2012). In Yellowstone National Park, grizzly bears (*Ursus arctos*) and black bears were responsible for 58-60% of elk (*Cervus canadensis*) calf mortality, whereas wolves were accounted for 14-17% of calf mortality (Barber-Meyer et al. 2008).

Other predators have also been identified as the main cause of death of caribou calves. In Newfoundland, Bergerud (1969) found that predation by lynx (*Lynx canadensis*) was the main cause of death among caribou calves, while Gustine et al. (2006) indicated wolverine (*Gulo gulo*) was the main predator of caribou calves in northern British Columbia.

Other prey species can also impact caribou populations. Apparent competition is the process by which a predator shared among prey species can alter the predator-prey dynamic, seemingly creating an indirect relationship between prey species (Decesare et al. 2011). Habitat alterations creating early seral stage forest favour ungulate species such as moose (*Alces alces*) and white-tailed deer (*Odocoileus virginianus*), which increases incidental predation of caribou by predators associated with the aforementioned ungulate species (Kinley and Apps 2001, Kuzyk 2002, Wittmer 2004, Lessard 2005, Wittmer et al. 2007, Latham et al. 2011*b*).

One of the main anti-predator tactics employed by parturient boreal woodland caribou involves spatially dispersing from other caribou, other ungulate species and most importantly, predators. In an effort to reduce predation during calving, parturient females dispersed to islands (Shoesmith 1978, Darby 1979, Cumming and Beange 1987, Bergerud et al. 1990, Metsaranta and Mallory 2007), shorelines (Darby 1979, Bergerud 1985, Carr et al. 2007), treed muskegs (DeMars et al. 2011), black spruce stands (Pinard et al. 2012) or high elevations (Stronen 2000, Gustine et al. 2006).

It is widely accepted that predator avoidance has a significant impact on calving habitat selection (Shoesmith 1978, Bergerud 1985, Cumming and Beange 1987, Bergerud et al. 1990, Barten et al. 2001, Wittmer et al. 2006, Gustine et al. 2006, Carr et al. 2007, Metsaranta and Mallory 2007, DeMars et al. 2011, Pinard et al. 2012). However, little is known regarding the use of caribou calving habitat by large mammal species other than caribou in southeastern Manitoba.

The objectives of this study were to determine whether large mammal species other than caribou utilize caribou calving habitat. Specific objectives were to: 1) identify signs indicating the presence of wolves, bears, moose and caribou in or near calving habitat, 2) determine whether the presence of caribou overlapped with the presence of wolves, bears or moose and 3) examine how the presence or absence of mammal signs relate to known calving sites, predicted low quality calving areas and predicted high quality calving areas.

4.1. STUDY AREA

A description of the study area is provided in chapter 1.

4.2. METHODS

4.2.1. FIELD TECHNIQUES

A description of the field techniques is provided in chapter 2.

4.2.2. DATA ANALYSIS

The data recorded along transects and within plots was organized in a flat file format into Microsoft Excel (2010 version). The database was then imported in the statistical program R (Version R-3.0.1).

Spatial Data – The start location (0 m) of transects sites and animal locations (found on transects and incidental observations) were imported into ArcGIS. The Euclidean distance between the start location of transect sites and the closest sign for each species (bear, caribou, moose and wolf) were calculated. For example, if an animal sign for a certain species was found at 40 m along the transect and that was the closest observation to the start of the transect site for that particular species, the distance between the transect site and that species would be 40 m. If however, there were no observations of a particular species on a transect, the distance would be calculated between the start of the transect site and the closest observation for that species, whether it was observed on a different transect or as an incidental observation.

Analysis – In order to compare variables within predicted low quality sites with variables within known calving sites, 61 predicted low quality sites were randomly selected for further analysis. In order to compare variables within predicted high quality sites with variables within known calving sites, 61 predicted high quality sites were randomly selected further analysis.

Using the statistical program R (Version R-3.0.1), the data were analyzed for normal distribution using box plots. Environmental data is often not normally distributed; therefore a logarithmic transformation was completed. In order to account for data with zeroes, 1 was added to all values (McCune and Grace 2002). The logarithmic transform was completed using the following formula:

$b = \log(x+1)$ where x = original value and b = adjusted value

The data were then analyzed using box plots. Variables were omitted from further analysis when there was not enough data for that particular variable to produce a box plot. Further analysis was conducted with variables for which variance and outliners were considerably reduced.

The Welch two sample t-test was performed to compare variables within: predicted low quality sites and known calving sites and predicted high quality sites and known calving sites.

4.3. RESULTS

A total of 632 caribou signs locations, 269 moose signs locations, 180 bear signs locations and 46 wolf signs locations were observed during the calving season. Signs were identified along transects and through incidental observations.

4.3.1. PREDICTED LOW QUALITY CALVING HABITAT VERSUS KNOWN CALVING SITES

There were no significant differences between predicted low quality sites and known calving sites when comparing distance to bear signs (P = 0.715) and distance to wolf signs (P = 0.742) (Table 4.1). There was evidence of shorter distances between caribou signs and known calving sites when compared to predicted low quality sites (P = <0.001). There was also evidence of more caribou signs within known calving sites when compared to predicted low quality sites (P = <0.001). There was evidence of shorter distances from moose signs and predicted low quality sites when compared to known calving sites (P = 0.01). Data also suggested a greater abundance of moose signs within known calving sites than within predicted low quality sites (P = 0.045).

Table 4-1. Welch Two Sample t-test results between the log transform of animal signs values at predicted low quality sites and known calving sites in southeastern Manitoba, 2009-2010

Variable	df	95% CI		Low Quality (Log Mean)	Calving (Log Mean)	p value
Caribou Signs (Abundance)	60	-1.31	-0.79	0.00	1.05	<0.001
Moose Signs (Abundance)	108	0.00	0.29	0.27	0.12	0.045
Distance to Bear Signs (m)	115	-0.49	0.34	6.34	6.42	0.715
Distance to Caribou Signs (m)	68	4.17	5.11	8.28	3.64	<0.001
Distance to Moose Signs (m)	108	-1.28	-0.18	5.14	5.87	0.010
Distance to Wolf Signs (m)	117	-0.36	0.26	7.46	7.51	0.742

4.3.2. PREDICTED HIGH QUALITY CALVING HABITAT VERSUS KNOWN CALVING SITES

There were no significant differences between predicted high quality sites and known calving sites when comparing distance to moose signs (P = 0.675), distance to bear signs (P = 0.465) and distance to wolf signs (P = 0.403) (Table 4.2). There was evidence of shorter distances between caribou signs and known calving sites when compared to predicted high quality sites (P = <0.001). Data also suggested a significantly greater abundance of caribou signs within known calving sites than within predicted high quality sites (P = <0.001).

Table 4-2. Welch Two Sample t-test results between the log transform of animal signs values at predicted high quality sites and known calving sites in southeastern Manitoba, 2009-2010

Variable	df	95% CI		High Quality (Log Mean)	Calving (Log Mean)	p value
Caribou Signs (Abundance)	95	-1.04	-0.44	0.31	1.05	<0.001
Distance to Bear Signs (m)	119	-0.53	0.24	6.27	6.42	0.465
Distance to Caribou Signs (m)	118	1.19	2.56	5.52	3.64	<0.001
Distance to Moose Signs (m)	102	-0.47	0.72	5.99	5.87	0.675
Distance to Wolf Signs (m)	120	-0.16	0.40	7.63	7.51	0.403

4.3.3. PREDICTED LOW QUALITY CALVING HABITAT VERSUS PREDICTED HIGH QUALITY CALVING HABITAT

There were no significant differences between predicted low quality sites and predicted high quality sites when comparing distance to bear signs (*P* = 0.058) (Table 4.3). There was evidence of shorter distances between caribou signs and predicted high quality sites when compared to predicted low quality sites (*P* = <0.001). There was also evidence of longer distances between wolf signs and predicted high quality sites when compared to predicted low quality sites (*P* = <0.001). Data also showed there were greater distances between moose signs within predicted high quality sites than within predicted low quality sites (*P* = 0.045).

Table 4-3. Welch Two Sample t-test results between the log transform of animal signs values at predicted low quality sites and predicted high quality sites in southeastern Manitoba, 2009-2010

Variable	**df**	**95% CI**		**Low Quality (Log Mean)**	**High Quality (Log Mean)**	**p value**
Distance to Bear Signs (m)	391	-0.01	0.50	6.55	6.30	0.058
Distance to Caribou Signs (m)	220	2.57	3.17	8.38	5.51	<0.001
Distance to Moose Signs (m)	399	-0.90	-0.20	5.56	6.11	0.002
Distance to Wolf Signs (m)	385	-0.76	-0.34	7.17	7.72	<0.001

Caribou signs were closer to known calving sites and predicted high quality sites compared to predicted low quality sites. Moose were further from known calving sites and predicted high quality sites when compared to predicted low quality sites. There were no significant differences between distances to bear signs and surveyed sites for all three comparisons. Wolf signs were further from predicted high quality sites when compared to predicted low quality sites, but the distance between wolf signs and known calving sites were not significantly different when compared to predicted low quality sites and predicted high quality sites.

4.4. DISCUSSION

Caribou –The distance between caribou signs and known calving sites were significantly shorter when compared to both predicted high quality and predicted low quality sites. There was also evidence of shorter distances between caribou signs and predicted high quality sites when compared to predicted low quality sites.

It is not surprising that caribou signs were closer to and more abundant within known calving sites when compared to both predicted low quality and predicted high quality sites seeing as most known calving sites were determined through GPS locations of parturient females. In addition to the calving sites determined through GPS locations, any newly discovered calving sites were classified as such based on caribou signs found at the site. Therefore, due to the nature of site classification (calving, high quality or low quality), the presence of caribou signs was biased towards calving sites.

Caribou occur at low densities on the landscape (Manitoba Conservation 2005). During springtime, female boreal woodland caribou disperse as an anti-predator strategy (Shoesmith 1978, Darby 1979, Edwards 1983, Bergerud 1985, Cumming and Beange 1987, Bergerud et al. 1990, Ferguson and Elkie 2004, Carr et al. 2007, Stotyn 2008). As caribou occur at low densities, there should be fewer caribou signs on the landscape compared to species occurring at greater densities. Despite the fact that female caribou disperse and occur at low densities, there were still caribou signs found within predicted high quality sites, suggesting that predicted high quality habitat were utilized by caribou. Conversely, there were no caribou signs found within predicted low quality sites, suggesting little to no use of low quality habitat.

Moose –When compared to predicted low quality, the distance between moose signs and known calving sites as well as the distance between moose signs and predicted high quality sites were significantly longer (P = 0.01 and P = 0.002 respectively). The distance between known calving sites and moose signs was not significantly different when compared to predicted high quality sites (P = 0.675). The abundance of moose signs was significantly greater within predicted low quality sites when compared to known calving sites (both P = 0.045).

Bowman et al (2010) indicated that wolves, moose and deer were associated with deciduous forest stands and early seral stage habitat, while caribou were associated with coniferous forest stands. Post-disturbance changes which alter caribou habitat to an early seral stage can trigger apparent competition (Kinley and Apps 2001, Wittmer 2004), a process by which indirect interactions between prey species are mediated by a shared predator (DeCesare et al. 2009). According to Wittmer et al. (2007), apparent competition can cause rapid declines and even extinction of a species. Lessard (2005) indicated that if moose utilize habitat traditionally used by caribou, caribou will probably not persist. Results for moose signs seem to suggest that apparent competition may not be of concern. When compared to predicted low quality, moose signs were further from both known calving sites and predicted high quality sites. However, the distance between known calving sites and moose signs was not significantly different compared to predicted high quality sites, suggesting that moose selected low quality caribou habitat versus caribou calving habitat and high quality caribou habitat.

Wolf and bear – The distance between known calving sites and both bear signs and wolf signs was not significantly different when compared to both predicted low quality sites and predicted high quality sites (P = 0.715 and P = 0.465 respectively for bears and P = 0.742 and P = 0.403 respectively for wolves). The distance between predicted high quality sites and bear signs was not significantly different compared to predicted low quality sites (*P* = 0.058). There was evidence of longer distances between wolf signs and predicted high quality sites when compared to predicted low quality sites (*P* = <0.001).

The results indicate there were no differences between the distances of bears and associated categories in all three cases (low quality and calving, high quality and calving and low quality and high quality). This suggests there is the same probability for bears to occur within predicted low quality sites, predicted high quality sites or known calving sites. Latham et al. (2011*a*) found that habitat selection by black bears varied greatly among different individuals and that some bears utilized habitats selected by caribou, which seems to reflect results within the Owl-Flintstone range. Bastille-Rousseau et al. (2011) found that bears did not actively search for caribou calves, but selected patches with abundant vegetation and frequently moved from one patch to another, which could increase the likelihood of an encounter with caribou calves. Black bear predation can have a significant impact on the calf population (Mahoney and Virgl 2003, Pinard et al. 2012). Ballard (1994) suggested, based on literature, that a proposed reintroduction of boreal woodland caribou in north-central Minnesota could experience black bear predation accounting for 6-30% of caribou calf mortality, while Pitt and Jordan (1996) indicated black bear predation was the main factor for the failure of a caribou reintroduction in Maine. Although the results do not suggest bears are actively selecting calving habitat, in light of the fact bears appear to occur through both low quality and high quality calving habitat, black bear predation has the potential to affect caribou calf populations.

Caribou have to balance forage requirements with predation risks when selecting calving sites (Shoesmith 1978, Bergerud 1985, Cumming and Beange 1987, Bergerud et al. 1990, Barten et al. 2001, Wittmer et al. 2006, Gustine et al. 2006, Carr et al. 2007, Metsaranta and Mallory

2007, DeMars et al. 2011, Pinard et al. 2012). The results indicate the distance between wolf signs and known calving sites were not significantly different when compared to both predicted low quality and predicted high quality sites. This suggests there is the same probability for wolves to occur within calving habitat and both low quality habitat and high quality habitat. Seeing as the total number of wolf signs found is relatively small compared to other species, results for wolf signs should be interpreted with caution. In addition to the small sample size, the majority of wolf signs were found due to incidental observations along linear features, particularly on logging roads, illustrating a bias towards linear features.

While wolves are associated with habitat selected by moose (Bowman et al. 2010, Basille et al. 2012), the potential for overlap between wolves and caribou increase during spring and summer (Edmonds 1991, Neufeld 2006, Whittington et al. 2011). As indicated earlier, moose signs were closer to predicted low quality sites when compared to predicted high quality sites. The same results were also found for wolf signs, which means both moose signs and wolf signs were closer to predicted low quality sites when compared to predicted high quality sites. These results seem to suggest wolves are utilizing habitat selected by moose.

4.5. CONCLUSIONS

The objectives of this study were to determine whether large mammal species other than caribou utilize caribou calving habitat. Based on animals signs found, the probability of caribou utilizing known calving sites and predicted high quality sites was significantly higher than predicted low quality sites. Moose on the other hand selected predicted low quality sites significantly more than both predicted high quality sites and known calving sites. Bears did not appear to utilize a type of site more than another. The probability of wolves utilizing predicted low quality sites was significantly higher than predicted high quality sites. However, wolves did not appear to utilize known calving sites or both predicted low quality and predicted high quality sites more than the other.

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CHAPTER 5.

FINE SCALE CHARACTERISTICS OF CALVING HABITAT – HOW DO THEY COMPARE TO A CALVING HABITAT MODEL?

Abstract: Model parameters used in a calving habitat model (Dyke 2008) and fine scale characteristics of known calving sites were studied in the Owl-Flintstone range in southeastern Manitoba during the months of May to August 2009/2010 in order to identify whether a the calving habitat model (Dyke 2008) correctly identified high quality and low quality calving habitat. Through a series of transects and plots (n=803), ground vegetation species, shrubs species, tree canopy species and downed woody debris were recorded. The distance between model parameters and known calving sites, predicted low quality calving habitat and predicted high quality calving habitat were determined. Within the ground vegetation layer, lichen cover was significantly greater, while forbs and herbs cover were significantly lower within known calving sites when compared to predicted low quality habitat. Black spruce cover within the shrub and tree canopy layer was significantly higher within known calving sites when compared to predicted low quality. Model parameters such as the distance to cutblocks, linear features, fires and hardwoods were significantly greater, while the distance to treed muskeg and intermediate black spruce were significantly shorter to calving sites when compared to predicted low quality habitat. The only differences between calving sites and high quality sites were the lower abundance of downed woody debris and the lower forb and herb cover within calving sites. The calving habitat model correctly identified both high quality and low quality calving habitat in the Owl-Flintstone range. To further refine the calving habitat model, parameters reflecting the use of islands and peninsulas on lakes and the selection of calving sites with lower forbs, herbs and downed woody debris values should be included within the model.

5.0. INTRODUCTION

Calving habitat selection involves weighing forage requirements with predation risk. In an effort to balance predation risk with forage requirements, ungulates often choose sites with minimal predation risk and sufficient forage. This behaviour was observed among moose (Edwards 1983, Bowyer et al. 1999), elk (Paquet and Brook 2004, Rearden et al. 2011, Van Beest et al. 2013) and caribou (Shoesmith 1978, Darby 1979, Barten et al. 2001, Gustine et al. 2006, Carr et al. 2007).

Bowyer et al. (1999) found that moose choose calving sites based on fine scale characteristics, which included predator detectability and greater forage quality and quantity. Rearden et al. (2011) showed that elk selected for forage at the macrohabitat scale, while selecting for areas with predator detectability at the microhabitat scale. Carr et al. (2007) indicated that parturient caribou utilized calving sites with greater slope, thicker groundcover vegetation, higher densities of mature trees and lower shrub density. According to the authors, many of these microhabitat characteristics were associated with forage abundance and predator avoidance strategies (Carr et al. 2007). Lantin et al. (2011) suggested more attention be given to forage and the role it plays in the decision making process of calving site selection.

White (1983) demonstrated that forage quality and quantity had significant impacts on ungulate health and reproduction. Access to forage in the fall can impact pregnancy rate (Cameron et al. 1993, 1994, Gerhart et al. 1996, 1997), while access to forage in late winter and spring can affect calf survival (Cameron et al. 1993, Adams 2003, Couturier et al. 2009). In addition to forage, various studies have shown that predator avoidance plays a significant role in the decision-making process of calving ground habitat selection (Shoesmith 1978, Bergerud 1985, Cumming and Beange 1987, Bergerud et al. 1990, Barten et al. 2001, Wittmer et al. 2006, Gustine et al. 2006, Carr et al. 2007, Metsaranta and Mallory 2007, DeMars et al. 2011, Pinard et al. 2012).

Parturient females have to balance both forage requirements and predation risk when choosing calving sites. The degree to which forage and predation affect the selection of calving sites can vary spatially, temporally and geographically. Some studies have looked at the role predator avoidance and habitat characteristics play in the decision-making process of calving habitat selection (Gustine et al. 2006, Lantin et al. 2011). However, few studies have examined the roles of fine scale characteristics of calving habitat and its effects on the selection of calving sites, especially in within the boreal woodland caribou range.

The objective of this study was to examine fine scale characteristics of calving habitat and their effects on calving habitat selection. Specific objectives were to: 1) examine which ground vegetation species, shrubs species, tree canopy species and whether downed woody debris were selected for or avoided at a fine scale, 2) examine whether a calving habitat model (Dyke 2008) correctly predicted low quality and high quality calving habitat based on field verification.

5.1. STUDY AREA

A description of the study area is provided in chapter 1.

5.2. METHODS

5.2.1. FIELD TECHNIQUES

A description of the field techniques is provided in chapter 2.

5.2.2. DATA ANALYSIS

The data recorded along transects and within plots was organized in a flat file format into Microsoft Excel (2010 version). The database was then imported in the statistical program R (Version R-3.0.1).

Spatial Data – The location of transect sites were imputed into ArcGIS. In order to use the same model parameters used by Dyke (2008), the Euclidean distance between transect sites and the closest polygon of the following features were calculated: fires (1968-2008), cutblocks (1968-2008), major linear features (transmission line, provincial highways and class 1 and 2 logging roads), intermediate black spruce (40-100 years), mature black spruce (>100 years), hardwoods (all ages), treed muskegs (all ages) and tamarack, cedar and balsam fir (all ages). The GIS shapefiles for fire, cutblocks and major linear features were provided by Manitoba Conservation. The tree canopy features were extracted from the Forest Resource Inventory (FRI) also provided by Manitoba Conservation. The FRI file used was last updated in 1997.

FRI patch attributes were determined in ArcGIS. Extracted patches consisted of all patches in which a transect was established. Using the Patch Analyst tool (Rempel et al 2012), the patch size, total edge, perimeter-area ratio and the shape index were calculated for each patch.

In order to compare variables within predicted low quality sites with variables within known calving sites, 61 predicted low quality sites were randomly selected for further analysis. In order to compare variables within predicted high quality sites with variables within known calving sites, 61 predicted high quality sites were randomly selected for further analysis.

The frequency, abundance, density, relative density, cover and relative cover were calculated for appropriate variables using methods described by Roberts-Pichette and Gillespie (1999). Due to the large number of species recorded within the ground vegetation layer, ground vegetation and abiotic components were combined in the following groupings: bryophytes, lichens, forbs, herbs, shrubs, fern/horsetails, graminoids, leaves/needles and rock. The model parameters and patch characteristics were also included in the analysis.

Using the statistical program R (Version R-3.0.1), the data were analyzed for normal distribution using box plots. Environmental data are often not normally distributed; therefore a logarithmic transformation was completed. In order to account for data with zeroes, 1 was added to all values (McCune and Grace 2002). The logarithmic transform was completed using the following formula:

$b = \log(x+1)$ where x = original value and b = adjusted value

The data were then analyzed using box plots. Variables were omitted from further analysis when there was not enough data for that particular variable to produce a box plot. Further analysis was conducted with variables for which variance and outliners were significantly reduced.

The Welch two sample t-test was performed to compare variables within: predicted low quality sites and known calving sites and predicted high quality sites and known calving sites.

5.3. RESULTS

5.3.1. GROUND VEGETATION

Within the ground vegetation layer, there were no significant differences between low quality sites and calving sites for values of cover and relative cover of bryophytes and shrubs (all $P = >0.05$; Table 5-1). There was evidence that cover ($P = 0.023$) and relative cover ($P = 0.019$) of lichens were greater within calving sites compared to low quality sites. There was evidence of lower forbs cover, forbs relative cover, herbs cover and herbs relative cover within calving sites when compared to low quality sites (all $P = <0.001$). There were no differences between high quality sites and calving sites for values of cover and relative cover of bryophytes, lichens and shrubs (all $P = >0.05$). There was strong evidence of lower forbs cover ($P = 0.01$), forbs relative cover ($P = 0.01$), herbs cover ($P = 0.004$) and herbs relative cover ($P = 0.004$) within calving sites when compared to high quality sites.

Table 5-1. Welch Two Sample t-test results between the log transform of ground vegetation variables of predicted low quality sites and known calving sites and predicted high quality and known calving sites in southeastern Manitoba, 2009-2010

Variable	df	95% CI		Low Quality (Mean)	Calving (Mean)	p value	df	95% CI		High Quality (Mean)	Calving (Mean)	p value
Ground Vegetation												
Bryophytes (Relative Cover)	79	-0.65	0.00	3.55	3.88	0.052	95	-0.34	0.16	3.79	3.88	0.491
Forbs (Relative Cover)	115	0.34	1.19	2.02	1.25	<0.001	119	0.13	0.91	1.77	1.25	0.010
Herbs (Relative Cover)	119	0.33	1.22	2.23	1.45	<0.001	120	0.20	1.04	2.07	1.45	0.004
Lichens (Relative Cover)	120	-1.28	-0.11	1.60	2.29	0.019	120	-0.84	0.32	2.03	2.29	0.372
Shrubs (< 1m in height) (Relative Cover)	114	-0.56	0.19	1.97	2.16	0.324	115	-0.35	0.40	2.18	2.16	0.906
Bryophytes (m)	79	-0.69	0.01	3.88	4.22	0.057	93	-0.34	0.20	4.15	4.22	0.599
Forbs (m)	116	0.37	1.34	2.31	1.46	<0.001	120	0.14	1.04	2.05	1.46	0.010
Herbs (m)	119	0.35	1.36	2.53	1.67	<0.001	120	0.23	1.18	2.38	1.67	0.004
Lichens (m)	120	-1.39	-0.10	1.78	2.53	0.023	120	-0.91	0.34	2.24	2.53	0.371
Shrubs (<1 m in height) (m)	114	-0.63	0.22	2.25	2.46	0.345	115	-0.40	0.45	2.48	2.46	0.909

5.3.2. SHRUB, TREE CANOPY AND DOWNED WOODY DEBRIS

Within the shrub layer, there was no significant difference between total shrub cover at low quality sites and calving sites (*P* = <0.081; Table 5-2). However, black spruce cover within calving sites had a greater value than low quality sites (*P* = 0.014). Within the tree canopy layer, there was no significant difference between tree canopy closure, jack pine abundance and jack pine density within low quality sites and calving sites. The relative cover of jack pine was lower within calving sites compared to low quality sites (*P* = <0.011). There was evidence that values for stand age, black spruce abundance, black spruce density and black spruce relative density were higher within calving sites when compared to low quality sites (all *P* = <0.001). There were no significant differences between high quality sites and calving sites for all variables within the shrub layer and tree canopy layer.

There was no evidence of differences in the number downed woody debris individuals between low quality sites and calving sites. However, the number of downed woody debris individuals was significantly higher within high quality sites than calving sites (*P* = 0.029).

5.3.3. MODEL PARAMETERS AND PATCH CHARACTERISTICS

There was a significant difference between low quality sites and calving sites for all model parameters with the exception of mature black spruce (*P* = 0.541; Table 5-3). The values for distance to fires, cutblocks and linear features displayed the greatest significance (all *P* = <0.001), being greater for calving sites compared to low quality sites. Differences in the value of patch variables between low quality and calving sites were not significant.

There was no significant difference between high quality sites and calving sites for model parameters and patch characteristics.

Table 5-2. Welch Two Sample t-test results between the log transform of tree canopy, shrub and downed woody debris variables of predicted low quality sites and known calving sites and predicted high quality and known calving sites in southeastern Manitoba, 2009-2010.

Variable	df	95% CI		Low Quality (Mean)	Calving (Mean)	p value	df	95% CI		High Quality (Mean)	Calving (Mean)	p value
Tree Canopy												
Age (Years)	100	-0.87	-0.52	3.67	4.37	<0.001	118	-0.09	0.19	4.42	4.37	0.489
Black Spruce (Abundance)	118	-1.78	-0.96	1.21	2.58	<0.001	119	-0.70	0.09	2.27	2.58	0.126
Jack Pine (Abundance)	119	-0.18	0.55	2.13	1.94	0.321	117	-0.26	0.52	2.07	1.94	0.512
Black Spruce (Density)[1]	94	-0.22	-0.11	0.07	0.24	<0.001	120	-0.11	0.02	0.19	0.24	0.188
Jack Pine (Density)[1]	113	-0.01	0.09	0.16	0.12	0.143	113	-0.01	0.09	0.16	0.12	0.138
Black Spruce (Relative Density)	102	-2.25	-1.10	2.08	3.76	<0.001	119	-0.82	0.11	3.40	3.76	0.130
Jack Pine (Relative Density)	120	0.16	1.17	3.60	2.94	0.011	118	-0.37	0.69	3.10	2.94	0.549
Tree Canopy Closure (%)[1]	118	-5.22	5.38	36.31	36.23	0.976	119	-4.55	5.70	36.8	36.23	0.825
Shrubs												
Black Spruce (Cover)	113	-0.90	-0.10	1.72	2.22	0.014	120	-0.56	0.12	2.00	2.22	0.204
Total Shrub (Cover)	113	-0.03	0.52	3.43	3.18	0.081	119	-0.29	0.21	3.14	3.18	0.728
Downed Woody Debris												
# of DWD Individuals	118	-0.08	0.82	1.95	1.58	0.105	117	0.05	0.82	2.02	1.58	0.029

[1] Not log transformed

Table 5-3. Welch Two Sample t-test results between the log transform of model parameters and patch characteristics of predicted low quality sites and known calving sites and predicted high quality and known calving sites in southeastern Manitoba, 2009-2010.

Variable	**df**	**95% CI**		**Low Quality (Mean)**	**Calving (Mean)**	**p value**	**df**	**95% CI**		**High Quality (Mean)**	**Calving (Mean)**	**p value**
Model Parameters (Dyke 2008)												
Distance to Intermediate Black Spruce (m)	120	0.41	1.88	5.80	4.66	0.003	120	-0.43	1.07	4.97	4.66	0.404
Distance to Mature Black Spruce (m)	100	-0.35	0.67	6.16	6.00	0.541	116	-0.59	0.54	5.98	6.00	0.930
Distance to Hardwood (m)	90	-0.86	-0.21	6.21	6.74	0.002	104	-0.11	0.42	6.9	6.74	0.250
Distance to Tamarack, Cedar and Balsam Fir (m)	119	-1.35	-0.18	6.69	7.46	0.011	108	-0.83	0.13	7.11	7.46	0.154
Distance to Treed Muskeg (m)	120	0.25	1.97	4.39	3.29	0.012	120	-0.43	1.26	3.7	3.29	0.335
Distance to Cutblock (m)	80	-3.05	-1.15	4.31	6.41	<0.001	118	-0.82	0.27	6.14	6.41	0.318
Distance to Fire (m)	83	-1.95	-0.72	6.81	8.14	<0.001	119	-0.66	0.02	7.82	8.14	0.067
Distance to Linear Feature (m)	85	-1.20	-0.57	7.48	8.37	<0.001	118	-0.21	0.20	8.36	8.37	0.972
Patch Characteristics												
Patch Size (ha)	120	-0.25	0.86	3.73	3.42	0.277	120	-0.67	0.45	3.31	3.42	0.696
Perimeter-Area Ratio (m/ha)	120	-0.17	0.09	5.28	5.32	0.540	109	-0.14	0.19	5.35	5.32	0.748
Shape Index	120	-0.06	0.25	1.52	1.42	0.214	120	-0.19	0.11	1.38	1.42	0.585
Total Edge (m)	120	-0.19	0.79	8.93	8.64	0.228	120	-0.64	0.36	8.5	8.64	0.584

5.4. DISCUSSION

Ground vegetation – There were significant differences for numerous attributes values found within calving sites and low quality sites. Conversely, there were no significant differences for the majority of ground vegetation variables found within calving sites and high quality sites. Only forbs and herbs cover were significantly lower within calving sites compared to high quality sites.

The results indicate there were significantly less forbs (P = <0.001) and herbs (P = <0.001), significantly more lichen (P = 0.023) within calving sites compared to low quality sites. Darby (1979) found that calving sites had substantial amounts of terrestrial lichens, arboreal lichens, deciduous shrubs and forbs. Observations of a foraging calf revealed an affinity for terrestrial lichens and the tip of leaves (Darby 1979). Bergerud (1972) indicated that during spring and summer, caribou selected for ericacean species, deciduous shrubs, sedges, reindeer lichens, but when available, preferred fungi, green leaves of deciduous shrubs, forbs and new spring growth of sedges. Much like calving sites in the Owl-Flintstone range, Carr (2007) found that calving sites had a greater abundance of lichens than sites with no calving. Lantin et al. (2011) indicated that both terrestrial lichens and ericacean species were important sources of forage for parturient females with increased nutritional demands. Despite reports by some authors that forbs can be an important source of forage for parturient females, calving sites had significantly less forbs than low quality sites and high quality sites in the Owl-Flintstone range. This could potentially be explained by the following; caribou may have other sources of forage available to them (Bergerud 1972, Carr et al. 2007, Lantin et al. 2011); the amount of forbs at calving sites may be sufficient for parturient females to meet their nutritional requirements; the selection of sites with lower cover of forbs is a mechanism used to avoid predators (Cumming and Beange 1987, Barten et al. 2001). Calving sites did have more lichens than low quality sites and as stated by some authors, lichens are often an important source of forage during calving (Bergerud 1972, Darby 1979, Carr et al. 2007, Lantin et al. 2011).

Shrub, tree canopy and downed woody debris – Black spruce values were significantly higher within calving sites when compared to low quality sites in both the shrub layer and the tree canopy layer. The tree canopy age of calving sites was also significantly higher when compared to low quality sites. Variable values within the shrub layer and the tree canopy layer were not significantly different between calving sites and high quality sites.

Parturient females selected for stands consisting of treed bog (Darby 1979, Fuller and Keith 1981, Stuart-Smith et al. 1997, Hirai 1998, Anderson 1999, Dyer 1999, James and Stuart-Smith 2000, Brown 2001, James et al. 2004, DeMars et al. 2011). In some cases, parturient females chose stands described as mature conifer (Edmonds 1988, Rettie 1998, Lander 2006, Courbin et al. 2009, Hins et al. 2009, Lantin et al. 2011, Moreau et al. 2012, Pinard et al. 2012). Parturient females in the Owl-Flintstone range choose older sites with greater black spruce values (cover, abundance, density and relative density), much like the aforementioned studies. The selection of relatively older stands dominated by black spruce within bog complexes offers spatial separation from alternate prey such as moose who utilize well-drained habitat and by doing so, parturient caribou ultimately separate themselves from predators such as wolves (Bergerud and Page 1987, James et al. 2004, McCutchen 2007). This anti-predator tactic could explain the strong selection of black spruce dominated habitat.

Downed woody debris was the only variable other than forbs and herds for which there was a difference between calving sites and high quality sites. There was less downed woody debris within calving sites than high quality sites in the Owl-Flintstone range. Hirai (1998) indicated that deadfall was common at calving sites, but rarely exceeded levels hindering human movement. Carr (2007) found there was little downed woody debris at calving sites. The significantly lower abundance of downed woody debris at calving sites could be an effort by parturient females to reduce obstructive features at calving sites in the event of a needed escape from a predator as well as to increase predator detectability as observed by Carr (2007) and Pinard et al (2012).

Model parameters and patch characteristics – The distance between calving sites and seven of the eight model parameters utilized by Dyke (2008) were significant when compared to low quality habitat (ranged between P = <0.001 and P = 0.012). The distance between calving sites and intermediate black spruce and treed muskeg were shorter when compared to the distance to low quality sites. The distance was longer between calving sites and hardwoods, fires, cutblocks, linear features and tamarack, cedar and balsam fir when compared to low quality sites. Mature black spruce was the only model parameter with no significant difference in distance between calving sites and low quality habitat (P = 0.541), which could be due to relatively higher amounts of downed woody debris within mature and over-mature sites (Dupont et al. 2006). Both Hirai (1998) and Carr et al (2007) found there were minimal levels of downed woody debris within calving sites.

In contrast, the distance between calving sites and all model parameters used by Dyke (2008) were not significant when compared to high quality habitat. All parameters had a relatively large P value (P > 0.25), with the exception of the distance to fires (P = 0.067). The relatively lower P value for the distance to fires was most likely due to the use of islands and peninsulas on lakes in areas burnt 30 years ago. The calving habitat model was produced based

16 calving events determined through the use of GPS collar data of seven calving females within the Owl-Flintstone range (Dyke 2008). Although it has been shown that parturient females use islands and peninsulas on lakes in the eastern part of the Owl-Flintstone range, none of the 16 calving events used to produce the calving habitat model occurred on islands or peninsulas on lakes. Therefore, the lower *P* value for the distance to fires is likely due to the use of islands and peninsulas on lakes, some of which have burnt in the past 30 years. Therefore, the calving events occurring in recently burnt islands and peninsulas are not reflected in the development of the calving habitat model.

Patch characteristics did not significantly differ between calving sites and both low quality sites and high quality sites. Analysis of patch characteristics was based on FRI stand delineations. It could be that the true delineations of stands were not reflected in the FRI. However, seeing as there was such a variety of patch characteristics among all three groupings (calving, low quality and high quality) it is more probable that the explanation is in fact that patch characteristics did not significantly differ between calving sites and both low quality sites and high quality sites.

Effectiveness of the predictive calving habitat model – Almost all recorded variables including the parameters used by Dyke (2008) were not significantly different between high quality sites and calving sites. The only exceptions were forbs, herbs and downed woody debris. The absence of significant differences between variables can be explained by the following; variables of importance to parturient females were not examined within this study; variables examined confirm that the model correctly predicted high quality calving habitat as such. Seeing as a wide array of variables was assessed, all of which were comparable to variables assessed in similar studies (Gustine et al. 2006, Carr et al. 2007, DeMars et al. 2011), it is unlikely that vegetation variables not assessed within this study would have significant impacts on calving habitat selection. Therefore, it is more probable that the model correctly predicted high quality calving habitat. The minor differences between calving sites and high quality sites suggest that both the model parameters utilized by Dyke (2008) and the fine scale variables assessed were good at identifying high quality habitat as potential calving habitat.

Conversely, the results suggest that other than distance to mature black spruce, the remaining seven model parameters utilized by Dyke (2008) as well as the majority of fine scale variables recorded within this study were significantly different between calving habitat and low quality habitat. There were a few variables for which there was no significant different. However, these variables, such as jack pine values within the tree canopy layer, were not associated with parameters used within the calving habitat model. The significant differences between calving sites and low quality sites suggest that both model parameters utilized by Dyke (2008) and fine scale variables were good at identifying high quality habitat as potential calving habitat.

5.5. CONCLUSIONS

This study examined which vegetation species were selected for and which vegetation species were avoided at a fine scale. Within the ground vegetation layer, lichen cover was significantly higher within known calving sites when compared to predicted low quality sites. Forbs and herbs were significantly lower within known calving sites when compared to both predicted low quality and predicted high quality sites. Black spruce cover within the shrub layer was significantly higher within known calving sites when compared to predicted low quality sites. In the tree canopy layer, black spruce abundance, density and relative density were significantly higher within known calving sites compared to predicted low quality sites. The distance to cutblocks, linear features, fires and hardwoods were significantly greater, while the distance to treed muskeg and intermediate black spruce were significantly shorter to known calving sites compared to predicted low quality sites. The only differences between known calving sites and predicted high quality sites were the lower abundance of downed woody debris and the lower forb and herb cover within calving sites.

The second objective of this study was to examine whether a calving habitat model (Dyke 2008) correctly predicted low quality and high quality calving habitat. When calving sites were compared to low quality sites, the majority of variables showed significant differences. Recorded variables were good at differentiating between calving habitat and low quality habitat. Calving sites and high quality sites attributes were very similar and only a few minor differences were found which suggest that both fine scale variables and model parameters utilized by Dyke (2008) were good at correctly identifying high quality habitat as potential calving habitat.

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CHAPTER 6.

MANAGEMENT RECOMMENDATIONS FOR THE OWL-FLINTSTONE RANGE

6.0. INTRODUCTION

During the last few decades, there has been growing concern with the state of boreal woodland caribou (*Rangifer tarandus caribou*) populations in Canada. In 2002, by recommendation of the Committee on the Status of Endangered Wildlife in Canada, the federal government listed boreal woodland caribou as Threatened under the *Species at Risk Act* (Thomas and Gray 2002). In 2006, Manitoba followed suit and listed boreal woodland caribou populations as Threatened under the *Endangered Species and Ecosystems Act* (Manitoba Conservation 2005). Boreal woodland caribou has been identified as threatened in Canada on the basis of declines in population throughout most of its range, habitat loss and increased predation, facilitated by increased human activity (Thomas and Gray 2002).

As specified in the Scientific Review for the Identification of Critical Habitat for Boreal Caribou, critical habitat is identified by determining "the quantity, quality and spatial configuration of habitat required for persistence of boreal caribou populations throughout their current distribution" (Environment Canada 2008). Caribou calving and nursing habitat is essential for the persistence of boreal woodland caribou and therefore is considered a component of critical habitat (Manitoba Conservation 2005, Environment Canada 2012*a*, *b*).

The Owl-Flintstone range, the most southern range of boreal woodland caribou in Manitoba (Martinez 1998), is among the most at risk in the province (Manitoba Conservation 2005). As the Owl-Flintstone range is the southern extent of current caribou occupation, is isolated from other ranges and is surrounded by human activities, it is very important to gather baseline data to further understand critical habitat use such as calving habitat.

The objectives of this chapter are to: 1) summarize findings of this study 2) and propose management recommendations for the Owl-Flintstone range.

6.1. CARIBOU CALVING HABITAT MODEL

This study examined whether a calving habitat model (Dyke 2008) correctly predicted low quality and high quality calving habitat. When both known calving and predicted high quality sites were compared to predicted low quality sites, the majority of variables showed significant differences. Recorded variables were good at differentiating between known calving habitat and predicted low quality habitat. Known calving sites and predicted high quality sites attributes were very similar and only a few minor differences were found which suggest that both fine scale variables and model parameters utilized by Dyke (2008) were good at correctly identifying high quality habitat as potential calving habitat. The model could be used to identify high quality calving habitat. Consequently, the habitat model would help identify areas where there may be potential risks to both parturient females and caribou calving habitat. However, there are aspects of the model that should be refined.

All calving events used to build the calving habitat model occurred on islands or peninsulas in bogs. Therefore, the calving habitat model reflects the selection of calving sites on islands and peninsulas within bogs. However, parturient females of the Owl-Flintstone range also utilize islands and peninsulas on lakes. As shown in chapter 3, the vegetation composition of calving sites on islands and peninsulas in bogs can differ from calving sites on islands and peninsulas on lakes. Consequently, to further refine the calving habitat model and reflect the different types of calving sites utilized by parturient females in the Owl-Flintstone range, the development of the calving habitat model should include calving sites on islands and peninsulas on lakes as well as islands and peninsulas in bogs.

In addition to including calving sites found on island and peninsulas on lakes in the development of the calving habitat model, a few fine scale characteristics could further refine a calving habitat model. Known calving sites had lower forbs, herbs and downed woody debris values when compared to predicted high quality sites. Adding forbs, herbs and downed woody debris as parameters to a calving habitat model would help identify potential calving sites within larger calving areas.

The model produced by Dyke (2008) should be updated every few years in order to reflect changes on the landscape (fires, cutblocks, roads) which could change the calving habitat quality model output. Although the predictive model is a powerful tool, it would be best used in conjunction with other management tools such as monitoring of females during the calving season.

6.2. PREDATORS AND OTHER PREY SPECIES

Based on animals signs found in this study, the probability of caribou utilizing known calving sites and predicted high quality sites was significantly higher than predicted low quality sites as predicted by a calving habitat model (Dyke 2008). Moose on the other hand selected predicted low quality sites significantly more than both predicted high quality sites and known calving sites. Bears did not appear to utilize a type of site more than another. The probability of wolves utilizing predicted low quality sites was significantly higher than predicted high quality sites. However, wolves did not appear to utilize known calving sites more than both predicted low quality and predicted high quality sites.

Predators and calving habitat - Results suggest the probability of having wolves or bears within calving sites was similar in both high quality and low quality sites. In most cases, predation of caribou during the calving season is attributed to bears (Edmonds 1991, Gasaway et al. 1992, Ballard 1994, Pitt and Jordan 1996, Mahoney and Virgl 2003, Latham et al. 2011, Pinard et al. 2012) and wolves (Bergerud 1974, Edmonds 1991, Gasaway et al. 1992). In light of this, it would be valuable for management purposes to get a better understanding of predator utilization of caribou calving habitat in southeastern Manitoba. A study in which predator and prey interactions are examined through the use of GPS collars could determine whether caribou in southeastern Manitoba are significantly impacted by predation during the calving season. Components of such a study could look at calf survivorship and potential underlying mechanisms such as: location of calving site, cause of calf mortality, climate, calf gender, predator densities, and density of other prey species.

Seeing as the study area has a long history with logging, forest extraction practices in the study area should include measures to reduce caribou and predator interactions. Bastille-Rousseau et al. (2011) indicated in order to reduce bear-caribou interactions as a result of logging, areas of high forage value to bears, such as roadsides, should be separated from large patches of mature conifer stands used by caribou. In order to reduce wolf-caribou interactions, Courtois et al. (2009) suggested large protected blocks should be composed predominantly of mature coniferous stands with lichen. They also indicated mixed and deciduous stands within protected blocks should be minimized, while roads and cutblocks should be far from protected blocks.

6.3. CHARACTERISTICS OF CALVING HABITAT

This study examined which species were selected for and which species were avoided at a fine scale. Within the ground vegetation layer, lichen cover was significantly higher, while forbs and herbs cover were significantly lower within both calving and high quality habitat compared to low quality. Black spruce cover within the shrub layer was significantly higher in both calving and high quality sites when compared to low quality. In the tree canopy layer, black spruce abundance, density and relative density were significantly higher within both calving and high quality habitat compared to low quality. The distance to cutblocks, linear features, fires and hardwoods were significantly greater, while the distance to treed muskeg and intermediate black spruce were significantly shorter to calving sites and high quality sites compared to low quality sites. The only differences between calving sites and high quality sites were the lower abundance of downed woody debris and the lower forb and herb cover within calving sites.

Future studies examining fine scale characteristics of calving sites could look at similar characteristics recorded within this study. Although downed woody debris and shrub cover could potentially be used as an indicator of visibility, future studies should include ways of recording visibility at calving sites.

Calving characteristics and industrial activity - Caribou calving habitat is essential for the persistence of boreal woodland caribou and therefore is considered critical habitat (Manitoba Conservation 2005, Environment Canada 2012*a*, *b*). In order to protect critical habitat, buffers in which resource extraction is prohibited should be established around currently used calving sites and also around a minimum percentage of potentially used calving areas within the core area of the Owl-Flintstone range. Parturient females utilized sites with high amounts of black spruce and lichen. These calving sites were also further from cutblocks, linear features, hardwoods and fire, making a strong case for protecting calving sites from potential disturbances such as forest harvesting. Seeing as the results of this study suggest the model produced by Dyke (2008) correctly predicted high quality and low quality calving habitat, the model (with revisions) could be used to establish buffer zones around high quality calving habitat within the core area of the Owl-Flintstone range. Hirai (1998) and Vors et al. (2007) recommend having buffers between 500 m and 1 km in width around calving areas in which there would be no resource extraction.

If forest harvesting does occur in proximity to calving areas, it should adopt harvest practices which maintain post-harvest conditions favourable to lichen growth (Stone et al. 2008), seeing as lichen appear to be a significant source of forage at calving sites. Hins et al. (2009) found that clearcuts hindered the search for mature stands. Demars et al (2011) suggested excluding or at least minimizing anthropogenic disturbance within calving habitat and travel corridors linking winter ranges to calving habitat. If protected blocks are used as a mitigation tool, Courbin et al (2009), suggested protected blocks should be comprised predominantly of coniferous stands with lichen, while minimizing mixed and deciduous stands. In Québec, caribou numbers were maintained by merging cutblocks into large areas and preserving large stands linked by travel corridors with a width greater than 400 m (Courtois et al. 2008). Lander (2006) recommended similar measures, by leaving a mosaic of mature jack pine, treed muskeg, and spruce stands at least 1 km in width, while amalgamating cutblocks, completely removing roads post-harvest and encouraging coniferous stands. Stone et al. (2008) proposed preserving post-harvest conditions suitable for lichen growth and employing selection cutting retaining lichen bearing trees. This study describes calving habitat characteristics used by parturient caribou in the Owl-Flintstone range which can be incorporated in local caribou management plans, especially for purposes relating to critical habitat.

6.4. KNOWN CALVING SITES

Parturient females utilized islands and peninsulas on lakes as well as islands and peninsulas in bogs. Ground vegetation consisted predominantly of bryophytes, lichens, ericacean species and rock. The shrub layer consisted mostly of black spruce, while the tree canopy layer consisted mostly of black spruce and to a lesser extent jack pine. Abundance values for downed woody debris were relatively small. Calving sites were characterized by gentle topography with gradual sloping shorelines (islands and shorelines on lake) or stand edge (islands or peninsulas in bog).

Protection of calving habitat - Chapter 5 illustrates that caribou utilized calving sites further from linear features, cutblocks and fires. While these are all examples of an avoidance of disturbance, it would be valuable to undertake a study looking at whether recreational use of lakes in the eastern part of the study area impact the selection process of parturient females and whether there are differences in behaviour or calf survival if females choose sites in proximity to areas used by outdoor enthusiasts. While this study did not specifically address whether human recreational use of these lakes influence calving site selection, it did identify sites utilized by parturient caribou. Seeing as the Owl-Flintstone range has already been classified as a high conservation concern by the Government of Manitoba due to habitat loss, fragmentation or degradation and other indirect impacts as a result of anthropogenic disturbances (Manitoba Conservation 2005), it would be prudent to err on the side of caution when protecting critical habitat such as calving areas until a study has determined the effects of recreational activities on calving habitat selection and calving success.

A significant portion of calving sites examined for this study were situated on islands or shorelines on lakes. The majority of the lakes utilized by parturient caribou are within an area of relatively high recreational use. There have been measures taken by the province of Manitoba to mitigate potential conflicts between recreational users and use of some lakes by parturient caribou. Overnight camping is prohibited on two of these lakes (Flintstone Lake and Seagrim Lake). Using GPS data, the calving habitat model produced by Dyke (2008) (once refined) and calving sites identified through this study, it would be beneficial to evaluate whether the areas currently identified for the backcountry camping prohibition should include other calving areas such as Hollinsworth Lake and an unnamed lake between Flintstone Lake and Black Lake.

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APPENDIX A

Species Identified

Table A1. Ground vegetation species identified through the study area in southeastern Manitoba, 2009-2010.

Ground Vegetation		
Scientific name	**Common name**	**Family**
Pleurozium schreberi	**Feather moss**	Moss
Sphagnum spp.	**Sphagnum moss**	Moss
Lycopodium clavatum	**Running club-moss**	Club-Moss
Lycopodium annotinum	**Stiff club-moss**	Club-Moss
Lycopodium complanatum	**Ground-cedar**	Club-Moss
Lycopodium abscurum	**Ground-pine**	Club-Moss
Cladina Mitis	**Green reindeer lichen**	Lichen
Cladina rangiferina	**Grey reindeer lichen**	Lichen
Cladonia unicialis	**Spike lichen**	Lichen
Cladina stellaris	**Northern reindeer lichen**	Lichen
Stereocaulon tomentosum	**Wooly coral**	Lichen
Vaccinium myrtilloides	**Blueberry**	Heath
Arctostaphylos uva-ursi	**Bearberry**	Heath
Gaultheria procumbens	**Wintergreen**	Heath
Vaccinium vitis-idaea	**Bog cranberry**	Heath
Rhododendron groenlandicum	**Labrador tea**	Heath
Chamaedaphne calyculata	**Leather leaf**	Heath
Oxycoccus microcarpus	**Small bog cranberry**	Heath
Gautheria hispidula	**Creeping-snowberry**	Heath
Kalmia polifolia	**Bog laurel**	Heath
Andromeda glaucophylla	**Bog rosemary**	Heath
Ribes spp.	**Currant**	Saxifrage
Diervilla lonicera	**Bush honeysuckle**	Honeysuckle
Linnaea borealis	**Twin flower**	Honeysuckle
Maianthemum canadense	**Wild lily-of-the-valley**	Lily
Smilacina trifolia	**Three-leaved false Solomon's-seal**	Lily
Clintonia borealis	**Blue-bead lily**	Lily
Smilacina stellata	**Star-flowered false salomon's seal**	Lily
Cypripedium acaule	**Moccasin flower**	Orchid
Habenaria hyperborea	**Northern green bog orchid**	Orchid
Goodyera repens	**Lesser rattlesnake-plantain**	Orchid
Anemone canadensis	**Canada anemone**	Buttercup
Coptis trifolia	**Goldthread**	Buttercup

Rubus idaeus	**Wild red raspberry**	Rose
Fragaria vesca	**Woodland strawberry**	Rose
Rubus chamaemorus	**Cloudberry**	Rose
Rubus pubescens	**Dewberry**	Rose
Potentilla tridentata	**Three-toothed cinquefoil**	Rose
Pyrola asarifolia	**Pink wintergreen**	Wintergreen
Chimaphila umbellata	**Prince's pine**	Wintergreen
Lathyrus spp.	**Vetch**	Pea
Viola spp.	**Violet**	Violet
Epilobium angustifolium	**Fireweed**	Evening-Primrose
Trientalis borealis	**Northern starflower**	Primrose
Achillea sibirica	**Common yarrow**	Aster
Aralia nudicaulis	**Wild sarsaparilla**	Ginseng
Cornus canadensis	**Bunchberry**	Dogwood
Apocynum androsaemifolium	**Spreading dogbane**	Dogbanes
Campanula rotundifolia	**Harebell**	Bellflower
Equisetum spp.	**Horsetail**	Horsetails
Polypodium virginianum	**Rock polypody**	Fern
Gymnocarpium dryopteris	**Oak fern**	Fern
Carex spp.	**Sedge**	Sedge
Eriophorum spp.	**Cottongrass**	Sedge
Potentilla palustris	**Marsh cinquefoil**	Aquatic
Sagittaria cuneata	**Arum-leaved arrowhead**	Aquatic
Calla palustris	**Water arum**	Aquatic
Poa spp.	**Grasses**	Grass
Sarracenia purpurea	**Pitcher plant**	Pitcher-Plant
Rock	**Rock**	Other
Leaves/needles	**Leaves/needles**	Other
Mud	**Mud**	Other
Water	**Water**	Other

Table A2. Shrub species identified through the study area in southeastern Manitoba, 2009-2010.

Shrubs		
Scientific name	**Common name**	**Family**
Picea mariana	**Black spruce**	Pine
Picea glauca	**White spruce**	Pine
Pinus banksiana	**Jack pine**	Pine
Larix laricina	**Tamarack larch**	Pine
Abies balsamea	**Balsam fir**	Pine
Betula papyrifera	**White birch**	Birch
Betula pumila	**Dwarf birch**	Birch
Alnus rugosa	**River alder**	Birch
Corylus cornuta	**Beaked hazelnut**	Birch
Populus tremuloides	**Trembling aspen**	Willow
Salix spp.	**Willow**	Willow
Acer negundo	**Manitoba maple**	Maple
Amelanchier alnifolia	**Saskatoon**	Rose
Prunus pensylvanica	**Pin cherry**	Rose
Rosa acicularis	**Prickly rose**	Rose
Rubus idaeus	**Wild red raspberry**	Rose
Ribes spp.	**Currant**	Saxifrage
Ribes oxyacanthoides	**Northern gooseberry**	Saxifrage
Juniperus communis	**Common juniper**	Cypress
Cornus stolonifera	**Red-osier dogwood**	Dogwood

Table A3. Tree canopy species identified through the study area in southeastern Manitoba, 2009-2010.

Tree Canopy		
Scientific name	**Common name**	**Family**
Picea mariana	**Black spruce**	Pine
Picea glauca	**White spruce**	Pine
Pinus banksiana	**Jack pine**	Pine
Larix laricina	**Tamarack larch**	Pine
Abies balsamea	**Balsam fir**	Pine
Betula papyrifera	**White birch**	Birch
Alnus rugosa	**River alder**	Birch
Populus tremuloides	**Trembling aspen**	Willow

Table A4. Downed woody debris species identified through the study area in southeastern Manitoba, 2009-2010.

Downed Woody Debris		
Scientific name	**Common name**	**Family**
Picea mariana	**Black spruce**	Pine
Picea glauca	**White spruce**	Pine
Pinus banksiana	**Jack pine**	Pine
Larix laricina	**Tamarack larch**	Pine
Abies balsamea	**Balsam fir**	Pine
Betula papyrifera	**White birch**	Birch
Populus tremuloides	**Trembling aspen**	Willow

Table A5. Large mammal species identified through the study area in southeastern Manitoba, 2009-2010.

Large Mammals		
Scientific name	**Common name**	**Family**
Rangifer tarandus caribou	**Boreal woodland caribou**	Deer
Alces alces	**Moose**	Deer
Canis lupus	**Gray wolf**	Canid
Ursus americanus	**Black bear**	Bear

APPENDIX B

Calving Habitat Model Map

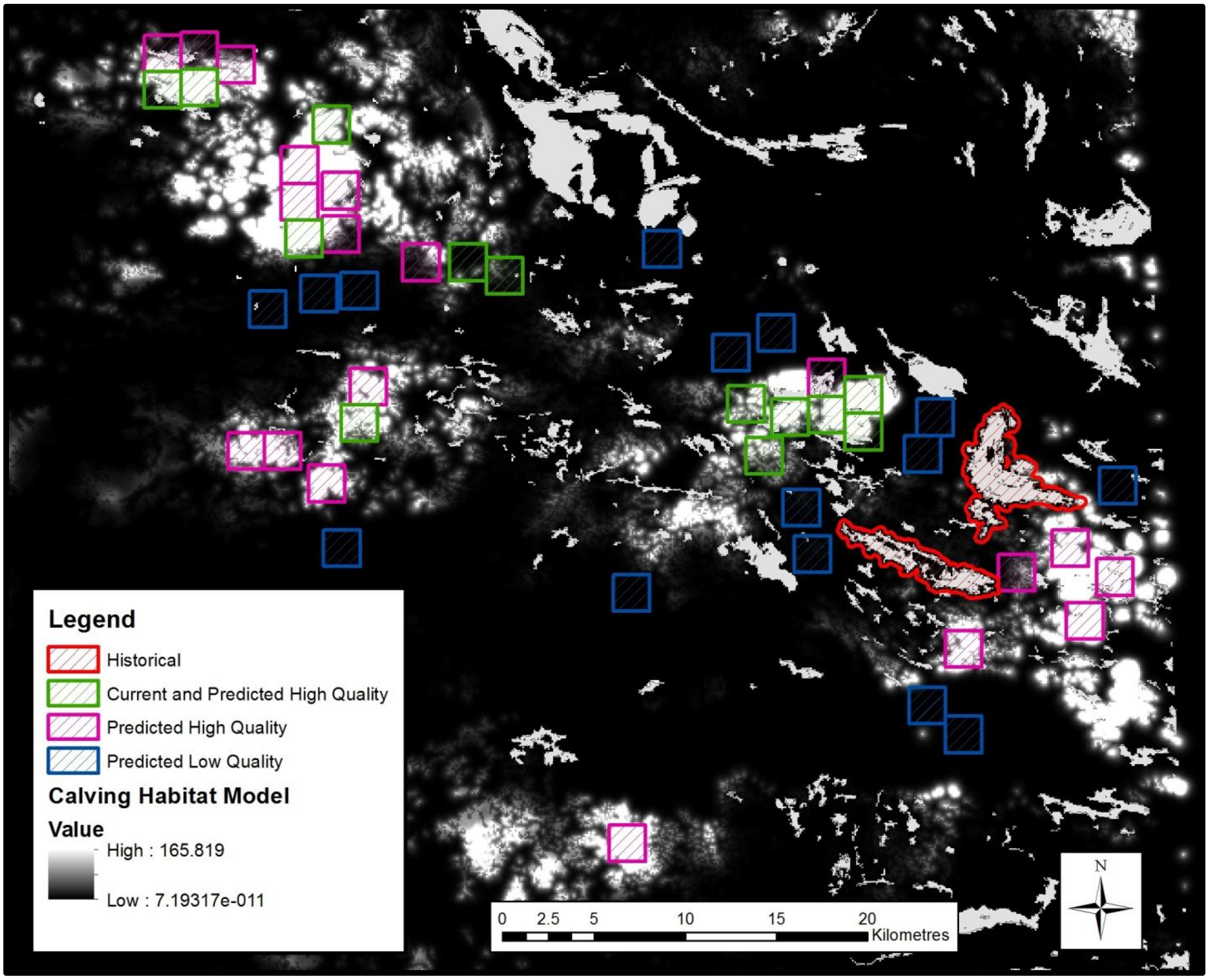

Fig. B1. Calving habitat model (Dyke 2008*a*) with survey blocks established within the survey area in southeastern Manitoba, 2009-2010.