THE ECOLOGY

OF THE BARRED OWL

AND ITS ROLE IN

SUSTAINABLE FORESTRY

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Abstract

Forest management should strive to maintain ecosystem and biological diversity. The old mixedwood forest is a highly species rich habitat within the boreal forest. A sustained quantity and distribution of this forest type is essential to maintain forest ecosystem and biological diversity. In order to determine if the Barred Owl (*Strix varia*) could serve as an indicator of old mixedwood forest we investigated its ecology including habitat selection, and the potential limiting factors of this habitat in the Prince Albert Model Forest, Saskatchewan from 1993 to 1996. We radio-marked 14 adult Barred Owls and determined their breeding and non-breeding home range sizes. Breeding season home ranges were relatively small (=148.6 ha, SD=111.6), while non-breeding season home ranges were the largest recorded for this species to date (=1234.0 ha, SD=630.7). The large home range size during the non-breeding period was attributed to a decrease in prey availability during the winter months. Breeding and non-breeding home ranges overlapped entirely in all but two owls.

Habitat selection was investigated at three levels: habitat selection determined from call-surveys, owl home range selection, and owl habitat use. Based on call-surveys, owls were found in association with old mixedwood forest, old deciduous forest and water, and avoided young forest and treed muskeg. Call-surveys are a cost and time effective method of monitoring owls, and these data substantiate habitat associations also found through radio-telemetry. Barred Owl breeding home ranges contained more old mixedwood forest than expected at random, and non-breeding home ranges contained more mature and old mixedwood, and mature and old deciduous forest than expected at random. Both breeding and non-breeding home ranges contained low proportions of young forest and treed muskeg. Breeding home ranges were found to contain higher proportions of old mixedwood than non-breeding home ranges. Habitat composition of home range core areas, of both breeding and non-breeding home ranges, did not differ from habitat composition of total home ranges. Bonferroni Confidence Intervals and Log-ratio Analysis revealed that habitat used by Barred Owls for foraging and roosting was not proportional to the habitat within the study area. During the breeding period, Barred Owls selected mature and old mixedwood, and mature deciduous forests. Similarly, in the non-breeding period, mature and old mixedwood, and mature and old deciduous forests were selected. Barred Owls are highly territorial, therefore limiting their movements within their home range. Barred Owl habitat use was compared to available habitat within the owl's home range. During the breeding period, owls used habitat in proportion to its availability within their home range, with the exception of young mixedwood forests which was selected against. Owls selected old mixedwood within their non-breeding home ranges and avoided young and coniferous forests, treed muskeg, open areas and water. Barred Owl habitat use in the breeding and non-breeding periods did not differ.

Nest site and prey availability are considered two primary limiting factors in habitat selection in birds. Barred Owls strongly selected for old mixedwood forest in the placement of their nests (87% of those found). Within old mixedwood forest, Barred Owl nests were in larger trees (=47.4 cm dbh) than expected at random (=23.0 cm dbh) and in taller trees (=18.8 m) than expected at random (=6.5 m). In this region, like others, Barred Owls appear to be limited by nest site availability.

The requirement of large tree diameter and height for a nest tree are likely a major factor influencing habitat selection by Barred Owls. The diet of Barred Owls represented that of a generalist predator, including insects, amphibians, birds and mammals. Frogs made up a considerable portion of the diet. However, the prey remains and pellets were collected during the summer, and winter diet may be somewhat different. Red and northern flying squirrels also contributed to a large portion of the diet. Considering the size of a squirrel, they are likely important prey items in terms of biomass. We found red squirrels to be more abundant in old mixedwood forest than in old aspen forest. A similar conclusion has been drawn for northern flying squirrels in the boreal forest of Alberta. Small mammal abundance was not greater in old mixedwood when compared to old aspen forest. However, the overall abundance of prey in old mixedwood is likely to be the important feature to a generalist predator like the Barred Owl.

In conclusion, Barred Owls are highly selective of old mixedwood forest. This selectivity appears to be a result of the requirement for large nest trees, and a diverse prey assemblage. Our study supports the use of the Barred Owl as a tool for the management of old mixedwood forest, both at the stand and landscape levels.

TABLE OF CONTENTS

Chapter **Page**

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

1 Introduction

Traditional large scale forest harvesting, with short rotations tends to reduce the quantity and distribution of old forest. Natural disturbances, such as fire, typically left some areas unaffected, creating a mosaic of forest ages. Large scale forest harvesting has the potential to remove this mosaic creating a less complex forest. The natural succession of forests has therefore been truncated by harvesting based on the maxim of optimal tree growth.

The mixedwood forest is widespread in the boreal forest region of Canada (Peterson and Peterson 1992). Recent studies in Alberta (Stelfox 1995b) have shown old mixedwood forest to be the most structurally diverse, hence the most species-rich, habitat of aspen mixedwood forests. Management that employs short rotations will eventually eliminate the old mixedwood forest and also result in an 'unmixing' of the mixedwood. The outcome will be the loss of the most species-rich forest habitat and the species reliant on this habitat in the boreal region.

The recent shift to ecosystem based forest management offers a way to maintain the forest mosaic and the species reliant within it. Management of forests for a few preferred species will not be adequate. Alternatively, management to ensure a representative quantity of the forest mosaic may be preferred. However, independent validation of this approach are required. Species with very specific habitat requirements and large area requirements may be useful for this purpose. The status of these species can be used as a yardstick by which the ecological health of a forest can be measured, along with other indicators of elements and process.

The Barred Owl (*Strix varia*) is a non-migratory raptor of the boreal forest. Its

relatively narrow habitat requirements and large area requirements make it a potential candidate as a forest management indicator. The presence of a viable Barred Owl population may be a reflection of an adequate supply of old forest. Conversely, its absence could indicate an inadequate supply of old forest with its requisite structure, and therefore the potential loss of the many species reliant on that habitat.

We nominated the Barred Owl as an indicator of old mixedwood forest in the boreal forest of Saskatchewan. However, for this species to be useful in forest management we must first understand its specific area and habitat requirements, as well as potential limiting factors in its habitat selection. We therefore began an investigation of Barred Owl ecology in the Prince Albert Model Forest in 1993. Our main objectives were to determine:

1. Annual area requirements (home range)
2. Specific habitat selection throughout the year
3. Quantify nesting habitat and its role in habitat selection
4. Quantify prey selection and its role in habitat selection

2 Methods

2.1 Study Site

The research was conducted from May 1993 to July 1996 within the southern boreal forest of Saskatchewan, Canada (53°35'-54°15'N, 105°05'-106°45'W). The 400,000-ha study area encompassed the Prince Albert Model Forest including a portion of Prince Albert National Park. The dominant tree species in the study area included trembling aspen (*Populus tremuloides*), balsam poplar (*Populus balsamifera*), white birch (*Betula papyrifera*), white spruce (*Picea glauca*), black spruce (*Picea mariana*), tamarack (*Larix laricina*), jack pine (*Pinus banksiana*), and balsam fir (*Abies balsamea*). The habitat included pure deciduous, mixed coniferous/deciduous, and pure coniferous forest, muskeg, and shrub lands. Elevation ranged from 490 to 698m. The topography was gently rolling, interspersed with numerous lakes and creeks. The climate is boreal continental, with an average annual precipitation of 401 mm; 281 mm as rain and 120 mm as snow. July and January temperatures average 17.6°C and -19.7°C respectively, with annual extreme temperatures of 36.1 °C and -48.3°C (Environment Canada Parks 1986). A portion of the study area is currently being commercially harvested for wood pulp and timber.

2.2 Call-Surveys

We estimated Barred Owl locations through nocturnal call-surveys from 28 April to 28 May, 1993. Call-surveys were restricted to randomly-selected, vehicle

accessible-roads, and were conducted between one half hour after sunset and one half hour prior to sunrise. Call-survey stops were spaced 1 km apart. Thirteen survey routes, totalling 275 call-survey stops, were each surveyed once. These call-survey stops represented the survey locations. Territorial calls of a male and a female Barred Owl were broadcast using a 12-watt battery powered tape recorder with 4 directional speakers (MTC Electronics), set approximately 1.5 metres (m) above the ground. Surveyors remained at each survey stop for 8 minutes consisting of an initial 1 minute listening period prior to broadcast, followed by a 2 minute broadcast, and concluding with a 5 minute post-broadcast listening period. McGarigal and Fraser (1985) and Mosher *et al*. (1990) found that 70%-80% of Barred Owls detected during the post-broadcast listening period responded within 5 minutes of the end of the broadcast period. Surveys were not conducted during periods of precipitation or when wind speed exceeded 15 km/hr as reported by Environment Canada, or scored 3 or greater on the Beaufort scale.

At each survey stop where owls responded, we recorded the following parameters: the apparent direction to the owl (to the nearest degree), number and sex of owls responding, time for owl to respond, and if the owl(s) was observed. Owl locations were determined by triangulation from at least two consecutive survey stops, or by direct observation of the owl, in which case the survey location was used as the owl location. One hundred random locations were generated throughout the study area, in order to compare available habitats. These random locations did not include locations on water surfaces.

2.3 Radio-telemetry

2.3.1 Owl Capture and Radio-Marking

Barred Owls were captured throughout the year, with most (78%) being caught during the breeding period (April - August). A variety of capture techniques were used including mist nets and movable mounted Barred Owl, mist nets and laboratory mice in a wire cage, free ranging live laboratory mouse and fish landing net, and a noose pole. Mist nets were two-shelved, 12 m long with 121 millimetre (mm) mesh and were supported between 1.27 centimetre (cm) diameter, 3.0 m long electrical conduit poles. Two mist nets were set in a "V", with either the mounted owl or mice and bal-chatri placed between the mist nest in the middle of the "V" (Elody and Sloan 1984). Owls were lured to the set up location by broadcasting a tape recorded call of a pair of Barred Owls. Owls became entangled in the mist net when stooping to drive off the "intruding" owl or attempting to capture the mouse. Observers sat hidden 10 - 20 m away. These two techniques were exclusively conducted at night. In the case of the fish landing net, a Barred Owl located during the day was approached and a live laboratory mouse was set out on a piece of styrofoam (approximately 20 cm x 20 cm). The person with the net sat immediately beside the mouse and as the owl stooped for the mouse, it was netted. Owls located near their nest were often bold, allowing one to approach quite closely. Once immediately below the tree the owl was perched in, a wire noose at the end of a 6.1 m extension pole could be slipped around the owl's neck and the owl would be brought to the ground.

Fourteen adult Barred Owls (10 - ♀, 4 - ♂) were captured. Six morphological

measurements were recorded (weight, wing chord length, tail length, food pad length, moult score and the number of complete tail bars on the central tail feather). The sex of the owls was determined by owl weight (females being approximately 25% heavier, Johnsgard 1988), presence of a brood patch and by vocalizations (Elderkin 1987). U.S. Fish and Wildlife aluminum leg bands were put on the owl's right leg and the owls were fitted with back-pack style radio-transmitters (AVM Electronics, Livermore, CA). Harnesses were constructed of 2.5 cm wide Teflon tubular ribbon, with two strands of nylon coated braided cable running through the Teflon ribbon (Duncan 1987). Tubular copper clamps secured the harness where it crossed at the owl's sternum and at the radio-transmitter. Feathers trapped under the harness were laid overtop of the harness, so that the harness sat immediately next to the owl's skin, facilitating more normal thermoregulation. The radio-transmitter and harness weighed 32 g, or between 3% and 5% of the owl's body weight. Radio-transmitters emitted a signal at a rate of 60 beats per minute with the signal detectable up to 10 kilometre (km) if the observer was on the ground. Radio-transmitter battery life ranged from eight to 12 months.

2.3.2 Radio-tracking

Radio-marked Barred Owls were located through triangulation or by direct observation. Owls were triangulated using a single 5 element Yagi antenna (AVM Electronics, Livermore, CA). This was either in the form of a vehicle roof-mount antenna (2 m above the roof of a pickup truck), or simply held by a person while standing on the ground (hand-held). The Yagi antenna was combined with a radio-

receiver (Lotek Engineering, NewMarket, ON) to determine the direction and strength of the radio-signal. The direction to the nearest degree was read from a compass rosette mounted on the inside of the truck roof, and the direction was corrected by determining the direction the truck was pointed. In the case of the hand-held Yagi, the direction of the signal was simply read from a compass. At least three strong directional signals were recorded and plotted onto 1:50,000 topographical maps or 1:25,000 forest inventory maps. The signal directions were then inputed to the Locate II computer program (Pacer, Truro, NS). Locate II calculated the estimated owl location and surrounding error polygon. Estimated owl locations with error polygons greater than 10 hectares (ha) were not retained. Larger error polygons indicate less accurate estimated locations, which introduce greater error into the estimate of the owl location.

Barred Owls were located on average every fifth day, with relocations being greater or equal to two days apart. Owls were relocated both during the day and during the night. Only one location of the nest site was used for the period in which any nesting owl was on the nest. During the breeding period, owls were tracked on average for 3.4 months obtaining an average of 21 relocations per owl, and in the non-breeding for 5.5 months, with an average of 35 relocations per owl.

2.4 Home Range

Home range values were calculated for breeding (1 April - 31 August) and non-breeding (1 September - 31 March) periods. Owl relocations used in home range calculation were separated by at least two days and location estimates had error

polygons less than 10 ha. Home range values were calculated by the 95% and 50% Minimum Convex Polygon (95MCP, 50MCP) home range estimator using the program Home Range (Ackerman *et al*. 1990). The 95% Minimum Convex Polygon home range has the outer most 5% of the animal's locations removed, as these may represent excursions outside the normal home range (Ackerman *et al*. 1990). The 95MCP was considered to represent the total home range. The 50% Minimum Convex Polygon home range has the outer most 50% of the animal's locations removed. The area within the remaining 50% of the locations was considered the core area of the home range (Ackerman *et al*. 1990). Numerous home range estimators exist (White and Garrott 1990); however many employ statistical computations requiring the assumption a bivariate normal distribution, and independence of successive relocations. These assumptions are often impossible to meet (McNay *et al*. 1994, Gautestad and Mysterud 1995). We therefore chose to use a home range estimator that was not statistical, and made few assumptions of the data. Furthermore, the Minimum Convex Polygon estimator is quite widespread in the literature, facilitating comparisons.

Breeding and non-breeding home range values failed to approximate a normal distribution and were therefore log transformed. A t-test ($\propto$ 0.05) was performed to determine if breeding and non-breeding home ranges differed in size (Zar 1996).

2.5 Habitat Selection

2.5.1 Call-Survey

We characterized habitat within 1.5 and 3.0 km radius circles (706 and 2827 ha, respectively) centred on *25 owl locations*, *100 random locations* and *275 survey locations*. Of the 25 owl locations where habitat was characterized, seven represented a pair of owls and 18 represented a single owl. Area of overlap of adjacent circles were intersected with Thiessen polygons and the overlap divided between the two circles to prevent double counting of any habitat area. Therefore, overlapping circles had a reduced area as the overlapping area was divided between the two circles.

Although previous studies used smaller circles as an estimate of the area used by Barred Owls (Laidig and Dobkin, 1995), radio-telemetry data from 14 adult Barred Owls revealed that annual home ranges (95%MCP) of Barred Owls in our study area ranged from 692 to 2489 ha (= 1361 ha). We therefore chose circles of 1.5 and 3.0 km radius which more closely approximated the area used by Barred Owls in this region. The circles do not represent an owl's home range, but rather provide an area with which an owl is likely to be associated.

We used the 1993 forest inventories for Prince Albert National Park (Padbury *et al*. 1978) and Saskatchewan Northern Provincial Forest (Lindenas 1985) to classify the available habitat into 12 types (Table 1). The proportional coverage of each habitat within each circle was calculated using an ARC/INFO geographic information system (GIS). As the data did not conform to a normal distribution we used nonparametric statistics (Zar 1996). We tested for differences between habitat

associated with *owl* and *random*, and *survey* and *random* locations for both 1.5 and 3.0 circles using the Mann-Whitney U-test (Zar 1996).

2.5.2 Radio-telemetry

The composition of Barred Owl home ranges (95MCP and 50MCP), 100 - 1.5 km radius (706 ha) buffers and the entire study area was calculated based on the 12 habitat types. Additionally, the habitat that each individual owl relocation fell within was determined. Radio-marked Barred Owl relocations with an associated error polygon of no more than 4 ha were included in habitat selection analysis. An error polygon limit of 4 ha was imposed on relocations used in habitat selection as greater accuracy of the owl location was desired. Relocations were again separated by at least 2 days. As for home range, the year was divided into breeding and non-breeding periods.

2.5.2.1 Home Range Composition

An initial assessment of habitat selection was based on home range habitat composition, where the home range is thought of as a form of habitat selection based on where the animal chooses to live (Johnson 1980). The habitat composition of Barred Owl breeding and non-breeding home ranges was compared to the habitat composition of 100 1.5 km radius buffers randomly distributed within the study area. Owl home range habitat composition values failed to approximate a normal distribution and nonparametric statistics were therefore applied. Differences in habitat

composition were tested with the Mann-Whitney U-test.

Aebischer *et al*. (1993) criticized habitat selection analysis which does not include a way of cross referencing to other habitat types selected. The problem is that, "avoidance of one habitat type will almost invariably lead to an apparent preference for other types" (Aebischer *et al*. 1993). To get around this they proposed that all habitat comparisons (use versus available) include a ratio of two habitat types; therefore selection of a habitat type is being assessed with reference to selection for all other habitat types. This was referred to as Log-ratio Analysis.

In Log-ratio Analysis a ratio of the natural log (*ln*) of percent observed habitat use of one habitat type over a second (constant) habitat type was calculated. From this value, the ratio of the *ln* of the percent available of the two habitat types was subtracted $(ln(X_{Ui}X_{Uj})-ln(X_{Ai}X_{Aj}))$. This was performed for all owls for all habitat types yielding a table of differences. If all habitats were being used equally these differences would be expected to be equal for all habitat types. As these data did not approximate a normal distribution, the null hypothesis of equal differences among habitat types was tested by using the Kruskal-Wallis test (Zar 1996). Further investigations into which habitats were of greater importance were made through a ranking matrix. Again a ratio of one habitat type over a second habitat type was calculated for habitat use and habitat available. The mean and standard error were calculated for the sample of owls and significant deviation from no habitat selection was assessed from the distribution of t (n-1 degrees of freedom) at $\propto$ 0.05. Habitat types were given ranks, with the habitat type of most importance having the highest rank. A habitat type with the highest rank would be considered more important than the following habitat type. The composition of home ranges was considered as

habitat use and the habitat composition of the study area considered the available habitat. All zero values were replaced with a value of 0.01%, as a zero numerator or denominator is invalid in a log-ratio transformation. Aebischer *et al*. (1993), recommend replacing all zero values with a value less than the non-zero proportion.

Differences between Barred Owl breeding and non-breeding home range habitat composition was tested with the Mann-Whitney U-test. As well, differences in habitat composition of core owl home ranges (50MCP) was compared to the habitat composition of the total home range (95MCP). This was performed for both breeding and non-breeding home ranges. Differences were tested using the Mann-Whitney U-test as the data failed to approximate a normal distribution.

2.5.2.2 Owl Habitat Use and Study Area Composition

Habitat selection based on owl relocations was compared to the available habitat within the entire study area. The habitat class "water" was not included in owl habitat use analysis, as water is not considered a habitat of possible use by Barred Owls. Chi-square goodness-of-fit tests were applied to determine if owls were using habitat equal to its availability (Neu *et al*. 1974, Byers *et al*. 1984). In order to determine which habitat types were being selected, Bonferroni Confidence Intervals ($\propto$ 0.05) were constructed (Neu *et al*. 1974, Byers *et al*. 1984). Log-ratio Analysis was also performed, with owl habitat use representing habitat use and the study area habitat composition representing available habitat. Ranking matrices were constructed to determine habitat importance. Again zero values were replaced by

0.01 %. Barred Owl habitat use during the breeding and non-breeding periods was compared with the Mann-Whitney U-test (Zar 1996).

2.5.2.3 Owl Habitat Use and Home Range Composition

Aebischer *et al*. (1993) argued that the definition of available habitat by the arbitrary definition of a study area is not entirely "available" to the animal. Therefore, we tested to see if owls were selecting habitat types within their home ranges. Bonferroni Confidence Intervals were constructed ($\propto$ 0.05), and Log-ratio Analysis was performed to determine the importance of habitat types. Owl habitat use again represented habitat use and home range (95MCP) habitat composition represented available habitat. In Log-ratio Analysis, habitats that were absent from a large proportion of owl home ranges were removed from the analysis as these removed habitats were not present as available habitat to the majority of owls (Aebischer *et al*. 1993). During the breeding period five habitats were removed: young deciduous, old deciduous, young mixedwood, young conifer and treed muskeg. Analysis of non-breeding home ranges did not include three habitats: young deciduous, young mixedwood, and young conifer. Zero values were again replaced by 0.01 %.

2.6 Nest Site Selection

Nests were located either by following a radio-marked female Barred Owl to a nest or by searching the area where a pair of barred owls had been detected during call-playback surveys (Frith *et al*. 1997). The forest stand that each nest fell within was classified into one of 12 habitat types (Table 1). The proportion of each habitat type in the study area was determined, and Barred Owl nest stands were compared to the available habitat. Chi-square Goodness of Fit test was used to determine if nest sites occur within forest stands at random within the study area.

After the completion of the nesting period, the vegetation surrounding 15 Barred Owl nests was sampled following a modified technique outlined by James and Shugart (1970). A 0.04 ha plot (11.3 m radius) centred on the nest tree was considered the nest site. Within the nest site all woody plants with a diameter breast height (dbh) greater than 2.5 cm were recorded according to species, dbh, and status (live, dead and/or snag). Snags were included only if greater than 2 m in height and 10 cm dbh.

Several attributes of the nest tree were also measured including height of the nest tree, height of the nest structure, status of the tree, dbh, tree species, type of nest structure, and the type of forest stand the nest tree was in.

Transects of the circular nest site plots, extending out from the central tree in each cardinal direction were used. Percent canopy cover was determined using an ocular tube, where presence or absence of canopy cover was assessed at each of 10 evenly spaced points along each of the four transects. Canopy height was calculated as the mean of four measurements each taken on one of the transects.

Canopy height was measured using a clinometer (Suunto, Espoo, Finland). When the edge of a plot fell into an open area, this was considered part of the plot. In this case a canopy height of zero was incorporated into the mean canopy height.

Shrubs per hectare were estimated by measuring the number of shrubs in 8 - 4 m^2 plots, with two plots evenly spaced on each transect. All shrubs under 2.5 cm dbh and greater than 1 m in height were tallied. Down woody debris was estimated by measuring the woody debris found within 2 m of each transect. Only logs greater than 10 cm diameter at the base were included. The volume of down woody material was calculated in m^3.

Distance to nearest water was measured from 1:50,000 topographical maps of the study area. Water was considered to be any lake, river, stream, bog, or marshy area.

Reference vegetation data were collected at 30 randomly selected sites located throughout the study area. All random sites consisted of old mixedwood habitat. They were all within 2 km of an accessible road. This was decided on for practical purposes. Beginning at approximately the middle of the stand, we proceeded in a predetermined cardinal direction until we came to a snag that was at least 10 cm dbh and 2 m in height. A snag was used as the centre of the random sample plots in order to remain consistent with a nest site sample plot. The sampling was the same at the random sites as that at the nest sites except for the nest tree specific variables.

Old mixedwood stands were chosen for random sites because it represents the dominant forest type within Barred Owl home ranges and Barred Owls nest almost exclusively in old mixedwood. Therefore, old mixedwood represents the primary habitat available to Barred Owls for nest site selection.

Table 2 lists the quantitative habitat variables measured or derived from collected data. The non-parametric Mann-Whitney U-test was used to determine differences between the vegetative characteristics at nest sites and at random sites. Statistical significance was considered at $P<0.05$.

2.7 Prey Selection

2.7.1 Diet

In order to determine which species of prey Barred Owls were utilizing, pellets (regurgitated, non-digestible hair and bone of consumed animals) were collected from the area surrounding Barred Owl nest sites and roost sites. Pellets were dissected and prey remains within the pellet were identified to species where possible. Once identified, the species were compared to the relative abundance of prey within the habitat selected by the Barred Owl.

2.7.2 Prey Abundance

We monitored the relative abundance of red squirrels (*Tamiasciurus hudsonicus*), and small mammals (Family Cricetidae) in 1995 and 1996. Chatter surveys were conducted during June and July, 1995 and 1996 to determine relative abundance of red squirrels in old mixedwood forest and mature aspen forest. Four old mixedwood and four mature aspen sites were surveyed. Surveys were conducted from fixed points 100 m from the edge of the forest stand. Survey points within the same forest stand were spaced by a minimum of 300 m. Each forest stand surveyed

had two to three survey points within it, and were surveyed twice during June and twice during July. Surveys consisted of a 10 minute listening period. All red squirrels detected were plotted on a map. Surveys were conducted between 0600h and 0800h.

Small mammal relative abundance was monitored in two old mixedwood and two mature aspen forest stands during May and October, 1995 and 1996. One hundred Museum Special snap-traps (Woodstream Corp., Lititz, PA), were set per plot with one trap per station, stations 10 m apart, in two parallel rows 100 m apart, ie. two 500 m rows of 50 snap-traps each. Traps were baited with peanut butter and rolled oats and checked each morning for the three mornings following set up. This yielded a total of 300 trap nights per plot.

3 Results

3.1 Home Range

Barred Owl breeding and non-breeding home ranges differed significantly in size ($t=8.803$, $P<0.001$, $df=23$; Table 3). Breeding home ranges averaged 148.6 ha (B=173.5, n=3; ♀=140.2, n=9), and non-breeding home ranges averaged 1234.0 ha (B=1331.0, n=4; ♀=1190.9, n=9). Both breeding and non-breeding home range values were calculated for 10 of the 14 owls. The breeding home ranges of eight owls were entirely contained within their non-breeding home ranges. Breeding home ranges of the remaining two owls did not overlap at all with their non-breeding home ranges.

3.2 Habitat Selection

3.2.1 Call-Survey

Habitat composition surrounding survey locations (i.e. habitat adjacent to roads) was found to differ from habitat composition found at random locations (i.e. habitat throughout the study area) (Figs. 1 a and 1b). Significant differences were found between the proportions of two habitat types within the 1.5 circles and four habitat types within the 3.0 circles. Survey 1.5 circles were found to have significantly less mature conifer ($z= -5.23$, $P=0.000$) and treed muskeg ($z= -5.06$, $P=0.000$) than did random 1.5 circles (Fig. 1 a). Within survey 3.0 circles, significantly more mature deciduous ($z= -2.09$, $P=0.025$), and significantly less mature mixedwood ($z= -3.07$, $P=0.001$), mature conifer ($z= -4.79$, $P< 0.001$), and treed muskeg ($z= -4.10$, $P< 0.001$) occurred than compared to random 3.0 circles (Fig. 1b).

Barred Owls located through survey efforts were found to be associated with habitat types in different proportions than expected from the available habitat. Habitat composition of owl 1.5 and 3.0 circles differed from that of random 1.5 and 3.0 circles for four habitat types within the 1.5 km circles and six habitat types within the 3.0 km circles (Figs. 2a and 2b). Within the 1.5 circles, owl locations were found to have significantly higher proportions of old mixedwood ($z= -3.53$, $P<0.001$) than random circles, and significantly lower proportions of young mixedwood ($z=-1.87$, $P=0.038$), young conifer ($z= -2.27$, $P=0.011$) and treed muskeg ($z= -3.24$, $P=0.001$) than random circles (Fig. 2a). Within the 3.0 circles, owl locations were found to have significantly higher proportions of old deciduous ($z= -2.39$, $P=0.014$), old mixedwood ($z= -2.29$, $P=0.021$) and water ($z= -3.82$, $P<0.001$) and significantly lower proportions of young

mixedwood (z= -2.36, P=0.012), young conifer (z= -2.44, P=0.010) and treed muskeg (z= -3.30, P<0.001) than random circles (Fig. 2b).

3.2.2 Home Range Composition

Barred Owl breeding home ranges and random buffers differed significantly in habitat composition for 7 out of 12 habitat types (Fig. 3). Barred Owl breeding home ranges were composed of less young deciduous (z=-2.024, P=0.042), less young mixedwood (z=-2.623, P=0.008), more old mixedwood (z=-4.513, P<0.001), less young coniferous (z=-3.003, P=0.003), less mature coniferous (z=-2.171, P=0.029), less old coniferous (z=-2.114, P=0.034), and less treed muskeg (z=-4.066, P<0.001) than random buffers. Barred Owl non-breeding home ranges and random buffers differed significantly in habitat composition for five habitat types (Fig. 4). Barred Owl non-breeding home ranges were composed of significantly more mature and old deciduous (z=-2.529, P=0.011, z=-2.341, P=0.019), more old mixedwood (z=-2.659, P=0.007), and less treed muskeg and open areas (z=-2.756, P=0.005, z=-2.241, P=0.025) than random buffers.

Based on Log-ratio Analysis, Barred Owl breeding and non-breeding home ranges were composed of habitat that differed significantly from random (H=22.366, P=0.008, H=21.790, P=0.010). This indicated that home ranges were not placed at random, but in areas of specific habitats. The ranking matrix for the breeding period (Table 4) indicates that old mixedwood > open areas > water > mature deciduous > young mixedwood > mature conifer > old conifer > old deciduous > young deciduous > young mixedwood > treed muskeg (where ">" refers to greater importance

according to rank). In the non-breeding period, habitat types were ranked as old mixedwood > mature mixedwood > open areas > old deciduous > mature deciduous > water > old conifer > mature conifer > treed muskeg > young deciduous > young mixedwood (Table 5). Habitat composition of breeding home ranges differed significantly from habitat composition of non-breeding home ranges for three habitat types (Fig. 5). Breeding home ranges contained significantly less old deciduous ($z=2.580$, $P=0.009$), more old mixedwood ($z=-2.121$, $P=0.033$) and less treed muskeg ($z=-2.046$, $P=0.040$) than non-breeding home ranges. Breeding core home ranges (50MCP) did not differ significantly in habitat composition from breeding total home ranges (95MCP) (Fig. 6). Non-breeding core home ranges contained significantly less water ($z=-2.167$, $P=0.030$) than non-breeding total home ranges (Fig. 7).

3.2.3 Owl Habitat Use and Study Area Composition

Barred Owls did not use available habitat within the study area at random, both during the breeding ($X^2=578.347$, $P<0.001$, $df=10$) and the non-breeding ($X^2=760.787$, $P<0.001$, $df=10$) periods. Evaluated by Bonferroni Confidence Intervals, Barred Owls selected against young deciduous, old deciduous, young mixedwood, young conifer, mature conifer, old conifer, treed muskeg and open areas during the breeding period (Fig. 8). They selected for mature deciduous and old mixedwood (Fig. 8). During the non-breeding period Barred Owls selected against young deciduous, young mixedwood, young conifer, mature conifer, old conifer, treed muskeg, and open areas. Mature deciduous, mature mixedwood, and old mixedwood were selected for by Barred Owls in the non-breeding period (Fig. 9).

Based on Log-ratio Analysis, Barred Owls did not use the available habitat within the study area at random during both the breeding (H=39.028, P<0.001) and non-breeding (H=50.064, P<0.001) periods. During the breeding period, habitat was ranked as old mixedwood > mature mixedwood > mature deciduous > old conifer > open areas > old deciduous > young deciduous > mature conifer > treed muskeg > young conifer (Table 6). Non-breeding period owl habitat use compared to the study area available habitat resulted in the ranking of old mixedwood > mature mixedwood > old deciduous > mature deciduous > mature conifer > young mixedwood > old confer > open areas > young conifer > treed muskeg > young mixedwood (Table 7).

Habitat use by Barred Owls during the breeding period did not significantly differ from habitat use during the non-breeding period (Fig. 10).

3.2.4 Owl Habitat Use and Home Range Composition

According to Bonferroni Confidence Intervals during the breeding period, Barred Owls used all habitat in equal proportions to availability within their home ranges except for young mixedwood which was selected against (Fig. 11). During the non-breeding period, Barred Owls showed habitat selection for seven habitat types when compared to habitat availability with their non-breeding home ranges (Fig. 12). Barred Owls selected against old deciduous, young conifer, mature conifer, old conifer, treed muskeg, and open areas. Barred Owls selected for old mixedwood during the non-breeding period.

Log-ratio Analysis revealed that Barred Owl use of habitat in the breeding and non-breeding periods was not significantly different (H=1.119, P=0.891, H=11.662,

P=0.070) from that expected by habitat available within breeding and non-breeding home ranges. Habitat use within the breeding period was ranked as old conifer > old mixedwood > mature deciduous > mature mixedwood > mature conifer > open areas (Table 8). Non-breeding habitat types were ranked as old mixedwood > mature mixedwood > old deciduous > mature deciduous > old conifer > mature conifer > treed muskeg > open areas (Table 9).

3.3 Nest Site Selection

Fifteen active Barred Owl nests were located between 1994 and 1996 (Table 10). Nest sites were located almost exclusively in old mixedwood forest (X^2=58.91, df=10, P=0.000), with one nest in old coniferous forest and one in mature deciduous (Table 10). Nest tree species were variable, with five nests in white spruce, five in trembling aspen, four in balsam poplar, and one in a white birch. The majority of the nest trees were live (10 of 15; 67%). Sixty seven percent (10) of nests were also in the form of a tree cavity, with the remainder as platforms (Table 10). Six of the cavity nests were formed where the top of the tree broke off leaving a cavity in the snag. The other four were formed where a limb broke off, likely from rot. In all cavity nests the owl was entirely concealed from view. Two of the platform nests were old stick nests (Accipitridae and Corvidae). These stick nests were used by the same owl in consecutive years. Old red squirrel nests constituted two platform nests, where the owl sat on top of the structure, and one owl nested on top of a witch's broom (dense branching caused by *Arceuthobium* spp.) in a white spruce tree. Nest tree height averaged 18.8 m and nest height averaged 13.3 m (Table 11). Nest trees were large, averaging 47.4 cm dbh. The proximity to an all-weather road was quite variable

ranging from 25 m to 2000 m (average 430 m).

Reuse of nests over years varied among owls. Summit and Beaver Glen owls used the same nest for two consecutive years, while Prospect and Spruce River owls used different nests within the same territory in consecutive years. The Whelan Bay female shifted her territory after 1994, and subsequently used a different nest in 1995, and also used a different nest in 1996 while remaining on the same territory. All other owls were only monitored for one year. Of the 15 nests found, three (20 %) had fallen down within the three year study period.

The height of the nest trees (=18.8 m) was significantly larger than the random central trees (=6.5 m) (z=-5.06, P=0.000), likewise, the dbh of the nest trees (=47.4 cm) was significantly larger than that of the random central trees (=23.0 cm) (z=-4.96, P=0.000) (Table 11).

Canopy cover, canopy height, shrub density, down woody material, basal area, stem densities, and the distance to water of the nest sites did not differ significantly from random sites (Table 11).

3.4 Prey Selection

Sixty Barred Owl pellets and/or prey remains were collected. Preliminary analysis has revealed a varied diet, including birds, amphibians, insects, cricetid rodents, shrews, Red Squirrels and Northern Flying Squirrels (*Glaucomys sabrinus*), Northern Pocket Gophers (*Thomomys talpoides*), and a single weasel (*Mustela erminea*) (Table 12).

Red squirrel relative abundance differed significantly between old mixedwood

and mature aspen forest (z=-5.92, P=0.000). Relative abundance was found to be 1.88 (SD=1.38) squirrels per station within old mixedwood forest compared to 0.20 (SD=0.40) squirrels per station in mature aspen forest.

Small mammal abundance differed between mature aspen forest and old mixedwood during 1995 and 1996 (X^2=8.89, df=1, P=0.003). Mature aspen contained more small mammals, specifically more deer mice (*Peromyscus maniculatus*) than old mixedwood (Table 13). The number of red-backed voles (*Clethrionomys gapperi*) was similar between the two forest types.

4 Discussion

4.1 Home Range

Barred Owls in the boreal forest of Saskatchewan maintained small home ranges in the breeding period and large home ranges in the non-breeding period. Non-breeding home ranges overlapped breeding period home ranges entirely, for all but two owls. Both of these owls shifted their non-breeding home ranges more than 20 km and subsequently established breeding home ranges the following year within their non-breeding home ranges. Non-breeding home ranges were expansions of the smaller breeding home ranges. Breeding home range size was similar to that reported by Elody and Sloan (1985) for Barred Owls in Michigan, and less than half the size of that reported by Hamer (1988) in Washington. Non-Breeding home ranges were on average eight times greater in size than breeding home ranges. Hamer (1988) found an increase of just over two times from breeding to annual home ranges in Washington Barred Owls. Non-breeding home range size in the boreal

forest was the largest recorded for this species to date. During both the breeding and non-breeding periods male and female home ranges were similar in size (Table 3). This supports Hamer's (1988) findings in Washington. Barred Owls are nest site specialists, usually nesting in a tree cavity of sorts (Devereux and Mosher 1984). The expansion of the non-breeding home range to include the breeding home range is thought to occur to defend the scarce nest site (Lundberg 1979). However, to remain on a home range throughout the year necessitates that all resources required throughout the year be present within the home range. Prey availability is considered to be the major factor determining home range size (Schoener 1968, Lindstedt *et al*. 1986). As a generalist predator, the Barred Owl is able to use the most available prey within its home range, facilitating a year-round residency. The size of the Barred Owl non-breeding home range is thought to be determined by the availability of prey. Due to patch depletion or prey cycling, Barred Owl multi-year home ranges may be larger than that of just one year. Carey *et al*. (1992) found the two year home range of Spotted Owls to be significantly larger than the home range of only one year. They attributed this to prey depletion within patches of the home range, therefore the Spotted Owls would hunt alternate patches annually.

Barred Owls are known to maintain rigid home range boundaries (Nicholls and Fuller 1987, Hamer 1988). However, extensive overlap occurs between mates throughout the year (Hamer 1988). Intraspecific competition is the primary mechanism involved in home range boundary maintenance. In this study, neighbouring Barred Owls were observed actively defending home range boundaries that were known through radiotelemetry. Both the male and female of a pair were involved in the territorial defence. These exclusive home ranges function to ensure

resource partitioning. Nicholls and Fuller (1987), found Barred Owl home ranges to be historical in nature, with the same home range maintained for numerous years even if its occupants had changed. This is likely a result of intraspecific competition with neighbours. Spotted Owls exhibit moderate to large home range overlap between neighbours (Forsman *et al*. 1984, Hamer 1988). This was attributed to the large size of their home ranges, at least twice as large as non-breeding Barred Owl home ranges in this study, resulting in the Spotted Owl's inability to defend the entire area.

Hamer (1988), suggested that 10.6 months of radio-tracking was required to estimate a Barred Owl's entire annual home range, with home ranges peaking in size in the winter. However, his home range calculation began in the spring, when home ranges are the smallest. If home ranges calculation began in September, a much shorter period would likely be needed to estimate the annual home range. Home range values reported in this study have been divided into breeding and non-breeding periods. Non-breeding values are likely comparable to annual values as the non-breeding values include the period when home ranges are the largest, as well as the breeding home range.

4.2 Habitat Selection

The results from the call-survey analysis indicate that Barred Owls in our study area are not randomly distributed relative to the available habitat. They demonstrated a greater than expected association with old deciduous forest, old mixedwood forest and water, and an avoidance of young forest and treed muskeg.

Habitat associated with survey locations (ie. roads) was found to be representative of the habitat within the study area, with the exception of four habitat types. Typically, roads were built on higher areas, avoiding low-lying muskeg and wetlands. This was evident as the percentage of treed muskeg associated with survey locations was significantly lower than that of random locations. We suggest that when comparing habitat use to availability, habitat adjacent to roads presents an available habitat bias, and therefore comparisons between habitat use and random habitat should be made.

Habitat characterization of circles centred on owls located through surveys contains biases making them not entirely representative of owl home ranges. Owls detected may have moved towards the tape playback, or the owl may have been detected calling from the periphery of its home range. However, Lehmkuhl and Raphael (1993) supported the use of circles as surrogates for home ranges in the analysis of habitat pattern associations of Spotted Owls (*Strix occidentalis*) in Washington. Few differences in habitat composition were apparent between 1.5 km circle comparisons and 3.0 km circle comparisons. However, the smaller circles would present a more conservative estimate of the area that the owl likely uses. Given that the 3.0 circle approximates the maximum Barred Owl home range size, this larger circle size may include large areas of unused habitat.

Based on radio-telemetry, Barred Owls displayed strong second order habitat selection. Breeding home ranges were placed in areas of old mixedwood forest, open areas, water and mature deciduous forests, while avoiding young forests and coniferous forests (Fig. 3, Table 4). The breeding home range must provide resources for successful reproduction. Of these, a suitable nest site is of high

importance, especially to cavity nesting birds (Lundberg 1979, Orians and Wittenberger 1991). Barred Owls primarily nest in secondary tree cavities, which likely act as a limiting feature of habitat (Devereux and Mosher 1984).

Non-breeding home range placement was also non-random, with Barred Owl home ranges containing more mature and old mixedwood, mature and old deciduous, open areas and water than expected at random. (Fig. 4, Table 5). Barred Owls maintain non-breeding home ranges that encompass the breeding home range and subsequently the nest site. This is thought to be a measure that protects the nest site (Lundberg 1979). However, the habitat within the non-breeding home range must supply the resources necessary for survival outside the breeding period. Prey availability likely relates to the size of the non-breeding home range and habitats within (Lindstedt *et al*. 1986). The association with water likely reflects the presence and abundance, at times, of amphibians in the diet of the Barred Owl. However, this is only a factor during ice free periods. The high proportion of old mixedwood forest in non-breeding home ranges may simply be an artifact of the placement of breeding home ranges within areas of old mixedwood forests .

Barred Owl non-breeding home ranges contained less old mixedwood forest than breeding home ranges (Fig. 5). Considering that nest sites are found almost exclusively in old mixedwood forest (see nest site selection section), breeding home ranges would be predicted to be composed largely of old mixedwood given their small size. Non-breeding home ranges represent considerably larger areas (see home range section), introducing greater geographic variation, and hence greater potential forest stand variability.
No difference was observed between the habitat composition of the core of

breeding home ranges and the total area of breeding home ranges (Fig. 6). The core represents the area tightly surrounding the nest, and is therefore highly representative of nest site habitat. Due to the small size of breeding home ranges, the total home range may only encompass a few individual forest stands, decreasing the chance of variability. Similarly, non-breeding core and total home range habitat composition was similar (Fig. 7). Water was more abundant in the total non-breeding home range, and old mixedwood appeared to be less abundant in the total home range, but the difference was not significant (Fig. 7). Again, the increasing size of the total home range introduces greater geographic and forest variability. Monitoring habitat use of a number of animals estimates the trajectory over time and space of habitat use by the population of animals (Aebischer *et al*. 1993). Habitat use by radio-marked Barred Owls was compared to the available habitat in the study area and within owl home ranges. Prey availability is probably the most important feature in owl habitat use (Morris 1987). Roost sites may also play an important role. Barred Owls are primarily active at night (Johnsgard 1988), but are known to hunt during the day as well (Caldwell 1972). Nocturnal owl locations were considered to be representative of foraging sites, and diurnal locations of roosting sites. Barred Owls were not found to use roost sites repeatedly, instead they were found to typically roost in the same stand they had hunted during the night. Therefore, Barred Owl habitat use represents both roosting and foraging habitat. Similar conclusions were drawn for the Spotted Owl (Carey *et al*. 1989).

During the breeding period, Barred Owls used mature and old mixedwood, and mature deciduous more than expected based on available habitat within the study area (Fig. 8, Table 6). The significant selection against and moderate rank of open

areas suggests that this habitat is not as important as revealed by the home range composition. However, in order to forage in this habitat, Barred Owls would likely have to hunt from adjacent forest edges, resulting in many of the locations indicating use of the adjacent forest, not the open area. Therefore, the use of open areas may be under represented here. Habitat use in the non-breeding period also revealed selection for mature and old mixedwood, and mature and old deciduous forests (Fig. 9, Table 7). However, there was considerably more variation in owl use of mature deciduous than in the breeding period (Figs. 8 and 9). Overall, Barred Owls used habitat in the same proportion during the breeding and non-breeding period (Fig. 10). This likely reflects the preference of certain habitats for essential resources such as prey.

Habitat selection in the second order, that of home range placement, affects all following habitat choices (Orians and Wittenberger 1991). Habitat within home ranges determines the availability of patches that must provide all necessary resources. Being endothermic and highly mobile, it may be argued that habitat within a wide area is available to a Barred Owl. However, due to intraspecific competition and nest site tenacity, only the habitat within an individual's home range is truly available. During the breeding period, Barred Owls used habitat in proportion to its availability within their home ranges (Fig. 11, Table 8). Only young mixedwood was shown to be selected against. This suggests that where a Barred Owl chooses to live is the primary form of habitat selection during the breeding period. However, given the small size of Barred Owl breeding home ranges, only a few forest stands may be available leaving the owls little choice. Conversely, in the non-breeding period Barred Owls further selected habitat from that available within their home ranges (Fig. 12,

Table 9). Barred Owls continued to use old mixedwood heavily, with a lesser use of mature mixedwood, and mature deciduous (Fig. 12, Table 9). This continued selection of old mixedwood forest reinforces the importance of this forest type. The larger variation of available forest types within non-breeding home ranges allowed for selection to be discerned.

Habitat use by Barred Owls in the boreal forest of Saskatchewan confirm what was predicted of this species (Boxall and Stepney 1982). These findings agree with the habitat selection found in other regions by Barred Owls (Elody and Sloan 1985, Bosakowski *et al*. 1987, Nicholls and Fuller 1987, Hamer 1988). Morris (1987) suggested that individuals should forage in habitats that maximize their fitness. This would include hunting to feed an incubating female, nestlings and the individual itself. As a generalist predator, Barred Owls should then forage in habitats that provide the most available and diverse prey. In the boreal forest this is the old mixedwood forest (McDonald 1995, Roy *et al*. 1995, Schieck and Nietfeld 1995). The structural complexity of this habitat leads to the higher diversity of organisms. Refuge from inclement weather or predators is often considered a feature for which a habitat is selected. Barrows and Barrows (1981) found Spotted Owls selecting roost sites with a cooler mean temperature in the summer, suggesting a potential for heat stress. This microhabitat selection occurred within the habitat previously selected. Similar to the Spotted Owl, Barred Owls are likely more susceptible to heat stress given their thick plumage, necessary for cold tolerance. Chesterman and Stelfox (1995) found old aspen mixedwood forest to be cooler during the day in summer than young aspen mixedwood forest, and warmer during the day in winter than young and mature aspen mixedwood forest. The microclimate may be a factor in the selection of old

mixedwood forest by Barred Owls. Barred Owls have few natural predators. However, the Great Horned Owl (*Bubo virginianis*) is one that poses the most likely risk. The Great Horned Owl is a bird of fragmented forests and grasslands (Fuller 1979, Johnsgard 1988). It is considered an edge specialist. Fragmentation of forests may therefore prove detrimental to Barred Owls as this may increase the numbers of Great Horned Owls.

4.3 Nest Site Selection

Barred Owl nests were predominantly found in old mixedwood forests. This is consistent with what has previously been recorded for this species (Bent 1938, Devereux and Mosher 1984, Johnsgard 1988). Nest sites, along with prey availability, are thought to be two primary factors involved in raptor habitat selection (Newton 1979). Within old mixedwood forests Barred Owls are selecting nest sites on the basis of the nest tree characteristics. The large body size of the Barred Owl demands a large tree cavity for nesting, hence a large tree. In the boreal forest of Alberta, old mixedwood forest was the only forest type found to contain both trees and snags of this large size (Lee *et al*. 1995). This is likely true for our study area as well.

Nest site requirements are considered the predominant factor involved in the Barred Owl's association with old forest (Devereux and Mosher 1982, Elderkin 1987, Johnsgard 1988). Elderkin (1987) found Barred Owls readily inhabiting young forest that contained nest boxes, and only located natural nests in mature forests. Furthermore, we found Barred Owls in the boreal forest selecting old mixedwood for

both roosting and hunting. The relationship between nest site availability and old forest has been established for other cavity-nesting North American owls such as the Boreal Owl (*Aegolius funereus*) and the Spotted Owl (*Strix occidentalis*) (Forsman *et al*. 1984, Lane and Anderson 1995).

Much literature on Barred Owls suggests an association with water (Bent 1938, Applegate 1975, Soucy 1976). However, we did not find any difference in the proximity to water of the Barred Owl nest sites in comparison with random sites. This mirrors Devereux and Mosher's (1984) conclusion.

Although found nesting in stick nests, Barred Owls are considered to be mainly secondary cavity nesters (Bent 1938, Devereux and Mosher 1982, Johnsgard 1988). Two thirds of the nests found in this study were in tree cavities, with one third on platform type nests, suggesting some flexibility in their nesting requirements. The use of a platform nest may be a behaviour imprinted on owls raised in stick nests, as suggested by Devereux and Mosher (1984). Suitable tree cavities may also be in short supply, limiting some owls to platform nests. Of the Barred Owls that used platform nests, one used a cavity (snag) one year and then used a stick nest the following two years, while another owl used a witch's broom one year and a squirrel nest the following year. In contrast, other owls used tree cavities exclusively.

The distance Barred Owl nest sites were from roads was quite variable, with many nests quite close to roads. As surveys for Barred Owls were conducted along roads, the distance nests were from roads may not be a true representation of the Barred Owl population in the study area. However, this does demonstrate that some Barred Owls made nesting attempts as close as 25 m from all-weather roads.

4.4 Prey Selection

The prey taken by Barred Owls in this study reflect a variability also reported in other areas (Elderkin 1987, Devereux and Mosher 1984). Our prey selection results support the classification of Barred Owls as true generalist predators.

Mammalian prey included a wide range of species, with squirrels being the most common mammalian prey group. Compared to mature aspen forest, we found Red Squirrels more abundant in old mixedwood forests. McDonald (1995), found Northern Flying Squirrels to be most abundant in old aspen mixedwood in Alberta. The abundance of squirrels in old mixedwood and their relative prominence in the Barred Owl's diet may be a factor influencing their habitat selection of old mixedwood. Small mammals (F. Cricetidae) were also prominent in the prey base of the owls. Although our data indicate that Cricetid rodents are more abundant in mature aspen than old mixedwood, they do occur in old mixedwood. Roy *et al*. (1995) reported a higher mammal species richness in old than in young or mature aspen mixedwood in Alberta. A high mammalian species richness may be a factor influencing the Barred Owl's selection of old mixedwood habitat.

Pocket gophers (*Thomomys talpoides*) were only found in the prey remains from a single Barred Owl nest. This may reflect the habitat surrounding that particular nest rather than prey selection amongst the entire population of owls. However, pocket gophers are certainly within the capturable size range of Barred Owls. As a generalist predator, Barred Owls presumably would select pocket gophers as prey if they were present in their home range.

A large number of amphibians were identified in the Barred Owl pellets.

Pellets containing frogs were located at 9 of the 12 nests where pellets were found. This may indicate that amphibians are a ubiquitous prey item, and may have some seasonal importance to owls during the nesting season. Similarly, beetles (Coleoptera) were also commonly found in pellets, present from 5 of the 12 nest sites.

Birds also contributed to the Barred Owl diet, ranging in size from small perching birds (passerines) to grouse. Schiek and Nietfeld (1995) found that old aspen mixedwood had greater bird species richness than young or mature stands. This may be an important factor to a generalist predator.

The fact that mature and old aspen mixedwood forests in Alberta contained the highest species diversity and abundance of the potential prey of Barred Owls (McDonald 1995, Roy *et al*. 1995, Schieck and Nietfeld 1995), may be an important factor in influencing the habitat selection of old mixedwood by the Barred Owl.

As the pellets collected were primarily from the area surrounding nest sites, the prey identified may represent prey available in the spring and summer months and may not adequately reflect prey taken in the winter months. As is the case with pellet prey studies, any soft-bodied prey will not be identified in the pellets and will hence be overlooked as prey, for example: earthworms (Elderkin 1987).

5 Summary

We examined the area requirements and habitat selection of Barred Owls in the boreal forest of Saskatchewan. We also investigated two potential factors limiting Barred Owl habitat selection: nest site selection and prey selection. We found home ranges of Barred Owls to be smallest during the breeding period and largest during the non-breeding period. The size is likely a reflection of prey availability during the periods. Owl non-breeding home ranges were expansions of the smaller breeding home range, so that the breeding home range was contained within the non-breeding home range. This may be a strategy to defend scarce nest sites which are within breeding home ranges. Barred Owls did not use habitat at random. They selected specific habitat types, particularly mature and old mixedwood, and mature deciduous forest. The only habitat that was consistently selected through our analyses was old mixedwood forest. We also observed an avoidance of young forest and treed muskeg by Barred Owls. Barred Owl nest sites were not found in forest types at random. Nearly all nests were found in old mixedwood forest. Nest trees were of large diameter and were tall. These two characteristics ultimately limit Barred Owls to old mixedwood forest for nesting as old mixedwood is likely the only forest type that provides trees large enough to serve as nest trees for Barred Owls. Diet analysis revealed that like other regions, Barred Owls in Saskatchewan are generalist predators consuming a wide array of species. Prey abundance from this study and that from others demonstrate old mixedwood forest to be a highly species-rich habitat. This high diversity of prey favours a generalist predator like the Barred Owl. This high prey abundance is likely very important for this species to be able to maintain

an annual home range, allowing protection of its scarce nest site.

6 Recommendations

In the boreal forest of Canada, forestry as an industry contributes significantly to local and national economies (Stelfox 1995a, Cumming *et al*. In Press). These economic gains are sometimes at odds with the natural ecological processes of the forest. Past and current harvest schedules are based on merchantable forests, employing short rotations, that result in monoculture type forest stands with low structural heterogeneity. This has resulted in the "unmixing" of the mixedwood forest (Stelfox *et al*. 1995, Cumming *et al*. In Press). The old mixedwood forest is the most species diverse forest type in the boreal forest: the rainforest of the north (Stelfox 1995b). Attempting to understand the ecological requirements of each species and managing for each species is very unrealistic. Instead, harvest practices that result in forest structure close to those occurring under natural conditions are preferred (Kabzems *et al*. 1995, Stelfox *et al*. 1995). Harvesting plans should attempt to mimic natural disturbance processes, such as fire, in order to maintain forest stand and structural diversity. This study has shown that Barred Owls in the boreal forest are strongly selective of old forests, particularly old mixedwood forest. This selection appears strongly based on nest site availability and prey diversity in this habitat. As a top predator and year-round resident in this habitat, it is very sensitive to changes in the structural environment. The presence or absence of a viable Barred Owl population from managed forest could indicate a healthy old mixedwood forest or lack thereof. Based on this study, management of forests specifically for Barred Owls is

not recommended, but instead the continued maintenance of the boreal forest mosaic which includes sufficient areas of old mixedwood forest, including its stand structure, should be the primary goal. In concert, Barred Owl populations in managed forests should be monitored in order to ensure the persistence of healthy old mixedwood for the many other species that inhabit such forests.

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8 Literature Cited

Ackerman, B.B., F.A. Leban, M.D. Samuel, and E.O. Garton. 1990. User's Manual for Program HOME RANGE. 2nd ed. Technical Report 15, Forestry, Wildlife and Range Experiment Station, University of Idaho, Moscow, Idaho. 80 pages.

Aebischer, N.J., P.A. Robertson, and R.E. Kenward. 1993. Compositional analysis of habitat use from animal radio-tracking data. Ecology 74(5):1313-1325.

Applegate, R.D. 1975. Co-roosting of Barred Owls and Common Grackles. Bird Banding 42:169-170.

Barrows, C.W. 1981. Roost selection by spotted owls: an adaptation to heat stress. Condor 83:302-309.

Bent, A.C. 1961. Northern Barred Owl. In Life Histories of North American birds of prey. Part II. Dover Publishing Inc., New York

Bosakowski, T., R. Speiser, and J. Benzinger. 1987. Distribution, density, and habitat relationships of the barred owl in northern New Jersey. In Biology and Conservation of Northern Forest Owls: Symposium Proceedings (R.W. Nero, R.J. Clark, R.J. Knapton, and R.H. Hamre, Eds). USDA Forest Serv. Gen. Tech. Rep. RM-142. pp. 135-143.

Boxall, P.C., and P.H.R. Stepney. 1982. The distribution and status of the Barred Owl in Alberta. Can. Field Nat. 96(1):46-50.

Byers, C.R., R.K. Steinhorst, and P.R. Krausman. 1984. Clarification of a technique for analysis of utilization-availability data. J. Wildl. Manage. 48(3):1050-1053.

Caldwell, L.D. 1972. Diurnal hunting by a Barred Owl. Jack-Pine Warbler 50(3):93-94.

Carey, A.B., S.P. Horton, and J.A. Reid. 1989. Optimal sampling for radiotelemetry studies of spotted owl habitat and home range. Res. Pap. PNW-RP-416, Portland, OR. 17 pages.

Carey, A. B., S. P. Horton, and B. L. Biswell. 1992. Northern spotted owls: influence of prey base and landscape character. Ecol. Mono. 62(2):223-250.

Chesterman, D., and J.B. Stelfox. 1995. Relationships between microclimate and stand age and structure in aspen mixedwood forests in Alberta. In Relationships between stand age, stand structure, and biodiversity in aspen mixedwood forests in Alberta (J.B. Stelfox, Ed). Jointly published by Alberta Environmental Centre (AECV95-R1), Vegreville, AB, and Canadian Forest Service (Project No. 0001A) Edmonton, AB. pp. 13-27.

Cumming, S.G., P.J. Burton, S. Prahacs, and M.R. Garland. In Press. Potential conflicts between timber supply and habitat protection in the boreal mixedwood of Alberta, Canada: A simulation study. For. Ecol. Manage. :000-000.

Devereux, J.G., and J.A. Mosher. 1982. Nesting habits of the barred owl in western Maryland. Maryland Birdlife 38:124-126.

Devereux, J.G., and J.A. Mosher. 1984. Breeding ecology of Barred Owls in the central Appalachians. J. Raptor Res. 18:49-58.

Duncan, J.R. 1987. Movement strategies, mortality, and behavior of radio-marked great gray owls in southeastern Manitoba and northern Minnesota. In Biology and Conservation of Northern Forest Owls: Symposium Proceedings (R.W. Nero, R.J. Clark, R.J. Knapton, and R.H. Hamre, Eds). USDA Forest Serv. Gen. Tech. Rep. RM-142 pp. 101-107.

Elderkin, M.F. 1987. The breeding and feeding ecology of a Barred Owl *Strix varia* Burton population in Kings County, Nova Scotia. M.Sc. Thesis, Acadia University, Wolfville, N.S., Canada. 203 pages.

Elody, B.I., and N.F. Sloan. 1984. A mist net technique useful for capturing Barred Owls. N.A. Bird Bander 9:13-14.

Environment Canada Parks. 1986. Prince Albert National Park Resource Description and Analysis. Environment Canada Parks, Prairie and Northern Region, Winnipeg. 2 vols.

Forsman, E.D., E.C. Meslow, and H.M. Wight. 1984. Distribution and biology of the Spotted Owl in Oregon. Wildl. Monogr. 87:1-64.

Frith, S.D., K.M. Mazur, and P.C. James. 1997. A method of locating barred owl nests in the southern boreal forest of Saskatchewan. In Biology and Conservation of Owls of the Northern Hemisphere: Second International Symposium. USDA Gen. Tech. Rep. NC-00. In Press.

Fuller, M.R. 1979. Spatiotemporal ecology of four sympatric raptor species. Ph.D. Thesis, University of Minnesota, Minneapolis. 220 pages.

Gautestad, A.O., and I. Mysterud. 1995. The home range ghost. Oikos 74:195-204.

Hamer, T. E. 1988. Home range size of the Northern Barred Owl and Northern Spotted Owl in western Washington. M.Sc. Thesis, Western Washington University. 86 pages.

James, F.C., and H.H. Shugart, Jr. 1970. A quantitative method of habitat description. Audubon Field Notes 24:727-736.

Johnsgard, P.A. 1988. North American Owls. Smithsonian Institution Press, Washington. 295 pages.

Johnson, D.H. 1980. The comparison of usage and availability measurements for evaluating resource preference. Ecology 61(1):65-71.

Kabzems, R., D. Coopersmith, and R. Negrave. 1995. Mixedwoods by Design. Forest Science Research. British Columbia Ministry of Forests.

Laidig, K.J., and D.S. Dobkin. 1995. Spatial overlap and habitat associations of Barred Owls and Great Horned Owls in Southern New Jersey. J. Raptor Res. 29(3):151-157.

Lane, W.H., and D.E. Anderson. 1995. Habitat requirements for boreal owls in northeastern Minnesota. Final Report prepared by Minnesota Cooperative Fish and Wildlife Research Unit, University of Minnesota for North Central Forest Experiment Station St. Paul, Minnesota. 52 pages.

Lee, P.C., S. Crites, M. Nietfeld, H. Van Nguyen, and J.B. Stelfox. 1995. Changes in snag and down woody material characteristics in a chronosequence of aspen mixedwood forests in Alberta. In Relationships between stand age, stand structure, and biodiversity in aspen mixedwood forests in Alberta (J.B. Stelfox, Ed). Jointly published by Alberta Environmental Centre (AECV95-R1), Vegreville, AB, and Canadian Forest Service (Project No. 0001 A) Edmonton, AB. pp. 49-61.

Lehmkul, J.F., and M.G. Raphael. 1993. Habitat pattern around Northern Spotted Owl locations on the Olympic Peninsula, Washington. J. Wild. Manage. 57:302-315.

Lindenas, D.G. 1985. Forest inventory interpretation and mapping manual. Forestry Branch Saskatchewan Parks and Renewable Resources.

Lindstedt, S.L., B.J. Miller, and S.W. Buskirk. 1986. Home range, time and body size in mammals. Ecology 67:413-418.

Lundberg, A. 1979. Residency, migration and a compromise: adaptations to nest-site scarcity and food specialization in three Fennoscandian owl species. Oecologia (Berlin) 41:273-281.

Mazur, K.M. 1997. Spatial habitat selection by Barred Owls in the boreal forest of Saskatchewan, Canada. M.Sc. Thesis. University of Regina, Regina, SK.

McDonald, L. 1995. Relationships between northern flying squirrels and stand age and structure in aspen mixedwood forests in Alberta. In Relationships between stand age, stand structure, and biodiversity in aspen mixedwood forests in Alberta (J. B. Stelfox, Ed). Jointly published by Alberta Environmental Centre (AECV95-R1), Vegreville, AB, and Canadian Forest Service, Edmonton, AB. pp. 227-240.

McGarigal, K., and J.D. Fraser. 1984. The effect of forest stand age on owl distribution in south western Virginia. J. Wildl. Manage. 48:1393-1398.

McNay, R.S., J.A. Morgan, and F.L. Bunnell. 1994. Characterizing independence of observations in movements of Columbian Black-Tailed Deer. J. Wildl. Manage. 58(3):422-429.

Morris, D.W. 1987. Ecological scale and habitat use. Ecology 68(2):362-369.

Mosher, J.A., M.R. Fuller, and M. Kopeny. 1990. Surveying woodland raptors by broadcast of conspecific vocalizations. J. Field Ornithol. 61:453-461.

Neu, C.W., C.R. Byers, and J.M. Peek. 1974. A technique for analysis of utilization-availability data. J. Wildl. Manage. 38(3):541-545.

Newton, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, South Dakota. 399 pages.

Nicholls, T.H., and M.R. Fuller. 1987. Territorial aspects of barred owl home range and behavior in Minnesota. In Biology and Conservation of Northern Forest Owls: Symposium Proceedings (R.W. Nero, R.J. Clark, R.J. Knapton, and R.H. Hamre, Eds). USDA Forest Serv. Gen. Tech. Rep. RM-142. pp. 121-128.

Orians, G.H., and J.F. Wittenberger. 1991. Spatial and temporal scales in habitat selection. Am. Nat. 137:829-849.

Padbury, G.A., W.K. Head, and W.E. Souster 1978. Biophysical resource inventory of the Prince Albert National Park, Saskatchewan. Saskatchewan Institute of Pedology Publication S185, Saskatoon, SK.

Peterson, E.B., and N.M. Peterson. 1992. Ecology, management, and use of aspen and balsam poplar in the prairie provinces, Canada. For. Can., Northwest Reg., North. For. Cent., Edmonton, AB. (Spec. Rep. 1.)

Roy, L.D., J.B. Stelfox, and J.W. Nolan. 1995. Relationship between mammal biodiversity and stand age and structure in aspen mixedwood forests in Alberta. In Relationships between stand age, stand structure, and biodiversity in aspen mixedwood forests in Alberta (J.B. Stelfox, Ed). Jointly published by Alberta Environmental Centre (AECV95-R1), Vegreville, AB, and Canadian Forest Service (Project No. 0001A) Edmonton, AB. pp. 159-189.

Schieck, J., and M. Nietfeld. 1995. Bird species richness and abundance in relation to stand age and structure in aspen mixedwood forests in Alberta. In Relationships between stand age, stand structure, and biodiversity in aspen mixedwood forests in Alberta (J.B. Stelfox, Ed). Jointly published by Alberta Environmental Centre (AECV95-R1), Vegreville, AB, and Canadian Forest Service (Project No. 0001A) Edmonton, AB. pp. 115-157.

Schoener, T.W. 1968. Sizes of feeding territories among birds. Ecology 49(1):123-141.

Soucy, L., Jr. 1976. Barred Owl nest. North Am. Bird Bander 1:68-69.

Stelfox, J.B. 1995a. Introduction. In Relationships between stand age, stand structure, and biodiversity in aspen mixedwood forests in Alberta (J.B. Stelfox, Ed). Jointly Published by the Alberta Environmental Centre (AECV95-R1), Vegreville, AB, and Canadian Forest Service (Project No. 0001A) Edmonton, AB. pp. 1-12.

Stelfox, J.B. (editor) 1995b. Relationship between stand age, stand structure, and biodiversity in aspen mixedwood forests in Alberta. Jointly Published by the Alberta Environmental Centre (AECV95-R1), Vegreville, AB, and Canadian Forest Service (Project No. 0001A) Edmonton, AB. 308 pages.

Stelfox, J.B., L.D. Roy, P.C. Lee, J. Schieck, S. Crites, L.H. Crampton, and L. McDonald. 1995. Recommendations. In Relationships between stand age, stand structure, and biodiversity in aspen mixedwood forests in Alberta (J.B. Stelfox, Ed). Jointly published by Alberta Environmental Centre (AECV95-R1), Vegreville, AB, and Canadian Forest Service (Project No. 0001A) Edmonton, AB. pp. 271-280.

White, G.C., and R.A. Garrott. 1990. Analysis of wildlife radio-tracking data. Academic Press, San Diego. 383 pages.

Zar, J.H. 1996. Biostatistical Analysis. 3rd ed. Prentice-Hall Inc., Upper Saddle River, NJ. 662 pages.

9 Presentations

o Integrated Resource Management 1993, Saskatoon, SK

o Vickers Elementary School 1993, Prince Albert, SK

o Prairie Universities Biological Seminars 1994, Calgary, AB

o Prince Albert National Park 1993, 1994

o University of Regina Graduate Seminars 1995, Regina, SK

o Waskesiu Learning Institute 1995, University of Saskatchewan/ Prince Albert National Park

o Prairie Universities Biological Seminars 1996, Lethbridge, AB

o Manitoba Naturalists' Society 1996, Winnipeg, MB

o American Ornithologists' Union 1996, Boise, ID

o Biology and Conservation of Owls of the Northern Hemisphere 1997, Winnipeg, MB

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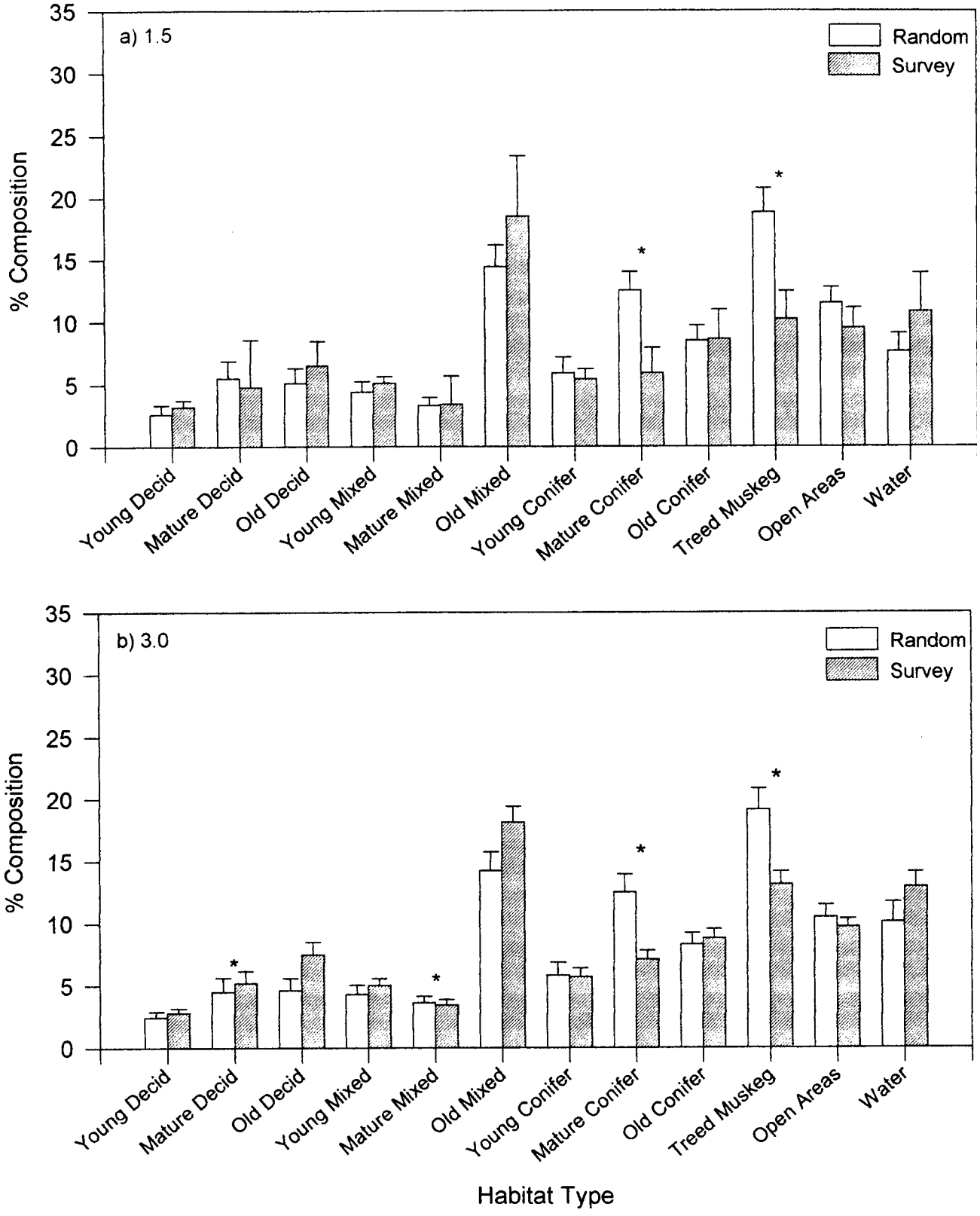

Figure 1.
Comparison of mean percent habitat composition (+SE) within a) 1.5 km radius circles (706 hectare), and b) 3.0 km radius circles (2827 hectare), centred on 100 random and 275 survey locations. Significant difference * (P<0.05).

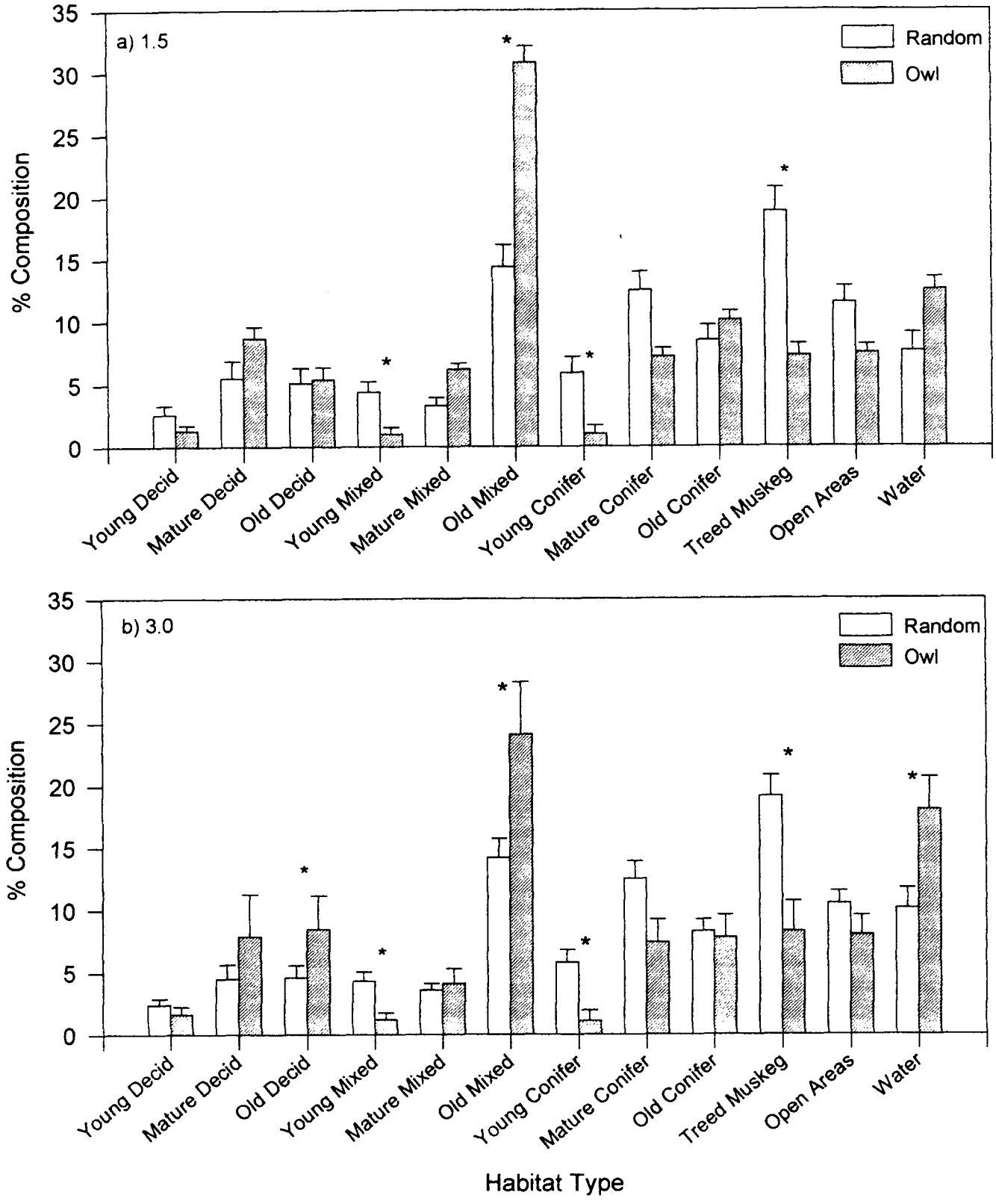

Figure 2.
Comparison of mean percent habitat composition (+SE) within a) 1.5 km radius circles (706 hectare), and b) 3.0 km radius circles (2827 hectare), centred on 100 random and 25 owl locations. Significant difference * (P<0.05).

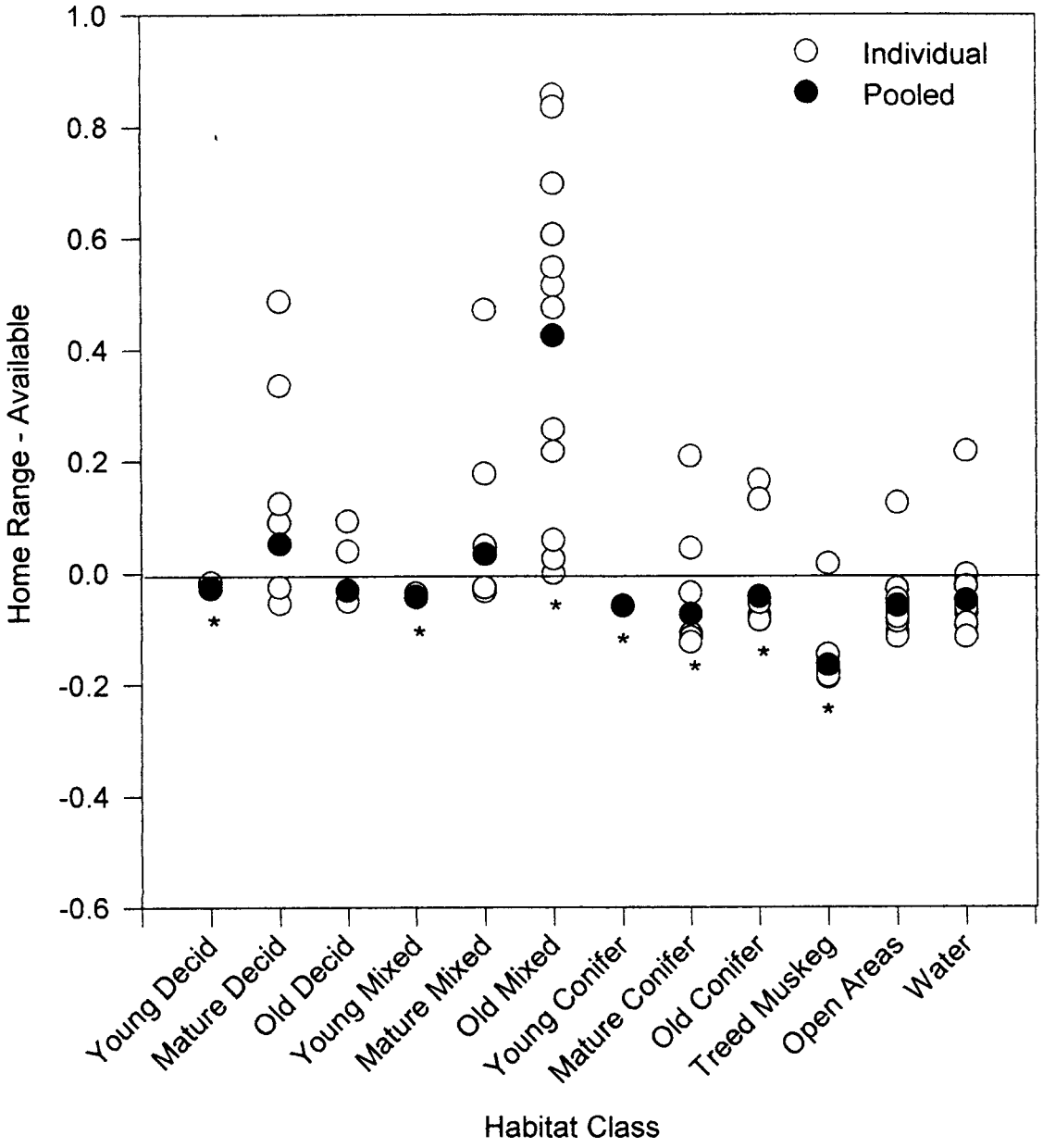

Figure 3.
Barred Owl habitat selection based on breeding home range habitat composition compared to available habitat within random 1.5 km buffers. Significant differences (") determined by Mann-Whitney U-test (P<0.05).

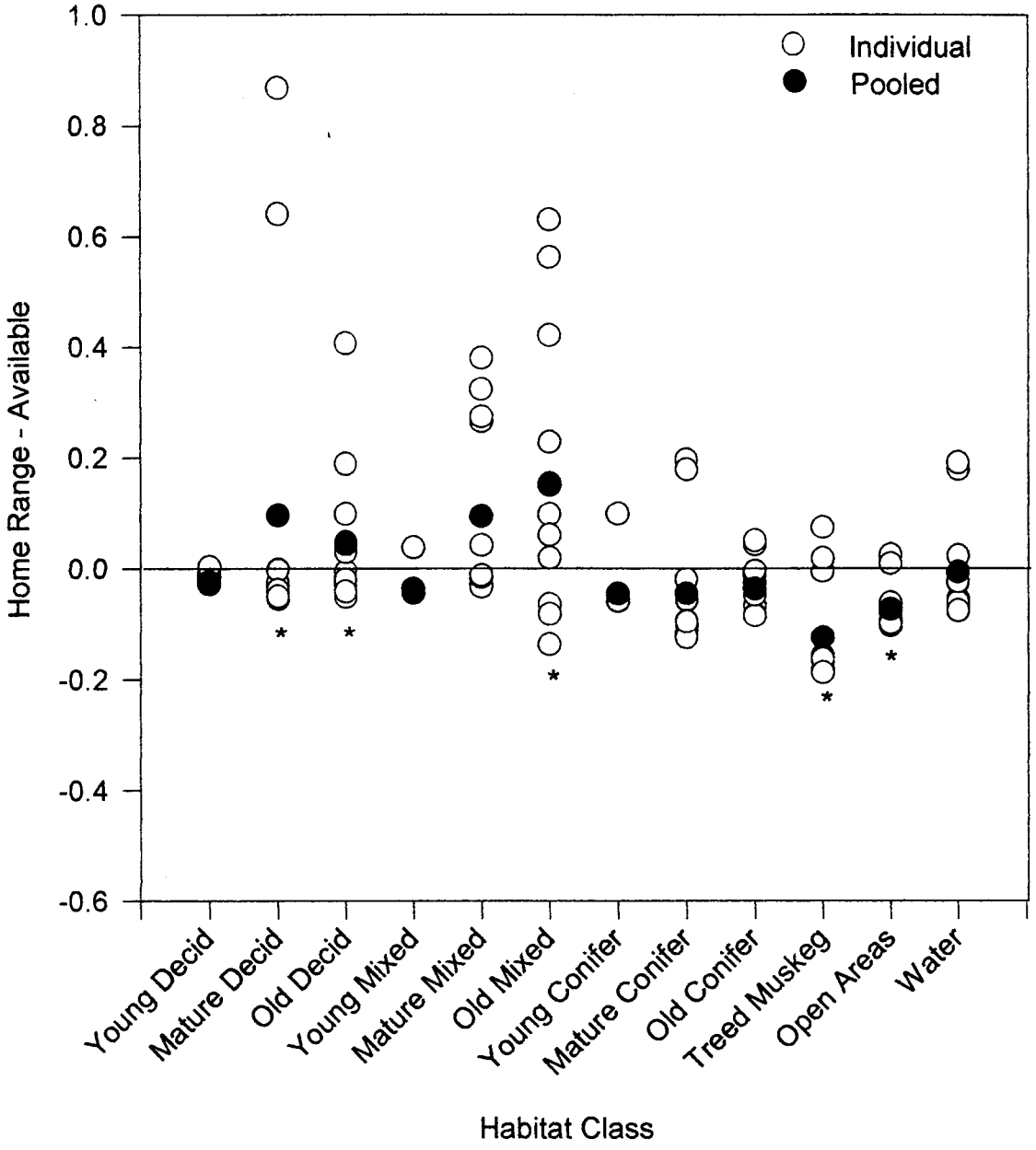

Figure 4.
Barred Owl habitat selection based on non-breeding home range habitat composition compared to available habitat within random 1.5 km buffers.
Significant differences (*) determined by Mann-Whitney U-test (P<0.05).

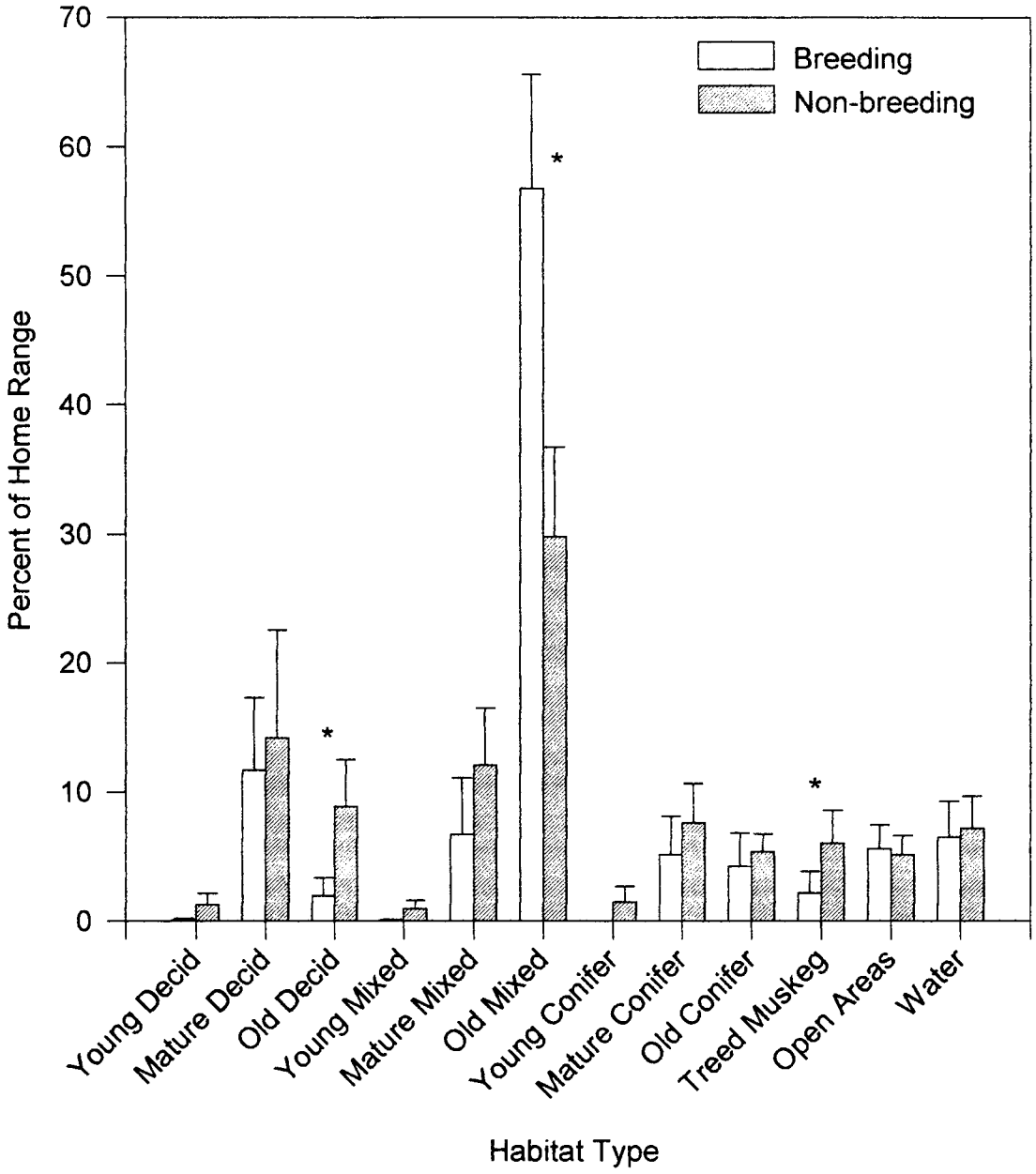

Figure 5.
Habitat composition (mean +SE) of Barred Owl breeding (n=12) and nonbreeding (n=13) home ranges. Significant (*) differences (P<0.05).

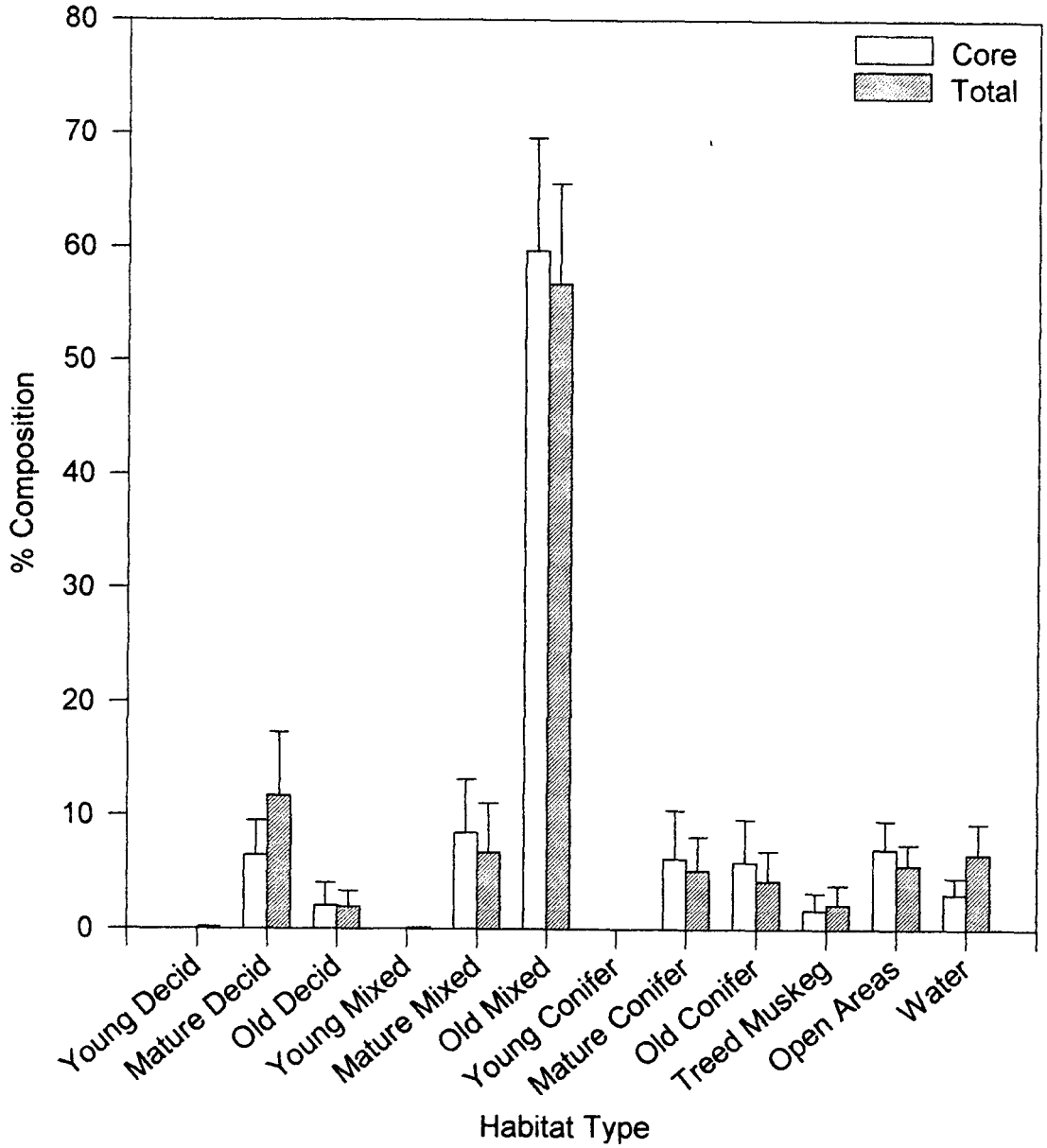

Figure 6.
Habitat composition (mean +SE) of Barred Owl core (50% Minimum Convex Polygon) breeding home range and total (95% Minimum Convex Polygon) breeding home range (n=12).
Significant (*) differences (P<0.05).

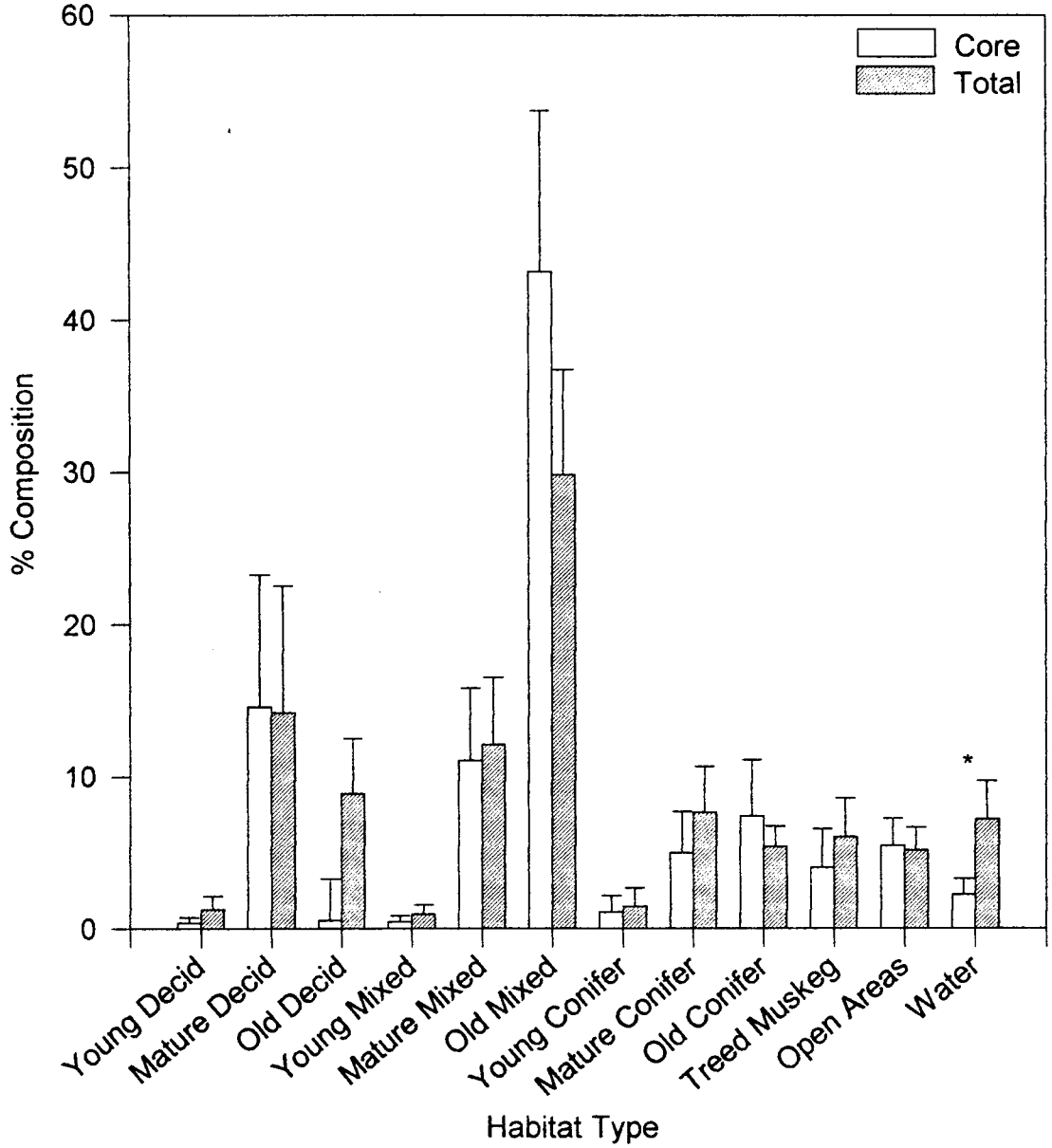

Figure 7.
Habitat composition (mean +SE) of Barred Owl core (50% Minimum Convex Polygon) non-breeding home range and total (95% Minimum Convex Polygon) non-breeding home range (n=13).
Significant (*) differences (P<0.05).

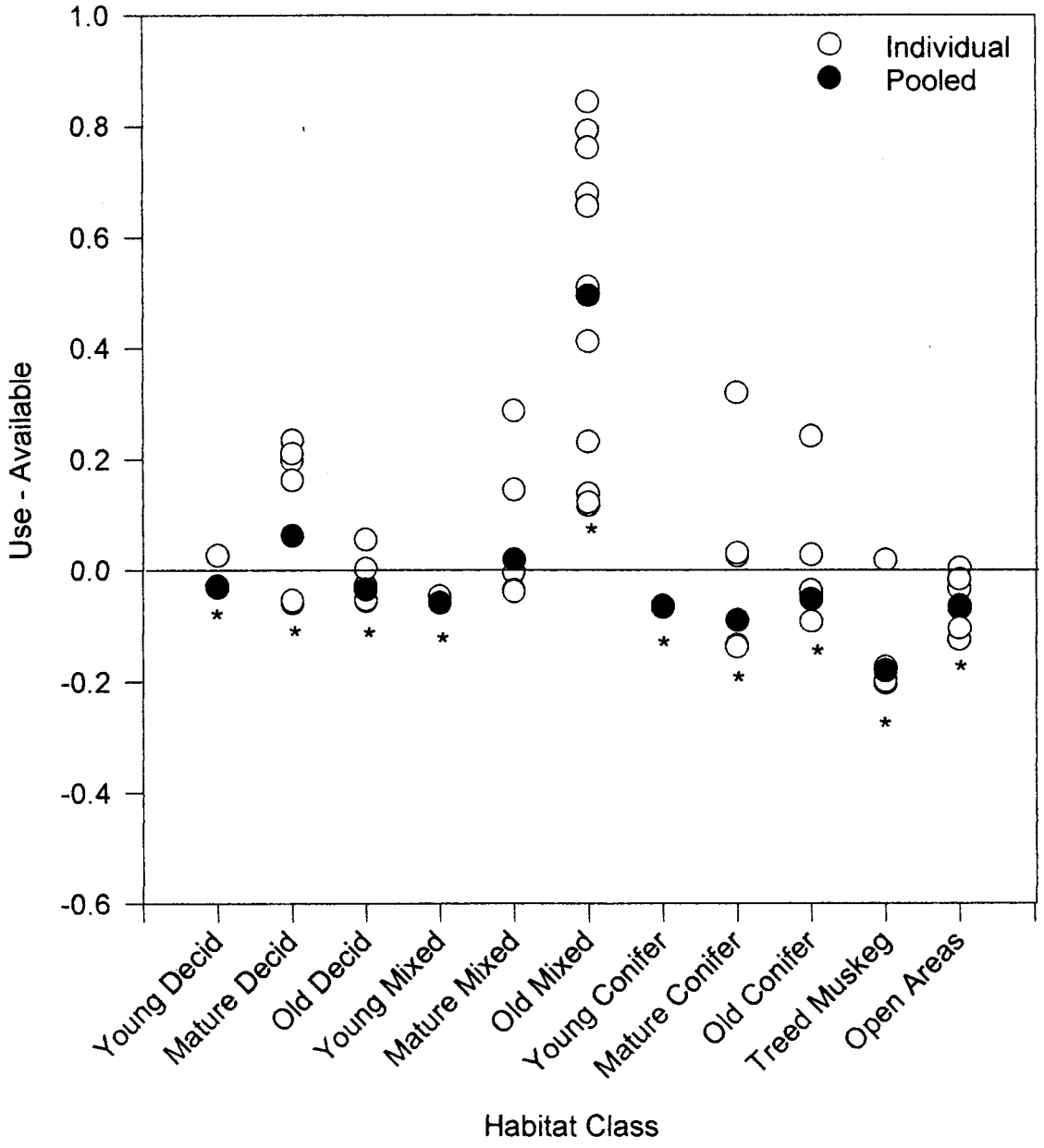

Figure 8.
Barred Owl habitat selection based on breeding (n=12) owl habitat use compared to available habitat within the study area. Significant differences (*) determined through Bonferroni Confidence Intervals ($\propto$ = 0.05).

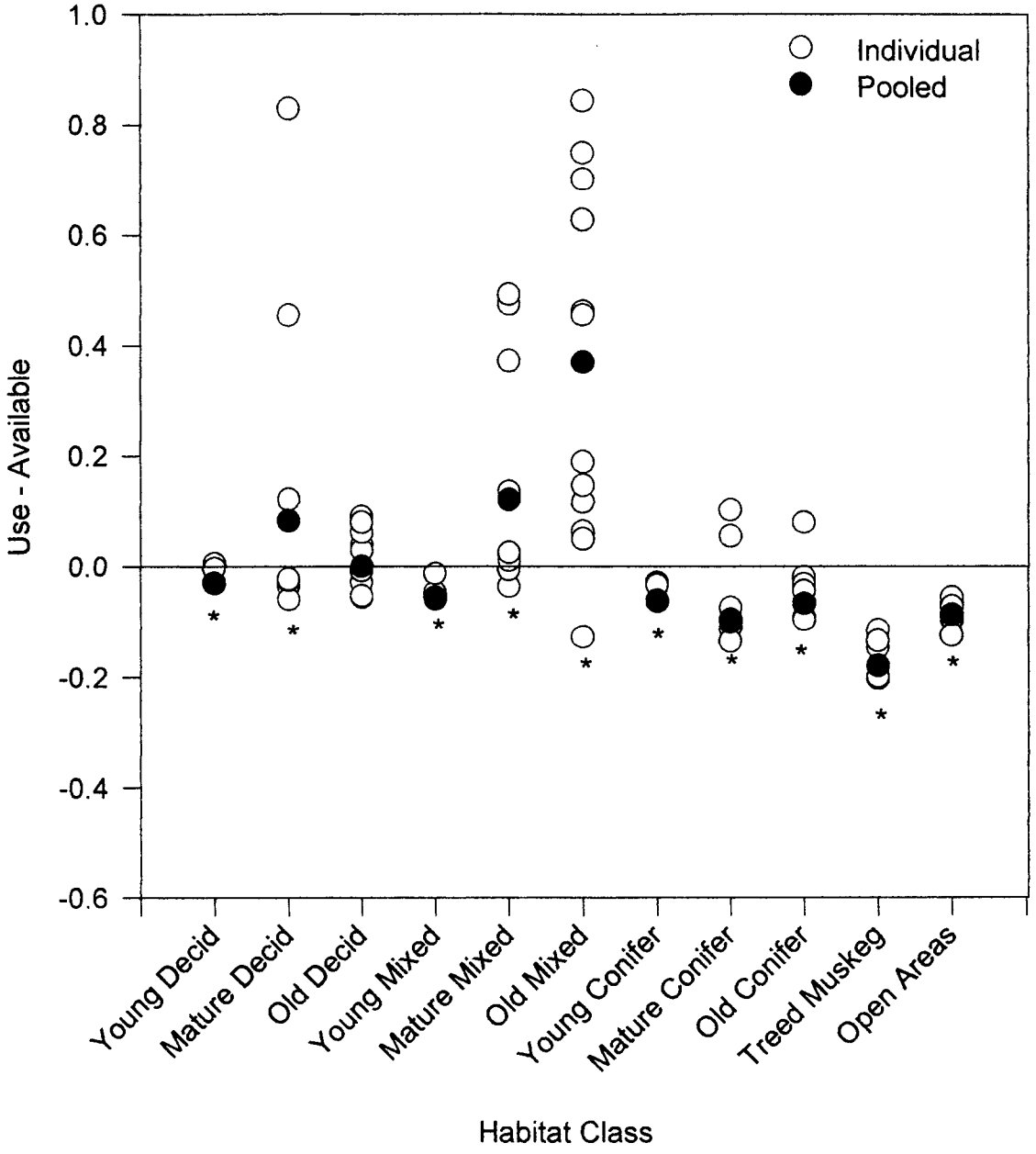

Figure 9.
Barred Owl habitat selection based on non-breeding (n=13) owl habitat use compared to available habitat within the study area. Significant differences (*) determined through Bonferroni Confidence Intervals ($\propto$ = 0.05).

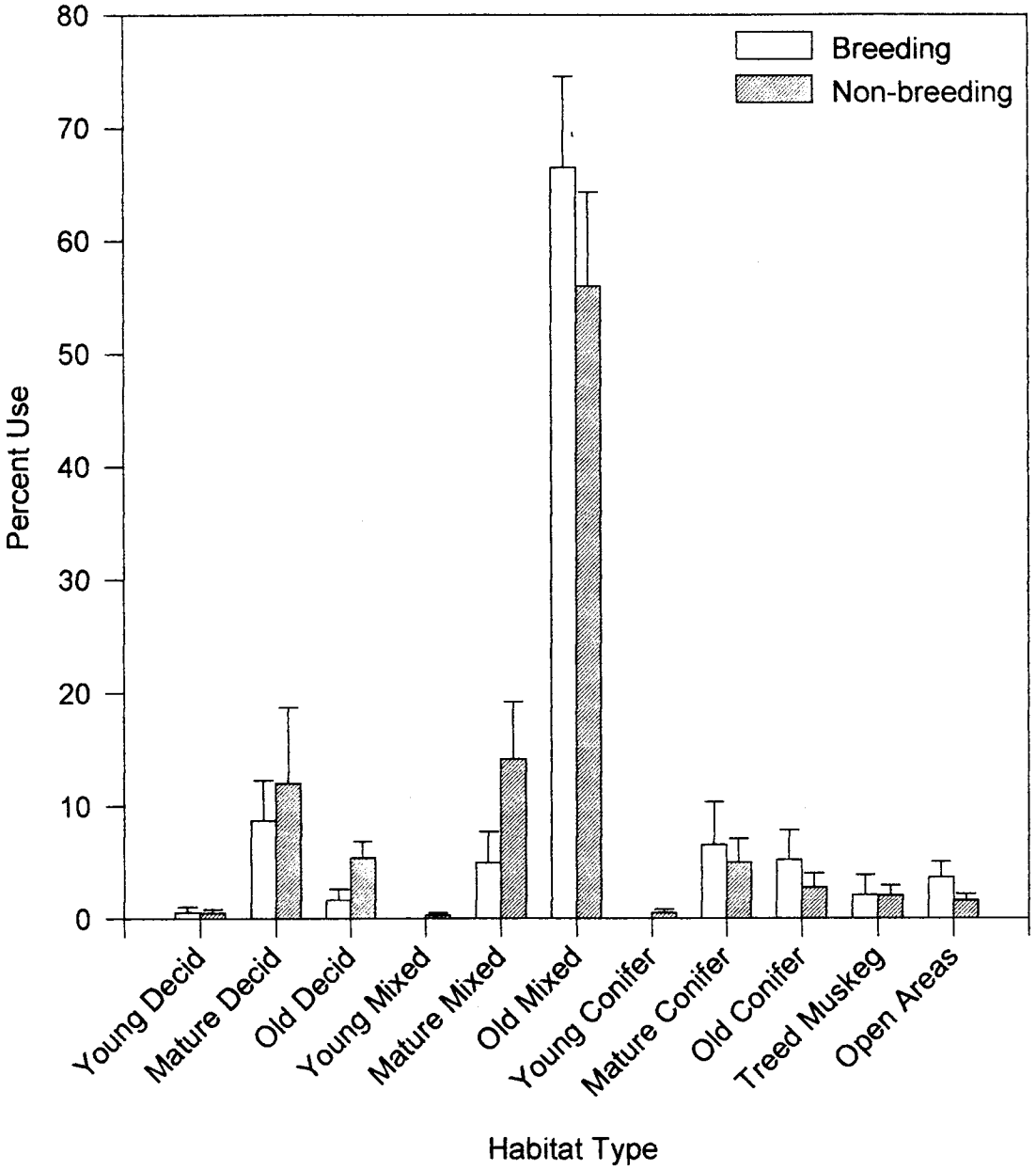

Figure 10.
Habitat use by Barred Owls (mean +SE) during the breeding (n=12) and non-breeding (n=14) periods.
*** Indicates a significant difference (P<0.05).**

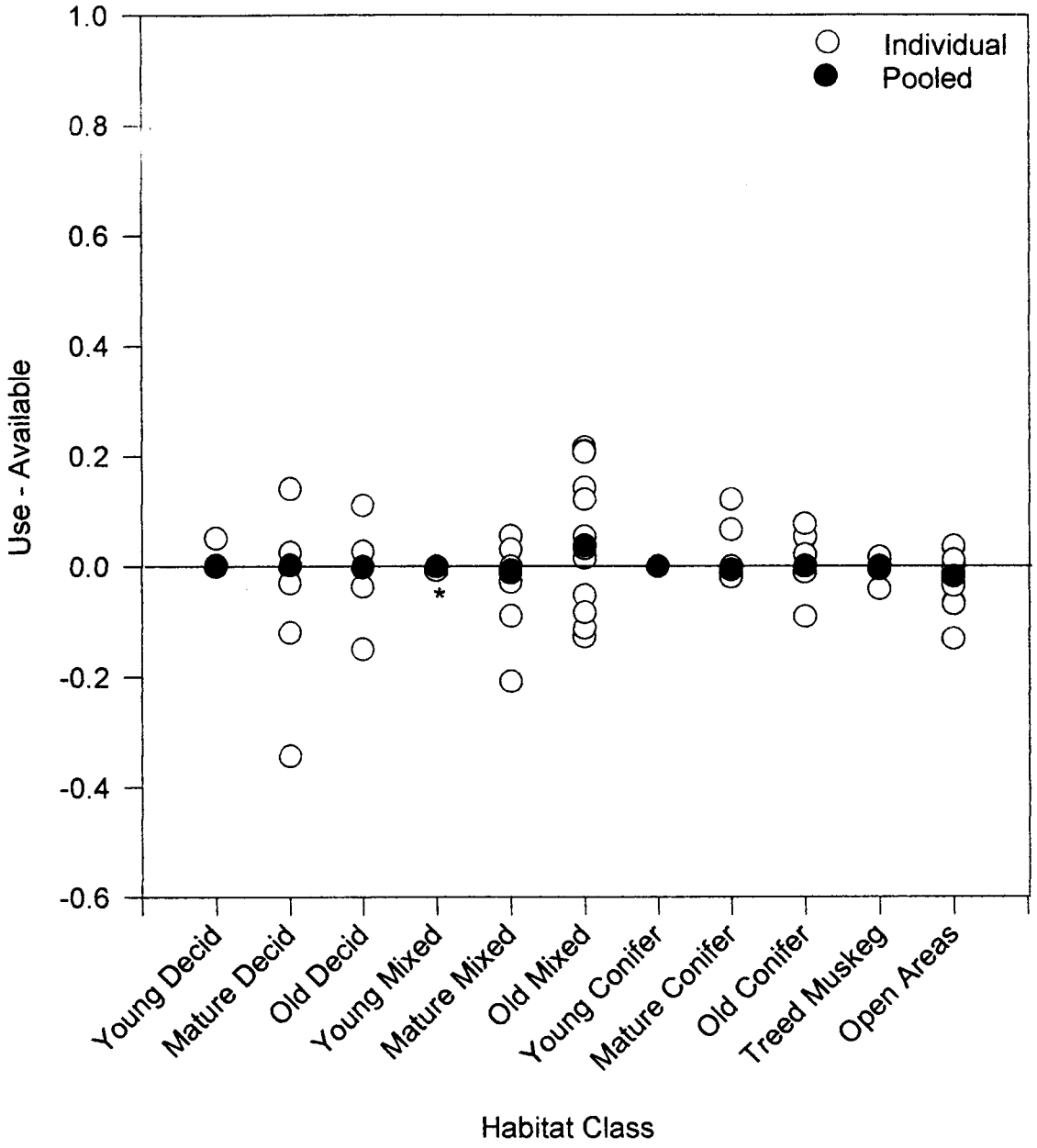

Figure 11.
Barred Owl habitat selection based on breeding owl habitat use compared to available habitat within breeding home ranges (n=12). Significant differences (*) determined through Bonferroni Confidence Intervals ($\propto$ = 0.05).

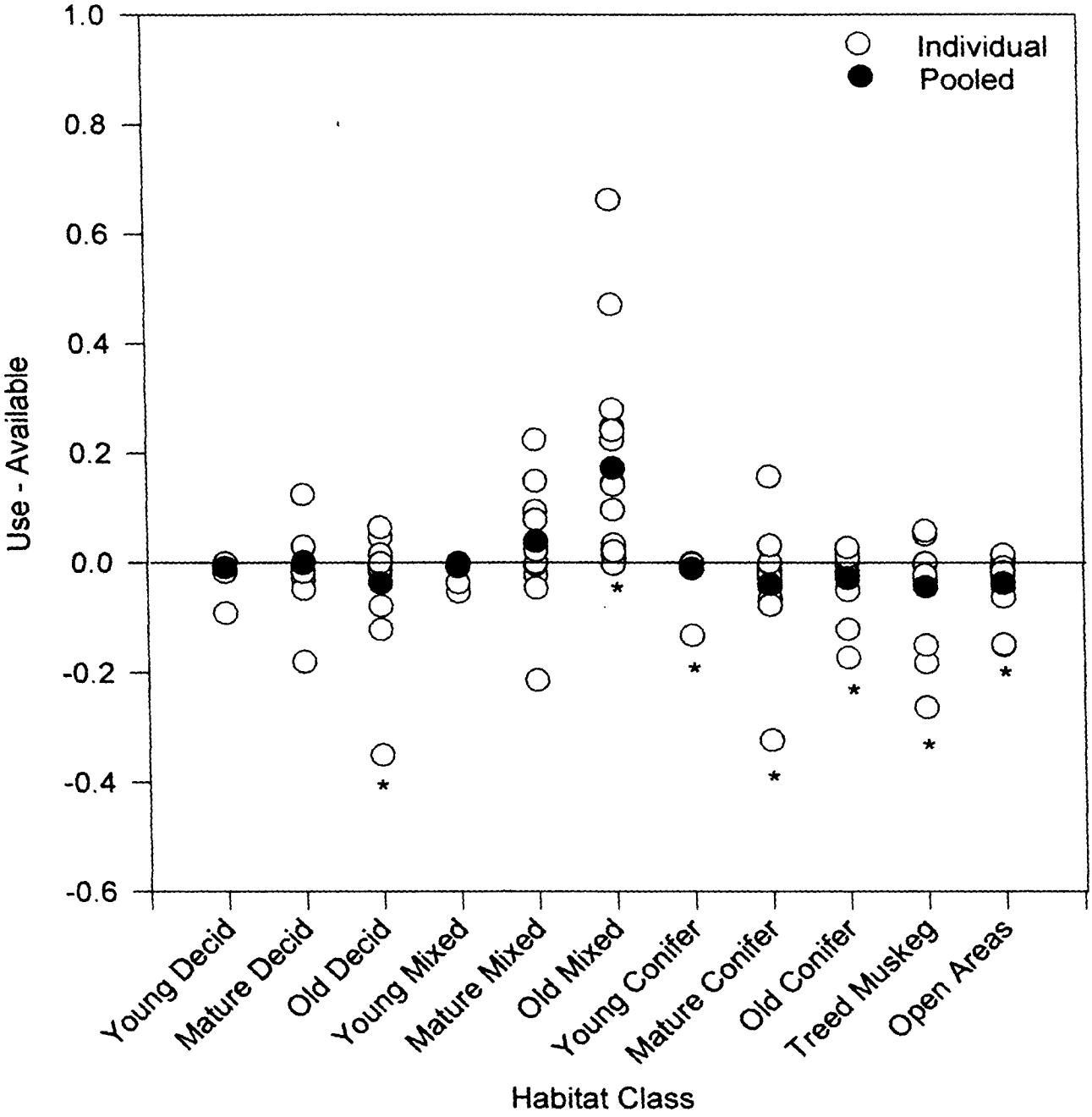

Figure 12.
Barred Owl habitat selection based on non-breeding owl habitat use compared to available habitat within non-breeding home ranges (n=13). Significant differences (*) determined through Bonferroni Confidence Intervals ($\propto$ = 0.05).

Table 1.
Habitat classification by habitat cover type and age.

Habitat Type	Cover Vegetation Description
Deciduous[1]	Trembling Aspen +/or Balsam Poplar +/or White Birch (<20% conifer)
Mixedwood[1]	Combination of deciduous and coniferous species: Trembling Aspen, Balsam Poplar, White Birch, White Spruce, Black Spruce, Jack Pine, Balsam Fir (≥20% conifer, ≥20% deciduous)
Coniferous[1]	White Spruce +/or Black Spruce +/or Jack Pine +/or Tamarack +/or Balsam Fir (<20% deciduous)
Treed Muskeg	Black Spruce +/or Tamarack, excessive moisture and retarded tree growth
Open	Cut Over, Burn Over, Flooded Land, Sand, Clearing, Open Muskeg, Herbs, Shrubs
Water	Lakes, Rivers, Creeks

[1] Could occur in three age classes: Young (<50 years). Mature (50-79 years), and Old (80+ years).

Table 2.
Description of quantitative habitat variables used in analysis of Barred Owl nest site habitat.

Mnemonic	Description
HEIGHT	Nest or central tree height (m)
DBH	Nest or central tree diameter breast height (cm)
CANCOV	Percent canopy cover
CANHT	Mean canopy height of four readings (m)
SHRBDEN	Shrub density (stems per hectare)(x 10^3)
DWNWOOD	Down woody debris (m^3 /ha)
BASAREA	Basal area (m^2 /ha)
STEMDEN	Stem density (trees /ha)(x 10^4)
DISWATER	Distance to closest water (m)

Table 3.
Barred Owl breeding and non-breeding home range values calculated by the 95 % Minimum Convex Polygon estimator. Difference between breeding and non-breeding home range values significant (P<0.05).

Owl	Home Range (ha)	
	Breeding	**Non-breeding**
Beaverglen ♂	91.4	1403.5
Shady Lake ♂	363.5	2010.5
Hillcrest ♂	66.7	1181.2
Birch Bay ♂	-	728.9
Birch Bay ♀	101.9	-
Beartrap ♀	-	1000.8
Paignton ♀	106	573.4
Heart Lakes ♀	129	1573.3
Candle Lake ♀	50	610.9
Prospect ♀	55.7	689.1
Spruce River ♀	341.8	1086.5
Summit ♀	38.1	588.8
Whelan Bay ♀	144.8	1917.1
Waskesiu ♀	-	2678.4
Whiteswan ♀	294.3	-
Mean	**148.6**	**1234**
SD	**111.6**	**630.7**

Table 4.
Ranking matrix for Barred Owl breeding home range habitat composition (n=12) compared to study area habitat composition.
A triple sign represents significant deviation from random at P < 0.05 (+ selected, - avoided).

Habitat Type	Habitat Type												
	Young Decid	Mature Decid	Old Decid	Young Mixed	Mature Mixed	Old Mixed	Young Conifer	Mature Conifer	Old Conifer	Treed Muskeg	Open Areas	Water	Rank
Young Decid		-	-	+	-	---	+	-	-	+	---	---	3
Mature Decid	+		+	+++	+	---	+++	+	+	+++	-	-	8
Old Decid	+	-		+	-	---	+	-	-	+	---	---	4
Young Mixed	-	---	-		-	---	+	-	-	+	---	---	2
Mature Mixed	+	-	+	+++		---	+++	+	+	+++	-	-	7
Old Mixed	+++	+++	+++	+++	+++		+++	+++	+++	+++	+	+	11
Young Conifer	-	---	-	-	---	---		-	-	-	---	---	0
Mature Conifer	+	-	+	+	-	---	+		+	+	-	-	6
Old Conifer	+	-	+	+	-	---	+	-		+	-	-	5
Treed Muskeg	-	---	-	-	-	---	+	-	-		---	---	1
Open Areas	+++	+	+++	+++	+	---	+++	+++	+++	+++		-	10
Water	+++	+	+++	+++	+	---	+++	+	+	+++	-		9

Table 5.
Ranking matrix for Barred Owl non-breeding home range habitat composition (n= 13) compared to study area habitat composition.
A triple sign represents significant deviation from random at P < 0.05 (+ selected, - avoided).

Habitat Type	Habitat Type												
	Young Decid	Mature Decid	Old Decid	Young Mixed	Mature Mixed	Old Mixed	Young Conifer	Mature Conifer	Old Conifer	Treed Muskeg	Open Areas	Water	Rank
Young Decid		---	---	+++	---	---	+++	---	---	-	---	---	2
Mature Decid	+++		-	+++	-	-	+++	+	+	+	-	-	7
Old Decid	+++	+		+++	-	-	+++	+	+	+	-	+	8
Young Mixed	---	---	---		---	---	+++	---	---	---	---	---	1
Mature Mixed	+++	+	+	+++		-	+++	+++	+++	+++	+	+	10
Old Mixed	+++	+	+	+++	+		+++	+++	+++	+++	+++	+++	11
Young Conifer	---	---	---	---	---	---		---	---	---	---	---	0
Mature Conifer	+++	-	-	+++	---	---	+++		-	+	-	-	4
Old Conifer	+++	-	-	+++	---	---	+++	+		+	-	-	5
Treed Muskeg	+	-	-	+++	---	---	+++	-	-		---	-	3
Open Areas	+	+	+	+++	-	---	+++	+	+	+++		+	9
Water	+++	+	-	+++	-	---	+++	+	+	+	-		6

Table 6.
Ranking matrix for Barred Owl breeding habitat use, based on radio-locations for 12 Barred Owls compared to the study area habitat composition. A triple sign represents significant deviation from random at P < 0.05 (+ selected, - avoided).

	Habitat Type											
Habitat Type	**Young Decid**	**Mature Decid**	**Old Decid**	**Young Mixed**	**Mature Mixed**	**Old Mixed**	**Young Conifer**	**Mature Conifer**	**Old Conifer**	**Treed Muskeg**	**Open Areas**	**Rank**
Young Decid		-	---	+++	-	---	+++	+	-	+	-	4
Mature Decid	+		+	+++	-	---	+++	+	+	+++	+	8
Old Decid	+	-		+++	-	---	+++	+	-	+	-	5
Young Mixed	---	---	---		---	---	+	-	---	+	---	1
Mature Mixed	+	+	+	+++		---	+++	+	+	+++	+	9
Old Mixed	+++	+++	+++	+++	+++		+++	+++	+++	+++	+++	10
Young Conifer	---	---	---	-	---	---		-	---	-	---	0
Mature Conifer	-	-	-	+	-	---	+		-	+	-	3
Old Conifer	+	-	+	+++	-	---	+++	+		+++	+	7
Treed Muskeg	-	---	-	-	---	---	+	-	---		-	2
Open Areas	+	-	+	+++	-	---	+++	+	-	+		6

Table 7.
Ranking matrix for Barred Owl non-breeding habitat use, based on radio-locations for 13 barred Owls compared to the study area habitat composition. A triple sign represents significant deviation from random at P < 0.05 (+ selected, - avoided).

	Habitat Type											
Habitat Type	**Young Decid**	**Mature Decid**	**Old Decid**	**Young Mixed**	**Mature Mixed**	**Old Mixed**	**Young Conifer**	**Mature Conifer**	**Old Conifer**	**Treed Muskeg**	**Open Areas**	**Rank**
Young Decid		-	-	+++	---	---	+++	-	-	+	-	5
Mature Decid	+		-	+++	---	---	+++	+	+	+	+	7
Old Decid	+	+		+++	-	---	+++	+	+	+++	+	8
Young Mixed	---	---	---		---	---	-	-	-	-	-	0
Mature Mixed	+++	+	+	+++		---	+++	+++	+++	+++	+++	9
Old Mixed	+++	+++	+++	+++	+++		+++	+++	+++	+++	+++	10
Young Conifer	-	-	---	+	---	---		-	-	+	-	2
Mature Conifer	+	-	-	+	---	---	+		+	+	+	6
Old Conifer	+	-	-	+	---	---	+	-		+	+	4
Treed Muskeg	-	-	---	+	---	---	-	-	-		-	1
Open Areas	+	-	-	+	---	---	+	-	-	+		3

Table 8.
Ranking matrix for Barred Owl breeding habitat use, based on radiolocations for 12 Barred Owls, compared to home range habitat composition. A triple sign represents significant deviation from random at P < 0.05 (+ selected, - avoided).

	Habitat Type						
Habitat Type	**Mature Decid**	**Mature Mixed**	**Old Mixed**	**Mature Conifer**	**Old Conifer**	**Open Areas**	**Rank**
Mature Decid		-	-	+	-	+++	3
Mature Mixed	+		-	+	-	+	2
Old Mixed	+	+		+	-	+++	4
Mature Conifer	-	-	-		-	+	1
Old Conifer	+	+	+	+		+++	5
Open Areas	---	-	---	-	---		0

Table 9.
Ranking matrix for Barred Owl non-breeding habitat use, based on radiolocations for 13 Barred Owls compared to home range habitat composition. A triple sign represents significant deviation from random at P < 0.05 (+ selected, - avoided).

Habitat Type	Mature Decid	Old Decid	Mature Mixed	Old Mixed	Mature Conifer	Old Conifer	Treed Muskeg	Open Areas	Rank
Mature Decid		-	-	---	+	+	+	+	4
Old Decid	+		-	---	+	+	+	+++	5
Mature Mixed	+	+		-	+++	+++	+++	+++	6
Old Mixed	+++	+++	+		+++	+++	+++	+++	7
Mature Conifer	-	-	---	---		-	+	+	2
Old Conifer	-	-	---	---	+		+	+	3
Treed Muskeg	-	-	---	---	-	-		+	1
Open Areas	-	---	---	---	-	-	-		0

Table 10.
Characteristics of 15 Barred Owl nests in the boreal forest of Saskatchewan.

Owl	Nest Stand	Nest Tree Species	Nest Tree Status	Nest Type
Prospect 95	Old Mixedwood	White Spruce	Live	Platform (Witch's Broom)
Prospect 96	Old Mixedwood	White Spruce	Live	Platform (Squirrel Nest)
Summit	Old Mixedwood	White Spruce	Dead	Cavity (Broken Top)
Spruce River 94	Old Mixedwood	White Spruce	Live	Cavity (Broken Top)
Candle Lake	Old Mixedwood	White Spruce	Live	Platform (Squirrel Nest)
Spruce River 95	Mature Deciduous	White Birch	Live	Cavity (Broken Top)
Beaver Glen	Old Mixedwood	Balsam Poplar	Dead	Cavity (Broken Top)
Heart Lakes 94	Old Mixedwood	Balsam Poplar	Live	Cavity (Broken Limb)
Heart Lakes 96	Old Mixedwood	Balsam Poplar	Live	Cavity (Broken Limb)
Point View	Old Mixedwood	Balsam Poplar	Live	Cavity (Broken Limb)
Whelan Bay 94	Old Mixedwood	Trembling Aspen	Dead	Cavity (Broken Top)
Whelan Bay 95	Old Mixedwood	Trembling Aspen	Live	Platform (Stick Nest)
Whelan Bay 96	Old Coniferous	Trembling Aspen	Live	Platform (Stick Nest)
Whiteswan	Old Mixedwood	Trembling Aspen	Dead	Cavity (Broken Limb)
Birch Bay	Old Mixedwood	Trembling Aspen	Dead	Cavity (Broken Top)

Table 11.
Mean, standard deviation, and range of the quantitative habitat variables surrounding Barred Owl nest sites and random sites. Results of Mann-Whitney U statistic testing for differences between the groups.

Characteristic	Nest	Random	Mann-Whitney U	
			z value	*P*-level
HEIGHT	18.8 ± 6.3 (7.8-29.5)	6.5 ± 2.2 (3.6-10.8)	-5.06	0.000
DBH	47.4 ± 12.9 (31.9-74.5)	23.0 ± 8.2 (11.4-41.7)	-4.960	0.000
CANCOV	57 ± 17 (20-75)	66 ± 18 (30-90)	-1.64	0.102
CANHT	19.5 ± 4.2 (12.9 - 28.4)	19.6 ± 4.3 (9.7-27.0)	-0.17	0.866
SHRBDEN	14 ± 16 (0.3-55)	5 ± 4.5 (0.3-12)	-1.66	0.097
DWNWOOD	157.9 ± 137.9 (15.6 - 376.8)	114.3 ± 91.4 (14.1 - 505.1)	-0.12	0.904
BASAREA	57.9 ± 39.5 (27.0-190)	50.1 ± 11.9 (21.7 - 78.7)	-0.14	0.885
STEMDEN	2.4 ± 0.9 (0.9-4.4)	2.2 ± 0.8 (1.1-4.6)	-0.64	0.523
DISWATER	680 ± 630 (100-2100)	490 ± 120 (50-1250)	-0.26	0.791

Table 12.
Barred Owl prey in the boreal forest of Saskatchewan as identified from pellets and prey remains.

	Prey Item	Number of Individuals
Amphibians		
	Frogs	147
Birds		
	Passerines	6
	Grouse	5
Mammals		
	Deer Mouse (*Peromyscus maniculatus*)	5
	Microtine rodents	12
	Soricidae rodents (shrews)	5
	Sciuridae rodents (unidentified squirrels)	8
	Red Squirrel (*Tamiasciurus hudsonicus*)	1
	Northern Flying Squirrel (*Glaucomys sabrinus*)	4
	Northern Pocket Gopher (*Thomomys talpoides*)	2
	Unidentified small mammal	1
Insects		
	Coleoptera (beetles)	35

Table 13.
Number of small mammals in mature aspen and old mixedwood forest. Average for trapping periods in spring and fall of 1995 and 1996 (Significant difference P < 0.05).

	Mature Aspen	Old Mixedwood
Red-backed Vole	19.3	21.6
Deer Mouse	15.5	1.9
Meadow Vole	1.5	0.1
Shrew spp.	0.4	0.3
Total*	36.8	23.9