NEST STRUCTURE AND BREEDING HABITAT CHARACTERISTICS OF BARRED OWLS (*STRIX VARIA*) IN MANITOBA, CANADA.

BY

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A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES
OF THE UNIVERSITY OF MANITOBA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF THE DEGREE OF

MASTER OF SCIENCE

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ABSTRACT

Barred Owls (*Strix varia*) were located through audio playback surveying searching in southern Manitoba. Sixty-one confirmed home ranges were located and nine nest sites were located. Mean diameter at breast height and cavity depth and width were determined to be limiting factors governing Barred Owl distribution. Barred Owl habitat use was examined at two scales: immediately around nest trees and within estimated breeding and non-breeding home ranges. Barred Owl breeding and non-breeding home ranges had significantly more hardwood and mixedwood than random plots. Barred Owl breeding season commenced in early March, egg laying in early April, hatching in early May, and fledging at the start of June. Mean and standard deviation of clutch size were 1.91 ± 0.83. Barred Owl diet was determined to be generalist in nature. Dietary breadth was calculated, using Simpson's formula for measurement of diversity in a sample, of D = 0.1525.

ACKNOWLEDGEMENTS

I would like to thank my advisor Dr. James Duncan for showing me the ropes, hanging precariously from 40 foot nests, slogging equipment through insect-infested swamps, watching motionless owls for hours on end, never saying “no” to one of my hair-brained ideas, and generally taking an interest in my success and future. Thanks Jim. A special thanks to my committee members Dr. Terry Galloway and Dr. Spencer Sealy; this project wouldn’t have gotten started if it wasn’t for your guidance and effort Terry and thank you Spencer for believing in me and that there is still a place for old-fashioned field work in biology.

Thanks to Guy Hamonic for volunteering to do some of my dirty work and double the surveying effort in 2009. Thanks to Dr. Robert Nero for his guidance and critique of draft manuscripts. Many thanks to Dr. Peter Taylor, Dr. Christian Artuso, Rob Parsons and all the other avid birders in Manitoba who contributed information to my study or who have participated in the Manitoba Nocturnal Owl Survey throughout the years, making life a little easier. A special thank you to Kurt Mazur for his advice in the early stages of this project and for laying the groundwork for this study. I thank Heather Hinam, Randy Mooi of the Manitoba Museum, Bill Koonz, Cal Cuthbert, and the Honourable Dr. Jon Gerrard for contributing data.

Thanks to Tim Swanson, Antonio Viveiros, Mike Hayward and others with Manitoba Conservation, Forestry Department for analyzing data, providing equipment and maps, and lending their expertise. Thanks to Tom Reaume for his assistance with literature mining, and David Johnson, Peter Singleton, Dr. Rob Bierregaard and Mike

Russell for lending their knowledge of this species to my study. Thanks to Dave Roberts for telemetry work and Chelsey Lumb for statistical advice.

I thank Mike van den Tillaart and the crew at Lotek Wireless, Inc., Rebecca Condon and Carla Fehr of Calm Air, Erin Wilcox and staff at the Thompson Zoo, Lisa Tretiak of the Prairie Wildlife Rehabilitation Centre, Nancy and Gunther Golinia and Allison Dube, and staff from the Hope for Wildlife Society.

Thanks to those who assisted in obtaining permits for my research: Jessica Elliott of the Parks and Natural Areas Branch of Manitoba Conservation, Bill Watkins of the Wildlife and Ecosystem Protection Branch of Manitoba Conservation, Tracy Van Osch and Richard Hodges of the Animal Care Committee at the University of Manitoba and Parks Canada.

I gratefully acknowledge the financial support of the Sustainable Development Innovations Fund c/o Manitoba Conservation, Manitoba Hydro, University of Manitoba Faculty of Science Graduate Student Scholarship, H. E. Welch Memorial Scholarship, Alice Chambers/Colomb Student Assistantship, Brian Kotak and the staff at the Manitoba Model Forest, Inc., The Dean Amadon Grant c/o Raptor Research Foundation, The Lady Gray'l Fund c/o The Winnipeg Foundation, and Dr. Robert and Ruth Nero. My research could not have been accomplished without all the funding provided.

A big thanks to my family and friends for their support, occasional forays into the field, helping with my minor nervous breakdowns, and tolerating hundreds of owl-related questions from co-workers, neighbours and friends, especially to Amanda who tolerates me more than most and never seems to get tired of my antics.

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THESIS INTRODUCTION: RESEARCH ON *STRIX* SPECIES FROM INTERNATIONAL TO LOCAL.

The genus *Strix*, "earless owls", contains 23 species (König and Weick 2008) that are found in mature forests throughout the world (Marcot 1995). Old world *Strix* species include: the African Wood Owl (*Strix woodfordii*) found across much of southern Africa, Bartel's Wood Owl (*Strix bartelsi*) found in western Java, Brown Wood Owl (*Strix leptogrammica*) found in pockets across southeast Asia, Great Gray Owl (*Strix nebulosa*) found across northern Eurasia and North America, Himalayan Wood Owl (*Strix newarensis*) ranging throughout the Himalayan region of Asia and east across southern China, Hume's Owl (*Strix butleri*) found in pockets in the Middle East, Mottled Wood Owl (*Strix ocellata*) found throughout most of the Indian sub-continent, Nias Wood Owl (*Strix niasensis*) which is located only on Nias island, off the coast of Sumatra, Sichuan Wood Owl (*Strix davidi*) found in the Sichuan mountains of China, Spotted Wood Owl (*Strix seloputo*) found in southeast Asia, Tawny Owl (*Strix aluco*) ranging throughout Europe and extending into parts of Asia and the Middle East and Ural Owl (*Strix uralensis*) located across northern Eurasia (Duncan 2003, König and Weick 2008). Of these 12 species, only the Great Gray Owl, Tawny Owl and Ural Owl have garnered any considerable scientific research (König and Weick 2008).

South and Central America contain nine *Strix* species: the Black and White Owl (*Strix nigrolineata*) found south from central Mexico to the northernmost parts of South America, Black-banded Owl (*Strix huhula*) found throughout most of northern and central South America, Chaco Owl (*Strix chacoensis*) located in a pocket in the centre of South America, Fulvous Owl (*Strix fulvescens*) found from southern Mexico through

much of Central America to Honduras, Mexican Wood Owl (*Strix squamulata*) ranging down the coastal edges of Mexico and Central America to the northernmost edge of South America, Mottled Owl (*Strix virgata*) found across most of northern South America, Rufous-banded Owl (*Strix albitarsis*) located in a U-shaped range in northwestern South America, incorporating parts of Venezuela, Columbia, Ecuador, Peru and Bolivia, Rufous-legged Owl (*Strix rufipes*) found from south-central Chile and southern Argentina south to Tierra del Fuego and a few adjacent islands and Rusty-barred Owl (*Strix hylophila*) ranging from eastern Brazil south into parts of Paraguay and northeastern sections of Argentina (Duncan 2003, König and Weick 2008). None of the Central and South American species of *Strix* have garnered any appreciable scientific research (König and Weick 2008).

North of Mexico, and more specifically in Canada, only three species of *Strix* are found: the Barred Owl (*S. varia*), Great Gray Owl (*S. nebulosa*) and Spotted Owl (*Strix occidentalis*) (Duncan 2003, König and Weick 2008).

In Canada, the Spotted Owl is only found in the southwestern-most corner of British Columbia. It inhabits mature coniferous forests, which has put it in conflict with the forestry industry across its range. The Spotted Owl has received a large amount of scientific research, mostly due to the listing of Northern Spotted Owl (*Strix occidentalis caurina*) as "endangered" in Canada and "threatened" in the United States of America (United States Fish and Wildlife Service 1990, Zabel *et al*. 1995, Bevis *et al*. 1997, Smith *et al*. 1999, Bond *et al*. 2002, Olson *et al*. 2005). Much study has been focused on the interaction and theorized competition between Spotted Owls and Barred Owls, where their ranges overlap (Hamer *et al*. 1994, Hamer *et al*. 2001, Kelly and Forsman 2004,

Olson *et al*. 2005, Hamer *et al*. 2007, Bailey *et al*. 2009). Although mostly anecdotal (Livezey and Fleming 2007), this research has stimulated further interest and funding for a disproportionately well-studied *Strix* species.

The Great Gray Owl is found across Canada from western Quebec to the Pacific coast and from the sub-arctic into northern portions of the United States of America. It inhabits dense coniferous forests, primarily across the boreal region (Duncan 2003, König and Weick 2008). In Manitoba, it occurs in all areas of the province, with the exception of the Hudson Bay coastal area (Nero 2003). Great Gray Owls are considered nomadic or a wide-ranging migrant, and a specialist predator (Cheveau *et al*. 2004). The importance of appropriate Great Gray Owl habitat in the province has been well documented (Nero 2003) and influential research is routinely conducted within the province (Nero 1969, Collins 1980, Nero and Copland 1981, Servos 1987, Duncan 1992, Duncan 1996b, Nero 2000). Great Gray Owls have been heavily studied throughout their range, covering most aspects of their life history strategies (Nero 1969, Korpimäki 1986, Franklin 1988, Bull *et al*. 1989, Sulkava and Huhtala 1997, Cheveau *et al*. 2004, Corace III *et al*. 2006, Van Riper and Van Wagtendonk 2006).

The Barred Owl is a large forest-dwelling owl that is widespread in North America (Bent 1938, Johnsgard 2002) (Fig. 1.1). In contrast to the Great Gray Owl's life history strategies the Barred Owl is considered a generalist predator and a year-round resident -- none of 158 band recoveries have occurred more than 10 km from the original banding location (Johnson 1987). Forest management influences its conservation status as it depends on large tree cavities for successful reproduction, hence it is recognized as an indicator species of healthy forest ecosystems (McGarigal and Fraser 1985).

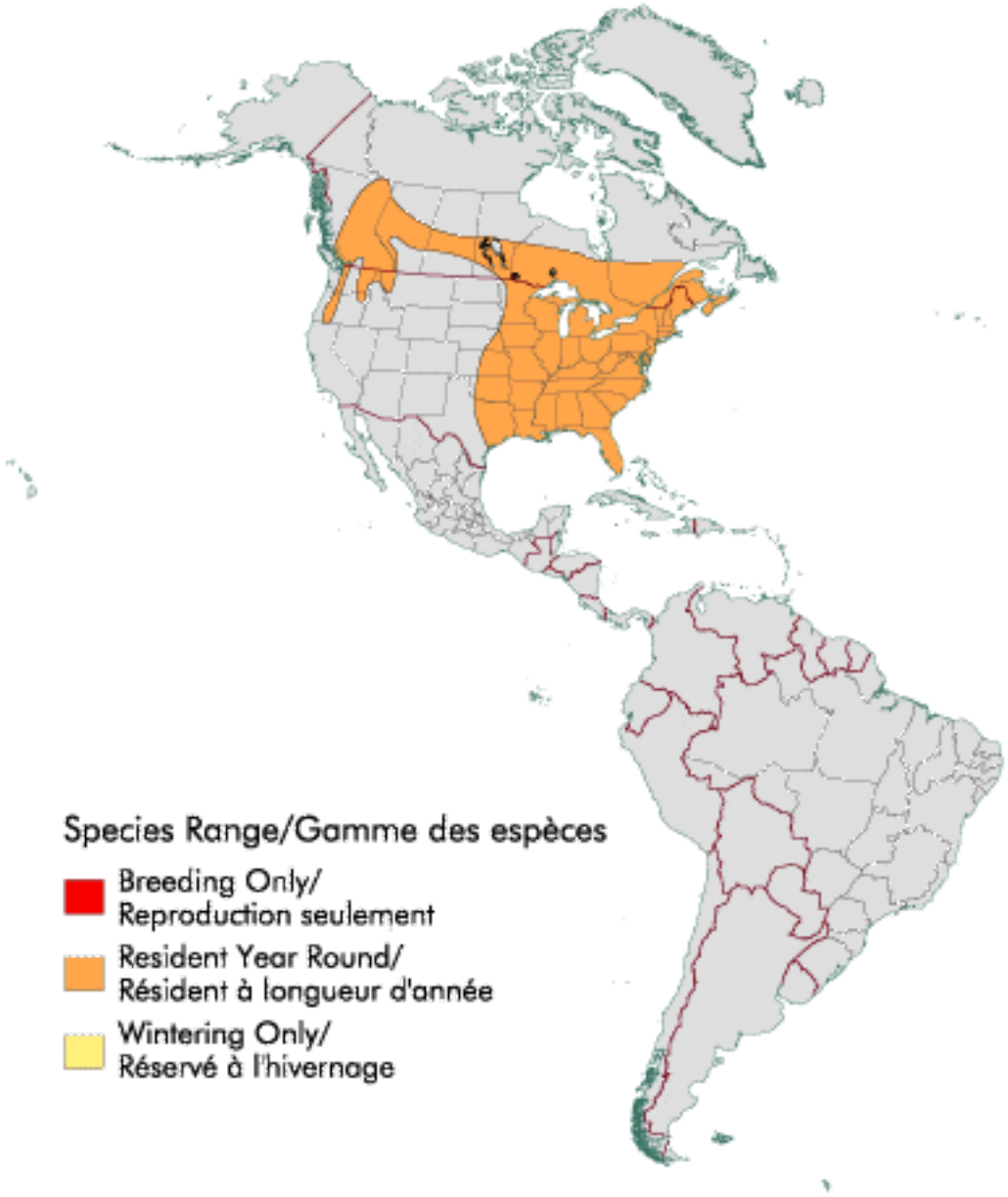

Figure 1.1: North American Range of the Barred Owl.
(http://www.on.ec.gc.ca/wildlife/wildspace/life.cfm?ID=BAOW&Page=RangeMap&Lang=e

While there have been field studies on Barred Owl breeding habitat use in Minnesota (Nicholls and Warner 1972, Nicholls and Fuller 1987), Saskatchewan (Mazur *et al.* 1997a, Frith *et al.* 1997, Mazur *et al.* 1998), and Alberta (Takats and Holroyd 1997), there has been no research to describe nest sites or known breeding habitat in Manitoba. For example, there are three Manitoba Barred Owl breeding records, but for only one of these was a nest tree identified (Holland *et al.* 2003). In contrast, the Barred Owl is known to occur extensively in Manitoba, based on the Manitoba Nocturnal Owl Survey (Duncan and Duncan 1997, Duncan and Kearns 1997) (Fig. 1.2). Nonetheless, its conservation status in Manitoba was "Uncommon-Apparently Secure (S3S4)" (Duncan 1996a) and "Sensitive" (J.R. Duncan, Pers. Comm.) based in part on a lack of Manitoba-specific information on its nest site and breeding habitat requirements (Duncan and Kearns 1997, Hinam 2002); consequently, there are no sustainable forest management guidelines for it in Manitoba. The void in Manitoba Barred Owl research can be best displayed by comparing it to Manitoba Great Gray Owl research, its closest relative in the province. A look at *The Birds of Manitoba* text lists 24 citations for the Great Gray Owl segment, with 19 of these being Manitoba-based research or accounts (Nero 2003). In the same book, the Barred Owl segment lists seven citations, with six of these being Manitoba based and only one being a Barred Owl research study (Holland *et al.* 2003).

Much of the research on Barred Owls has been concentrated on their relationship with Spotted Owls (Hamer *et al*. 1994, Hamer *et al*. 2001, Kelly and Forsman 2004, Olson *et al*. 2005, Pearson and Livezey 2007, Hamer *et al*. 2007, Bailey *et al*. 2009) or lacking in specific data related to breeding and habitat requirements or behaviour (Bell 1964, Leder and Walters 1980, Sharp 1989, Laidig and Dobkin 1995, Dark *et al*. 1998,

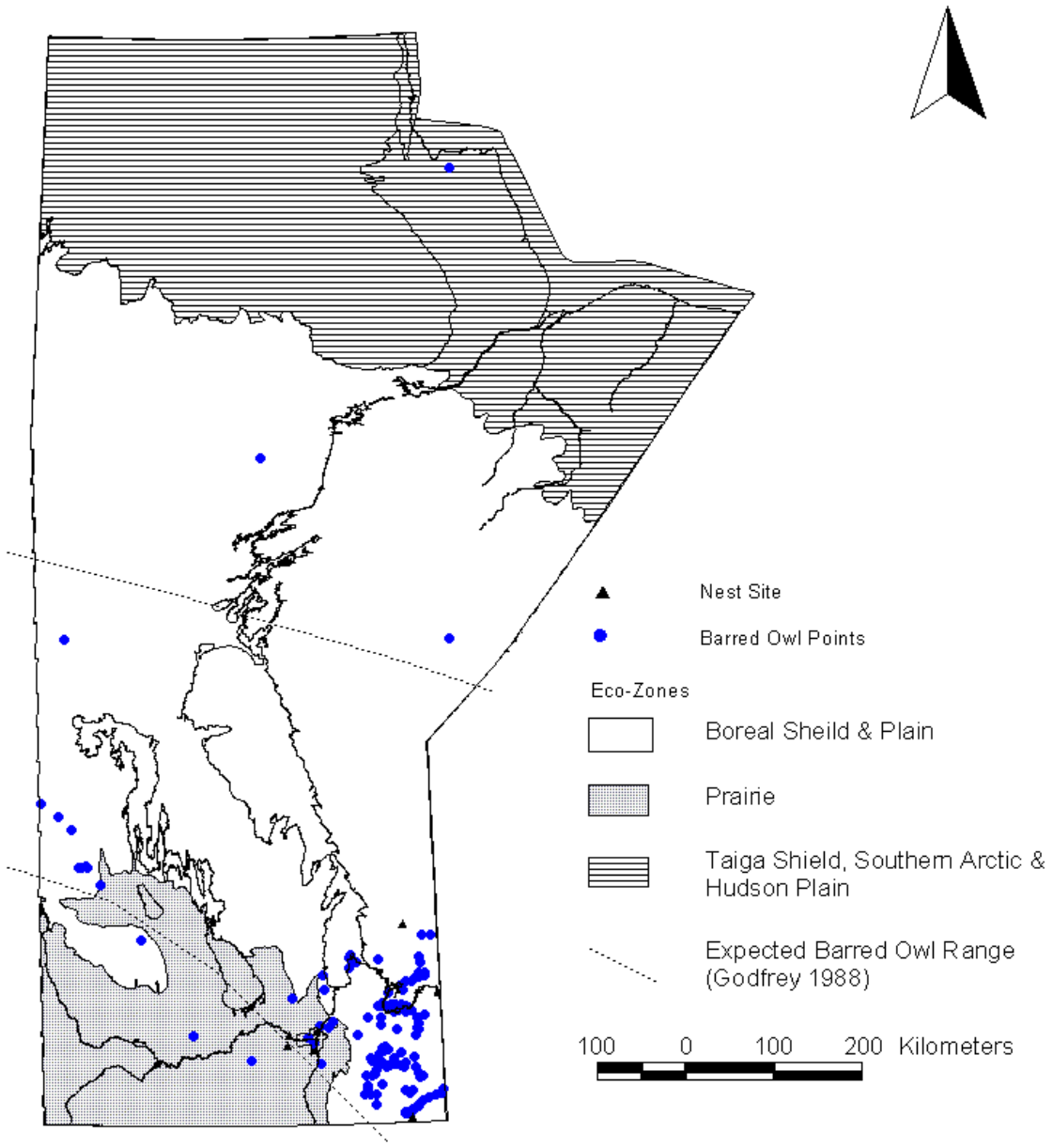

Figure 1.2: Range of the Barred Owl (*S. varia*) in Manitoba, Canada.
(used with permission by J.R. Duncan, Manitoba Conservation)

Freeman 2000). Studies like these provide little information to preserve Barred Owl populations (Livezey 2009a, Livezey 2009b), and in some cases, promotes the removal of Barred Owls by lethal and non-lethal means to conserve Spotted Owls (Livezey *et al*. 2007, Livezey 2010). Without a more concerted research effort focused on Barred Owls across their entire range, regulations to conserve populations cannot be developed and implemented. Such research is needed to determine the effect and severity of interspecific competition between Barred Owls and Spotted Owls and if the removal of Barred Owls, by lethal and non-lethal means, is necessary.

The goal of this study is to shed light on an under-studied species by providing basic data on habitat requirements, behaviour, breeding and diet. Although Barred Owls are a wide-ranging species, the data provided from my study will assist with its conservation across North America. Similar studies elsewhere in its range will assist wildlife managers to prevent the extirpation of local populations in light of ever expanding human use of forest resources.

CHAPTER I: CHARACTERISTICS OF NEST TREES AND NESTING STRUCTURES OF BARRED OWLS (*STRIX VARIA*) IN MANITOBA, CANADA.

INTRODUCTION

Barred Owls have nested on the ground (Robertson 1959), in earthen cavities (Shackleford 1996), in man-made structures (Houston 1999), in witch's brooms, on squirrel nests, and on stick nests built by other bird species, but are considered primarily as a secondary cavity-nester (Mazur *et al.* 1997a, Mazur *et al.* 1997b). They use tree cavities created by other species, disease, rot and/or damage to the tree (Mazur *et al.* 1997a, Vaillancourt *et al*. 2009). Reliance on large diameter trees for nesting has led the Barred Owl to be considered as a indicator species of forest health (McGarigal and Fraser 1985). Secondary cavity nesting also means that nest site availability limits its distribution, population size and density (Robertson and Rendell 1990).

A highly adaptable species (Robertson 1959, Shackleford 1996), the Barred Owl is less impacted by human activity than other owl species (Kelly *et al*. 2003, Houston 1999). However, nesting requirements must be met in order to maintain avian populations (Robertson and Rendell 1990). These parameters are poorly documented for the species as a whole (Mazur *et al.* 1997a), and specifically in Manitoba. Objectives were to: 1) locate and document active Barred Owl nest sites, 2) identify nest tree species and characterize nest structure dimensions, and 3) compare and contrast the variation in Barred Owl nest structure use in Manitoba and elsewhere in its range.

METHODS

Study Area

Areas of high Barred Owl activity were selected through an analysis of Manitoba Nocturnal Owl Survey data (J.R. Duncan and H. Hinam, Unpubl. Data). Other historical accounts of Barred Owls were examined (Duncan and Kearns 1997), along with records of dead or injured birds (J.R. Duncan, Unpubl. Data). Coordinates from all these sources were plotted using GoogleEarth©. Areas of consistent or recent Barred Owl activity were considered for further surveying. Adjacent areas with similar habitat or forest density were also considered for surveying. The study area was southern Manitoba north to 53º 52.673'N. (Fig. 1.3).

Locating Breeding Pairs and Nests

Barred Owl territories were located using audio playback and passive observation during the breeding season (February – June in 2009 and 2010) (Frith *et al.* 1997, Winton and Leslie, Jr. 2004).

- Recorded Barred Owl calls were broadcast (Appendix A) after sunset at one-kilometer intervals along roads or trails.
- A playback loop of Barred Owl calls (Appendix A), approximately 3 minutes in length, was broadcast at each interval, followed by a 5-minute listening period.
- GPS points were recorded at all sites where vocal or visual responses to the audio lure were detected.
- These points were transferred to GoogleEarth© for mapping (Fig. 1.4 – 1.5).

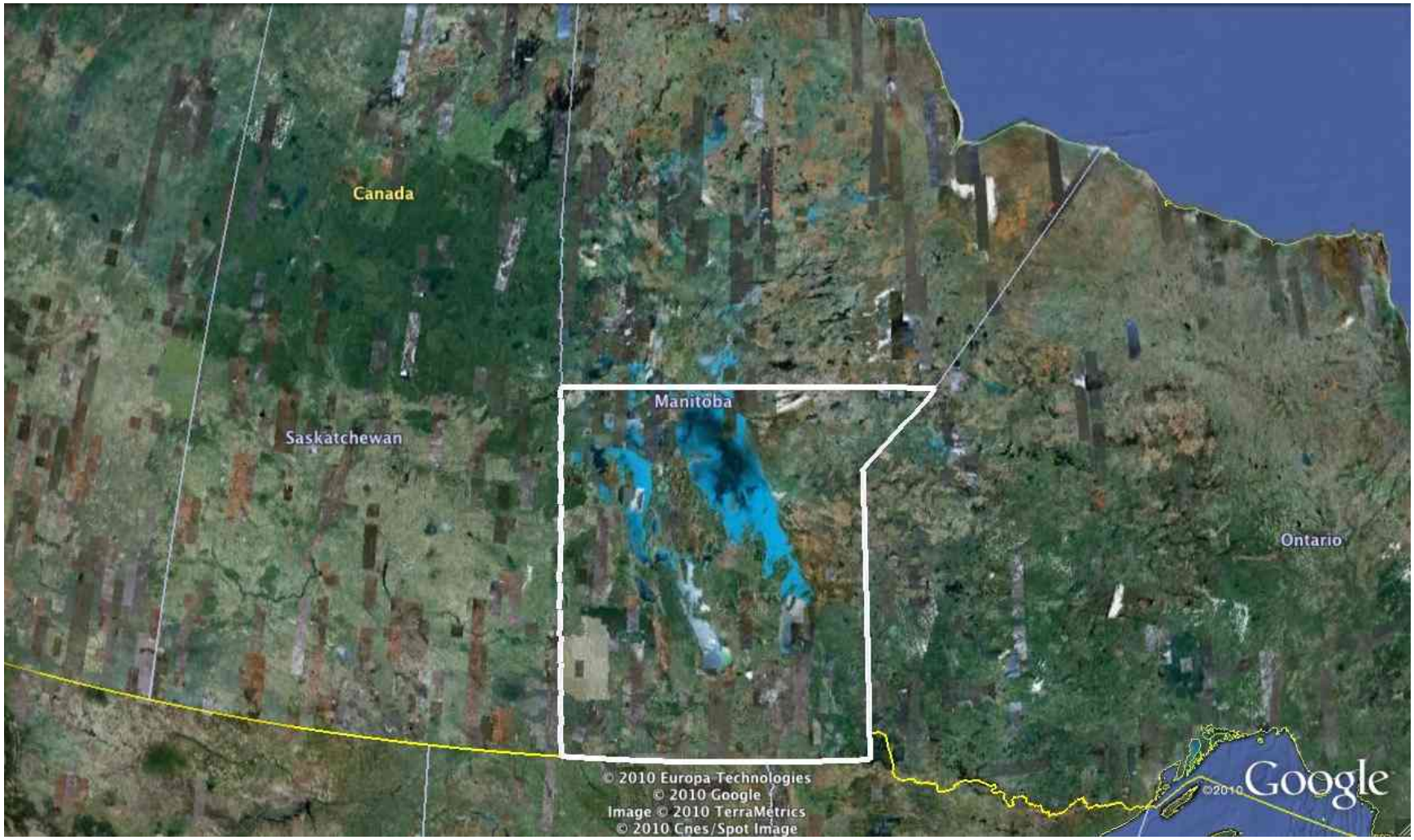

Figure 1.3: Barred Owl Study Area in Manitoba, Canada (2009-2010).

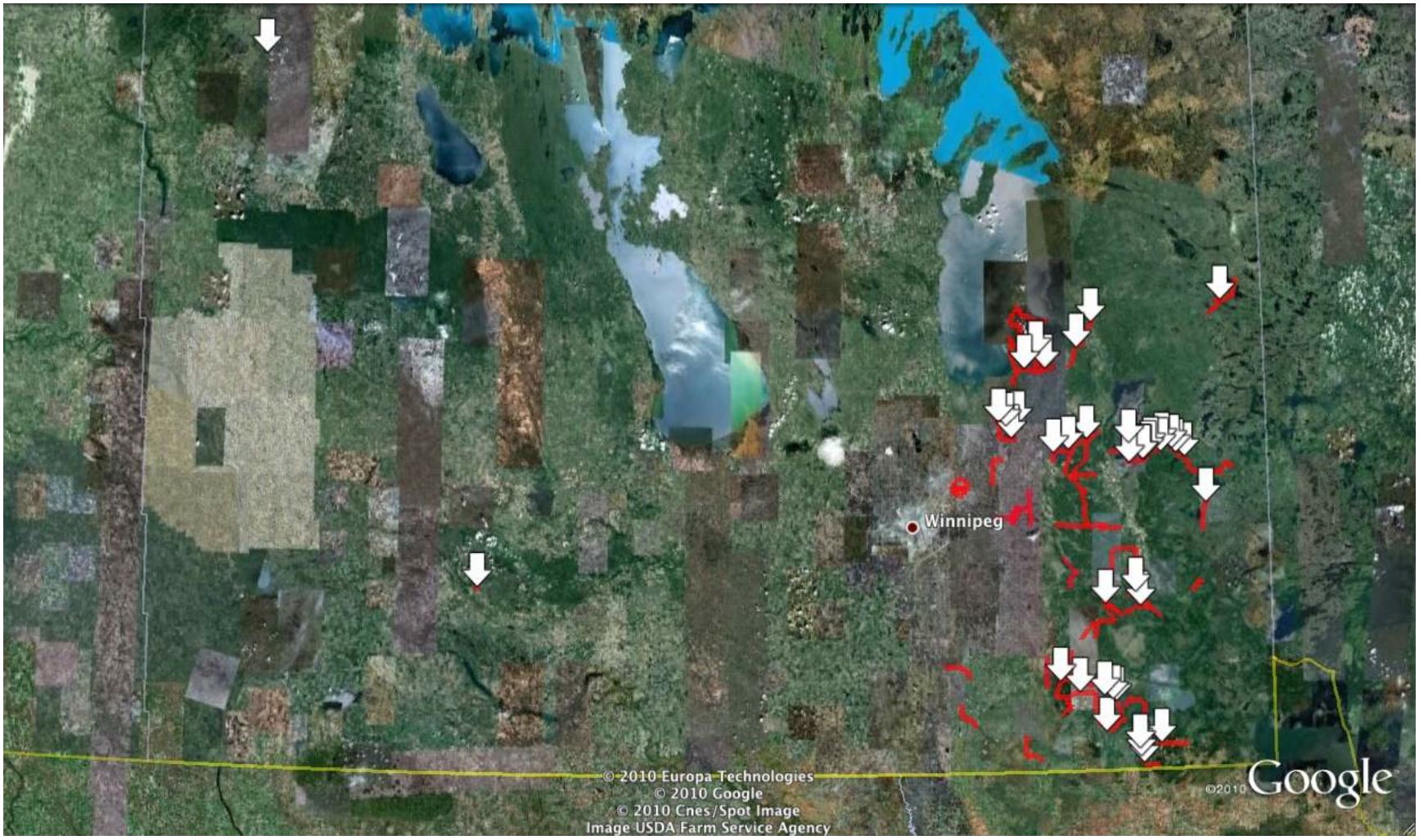

Figure 1.4: Transects Surveyed and Barred Owl Encounter Points for 2009 in Manitoba, Canada.

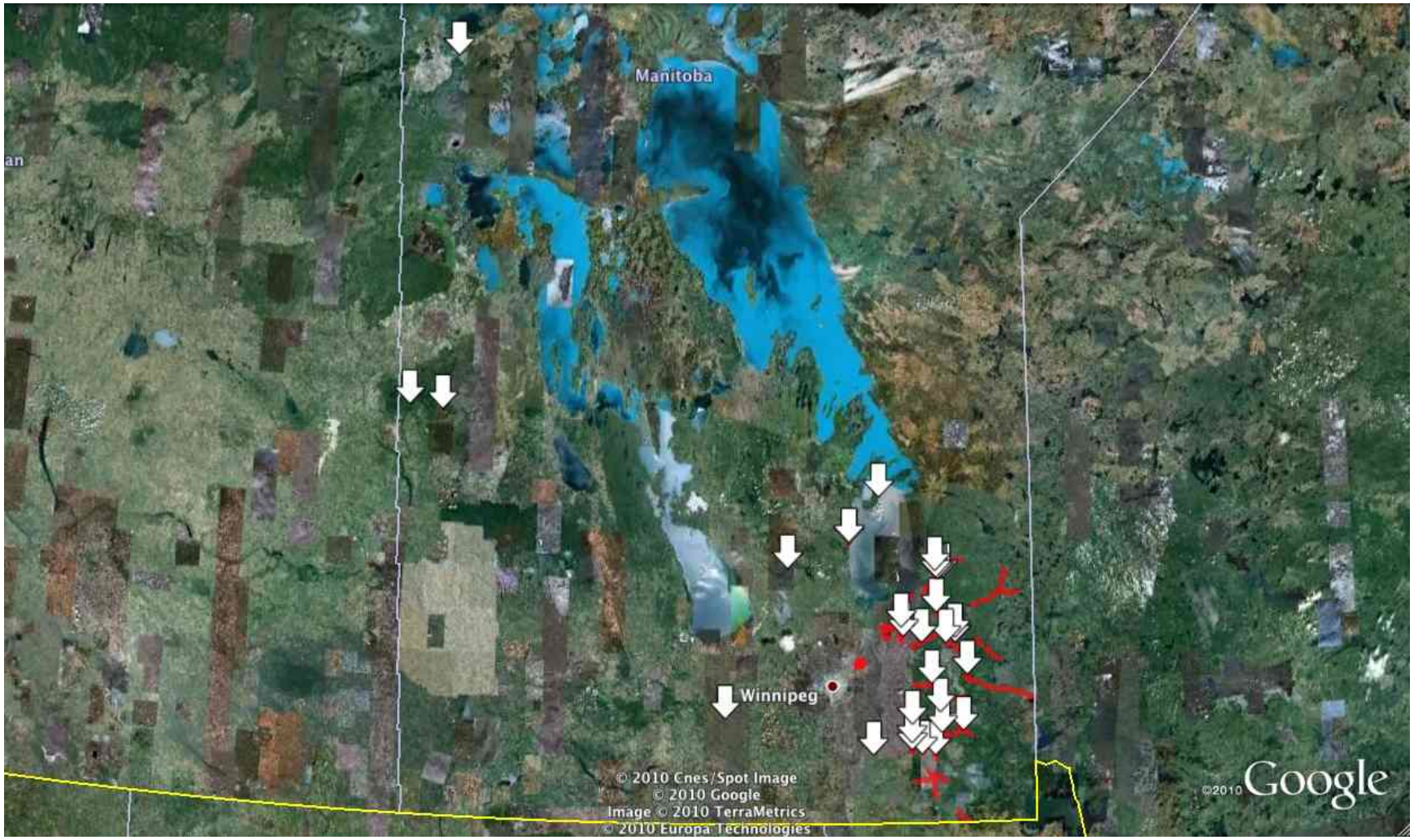

Figure 1.5: Transects Surveyed and Barred Owl Encounter Points for 2010 in Manitoba, Canada.

Locations where both male and female Barred Owls were heard "caterwauling" (Odom and Mennill 2010) or seen were considered a potential breeding pair. A search was made for active nests in these "high priority locations". Further surveying of "high priority locations" using playback was conducted in the weeks following initial detections. Locations of Barred Owl vocalizations at these sites over successive evenings were used to triangulate the nest search area, followed by diurnal nest searches, as this behaviour is indicative of nesting activity within 500 m of the audio survey location (Frith *et al.* 1997).

Audio playback of female Barred Owl calls (Appendix B) was used to initiate contact with nesting pairs during daylight hours. Females were identified when both owls were calling in close proximity to the audio lure. Females were followed as they returned to their nests. Possible nest trees were visually inspected for signs of breeding activity using binoculars and/or a wireless digital video camera on an extendable pole (Tree-Top Peeper®, Sandpiper Technologies, CA). Breeding owls and nests were also detected by any combination of the following:

- aggressive reaction of the breeding pair when I was in close proximity to the nest;
- presence of feathers and/or pellets near a suitable tree;
- knocking on suitable tree trunks causing an owl to emerge from the nest;
- vocalizations or the presence of young Barred Owls in or near their nests.

Methods for nest searching were expanded in 2010 to include following radio marked owls to active nest sites. Barred Owls on territories were lured close enough to trap for banding and to attach radio transmitters with a broadcast of a taped Barred Owl

call (Appendix A). Owls were offered live mice (*Mus musculus*) in a bal-chatri trap, a wire cage with 20 lb test monofilament nooses attached to it (Berger and Meuller 1959). Owls were trapped when their toes or feet were ensnared in the nooses and they could not fly away with the heavy trap. Owls were disentangled from the trap, measured, marked and released. In cases where an owl became "trap shy" (had struck the bal-chatri trap and failed to be snared) or was naturally wary of the bal-chatri trap, refusing to attempt a strike, a mist net was used (Elody and Sloan 1984) to capture it. A live mouse was placed on a 15cm x 25cm plywood platform 60cm off the ground, in front of a mist net. The owls were caught in the net as they approached or flew over the lure animal.

Once owls had been captured, they were banded (with Canadian Wildlife Service Bird Banding Office issued bands) and fitted with a 17gram radio transmitter (21mm x 20mm x 40mm, from Lotek Wireless, Inc.) (Fair *et al.* 2010). Radio transmitters were tied to the two central rectrices and set with Instabond ™ glue. Antennae were also glued to the length of the central rectrix. Owls were measured, marked, and released within 30 minutes of capture. Diurnal nest searching on foot followed, as described for year one, with the assistance of radio telemetry.

Characterization of Barred Owl Nest Structures and Nest Trees

A detailed description of each nest tree was recorded, including species, condition, tree height, diameter at breast height (DBH), nest height, diameter at nest height (DNH), and nest type. Both DBH and DNH were calculated by measuring the circumference of the tree at each respective location, then inputting into the formula:

$$\boldsymbol{D = C / \pi}$$

Tree height was determined with the use of a Suunto™ PM-5/1520 clinometer or, when possible, with a tape measure. Nest height was determined by measuring from the lowest part of the cavity opening to the ground, with a tape measure.

Nest tree condition was categorized as good (living with no visible damage or disease), partial damage (living with visible damage or disease), or standing snag (dead but standing at $\geq$ 45º from the ground).

Nest type was categorized as apex cavity (any cavity found at the apex of a trunk or branch, where the opening faces approximately 180º from the ground) or, lateral cavity (any cavity found on the tree where the opening does not face 180º from the ground).

Detailed descriptions of nest structures used were also generated. Cavity opening size, approximate cavity or platform size, and a description of nest substrate material were recorded. Cavity opening was measured as the circumference of the opening. In the case of apical cavities, this measurement would be diameter at nest. Only useable portions of a cavity opening were measured. Cavity openings may have long channels extending outward due to continued deterioration of the nest tree (Fig. 1.6), of which any that were too small to provide access to the nesting cavity were excluded from this measurement. Approximate cavity and platform size was recorded as the volume of each nest. Cavity volume was calculated by the product of cavity height (greatest vertical distance from the nesting substrate up to the nesting cavity roof or top of the nesting structure), cavity depth (distance from the cavity opening to the farthest point in a straight line to the back of the nesting cavity), and cavity width (the distance that is at 90º to the height and depth). Platform volume was calculated by platform height (greatest vertical

Figure 1.6: Image Depicting Cavity Extensions Caused by Deterioration.

distance to the uppermost edge of the platform), platform width (greatest distance across the platform), and platform depth (distance across the platform at 90º to the platform width). Lateral cavity type nests had the orientation of the opening recorded.

Data Analysis

Numerical data were log transformed and non-numerical data were transformed into a presence/absence table prior to analysis. Both presence/absence data and numerical data had the lowest obtained value (1) added to each value before log transformation, to deal with the inability to log transform values of zero. Principal Component Analysis (PCA) was used to determine which parameters among all nest trees and nesting structures were most prevalent and thus most important in nest selection. Nest sites were compared using PCA to determine which nest sites were similar to each other.

RESULTS

Locating Breeding Pairs and Nests

Over the two breeding seasons, 62 breeding territories were located (2009 (Fig. 1.4) – 2010 (Fig. 1.5)). Of these territories, 26 were located by the presence of both male and female adult owls. One territory was located via the collection of an injured fledgling owl. One territory was located through the collection of molted Barred Owl feathers. The remaining 34 territories were located via the presence/vocalization of either the male or female adult owl. Nine active nests were located in Agassiz Provincial Forest, Bél-air Provincial Forest, Hadashville area, Mars Hills area, Sandilands area, Whiteshell Provincial Park, Woodridge area, and the Wampum Ecological Preserve (Fig. 1.7).

Figure 1.7: Barred Owl Nest Sites Located in Manitoba, Canada (2009-2010).

Capture techniques proved to be time consuming and non-productive. Several attempts were made to lure in owls and capture them using various recognized raptor-trapping methods. None of the nest sites found during the course of this study were located with the assistance of radio telemetry.

Characterization of Barred Owl Nest Structures and Nest Trees

Nest tree data are summarized in Table 1.1. Five of the nests were found in Balsam Poplar (*Populus balsamifera*), two in Paper Birch (*Betula papyrifera*), one in Trembling Aspen (*Populus tremuloides*), and one in Burr Oak (*Quercus macrocarpa*). Six of the nine nest trees were standing snags, with the remaining three being partially damaged trees. All nine nests were located in cavity type nests. One-third of the nests (3) were apical and two-thirds (6) were lateral in orientation. Cavity-opening orientations of the six lateral cavities were south-southeast, south-southwest, north-northeast, south, north-northeast, and southeast, respectively. Tree height ranged from 5.41 to 29.35m, with a mean and standard deviation of 14.2m ± 9.0m. Nest height ranged from 5.41 to 12.11m, with a mean and standard deviation of 7.7m ± 2.6m. Diameter at breast height ranged from 33.3 to 95.5cm, with a mean and standard deviation of 49.2cm ± 18.9cm. Diameter at nest height ranged from 27.5 to 108.3cm, with a mean and standard deviation of 46.9cm ± 24.7cm. Cavity area ranged from 0.0241 to 0.4854m^3, with a mean and standard deviation of 0.1029m^3 ± 0.1472m^3. Cavity opening circumference ranged from 83.1 to 180cm, with a mean and standard deviation of 134.6cm ± 75.5cm, with one nest lacking cavity-opening data.

Table 1.1: Barred Owl Nest Structure Data for Manitoba, Canada (2009-2010).

	Site 4	Site 5	Site 11	Site 20	Site 27	Site 31	Site 36	Site 55	Site 56	**Mean**	**± SD**
Year	2010	2009	2009	2009	2009	2009	2009	2010	2010		
Tree Species	*Populus Balsamifera*	*Betula papyrifera*	*Populus Balsamifera*	*Populus Balsamifera*	*Populus Balsamifera*	*Populus Balsamifera*	*Betula papyrifera*	*Populus Tremuloides*	*Quercus macrocarpa*		
Tree Cond'n	Snag	Snag	Snag	Snag	Partial Damage	Snag	Snag	Partial Damage	Partial Damage		
Nest Orientation	Lateral	Apex	Lateral	Lateral	Lateral	Apex	Apex	Lateral	Lateral		
Nest Type	Cavity	Cavity	Cavity	Cavity	Cavity	Cavity	Cavity	Cavity	Cavity		
Cavity Orientation	NNE	N/A	SSE	SSW	NNE	N/A	N/A	S	SE		
Tree Height (m)	7.8	7.4	19.7	8.1	20.9	5.8	5.4	23.0	29.4	**14.2**	**9.0**
Nest Height (m)	4.5	7.4	10.2	6.4	12.1	5.8	5.4	7.6	9.9	**7.7**	**2.6**
DBH (cm)	43.1	42.9	50.0	39.7	56.2	33.7	33.3	48.7	95.5	**49.2**	**18.9**
DNH (cm)	36.6	33.0	50.6	40.9	54.1	27.5	29.4	41.8	108.3	**46.9**	**24.7**
Cavity Height (cm)	68.8	24.9	156.0	121.1	67.9	11.4	42.0	102.2	52.2	**71.8**	**46.9**
Cavity Depth (cm)	26.4	32.9	127.0	22.8	35.9	22.3	29.8	30.8	51.0	**42.1**	**33.0**
Cavity Width (cm)	27.8	29.4	24.5	26.1	35.9	21.5	21.2	35.1	24.0	**27.3**	**5.4**
Estimated Cavity Area (m^3)	0.1	0.0	0.5	0.1	0.1	0.0	0.0	0.1	0.1	**0.1**	**0.1**
Cavity Opening Circumference (cm)	147.0	103.7	300.0	83.1	180.0	86.3	92.4	84.0	N/A	**134.6**	**75.5**

Transformed data used for further analysis are displayed in Table 1.2. Due to the variation in tree species used, in this and other studies (Mazur *et al.*, 1997a, Mazur *et al*. 1997b), and the strong correlation between tree species and cavity orientation, tree species data were removed prior to PCA. Figure 1.8 displays the PCA bi-plot for nest tree data. The first axis contained 73.45% of the variation in the data set and the cumulative percent of variation of the first two axes was 87.11%. Sites 5, 31, and 36 were grouped together, sites 4, 20, and 11 were grouped together, and sites 27, 55, and 56 were grouped together. Short vectors show limited variation within the data set as a whole.

DISCUSSION

When considering the bi-plot, variation within the data set was based mainly on tree height, DBH, and DNH. Variation along the second axis was mainly due to cavity orientation (lateral versus apical).

The group of sites 5, 31,and 36 all consisted of apical cavities in standing snags of either *B. papyrifera* (n=2) or *P. balsamifera* (n=1). Sites 4, 11 and 20 were grouped due to both having lateral cavities in standing snags of *P. balsamifera* (n=3). Sites 27, 55, and 56 were all lateral cavities in partially damaged large *P. balsamifera* (n=1), *P. tremuloides* (n=1), and *Q. macrocarpa* (n=1). Although the main axis showed the most variation based on tree height, DBH, and DNH, the groupings and variation were better described based on tree size and cavity orientation. Group 1 (site 5, 31, 36) included smaller sized trees with apical cavities, group 2 (site 4, 11, 20) included smaller sized trees with lateral cavities, and group 3 (site 27, 55, 56) included larger sized trees with lateral cavities. Due to the multiple tree species utilized in this and other studies (Mazur

Table 1.2: Log Transformed Barred Owl Nest Tree Data for Manitoba, Canada (2009-2010).

	Populus balsamifera	*Betula papyrifera*	*Populus tremuloides*	*Quercus macrocarpa*	Snag	Partial Damage	Lateral Cavity	Apex Cavity	Tree Height	Nest Height	DBH	DNH
Site 4	0.30	0.00	0.00	0.00	0.30	0.00	0.30	0.00	0.95	0.74	1.64	1.58
Site 5	0.00	0.30	0.00	0.00	0.30	0.00	0.00	0.30	0.92	0.92	1.64	1.53
Site 11	0.30	0.00	0.00	0.00	0.30	0.00	0.30	0.00	1.32	1.05	1.71	1.71
Site 20	0.30	0.00	0.00	0.00	0.30	0.00	0.30	0.00	0.96	0.87	1.61	1.62
Site 27	0.30	0.00	0.00	0.00	0.00	0.30	0.30	0.00	1.34	1.12	1.76	1.74
Site 31	0.30	0.00	0.00	0.00	0.30	0.00	0.00	0.30	0.83	0.83	1.54	1.45
Site 36	0.00	0.30	0.00	0.00	0.30	0.00	0.00	0.30	0.81	0.81	1.54	1.48
Site 55	0.00	0.00	0.30	0.00	0.00	0.30	0.30	0.00	1.38	0.93	1.70	1.63
Site 56	0.00	0.00	0.00	0.30	0.00	0.30	0.30	0.00	1.48	1.04	1.98	2.04

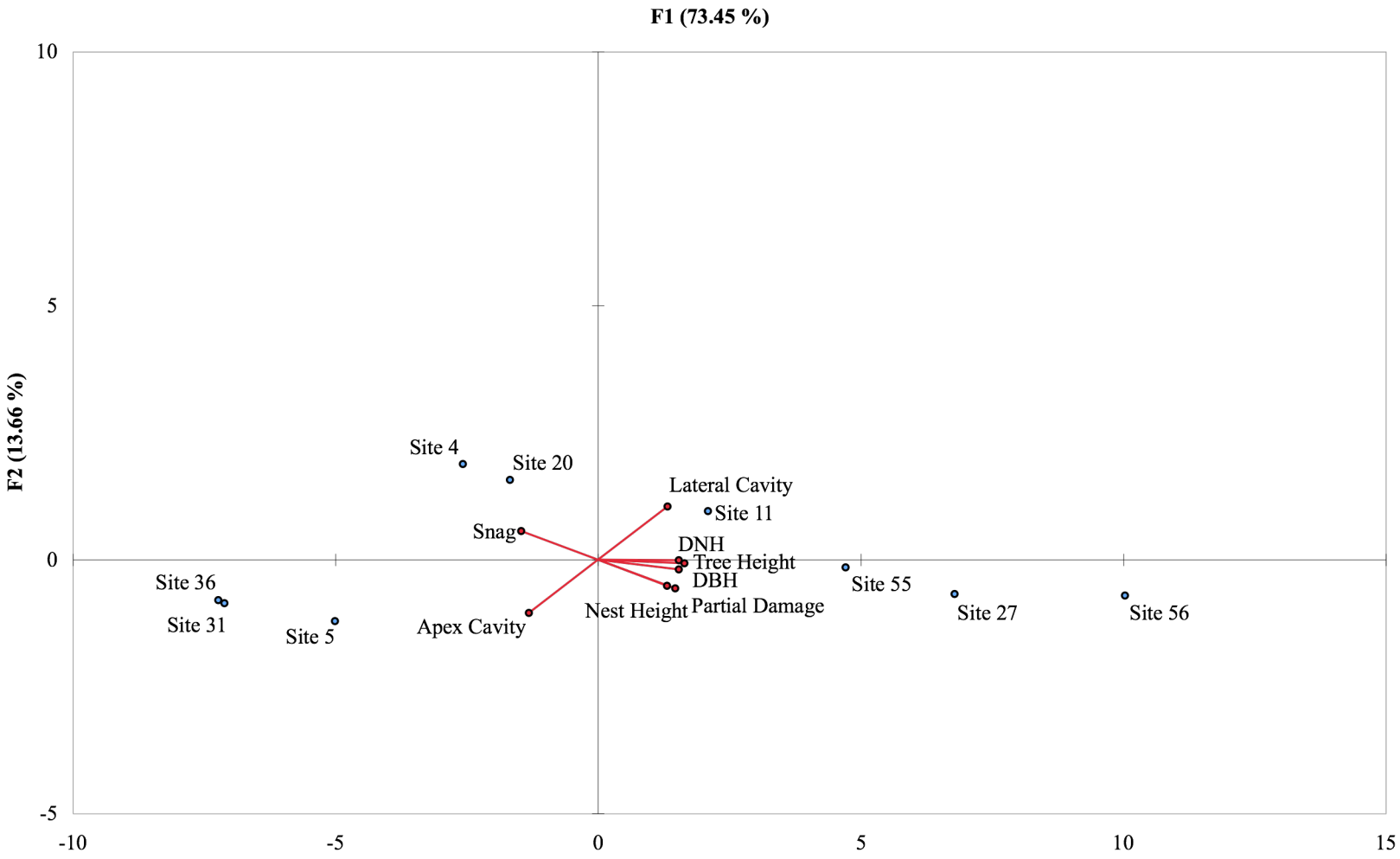

Figure 1.8: Bi-plot for Barred Owl Nest Tree Data in Manitoba, Canada (2009-2010).

et al., 1997a, Mazur *et al.* 1997b), tree species appears not to be a determining factor in Barred Owl nesting.

DBH weighed heavily on the data set and may be an indicator of suitability for Barred Owl nesting. Mazur *et al.* (1997a) recorded an average DBH of 47.4 cm ± 12.8cm (n=15), which was similar to my findings of average DBH = 49.2cm ± 18.9cm, despite recording higher values for tree height (18.8m ± 6.2m) and nest height (13.3m ± 4.1m) than this study. Mazur *et al.* (1997a) also located 30% of their sample nests in structures other than cavities, and showed differences in tree species utilized (*Picea glauca* n=5, *B. papyrifera* n=1, *P. balsamifera* n=4, *P. tremuloides* n=5) from this study. Olsen *et al.* (2006) recorded an average DBH of 51.6cm ± 13.6cm, similar to this study, along with higher average tree height (16.0m ± 8.2m) and nest height (10.4m ± 6.6m). However, Olsen *et al.*'s (2006) sample contained only *P. balsamifera* (n=8) and *P. tremuloides* (n=2) and 90% of nests were cavity type. With relatively large differences in some variables between these studies, e.g., nest structures and tree species, the similarities in DBH values suggest it is a valid indicator of nest tree suitability for breeding Barred Owls.

Cavity dimensions provided other nest tree suitability indicators. Although many cavity dimensions recorded provided unreliable data, due to high standard deviation, values for cavity depth and width were more consistent. Cavity width was remarkably consistent (27.3cm ± 5.4cm) across the varying tree species and sizes. There was no correlation between DBH, DNH, tree species and cavity width, and no obvious outlier in the sample. Cavity depth, at first glance, appears inconsistent (42.1cm ± 33.0cm) and invaluable for further study. However, much of the deviation about the mean can be

attributed to Site 11, this cavity was elongated and lacked a definitive ceiling or floor (Fig. 1.6). Advanced stages of decay had weakened the basic framework of the cavity, making accurate measurement difficult and leading to the collapse of the tree during the second year of study. When Site 11 was treated as an outlier and removed from the data set, mean cavity depth = 31.5cm ± 9.2cm and mean cavity width = 27.6cm ± 5.6cm. Postupalsky *et al*. (1997) recorded mean cavity width = 26.9cm (range = 18-44cm) (n=25) over two study areas, but lacked cavity depth measurements (as defined in this study) or standard deviations. Regardless, the similarities in cavity width necessitate further study.

In contrast to Mazur *et al.* (1997a) and Olsen *et al.* (2006), 100% of nests found in this study were found in tree cavities, a fact corroborated by the lack of Barred Owls found nesting on a total of 2,527 natural or artificial stick platform nests checked for nesting owls over a 27 year-period (1984-2010) in southeastern Manitoba (J. R. Duncan, Pers. Comm.b). The importance of hear trot in hardwood species to cavity-nesting animals, as well as the role of snags in an ecosystem is well documented (Witt 2010, Thomas *et al.* 1979), but these conditions are not exclusive to Manitoba. The differences in Barred Owl nest type use across studies may be influenced by how study areas are selected or defined. This study encompassed a large area with more varied habitat than smaller areas studied elsewhere: Mazur *et al.*'s (1997a) study was conducted within a national park, and Olsen *et al.* (2006) studied a 400km^2 predetermined area. Smaller study areas, or protected areas, may be limited in nesting opportunities or contain greater intraspecific competition, resulting in a greater variety of nest structures used by breeding Barred Owls.

CHAPTER II: HABITAT USE OF BARRED OWLS (*STRIX VARIA)* IN MANITOBA, CANADA (2009 – 2010).

INTRODUCTION

Barred Owls occupy a variety of nest types, but are primarily considered a secondary cavity nester (Mazur *et al.* 1997a). Barred Owls use forest types down a gradient from hardwood to mixedwood to coniferous forests (Nicholls and Warner 1972). Hardwood forests are rare throughout a large portion of their northern range, leaving only mixedwood and mostly boreal forest (Duncan and Kearns 1997). Nest site availability is a limiting factor for cavity-nesters within these northern forests (Robertson and Rendell 1990) and may affect the distribution of Barred Owls.

Forestry activities can have a heavy impact on cavity nesting species by reducing or eliminating available nesting opportunities (Vaillancourt *et al*. 2009), as both forestry companies and cavity nesting species select for mature forest stands (Hodson 2003, McGarigal and Fraser 1984, Potvin *et al*. 2000). Forestry management is said to reduce the complexity of forests (Andruskiw 2003), affecting all aspects of a cavity-nester's life history strategies (Hodson 2003). Response rates of Barred Owls decrease in areas of forest management and agricultural activity (McGarigal and Fraser 1984). Artificial nesting opportunities have shown some promise is offsetting anthropogenic effects on cavity-nesters (McComb and Noble 1981, Smallwood and Collopy 2009, Smallwood *et al*. 2009).

The link between large cavity-nesting species and mature stands of mixedwood forests is known (McGarigal and Fraser 1984, Potvin *et al*. 2000, Hodson 2003, Payer and Harrison 2003). However, little empirical evidence has been offered to explain what

impact anthropogenic activities have on cavity-nesters (McGarigal and Fraser 1984, Vaillancourt *et al*. 2009). Without a solid understanding of what factors create suitable Barred Owl habitat, management of cavity-nesting species cannot be accomplished. Objectives were to: 1) document habitat associated with active Barred Owl nest sites, 2) compare habitat within estimated Barred Owl home ranges with same-sized random plots, and 3) determine which habitat variables are most closely associated with Barred Owls in Manitoba.

METHODS

Study Area

The study area was southern Manitoba north to 53º 52.673'N (Fig. 1.3). All survey transects were run during the Barred Owl's breeding season using methods and survey transects described in Chapter 1.

Barred Owl breeding pairs were located during audio surveys and nest sites were located (see nest searching discussed in Chapter 1). Barred Owl habitat use was examined at two scales: immediately around nest trees and within breeding and non-breeding home ranges.

Characterization of Barred Owl Nest Tree Habitat

A 30-meter diameter plot, with the nest tree at the center, was studied to obtain percent cover, tree species composition, seedling/sapling/tree ratios, and ground cover composition. Plots consisted of two vectors radiating in orthagonal directions across the projected center of the nest tree trunk, four pegs were used to indicate the external limit

of the plot. Direction of the first 30-meter vector was randomly set, followed by the second vector at 90º to the first. Virtual lines were used to connect pegs, completing the circular plot.

All mature trees (height ≥2m) within the 30-meter plot had their species recorded and diameter at breast height categorized as 0-10cm, 11-20cm, 21-30cm, or >30cm. Trees with their trunk straddling the virtual line delineating the 30-meter plot were considered as part of the plot.

A detailed inventory of the habitat around nest trees was conducted. Canopy coverage was recorded as total percent cover of the 30-meter plot. Canopy cover from trees outside the 30-meter plot was not considered in the percent cover calculation. Nest tree canopy cover was considered, if applicable in the percent cover calculation.

Seedling/sapling/tree ratios were calculated, by categorizing all trees within or straddling the line delineating the 30-meter plot as seedling (0-50cm in height), sapling (51-199cm in height), or tree (≥ 2m in height).

Ground cover composition was recorded as a percent cover on the entire 30-meter plot, in the categories of grasses, mosses, sedges, forbs, lichens, and shrubs. Due to the overlapping nature of plant species, total percent cover for a 30-meter plot may have exceeded 100%.

Each plot was labeled with the Manitoba Forest Inventory categorization (Zoladeski *et al*. 1995) that most closely described the species and conditions found at that plot.

Comparison of Forest Habitat Variables between Barred Owl Home Range Plots and Random Plots

Barred Owl breeding and non-breeding home ranges were estimated as circular plots equal in size (148.5ha and 1234.1ha, respectively) to breeding and non-breeding home ranges estimated by Mazur *et al.* (1998) and centered on either an estimated Barred Owl location (from audio survey data) or a nest tree (where applicable) located during this study. Random plot points were created on a one-to-one basis with Barred Owl home ranges. For example, two random plot points were created along a survey transect line that yielded two Barred Owl territories. Random plot points were created by a random number generator and were only accepted if they fell within 1 kilometer of a survey transect route, to remain consistent with Barred Owl home ranges, and if the associated breeding and non-breeding home range plot sizes did not overlap with Barred Owl home range plots or other generated random plots.

Forest habitat variables within Barred Owl territories and same-sized random plots were measured using Forest Resource Inventory (FRI) and Earth Observation for Sustainable Development of Forests (EOSD) databases and analyzed.

Data Analysis

One sample t-tests were run on canopy and ground cover data. A constant value (1) was added to tree species composition data to deal with the inability to log transform values of zero and then were log transformed prior to analysis. Principal Component Analysis (PCA) was used to determine which sites were similar and if trends in tree species composition or forest stand age existed.

FRI and EOSD variables (Appendix C and D) were compared between Barred Owl breeding home range plots and same-sized random plots, and between Barred Owl non-breeding home range plots and same-sized random plots. Two-tailed t-tests were run for each variable between the pairings. Any variable that displayed a significant difference was subjected to both an upper and lower one-tailed t-test.

RESULTS

Characterization of Barred Owl Nest Tree Habitat

Nine active nests were located in Agassiz Provincial Forest, Bél-air Provincial Forest, Hadashville area, Mars Hills area, Sandilands area, Whiteshell Provincial Park, Woodridge area, and Wampum Ecological Preserve.

Data for nest tree habitat associated with the nine nest sites are summarized in Table 2.1. Canopy cover had a mean and standard deviation of 42.8% ± 27.2%, grass cover had a mean and standard deviation of 23.9% ± 30.1%, moss cover had a mean and standard deviation of 13.8% ± 14.4%, sedge cover had a mean and standard deviation of 21.9% ± 27.7%, forb cover had a mean and standard deviation of 31.7% ± 28.3% and shrub cover had a mean and standard deviation of 44.4% ± 37.5%. Lichen cover was 0.0% for all sites. One sample t-tests resulted in significant differences between sites in canopy cover ($p = 0.001$), grass cover ($p = 0.044$), moss cover ($p = 0.021$), sedge cover ($p = 0.045$), forb cover ($p = 0.010$), and shrub cover ($p = 0.007$). Lichen cover could not be analyzed due to lack of data.

Sites 4, 5, 11, and 36 were categorized as Manitoba forest classification V1 (balsam poplar hardwood and mixedwood). Sites 27 and 55 were categorized as

Table 2.1: Barred Owl Nest Tree Habitat Data for Manitoba, Canada (2009 - 2010).

	Site 4	Site 5	Site 11	Site 20	Site 27	Site 31	Site 36	Site 55	Site 56	Mean	SD (±)	p (1 sample t-test)
Year	2010	2009	2009	2009	2009	2009	2009	2010	2010			
Canopy Cover (%)	30	35	60	0	70	75	5	50	60	42.8	27.2	0.001
Grasses (%)	80	55	0	0	0	5	30	0	45	23.9	30.1	0.044
Mosses (%)	5	1	30	30	25	30	1	2	0	13.8	14.4	0.021
Sedges (%)	10	15	0	70	60	0	2	40	0	21.9	27.7	0.045
Forbs (%)	10	10	45	15	15	85	20	70	15	31.7	28.3	0.010
Lichens (%)	0	0	0	0	0	0	0	0	0	0.0	0.0	N/A
Shrubs (%)	40	95	50	0	15	10	90	85	15	44.4	37.5	0.007
Estimated Tree/sapling/seedling Ratio	10:1:1	10:1:1	10:1:1	0:0:0	10:2:1	2:4:1	2:2:1	100:5:1	100:1:1			
Manitoba Forest Classification	V1	V1	V1	N/A*	V2	V21	V1	V2	V3			
Tree Species Composition												
Abies balsamea												
<10cm	0	0	83	0	2	61	0	0	0			
<20cm	1	0	14	0	0	3	0	0	0			
<30cm	1	0	4	0	0	3	0	0	0			
>30cm	0	0	0	0	0	0	0	0	0			
Acer negundo												
<10cm	0	0	0	0	0	0	0	0	4			
<20cm	0	0	0	0	0	0	0	0	0			
<30cm	0	0	0	0	0	0	0	0	0			
>30cm	0	0	0	0	0	0	0	0	0			
Betula papyrifera												
<10cm	1	0	0	0	0	0	3	0	0			
<20cm	0	2	0	0	0	1	0	2	0			
<30cm	0	0	0	0	0	0	0	0	0			
>30cm	0	0	0	0	0	0	1	0	0			
Fraxinus nigra												
<10cm	0	9	24	0	0	0	0	37	1			
<20cm	0	5	0	0	0	0	1	0	0			

Table 2.1: Continued.

<30cm	0	0	0	0	0	0	0	0	0
>30cm	0	0	0	0	0	0	0	0	0
Larix laricina									
<10cm	0	0	0	0	0	0	0	0	0
<20cm	2	0	0	0	0	0	0	0	0
<30cm	1	0	0	0	0	0	0	0	0
>30cm	0	0	0	0	0	0	0	0	0
Picea glauca									
<10cm	2	0	0	0	31	23	0	3	0
<20cm	1	0	0	0	2	17	0	0	0
<30cm	1	0	0	0	0	15	0	0	0
>30cm	0	0	0	0	0	3	0	1	0
Populus balsamifera									
<10cm	1	0	0	0	8	1	20	3	0
<20cm	0	1	0	0	2	1	0	3	0
<30cm	1	0	0	0	6	5	0	2	0
>30cm	0	0	2	0	0	11	0	0	0
Populus tremuloides									
<10cm	1	12	0	0	0	0	13	3	0
<20cm	2	11	0	0	0	0	1	3	0
<30cm	2	3	1	0	0	1	0	10	0
>30cm	3	0	6	0	0	0	0	1	0
Quercus macrocarpa									
<10cm	0	0	0	0	0	0	0	0	170
<20cm	0	0	0	0	0	0	0	0	2
<30cm	0	0	0	0	0	0	0	0	0
>30cm	0	0	0	0	0	0	0	0	0
Thuja occidentalis									
<10cm	0	0	0	0	0	0	0	0	0
<20cm	0	0	0	0	0	0	0	0	0
<30cm	0	0	0	0	0	1	0	0	0

Table 2.1: Continued.

>30cm	0	0	0	0	0	0	0	0	0
Ulmus americana									
<10cm	0	0	0	0	67	0	0	0	4
<20cm	0	0	0	0	16	0	0	0	1
<30cm	0	0	0	0	1	0	0	0	0
>30cm	0	0	0	0	0	0	0	0	0
Total									
<10cm	5	21	103	0	106	85	36	46	179
<20cm	6	19	14	0	20	23	2	6	3
<30cm	6	3	5	0	7	13	0	12	0
>30cm	3	0	8	0	0	12	1	2	0
Sum	20	43	130	0	133	133	39	66	182

***** Unclassifiable under Manitoba Forest Classification criteria due to lack of living woody vegetation.

Manitoba forest classification V2 (black ash hardwood). Site 31 was categorized as Manitoba forest classification V21 (white spruce/balsam fir shrub). Site 56 was categorized as Manitoba forest classification V3 (miscellaneous hardwoods). Site 20 was unclassifiable under the criteria of the Manitoba forest classification system, due to the elevated water table and lack of living trees.

Tree/sapling/seedling ratio varied widely (Table 2.1), reflecting the variation in forest succession stages associated with Barred Owl nest trees, and could not be analyzed further.

Tree species composition varied widely between sites, with 11 of the 16 tree species native to Manitoba (Zoladeski *et al*. 1995) being found in one or more sites.

Site 4 was in a boggy area with interspersed sections of dense/dry mixed-wood forest. The nest tree itself was located in a low open area, populated by sparse tree (*Populus* spp. and *L. laricina*) cover and high water table.

Site 5 was predominately hardwood, with a closed canopy reducing ground cover. Values for site 5 were lower than the surrounding forest because much of the 30m plot fell onto the ditch and a provincial road right of way (Fig. 2.1). The ditch and right of way lacked woody vegetation, canopy cover, and consisted of grasses and forbs. Although this area needed to be included in the data to remain consistent with the protocol, it was not indicative of the surrounding breeding habitat.

Site 11 was in a mature mixedwood forest with an even proportion of deciduous and coniferous species. Located in Bél-air Provincial Forest, disturbance to the area was limited to an old cut-line within 80m of the nest tree. Damp conditions and wind damage did cause patchiness within the vicinity of the nest.

Figure 2.1: Provincial Road and Approach Present at Site 5, Manitoba, Canada.

Site 20 lacked living trees and therefore had no tree species composition (Fig. 2.2). Canopy cover was comprised of standing snag limbs. Beaver (*Castor canadensis*) activity in the area had blocked a stream and raised the water table. Ground cover consisted of submerged mosses and sedges, and vegetation growing on hummocks and on the beaver dam.

Site 27 was in a mature mixedwood forest, with predominately hardwood species and smaller stands of conifers interspersed. This site was found within a protected provincial park. However, the plot was less than 50m from a disturbed hydro line right-of-way.

Site 31 was a predominately coniferous forest, with a small hardwood component. This site was the most mature stand of forest containing a nest site. While this site appeared pristine, it was on private land and near an active human residence. A cabin with a cleared yard, ATV trails, and a gravel pit were all within 100m of the plot.

Site 36 was an early successional mixed-wood forest resulting from logging in recent years. In addition to the nesting snag, only a few mature trees remained in the vicinity of the plot. Due to the advanced stage of deterioration of the nesting snag and the accumulation of nesting material found within the cavity, this nest is believed to have been active before logging occurred in the area.

Site 55 was located in Agassiz Provincial Forest, in a mature mixed-wood forest, with *Populus* spp. comprising the majority of the mature trees. This site was located within 100m of two ATV trails, a forestry road, and an older (>5 year old) clear cut. Areas of high water table were found on three sides of the nest tree, contributing to a high number of standing snags and downed woody material in the plot.

Figure 2.2: Lack of Living Trees and Elevated Water Table Present at Site 20, Manitoba, Canada.

Site 56 was located along the Brokenhead River on private property, with little mature tree cover. Perhaps owing to human disturbance and seasonal riparian flooding, tree cover was low and immature and the nest tree was the largest tree in the area. This site was subjected to more disturbance than any other site in this study. A yard site was located to the north, a hydro clearance was located to the south, pastureland was located to the west, and the river was located to the east.

Log transformed tree species composition data can be found in Table 2.2. Figure 2.3 displays the PCA bi-plot for tree species/tree size of Barred Owl nest tree habitat. Most sites were widely spaced across the bi-plot, variable vectors were long and the maximum variation across the data set that could be presented was only 45.66% (Axis 1 = 26.35%, Axis 2 = 19.31%). These factors suggested high variability throughout the sites.

Comparison of Forest Habitat Variables Between Barred Owl Home Range and Random Plots

Table 2.3 displays FRI data (Appendix C) for paired Barred Owl breeding home range plots and same-sized random plots. Two-tailed t-tests resulted in no significant difference for hectares of water ($p = 0.903$), mixedwood[a] ($p = 0.198$), non-forested land ($p = 0.062$), non-productive land ($p = 0.084$), softwood ($p = 0.167$), and lacking data ($p = 0.316$). There was a significant difference in hectares of hardwood ($p = 0.003$) and mixedwood[b] ($p = 0.009$). Barred Owl breeding home range plots had significantly more

[1] $p = (\text{Mean } 1 - \text{Mean } 2 < 0)$
[a] See Appendix C.
[b] See Appendix C.

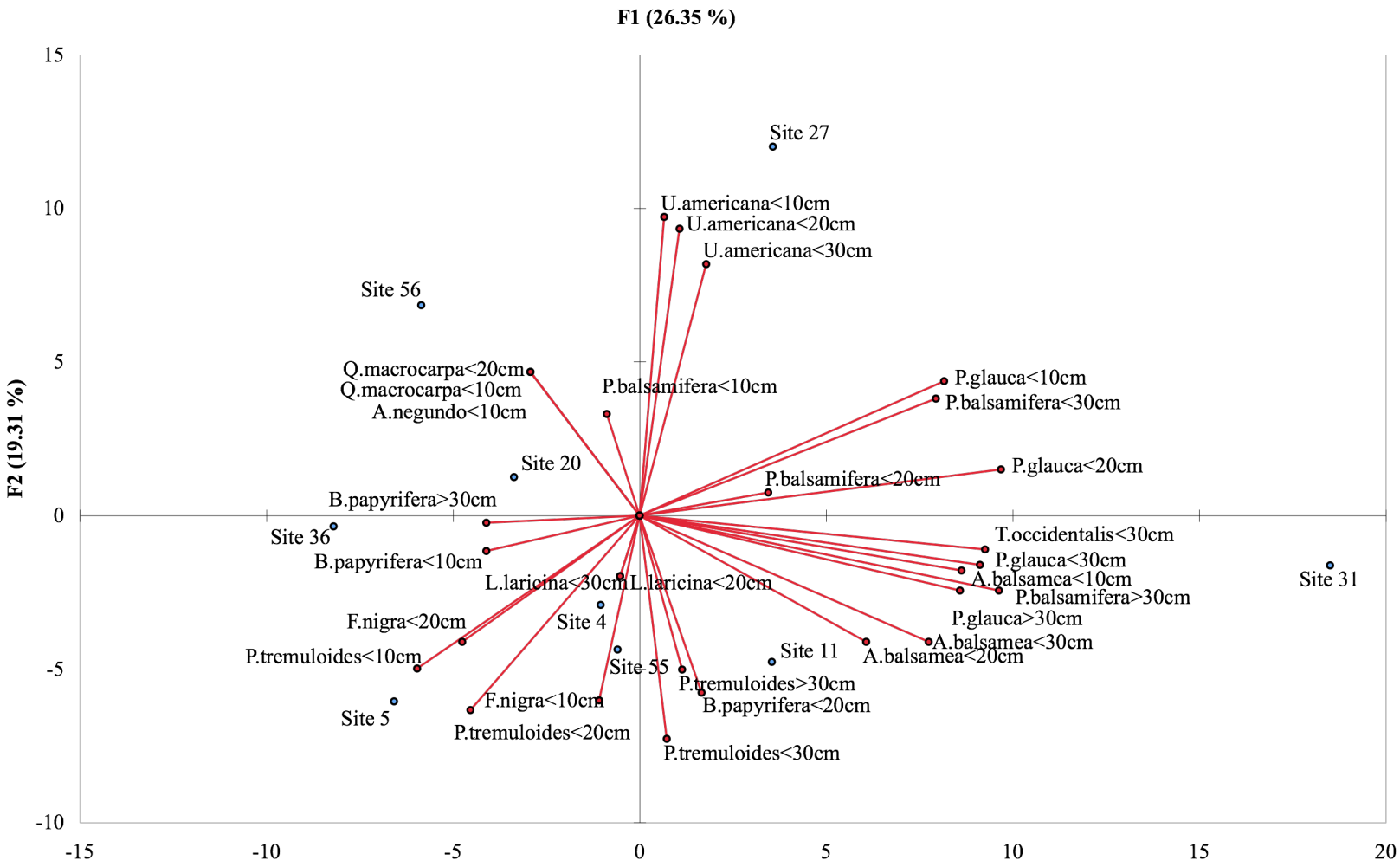

Figure 2.3: Biplot for Barred Owl Nest Tree Habitat Data in Manitoba, Canada (2009 - 2010).

Table 2.2: Log Transformed Barred Owl Nest Tree Habitat Data for Manitoba, Canada (2009 - 2010).

	Site 4	Site 5	Site 11	Site 20	Site 27	Site 31	Site 36	Site 55	Site 56
Abies balsamea<10cm	0.000	0.000	1.924	0.000	0.477	1.792	0.000	0.000	0.000
Abies balsamea<20cm	0.301	0.000	1.176	0.000	0.000	0.602	0.000	0.000	0.000
Abies balsamea<30cm	0.301	0.000	0.699	0.000	0.000	0.602	0.000	0.000	0.000
Abies balsamea>30cm	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Acer negundo<10cm	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.699
Acer negundo<20cm	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Acer negundo<30cm	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Acer negundo>30cm	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Betula papyrifera<10cm	0.301	0.000	0.000	0.000	0.000	0.000	0.602	0.000	0.000
Betula papyrifera<20cm	0.000	0.477	0.000	0.000	0.000	0.301	0.000	0.477	0.000
Betula papyrifera<30cm	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Betula papyrifera>30cm	0.000	0.000	0.000	0.000	0.000	0.000	0.301	0.000	0.000
Fraxinus nigra<10cm	0.000	1.000	1.398	0.000	0.000	0.000	0.000	1.580	0.301
Fraxinus nigra<20cm	0.000	0.778	0.000	0.000	0.000	0.000	0.301	0.000	0.000
Fraxinus nigra<30cm	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fraxinus nigra>30cm	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Larix laricina<10cm	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Larix laricina<20cm	0.477	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Larix laricina<30cm	0.301	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Larix laricina>30cm	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Picea glauca<10cm	0.477	0.000	0.000	0.000	1.505	1.380	0.000	0.602	0.000
Picea glauca<20cm	0.301	0.000	0.000	0.000	0.477	1.255	0.000	0.000	0.000
Picea glauca<30cm	0.301	0.000	0.000	0.000	0.000	1.204	0.000	0.000	0.000
Picea glauca>30cm	0.000	0.000	0.000	0.000	0.000	0.602	0.000	0.301	0.000
Populus balsamifera<10cm	0.301	0.000	0.000	0.000	0.954	0.301	1.322	0.602	0.000
Populus balsamifera<20cm	0.000	0.301	0.000	0.000	0.477	0.301	0.000	0.602	0.000
Populus balsamifera<30cm	0.301	0.000	0.000	0.000	0.845	0.778	0.000	0.477	0.000
Populus balsamifera>30cm	0.000	0.000	0.477	0.000	0.000	1.079	0.000	0.000	0.000
Populus tremuloides<10cm	0.301	1.114	0.000	0.000	0.000	0.000	1.146	0.602	0.000
Populus tremuloides<20cm	0.477	1.079	0.000	0.000	0.000	0.000	0.301	0.602	0.000
Populus tremuloides<30cm	0.477	0.602	0.301	0.000	0.000	0.301	0.000	1.041	0.000
Populus tremuloides>30cm	0.602	0.000	0.845	0.000	0.000	0.000	0.000	0.301	0.000
Quercus macrocarpa<10cm	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.233
Quercus macrocarpa<20cm	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.477
Quercus macrocarpa<30cm	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Quercus macrocarpa>30cm	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Thuja occidentalis<10cm	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Thuja occidentalis<20cm	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Thuja occidentalis<30cm	0.000	0.000	0.000	0.000	0.000	0.301	0.000	0.000	0.000
Thuja occidentalis>30cm	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ulmus americana<10cm	0.000	0.000	0.000	0.000	1.833	0.000	0.000	0.000	0.699
Ulmus americana<20cm	0.000	0.000	0.000	0.000	1.230	0.000	0.000	0.000	0.301
Ulmus americana<30cm	0.000	0.000	0.000	0.000	0.301	0.000	0.000	0.000	0.000
Ulmus americana>30cm	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 2.3: Forest Resource Inventory Data for Estimated Barred Owl Breeding Home Ranges and Same Sized Random Plots in Manitoba, Canada (hectares).

Same Sized Random Plots															
Water	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.0	0.0
Hardwood	20.8	96.8	83.6	0.0	3.1	12.9	0.0	45.0	0.0	0.0	0.0	86.2	28.9	0.0	22.9
Mixedwood[a] (conifers 51- 75%)	1.2	0.0	0.0	0.0	1.9	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mixedwood[b] (conifers 26 - 50%)	2.0	0.0	0.0	0.0	3.4	17.6	0.0	0.7	0.0	0.0	0.0	6.0	0.0	0.0	15.9
Non-Forested Land	14.2	4.7	40.0	22.5	3.9	5.4	0.0	14.5	10.0	7.9	0.0	45.2	98.7	0.0	0.0
Non-Productive Land	37.9	33.7	24.7	37.5	0.8	1.0	73.9	77.2	0.0	0.0	102.4	11.2	10.2	21.7	63.2
Softwood	71.2	13.3	0.2	88.5	135.4	106.1	74.6	11.3	138.5	140.5	46.1	0.0	10.7	82.8	46.4
No data (blank)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Estimated Barred Owl Territories															
Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.1	0.0	3.6	0.0	0.0	2.0	1.3	0.0
Hardwood	4.1	82.9	73.3	80.2	41.3	49.2	133.7	63.1	26.8	41.6	42.6	112.6	59.0	14.3	24.3
Mixedwood[a] (conifers 51- 75%)	0.0	0.0	29.5	19.3	0.0	0.6	2.7	8.2	16.4	24.5	9.4	25.6	11.0	0.0	15.7
Mixedwood[b] (conifers 26 - 50%)	29.9	0.0	16.5	1.1	32.1	7.8	1.2	14.4	17.0	0.0	36.7	8.3	30.4	45.3	48.8
Non-Forested Land	20.8	5.9	19.0	9.9	10.4	0.0	0.0	20.5	0.8	19.6	5.4	0.0	12.3	27.0	24.6
Non-Productive Land	8.7	0.0	1.9	36.2	40.4	79.7	0.0	10.7	11.7	3.0	9.4	0.0	10.4	47.0	30.9
Softwood	85.0	59.7	8.3	1.8	24.3	11.2	10.9	11.4	75.7	56.3	45.0	2.0	23.4	13.6	4.2
No data (blank)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2.3: Continued.

Same Sized Random Plots																		
0.0	4.4	16.8	0.0	0.0	0.0	0.0	0.0	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	
43.6	51.7	76.0	16.9	60.8	6.5	39.1	0.0	9.4	5.7	67.4	14.8	0.0	15.5	0.0	0.1	0.0	66.1	86.0
0.0	19.8	27.8	4.0	0.0	0.0	36.5	0.0	0.0	0.0	10.9	0.0	0.0	0.0	0.0	0.0	0.0	17.6	0.0
0.0	17.1	0.0	14.0	0.0	0.0	44.5	0.0	0.0	21.2	0.0	0.0	0.0	0.0	0.0	0.5	0.0	18.3	0.0
92.5	13.1	20.2	26.2	23.3	6.5	0.0	148.5	134.6	107.0	0.0	122.6	148.5	133.0	52.7	22.4	14.8	19.3	0.0
7.2	0.0	7.7	52.3	61.3	43.9	0.0	0.0	0.0	0.0	3.1	11.0	0.0	0.0	69.3	81.1	114.8	26.3	39.8
5.2	42.3	0.0	35.1	3.0	91.5	28.5	0.0	0.0	14.6	67.1	0.0	0.0	0.0	26.5	44.4	18.8	0.0	22.6
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Estimated Barred Owl Territories																		
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.3	35.8	0.6	0.0	8.2	15.0	0.0	8.5
21.1	75.8	95.1	19.5	49.2	1.9	45.2	33.1	97.4	89.3	80.0	32.5	0.0	0.0	35.3	28.3	61.0	24.0	25.6
0.0	12.3	4.7	16.8	12.1	43.3	61.2	1.4	0.0	6.9	0.0	0.0	0.0	43.7	2.6	9.3	0.0	0.0	0.0
0.0	21.5	17.4	25.1	37.4	25.7	11.6	26.2	3.2	22.0	5.1	0.0	0.0	41.9	74.0	10.4	0.0	7.0	63.5
0.0	29.3	9.0	27.4	12.8	15.6	14.0	13.4	13.1	6.3	37.5	96.9	8.9	24.4	19.6	32.2	67.6	8.0	27.4
108.3	9.5	22.3	6.0	4.8	26.4	13.1	11.6	1.2	0.0	3.5	9.8	40.0	5.0	17.0	19.4	4.8	19.8	8.9
19.1	0.0	0.1	53.7	32.3	35.6	3.3	62.8	33.5	23.9	22.5	0.0	63.8	32.8	0.0	40.7	0.0	89.6	14.6
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2.3: Continued.

Same Sized Random Plots																		
0.0	76.4	0.0	0.0	0.1	2.6	27.0	32.8	0.0	0.0	0.0	0.0	3.2	0.0	0.0	0.0	0.0	0.0	0.0
3.0	36.7	64.0	16.6	77.5	13.1	30.0	6.0	11.6	44.5	55.6	52.0	41.1	51.0	76.5	60.2	6.1	0.0	74.2
3.5	0.0	1.6	0.0	18.3	47.0	10.1	31.4	19.0	0.0	0.0	0.0	9.0	4.2	13.8	7.7	20.4	0.0	0.0
13.9	9.6	35.7	0.0	17.3	5.6	38.6	19.0	3.4	0.0	0.0	0.0	74.2	15.3	17.9	25.6	25.2	0.0	0.0
0.0	0.2	20.4	47.7	35.2	14.0	42.7	26.2	8.1	104.0	92.9	96.5	14.6	14.9	7.6	6.3	0.0	0.0	56.8
101.6	25.6	6.1	40.4	0.0	2.2	0.2	13.2	4.8	0.0	0.0	0.0	1.2	48.8	6.1	18.1	0.4	54.3	16.8
26.5	0.0	20.7	43.8	0.0	63.9	0.0	19.8	101.7	0.0	0.0	0.0	5.2	14.3	26.5	30.6	96.4	94.2	0.6
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Estimated Barred Owl Territories																		
0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	7.6	0.0	0.0	0.0	0.0	31.6	75.7	3.3	0.0	0.0	0.0
46.2	40.9	103.2	0.0	109.2	83.2	94.7	45.4	52.3	21.3	61.7	44.2	74.8	18.8	5.8	104.0	49.6	78.7	0.0
0.0	6.9	0.0	70.7	0.0	0.0	0.0	0.0	0.0	5.6	0.0	2.9	0.0	0.0	0.0	0.0	0.0	27.4	0.0
0.0	0.0	0.0	0.0	0.0	11.5	34.9	0.0	0.0	59.9	0.0	25.4	0.0	0.0	14.9	26.2	40.2	0.0	32.6
47.8	2.3	7.2	24.8	6.0	6.6	6.3	95.6	88.6	0.0	84.4	13.4	73.7	98.1	3.2	6.3	6.2	10.4	0.5
35.2	46.3	38.1	21.5	27.4	9.1	6.4	0.0	0.0	5.5	2.3	3.8	0.0	0.0	48.8	0.0	5.6	0.0	0.0
19.3	52.0	0.0	4.1	5.8	38.2	6.3	0.0	0.0	56.2	0.0	58.8	0.0	0.0	0.0	8.7	46.7	31.9	115.4
0.0	0.0	0.0	27.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0

Table 2.3: Continued.

SUM	MEAN	SD (±)	p (2 tailed t-test)	p^1 (Mean1-Mean2<0)	p^2 (Mean1-Mean2>0)
213.9	4.0	13.2	0.903		
1679.5	31.7	30.2	*0.003*	*0.001*	*0.999*
311.3	5.9	10.7	0.198		
462.5	8.7	14.5	*0.009*	*0.004*	*0.996*
1940.0	36.6	44.6	0.062		
1353.1	25.5	31.3	0.084		
1909.6	36.0	41.2	0.167		
0.0	0.0	0.0	0.316		
230.0	4.3	12.4			
2697.6	50.9	34.1			
490.7	9.3	15.7			
926.9	17.5	19.0			
1221.1	23.0	27.3			
871.6	16.4	21.3			
1404.5	26.5	28.0			
27.6	0.5	3.8			

hectares of hardwood ($p^1 = 0.001$) and mixedwood[b] ($p^1 = 0.004$), than same-sized random plots.

Table 2.4 displays FRI data for paired Barred Owl non-breeding home range plots and same-sized random plots. Two-tailed t-tests resulted in no significant difference for hectares of water ($p = 0.97$), non-forested land ($p = 0.20$), non-productive land ($p = 0.25$), softwood ($p = 0.48$), and lacking data ($p = 0.61$). A significant difference was seen in hectares of hardwood ($p = 0.04$), mixedwood[a] ($p = 0.03$) and mixedwood[b] ($p = 0.03$). Barred Owl non-breeding home range plots had significantly more hectares of hardwood ($p^1 = 0.02$), mixedwood[a] ($p^1 = 0.01$) and mixedwood[b] ($p^1 = 0.01$), than same-sized random plots.

Figure 2.4 displays crown closure data for Barred Owl breeding home ranges and same-sized random plots obtained from FRI data. Crown closure class 0 (Appendix C) comprised the majority of Barred Owl home ranges at ~88%. Barred Owl home ranges did contain more crown closure class 4 (Appendix C) than random plots, although the difference was not significant ($P = 0.140$).

Table 2.5 displays EOSD data (Appendix D) for paired Barred Owl breeding home range plots and same-sized random plots. Two-tailed t-tests resulted in no significant difference for hectares of broadleaf – open ($p = 0.64$), coniferous – dense ($p = 0.29$), coniferous – open ($p = 0.99$), coniferous – sparse ($p = 0.65$), exposed/barren land ($p = 0.41$), herbs ($p = 0.09$), mixedwood – dense ($p = 0.43$), mixedwood – open ($p = 0.32$), water ($p = 0.90$), shrub low ($p = 0.53$), shrub tall ($p = 0.64$), wetland – herb ($p = 0.72$),

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[1] p = (Mean 1 – Mean 2 < 0)
[a] See Appendix C.
[b] See Appendix C.

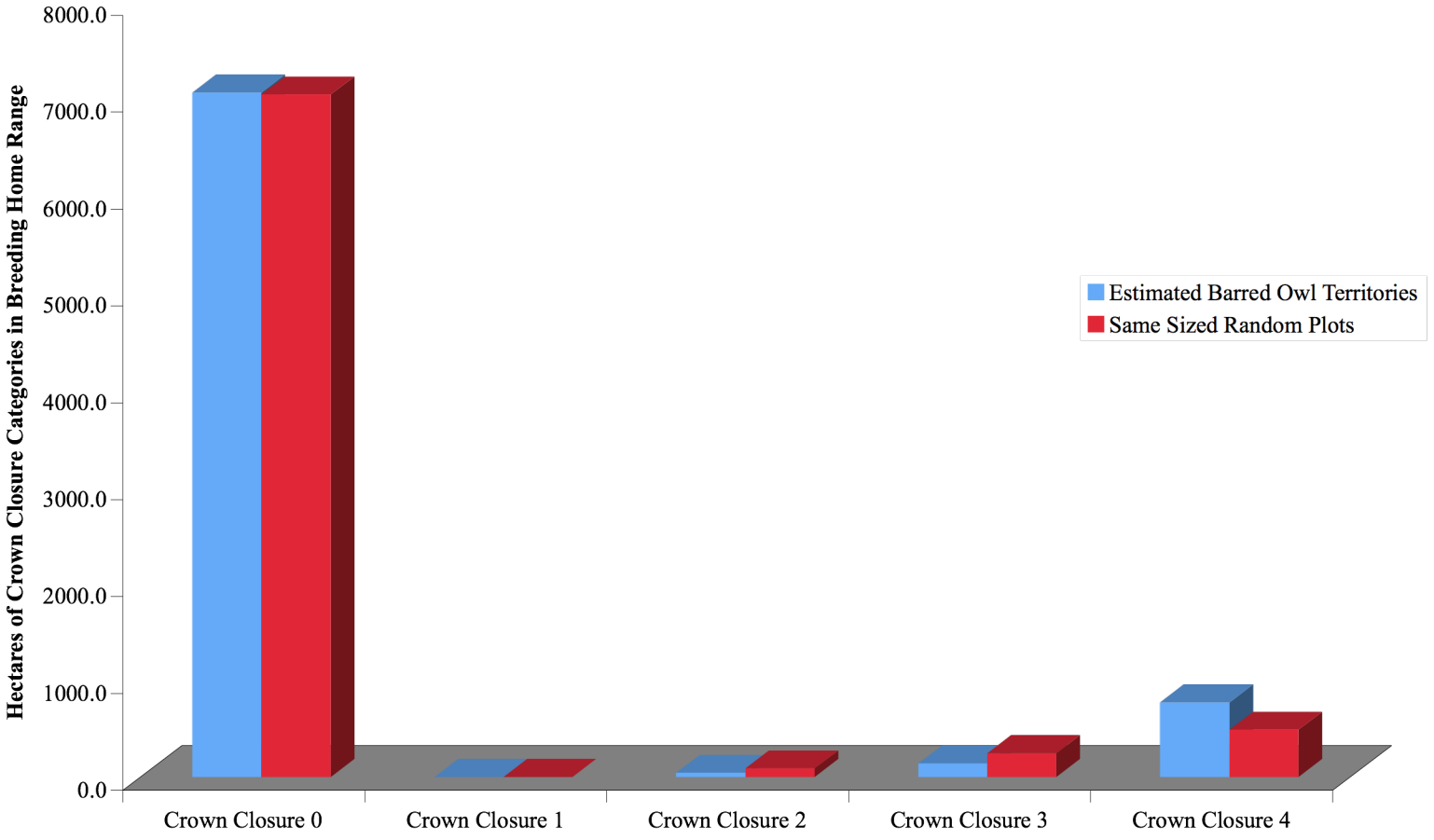


Figure 2.4: Forest Resource Inventory Crown Closure for Estimated Barred Owl Breeding Home Ranges and Same Sized Random Plots in Manitoba, Canada.

Table 2.4: Forest Resource Inventory Data for Estimated Barred Owl Non-Breeding Home Ranges and Same Sized Random Plots in Manitoba, Canada (hectares).

Same Sized Random Plots															
Water	29.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	287.1	0.0
Hardwood	107.3	736.1	651.6	43.9	17.6	92.5	35.5	487.6	276.6	73.4	47.4	543.0	257.5	5.5	203.7
Mixedwood[a] (conifers 51- 75%)	32.0	0.0	8.4	13.9	9.5	76.2	0.0	4.0	24.0	18.3	6.4	0.0	1.4	0.0	40.3
Mixedwood[b] (conifers 26 - 50%)	48.2	4.0	5.3	5.1	67.6	44.7	20.6	30.9	35.4	89.0	1.9	12.3	31.5	0.0	61.4
Non-Forested Land	192.8	110.1	334.5	81.3	34.4	88.3	19.2	91.0	88.1	50.2	213.8	216.5	536.0	41.6	27.8
Non-Productive Land	313.0	305.7	220.2	474.7	18.9	85.8	615.2	415.2	142.3	0.0	542.7	264.2	209.4	180.5	508.3
Softwood	511.0	78.2	14.0	615.2	1086.2	846.6	543.7	205.3	667.6	1003.2	418.1	196.4	198.2	719.4	392.6
No data (blank)	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0	0.0	0.0
Estimated Barred Owl Territories															
Water	0.0	0	0	0	0	0	0	65.9	0	13.3	178.5	0	370.4	55.4	138.5
Hardwood	55.0	448.0	374.0	564.2	247.8	328.2	728.8	307.6	168.9	375.8	192.7	554.1	191.7	157.6	91.8
Mixedwood[a] (conifers 51- 75%)	11.1	58.4	101.4	102.7	50.4	16.5	165.7	75.6	53.5	64.7	160.5	136.0	94.1	17.8	90.1
Mixedwood[b] (conifers 26 - 50%)	190.3	38.1	103.9	92.5	104.2	42.5	87.2	281.3	74.4	41.5	196.0	106.8	114.0	200.4	260.5
Non-Forested Land	54.6	167.0	181.3	96.6	70.1	204.5	17.4	174.3	30.1	243.5	106.6	64.3	114.1	225.1	153.7
Non-Productive Land	121.8	179.9	99.4	210.0	567.4	504.9	17.4	192.9	156.6	10.6	85.6	217.2	55.4	403.5	358.7
Softwood	801.2	342.7	374.2	168.1	194.3	137.6	217.7	136.5	750.5	484.7	314.1	155.7	294.4	174.4	140.9
No data (blank)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2.4: Continued.

Same Sized Random Plots																	
72.7	17.7	84.0	0.0	0.0	0.0	0.0	21.1	19.7	0.0	0.0	0.0	0.0	0.0	0.0	10.9	0.0	133.1	0.0
305.5	162.2	517.8	195.1	488.7	61.3	287.7	64.3	76.0	133.1	283.0	255.8	113.0	72.9	7.5	120.6	155.5	258.9	198.6
0.0	60.2	51.8	42.7	62.5	0.0	118.4	0.0	0.0	35.0	122.6	29.5	0.0	0.0	0.0	40.3	74.2	40.8	70.1
4.4	280.9	36.6	83.1	24.8	0.0	175.0	0.0	0.0	198.2	129.2	0.0	6.0	0.3	3.1	184.3	17.5	26.7	5.6
684.5	110.2	356.6	244.8	303.0	476.3	41.0	1145.8	1137.3	555.2	138.7	902.2	1114.1	1158.1	702.3	154.4	92.9	275.9	90.1
75.7	135.6	61.3	307.7	259.2	165.9	26.6	2.9	1.0	49.5	84.2	41.9	1.0	2.7	347.0	440.7	500.4	413.1	666.1
91.4	467.2	126.1	360.8	96.0	530.7	585.5	0.0	0.0	263.1	475.4	4.7	0.0	0.0	174.2	283.0	393.7	85.7	203.6
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Estimated Barred Owl Territories																	
0	111.5	69.7	123.8	0	65.7	0	0	0	0	0	43.0	255.5	149.1	147.6	189.6	187.3	34.3	36.0
71.1	333.6	537.9	188.8	189.6	59.6	186.6	231.5	349.1	283.7	382.8	306.3	10.3	0.0	278.9	231.6	356.3	290.5	358.2
35.0	76.6	69.8	143.0	229.1	165.1	198.9	34.3	5.0	51.3	7.7	0.0	7.5	252.5	36.7	22.3	2.4	17.9	67.7
21.4	138.4	74.7	154.9	283.1	222.8	128.5	120.8	43.2	188.1	31.5	0.0	0.0	145.9	240.4	38.4	1.5	52.1	217.3
269.1	307.5	147.3	212.7	57.8	288.9	106.7	211.2	68.8	71.9	470.9	838.5	64.5	173.5	188.1	290.8	616.8	210.2	102.1
574.7	171.5	302.8	187.6	58.5	245.5	128.4	99.8	124.2	64.5	177.8	46.3	217.9	155.2	150.2	198.7	64.6	186.0	77.2
262.9	95.0	31.8	223.4	416.0	186.5	485.0	536.4	643.8	574.7	163.3	0.0	678.4	358.1	192.3	262.8	5.4	443.1	375.6
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2.4: Continued.

Same Sized Random Plots																		
29.2	506.7	76.5	341.1	303.4	125.1	395.1	426.9	0.0	9.3	109.1	22.2	272.0	56.9	11.9	0.0	8.5	0.0	0.0
221.8	242.9	197.3	99.5	211.5	117.0	90.5	61.3	132.7	427.9	567.3	435.8	163.8	529.0	607.9	410.7	178.9	3.8	510.3
61.4	27.7	44.2	5.4	178.1	188.2	61.1	141.2	31.8	0.0	0.0	5.9	23.6	39.9	25.1	44.4	115.2	16.5	0.0
153.8	158.6	199.5	0.3	169.4	50.3	260.8	162.8	24.7	0.0	14.3	0.0	448.9	160.9	99.4	92.1	187.2	7.3	4.9
139.9	74.3	194.6	396.1	163.7	190.5	200.5	126.9	60.1	779.1	533.9	746.8	137.5	161.8	158.4	97.5	41.0	53.3	607.4
319.4	195.7	332.0	202.3	100.4	112.4	64.1	209.2	127.3	17.8	9.6	19.3	86.2	201.0	197.4	78.5	92.5	222.3	83.8
308.6	28.2	190.0	189.5	107.6	450.6	162.2	105.8	857.6	0.0	0.0	4.0	102.2	84.7	134.1	510.9	610.8	931.0	27.7
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Estimated Barred Owl Territories																		
0	0	0	4.3	0	0	0	27.9	22.6	0	321.0	0.0	0	445.0	346.0	13.4	0	0	0.0
339.2	264.7	726.5	394.0	678.0	521.6	297.0	158.5	159.2	340.6	326.2	247.9	372.4	294.8	71.0	860.0	304.2	522.8	181.7
0.0	9.3	1.5	83.5	0.0	11.5	52.4	0.0	5.5	176.0	0.0	43.7	0.0	0.0	44.6	3.4	12.2	297.6	44.7
29.9	15.5	0.0	133.8	3.5	43.8	189.2	0.0	0.0	225.1	3.5	96.6	73.5	0.0	477.1	122.8	215.2	115.9	305.6
699.9	37.7	136.2	85.3	178.6	69.5	59.1	1047.3	1046.8	42.6	549.4	66.8	686.9	462.9	179.0	128.1	490.0	90.0	139.5
97.3	430.8	355.4	81.3	355.2	197.5	193.2	0.4	0.0	28.7	34.0	82.2	77.8	31.2	99.6	75.0	14.8	11.8	67.9
67.9	476.1	14.4	451.8	18.9	390.2	443.2	0.0	0.0	421.1	0.0	696.9	23.3	0.0	16.8	31.3	196.7	194.4	494.7
0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.9	1.6	0.0

Table 2.4: Continued.

SUM	MEAN	SD (±)	p (2 tailed t-test)	p^1 (Mean1-Mean2<0)	p^2 (Mean1-Mean2>0)
3371.4	63.6	125.3	0.97		
12546.5	236.7	191.6	*0.04*	*0.02*	*0.98*
1992.5	37.6	45.7	*0.03*	*0.01*	*0.99*
3828.7	72.2	93.4	*0.03*	*0.01*	*0.99*
16672.4	314.6	325.4	0.20		
10549.7	199.1	174.8	0.25		
16442.0	310.2	293.0	0.48		
5.2	0.1	0.5	0.61		
3415.1	64.4	109.2			
16492.7	311.2	185.2			
3407.3	64.3	72.3			
6087.7	114.9	101.2			
12796.3	241.4	247.5			
8647.0	163.2	142.3			
14559.2	274.7	221.1			
3.0	0.1	0.3			

Table 2.5: Earth Observation for Sustainable Development of Forests Data for Estimated Barred Owl Breeding Home Ranges and Same Sized Random Plots in Manitoba, Canada (hectares).

Same Sized Random Plots															
Broadleaf - Dense	0.0	97.6	88.1	0.0	3.0	0.0	12.4	68.4	5.4	0.0	0.0	92.4	8.7	0.0	0.0
Broadleaf - Open	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	1.4	0.0	0.0
Coniferous - Dense	22.4	6.1	0.0	72.9	7.8	23.9	22.3	10.3	35.4	63.7	23.1	0.8	8.1	51.9	10.4
Coniferous - Open	77.2	0.0	0.0	30.1	9.4	26.9	58.3	0.0	11.2	0.0	18.7	4.8	2.1	11.4	0.0
Coniferous - Sparse	3.9	0.0	0.0	14.6	53.5	88.4	10.7	22.2	86.3	8.9	10.1	0.0	2.6	2.1	0.0
Exposed / Barren Land	1.7	2.6	4.3	4.1	7.2	6.1	0.0	3.7	10.4	7.4	0.0	7.1	9.9	0.0	0.0
Herbs	0.0	0.0	38.8	6.9	13.8	0.4	0.0	0.7	0.0	0.0	0.0	31.2	93.6	0.0	0.0
Mixedwood - Dense	2.3	8.2	4.0	0.0	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	15.9
Mixedwood - Open	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Water	0.7	0.0	0.2	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.4	4.9	48.1	0.0
Shrub Low	0.0	0.0	0.0	0.0	18.1	2.8	0.0	0.0	0.0	63.6	0.0	0.0	0.0	0.0	0.0
Shrub Tall	0.0	0.0	0.0	0.0	7.4	0.0	0.5	39.4	0.0	5.3	0.0	0.0	15.8	28.8	0.0
Wetland - Herb	0.9	0.0	0.0	9.1	0.0	0.0	0.0	0.0	0.0	0.0	29.1	2.4	0.0	0.0	2.4
Wetland - Shrub	34.4	0.0	2.8	10.6	7.2	0.0	44.3	1.3	0.0	0.0	67.7	8.4	0.0	2.2	65.0
Wetland - Treed	4.9	33.9	10.3	0.0	15.9	0.0	0.0	1.4	0.0	0.0	0.0	0.8	0.0	0.6	54.8
Estimated Barred Owl Territories															
Broadleaf - Dense	7.7	101.4	82.1	0.0	105.4	56.6	107.8	92.4	77.1	35.5	7.9	135.8	27.2	86.6	73.4
Broadleaf - Open	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coniferous - Dense	21.4	23.8	25.5	1.6	4.4	33.6	12.3	6.4	3.9	9.2	10.3	0.0	0.1	0.0	2.8
Coniferous - Open	2.7	0.0	0.0	0.0	0.0	0.0	3.4	1.0	0.6	43.8	33.4	0.0	41.7	6.1	33.2
Coniferous - Sparse	0.0	0.0	0.0	46.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
Exposed / Barren Land	0.0	3.8	11.3	0.0	0.1	0.0	0.0	2.4	1.3	9.6	0.0	0.0	1.6	0.0	0.6
Herbs	0.0	0.0	13.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0
Mixedwood - Dense	13.3	2.1	9.4	3.6	0.6	0.4	6.4	17.3	58.1	0.8	65.8	7.0	73.1	14.5	35.8
Mixedwood - Open	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Water	0.0	0.0	0.0	2.0	0.8	0.0	0.0	28.9	0.0	5.3	0.0	0.2	3.3	1.5	0.1
Shrub Low	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shrub Tall	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wetland - Herb	20.5	0.0	0.4	0.0	0.0	0.0	0.8	0.0	2.6	0.9	2.5	0.0	0.0	0.0	0.0
Wetland - Shrub	29.0	3.2	1.6	94.0	20.0	39.3	10.6	0.3	0.0	24.1	17.9	0.0	0.2	38.4	2.1
Wetland - Treed	54.0	14.2	4.0	0.4	17.3	18.6	7.2	0.0	4.9	19.6	10.8	5.6	0.0	1.6	0.0

Table 2.5: Continued.

Same Sized Random Plots																		
0.0	17.0	87.4	33.1	80.9	40.3	126.1	48.8	0.3	32.6	69.8	19.2	0.7	0.2	13.9	0.0	126.4	126.4	21.2
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	2.2	0.0	31.1	17.1	58.0	0.8	44.8	0.0	1.5	39.4	0.0	0.0	18.4	71.5	7.9	3.4	14.7	97.5
0.0	1.8	22.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	13.3	4.5	0.0
0.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.3	0.0	1.4	7.9	3.1	7.0	1.1	0.7	6.7	7.6	19.3	6.8	9.0	7.1	0.0	0.0	3.6	0.0	0.0
86.1	0.0	22.8	3.6	26.9	1.9	0.0	3.8	141.6	100.6	0.0	122.7	137.8	50.3	0.0	0.0	0.0	0.0	0.0
52.2	35.8	0.0	44.3	0.4	4.7	7.4	0.7	0.0	0.8	3.4	0.0	0.0	14.3	1.8	0.0	0.0	1.3	29.9
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	7.8	14.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	41.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	2.1	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0
0.0	37.1	0.0	3.3	7.6	4.1	2.4	18.8	0.0	0.2	8.4	0.0	0.1	0.0	29.3	5.0	0.0	1.3	0.0
0.0	0.8	0.0	18.5	12.1	32.8	9.8	30.9	0.0	5.2	5.9	0.0	0.0	58.2	29.9	134.5	0.0	0.4	0.0
Estimated Barred Owl Territories																		
35.3	36.7	0.7	0.0	99.9	0.5	19.8	12.2	38.2	84.1	36.4	33.8	0.0	3.9	85.3	0.0	6.6	102.6	67.7
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	2.0	76.1	10.1	0.0	0.0	0.0	0.0	0.0
91.3	0.0	0.5	18.2	12.8	19.1	1.1	27.6	8.1	5.8	0.0	0.0	5.3	52.2	29.5	0.0	9.2	3.7	13.8
21.9	52.4	99.3	48.3	0.0	24.6	3.4	2.0	6.3	0.3	1.4	0.0	0.8	2.9	9.6	0.0	20.9	10.8	2.1
0.0	28.3	16.3	17.6	0.0	24.8	4.8	60.9	21.7	5.6	18.9	0.0	6.1	0.0	0.0	0.0	0.0	0.9	0.4
0.0	4.4	16.9	0.0	2.9	8.6	6.1	13.1	12.8	8.6	3.1	0.0	0.0	7.9	3.9	5.0	0.0	0.0	1.9
0.0	0.0	0.0	0.0	0.0	0.0	2.3	7.3	27.9	0.0	39.7	101.4	5.8	0.0	0.0	78.5	4.6	0.0	56.8
0.0	0.1	0.0	33.7	32.9	3.6	99.6	0.0	0.0	0.0	0.0	0.0	0.0	52.8	10.1	51.2	11.9	12.6	0.6
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.1	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.6	37.4	8.2	10.2	13.9	0.4	11.1	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	0.0	23.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	8.6	9.1	29.6	20.6	39.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1	3.8	2.7	1.9	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	0.0	0.0	0.6	3.4	0.0
0.0	20.9	11.8	18.9	0.0	42.3	3.1	1.5	0.0	0.0	8.3	0.0	11.8	1.7	0.0	0.0	89.4	3.8	0.0
0.0	0.9	0.5	7.4	0.0	24.2	0.0	0.0	3.8	0.2	0.0	0.0	5.4	0.0	0.0	0.0	4.9	0.0	5.4

Table 2.5: Continued.

Same Sized Random Plots																
20.4	98.8	67.8	78.7	3.5	6.1	13.5	26.7	0.0	47.5	30.9	23.1	8.9	25.4	85.4	33.9	20.9	35.2
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.4	0.0	0.0	52.1	2.4	0.0	0.0	0.0	0.0	2.7
0.4	12.4	35.3	3.3	4.9	0.3	1.6	23.4	0.0	0.0	0.0	0.0	44.5	12.7	1.6	22.2	24.9	0.0
8.5	15.3	5.5	21.7	49.2	20.4	28.5	4.6	0.0	0.0	0.0	0.0	6.3	8.6	21.8	10.0	15.2	0.0
0.4	0.0	0.0	0.0	47.3	0.0	23.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	7.6	2.9	0.0	0.0	10.5	5.3	0.4	0.0	3.6	5.7	0.0	4.8	6.1	4.4	0.0	0.0	2.8
0.0	0.0	30.2	0.0	0.0	0.0	0.0	0.0	115.5	91.6	93.0	0.0	0.0	0.0	0.0	0.0	0.0	49.6
29.7	0.0	0.0	31.0	9.2	54.9	0.8	69.0	0.0	6.1	15.8	46.1	72.9	94.6	0.0	15.8	17.9	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
84.7	0.0	0.1	2.1	4.3	27.2	37.1	0.0	0.0	0.0	3.3	5.0	1.1	0.3	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	51.8
0.0	1.0	0.0	0.0	1.3	0.8	1.1	1.6	0.0	0.0	0.0	12.8	2.4	0.0	0.5	8.1	0.0	0.0
4.6	13.4	6.9	11.8	25.7	26.8	35.9	8.9	9.5	0.0	0.0	9.4	4.4	0.0	13.6	36.6	15.3	6.6
0.0	0.0	0.0	0.0	3.4	1.7	1.3	13.8	0.0	0.0	0.0	0.0	0.0	0.0	21.1	21.9	54.2	0.0
Estimated Barred Owl Territories																
40.4	127.0	24.0	53.1	104.4	90.9	45.5	58.7	77.3	60.3	39.1	77.8	15.2	0.0	31.3	67.9	81.3	35.1
0.0	0.0	0.0	19.9	0.0	0.0	0.0	0.0	4.3	0.0	5.4	0.0	0.0	0.0	8.9	0.0	0.0	0.0
33.6	0.0	4.1	0.0	13.4	11.4	0.0	0.2	5.5	0.0	13.7	0.0	0.0	0.0	5.8	51.2	28.0	96.1
0.9	0.0	0.0	0.0	15.2	5.3	0.0	0.0	0.0	0.0	19.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	4.1	6.0	0.0	0.0	0.0	0.0	4.3	0.0	32.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.1	0.0	10.5	0.0	0.0	2.2	3.8	4.1	0.0	51.2	5.3	1.4	68.3	0.0	1.5	3.3	5.4	0.0
0.0	4.2	11.4	0.6	0.0	0.0	93.6	80.4	0.0	19.9	0.0	68.8	16.1	0.0	0.0	2.4	12.6	0.1
20.3	0.6	67.1	0.0	0.0	8.9	0.0	0.0	0.0	17.0	0.0	0.3	19.6	43.1	98.3	2.0	0.0	0.0
0.0	0.0	16.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	4.6	0.0	0.0	0.0	5.9	4.8	0.0	0.0	0.0	0.0	28.4	77.6	2.8	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	3.5	54.4	0.0	0.0	0.0	0.0	54.0	0.0	30.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	1.8	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.3	0.0	0.0	1.0	0.0
30.9	1.4	2.7	14.6	6.5	18.5	0.0	0.1	2.5	0.0	2.3	0.0	0.9	14.6	0.0	4.3	13.3	12.1
20.3	14.6	0.0	0.0	7.2	11.1	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.7	7.1	4.9

Table 2.5: Continued.

SUM	MEAN	SD (±)	p (2 tailed t-test)	p^1 (Mean1-Mean2<0)	p^2 (Mean1-Mean2>0)
1847.1	35.5	38.6	*0.03*	*0.02*	*0.98*
82.0	1.6	7.8	0.64		
954.8	18.4	23.0	0.29		
514.8	9.9	15.8	0.99		
377.1	7.3	19.4	0.65		
209.9	4.0	4.1	0.41		
1263.2	24.3	42.0	0.09		
698.1	13.4	22.2	0.43		
0.0	0.0	0.0	0.32		
245.3	4.7	14.6	0.90		
84.4	1.6	9.1	0.53		
191.7	3.7	11.2	0.64		
81.1	1.6	4.6	0.72		
590.4	11.4	16.2	0.88		
579.1	11.1	23.1	0.12		
2689.8	51.7	38.3			
128.1	2.5	10.9			
716.1	13.8	20.6			
513.2	9.9	18.9			
300.7	5.8	12.7			
284.7	5.5	11.8			
648.9	12.5	26.2			
894.3	17.2	26.2			
16.6	0.3	2.3			
262.6	5.1	12.9			
39.3	0.8	3.8			
250.2	4.8	13.0			
66.2	1.3	3.6			
618.9	11.9	19.7			
294.0	5.7	9.6			

wetland – shrub (p = 0.88) and wetland – treed (p = 0.12). A significant difference was seen in hectares of broadleaf – dense (p = 0.03), as Barred Owl breeding home range plots had significantly more hectares of broadleaf – dense ($p^1 = 0.02$), than same-sized random plots.

Table 2.6 displays EOSD data for paired Barred Owl non-breeding home range plots and same-sized random plots. Two-tailed t-tests resulted in no significant difference for any variables measured.

DISCUSSION

Characterization of Barred Owl Nest Tree Habitat

Ground cover data were varied across all sites, with significant differences in the means and obvious differences between individual sites (Table 2.1). One problem in interpreting these data is the lack of detailed ground cover information in other Barred Owl studies (Nicholls and Warner 1972, Haney 1997, Postupalsky *et al*. 1997, Mazur *et al*. 1998). These findings suggested that ground cover composition plays no role in nest tree habitat use by Barred Owls.

Canopy cover has long been cited as a determining factor in Barred Owl breeding habitat use (Haney 1997, Winton and Leslie, Jr. 2004, Nicholls and Warner 1972, Grossman *et al*. 2008). Mazur *et al*. (1997b) reported a mean canopy cover of 57% with a standard deviation of ± 17%, Haney (1997) reported a mean foliage cover within Barred Owl breeding habitat of 96% with standard error of ± 1.1%, Grossman *et al*. (2008) found Barred Owls were most likely to be found in areas with >66% canopy cover, Nicholls and

[1] p = (Mean 1 – Mean 2 < 0)

Table 2.6: Earth Observation for Sustainable Development of Forests Data for Estimated Barred Owl Non-Breeding Home Ranges and Same Sized Random Plots in Manitoba, Canada (hectares).

Same Sized Random Plots															
Broadleaf - Dense	170.8	817.0	716.1	101.6	15.3	20.9	47.4	488.9	106.1	17.0	19.0	509.3	134.2	0	0
Broadleaf - Open	0.0	0	0.0	0.0	0.0	0.0	10.8	13.6	0.9	1.8	0.0	0.0	14.1	0.0	0.0
Coniferous - Dense	80.4	7.7	0.0	437.0	160.9	375.9	283.2	112.7	406.8	452.9	168.2	236.9	87.3	402.8	210.8
Coniferous - Open	421.6	0	0.0	198.1	54.5	60.3	240.6	20.8	41.3	9.1	189.7	76.7	60.3	135.3	34.1
Coniferous - Sparse	20.3	0	0.0	216.3	214.6	558.4	198.7	96.3	339.1	118.8	110.1	0.0	47.8	19.4	3.9
Exposed / Barren Land	71.0	11.6	43.0	36.6	45.0	58.2	16.6	27.1	48.1	52.4	14.8	37.6	41.6	4.7	16.9
Herbs	0.0	2.1	164.8	6.9	47.2	38.6	124.1	19.1	71.8	10.8	219.8	135.4	536.4	0.0	0.0
Mixedwood - Dense	6.3	88.0	63.1	13.4	89.1	0.0	25.8	0.0	4.6	1.8	0.0	72.1	26.9	33.6	134.9
Mixedwood - Open	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.2	0.0	0.0
Water	46.6	21.1	2.5	0.0	8.3	0.0	0.0	1.5	1.1	0.0	0.0	12.3	16.9	313.6	4.8
Shrub Low	0.0	0.0	0.0	0.0	201.0	90.8	0.0	0.0	0.0	496.0	17.1	0.0	2.5	0.0	0.0
Shrub Tall	0.0	0.0	0.0	53.3	79.6	6.0	62.8	382.4	177.5	62.5	24.9	0.0	188.3	209.9	0.0
Wetland - Herb	5.7	0	4.2	35.6	1.0	0.0	60.9	19.8	0.1	0.0	137.5	10.1	0.0	0.6	27.8
Wetland - Shrub	318.1	19.7	86.6	103.2	160.1	25.2	160.7	50.6	34.8	8.6	326.4	128.0	66.3	92.5	399.6
Wetland - Treed	93.4	266.8	153.9	32.0	157.9	0.0	2.3	1.4	2.3	2.9	0.4	15.2	0.0	21.0	401.7
Estimated Barred Owl Territories															
Broadleaf - Dense	47.1	551.4	486.2	0.0	698.1	429.9	627.9	477.6	485.9	322.7	26.4	615.6	90.9	478.5	373.3
Broadleaf - Open	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coniferous - Dense	227.8	298.9	363.6	49.6	158.2	270.6	114.4	216.7	37.5	115.9	143.3	177.9	39.0	132.3	48.9
Coniferous - Open	30.6	0.0	0.0	42.3	15.5	0.0	40.8	66.0	13.1	180.1	249.3	0.0	256.8	129.8	263.3
Coniferous - Sparse	0.0	0.0	0.0	194.6	1.4	0.0	0.0	0.9	0.0	0.0	15.4	0.0	2.3	0.4	4.6
Exposed / Barren Land	26.9	30.9	29.7	20.3	10.8	19.9	8.1	17.6	17.6	55.8	21.4	18.6	15.1	11.8	6.3
Herbs	0.0	143.8	166.2	0.0	0.0	134.6	0.0	3.3	0.0	129.3	0.7	10.1	4.8	0.0	0.0
Mixedwood - Dense	247.4	37.6	50.8	95.4	49.8	4.3	161.6	268.4	447.6	67.4	282.5	161.4	402.8	155.3	264.9
Mixedwood - Open	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Water	0.0	0.0	1.2	4.8	1.4	9.5	0.0	95.9	0.0	25.6	188.4	12.6	392.3	66.8	152.4
Shrub Low	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shrub Tall	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wetland - Herb	44.6	0.4	1.0	1.1	0.0	1.9	5.0	28.9	16.8	14.4	22.3	0.2	2.4	27.4	8.6
Wetland - Shrub	268.7	40.6	27.0	794.9	53.7	214.9	157.8	59.2	109.7	195.1	179.9	9.7	26.4	194.1	106.9
Wetland - Treed	340.9	129.8	107.8	30.9	245.3	148.5	118.6	0.0	106.3	127.9	104.6	228.4	0.6	38.1	5.1

Table 2.6: Continued.

Same Sized Random Plots																		
0	269.6	635.0	208.7	559.8	321.1	646.3	238.8	90.1	364.2	445.8	279.4	139.1	4.5	245.5	119.0	539.4	557.9	435.1
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.5	108.7	18.6	234.9	165.4	250.3	254.4	261.3	0.0	215.5	412.0	3.4	0.0	210.4	510.3	233.9	51.8	139.9	451.6
1.6	67.8	106.8	28.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.1	203.4	99.4	9.9
49.5	18.0	1.4	2.1	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9
54.8	0.0	19.6	50.2	28.6	32.8	39.6	14.9	49.9	62.3	117.9	52.9	49.2	34.1	6.9	6.4	29.7	23.1	24.3
617.5	0.0	331.8	150.1	369.1	461.3	0.0	192.4	1082.4	509.1	15.8	891.2	1045.1	680.2	0.0	0.0	184.4	19.3	68.2
190.8	199.4	6.6	325.8	7.8	21.8	126.8	109.4	0.0	13.9	8.5	0.0	0.0	56.9	195.3	174.8	0.0	121.3	182.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60.7	30.9	95.4	6.5	0.0	0.0	0.0	0.0	11.8	0.0	2.1	1.3	0.0	2.1	11.4	0.0	150.6	3.4	41.4
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	289.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.7	30.6	1.9	0.0	0.0	0.3	2.9	0.0	0.0	4.1	6.6	0.0	0.0	0.0	92.8	0.8	0.0	0.0	0.0
229.7	186.4	15.0	34.0	42.1	25.9	36.9	118.5	0.0	17.5	132.6	6.3	0.3	0.8	64.0	109.9	21.1	189.3	2.4
12.3	32.9	2.1	193.9	60.5	120.8	127.9	296.4	0.0	47.5	92.8	0.0	0.0	245.6	107.4	560.1	53.0	80.7	17.8
Estimated Barred Owl Territories																		
105.7	152.0	3.1	7.2	703.3	13.0	118.1	124.9	232.0	268.8	141.2	232.0	681.1	12.6	533.4	35.1	147.8	571.2	396.3
0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	1.8	3.6	6.1	70.4	0.0	28.1	0.0	0.0	0.0	0.0	0.0
645.1	8.5	33.1	233.6	230.9	87.1	335.3	193.5	222.6	149.1	55.4	0.0	761.8	461.5	245.8	0.3	170.8	77.1	22.8
89.7	416.9	621.5	320.8	0.0	282.4	63.5	40.2	171.4	199.4	21.4	0.0	137.4	22.3	96.0	28.9	170.3	122.1	3.1
0.0	166.1	115.9	110.8	0.0	164.2	138.3	207.7	211.8	96.9	76.3	0.0	10.5	0.0	0.0	5.1	8.1	15.7	3.1
14.6	22.9	51.7	26.5	16.9	57.1	19.6	68.5	46.4	87.2	28.6	13.4	47.3	20.3	18.2	52.9	22.9	4.6	29.3
148.0	0.0	0.0	0.0	0.0	0.0	85.2	148.5	73.7	7.1	536.9	849.8	26.3	0.0	127.3	606.1	150.3	0.0	732.3
40.9	1.4	1.1	130.2	277.7	8.9	253.5	0.0	1.6	1.4	24.0	0.0	205.1	219.9	10.1	279.8	128.6	124.8	25.3
0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	7.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	223.1	63.8	131.8	0.0	75.4	0.4	0.0	0.0	0.0	0.0	62.6	455.4	183.2	203.4	184.2	32.9	45.2	0.0
0.0	0.0	0.0	0.0	0.0	0.0	7.8	236.3	72.9	330.6	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	107.1	181.4	181.3	58.5	154.5	0.0	0.0	0.0	0.0	0.0	0.0	64.3	0.0
56.4	32.3	55.5	14.7	0.0	23.9	16.6	2.9	0.0	17.8	1.4	0.0	0.0	241.7	0.0	0.4	2.0	27.3	0.0
120.2	198.3	274.8	194.8	5.2	443.1	85.3	28.8	4.3	5.1	181.1	6.3	93.5	44.5	0.0	40.7	361.1	167.1	0.8
13.3	12.9	14.1	64.4	0.1	79.1	1.5	0.0	14.3	9.6	0.0	0.0	47.6	0.0	0.0	0.9	39.4	14.9	21.3

Table 2.6: Continued.

Same Sized Random Plots																	
268.1	415.2	290.5	160.8	27.2	15.3	38.8	319.5	114.3	511.6	284.7	135.8	240.4	301.4	420.6	361.4	67.6	182.8
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	164.9	0.0	0.0	167.7	15.1	68.4	0.0	0.0	0.0	13.2
19.4	284.3	163.4	117.1	112.1	114.1	97.5	173.6	0.0	7.5	2.3	24.3	165.0	208.3	102.3	254.4	222.2	0.0
72.3	92.1	39.6	168.1	368.2	188.1	214.2	67.1	0.0	0.0	0.0	0.0	20.4	43.5	99.6	33.7	186.8	0.0
0.7	0.0	0.0	2.2	252.3	43.8	106.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3
0.6	23.6	28.6	3.9	0.0	30.1	18.7	5.3	30.0	66.4	52.6	10.5	46.5	44.5	55.9	7.1	11.4	27.1
0.0	0.0	279.8	3.0	0.0	0.0	0.0	0.0	899.4	429.1	718.4	0.0	35.6	12.4	0.6	0.0	0.0	516.6
221.4	77.2	27.7	300.8	66.8	228.1	8.8	346.6	0.0	107.1	144.7	369.8	532.8	464.8	40.6	93.1	149.5	43.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0
535.4	91.8	356.7	340.9	139.7	402.1	445.0	0.0	15.6	103.8	29.9	301.4	87.3	24.3	2.4	14.9	0.0	10.1
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	5.6	0.0	0.0	0.0	271.3
0.0	28.1	2.7	3.3	15.9	11.6	14.5	23.6	0.0	0.0	0.0	118.0	62.4	18.0	43.6	77.9	43.6	28.6
112.9	204.6	45.6	104.7	216.0	151.0	238.3	90.7	9.6	9.2	1.6	106.8	24.7	27.8	304.2	180.3	141.3	79.6
3.3	17.1	0.0	30.5	36.3	50.3	52.5	207.8	0.0	0.0	0.0	0.0	1.6	15.3	164.2	211.4	411.8	60.0
Estimated Barred Owl Territories																	
243.9	839.9	227.3	453.9	635.4	357.8	156.2	180.4	470.8	272.8	154.3	411.3	279.0	72.4	425.7	481.7	524.6	489.3
0.0	0.0	3.9	93.8	0.0	0.0	0.0	0.0	9.9	0.0	21.5	0.0	0.0	46.3	133.5	0.0	0.0	0.0
237.8	0.0	157.8	0.0	140.8	300.9	0.0	1.1	135.1	1.7	293.0	19.6	0.0	7.9	91.6	150.4	328.8	377.1
53.2	0.0	62.3	0.0	102.9	81.4	0.0	0.0	28.6	0.0	169.2	0.0	0.0	5.9	10.9	0.0	0.0	0.0
0.0	0.0	106.9	13.0	7.8	0.0	0.0	0.0	125.0	0.0	275.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.8	17.6	62.5	11.4	0.1	60.8	43.6	44.7	10.8	138.2	35.3	41.5	153.2	17.4	31.3	34.4	58.0	18.0
0.0	16.2	37.9	20.1	0.0	0.0	1013.2	990.1	0.0	353.5	31.9	659.1	230.4	0.0	0.0	482.0	135.4	146.8
140.6	35.8	214.8	0.5	16.8	114.7	0.0	0.0	0.0	149.1	26.9	3.1	133.5	518.6	478.8	11.9	2.7	0.4
0.0	0.0	27.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	3.9	15.1	0.0	3.5	0.0	21.3	15.1	0.0	315.8	0.0	0.0	436.2	373.8	18.7	0.0	0.0	0.0
0.0	0.0	74.3	0.0	0.0	0.0	0.0	0.0	102.1	0.0	32.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	169.9	400.5	0.0	0.0	0.0	0.0	340.4	0.0	168.9	0.0	0.0	0.0	9.1	0.0	0.0	0.0
47.8	6.2	5.3	2.1	16.2	4.4	0.0	0.0	3.3	0.0	3.4	1.1	0.0	123.8	18.4	0.0	5.9	6.5
260.6	92.7	60.9	235.9	100.1	163.8	0.0	1.0	8.0	2.4	12.4	54.1	1.7	68.9	14.8	20.0	126.9	115.3
231.6	220.9	8.0	2.9	210.6	150.2	0.0	1.8	0.0	0.0	1.6	44.2	0.0	0.0	1.4	53.4	52.0	80.6

Table 2.6: Continued.

SUM	MEAN	SD (±)	p (2 tailed t-test)
13418.5	258.0	213.7	0.13
470.4	9.0	33.3	0.87
9026.4	173.6	142.4	0.77
3682.3	70.8	96.0	0.42
2423.4	46.6	105.2	0.71
1684.7	32.4	22.7	0.79
10889.4	209.4	303.6	0.36
5524.2	106.2	126.5	0.58
12.6	0.2	1.6	0.31
3747.6	72.1	132.8	0.96
807.4	15.5	74.4	0.94
1814.1	34.9	85.1	0.98
938.5	18.0	30.9	0.94
5261.5	101.2	97.2	0.53
4465.1	85.9	123.0	0.21
16866.9	324.4	225.2	
420.5	8.1	24.9	
8572.1	164.8	161.7	
4609.0	88.6	125.3	
2078.5	40.0	71.6	
1757.0	33.8	29.3	
8200.5	157.7	269.2	
6279.4	120.8	137.6	
44.0	0.8	4.0	
3815.6	73.4	123.5	
858.7	16.5	58.3	
1835.9	35.3	86.0	
911.9	17.5	38.3	
6032.8	116.0	140.2	
3125.1	60.1	82.3	

Warner (1972) found Barred Owls avoided open areas and utilized "dense" cover disproportionately (no values given) and Singleton *et al*. (2010) reported Barred Owl home ranges contained canopy cover of >56%. Haney (1997) also indicated that closed canopy forests might exhibit solar insulating properties that promote successful incubation. One difficulty in comparing these findings to other studies is the difference in scale used when measuring canopy cover. Of the other studies reporting canopy cover within Barred Owl home ranges (Haney 1997, Winton and Leslie Jr. 2004, Nicholls and Warner 1972, Grossman *et al*. 2008, Mazur *et al*. 1997b, Singleton *et al*. 2010) only Mazur *et al*. (1997b) used a small-scale plot (11.3m radius) with the nest tree at the center, similar to the methods of this study. Findings from this study suggested canopy cover was not a limiting factor to Barred Owl nest tree habitat use or nesting (Table 2.1), with more than half my sample having canopy cover of ≤50%. Also, ~44% of nest trees had no canopy directly covering them (Sites 4, 20, 36, and 56). Sites 20 and 36 had little to no cover (0% and 5%) within the 30-meter plot, yet successfully fledged young. Canopy cover was lower than in other studies (Haney 1997, Winton and Leslie Jr. 2004, Nicholls and Warner 1972, Grossman *et al*. 2008, Mazur *et al*. 1997b, Singleton *et al*. 2010) when examined on a larger scale (Fig. 2.4). The majority of area within Barred Owl breeding home ranges (148.5ha) was categorized as crown closure class 0 (Appendix C); this is lower than values obtained within nest tree stands (Table 2.1). High density stands, crown closure class 4 (Appendix C), comprised ~9.6% of Barred Owl breeding home ranges. This was greater than the ~6.2% found in random plots but not significant ($P = 0.140$).

No inferences could be made from the tree species composition PCA bi-plot (Fig. 2.7). The inability to present a majority of the variation found within the data set left the analysis unreliable. One discovery made was the variation itself, with ~69% of tree species found in Manitoba (Zoladeski *et al*. 1995) being represented in Barred Owl habitat. Olsen *et al*. (2006) used methods similar to this study in counting and measuring tree species composition within Barred Owl nest tree habitat in Alberta. They counted five different tree species (*Abies balsamea*, *P. tremuloides*, *P. balsamifera*, *P. glauca*, *Picea mariana*) within Barred Owl habitat, in contrast to the 11 species found in this study. These discrepancies may be due to the study area used by Olsen *et al*. (2006) which consisted of managed forests.

Comparison of Forest Habitat Variables Between Barred Owl Home Range and Random Plots

FRI analysis displayed significantly more hardwood species in Barred Owl breeding and non-breeding home range plots as they contained relatively high areas of "mixedwood" and "hardwood" stands compared to same-sized random plots. It should be noted that the "hardwood" label used in FRI data is defined as "all stands where the basal area of all coniferous species is less than 25 percent of the total basal area" (Appendix C); therefore, these are not strictly hardwood stands. Further analysis with EOSD data corroborated this result, as there was a significantly greater area of dense broadleaf cover in Barred Owl breeding home range plots over same-sized random plots. This association of Barred Owls with hardwood/mixedwood forests has been found in other studies on this species (Booth and Harrison 1997, Mazur *et al*. 1998, Russell 2008) and other cavity-

nesting species (Potvin *et al*. 2000, Hodson 2003). Analysis showed no link, in this study, between Barred Owl habitat use and water, similar to Singleton *et al*. (2010).

Barred Owls have been reported as being associated with water (Mazur *et al.* 1997b, Hamer *et al*. 2007), mature or "old-growth" forest stands (McGarigal and Fraser 1984, Mazur *et al*. 1998) and mixedwood or hardwood stands (Booth and Harrison 1997, Mazur *et al.* 1997b, Russell 2008). Variable habitat associations seem to relate to a single factor limiting Barred Owl distribution and populations, namely the formation and availability of suitable nest cavities.

Firstly, mature forests are required to produce cavities large enough for large cavity-nesting species such as Barred Owls (Haney 1997). Secondly, all Barred Owl nest cavities found in this study were natural and had resulted from damage and decay of the tree, not from excavation by primary cavity-nesters. Cavities not created by primary cavity-nesters are often created by tree decay and rot (Bunnell *et al*. 2002). Fungal rot is prevalent in older and/or larger stands of trees (Witt 2010) and has positive effects for both primary and secondary cavity nesters (Bunnell *et al*. 2002). Higher levels of moisture and humidity, factors found at sites within close proximity to water, increase the rate of decay in trees (Jackson and Jackson 2004). In Manitoba, hardwood species decay at a higher rate than most softwood species; annual losses of hardwood species to decay are double that of softwood species (Brandt 1995).

The concept that Barred Owl home ranges contain habitat that is conducive to suitable nest cavity production explains the large variation of habitat features reported within this study (e.g., Table 2.1) and other studies.

CHAPTER III: BREEDING SEASON BEHAVIOUR AND REPRODUCTIVE SUCCESS OF BARRED OWLS (*STRIX VARIA*) IN MANITOBA, CANADA.

INTRODUCTION

Three breeding records of Barred Owls have been reported in Manitoba, with information on the nest tree being available in only one of these cases (Holland *et al*. 2003). Barred Owls rely heavily on large tree cavities for nesting in other areas (McGarigal and Fraser 1984, Mazur *et al.* 1997a). However, Barred Owls will utilize a variety of nesting structures (Robertson 1959, Shackleford 1996, Mazur *et al.* 1997b), including artificial nest boxes (McComb and Noble 1981). Tree cavities, however, provide a higher reproductive output than other structures (Postupalsky *et al*. 1997).

Barred Owls begin breeding in February and continue into June (Winton and Leslie, Jr. 2004). Some authors report the breeding season as extending until August, as this is the time when fledged young of the year are dispersing (Mazur *et al.* 1997b, Mazur *et al.* 1997a, Mazur *et al.* 1998). The Manitoba Nocturnal Owl Surveys run from late March to early April (Duncan and Duncan 1997). Until this research, Barred Owl vocal detections during these surveys have provided the vast majority of information on Barred Owl breeding behaviour in Manitoba (Duncan and Duncan 1997). Heightened rates of Barred Owl vocalizations during the breeding season are a well-documented behaviour (Leder and Walters 1980, McGarigal and Fraser 1984, Mosher *et al*. 1990, Winton and Leslie, Jr. 2004, Hardouin *et al*. 2006) but information on other breeding behaviour is anecdotal at best.

Clutch size and breeding success are unknown for Manitoba, as few fledged young have been encountered and banded (Holland *et al*. 2003). Objectives were to: 1)

document Barred Owl behaviour to determine their breeding season phenology in Manitoba and 2) observe and report other breeding behaviour.

METHODS

Study Area

The study area was southern Manitoba north to 53º 52.673 N (Fig. 1.3). All survey transects were run during Barred Owl breeding season, as reported elsewhere (Winton and Leslie, Jr. 2004); methods and survey transects are described in Chapter 1.

Barred Owl breeding pairs were located during audio surveys and then nest sites were located (see nest searching discussed in Chapter 1).

Breeding Season Phenology

During audio surveys and nest searches discussed in Chapter 1, breeding behaviour observations were made and GPS coordinates of nest sites were taken.

Induced responses of Barred Owls to audio playback, characterized by aggressive and extended bouts of vocalizations (Odom and Mennill 2010), along with individuals approaching the source of audio playbacks, aggressive displays (e.g. mock dive-bombing, bill snapping, wing clapping, frequent perch movement), and pair activity (e.g. duet calls, caterwauling, pairs approaching), were considered as signs of breeding activity and breeding territory defense (Odom and Mennill 2010). These were considered to be consistent with the breeding season behaviour of Barred Owls and exclusive to this time period (Frith *et al.* 1997). Earliest dates for observed breeding activity, females on

suspected nests, presence of young, and young fledging, were recorded. These were used to form a breeding season phenology for Manitoba.

Visits to active nests sites were used to document other breeding information, such as approximate egg laying dates and incubation period.

Reproductive Success

Active Barred Owl nest sites were visited during the incubation period and nearing the end of the breeding season (early June). Young in nests or near nests were captured using a landing net or snare pole and were measured and banded with a Canadian Wildlife Service leg band.

At nest sites where the nest appeared empty, audio playback was used to locate the adult female (Appendix B). Behaviour of the adult female in the vicinity of the nest and researcher (e.g. direction of female approach, area female frequently focused attention on) was used to locate fledged young. These young were also captured, measured and banded.

Depredated nests were investigated to identify the predator and evidence of nesting (e.g. egg shells, owlet remains). These nests were considered as viable but failed nesting attempts. Evidence from depredated nests was used to approximate number and age of offspring taken from the nest.

Data Analysis

Number of nests, fledged young, and remains from depredated nests were tabulated. Average and standard deviation for number of fledged young were calculated.

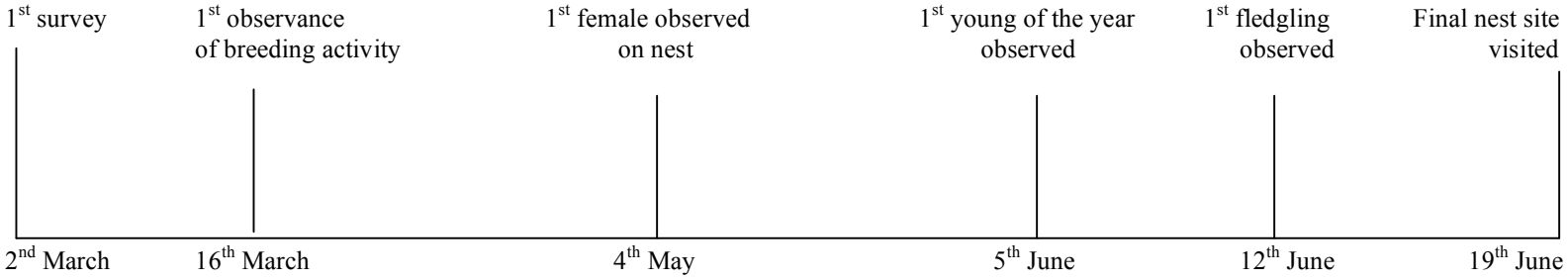
RESULTS

Breeding Season Phenology

A total of 880 kilometers of transect lines were surveyed in 2009 (Fig. 1.4) and 503 kilometers of transect lines were surveyed in 2010 (Fig. 1.5). Over the two breeding seasons, 62 breeding territories were located. Of these territories, 26 were located by the presence of both male and female adult owls. One territory was located via the collection of an injured fledgling owl. One territory was located through the collection of molted Barred Owl feathers. The remaining 34 territories were located via the presence/vocalization of either the male or female adult. Nine active nests were located in Agassiz Provincial Forest, Bél-air Provincial Forest, Hadashville area, Mars Hills area, Sandilands area, Whiteshell Provincial Park, Woodridge area and Wampum Ecological Preserve (Fig. 1.7).

Data for Barred Owl breeding phenology are depicted in Figure 3.1. Audio surveying began on 2 March 2009, the first encounter with breeding activity in year one occurred on 16 March 2009. Breeding activity was encountered consistently from this point forward throughout March, April, and May. First encounter with an adult female on nest occurred on 4 May 2009. First young were sighted, from the ground, on 5 June 2009 and first fledging occurred on 12 June 2009. Audio surveying began on 1 March 2010, the first encounter with breeding activity in year two occurred on 8 March 2010. Breeding activity, as defined *a posteriori*, was not observed on a consistent basis until the third week of March 2010, and continued through March, April, and May. First encounter with a female on nest occurred on 12 April 2010. First young were sighted on 4 May 2010, inside an active nest cavity using the Tree-Top Peeper®. Earliest fledging in year

Year 1 (2009)



Year 2 (2010)

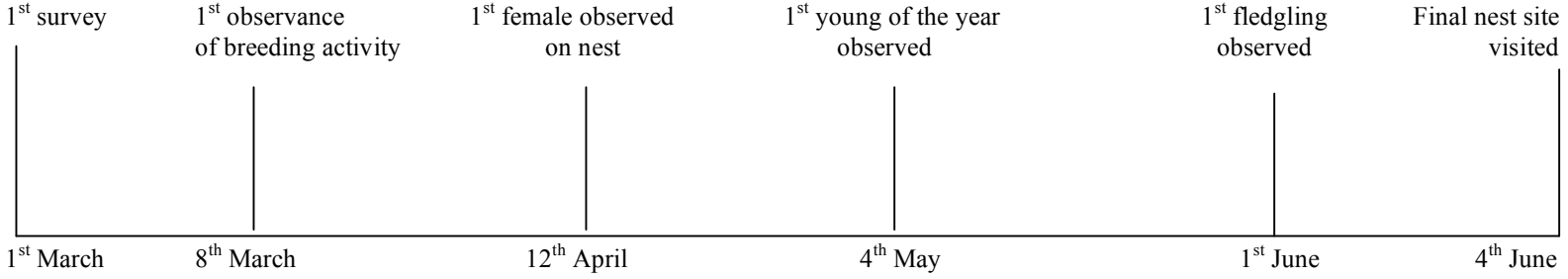


Figure 3.1: Barred Owl Breeding Season Phenology for Manitoba, Canada (2009-2010).

two occurred on 2 June 2010. Barred Owl breeding season stages in Manitoba are presented in Figure 3.2.

Six of the 17 breeding pairs located in year one ceased responding to audio playback during early stages of the breeding season. Four of the 17 continued to respond to audio playback, but showed no nesting activity as determined by continual observation of the adult female for a time period equal to or greater than one hour during the incubation period.

Reproductive Success, Clutch Size and Fledging Rate

Data for nest success are displayed in Table 3.1. On 22 May 2009, site 11 was visited and found depredated. Adult owls were non-responsive to audio playback and remains of one egg were collected from the ground adjacent the nest tree. The nest was examined and was empty.

On 5 June 2009, two nests were checked (sites 5 and 36); both had adult females remaining in the nests. One had a large, well-developed owlet visible in the nest (site 5).

On 10 June 2009, a large owlet was seen at the cavity opening at site 20, male and female adults were vocalizing but never visited the nest.

On 12 June 2009, site 20 was revisited; one smaller owlet was found on top of the nesting snag. This bird was captured and banded. A larger owlet was discovered ~80m from the nest, ~30m high in a tree. This bird was captured and banded, as was the adult female which appeared during the processing of the owlets.

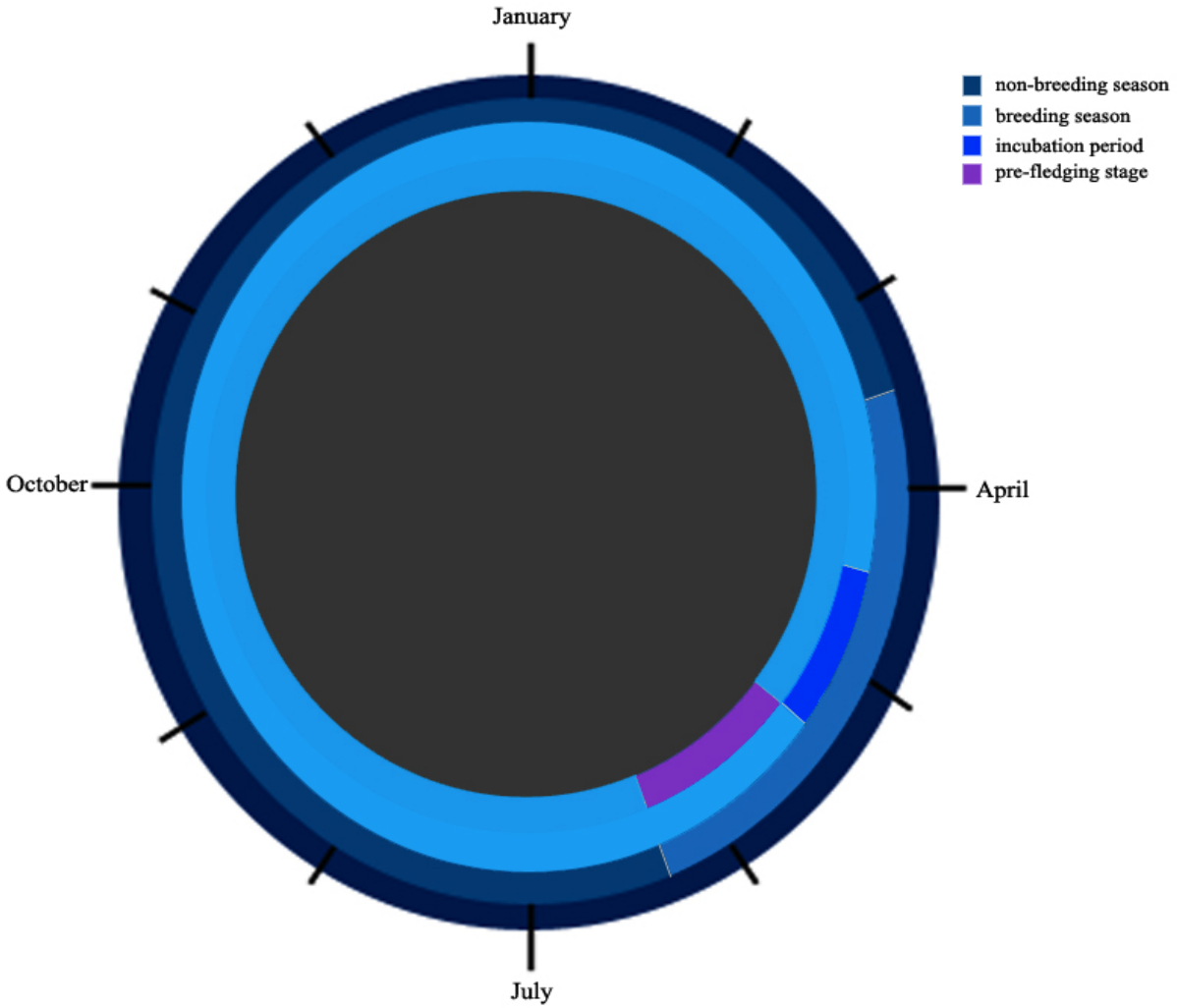


Figure 3.2: Barred Owl Breeding Season Wheel for Manitoba, Canada.

Table 3.1: Reproductive Success of Barred Owl Nests in Manitoba, Canada.

Site No.	Year	Failure/Success	Evidence
5	2009	Success	Owlets observed/No evidence of depredation.
11	2009	Failure	Remains of egg (1) located near nest tree.
20	2009	Success	Two owlets captured and banded.
27	2009	Failure	Remains of egg (1) located near nest tree.
31	2009	Failure	Remains of owlets (2) located near nest tree.
36	2009	Success	One owlet captured and banded.
4	2010	Success	One owlet captured and banded.
5	2010	Success	Three owlets captured and banded.
11	2010	N/A	Nest tree collapsed.
20	2010	Success	Three owlets captured and banded.
27	2010	Failure	Female adult captured, evidence of brood patch without nesting activity.
31	2010	N/A	Nest unoccupied.
36	2010	N/A	Nest unoccupied.
55	2010	Success	Owlets observed/No evidence of depredation.
56	2010	Failure	Remains of owlets ($n \geq 1$) located in nest cavity.

On 19 June 2009, sites 5 and 36 were revisited. No owlets were discovered at site 5 and capture attempts made on the adult female failed. One owlet was discovered 41m up a tree near the nest and banded at site 36, along with the adult female.

On 12 June 2009, site 27 was revisited and found depredated. Adult owls were non-responsive to audio playback and remains of one egg were collected. Marten (*Martes americana*) faeces (Rezendez 1999) were discovered near the base of the nest tree.

On 19 June 2009, site 31 was revisited. Remains of two owlets were collected near the base of the nest tree. The adult male responded to audio playback but would not approach. Black Bear (*Ursus americanus*) tracks were discovered nearby and hair, consistent with that of a black bear (Rezendez 1999), was found on the nest tree.

On 27 May 2010, site 55 was revisited. Three owlets were discovered in the nest and the adult female was near by.

On 1 June 2010, two nests were revisited (sites 4 and 5); both nests contained owlets. One contained a single owlet (site 4) in the cavity, which was captured and banded. The other (site 5) contained two owlets in the cavity and a third near by; were captured and banded.

On 2 June 2010, site 55 was revisited. No owlets were located in the cavity or the surrounding area. One adult was located in the vicinity of the nest site.

On 3 June 2010, site 20 was revisited and one owlet was discovered atop the nest. This owlet was captured and banded. A second owlet which emerged from the nest cavity during processing of the first, was captured and banded as well.

On 4 June 2010, site 20 was revisited. A third owlet was located at the nest site, which was captured and banded.

Eleven accounts of nesting were recorded over the two-year study (Table 3.2). Average clutch size was calculated to be 1.91 ± 0.83, number of young fledged resulted in a mean of 1.36 ± 1.29, giving a total mean proportion of young fledged as 0.64 ± 0.50.

Nest Site Fidelity

Two of six nests found in 2009 were reused in 2010. Sites 5 and 20 were used by the same (banded) female Barred Owls in both years (Table 3.1).

Of the remaining four nest sites, site 11 experienced a collapse of the nest tree, site 31 had adult Barred Owls in the vicinity but displayed no signs of nesting activity, site 36 had no signs of nesting activity, and site 27 had adult Barred Owls in the vicinity with a brood patch present on the female, but displayed no signs of nesting activity.

DISCUSSION

Breeding Season Phenology

Throughout the two years of this study, breeding behaviour was first detected in March. Consistent breeding behaviour, the point at which the majority of mature owls began to exhibit breeding behaviour, began in the second week of March in both years. Therefore, the second week of March was the start of Barred Owl breeding in Manitoba.

Egg laying dates were inconsistent between the 2009 and 2010 due to differences in methods used and knowledge of previously used nest sites, rather than a direct reflection of differences in egg laying. In 2010, nest site revisits occurred earlier in the season and the use of the Tree-Top Peeper® to examine nest cavities allowed a more

Table 3.2: Clutch Size and Fledging Rate of Barred Owls in Manitoba, Canada.

Site No.	Year	Minimum Clutch Size	Minimum Number of Young Fledged	Proportion of Clutch Fledged
5	2009	2	2	1.0
11	2009	1	0	0.0
20	2009	2	2	1.0
27	2009	1	0	0.0
31	2009	2	0	0.0
36	2009	1	1	1.0
4	2010	1	1	1.0
5	2010	3	3	1.0
20	2010	3	3	1.0
55	2010	3	3	1.0
56	2010	2	0	0.0
		1.91 +/- 0.83	**1.36 +/- 1.29**	**0.64 +/- 0.50**

accurate date on which females began occupying nests full time. Therefore, the first week of April was the egg laying period for Barred Owls in Manitoba.

No hatch date could be accurately obtained in 2009, but changes in methods used allowed better estimation of this timeframe in 2010. First owlets of 2010 were observed in the cavity with the use of the Tree-Top Peeper®. These owlets were estimated to be no more than two days old at this point and remains of eggshells were present in the nest. Therefore, the first week of May was the end of the incubation period of Barred Owls in Manitoba.

Young were observed to fledge during the first week of June in both 2009 and 2010. Therefore, the first week of June was the fledging period of Barred Owls in Manitoba. This timeline (Fig. 3.2) was consistent with the annual cycles of northern populations of Barred Owls published elsewhere (Mazur and James 2000).

Reproductive Success, Clutch Size and Fledging Rate

Barred Owls have a mean clutch size of 2.46 across varying latitudes, with insignificant differences occurring between northern and southern portions of their range (Murray 1976). As important as clutch size accounts are, breeding success rates would be more indicative of conditions in a given area for a given year. I estimated a mean clutch size of 1.91 ± 0.83 (Table 3.2). This was considered a minimum because partial clutches were observed in some cases (Table 3.1). Regardless, this value was in line with other estimates of clutch size in this region (Murray 1976, Johnson 1987). Murray (1976) recorded a clutch size of 2.00 for northern latitudes, Johnson (1987) recorded mean clutch size of 2.68, Roberts (1932) recorded mean clutch size of 3.2 and König *et al.*

(1999) reported a clutch range of 2-3 eggs. A larger sample of nesting data is needed to accurately describe Barred Owl clutch size and other breeding statistics for Manitoba populations.

Secondary cavity-nesters exhibit a high percentage of nest site fidelity, with 30.2% of cavities being reused by the same species in sequential years (Aitken *et al.* 2002). However, it is difficult to determine if the same individual reuses nest cavities (Aitken *et al.* 2002); this is true of Barred Owls as well, with accounts of nests being reused for decades (König *et al*. 1999, Mazur and James 2000). Nest reuse and nest fidelity are a result of nest success in many bird species (Darley *et al*. 1977, Hepp and Kennamer 1992, Hazlitt and Butler 2001). Of the six nests discovered in 2009, three were successful, and two of those three were reused by the same females in 2010 (Table 3.1). Furthermore, none of the three unsuccessful nest sites from 2009 were reused, despite the fact they remained in good condition. Monitoring of these and additional nest sites in coming years will add to the understanding of nest site fidelity in Barred Owls.

CHAPTER IV: DIETARY ANALYSIS OF BARRED OWLS (*STRIX VARIA*) IN MANITOBA, CANADA.

INTRODUCTION

Barred Owls are categorized as generalist predators throughout their range (Fowle and Edwards 1955, Mazur *et al*. 1997b, Shultz 2005), as they take a wide variety of prey types (Errington 1932b, Mazur *et al*. 1997b) in proportion to its availability (Marks *et al*. 1984, Fowle and Edwards 1955). Diet studies of this species also document a shift in prey use with a change in geography (Vahn and Kemp 1930, Errington 1932b, Wilson 1938, Mazur *et al*. 1997a).

Pellet production is common practice in avian species (Glue 1971). An estimated 300 species of birds produce pellets; however, the identification of prey remains from pellets is best stuited to raptors (Glue 1971). The combination of swallowing smaller prey whole and weak stomach acid, which is unable to dissolve skeletal material, results in owls producing the most complete pellets in the avian world (Glue 1971). Pellet analysis is a reliable tool used to determine diets of owls (Dickman *et al*. 1991, Blem *et al*. 1993, Balciauskiene and Narusevicius 2006). Barred Owls produce pellets that are approximately 90% accurate, when compared to known diet (Jaksic 1983). Other forms of dietary analysis cannot produce the accuracy found through pellet analysis (Errington 1932a, Balciauskiene and Narusevicius 2006). Other techniques to obtain dietary information (e.g. shooting predators to examine stomach contents) (Errington 1930, Errington 1932a) are no longer viewed as sustainable or humane.

In Manitoba, the lack of Barred Owl studies has limited dietary analysis to infrequent anecdotal diet samples such as pellets from injured wild owls or dead bird

stomach content analysis. Objectives were to: 1) document diet of Barred Owls through analysis of pellets, nest materials, and prey remnants and 2) infer Barred Owl predatory strategies for this portion of its range based on its diet.

METHODS

Study Area

The study area (Fig.1.3) was southern Manitoba north to 53º 52.673'N. Active Barred Owl nest sites and breeding habitats were documented using audio surveys and nest searches (see Chapter 1). Other sources of dietary information included stomach contents of road-killed owls and pellets collected near roosting owls (Table 4.1).

Dietary Composition

Known Barred Owl nest sites were visited after young had fledged or nest sites were depredated. Prey were identified and recorded from pellets and prey remains collected from nest sites, near nest trees, and Barred Owl roost sites. Stomach contents from road-killed Barred Owls were obtained from Dr. James Duncan, Manitoba Conservation. Specimens were dissected, stomach contents removed, prey items identified and data recorded.

Data Analysis

All dietary material collected was dried, dissected, and analyzed to determine species composition (Banfield 1975). Dietary make-up was tabulated and proportion of

each prey type was calculated. Diet data was subjected to analysis using Simpson's (1949) formula for measurement of diversity in a sample:

$$D = \sum p_i^2,$$

where D is equal to the sum of the squared proportions of each prey type.

RESULTS

Prey data (n = 123 prey items) from collected pellets, nest materials, and stomach contents are presented in Table 4.1. Pooled prey data are presented in Table 4.2. Unidentifiable rodent remains ("Rodentia spp.") comprised 25% of total diet (n = 31). All birds ("Aves spp.") made up 22% of diet (n = 27). Meadow Voles (*Microtus pennsylvanicus*) comprised 15% (n = 18). Sphinx moths ("Sphingidae spp.") and scarab beetles ("*Phyllophaga* spp.") each made up 7% of total diet (n = 9). Star-nosed Moles (*Condylura cristata*) and shrews ("*Sorex* spp.") each comprised 5% (n = 6). Unidentifiable mice ("Cricetidae spp.") and Short-tailed Shrews (*Blarina brevicauda*) each comprised 4% of total diet (n = 5). All other prey items comprised 7% of diet (n = 7). Analysis using Simpson's (1949) formula for measurement of diversity in a sample yielded a value of D = 0.1525 (Table 4.2).

DISCUSSION

The diversity of prey recorded in the diet of Barred Owls in Manitoba (Table 4.2) has also been reported in other areas of its range (Errington 1932b, Wilson 1938, Mazur 1997b). Throughout its North American range, small mammals and birds comprise the majority of its diet, but arthropod prey are also frequently found (Cahn and Kemp 1930,

Table 4.1: Prey Data for Barred Owls in Manitoba, Canada.

Location	Day	Month	Year	Source	Species
Hwy 44, MB	10	3	1995	Stomach contents	*Clethrionomys gapperi* (2) *Synaptomys borealis*
Cranberry Portage	7	7	1997	Stomach contents	*Phyllophaga* spp. Sphingidae spp. (5)
Carrick, MB		5	2009	Pellet	*Condylura cristata*
Site 20	15	6	2009	Pellet	Aves spp.
Site 36	19	6	2009	Food cache	Aves spp. *Condylura cristata* *Tamiasciurus hudsonicus*
Site 5	22	6	2009	Roost site	Aves spp. *Microtus pennsylvanicus*
Site 36	8	7	2009	Nest material	*Blarina brevicauda* (2) *Condylura cristata* (2) Cricetidae spp. (3) *Felis domesticus* *Microtus pennsylvanicus* (2) *Myotis lucifuga* Rodentia spp. (2) *Sorex* spp. (2)
Duck Mountain P.P.	5	8	2009	Stomach contents	*Microtus pennsylvanicus*
Site 5	2	10	2009	Nest material	Aves spp. (2) *Microtus pennsylvanicus* Rodentia spp. (2) *Sorex* spp.
Site 31	2	10	2009	Nest material	Aves spp. *Blarina brevicauda* (2) *Condylura cristata* Cricetidae spp. *Microtus pennsylvanicus* (3) *Phyllophaga* spp. Rodentia spp. (5) *Sorex* spp. Sphingidae spp. (3)
Site 20	18	10	2009	Nest material	Aves spp. (12) *Condylura cristata* Cricetidae spp. *Microtus pennsylvanicus* (7) *Phyllophaga* spp. (5)

Table 4.1: Continued.

					Rodentia spp. (20) Sciuridae spp. *Sorex* spp. Sphingidae spp.
Site 27	30	10	2009	Nest material	Aves spp. *Phyllophaga* spp.
Site 20	4	5	2010	Pellet	Aves spp. *Sorex* spp.
Site 4	N/A	5	2010	Nest material	Aves spp. (5) *Microtus pennsylvanicus*
Site 11	N/A	5	2010	Nest material	Aves spp. (3) Rodentia
Site 56	N/A	6	2010	Nest material	Aves spp. *Blarina brevicauda* *Microtus pennsylvanicus* (2) *Phyllophaga* spp. Rodentia spp.
					Total = 123

Table 4.2: Diet of Barred Owls in Manitoba, Canada.

Prey Type	Number of Prey	Proportion of Diet (p_i)	$p_i 2$
Rodentia spp.	31	0.2520	0.0635
Aves spp.	27	0.2195	0.0482
Microtus pennsylvanicus	18	0.1463	0.0214
Phyllophaga spp.	9	0.0732	0.0054
Sphingidae spp.	9	0.0732	0.0054
Condylura cristata	6	0.0488	0.0024
Sorex spp.	6	0.0488	0.0024
Cricetidae spp.	5	0.0407	0.0017
Blarina brevicauda	5	0.0407	0.0017
Clethrionomys gapperi	2	0.0163	0.0003
Felis domesticus	1	0.0081	0.0001
Myotis lucifuga	1	0.0081	0.0001
Sciuridae spp.	1	0.0081	0.0001
Synaptomys borealis	1	0.0081	0.0001
Tamiasciurus hudsonicus	1	0.0081	0.0001
	123	**1.0000**	**0.1525**

Errington 1932b, Gronau 2005). However, prey lacking bony skeletal structures are difficult to locate within Barred Owl prey remains causing them to be under-represented in their diet (Livezey *et al*. 2008).

Barred Owls capture prey types in proportion to that prey's availability (Fowle and Edwards 1955, Marks *et al*. 1984). This trend can be inferred in the data from Manitoba (Table 4.3). Sites with low water table and little undergrowth have a greater incidence of small mammals in their diet. Sites with high water table and little undergrowth have a greater proportion and variety of avian prey. Other sites show a more even distribution of prey types, similar to the varied habitat in which they are found (Table 4.3).

Odd or infrequent prey types found in the data from Manitoba, such as remains of a domestic cat (*Felis domesticus*) and a Little Brown Bat (*Myotis lucifuga*) are likely rare cases of opportunistic predation based on chance encounters. These data support the suggestion that Barred Owls are opportunistic predators (Errington 1932b, Mazur 1997b).

The prey diversity metric estimated with this sample was relatively low (D = 0.1525). The scale on which this is ranked is between 1 and 0, where values close to 1 indicate lower diversity and values closer to 0 indicate higher diversity (Simpson 1949). Therefore, Barred Owls in Manitoba display a diet with high diversity in the prey types utilized.

Table 4.3: Variation of Barred Owl Prey Types by Habitat in Manitoba, Canada.

Habitat Grouping	Prey Type	Number of Prey	Proportion of Diet (p_i)
Open undergrowth/High water table (Site 4 & 20)	Aves spp.	19	0.3276
	Condylura cristata	1	0.0172
	Cricetidae spp.	1	0.0172
	Microtus pennsylvanicus	8	0.1379
	Phyllophaga spp.	5	0.0862
	Rodentia spp.	20	0.3448
	Sciuridae spp.	1	0.0172
	Sorex spp.	2	0.0345
	Sphingidae spp.	1	0.0172
		58	**1.0000**
Open undergrowth/Low water table (Site 31, 36 & 56)	Aves spp.	3	0.0750
	Blarina brevicauda	5	0.1250
	Condylura cristata	4	0.1000
	Cricetidae spp.	4	0.1000
	Felis domesticus	1	0.0250
	Microtus pennsylvanicus	7	0.1750
	Myotis lucifuga	1	0.0250
	Phyllophaga spp.	2	0.0500
	Rodentia spp.	8	0.2000
	Sorex spp.	3	0.0750
	Sphingidae spp.	1	0.0250
	Tamiasciurus hudsonicus	1	0.0250
		40	**1.0000**
Varied undergrowth and water table (Site 5, 11 & 27)	Aves spp.	7	0.5000
	Microtus pennsylvanicus	2	0.1429
	Phyllophaga spp.	1	0.0714
	Rodentia spp.	3	0.2143
	Sorex spp.	1	0.0714
		14	**1.0000**

THESIS DISCUSSION

Barred Owl Breeding Habitat and Nest Structures

Barred Owls have long been thought to be a habitat specialist, dependent exclusively on intact mature forest stands (McGarigal and Fraser 1984, Mazur *et al*. 1998) and, hence, similar to the Spotted Owl (Hamer *et al*. 2007). This study and that of Elderkin (1987) have illustrated that this is not necessarily the case; with proper forest management practices an area may be used by nesting Barred Owls before and after logging. The importance of multiple suitable nesting structures (primarily cavities) seems to be more crucial than any other factor to an area's ability to sustain Barred Owls. With rotten or damaged trees being the source of these nesting opportunities, nest tree collapse is a normal and, at times, regular occurrence. Multiple suitable nest sites may be needed for a male to attract a mate or for a pair to re-nest, if their nest is destroyed early in the breeding season. However, a persistent nest that provides cover, accessibility and safety from depredation, the last being the most important factor, will be used for multiple years.

Many studies have described Barred Owl habitat as the determining factor in their distribution, in essence that they are "selecting" a habitat type or types. Much has been made of their use of hardwood or mixed-wood forests (Booth and Harrison 1997, Mazur *et al.* 1997b, Russell 2008), and many studies discuss proximity to water when looking at Barred Owl habitat (Mazur *et al.* 1997b, Hamer *et al*. 2007). Even colloquial names for Barred Owls, such as the "swamp owl" (König and Weick 2008), suggest they select areas based on habitat type. A simpler explanation is that Barred Owls will use any

habitat type that can provide suitable nesting opportunities. These habitats happen to coincide with wet areas, with a hardwood component to the forest. The willingness of Barred Owls to use different nesting structures (Mazur *et al.* 1997a, Mazur *et al.* 1997b, Houston 1999, Priestley 2004) including artificial nest boxes (Elderkin 1987, Johnson 1987) indicates that quality nesting cavities are a limiting factor to their distribution and nesting success. Barred Owl nesting habitat, documented in the present study, varied greatly with respect to canopy cover, ground cover and distance to human development. This variability suggests that future Barred Owl research should focus more on factors that influence nest site availability. For example, Manitoba contains few hardwood tree species; the Balsam Poplar is among the largest and quickest growing tree species (Chapin III *et al*. 1986) and is the tree species most frequently used by nesting Barred Owl in the province. Balsam Poplar is found in moist to wet areas and can easily develop heart rot (Thomas *et al*. 1960), resulting in hollow trees of a considerable size. Findings of this study suggest that Barred Owls are using nest cavities in proportion to their availability and are not selecting the tree species or habitat in which they occur - the source of the suitable nest cavity is of little importance.

All nine nests located during this study were cavity types, both apical and lateral. Four additional cavity nest sites were located in 2011 (Whiklo, unpubl. data). Barred Owl studies elsewhere in its range have documented its use of different types of nesting structures. This may be due to limited availability of cavity nests and/or high levels of intraspecific competition. Such conditions may not have existed in the present study because either the habitat therein was relatively undeveloped and/or the methods used. The study area was not limited to any specific habitat or geographic region with the

exception of northern parts of Manitoba for logistical reasons. Instead, as much information as possible was gleaned from the Manitoba Nocturnal Owl survey data to determine areas of high or consistent Barred Owl vocal activity. This resulted in a relatively unbiased habitat sample. This is perhaps the reason for the difference between this study and others that reported the use of non-cavity type nests by breeding Barred Owls. Further research in Manitoba will eventually result in the location of non-cavity type Barred Owl nests in areas of high Barred Owl population density and heavy intraspecific competition. Manitoba contains many large tracts of mixedwood forests with many hollows and snags; in these areas there appears to be no shortage of Barred Owl nesting opportunities.

Further research is needed to determine the reliability of cavity dimensions or nest tree dimensions as an indicator of nest tree and/or breeding habitat suitability for Barred Owls. It is crucial that other Barred Owl researchers collect these types of data, because this type of index would be invaluable for forest managers and researchers alike.

Barred Owl Breeding and Diet

Many of the findings in this study were similar to previously published data on Barred Owl breeding habits and diet. However, the limited number of published accounts of this type of basic data for the Barred Owl (Errington 1932b, Wilson 1938, Murray 1976, Johnson 1987, Mazur 1997b, Mazur and James 2000, Odom and Mennill 2010) limits the comparison of new data, or to explore other trends over time and throughout its North American range. Publications regarding Barred Owl diet are few (Mazur 1997b, Mazur and James 2000) and often not focused solely on Barred Owls (Errington 1932b,

Wilson 1938), in contrast Birrer (2009) synthesized the literature on Long-eared Owl (*Asio otus*) diet by compiling 475 articles and over 400 different prey types for this species. Behavioural studies on Barred Owls primarily concentrate on vocalization (Bell 1964, Odom and Mennill 2010) or consist of short communications (Carter 1925, Robertson 1959, Houston 1999), a contrast to work on the behaviour of Tawny Owls (*S. aluco*), where a search of the literature results in many studies covering most aspects of Tawny Owl behaviour (Vaughan and Muir 1954, Hirons 1985, Wallin 1987, Redpath 1995, Galeotti 1998, Overskaug *et al*. 1999, Sunde *et al*. 2001, Sunde *et al*. 2003). Further research on Barred Owl diet and breeding behaviour is needed in Manitoba and many other parts of its range.

On the Capture of Barred Owls

Over the duration of this study, the most effective methods for capturing Barred Owls were researched and implement only to discover that many published reports of Barred Owl capture techniques were not as effective as the authors suggested (Nicholls and Warner 1972, Elody and Sloan 1984, Frith *et al*. 1997, Olsen *et al*. 2006, Russell 2008, Singleton *et al*. 2010).

The main trapping method in this study began as a bal-chatri trap baited with a mouse (see Chapter I methods), which proved to be ineffective, especially on cold spring nights. Only one owl struck the bal-chatri in nine trapping attempts, and in that case the bal-chatri's loops failed to ensnare the owl's feet. Either poor construction of the trap's loops or the "fly-by" strike behaviour of the Barred Owls (as opposed to the pounce and

sit strike behaviour of other raptors typically caught with this type of trap) resulted in this failed capture attempt.

The secondary trapping method was a mist net baited with a mouse on a raised platform in front of the net. This was inefficient and failed as only one owl was captured in twelve different trapping attempts. In both cases, the bal-chatri and mist net, the inactivity of the mouse seemed to be a factor in the ineffectiveness. The owl that struck the bal-chatri was also the one that was caught by the mist net technique, on the same day. This trapping attempt occurred on a warm afternoon and the bait mice were quite active, which seemed to trigger the strikes. Night or evening trapping attempts during the early breeding season resulted in lethargic mice that would often huddle in a corner of the bal-chatri or platform. In these cases, Barred Owls would show little interest in the bait, even when they were perched within meters of the trap set-up.

Hours waiting for a strike attempt on a baited trap, or conditioning owls to capture mice in the presence of humans, was not feasible in this study. Also the inaccurate published accounts of these aforementioned capture techniques imply an high level of capture efficiency that is a deterrent to the development of more effective methods for trapping Barred Owls. Research on simpler and more efficient methods to capture Barred Owls are needed and would encourage more research on its biology elsewhere in its range.

The plan to use radio telemetry to locate Barred Owl nests failed because owls proved too difficult to capture, using published trapping techniques (Nicholls and Warner 1972, Elody and Sloan 1984, Frith *et al*. 1997, Olsen *et al*. 2006, Russell 2008, Singleton

et al. 2010). Rather, diurnal nest searching using audio playback was simpler, more cost effective and quicker.

On the Status and Fate of the Barred Owl

In recent years the Barred Owl has had a personality makeover foisted upon it, which has resulted in some unprecedented actions. A once majestic bird or phantom of the forest has become an intruder and the perpetrator of malice against the Spotted Owl Although Barred Owl attacks on humans have been documented (Duncan 2003), their vicious reputation is completely unwarranted. Through the duration of this study researchers have been in close contact with ninety-four Barred, owlets have been banded, antagonistic calls have been broadcast in Barred Owl territories at the height of the breeding season and but for one close encounter, no behaviour was experienced that fit with the reputation that precedes Barred Owls. Other owls, many smaller than Barred Owls, have been recorded calling in Barred Owl habitat (Whiklo, unpubl. data). These owls would, and sometimes do, make easy prey for a formidable predator like the Barred Owl, but they do not appear to displace these species or impact upon their numbers (Duncan 2010).

Much has been published on the "range expansion" of Barred Owls and its theorized impacts on the threatened Spotted Owls of the Pacific Northwest (Kelly *et al*. 2003, Livezey *et al*. 2007, Livezey 2009a, Livezey 2009b). The truth is that no one knows when or how Barred Owls moved westward, or if this is a natural action or anthropogenically-based. Little concrete information on the impact of Barred Owls on Spotted Owls has been put forth (Olson *et al*. 2005, Livezey and Fleming 2007, Livezey

et al. 2007). This came to a head in January of 2010 when the USFWS announced plans to move forward with the "experimental removal" of Barred Owls, or the lethal control of Barred Owls. More detailed and rigorous studies on basic Barred Owl biology both within and outside of the range of the Spotted Owl are required before implementing such a drastic and expensive management plan.

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PERSONAL COMMUNICATIONS

Duncan, J. R. Winnipeg, Manitoba. 10 December 2008.

Duncan, J. R. Winnipeg, Manitoba. 27 July 2010b.

APPENDIX A: Audio Playback Utilized for Nocturnal Barred Owl Surveying.

The goal of the nocturnal audio playback loop used in this survey was to incite a rapid response from any Barred Owl in the vicinity of the survey stop. This was achieved by attempting to recreate a natural sounding interaction between a territorial pair (Odom & Mannell 2010). The playback used was as follows:

1. Male two-phrase hoot (6 sec.) (Odom & Mannell 2010).
2. Repeat 1.
3. Female two-phrase hoot (4 sec.) (Odom & Mannell 2010).
4. Repeat 1.
5. Male ascending call (10 sec.) (Odom & Mannell 2010).
6. Repeat 3.
7. Caterwauling (29 sec.) (Odom & Mannell 2010).
8. Female scream (16 sec.) (Odom & Mannell 2010).
9. 5-minute listening period.

APPENDIX B: Audio Playback and Protocol Utilized for Diurnal Nest Searching.

Through trail and error I ascertained that caterwauling (Odom & Mannell 2010) and female vocalizations were more likely to incite a response during daylight hours than male vocalizations. Diurnal playback and nest searching protocol was as follows:

1. Female two-phrase hoot (4 sec.) (Odom & Mannell 2010).
2. Female scream (16 sec.) (Odom & Mannell 2010).
3. Caterwauling (29 sec.) (Odom & Mannell 2010).
4. Wait for visual contact and distinguish female owl.
5. Determine direction of travel of female owl.
6. Wait for female owl to flee playback area.
7. Move towards direction of travel of female owl.
8. Repeat 1 – 6.
9. Make visual verification of female entering nest cavity.
10. Verify cavity occupancy by knocking on the suspected tree trunk while observing the suspected cavity opening.

APPENDIX C: Summary of Forest Resource Inventory (FRI) Data Codes Used (Natural Resources Manitoba 1996)**.**

Productive Forested Land

Includes all forest land capable of producing merchantable wood regardless of its existing stage of productivity.

1) Softwood: - includes all stands where 76% and over of the total basal area consists of coniferous species.

2) Mixedwood[a]: - includes all stands where the basal area of all the coniferous species is between 51% and 75% of the total basal area.

3) Mixedwood[b]: - includes all stands where the basal area of all coniferous species is between 26% and 50% of the total basal area.

4) Hardwood: - includes all stands where the basal area of all coniferous species is less than 25% of the total basal area.

Non-Productive Forested Land

Includes all forest land not capable of producing merchantable timber due to very low productivity.

i) Treed Muskeg - Similar to open muskeg, except that the area is supporting semi-stagnated or stagnated trees. Some of the trees may produce "Christmas" trees or fence posts, but will not produce pulpwood size trees within a rotation age of 140 years (9.0+cm d.b.h., height over 10.0m and $20m^3$ of net merchantable volume per hectare). At least 10 percent of the area will be tree covered.

ii) Treed Rock - Rock with a very shallow soil, supporting semi-stagnated or stagnated trees. At least 26 percent of the area will be tree covered. These sites do not produce merchantable stands.

iii) Willow/Alder - Low lying areas with a saturated water table presently supporting willow or alder growth. Without improvements these sites are not capable of producing merchantable timber stands. At least 51 percent of the area must be shrub covered.

iv) Protection Forest - Presently developed or reserved recreational areas and small islands (less than 2 hectares).

Non-Forested Land

Includes areas withdrawn from timber production for a long period of time, such as cultivated fields, hay meadows, pastures, settlements, rights-of-way, gravel pits, beaches, wide ditches, summer resorts, bare rock, barren, mines, marsh and muskeg.

i) Barren-Bare Rock - Tundra and rock with less than 25 percent tree cover.

ii) Fields (Agriculture) - Areas of private and leased land
cleared of tree cover and presently under an agricultural use.
Less than 10 percent of the area will be tree covered.

iii) Meadow - Moist to wet grassland suitable for hay production (natural hay land), at least 51 percent of the area is covered by grass.

iv) Marsh - Muskeg

v) Unclassified - right-of-way, roads, gravel pits, beaches, summer resorts, mines, oil fields, etc.

Water

Includes lakes and rivers, measured at the high water mark, able to be delineated with a double line on the aerial photographs. Narrow river and creeks marked by a single blue line are not to be considered as separate types, nor as type boundaries.

Crown Closure Class

0 - 0 % - 20% crown closure

2 - 21% - 50% crown closure

3 - 51% - 70% crown closure

4 - 71% and over

APPENDIX D: Summary of Earth Observation for Sustainable Development of Forests (EOSD) Data Codes Used (Natural Resources Manitoba 1996)**.**

1) Broadleaf – Dense: Greater than 60% crown closure; broadleaf trees are 75% or more of total basal area.
2) Broadleaf – Open: 26-60% crown closure; broadleaf trees are 75% or more of total basal area.
3) Coniferous – Dense: Greater than 60% crown closure; coniferous trees are 75% or more of total basal area.
4) Coniferous – Open: 26-60% crown closure; coniferous trees are 75% or more of total basal area.
5) Coniferous – Sparse: 10-25% crown closure; coniferous trees are 75% or more of total basal area.
6) Exposed/Barren Land: River sediments, exposed soils, pond or lake sediments, reservoir margins, beaches, landings, burned areas, road surfaces, mudflat sediments, cutbanks, moraines, gravel pits, tailings, railway surfaces, buildings and parking, or other non-vegetated surfaces.
7) Herbs: Vascular plant without woody stem (grasses, crops, forbs, gramminoids); minimum of 20% ground cover or one-third of total vegetation must be herb.
8) Mixedwood – Dense: Greater than 60% crown closure; neither coniferous nor broadleaf tree account for 75% or more of total basal area.
9) Mixedwood – Open: 26-60% crown closure; neither coniferous nor broadleaf tree account for 75% or more of total basal area.
10) Water: Lakes, reservoirs, rivers, streams, or salt water.

11) Shrub – Low: At least 20% ground cover which is at least one-third shrub; average shrub height less than 2 m.
12) Shrub – Tall: At least 20% ground cover which is at least one-third shrub; average shrub height greater than or equal to 2 m.
13) Wetland – Herb: Land with a water table near/at/above soil surface for enough time to promote wetland or aquatic processes; the majority of vegetation is herb.
14) Wetland – Shrub: Land with a water table near/at/above soil surface for enough time to promote wetland or aquatic processes; the majority of vegetation is tall, low, or a mixture of tall and low shrub.

Wetland – Treed: Land with a water table near/at/above soil surface for enough time to promote wetland or aquatic processes; the majority of vegetation is coniferous, broadleaf, or mixedwood.