Habitat Associated with Barred Owl (*Strix varia*) Locations in Southeastern Manitoba: A Review of a Habitat Model

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Abstract.—A Habitat Suitability Index (HSI) model was developed for the Barred Owl (*Strix varia*) in southeastern Manitoba. An initial validation of the model was performed within three sizes of circular plots (314, 1,256, and 2,827 ha) centered on 28 Barred Owl locations. The model was able to predict suitable habitat at the 314 ha scale. Forest habitat characteristics within the 314 ha plots were described to suggest improvements to the model's performance. The observed values of the three forest resource inventory variables used in the HSI model; cutting class, crown closure, and tree species composition were generally consistent with the model's predictions. The HSI model emphasized the relative importance of white spruce (*Picea glauca*). This species, while present in the study area, was not detected in the habitat association analysis. A site classification variable not used in the HSI model may have some predictive value. Some of the land units identified as "unproductive areas" may also be important to Barred Owls. Data on the Barred Owl's nesting ecology and actual home ranges are required to further validate the model. Quantifying linkages between Barred Owl habitat and viable population statistics would foster more effective forest management for this species.

Habitat Suitability Index (HSI) models are hypotheses of species-habitat relationships. They are among the most influential management tools in use today (Brooks 1997). Incremental improvements in the modelling process, from development through validation, is recommended and facilitated by publishing interim models that have not been completely validated (Brooks 1997). This paper briefly reviews the development and initial validation of a Barred Owl (*Strix varia*) HSI model for Manitoba and then describes forest habitat associated with 28 Barred Owl locations to suggest improvements to the model.

The Barred Owl (*Strix varia*) is a wide ranging species found in relatively heavy, mature woods, varying from upland forests to lowland swamps in North America (Johnsgard 1988). Godfrey (1986) described its range as: *"Southern wooded Canada (from eastern British Columbia east to Nova Scotia) southward through the United States (east of the Rocky Mountains), and the mountains of Mexico to western Guatemala and Honduras."* The Barred Owl is considered uncommon in Manitoba (Duncan 1996b); it is estimated that there are approximately 1,000-1,500 Barred Owls in the province (Duncan 1994). At least 80 Barred Owl locations have been identified in Manitoba, yet only three Barred Owl breeding occurrences have been documented (Duncan 1994).

Changes in forest landscapes have had a profound effect on endemic wildlife, including the Barred Owl. It has only recently (early 1900's) expanded its range westward into British Columbia, Alaska, Washington, Oregon, Montana, and northern California (Dunbar *et al.* 1991, Grant 1966, Hamer *et al.* 1994, Jones 1987, Munro and Cowan 1947, Oeming and Jones 1955, Shea 1974, Simpson 1915, Taylor and Forsman 1976) from the east via Saskatchewan and Alberta. While the timing and cause of this expansion is questionable, human-induced habitat change (conversion of pure coniferous forest to mixed wood forest as a result of forest harvesting) is cited as the main reason (Allen 1987, Voous 1988).

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Conversely, the Barred Owl is also vulnerable to habitat loss from forest harvesting (Van Ael 1996). Mazur *et al*. (1997) describe it as an old growth dependent species. Barred Owl populations in southern Ontario have likely been severely reduced over the last 150 years as a result of habitat loss and forest fragmentation (Austen *et al.* 1994). Forest fragmentation has also had a negative impact on the Barred Owl in New Jersey (Bosakowsky *et al.* 1987). In order to address these concerns, Barred Owl HSI models have been developed to integrate wildlife habitat values in forest management planning (Allen 1987, Manitoba Forestry Wildlife Management Project [MFWMP] 1994, Olsen *et al.* 1996).

HSI MODEL DEVELOPMENT

The HSI model for the Barred Owl in Manitoba was developed based on a habitat use literature review (Duncan 1994) and focused on its reproductive cover requirements (MFWMP 1994). The assumption was that if the Barred Owl's reproductive cover requirements were met then all of its life requisites would be similarly met. The rationale for developing the model was to put information about Barred Owl habitat use into a form compatible with existing Manitoba forest resource inventory (FRI) data. The Manitoba Barred Owl HSI model is expressed as the interaction between three FRI variables cutting class (V1), canopy closure (V2) and tree species composition (V3) as follows: $\boldsymbol{HSI = (V1 \times V2 \times (V3^{1/2}))^{2.5}}$. Cutting class and canopy closure are variables used to describe forest age distribution. Species composition was simplified to reflect the percent conifers within a forest stand.

Forest Resource Inventory Variables

Cutting Class (V1)

According to Natural Resources Manitoba (1996), cutting class is a forest variable based on *"... size, vigor, state of development and maturity of the stand for harvesting purposes; the variable is interpreted from aerial photographs and ground truthing."* Cutting class is subdivided into five separate categories from one to five (table 1, appendix 1). Cutting class relates to the relative age distribution of each forest stand; it was designed to express the age of a stand with respect to its rotation age. Rotation age is the time at which a stand is ready for harvesting. In Manitoba, rotation age varies from 60 to 140 years. Rotation ages of 140 years are generally reserved for poor and wet sites with slow growth. Using rotation age as a harvesting criteria, overmature stands are defined as any stand 10 years over rotation age. These stands are designated as high priority sites for timber harvesting. The HSI model stated that the Barred Owl was associated with canopy heights > 23m. Consequently, class 3 was estimated to be of very limited value to the Barred Owl only at its upper age/size limit, and then increasingly so for classes 4 and 5 (fig. 1).

Crown Closure (V2)

The second forest variable used in the model is crown closure. It is defined as *"... a variable estimated from aerial photographs. Four classes are recognized and entered for each stand type aggregate. Changes to the estimate*

Table 1.—*Mean area (ha) represented by each cutting class for a series of 28 circular 314 ha plots in southeastern Manitoba containing at least one Barred Owl (*Strix varia*).*

Cutting (age) class	Mean area	95 percent C.I.	S.D.
0 Grass/forb	14.1	6.5	17.5
1 Shrub/seedling (<3m)	35.8	17.6	47.6
2 Pole/sapling (>3m)	44.4	22.6	60.9
3 Intermediate (>10m)	170.5	50.8	137.1
4 Mature	59.5	24.9	66.1
5 Overmature	42.1	27.4	75.2
Unproductive forest	115.8	29.9	80.7

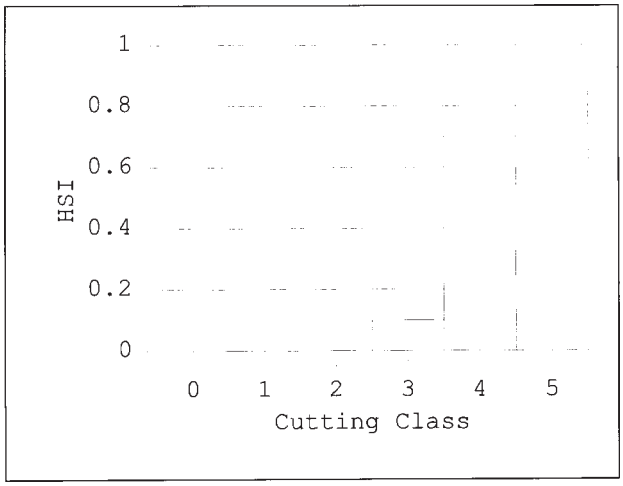

Figure 1.—*Manitoba Barred Owl (*Strix varia*) habitat suit-ability index (HSI) for cutting class (variable 1). Class 0 = grass/forb, 1 = shrub/seed-ling, 2 = pole/sapling, 3 = intermediate, 4 = mature, and 5 = overmature (modified from MFWMP 1994).*

can be only made under exceptional circumstances." Crown closure classes are defined as Class 0: 0-20 percent crown closure; Class 2: 21-50 percent; Class 3: 51-70 percent; and Class 4: >70 percent. The Barred Owl was thought to avoid code 0 and increasingly prefer codes 2 to 4 (fig. 2). [N.B. Code 1 is not defined and does not exist in the FRI database].

Species Composition (V3)

The third forest variable, species composition, is based on *"... the tree count (basal area), for each species in relation to the total tree count (basal area) of the stand expressed as a percentage. It is calculated to the nearest 1/10 percent for a species group determination and then rounded to the nearest 10 percent before being entered into the type aggregate."* A stand type aggregate is comprised of the forest cover type, the subtype, site class, cutting class, and lastly crown closure.

Relative to the first two variables, species composition was considered less important to the Barred Owl (MFWMP 1994). Given that in Manitoba the predominant hardwood is aspen (*Populus* spp.), and that shelter in winter can be provided by all conifers except tamarack (*Larix laricina*), this variable was simplified to reflect the percent softwood (fig. 3). Furthermore, when the conifer component of a mixed wood stand is largely white spruce (*Picea glauca*), it was considered to provide even greater opportunities for nesting (MFWMP 1994). Extensive stands of pure to nearly pure deciduous or coniferous trees were thought to be strongly avoided by the Barred Owl. Conversely, it was considered to prefer mixed wood stands (fig. 3). The model predicts the habitat associated with the Barred Owl at the forest stand level. A more in-depth discussion of the

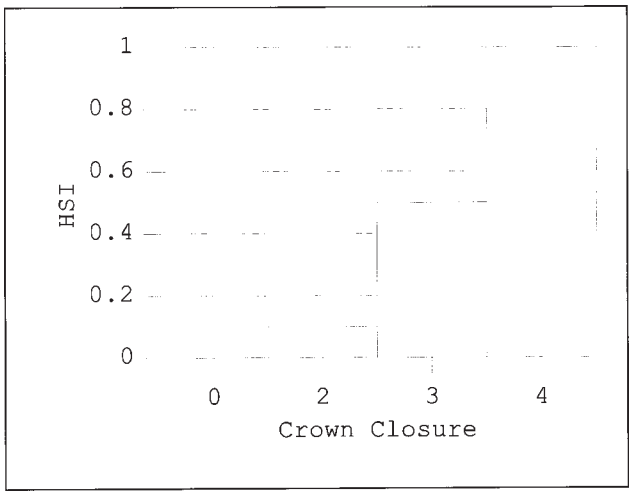

Figure 2.—*Manitoba Barred Owl (*Strix varia*) habitat suitability index (HSI) for crown closure (vari-able 2). Crown Closure 0 = 0-20 percent, 2 = 21-50 percent, 3 = 51-70 percent, and 4 = 71-100 percent (modified from MFWMP 1994).*

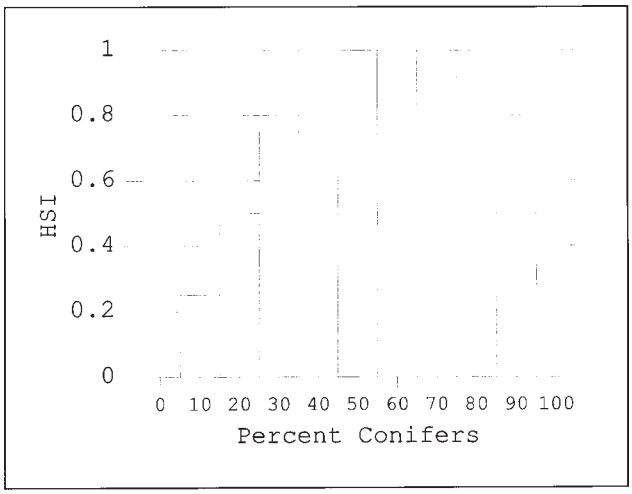

Figure 3.—*Manitoba Barred Owl (*Strix varia*) habitat suit-ability index (HSI) for tree species compos-ition (variable 3). Includes all conifers except tamarack. For all conifers except white spruce, HSI is reduced by 0.5 (modified from MFWMP 1994).*

model can be found in MFWMP (1994) available from the first author.

HSI MODEL INITIAL VALIDATION

Owls were surveyed in southeastern Manitoba using nocturnal surveys in March/April from 1991-1995 (Duncan and Duncan 1997). Individual locations of Barred Owls were determined using triangulation and their location was assigned a latitude and longitude value and digitized into a GIS layer. It was assumed that owls were located within their home range (Duncan 1996a). As a result, a series of concentric circular plots representing the range of reported Barred Owl home range sizes (Duncan 1994) were plotted around each Barred Owl point location. Due to financial and technical constraints, circular plot sizes with radii of 1 km (314 ha), 2 km (1,256 ha) and 3 km (2,827 ha) were chosen.

A series of 94 point locations were randomly generated and digitized into a GIS layer and circular plots of the same size were assigned to these random locations. The model was applied to the FRI to generate HSI values by intersecting the database with the circular plots (Duncan 1996a). HSI values were then calculated for each forest stand polygon within the circular plots. Habitat units (HU) and habitat areas (HA) were calculated for the circular plots at all three spatial scales. Habitat units (HU) were calculated by multiplying the HSI value for each polygon by the polygon's area. A weighted measure of habitat area (HA) was then calculated as the sum of the HU's divided by area and multiplied by 100.

These data were used to make comparisons between Barred Owl and random circular plots. The data failed to approximate a normal distribution (Duncan 1996a), therefore non-parametric tests (Daniel 1978) were used to evaluate the model. Barred Owl plots with 1 km radii had significantly greater median HA values than random plots of the same size ($P = 0.008$, Median Test; $P = 0.034$, Rank Sum Test, Duncan 1996a). Laidig and Dobkin (1995) used a similar technique to evaluate Barred Owl and Great Horned Owl (*Bubo virginianus*) habitat in southern New Jersey.

DESCRIPTION OF ASSOCIATED FOREST HABITAT

In order to more closely examine the model's ability to predict suitable Barred Owl habitat, the description of forest stand variables (cutting class, crown closure, and species composition) in areas associated with Barred Owl locations were tabulated from Manitoba's FRI database. This was limited to the scale (314 ha) at which the model was able to statistically predict habitat suitability (Duncan 1996a). Habitat data were summarized by cutting class, crown closure, species composition and site classification. Site classification was added for this descriptive exercise. The mean, standard deviation and 95 percent confidence intervals were calculated for the variables.

Cutting Class

The Barred Owl typically nests in natural cavities in large deciduous or coniferous trees (Johnsgard 1988). McGarigal and Fraser (1984) indicated that in Virginia it preferred old stands (> 80 years old) rather than young stands (< 80 years old). In the central Appalachians, Devereux and Mosher (1984) determined that eight Barred Owl nest sites were in relatively mature forest stands compared to 76 randomly selected sites. Sutton and Sutton (1985) subjectively noted that in southern New Jersey the Barred Owl was associated with "the oldest growth and uncut stands ... of hardwood forest." In Saskatchewan (Mazur 1997) and Ontario (Van Ael 1996), it preferred mixed-age to mature forests. The consistent relationship between the Barred Owl and older mature forests reflects its need for suitable nesting cavities. These are more likely to be found in large diseased or dying trees. Therefore, substantial areas with older and larger trees (cutting classes 4 and 5) increases the likelihood of the presence of suitable nest structures. However, the most prevalent cutting class associated with the Barred Owl in this study was the intermediate class (table 1). Duncan (1994) suggested that this class was of very limited value in providing nest sites for Barred Owls, except at its upper age/size limit. There are a number of possible explanations why class 3 was so prevalent, and classes 4 and 5 were less abundant.

First, circular plots are likely poor approximations for actual Barred Owl home ranges. Second, large diameter snags with suitable Barred Owl nest sites may be present as residuals within stands designated as cutting class 3. Third, the amount of forest classified as either mature and overmature (table 1) may be sufficient to provide nest sites.

A large proportion of the plots were classified as unforested or unproductive forests (table 1); these areas included treed and untreed muskeg, beaver (*Castor canadensis*) ponds, roads, and other areas not considered in the model.

Crown Closure

The HSI model predicted that the Barred Owl would avoid crown closure code 0, and increasingly prefer codes 2 to 4 (fig. 2). The observed distribution of crown closure classes qualitatively agrees with that prediction; the most prevalent crown class present was the > 71 percent canopy closure class (table 2). However, this is likely related to the corresponding prevalence of immature cutting classes (table 1). The HSI model may possibly be improved by increasing the predicted HSI value of lower crown closure classes for stands that are mature or overmature (cutting class 4 or 5).

Table 2.—*Mean area (ha) represented by each crown class for a series of 28 circular 314 ha plots in southeastern Manitoba containing at least one Barred Owl (*Strix varia*).*

Crown closure class	Mean area	95 percent C.I.	S.D.
0: 0-20 percent	14.1	6.5	17.5
2: 21-50 percent	40.7	16.5	44.4
3: 50-71 percent	84.4	30.1	81.4
4: >71percent	226.7	53.9	145.7
Unproductive forest	115.8	29.9	80.7

Species Composition

There was a wide diversity of general forest cover types present (appendix 2). When tree species composition is simplified to general percentage conifer classes (table 3), the mean area of stands associated with Barred Owl circular plots that are either 'pure' conifer or deciduous is large. The HSI model simplified species composition and predicted that pure or nearly pure stands of deciduous or coniferous trees were relatively unimportant to the Barred Owl, while mixed wood stands were preferred (MFWMP 1994). Because the FRI database rounds percent tree species to the nearest 10 percent, 'pure' conifer stands may actually contain deciduous trees and vice versa. Smaller stands of coniferous or deciduous trees within a mosaic of forest stand types may indeed provide useful habitat. Perhaps the relevance of the tree species composition variable to the predictive ability of the Barred Owl model is minimal.

Table 3.—*Mean area (ha) represented by four general tree species composition classes for a series of 28 circular 314 ha plots in southeastern Manitoba containing at least one Barred Owl (*Strix varia*).*

Species composition[1]	Mean area	95 percent C.I.	S.D.
0 percent conifer	80.4	27.4	73.9
< 51 percent conifer	172.8	45.5	122.8
> 50 percent conifer	35.8	17.2	46.4
100 percent conifer	71.8	36.4	98.2

[1] Conifer = all conifers except tamarack (*Larix laricina*)

Trembling aspen (*Populus tremuloides*) dominated stands had the greatest mean area, followed by black spruce (*Picea mariana*) and tamarack, respectively (table 4). The majority of Barred Owl nests found in North America were in deciduous trees, including aspen (Apfelbaum and Seelbach 1983, Duncan 1994). The relevance of black spruce to the Barred Owl is uncertain; in western Ontario (Van Ael 1996) and central Saskatchewan (Mazur 1997) it strongly avoided lowland black spruce associations. Conversely, anecdotal winter sightings of the Barred Owl in Saskatchewan were almost exclusively in black spruce bogs (W.C. Harris, pers. comm.).

The HSI Model also emphasized the relative importance of white spruce as a source of nest structures (fig. 3), yet this species was not represented (table 4, appendix 2). However, this does not refute the Model's prediction. White spruce is readily detectable from other conifers (except perhaps balsam fir) in aerial photographs, from which FRI data is derived, and is present in the study area, but likely at densities too low (< 10 percent stand volume) to be included in a stand's tree species composition code (G. Peterson, pers. comm.).

While no conclusions about habitat selection can be made from this information, it is interesting to note that the dominant forest cover types (table 4, appendix 2) are often associated with moist sites. Such sites are

Table 4.—*Mean area (ha) represented by dominant tree species composition for a series of 28 circular 314 ha plots in southeastern Manitoba containing at least one Barred Owl (*Strix varia*).*

Dominant tree species composition	Mean area	95 percent C.I.	S.D.
Trembling aspen dominated stands			
100 percent trembling aspen	12.0	6.0	16.2
>50 percent trembling aspen	159.4	46.1	124.5
<50 percent trembling aspen[1]	10.0	4.9	13.1
Black spruce dominated stands			
100 percent black spruce	10.1	4.3	11.5
<50 percent black spruce	62.1	34.0	91.7
Tamarack dominated stands			
100 percent tamarack	8.0	11.1	30.1
>50 percent tamarack	40.5	18.5	50.1
<50 percent tamarack	6.6	5.9	16.0
Other tree species dominated stands			
100 percent jack pine	13.5	16.1	43.4
>50 percent jack pine	8.5	6.4	17.2
>50 percent ash	5.3	6.4	17.2
<50 percent ash	7.7	9.8	26.6
100 percent red pine	5.7	6.3	17.0
<50 percent balsam fir	4.5	6.1	16.5

[1] Other species present in lesser amounts than dominant species.

sometimes associated with a greater diversity of potential Barred Owl prey (Bosakowski *et al.* 1987, Sutton and Sutton 1985). The plots were dominated by a Fresh-wet to Saturated soil regime (table 5). The mean area values for site classification (Barred Owl plots) should be compared to random plots in order to investigate if soil moisture regime is an important variable for the HSI model.

Table 5.—*The mean area (ha) represented by each site classification category for 28 circular 314 ha plots in southeastern Manitoba containing at least one Barred Owl (*Strix varia*).*

Site classification	Mean area	95 percent C.I.	S.D.
Arid-dry	11.1	10.8	29.3
Dry	0.9	2.7	1.0
Fresh-very moist	10.8	9.7	26.2
Fresh-wet	214.8	63.6	171.7
Moist-very moist	2.7	3.4	9.3
Very moist-wet	5.8	3.2	8.7
Saturated	87.4	31.9	86.0
Unclassified	30.6	17.7	47.7
Unproductive forest	115.8	29.9	80.7

CONCLUSIONS

Some cautionary notes regarding interpretations of the observed forest habitat variable distributions are warranted. These values are mean areas for 28 circular plots and do not reflect habitat complexity within and between individual stands of trees. Barred Owl home ranges are irregularly shaped (Mazur 1997); the circular plots associated with Barred Owls likely encompass only a portion of their home range. In addition, 28 Barred Owl locations is not a large enough sample to make statistically powerful conclusions. Nonetheless, the salient and essential elements of Barred Owl habitat may be captured by the current HSI model. Additional research is recommended to further validate and refine the model.

Site classification (soil moisture regime), which is described in part by tree species composition, may be an important variable to incorporate into the model. Currently, the model is unable to evaluate unclassified areas; it ranks these areas as having no value to Barred Owls. The presence of unproductive forests and unclassified areas may in fact enhance breeding

success. The model should ideally be revised according to how both biotic and abiotic factors influence breeding success of the Barred Owl in Manitoba.

The interaction between forest cover types within a Barred Owl's home range may influence the habitat's ability to provide critical breeding, foraging and roosting habitat for the Barred Owl. Distance to water, proximity to human habitation and forest fragmentation may influence Barred Owl breeding success and survival.

Change in habitat availability and quality over time and across a given landscape can greatly influence nesting success of the Barred Owl given its high nest site fidelity and territorial nature. Forest cover heterogeneity and contiguity over time should be incorporated into the model to help maintain viable populations of the Barred Owl. Quantifying linkages between Barred Owl habitat and viable population statistics would foster more effective forest management for this species.

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Appendix 1.—*Manitoba Forest Resource Inventory Cutting Class Variable (Natural Resources Manitoba 1996).*

Cutting class is subdivided into five separate categories from one to five based on size, vigor, state of development and maturity of the stand for harvesting purposes; the variable is interpreted from aerial photographs and ground truthing.

Class 0: Grass/forb: Forest land not restocked following fire, cutting, windfall or other major disturbances (hence potentially productive land). Some reproduction or scattered residual trees (with net merchantable volume less than 20 m^3 per hectare) may be present.

Class 1: Shrub/seedling: Stands which have been restocked either naturally or artificially. There may be scattered residual trees present as in class 0. To be in class 1 the average height of the stand must be less than 3 m.

Class 2: Pole/sapling: Advanced young growth of post size, with some merchantable volume. The average height of the stand must be over 3 m in order to be in this cutting class.

Class 3: Intermediate: Immature stands with merchantable volume growing at or near their maximum rate, which definitely should not be cut. The average height of the stand should be over 10 m and the average diameter should be over 9 cm at d.b.h. (1.3 m above ground).

Class 4: Mature: Mature stands which may be cut as they have reached rotation age. Rotation age is the time at which a stand is ready for harvesting. In Manitoba, rotation age varies from 60 to 140 years. Rotation ages of 140 years are generally reserved for poor and wet sites with slow growth.

Class 5: Overmature: Overmature stands are at least 10 years older than rotation age and should be given a high cutting priority.

Appendix 2.—*Mean area (ha) represented by tree species composition for a series of 28 circular 314 ha plots in southeastern Manitoba containing at least one Barred Owl (*Strix varia*).*

Tree species[1]	**Mean area**	**95 percent C.I.**	**S.D.**	**Count**[2]
Unproductive forest	115.8	29.9	80.7	28
Tamarack 70; black spruce 30	24.3	12.7	34.4	17
Trembling aspen 70; black spruce 30	21.8	14.6	39.5	11
Black spruce 70; tamarack 30	20.6	16.4	44.2	11
Trembling aspen 80; balsam poplar 20	16.3	4.3	23.0	12
Jack pine 100	13.1	8.1	42.7	6
Trembling aspen 100	12.0	3.1	16.2	17
Black spruce 100	10.1	2.2	11.5	21
TA[3] 70; white birch 20; balsam poplar 10	9.9	5.2	27.3	6
Tamarack 100	8.0	5.7	30.1	6
Black spruce 80; tamarack 20	7.6	3.4	17.8	5
BS[3] 60; eastern cedar 30; tamarack 10	6.0	2.9	15.4	6
TA 60; BP[3] 20; WB[3] 10; balsam fir 10	6.0	3.4	18.3	4
Tamarack 60; black spruce 40	5.8	2.7	14.5	5
Black spruce 90; tamarack larch 10	5.8	2.7	14.4	5
Red pine 100	5.7	3.2	17.0	7
TA 60; white birch 20; balsam fir 20	5.5	2.9	15.2	4
Black spruce 70; trembling aspen 30	5.1	1.8	9.5	10
Tamarack larch 80; black spruce 20	4.9	1.2	6.4	13
Trembling aspen 70; balsam fir 30	4.6	2.1	10.9	8
Trembling aspen 90; balsam poplar 10	3.7	1.9	10.2	7
Trembling aspen 90; jack pine 10	3.1	1.3	6.9	10
Jack pine 80; trembling aspen 20	3.0	1.5	7.9	8
Trembling aspen 80; black spruce 20	2.3	0.9	4.8	9
TA 70; balsam poplar 20; white birch 10	2.2	1.5	7.7	5
TA 70; black spruce 20; balsam fir 10	1.5	0.8	4.0	6
TA 60; balsam poplar 30; balsam fir 10	1.5	0.6	3.1	6
Black spruce 80; trembling aspen 20	1.4	0.6	3.2	8

[1]Main cover species with percentages.
[2]Number of Barred Owl plots with tree species composition group.
[3]TA = Trembling Aspen; BS = Black Spruce; BP = Balsam Poplar; WB = White Birch.