BIRD SPECIES-HABITAT RELATIONSHIPS IN MANAGED NORTHERN HARDWOODS ON THE OTTAWA NATIONAL FOREST

BY

Katherine Elaine Brashear

A Thesis

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

IN

NATURAL RESOURCES

(WILDLIFE)

College of Natural Resources

UNIVERSITY OF WISCONSIN

Stevens Point, Wisconsin

28 June 2006

APPROVED BY THE GRADUATE COMMITTEE OF:

Dr. Timothy F. Ginnett, Graduate Advisor
Assistant Professor of Wildlife Ecology and Management

Dr. James E. Cook
Professor of Forestry

Dr. Michael J. Hansen
Professor of Fisheries

Dr. Robert N. Rosenfield
Professor of Biology

PREFACE

The chapters of this thesis were written in the format of the journals *Forest Ecology and Management* and *Michigan Birds and Natural History*, respectively. Any duplication, citations, and stylistic variations between chapters are intentional.

ACKNOWLEDGEMENTS

This study is the result of a collaborative effort between the United States Forest Service and the University of Wisconsin-Stevens Point College of Natural Resources. It has been under the direct supervision of Dr. Timothy Ginnett, a dear friend and mentor for the past five years. Further academic guidance, insight and friendship have been provided by Dr. James Cook, Dr. Michael Hansen, and Dr. Robert Rosenfield. I am deeply grateful to Robert Evans and Brian Bogaczyk for invaluable support in this study's design, implementation, and future applicability for the Ottawa National Forest. Erv and Sam Drabek and Randall Wollenhaup provided early field assistance.

This research was supported by contributions from the USDA Ottawa National Forest, McIntire-Stennis Cooperative Research Grant, and the Becoming an Outdoors-Woman (BOW) Program. Special thanks to Dr. Christine Thomas for offering me the position and funding through the BOW program early on, thereby making my first year of graduate school possible. Sincere thanks also to Dr. Diane Lueck and Peggy Farrell of the BOW program for all of the professional opportunities and continued support and friendship throughout graduate school.

Deepest thanks to my beloved family and friends, most notably to my parents for supporting my ornithological passions and teaching me to follow my own thoughts and path. Lastly, but most importantly, thank you to my dear soulmate, Jeff Koch. With him, I experience the true joy of love in this life, childlike awe for the natural world, and shared ambition for achieving our dreams.

TABLE OF CONTENTS

PREFACE…………………………………………………………………………………iii

ACKNOWLEDGEMENTS…………………………………………………………………..iv

LIST OF TABLES…………………………………………………………………………vii

LIST OF FIGURES………………………………………………………………….....viii

LIST OF APPENDICES…………………………………………………………………..xi

ABSTRACT………………………………………………………………………………...1

VARIATION IN BIRD COMMUNITIES AMONG THREE SILVICULTURAL TREATMENTS IN NORTHERN HARDWOOD FORESTS……………………………………………….…….3

Abstract…………………………………………………………………...…...….3

Introduction……………………………………………………………….……....4

Methods.……………………………………………………………………….….…7

Study Area…………………………….…………………………………...…7

Habitat Sampling……………………….………………………………….……..9

Bird Community Sampling……………….…………………………….....10

Data Analysis……………………………….………………………….....11

Results…………………………………………….…………………………..12

Habitat Variation………………………………………………….……….12

Bird Community Variation……………………………….….…….….13

Bird Species-Habitat Relationships……………………………….……......14

Discussion……………………………………………………………....….….…15

Conclusion………………………………………………………………….….…..19

Acknowledgements……………………………………………………….......21

References……………………………………………………………………21

BLACK-THROATED BLUE WARBLER BREEDING HABITAT IN WESTERN UPPER MICHIGAN……………………………………………………………………………42

Introduction…………………………………………………………………..42

Study Area……………………………………………………………….…..44

Methods……………………………………………………………………...45

Results…………………………………………………………………..……46

Discussion…………………………………………………………………...47

Management Implications…………………………………………….……...48

Acknowledgements………………………………………………………..…...49

Literature Cited………………………………………………………….……..49

APPENDICES……………………………………………………………….………62

LIST OF TABLES

VARIATION IN BIRD COMMUNITIES AMONG THREE SILVICULTURAL TREATMENTS IN NORTHERN HARDWOOD FORESTS

Table 1. Sample effort and history for the 36 stands sampled on the Ottawa National Forest, Upper Michigan, USA (Ottawa National Forest Compartment Records located in the Watersmeet and Bessemer Ranger District Offices)……….……………………………………….……30

Table 2. Habitat structure variables in clear cut, shelterwood cut, and selection cut northern hardwood forest stands 2004-2005 in the Ottawa National Forest, Upper Michigan, USA…..31

Table 3. Principal Components Analysis (PCA) results describing variation among silvicultural treatments according to nine habitat variables measured August 2004 in the Ottawa National Forest, Upper Michigan, USA..….32

Table 4. Mean number of birds detected per stand among clear cut, shelterwood cut, and selection cut northern hardwood forests during June-July 2004 and 2005 on the Ottawa National Forest, Upper Michigan, USA............33

BLACK-THROATED BLUE WARBLER BREEDING HABITAT IN WESTERN UPPER MICHIGAN

Table 1. DFA scores for nine habitat variables measured at points where BTBW both were present and not detected June1-July 15, 2004 in the Upper Peninsula of Michigan, USA……………………………………………53

Table 2. DFA scores for nine habitat variables measured at points where BTBW both were present and not detected June1-July 15, 2005 in the Upper Peninsula of Michigan, USA……………………………………………54

LIST OF FIGURES

VARIATION IN BIRD COMMUNITIES AMONG THREE SILVICULTURAL TREATMENTS IN NORTHERN HARDWOOD FORESTS

Figure 1. Map of the Ottawa National Forest in the Upper Peninsula of Michigan, USA (USDA Forest Service 2006).…………..…………………………34

Figure 2. Representative 40-60 year old even-aged northern hardwood stand that had received a clear cut treatment on the Ottawa National Forest, Upper Michigan, USA………………………………………………….…….35

Figure 3. Representative uneven-aged, selectively cut northern hardwood stand on the Ottawa National Forest, Upper Michigan, USA…………….…...….36

Figure 4 Representative two-aged northern hardwood forest stand that had received a shelterwood cut treatment on the Ottawa National Forest, Upper Michigan, USA……………………………….………………..…...37

Figure 5. Map of shelterwood cut stands sampled June-July 2004 and 2005 on the Bessemer Ranger District of the Ottawa National Forest, Upper Michigan, USA…………………………………………………………….…..38

Figure 6. Map of clear cut, shelterwood cut, and selection cut stands sampled June-July 2004 and 2005 on the Watersmeet Ranger District of the Ottawa National Forest, Upper Michigan, USA…………….…..………….…....39

Figure 7. Principal components analysis (PCA) plot of northern hardwood stand variation by treatment type between the first two factors June-July 2004 and 2005 from the Ottawa National Forest, Upper Michigan, USA...….40

Figure 8. CCA triplot for bird species as they relate to PCA-reduced set of five northern hardwood forest habitat variables June-July 2004 and 2005 on the Ottawa National Forest, Upper Michigan, USA..………...………………41

BLACK-THROATED BLUE WARBLER BREEDING HABITAT IN WESTERN UPPER MICHIGAN

Figure 1. Map of the Ottawa National Forest in the Upper Peninsula of Michigan, USA (USDA Forest Service 2006)…………...…………………………55

Figure 2. Breeding distribution of the Black-throated Blue Warbler in Michigan (Brewer et al. 1991)…………………………………………………..56

Figure 3. Discriminant function scores of random and BTBW-used sites June 1-July 15, 2004 in northern hardwood stands of the Ottawa National Forest, Upper Michigan, USA. Horizontal line represents the mean, the bar above and below mean is 1 S.E., and the vertical line represents the range of values..……………………………………………………………….57

Figure 4. Discriminant function scores of random and BTBW-used sites June 1-July 15, 2005 in northern hardwood stands of the Ottawa National Forest, Upper Michigan, USA. Horizontal line represents the mean, the bar above and below mean is 1 S.E., and the vertical line represents the range of values..……………………………………………………………….58

Figure 5. BTBW Nest 1 was located in the blue-flagged White Spruce sapling (a) adjacent to a former logging road and surrounded by a dense Sugar Maple sapling layer (b)…………………………………………………………59

Figure 6. BTBW Nest 2 was affixed to the trunk of an Eastern Hemlock sapling 0.3m above the ground in the crotch of a main lower branch…………..60

Figure 7. BTBW Nest 3 contained four nestlings (a) and was located in a dense Eastern Hemlock sapling clump under a predominantly Sugar Maple canopy layer (b)……………………………………………………………………….61

LIST OF APPENDICES

Appendix A. List of AOU codes, common names, and scientific names for all birds….55

Appendix B. First documented breeding of Wood Thrush population in Gogebic County, MI (submitted to *Michigan Birds and Natural History*, in review)……………………..56

ABSTRACT

Silvicultural treatments alter the composition and structure of forests for the purpose of producing timber and other forest products. With growing concerns for bird populations in forested habitats, the need to merge timber harvest goals with promoting bird biodiversity increasingly has become an important component of resource management for many National Forests. I investigated the relationship between three commonly applied silvicultural treatments (clear cut, selection cut, and shelterwood cut) and bird community composition in northern hardwood stands of the Ottawa National Forest, located in Upper Michigan, USA. My objective was to determine if differences in habitat structure were related to differences in bird community composition among silvicultural treatments. Multivariate analyses revealed that silvicultural treatment significantly was related to overall variation in habitat features among northern hardwood stands. Of nine vegetation features sampled, basal area, vertical structure, and diameter at breast height varied among treatment types. Five of nine habitat variables explained 87% of the variation in stand habitat structure among silvicultural treatments. These analyses also identified specific habitat features unique to individual silvicultural treatments. Seven of the 37 bird species detected 2004 and 2005 differed significantly among treatment type. The canonical correspondence output identified specific linkages between bird species presence and habitat variables as they related to silvicultural treatments. These findings will help resource managers in the Great Lakes northern hardwood forest region maintain habitat for viable bird populations by using a combination of silvicultural treatments. Implementing a mosaic of silvicultural treatments within the Ottawa National Forest should provide for regional bird biodiversity goals to be met.

The black-throated blue warbler, a lower shrub-layer nesting bird, has been identified as an area-sensitive species within the Ottawa National Forest, Michigan. The black-throated blue warbler is thus often used as an indicator species for quality, unfragmented mature interior forest. My objective was to determine if black-throated blue warblers selected their nesting territories for particular attributes of northern hardwood forests in the Ottawa National Forest. Territorial calls of black-throated blue warblers and habitat characteristics were noted during June 1-July 15 2004 and 2005 at 90 randomly generated point count locations. Discriminant function analyses revealed that sapling height and canopy height were important predictors of black-throated blue warbler occurrences in both years. Additionally, basal area and percent vertical cover 0-2.5 m were important habitat metrics in 2004 and 2005, respectively. Four black-throated blue warbler nests found in 2005 also confirmed the importance of conifer regeneration as nesting substrate in sugar maple-dominated forests. Conservation of this and other Neotropical bird species requires an understanding of regional habitat requirements necessary for population maintenance.

28 June 2006
Katherine Elaine Brashear
11689 S. Paynesville Rd.
Trout Creek, MI 49967
906-852-3288
E-mail: kbras782@uwsp.edu

VARIATION IN BIRD COMMUNITY COMPOSITION AMONG SILVICULTURAL TREATMENTS IN NORTHERN HARDWOOD FORESTS

KATHERINE E. BRASHEAR, College of Natural Resources, University of Wisconsin-Stevens Point, Stevens Point, WI 54481

Abstract: Silvicultural treatments alter the composition and structure of forests for the purpose of producing timber and other forest products. With growing concerns for bird populations in forested habitats, the need to merge timber harvest goals with promoting bird biodiversity increasingly has become an important component of resource management for many National Forests. I investigated the relationship between three commonly applied silvicultural treatments (clear cut, selection cut, and shelterwood cut) and bird community composition in northern hardwood stands of the Ottawa National Forest, located in Upper Michigan, USA. My objective was to determine if differences in habitat structure were related to differences in bird community composition among silvicultural treatments. Multivariate analysis revealed that silvicultural treatment significantly was related to overall variation in habitat features among northern hardwood stands. Of nine vegetation features sampled, basal area, vertical structure, and diameter at breast height varied among treatment types. Five of nine habitat variables explained 87% of the variation in stand habitat structure among silvicultural treatments. These analyses also identified specific habitat features unique to individual silvicultural treatments. Seven of the 37 bird species detected in 2004 and 2005 differed significantly among treatment type. The canonical correspondence output identified specific linkages between bird species presence and habitat variables as they related to silvicultural treatments. These findings will help resource managers in the Great Lakes northern hardwood forest region maintain habitat for viable bird populations by using a combination of silvicultural treatments.

Key words: bird communities, silviculture, northern hardwoods, Upper Peninsula

---

1. Introduction

Forest management practices alter composition and structure of forests for many purposes, among them timber and other forest products. Various silvicultural methods are used to control the establishment, growth, composition, health, and quality of forests and to meet the diverse needs and values of forest managers and various publics (Helms, 1998). Silvicultural treatments are applied at a stand level to change the structure and composition of vegetation. Studies throughout North America suggest that breeding bird communities vary significantly among different silvicultural treatment types (Annand and Thompson, 1997; Anderson and Crompton, 2002; Hayes et al., 2003; Jobes et al., 2004; Lesak et al., 2004; Doyon et al., 2005). Many studies cite declining trends in many forest-dwelling bird populations, most notably long-distance migrant songbirds (Robinson et al., 1995, Rich et al., 2004), but in-depth investigations of Breeding Bird Survey trends show that an overall higher proportion of these species have increased during the survey period (Peterjohn and Sauer, 1994; James et al., 1996). Further investigation of population trends at a more regional scale in forested habitats could better guide forest management decisions to benefit those species of conservation concern (James, 1998).

In Great Lakes northern hardwood forests, management emphasis has shifted from clear-cutting to alternative, partial-harvest practices. Commonly-perceived advantages of these alternative practices include enhanced wildlife habitat and increased aesthetic value by maintaining an overstory (Fuller et al., 2004). More intensively managed (clear-cut) hardwood forests support significantly fewer species and lower abundances of Neotropical migrants than less intensively managed (selective cut) forests (Howe and Mossman, 1996). In a bottomland hardwood forest, patch-retention retained more bird species and supported a higher abundance than traditional clear-cuts (Harrison and Kilgo, 2004). Two-aged (even-aged) harvests, such as shelterwood cuts, also have been identified as a viable alternative to clear-cuts (Norton and Hannon, 1997; Dugay et al,. 2001). Group-selection harvesting recently has been recommended as a more environmentally-friendly harvest method (USDA, 2000).

Partial or selective cuts may produce small changes in the bird community and continue to provide habitat for those species found in mature stands (Annand and Thompson, 1997). Group selection harvest practices did not impact forest interior bird abundance when adequate mature forest tracts were left untouched (Moorman and Guynn, 2001). In montane hardwood-conifer forests, group-selection harvests also did not negatively impact 16 species of breeding birds over a seven-year period as compared to control stands (Garrison et al., 2005). Selection cutting mimics gap-phase disturbances and small-scale blowdowns (Lorimer, 1989; Hunter, 1990). These stands typically retain much of the mature forest community and provide habitat for early successional species that use the shrub-sapling layer (Thompson, 1993). In hardwood forests in Ontario, canopy gaps resulting from more recently-harvested stands provided suitable nesting habitat for edge/shrub layer species in an otherwise closed canopy mature forest (Jobes et al., 2004). Two-story (shelterwood) stands with both early seral stage conditions and retention of large trees also provided habitat for more species than clear-cut treatments (Chambers et al., 1999).

As forest management policies undergo change and revision, analyses of breeding bird community response to forest management are needed to facilitate management decisions for the conservation of these species. Timber harvest has been the most often-studied human disturbance to bird communities in western North America (Marzluff and Sallabanks, 1998). Relevance of these investigations to the Great Lakes region, however, is unclear, and broad-scale, coarse-filter prescriptions for bird conservation do not exist (Howe et al., 1996). Breeding bird communities have only rarely been studied within local management regimes in western Great Lakes northern hardwood forests (Flaspohler et al., 2001a; Flaspohler et al., 2002; Hanowski et al., 2003). Comparisons of bird communities in the Ottawa National Forest in 1994-1995 among four plot types (unmanaged old growth, managed old growth, selection cuts, and clear-cuts) revealed that unmanaged old growth plots had consistently more breeding bird territories than the three actively managed forest types (Andres 1996). Among the managed forest stands, observed highest breeding densities in selection cut plots were attributed to those forests having the greatest habitat complexity. A follow-up study was recommended to examine long-term changes in local bird populations and a more in-depth investigation of specific bird-habitat relationships in managed northern hardwood forests.

My objective was to determine if differences in habitat structure were related to differences in bird community composition among silvicultural treatments in northern hardwood forests. In general, a clear understanding of variation in bird communities as it relates to variation in stand structure is lacking from the western Great Lakes region (Hamady, 2000). I identified specific relationships between bird species and habitat features associated with individual silvicultural treatments. These findings are intended to assist ONF land managers with using forest management to maintain quality habitat for viable bird populations.

2. Methods

2.1. Study Area

The Ottawa National Forest (ONF) predominantly is a second-growth forest that is managed for multiple uses and regularly is subjected to vegetative management practices (Figure 1). The ONF is located in the western Upper Peninsula of Michigan within the transition zone between northern boreal forests and eastern deciduous forests. The patchiness associated with this transition zone has been related to high bird species richness (Temple et al., 1979; Pastor and Brochart, 1990). Historically, this region was shaped by frequent, small-scale disturbances caused by high winds resulting in single- or multiple-tree canopy gaps, and infrequent large-scale blowdown events (McGee et al., 1999; Frelich and Lorimer, 1991). Fire historically has not been a major part of the natural disturbance regime, with occasional lightning strikes creating small fires across the landscape (Bormann and Likens, 1979; Frelich and Lorimer, 1991). Timber harvesting more recently has become the main disturbance regime (Frelich, 2002). This region is characterized as having acidic, rocky, sandy loam, or loamy sand soils derived from iron-rich Precambrian rock (Crow et al., 2002). Of the Upper Great Lakes region, Michigan has been cited as having the largest area of northern hardwoods (Howe et al., 1996). Extensively unfragmented northern hardwoods are an ecologically important forest type in western Upper Michigan (Howe et al., 1996; Hamady, 2000). The forests are heavily dominated by sugar maple (*Acer saccharum*), with the remaining overstory comprised of yellow birch (*Betula alleghaniensis*), basswood (*Tilia americana*), eastern hemlock (*Tsuga canadensis*), and ironwood (*Ostrya virginiana*) (Crow et al., 2002). Leatherwood (*Dirca palustris*), beaked hazel (*Corylus cornuta*), and dominant tree species' saplings dominate the understory (Flaspohler et al., 2001a). The ground layer most often contains a mix of spring ephemerals, tree seedlings, club mosses

(*Lycopodium* spp.), and wild leek (*Allium tricoccum*) (Flaspohler et al., 2001a), oftentimes with a wet leaf litter layer from early spring into mid-summer. The climate is characterized as continental humid, with an average annual air temperature of 4.4° C, an average maximum of 10.8° C, and an average minimum of -2° C. The average annual precipitation is 85.37 cm and the average annual snowfall is 288.5 cm (Anonymous, 2004).

National forest land is broken into management units called stands, which also are integrated into compartments for large-scale planning. Silvicultural treatments occur within the stand level because forest stands delineate a contiguous group of trees relatively uniform in species composition and structure (Thompson et al., 1996). My study focused on three silvicultural treatments (Table 1) along a general gradient from traditional forestry practices to partial-cut, alternative practices: 1) 40-60 year-old even-aged stands that had been clear cut (CC, Figure 2); 2) uneven-aged, selectively-cut stands (SC, Figure 3); and 3) two-aged (even-aged) shelterwood stands with a mature residual overstory and well-established understory layer (SW, Figure 4). Northern hardwood stands (N = 36) that had not been harvested in at least ten years were selected within the Watersmeet and Bessemer Ranger Districts to represent these three silvicultural treatments (Figures 5-6). Stands were further selected on the basis of overstory composition and treatment history (Ottawa National Forest Compartment Records, 2002). Northern hardwood stands were selected from the following composition classes: sugar maple (>75%), hardwoods-yellow birch (>20%), hardwoods-basswood (>20%), or mixed hardwood species (80%). Clear cut stands had not received a harvest following initial cut-over and were dominated (>70%) by one age class of pole-sized timber (12.7-27.7 cm). Selection cut stands had at least three distinct age classes present, were dominated (>70%) by sawtimber-sized trees (27.8 cm), and had received a single-tree selection cut with larger canopy gaps immediately post-harvest. Shelterwood stands had two distinct age classes present, contained a 1.5- to 6.1-m seedling-sapling layer, and had been reduced to an overstory basal area of 11-16 m^2/ha. Despite variability among stand ages, pre-existing conditions, and stand sizes, my research focused on three distinct silvicultural treatments to infer specific linkages between treatments and bird-habitat relationships.

2.2. Habitat Sampling

I characterized physical stand structure for each randomly selected point count location during July-August 2004. I assumed that habitat features did not differ significantly between 2004 and 2005 (e.g. basal area, canopy cover, etc.). Time and personnel constraints limited habitat sampling to summer 2004. Four 400-m^2 (11.3 m radius) circular vegetation plots were established with one at the point-count center and three plots 70 m from the center at 0°, 120°, and 240° (Machtans and Latour, 2003). Habitat measurements included percent canopy cover, basal area, snag abundance, percent ground cover, maximum sapling height, canopy height, percent vertical cover 0-2.5 m, diameter at breast height (dbh), and percent overstory conifer cover. Total percent canopy cover was derived from spherical densiometer counts at centers of the four vegetation plots (Lesak et al., 2004). A 10-factor prism was used to determine the trees that comprised basal area (BA, m^2/ha), which was calculated by multiplying the number of "in" trees at least 14 cm in diameter by ten. Snag abundance (number/ha) was determined by counting the number of snags that also were determined to be "in" by the 10-factor prism. Percent ground cover was visually estimated at 5% intervals within a 1-m^2 area 11.3 m from the vegetation plot center in each of the cardinal directions and averaged for each vegetation plot. Sapling height was measured with either a meter-stick or clinometer for the three tallest saplings and then averaged. Canopy height was measured with a clinometer for the three tallest canopy trees according to Moorman and Guynn (2001) and then averaged. Vertical cover was calculated by placing a 2.5-m density board divided into five 0.5-m intervals at the center of the vegetation plot and recording the percent of each interval obscured by vegetation from 25 m away in each of the cardinal directions (Turner et al., 2002). Percent vertical cover was derived by averaging the vertical cover measurements for each of the five segments and again for the four habitat locations for each point to serve as an index of understory development. Average dbh was calculated from the dbh, measured to the nearest 0.5 cm, for all trees counted "in" for basal area. Percent conifer cover was calculated by determining the proportion of trees counted as "in" for basal area that were either eastern hemlock or eastern white cedar (*Thuja occidentalis*) from the total number of trees comprising the basal area. All point count vegetation data were averaged for each stand to avoid pseudoreplication (Hurlbert, 1986).

2.3. Bird Community Sampling

I sampled bird communities using the point count method described by Ralph et al. (1993) during June 1 – July 15 of 2004 and 2005. This start date minimizes detection of migrants. Also, all species detected were cross-referenced with the breeding bird atlas for Michigan (Brewer et al., 1991) to ensure omission of vagrant species from my analyses. Points (n = 90) were randomly located 300 m apart to avoid double-counting individuals and 100 m away from stand boundaries and riparian areas (i.e., lakes, rivers, streams) to reduce mixing of riparian bird communities with upland hardwood bird communities (Ralph et al., 1993; Jobes et al., 2004). I visited each point count location three times during each field season, and order of visitation was randomly altered to account for seasonal and temporal variability of bird behavior and thus detection (Chambers et al., 1999; Duguay et al., 2001). All point count sampling occurred during 0400-0900 Central Standard Time on days when wind was less than Beaufort 3

(12.9-19 km/h) and rain was not falling (Ralph et al., 1993; Machtans and Latour, 2003). Species were counted in the order in which they were first detected (by sight and, more often, sound) during three time intervals: 0-3 minutes, 3-5 minutes, and 5-10 minutes and mapped relative to the point center in two radius categories: $\leq$ 50 m, and 51-100 m (Thompson et al., 2002). Birds that flew over the point during the 10-minute period were counted separately as flyovers and omitted from later analysis to avoid double-counting individuals. Visits to individual point count locations were averaged across years (2004-2005) and then were averaged within stands to avoid pseudoreplication (Hurlbert, 1986). Because I wanted to generalize conclusions for the short study period rather than focus on any differences in detection between the two years, I assumed that any between-year differences would be equal across treatments.

2.4. Data Analysis

Multivariate analysis of variance (MANOVA) was used to compare stand habitat structure among treatments (SAS Institute 2001). Univariate ANOVA was used for individual habitat variables to test the null hypothesis of no effect of silvicultural treatment on stand structure. Silvicultural treatments served as the predictor (categorical) variable, and individual habitat variables served as response (continuous) variables. Tukey's post hoc tests were used to compare differences in a habitat variable among three pairs of treatments (i.e., clear cut vs. shelterwood cut, clear cut vs. selection cut, and shelterwood cut vs. selection cut) if an overall effect of treatment was identified by the univariate ANOVA ($p < 0.05$). I used principal components analysis (PCA) to describe overall variation in stand habitat structure. To interpret factor loadings, I used the criteria of Tabachnik and Fidell (1989) in which loadings greater than 0.63 or less than -0.63 are deemed very good and those greater than 0.71 or less than -0.71 are considered excellent. Log and square root transformations were used as necessary to meet the assumptions of normality when required.

Univariate analysis of variance (ANOVA) was used to test the null hypothesis of no effect of silvicultural treatment on individual bird species' abundances (SAS Institute, 2001). Silvicultural treatments served as the predictor (categorical) variable, and individual bird species densities served as response (continuous) variables. I also used Tukey's post hoc tests to compare differences in a particular species' abundance among three pairs of treatments (i.e., clear cut vs. shelterwood cut, clear cut vs. selection cut, and shelterwood cut vs. selection cut), if an overall effect of treatment was identified by the univariate ANOVA ($p < 0.05$).

Canonical Correspondence Analysis (CCA) was used to relate bird community composition to the PCA-reduced set of stand habitat variables for each of the three silvicultural treatments (ter Braak, 1986; Palmer, 1993). Individual bird species densities served as multiple dependent variables for comparison against the five habitat (independent) variables. Some similar studies used only those bird species found in at least 15% of the study sites (Jobes et al., 2004; Doyon et al., 2005). However, valuable information about regionally rare species can be lost with this practice, so I included all species in my analysis.

3. Results

3.1. Habitat Variation

Northern hardwood forest stands differed significantly in habitat structure among silvicultural treatments (Wilks' Lambda, $p < 0.0001$). Of the nine habitat variables sampled, three varied significantly among treatments (Table 2). Selection cut stands had significantly higher basal area than shelterwood stands. Percent vertical cover (0-2.5 m) was greater in shelterwood stands than clear cut stands. Average dbh was highest for shelterwood stands, intermediate for selection cut stands, and lowest for clear cut stands.

Eighty-seven percent of the variation in habitat metrics among silvicultural treatments was explained by the first five principal components (Table 3). Stand dbh, maximum sapling height, and percent overstory conifer cover had excellent loadings on the first principal component. The second principal component had an excellent loading for snag abundance and a very good loading for percent ground cover. The third principal component had a very good loading for percent vertical cover, although percent canopy cover and basal area also loaded high. In the fourth and fifth axes no variables met the excellent or very good criteria. Clear cut and shelterwood stands were clearly separated along the first principal component axis, whereas selection cut stands were intermediate (Figure 7). Shelterwood cut stands contained larger diameter trees, more conifer overstory cover, and a greater percent vertical cover 0-2.5 m than clear cut or selection cut stands.

3.2. Bird Community Variation

Seven of the thirty-seven bird species detected during 2004 and 2005 showed significant variability among silvicultural treatment types within the Ottawa National Forest (Table 4). American redstarts were more abundant in shelterwood stands than the other two treatment types (common names will be used throughout this manuscript--see Appendix A for scientific names). Blue-headed vireos were the least abundant in the even-aged, clear cut stands. Veeries were significantly more abundant in shelterwood stands than clear cut stands. Conversely, the least flycatcher was more abundant in clear cut stands than shelterwood stands. Brown creepers and rose-breasted grosbeaks were found significantly more often in selection cut than clear cut stands, and winter wrens were significantly more abundant in selection cut and shelterwood stands than clear cut stands.

Several bird species were absent from one or more treatment types represented by the random point count locations. No black-billed cuckoos were found on clear cut stands, although no significant effect of treatment on cuckoo abundance was revealed by the univariate ANOVA. Brown-headed cowbirds and wood thrushes were only present within the shelterwood stands on the Bessemer Ranger District of the Ottawa National Forest but statistical tests failed to detect significant differences among treatments for these species.

3.3. Bird Species-Habitat Relationships

Several bird species showed strong relationships to the PCA-reduced habitat features (Figure 8). Winter wrens, blue-headed vireos, and pileated woodpeckers were more associated with stands containing larger diameter trees and more conifer cover. Recall that shelterwood stands were shown to have significantly larger diameter trees and more conifer cover than clear cut stands but did not differ from selectively-cut stands. Greater snag abundance was most associated with chimney swifts and brown creepers, a feature most strongly related to selection cut stands. Clear cut stands containing smaller diameter trees, less conifer cover, and less vertical cover 0-2.5 m were related to more detections of least flycatchers, eastern wood-pewees, ovenbirds, red-eyed vireos, hermit thrushes, and black-throated green warblers. Conversely, shelterwood stands containing largest diameter trees and greatest vertical cover 0-2.5 m were more related to more detections of veeries, chestnut-sided warblers, Swainson's thrushes, wood thrushes, American redstarts, and white-throated sparrows.

4. Discussion

My findings revealed a significant relationship among silvicultural treatments, bird species' abundances, and stand habitat conditions, as with other similar studies (Dugay et al., 2001; Anderson and Crompton, 2002; Jobes et al., 2004; Doyon et al., 2005). Clear cut stands (40-60 years post –harvest) typically have not been identified as areas of high bird abundance (Andres, 1996; Annand and Thompson, 1997; Chambers et al., 1999; Anderson and Crompton, 2002). Red-eyed vireos, eastern wood-pewees, and black-throated green warblers also were associated with habitat conditions consistent with clear cut stands (Figure 8), but this relationship was not statistically significant (Table 4). Blue-headed vireos were least abundant in clear cut stands (Table 4). Most often associated with mature northern mixed-conifer forests during the breeding season (James, R.D, 1998), blue-headed vireos likely were less abundant in clear cut stands because of the overall lack of overstory conifer cover. Most notable was the least flycatcher's significantly greater preference for clear cut stands over shelterwood stands. The least flycatcher has continued to decline in many northern hardwood forests, likely representing an inverse relationship with forest succession (Holmes and Sherry, 2001). Despite being the most abundant bird species on the ONF in the mid-1990's (Andres, 1996), it is expected to continue to decline as vegetation changes with forest succession (Edde 2005). Least flycatcher preference for habitat conditions on these 40-60 year-old clear cut stands supports maintaining these stands within the ONF to provide for a species that is disappearing from other parts of its range.

Selection cut stands resembled both clear cut and shelterwood stands but contained more snags, larger trees, and denser ground cover, resembling a later seral-stage forest (Lorimer, 1989; Hunter, 1990; Doyon et al., 2005; Edde, 2005). Chimney swifts were more detected (not significantly) in selection cut stands, presumably because of the greater availability of snags for nest and roost sites (Ehrlich et al., 1998). Higher detections of winter wrens and brown creepers likely were related to later seral-stage conditions in selection cut stands. Winter wrens nest in root tip-ups following small blow-down or decay events (Edde 2005). Brown creepers have a strong association with flaking bark for both foraging and nesting sites (Ehrlich et al., 1998), which could suggest a need for larger diameter trees. Both species have decreased in other Great Lakes forests, but long-term Breeding Bird Count data indicate they are increasing on the Ottawa National Forest (Edde, 2005). Providing refugia for these species as they decline elsewhere justifies maintaining selection cut silvicultural systems within the Ottawa National Forest landscape to promote viable populations in the western Great Lakes region. The rose-breasted grosbeak’s greater presence in selection cut stands than in clear cut stands cannot be immediately inferred. Rose-breasted grosbeaks are reputed habitat generalists, and their tolerance of human disturbance to habitats is evidenced by their use of edges and secondary habitats (Martinson, 2006). Anecdotal evidence suggests that, in northern extents of its range, the rose-breasted grosbeak nests more often in conifers (Martinson, 2006). More overstory conifer cover in selection cut and shelterwood stands could have explained higher observed rose-breasted grosbeak numbers.

USDA Forest Service increasingly is relying on partial harvest systems because of growing public concern about clear cuts (Thill and Koerth 2005). Shelterwood cuts can provide habitat for early-successional species not otherwise found in forested landscapes (Annand and Thompson, 1997; Chambers et al., 1999). While not detected in this study, cerulean warblers have been reported as five times more abundant in two-aged treatments than clear cut treatments 12-15 years post-harvest (Wood et al., 2005). The American redstart’s observed preference for shelterwood stands over selection cut and clear cut stands in this study can be explained by both its habitat requirements and potentially by an underlying sympatric relationship with least flycatchers (Edde, 2005). Twenty-seven percent of American redstart nests found in Wisconsin during 1995-2000 were located within 5 m of the ground in both upland and lowland shrub habitats (Sherry and Holmes, 1997; Elias 2006). Shelterwood stands afforded the best shrub-sapling understory layer of the three treatments, likely providing more ideal habitat conditions for nesting redstarts. Recall that least flycatchers were less abundant in shelterwood stands than either clear cut or selection cut stands (Table 4). Sherry and Holmes (1988) examined the unusual example of sympatric competition between redstarts and least flycatchers in New Hampshire. They experimentally showed that, while both species shared a "flycatcher" niche (Sherry 1979), least flycatchers used aggressive behavior to exclude redstarts from mutually preferred habitat, thus resulting in a special case of partial interspecific territoriality. Redstarts have been cited as opportunistic in both foraging and nesting habitat requirements (Elias 2006), which may have afforded them success in occupying shelterwood stands with lower reported least flycatcher numbers. The veery's significant preference for shelterwood stands over clear cut stands argues the importance of retaining early successional habitat within the Ottawa National Forest. With noted declines throughout much of the veery's range, including the ONF during a recent 12-year study (Johnson, 2004), close monitoring of habitats supporting breeding populations should be closely monitored (Epstein 2006). Wood thrushes also were attracted to the greater understory cover amidst scattered, mature trees afforded by shelterwood stands. Their presence, in particular first confirmed nesting in Gogebic County (Appendix B), solely in shelterwood stands serves as additional support for the importance of these treatments to many Neotropical migrant birds.

Presence of brown-headed cowbirds on two of the shelterwood stands may potentially be of future research interest. Brown-headed cowbirds have not been considered a deleterious factor in the breeding success of birds in continuous forest cover, such as the ONF (Andres, 1996; Flaspohler et al., 2001b), and their populations have declined, likely with forest regeneration (Price et al., 1995). Future monitoring for brown-headed cowbirds should continue in conjunction with breeding bird surveys on the Ottawa National Forest. Of particular interest would be if 1) cowbirds only arrive relatively recently post-harvest and then disappear with sufficient regeneration, 2) their numbers increase on the ONF over time, and 3) their presence remains within small, isolated patches or spreads throughout the ONF with timber harvesting activities or adjacent private land development.

A lack of detailed stand management history and pre-treatment data likely resulted in substantial internal inconsistency within a silvicultural treatment category. Habitat metrics such as snag abundance and percent conifer cover may not have been adequately indexed from the basal area prism alone. Sampling downed woody debris also could have provided a better index of forest decay in conjunction with snag abundance (McGee et al., 1999). Placing fewer points in individual stands and increasing the number of stands surveyed throughout Ottawa National Forest northern hardwoods in future studies would allow for even broader landscape coverage.

Relating habitat quality to bird presence-absence has received criticism by several investigators (Johnson, 1995; Swanson, 1999). Whereas the point-count method is feasible for researchers constrained by time, funding, and personnel, and provides a coarse-filter approach to bird population monitoring, distinctions cannot be made between ideal and marginal habitat for breeding birds. Mist-netting is often more recommended for relating quality habitat to bird distributions, but differences in species' behavior patterns and net avoidance may confound results (Swanson, 1999). Breeding bird investigations also would reveal fine-scale relationships between species' survival and reproductive success and quality habitat to be used in concert with landscape-level studies (Ganey and Dargan, 1998).

5. Conclusion

Forested regions, such as the Upper Peninsula of Michigan, are important source habitat for area-sensitive forest birds (Hamady, 2000; Temple et al., 1979). Breeding Bird Census (BBC) data that suggest bird populations on the Ottawa National Forest (ONF) have mostly remained stable during a 12-year monitoring period (Johnson, 2004). I recommend implementing a mosaic of silvicultural systems on the landscape to maintain bird species populations. I hypothesis that this mosaic would accommodate both populations increasing as forests mature and also the early seral stage-species that are disappearing from other Great Lakes northern hardwood forests (Johnson, 2004; Edde, 2005). Whereas selection cut systems have been shown to mimic natural disturbance regimes (e.g., canopy gap creation by wind disturbances) for late-successional forests (Lorimer, 1989; Hunter, 1990; Doyon et al., 2005), relying on a single silvicultural treatment across a large area has been shown to benefit some avian species while hindering others (Thompson et al., 1992; Jobes et al., 2004; Doyon et al., 2005). DeGraaf and Yamasaki (2003) concluded that forests extensively managed with selection cut harvests jeopardized early secondary succession bird species.

Shelterwood harvests should remain an important forest management technique on the Ottawa National Forest for achieving both regional timber harvest goals and maintaining unique bird communities. Shelterwood stands provided a mixture of mature, albeit sparser canopy trees with a dense understory layer that benefited a host of early-successional species disappearing from much of the maturing hardwoods on the rest of the Ottawa National Forest (Johnson, 2004;

Edde, 2005). Additionally, the strong tie between the veery, declining both on the Ottawa National Forest and throughout North America (Johnson, 2004; Rich et al., 2004), more often found in shelterwood stands, supports the use of this silvicultural treatment. Thompson et al. (1992) reported that early-successional bird species with limited distributions in the Missouri Ozarks completely relied on natural disturbance and timber harvesting to create suitable habitat. Early seral stage conditions present at these sites should remain a management goal for maintaining these species on the Ottawa National Forest and in surrounding Great Lakes northern hardwood forests. In particular, reserve shelterwood systems have been shown to increase structural diversity within an even-aged harvest system and contribute to both coarse woody debris and cavity-tree retention for wildlife habitat (McGee et al., 1999).

While supporting less bird diversity on the whole, 40-60 year-old post-clear-cut stands should be maintained as important habitat for birds declining as forests mature. Whereas these stands provided less dense understory for sapling-layer nesting birds, they did provide closed canopy conditions with an open understory required by several species (least flycatcher, hermit thrush, and ovenbird). Future studies should continue to investigate the bird-habitat relationship at this landscape scale in combination with more-detailed, localized investigations. Studies such as the Ottawa BBC (Johnson 2004) should be used in concert with these investigations to relate changes in species abundance with overall stand condition. More immediate effects of silvicultural treatment can be inferred by comparing bird-habitat relationships pre- and more immediately post-harvest (Marzluff and Sallabanks, 1998). Measuring forest bird nest success and recruitment also could serve as a better index to quality nesting habitat in northern hardwood forests.

Acknowledgements

I sincerely thank T.F. Ginnett, R.A. Evans, and B.A. Bogaczyk for invaluable support and guidance in study design and implementation. R.N. Rosenfield, M.J. Hansen, and J.E. Cook provided constructive feedback in overall study design and editorial comments during preparation of this manuscript. E. Drabek, S. Drabek, and R. Wollenhaup provided early assistance in study site preparation. Funding was provided by the McIntire-Stennis Cooperative Research Grant, USDA Forest Service, and Becoming an Outdoors-Woman Inc. Special thanks to J. Koch for additional feedback and logistical support throughout the tenure of this project.

References

Anderson, S.H., Crompton, B.J., 2002. The effects of shelterwood logging on bird community composition in the Black Hills, Wyoming. Forest Science 48, 365-372.

Andres, S., 1996. Monitoring breeding birds in the Ottawa National Forest, 1994-1995: effects of management on Neotropical bird populations. Michigan Birds and Natural History 3, 141-147.

Annand, E.M., Thompson, III, F.R., 1997. Forest bird response to regeneration practices in central hardwood forests. Journal of Wildlife Management 61, 159-171.

Anonymous, 2004. Michigan Climatological Resources Program: Watersmeet, Michigan, USA. Michigan State University. East Lansing, Michigan, USA. http://climate.geo.msu.edu/w-upper.html. Accessed 25 February 2004.

Bormann, F.H., Likens, G.E., 1979. Patterns and processes in a forested ecosystem. Springer-Verlag, New York, New York, USA.

Brewer, R., McPeek, G.A., Adams, Jr., R.J., 1991. The atlas of the breeding birds of Michigan. Michigan University Press, East Lansing, Michigan, USA.

Chambers, C.L., McComb, W.C., Tappeiner II, J.C., 1999. Breeding bird responses to three silvicultural treatments in the Oregon Coast Range. Ecological Applications 9, 171-185.

Crow, T.R., Buckley, D.S., Nauertz, E.A., Zasada, C.J., 2002. Effects of management on the composition and structure of northern hardwood forests in Upper Michigan. Forest Science 48, 129-145.

DeGraff, R.M., Yamasaki, M., 2003. Options for managing early successional forest and shrubland bird habitats in the Northeastern United States. Forest Ecology and .Management 185, 179-191.

Doyon, F., Gagnon, D., and Giroux, J.F., 2005. Effects of strip and single-tree selection cutting on birds and their habitat in a southwestern Quebec northern hardwood forest. Forest Ecology and Management 209, 101-115.

Duguay, J.P., Wood, P.B., Nichols, J.V., 2001. Songbird abundance and avian nest survival rates in forests fragmented by different silvicultural treatments. Conservation Biology 15, 1405-1415.

Edde, J.W., 2005. Bird population trends in managed and un-managed northern hardwood forests: a comparison of long-term databases from the national forests in the Great Lakes and New Hampshire. Michigan Birds and Natural History 12, 98-117.

Ehrlich, P.R., D. S. Dobkin, and D, Wheye. 1988. The birder's handbook: a field guide to the natural history of North American birds. Simon and Schuster, New York, New York, USA.

Elias, J.E., 2006. American redstart (*Setophaga ruticilla*). In: Cutright, N.J., Harriman, B.R., and Howe, R.W. (Eds.). Atlas of the breeding birds of Wisconsin. The Wisconsin Society for Ornithology, Inc., Waukesha, Wisconsin, USA. p. 404-405.

Epstein, E., 2006. Veery (*Catharus fuscens*). In: Cutright, N.J., Harriman, B.R., and Howe, R.W. (Eds.). Atlas of the breeding birds of Wisconsin. The Wisconsin Society for Ornithology, Inc., Waukesha, Wisconsin, USA. p. 348-349.

Flaspohler, D.J., Temple, S.A., Rosenfield, R.N., 2001a. Species-specific edge effects on nest success and breeding bird density in a forested landscape. Ecological Applications 11, 32-46.

______, _____, _____, 2001b. Effects of forest edges on ovenbird demography in a managed forest landscape. Conservation Biology 15: 173-183.

Flaspohler, D.J., Fisher Huckins, C.J., Bub, B.R., and Van Dusen, P.J., 2002. Temporal patterns in aquatic and avian communities following selective logging in the upper Great Lakes region. Forest Science 48, 339-349.

Frelich, L.E., Lorimer, C.G., 1991. Natural disturbance regimes in hemlock-hardwood forests of the Upper Great Lakes region. Ecological Monographs 6, 145-164.

Frelich, L.E., 2002. Forest dynamics and disturbance regimes. Cambridge University Press, Cambridge, United Kingdom.

Fuller, A.K., Harrison, D.J., Lachowski, H.J., 2004. Stand scale effects of partial harvesting and clearcutting on small mammals and forest structure. Forest Ecology and Management 191, 373-386.

Ganey, J.L., Dargan, C.M., 1998. Avian conservation on National Forest System lands: linking research and management. In: Marzluff, J.M., Sallabanks, R. (Ed.), Avian Conservation: Research and Management. Island Press, Washington, DC, USA. pp.439-443.

Garrison, B.A., Triggs, M.L., Wachs, R.L., 2005. Short-term effects of group-selection timber harvest on landbirds in montane hardwood-conifer habitat of the central Sierra Nevada. Journal of Field Ornithology 76, 72-82.

Hamady, M.A., 2000. An ecosystem approach to assessing the effects of forest heterogeneity and disturbance on birds of the northern hardwood forests of Michigan's Upper Peninsula. Dissertation, Michigan State University, Lansing, Michigan, USA.

Hanowski, J., Danz, N., Lind, J., Niemi, G., 2003. Breeding bird response to riparian forest harvest and harvest equipment. Forest Ecology and Management 174, 315-328.

Harrison, C.A., Kilgo, J.C., 2004. Short-term breeding bird response to two harvest practices in a bottomland hardwood forest. Wilson Bulletin 116, 314-323.

Hayes, J.P., Weikel, J.M., Huso, M.M.P., 2003. Response of birds to thinning young Douglas-fir forests. Ecological Applications 13, 1222-1232.

Helms, J.A., 1998. The dictionary of forestry. The Society of American Foresters, Bethesda, Maryland, USA.

Holmes, R.T., Sherry, T.W., 2001. Thirty-year bird population trends in an unfragmented temperate deciduous forest: importance of habitat change. Auk 118, 589-609.

Howe, R.W., Mossman, M., 1996. The significance of hemlock for breeding birds in the western Great Lakes region. In: Mroz, G., Martin, J. (Eds.), Hemlock Ecology and Management. Department of Forestry, University of Wisconsin-Madison, Madison, Wisconsin, USA. pp. 125-140.

______, Neimi, G., Probst, J.R., 1996. Management of western Great Lakes forests for the conservation of neotropical migratory birds. In: Thompson III, F.R. (Ed.), Management of Midwestern landscapes for the conservation of neotropical migratory birds. USDA Forest Service General Technical Report NC-187, Detroit, Michigan, USA. pp. 144-167.

Hunter, Jr., M.L., 1990. Wildlife, forests, and forestry: principles of managing forests for biological diversity. Prentice Hall, Englewood Cliffs, New Jersey, USA.

Hurlbert, S.H., 1984. Pseudoreplication and the design of ecological field experiments. Ecological Monographs 54, 187-211.

James, F.C., McCulloch, C.E., Wiedenfeld, D.A., 1996. Special Feature: New approaches to the analysis of population trends in land birds. Ecology 77: 13-27.

______, 1998. The growing pains of avian conservation biology. In: Marzluff, J.M., Sallabanks, R. (Ed.), Avian Conservation: Research and Management. Island Press, Washington, DC, USA. pp.5-14.

James, R.D., 1998. Blue-headed vireo (*Vireo solitarius*). In: Poole, A., Gill, F. (Eds). The Birds of North America, no. 227. Academy of Natural Sciences, Philadelphia, Pennsylvania, USA and American Ornithologists' Union, Washington, DC, USA.

Jobes, A.P., Nol, E., Voigt, D.R., 2004. Effects of selection cutting on bird communities in contiguous eastern hardwood forests. Journal of Wildlife Management 68, 51-60.

Johnson, B., 2004. The Ottawa National Forest Breeding Bird Census: an analysis of twelve years of data. (Unpublished Report) Accessible at http://www.fs.fed.us/r9/ottawa/forest_management/wildlife/index.html.

Johnson, D.H., 1995. Point counts of birds: what are we estimating? In: Ralph, C.J., Sauer, J.R., Droege, S. (Eds.). Monitoring bird populations by point counts. USDA Forest Service General Technical Report GTR-149, Albany, California, USA. pp. 117-123.

Lesak, A.A., Wang, Y., Schweitzer, C.J., 2004. Songbird community variation among five levels of overstory retention in Northern Alabama. In: Conner, K.F. (Ed.), Proceedings of the 12th biennial southern silvicultural research conference. USDA Forest Service General Technical Report SRS-71, Asheville, North Carolina, USA. pp. 11-17.

Lorimer, C.G., 1989. Relative effects of small and large disturbance on temperate hardwood forest structure. Ecology 70, 565-567.

Machtans, C.S., Latour, P.B., 2003. Boreal forest songbird communities of the Liard Valley, Northwest Territories, Canada. Condor 105, 27-44.

Martinson, T., 2006. Rose-breasted grosbeak (*Pheuticus ludovicianus*). In: Cutright, N.J., Harriman, B.R., and Howe, R.W. (Eds.). Atlas of the breeding birds of Wisconsin. The Wisconsin Society for Ornithology, Inc., Waukesha, Wisconsin, USA. p. 464-465.

Marzluff, J.M., Sallabanks, R., 1998. Past approaches and future directions for avian conservation biology. In: Marzluff, J.M., Sallabanks, R. (Ed.), Avian Conservation: Research and Management. Island Press, Washington, DC, USA. pp.5-14.

McGee, G.G., Leopold, D.J., Nyland, R.D., 1999. Structural characteristics of old-growth, maturing, and partially cut northern hardwood forests. Ecological Applications 9, 1316-1329.

Moorman, C.E., Guynn, Jr., D.C., 2001. Effects of group selection opening size on breeding bird habitat use in a bottomland forest. Ecological Applications 11, 1680-1691.

Norton, M.R., Hannon, S.J., 1997. Songbird response to partial-cut logging in the boreal mixed-wood forest of Alberta. Canadian Journal of Forestry 27, 44-53.

Palmer, M.W., 1993. Putting things in even better order: the advantages of canonical correspondence analysis. Ecology 74, 2215-2230.

Pastor, J., Brochart, M., 1990. The spatial pattern of a northern hardwood-conifer landscape. Landscape Ecology 4, 55-68.

Peterjohn, G.B., Sauer, J.R., 1994. Population trends of woodland birds from the North American breeding bird survey. Wildlife Society Bulletin 22, 155-164.

Price, J., Droege, S., Price, A., 1995. The summer atlas of North American birds. Academic Press, New York, New York, USA. 364 pp.

Ralph, C.J., Guepel, G.R., Pyle, P., Martin, T.E., DeSante, D.F., 1993. Handbook of field methods for monitoring landbirds. USDA Forest Service, General Technical Report PSW-GTR-144, Albany, California, USA.

Rich, T.D., Beardmore, C.J, Berlanga, H., Blancher, P.J., Bradstreet, M.S.W, Butcher, G.S., Demarest, D.W., Dunn, E.H., Hunter, W.C., Inigo-Elias, E.E., Kennedy, J.A., Martell, A.M., Panjabi, A.O., Pashley, D.N., Rosenberg, K.V., Rustay, C.M., Wendt, J.S., Will, T.C., 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology, Ithaca, NY, USA.

Robinson, S.K., Thompson, III, F.R., Donovan, T.M., Whitehead, D.R., Faaborg, J., 1995. Regional forest fragmentation and the nesting success of migratory birds. Science 267, 1987-1990.

SAS Institute, 2001. SAS. SAS Institute, Inc., Cary, North Carolina, USA.

Sherry, T.W., 1979. Comparative interactions and adaptive strategies of American redstarts and least flycatchers in a northern hardwoods forest. Auk 96, 265-283.

Sherry, T.W., Holmes, R.T., 1988. Habitat selection by breeding American redstarts in response to a dominant competitor, the least flycatcher. Auk 105, 350-364.

______, _____, 1997. American redstart (*Setohpaga ruticilla*). In: Poole, A., Gill, F. (Eds). The Birds of North America, no. 227. Academy of Natural Sciences, Philadelphia, Pennsylvania, USA and American Ornithologists' Union, Washington, DC, USA.

Swanson, D.L., 1999. Avifauna of an early successional habitat along the middle Missouri River. Prairie Naturalist 31, 145-164.

Tabachnik, B.G., Fidell, L.S., 1989. Using multivariate statistics. Harper and Row, New York, New York, USA. 746 pp.

Temple, S.A., Mossman, M.J., Ambuel, B. 1979. The ecology and management of avian communities in mixed hardwood-coniferous forest. In: DeGraaf, R.M., Evans, K.E. (Eds.). Management of North Central and Northeastern forests for nongame birds. USDA Forest Service, General Technical Report NC-39. St Paul, Minnesota, USA. pp. 132-151.

ter Braak, C.J.F., 1986. Canonical correspondence analysis: a new eigenvector technique for multivariate direct gradient analysis. Ecology 67, 1167-1179.

Thill, R.E., Koerth, N.E., 2005. Breeding birds of even- and uneven-aged pine forests of eastern Texas. Southeastern Naturalist 41, 153-176.

Thompson, III, F.R., Dijak, W.D., Kulowiec, T.G., Hamilton, D.A., 1992. Breeding bird populations in Missouri Ozark forests with and without clearcutting. Journal of Wildlife Management 56, 23-40.

______, Probst, J.R., Raphael, M.G., 1993. Silvicultural options for Neotropical migratory birds. In: Finch, D.M., Stangel, P.W. (Eds.), Status and management of Neotropical migratory birds. USDA Forest Service, General Technical Report RM-229. Rocky Mountain Forest Experimental Station. pp. 353-362.

______, _____., _____ 1996. Impacts of silviculture: overview and management recommendations. In: Martin, T.E., Finch, D.M. (Eds.), Ecology and management of Neotropical migratory birds: a synthesis and review of critical issues. Oxford University

Press, Oxford, England. pp. 201-219.

______, Burhans, D.E., Root, B., 2002. Effects of point count protocol on bird abundance and variability estimates and power to detect population trends. Journal of Field Ornithology 73, 141-150.

Turner, C.J., Gerwin, J.A., Lancia, R.A., 2002. Influence of hardwood stand area and adjacency on breeding birds in an intensively managed pine landscape. Forest Science 48, 232-330.

USDA, 2000. Sierra Nevada Forest Plan Amendment, Draft Environmental Impact Statement, Summary. USDA Forest Service, Pacific Southwest Region, Vallejo, California, USA.

______, 2002. Ottawa National Forest Compartment Records. USDA. Available at any of the Ottawa National Forest Ranger Districts, Upper Michigan, USA.

______, 2005. Ottawa National Forest 2005 Year In Review. Available online at http://www.fs.fed.us/r9/Ottawa/forest_management/forest_plan/revision/Ottawa_2005_yr_n_review.pdf. Accessed 4 May 2006.

Wood, P.B., Duguay, J.P., Nichols, J.V., 2005. Cerulean warbler use of regenerated clearcut and two-age harvests. Wildlife Society Bulletin 33, 851-858.

TABLES

Table 1. Sample effort and history for the 36 stands sampled on the Ottawa National Forest, Upper Michigan, USA (Ottawa National Forest Compartment Records located in the Watersmeet and Bessemer Ranger District Offices).

Treatment	Compartment ID	Stand ID	Number of Points	Stand Size (ha)	Most Recent Harvest
Clear Cut					
A	9	9	4	195.5	#
B	11	8	3	25.9	Late 1960's
C	11	18	2	13.4	#
D	12	3	2	53.4	1966
E	58	26	2	53.0	#
F	72	25	4	51.4	#
G	73	20	1	9.7	#
H	90	9	2	16.2	#
I	90	10	2	10.5	#
J	137	10	2	14.2	#
K	137	13	3	15.4	#
L	137	17	3	11.3	#
N = 12			n = 30		
Shelterwood					
A*	27	10	3	7.7	1994
B*	27	16	1	4.5	1994
C*	32	3	3	15.8	1994
D*	32	30	1	2.0	1994
E	90	12	1	10.5	1985
F	90	13	2	36.8	1985
G	119	6	4	39.3	1990
H	128	16	1	8.5	1987
I	138	4	3	15.8	1988
J	138	6	2	13.4	1987
K	141	36	2	22.3	1984
L	155	4	4	63.9	1984
M	155	8	3	14.2	1984
N = 13			n = 30		
Selection Cut					
A	9	11	4	66.4	1980
B	45	3	2	74.1	1986
C	45	4	4	44.5	1987
D	45	12	5	30.4	1981
E	73	2	2	36.8	1989
F	73	4	2	12.9	#
G	112	4	3	51.4	1989
H	112	41	2	93.1	#
I	125	36	3	102.8	#
J	125	38	2	8.1	#
K	137	33	1	21.4	#
N = 11			n = 30		

* indicates stands located on the Bessemer Ranger District. All others were on the Watersmeet Ranger District.
# indicates exact date not available.

Table 2. Habitat structure variables in clear cut, shelterwood cut, and selection cut northern hardwood forest stands 2004-2005 in the Ottawa National Forest, Upper Michigan, USA.

	Treatment Type			
Habitat Variable	Clear Cut	Shelterwood Cut	Selection Cut	*P*[a]
Percent Canopy Cover	97.6 ± 0.9[b]	97.5 ± 0.9	97.6 ± 0.6	0.5679
	[96.8, 100.1][c]	[87.1, 100.1]	[92.8, 99.7]	
Basal Area (m^2/ha)	15.8 ± 1.1a,b	15.2 ± 1.3b	19.9 ± 1.1a	0.0200
	[11.6, 23.0]	[7.5, 22.1]	[10.3, 25.0]	
Snag Abundance (#/ha)	0.2 ± 0.1	0.3 ± 0.1	0.3 ± 0.1	0.7306
	[0, 0.6]	[0, 0.8]	[0, 0.8]	
Percent Ground Cover	18.3 ± 2.2	15.5 ± 2.2	19.3± 2.7	0.5273
	[10.7, 33.3]	[4.5, 22.1]	[7.3, 37.8]	
Sapling Height (m)	3.5 ± 0.2	3.7 ± 0.3	3.8 ± 0.2	0.7686
	[2.5, 4.7]	[3.0, 6.0]	[2.8, 5.6]	
Canopy Height (m)	16.5 ± 0.2	17.1 ± 0.2	16.7 ± 0.3	0.0779
	[15.5, 17.4]	[15.0, 18.2]	[15., 17.5]	
Percent Vertical Cover	12.7 ± 5.1a	27.9 ± 8.6b	8. 8 ± 2.3a,b	0.0234
	[0.3, 24.1]	[3.4, 77.3]	[1.2, 28.1]	
DBH (cm)	31.5 ± 1.8a	41.7 ± 1.2b	35.9 ± 1.4c	<0.0001
	[23.5, 33.6]	[35.4, 50.2]	[30.6, 46.1]	
Percent Conifer Overstory	29.9 ± 3.3	41. 7 ± 4.2	35.9 ± 4.7	0.0691
	[23.57, 33.6]	[35.4, 50.2]	[30.6, 46.1]	0.0691

[a] One-way ANOVA.
[b] Mean ± 1S.E. Means followed by different letters indicate differences among treatments detected by Tukey's post hoc tests.
[c] [Min, Max].

Table 3. Principal Components Analysis (PCA) results describing variation among silvicultural treatments according to nine habitat variables measured August 2004 in the Ottawa National Forest, Upper Michigan, USA.

Habitat Variable	First PC	Second PC	Third PC	Fourth PC	Fifth PC
Percent Canopy Cover	-0.3696[a]	-0.4292	0.6103	0.1927	0.3479
Basal Area (m^2/ha)	-0.3879	0.5070	0.6266	-0.0921	-0.0111
Snag Abundance	-0.0852	0.7750	0.0299	-0.4782	-0.0898
Percent Ground Cover	-0.0775	0.6679	-0.4404	0.4092	-0.0022
Sapling Height (m)	0.9214	0.5311	0.5352	0.5210	-0.133
Canopy Height (m)	0.5624	-0.4586	0.4090	0.0361	-0.4777
Percent Vertical Cover	0.4736	-0.0362	-0.6995	0.1689	0.0581
DBH (cm)	0.9214	0.1916	0.2458	-0.0782	0.1967
Percent Conifer Overstory	0.9125	0.1960	0.2576	-0.0839	0.2142
% Variation	28.26	23.00	22.55	8.40	5.14

[a] Values greater than 0.6500 indicate significant loading for PC axis

Table 4. Mean number of birds detected per point among clear cut, shelterwood cut, and selection cut northern hardwood forests during June-July 2004 and 2005 on the Ottawa National Forest, Upper Michigan, USA.

	Treatment Type			
Species	Clear Cut	Shelterwood Cut	Selection Cut	*P*[a]
AMGO	0.005 ± 0.005	0.050 ± 0.022	0.030 ± 0.016	0.1486
AMRE	0.008 ± 0.008a[b]	0.208 + 0.058b	0.059 ± 0.023a	0.0020
AMRO	0.257 ± 0.061	0.268 ± 0.043	0.339 ± 0.066	0.5532
BBCU	0.000 ± 0.000	0.004 ± 0.004	0.006 ± 0.004	0.4575
BCCH	0.226 ± 0.074	0.272 ± 0.065	0.187 ± 0.065	0.6868
BHCO	0.000 ± 0.000	0.038 ± 0.022	0.000 ± 0.000	0.0969
BHVI	0.013 ± 0.009a	0.283 ± 0.046b	0.216 ± 0.057b	0.0002
BLBW	0.083 ± 0.037	0.209 ± 0.072	0.229 ± 0.069	0.2148
BLJA	0.116 ± 0.032	0.222 ± 0.065	0.089 ± 0.028	0.1186
BRCR	0.079 ± 0.026a	0.165 ± 0.040a,b	0.243 ± 0.058b	0.0392
BTBW	0.165 ± 0.054	0.205 ± 0.072	0.154 ± 0.061	0.8310
BTNW	0.991 ± 0.102	1.152 ± 0.137	1.104 ± 0.085	0.5867
BWHA	0.046 ± 0.042	0.017 ± 0.009	0.024 ± 0.011	0.6982
CHSW	0.009 ± 0.009	0.013 ± 0.009	0.024 ± 0.017	0.6582
CSWA	0.052 ± 0.023	0.192 ± 0.082	0.051 ± 0.032	0.1258
DOWO	0.036 ± 0.020	0.024 ± 0.019	0.032 ± 0.016	0.8857
EAWP	0.116 ± 0.035	0.052 ± 0.029	0.130 ± 0.050	0.3026
HAWO	0.026 ± 0.012	0.041 ± 0.025	0.040 ± 0.17	0.8156
HETH	0.540 ± 0.113	0.616 ± 0.114	0.723 ± 0.066	0.4730
LEFL	0.594 ± 0.205a,b	0.149 ± 0.041a	0.854 ± 0.224b	0.0188
MOWA	0.014 ± 0.010	0.009 ± 0.007	0.001 ± 0.001	0.9099
MYWA	0.049 ± 0.034	0.066 ± 0.027	0.033 ± 0.030	0.7547
NAWA	0.005 ± 0.005	0.042 ± 0.022	0.052 ± 0.033	0.3217
NOPA	0.017 ± 0.010	0.067 ± 0.029	0.077 ± 0.038	0.2244
OVEN	1.629 ± 0.148	1.370 ± 0.095	1.545 ± 0.177	0.4033
PIWO	0.017 ± 0.010	0.056 ± 0.020	0.026 ± 0.012	0.1571
RBGR	0.216 ± 0.041a	0.360 ± 0.056a,b	0.399 ± 0.052b	0.0383
REVI	1.465 ± 0.067	1.338 ± 0.120	1.295 ± 0.062	0.4033
RUGR	0.000 ± 0.000	0.033 ± 0.018	0.029 ± 0.017	0.2097
SCTA	0.122 ± 0.052	0.129 ± 0.030	0.171 ± 0.049	0.7169
SWTH	0.000 ± 0.000	0.034 ± 0.021	0.008 ± 0.008	0.1786
VEER	0.014 ± 0.014a	0.259 ± 0.099b	0.092 ± 0.037a,b	0.0322
WBNU	0.026 ± 0.012	0.104 ± 0.034	0.059 ± 0.029	0.1293
WIWR	0.032± 0.023a	0.333 ± 0.073b	0.235 ± 0.059b	0.0020
WOTH	0.000 ± 0.000	0.160 ± 0.095	0.000 ± 0.000	0.0991
WTSP	0.035 ± 0.012	0.083 ± 0.0500	0.038 ± 0.021	0.5272
YBSA	0.378 ± 0.0703	0.463 ± 0.079	0.475 ± 0.057	0.5797

[a] One-way ANOVA.
[b] Mean ± 1S.E. Means followed by different letters indicate differences among treatments detected by Tukey's post hoc tests.

FIGURES

Figure 1. Map of the Ottawa National Forest in the Upper Peninsula of Michigan, USA (USDA Forest Service, 2006).

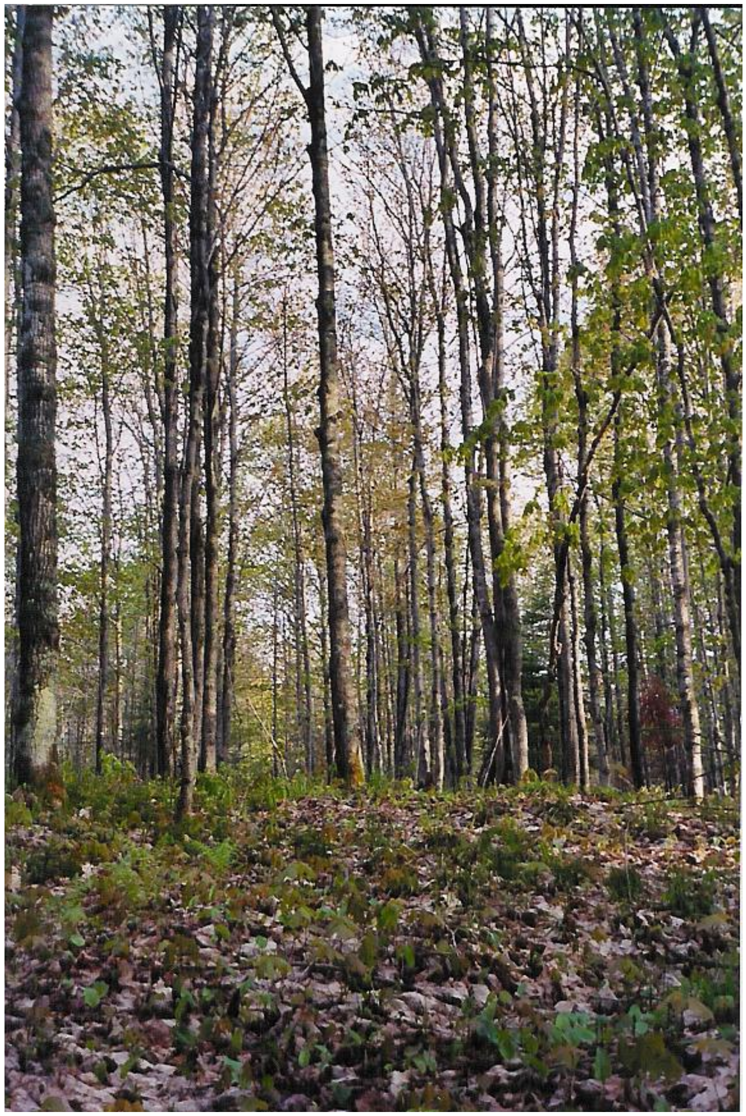


Figure 2. Representative 40-60 year old even-aged northern hardwood stand that had received a clear cut treatment on the Ottawa National Forest, Upper Michigan, USA.

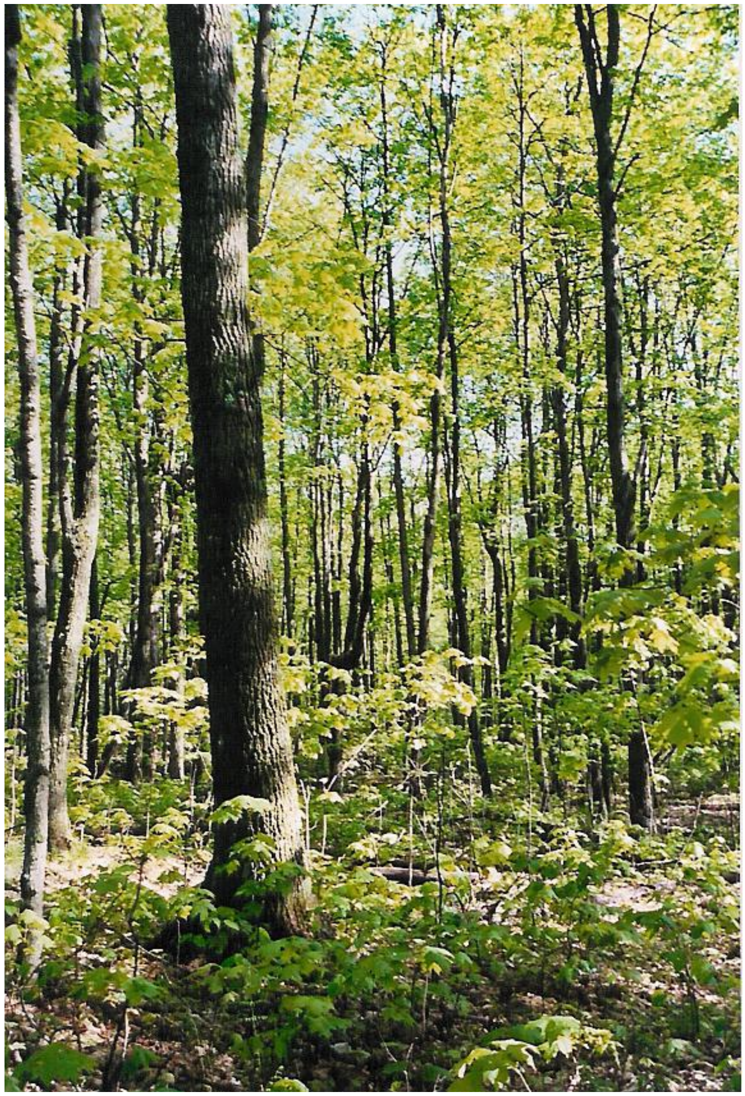


Figure 3. Representative uneven-aged, selectively cut northern hardwood stand on the Ottawa National Forest, Upper Michigan, USA.

Figure 4. Representative two-aged northern hardwood forest stand that had received a shelterwood cut treatment on the Ottawa National Forest, Upper Michigan, USA.

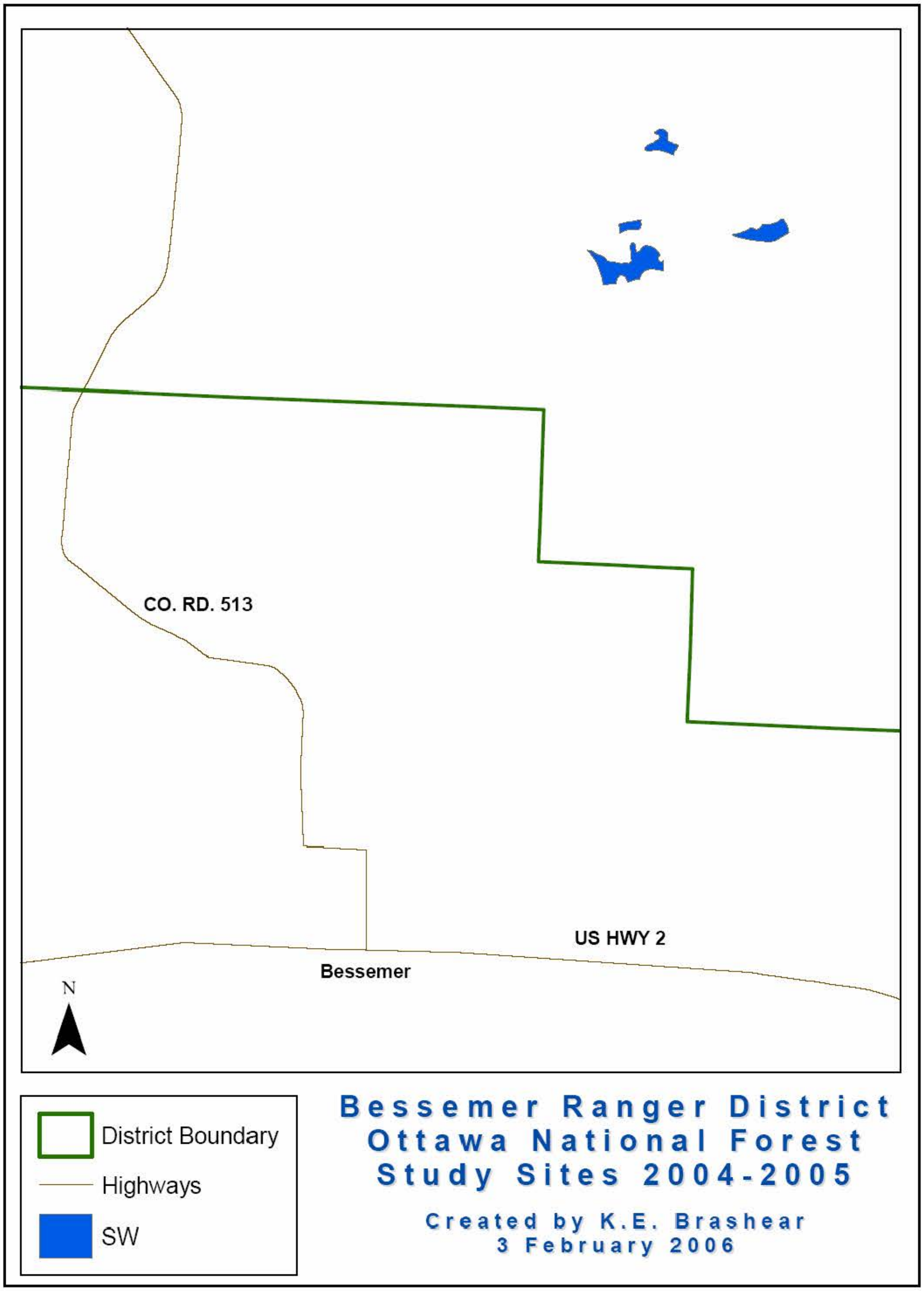


Figure 5. Map of shelterwood cut stands sampled June-July 2004 and 2005 on the Bessemer Ranger District of the Ottawa National Forest, Upper Michigan, USA.

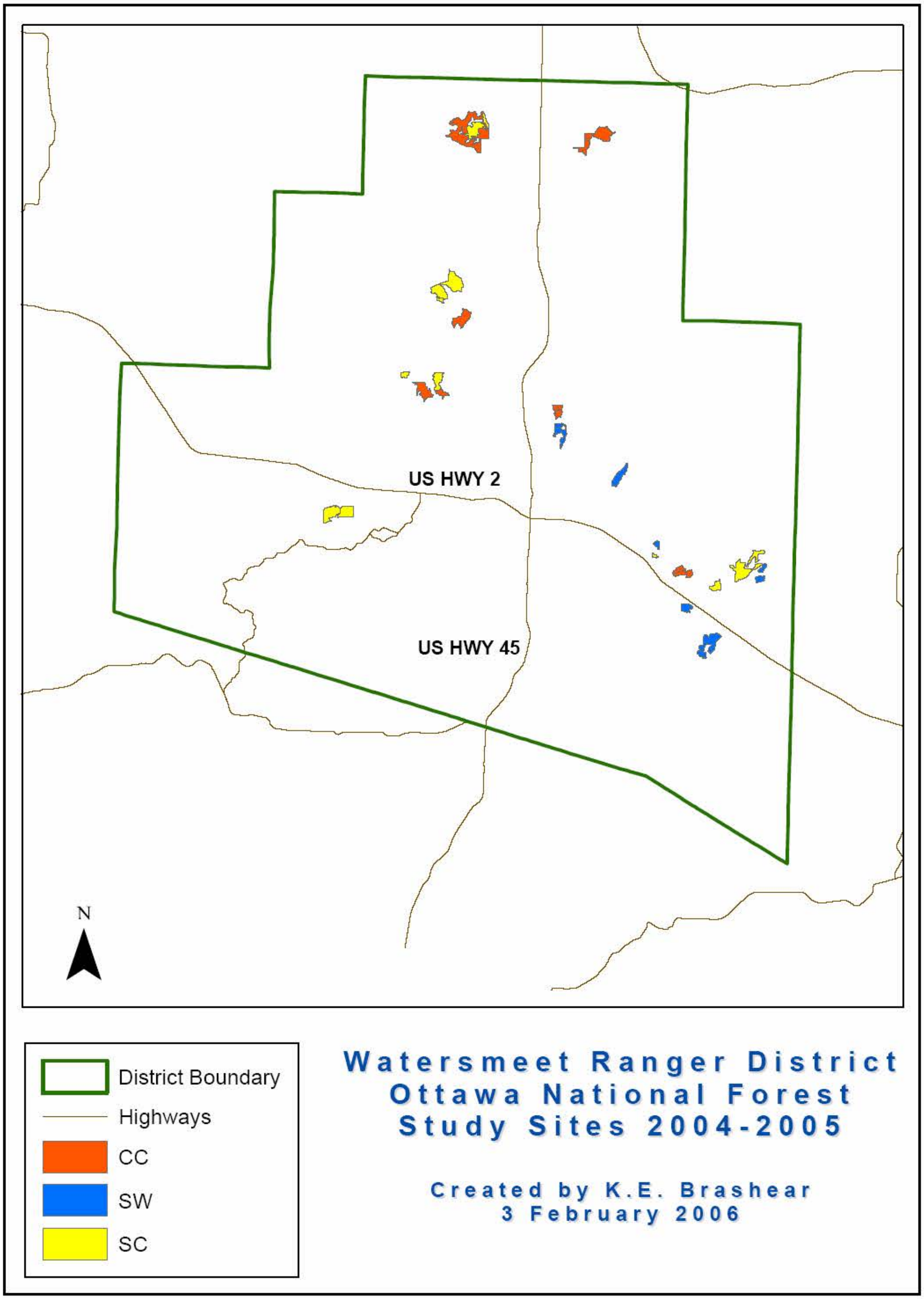


Figure 6. Map of clear cut, shelterwood cut, and selection cut stands sampled June-July 2004 and 2005 on the Watersmeet Ranger District of the Ottawa National Forest, Upper Michigan, USA.

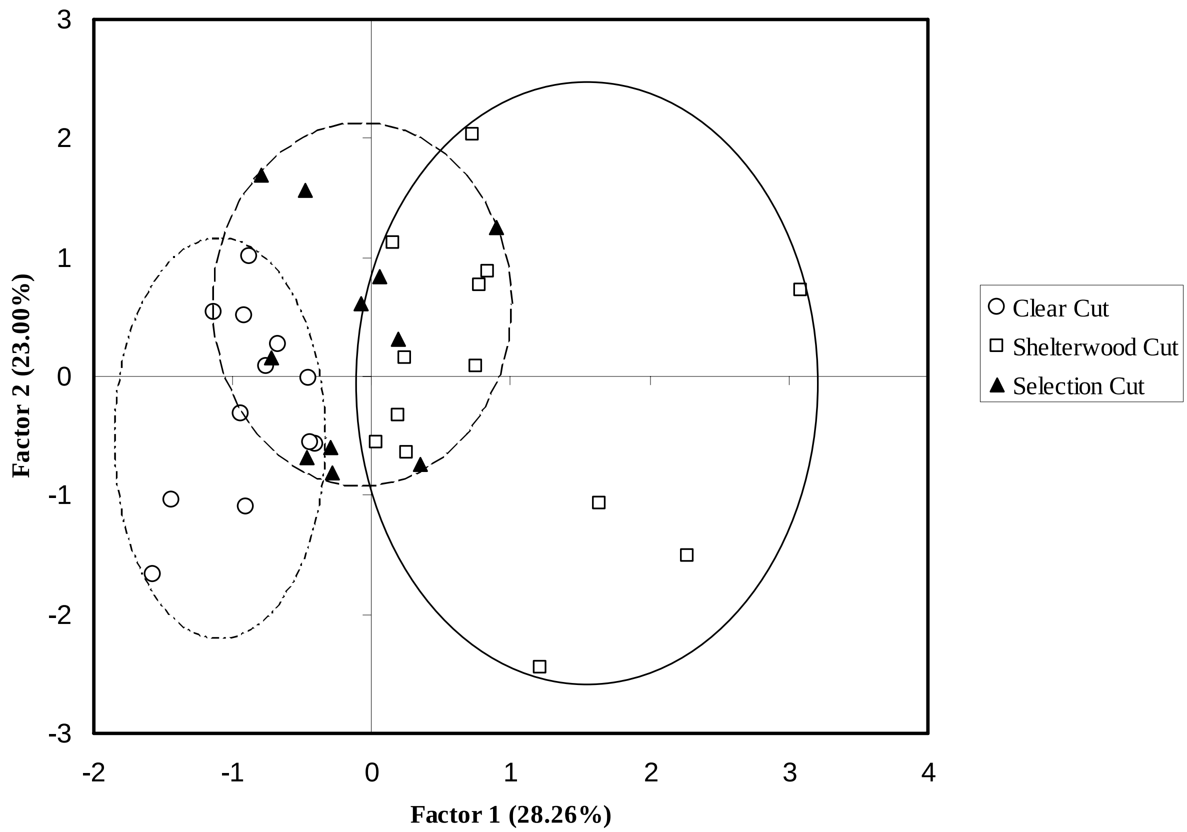


Figure 7. Plot of stands in ordination space defined by the first two PCA factors June-July 2004 and 2005 from the Ottawa National Forest, Upper Michigan, USA. The percent variation explained by each factor is indicated in parantheses.

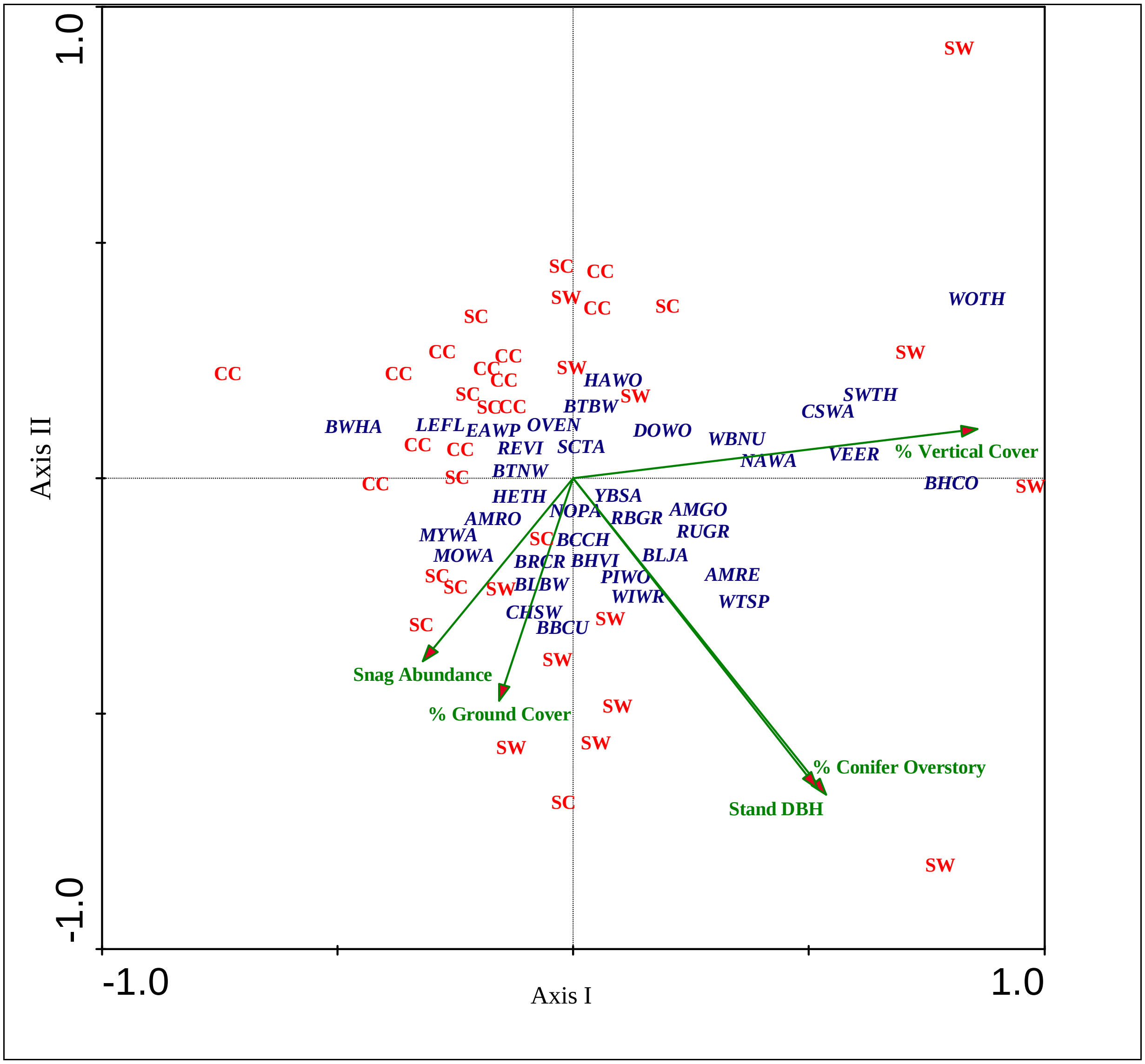


Figure 8. CCA triplot for bird species as they relate to PCA-reduced set of five northern hardwood forest habitat variables June-July 2004 and 2005 on the Ottawa National Forest, Upper Michigan, USA.

Black-throated Blue Warbler (*Dendroica caerulescens*) breeding habitat in western Upper Michigan

K.E. Brashear

College of Natural Resources, University of Wisconsin-Stevens Point, Stevens Point, WI 54481

The Black-Throated Blue Warbler (BTBW) has been noted as one of the most sexually dimorphic wood warblers in North America (Ehrlich et al. 1988). Sometimes found near clearings, this warbler currently is thought to prefer mature forest interiors with dense shade, where moderately dense shrub-cover is easily negotiable (Brewer et al. 1991). The BTBW typically breeds about one meter high in the shrub-sapling layer. Long-term monitoring of BTBW at Hubbard Brook Research Station (New Hampshire) suggests that BTBW regularly double-brood. Females lay one egg per day for two to five days and incubate the eggs for 13 days, and young typically fledge 8 days after hatching (Holmes 1994, Jones et al. 2005). BTBW often double-brood and occasionally raise three broods, resulting in a range of 4-15 young per breeding season (Holmes 1994). Often, the male remains close to the nesting female, singing softly overhead (Holmes et al. 1992). If disturbed, females exhibit a broken-wing display accompanied by chipping notes to lead intruders away from the nest (Holmes 1994). Nests in Michigan were built on terminal branches of a fallen birch 35 cm above the ground and shaded by maple sapling leaves (Walkinshaw and Dyer 1953). At Hubbard Brook BTBW nested at an average height of 0.6 m above ground, mostly in Hobblebrush (*Viburnum alnifolium*), but also in other shrub level-vegetation (Holmes 1994). Nests have been documented low in saplings of Sugar Maple (*Acer saccharum*), Beech (*Fagus grandifolia*), Red Spruce (*Picea rubens*), and occasionally in dense clumps of Fern (*Pteridium* sp.) (Holmes et al. 1992).

The Black-Throated Blue Warbler has been identified as an area-sensitive species within the Ottawa National Forest, Michigan. Statewide breeding bird surveys have revealed an overall decline of BTBW in Michigan (Brewer et al., 1991). The 2002 Birds of Conservation Concern report (USFWS) listed the BTBW as a priority species in Bird Conservation Region 12 (BCR), the Boreal Hardwood Transition Zone. This species was listed as the fourth-highest ranked species of concern for BCR 12 in the Partners in Flight handbook on species assessment and conservation (Panjabi 2001). The BTBW is thus often used as an indicator species for quality, unfragmented mature interior forest. Long-term BBS route monitoring indicates an increase in BTBW abundance in New Hampshire (Holmes and Sherry 2001), which may indicate an increase in unfragmented interior forest cover across the New England landscape.

My objective was to determine if black-throated blue warblers selected their nesting territories for particular attributes of northern hardwood forests in the Ottawa National Forest. Most knowledge of life history and habitat requirements for the BTBW results from research conducted in New Hampshire's Hubbard Brook Experimental Forest (Holmes 1994), but the applicability of this information to the western Great Lakes region is unclear. In New Brunswick, BTBW were shown to be more abundant in selection cut stands with high shrub density than uncut stands, but reproductive success did not increase (Bourque and Villard 2001). However, relatively shorter frost-free periods in more northern habitats likely prevented double-brooding and thus higher productivity levels such as those observed in New Hampshire (Holmes et al. 1992, Bourque and Villard 2001). Conservation of this species requires an understanding of regional habitat requirements necessary for regional population maintenance. Most large-scale monitoring programs have not considered habitat when designating survey locations or do not use a well-defined plan to select sampling sites (Bart 2005). Increasing population trends during a 12-year period (Johnson 2004) conflict with the overall decreasing trend identified by Brewer et al. (1991). Specific BTBW habitat requirements in western Upper Michigan thus are not fully understood.

Study Area

The Ottawa National Forest (ONF; Figure 1), located in the western Upper Peninsula of Michigan, predominantly is a second-growth forest that is managed for multiple uses and regularly is subjected to logging. This region was shaped by frequent, small-scale disturbances caused by high winds resulting in single- or multiple-tree canopy gaps and, less often, small, lightning-ignited fires (McGee et al., 1999; Frelich and Lorimer, 1991). Timber harvesting more recently has become the main disturbance regime (Frelich, 2002). This region is defined by acidic, rocky, sandy loam, or loamy sand soils derived from iron-rich Precambrian rock. The forests are heavily dominated by Sugar Maple, with the remaining overstory comprised of Yellow Birch (*Betula alleghaniensis*), Basswood (*Tilia americana*), Eastern Hemlock (*Tsuga canadensis*), and Ironwood (*Ostrya virginiana*) (Crow et al. 2002). Leatherwood (*Dirca palustris*), beaked hazel (*Corylus cornuta*), and dominant tree species' saplings dominate the understory (Flaspohler et al., 2001). The ground layer most often contains a mix of spring ephemerals, tree seedlings, club mosses (*Lycopodium* spp.), and wild leek (*Allium tricoccum*) (Flaspohler et al., 2001), oftentimes with a wet leaf litter layer from early spring into mid-summer. The climate is characterized as continental humid, with an average annual air temperature of 4.4° C, an average maximum air temperature of 10.8° C, and an average minimum air temperature of -2° C. The average annual precipitation is 85.37 cm and the average annual snowfall is 288.5 cm (Anonymous, 2004).

Methods

Black-throated Blue Warbler Locations

Territorial calls of BTBW were noted during June 1-July 15 2004 and 2005 at randomly generated point counts (see Ralph et al. 1993 for point count methodology). Points were randomly located 300 m apart to avoid double-counting individuals and 100 m away from stand edges and riparian area to avoid edge effects. Points were visited three times during each summer to account for seasonal and temporal variability of behavior and thus detection. BTBW presence was confirmed by detection during at least one of three visits to the point per season.

Territorial-male BTBW locations from randomly established point count survey locations and opportunistic detections were re-visited for nest investigations. Nests were found by following nest-building or incubating females or males visiting the nest. Nest site were described and number of BTBW eggs or young were counted, and exact nest locations were determined using a handheld Global Positioning System unit.

Habitat Sampling

Habitat variables were measured at each point-count location during July-August 2004. Time and personnel constraints limited habitat sampling to summer 2004, and I assumed that habitat features did not differ significantly between 2004 and 2005 (e.g. basal area, canopy cover, etc.). Habitat measurements included percent canopy cover, basal area, snag abundance, percent ground cover, sapling height, canopy height, percent vertical cover 0-2.5 m, stand average diameter at breast height (dbh), and overstory percent conifer cover. Four 400-m^2 (11.3 m radius) circular vegetation plots were established with one at the point count center and three plots 70 m from the center at 0°, 120°, and 240° (Machtans and Latour 2003). Measurements from these plots were averaged per point count location (Brashear 2006).

Statistical Analysis

BTBW nesting-habitat selection was modeled as a function of habitat variables using discriminant function analysis (DFA). Detections during at least one of the visits per season were assigned a value of 1.0 and no detections were assigned a value of 0. DFA allowed identification of environmental gradients from a multivariate set that predicted BTBW occurrence in northern hardwood stands (McGarigal et al. 2000). Habitat variables were log- or square root-transformed as necessary to meet the assumptions of normality. Each year was analyzed separately to avoid double-counting the same individual from year to year as no mark-recaptures methods were employed.

Results

BTBW (predominantly singing males) were detected at 19 of 90 point count locations in 2004, and 25 of 90 point count locations contained BTBW in 2005. In 2004, three habitat variables (sapling height, canopy height, and basal area) that best predicted BTBW presence (Figure 3); (Table 1; classification rate = 0.4723). In 2005, basal area and sapling height, in addition to percent vertical cover 0-2.5 m (Table 2, classification rate = 0.3636), best predicted BTBW presence (Figure 4).

No BTBW nests were located in 2004, and only four BTBW nests were located in 2005. All of the nests were located in conifer sapling clumps in closed canopy hardwood forests. Nest 1 (Figure 5) was located in a White Spruce (*Picea glauca*) sapling clump adjacent to a former USFS logging road. This nest was partially attached to the Spruce trunk, and most of the nest was on the ground, presumably because of disturbance or predation. Beyond the road edge, few other conifer clumps were within the surrounding northern hardwood cover (40-60 year old post clear cut). Nest 2 (Figure 6) was located in a Balsam Fir (*Abies balsamea*) sapling within an Eastern Hemlock regeneration pocket under a predominantly Sugar Maple canopy. Three BTBW nestlings present during the initial visit were absent during a follow-up visit one week later. This forest stand had received a selection cut in the recent past. Nest 3 (Figure 7) contained four young and was located on the crotch of a main branch 0.67 m off the ground in an Eastern Hemlock sapling that was within a pocket of conifer regeneration in an otherwise deciduous-dominated sapling layer. Nest 3 was located east of Nest 2 within the same forest stand. Nest 4 (not pictured) was located 0.3 m off the ground in a White Spruce sapling pocket. Several leaves were affixed to the sapling in the nearest crotch above the nest. This conifer regeneration pocket was on a small ridge overlooking a swamp pocket to the east, and several other conifer pockets were located on the ridge line directly across from the swamp. Nest 4 contained three slightly feathered BTBW with open eyes. This northern hardwood stand had received a selection cut treatment in the recent past.

Discussion

My results must be interpreted carefully because of the short study period. The association between BTBW predicted and observed occurrence and lower sapling heights during 2004 and 2005 is well-supported by this species' nesting habitat needs during the breeding season (Holway 1991, Holmes 1994). The habitat variables most associated with predicted and observed BTBW locations during 2004 and 2005 were consistent with forests that had received a shelterwood or selection cut (Brashear 2006). Anecdotal evidence suggests that some forest interior species, such as the black-throated blue warbler, persist in higher than expected abundances in shelterwood stands that contain a significant shrub layer (Bogaczyk, personal communication). In 2004-2005, BTBW abundance was greater in selection cut and shelterwood cut stands than in 40-60 year old stands that had been previously clear cut (Brashear 2006).

Documenting four BTBW nests strictly in conifer regeneration pockets in western Upper Michigan is noteworthy. Efforts to find nests where territorial males had been recorded revealed a greater presence of conifer regeneration clumps. Research in the central and eastern Upper Peninsula of Michigan has revealed a widespread BTBW preference for Balsam Fir sapling clusters for nest sites (Hall, personal communication). This represents an interesting deviation from nest-site descriptions derived from investigations elsewhere that suggest the deciduous sapling layer is the prominent nesting substrate (Holway 1991, Steele 1992, Holmes 1994). BTBW selection of dense conifer saplings for nesting suggests the need to maintain sufficiently large canopy gaps to allow conifer regeneration amidst a predominantly sugar maple sapling layer (Evans, personal communication; Hall, personal communication).

Management Implications

The Ottawa National Forest provides relatively unfragmented forest cover and could be considered important habitat for western Great Lakes BTBW populations (Howe et al., 1996). Large-scale forest management could impact the conservation of this Neotropical migrant (Bourque and Villard 2001). If forest managers are to provide long-term breeding habitat for bird species of special concern, in addition to forest products, further investigations are needed to provide specific recommendations for promoting the sustainability of breeding bird communities. Special consideration should be given to conifer retention in the western Upper Peninsula of Michigan in concert with current silvicultural practices to ensure stable BTBW populations in the future. Follow-up investigations with a larger sample size of BTBW nests and to quantify specific nest-site habitat conditions are recommended.

Acknowledgements

I sincerely thank T.F. Ginnett, R.A. Evans, and B.A. Bogaczyk for invaluable support and guidance in study design and implementation. R.N. Rosenfield, M.J. Hansen, and J.E. Cook provided constructive feedback in overall study design and editorial comments during preparation of this manuscript. E. Drabek, S. Drabek, and R. Wollenhaup provided early assistance in study site preparation. Funding was provided by the McIntire-Stennis Cooperative Research Grant, USDA Forest Service, and Becoming an Outdoors-Woman Inc. Special thanks to J. Koch for additional feedback and support throughout the tenure of this project.

Literature Cited

Anonymous. 2004. Michigan Climatological Resources Program: Watersmeet, Michigan, USA. Michigan State University. East Lansing, Michigan, USA. http://climate.geo.msu.edu/w-upper.html. Accessed 25 February 2004.

Bart, J. 2005. Monitoring the abundance of bird populations. Auk 122: 15-25.

Bourque, J., and M.A. Villard. 2001. Effects of selection cutting and landscape-scale harvesting on the reproductive success of two Neotropical migrant bird species. Conservation Biology 15: 184-195.

Brashear, K.E. 2006. Bird species-habitat relationships in managed northern hardwoods on the Ottawa National Forest. Master’s thesis, University of Wisconsin-Stevens Point, Stevens Point, Wisconsin, USA.

Brewer, R., G.A. McPeek, and R.J. Adams, Jr. 1991. The atlas of the breeding birds of Michigan. Michigan University Press, East Lansing, Michigan, USA.

Crow, T. R., D. S. Buckley, E. A. Nauertz, and J. C. Zasada. 2002. Effects of management on the composition and structure of northern hardwood forests in Upper Michigan. Forest Science 48:129-145.

Ehrlich, P.R., D. S. Dobkin, and D, Wheye. 1988. The birder's handbook: a field guide to the natural history of North American birds. Simon and Schuster, New York, New York, USA.

Flaspohler, D.J., S.A. Temple, R.N. Rosenfield. 2001. Species-specific edge effects on nest success and breeding bird density in a forested landscape. Ecological Applications 11: 32-46.

Frelich, L.E., and C.G. Lorimer. 1991. Natural disturbance regimes in hemlock-hardwood forests of the Upper Great Lakes region. Ecological Monographs 6: 145-164.

Frelich, L.E. 2002. Forest dynamics and disturbance regimes. Cambridge University Press, Cambridge, United Kingdom.

Holmes, R.T., T.W. Sherry, P.R. Marra, and K.E. Petit. 1992. Multiple brooding and productivity of a Neotropical migrant, the black-throated blue warbler (*Dendroica caerulescens*), in an unfragmented temperate forest. Auk 109: 321-333.

Holmes, R.T. 1994. Black-throated blue warbler *In* The Birds of North America, No. 87 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia PA and The American Ornithologists' Union, Washington, DC.

______, and T.W. Sherry. 2001. Thirty-year bird population trends in an unfragmented temperate deciduous forest: importance of habitat change. Auk 118: 589-609.

Holway, D. A. 1991. Nest-site selection and the importance of nest concealment in the black-throated blue warbler. Condor 93: 575-581.

Howe, R.W., G. Neimi, and J.R. Probst. 1996. Management of western Great Lakes forests for the conservation of neotropical migratory birds. In: Thompson III, F.R. (Ed.), Management of Midwestern landscapes for the conservation of neotropical migratory birds. USDA Forest Service General Technical Report NC-187, Detroit, Michigan, USA. pp. 144-167.

Johnson, B. 2004. The Ottawa National Forest Breeding Bird Census: an analysis of twelve years of data. (Unpublished Report) Accessible at http://www.fs.fed.us/r9/ottawa/forest_management/wildlife/index.html.

Jones, J., P.J. Doran, L.R. Nagy, and R.T. Holmes. 2005. Relationship between Mayfield nest-survival estimates and seasonal fecundity: a cautionary note. Auk 122: 306-312.

Machtans, C.S., and P.B. Latour. 2003. Boreal forest songbird communities of the Liard Valley, Northwest Territories, Canada. Condor 105: 27-44.

McGarigal, K., S. Cushman, and S. Stafford. 2000. Multivariate Statistics for Wildlife and Ecology Research. Springer Science + Business Media, Inc., New York, New York, USA.

McGee, G.G., D.J. Leopold, R.D. Nyland. 1999. Structural characteristics of old-growth, maturing, and partially cut northern hardwood forests. Ecological Applications 9: 1316-1329.

Panjabi, A. (Preparer). 2001. The partners in flight handbook on species assessment and prioritization. Rocky Mountain Bird Observatory, Brighton, Colorado, 26 pp.

Ralph, C.J., G.R. Guepel, P. Pyle, T.E. Martin, and D.F. DeSante. 1993. Handbook of field methods for monitoring landbirds. USDA Forest Service, General Technical Report PSW-GTR-144, Albany, California, USA.

Steele, B.B. 1992. Habitat selection by breeding black-throated blue warblers at two spatial scales. Ornis Scandinavica 23: 33-42.

USDA. 2005. Ottawa National Forest 2005 Year In Review. Available online at http://www.fs.fed.us/r9/Ottawa/forest_management/forest_plan/revision/Ottawa_2005_yr_n_review.pdf. Accessed 4 May 2006.

USFWS. 2002. Birds of conservation concern 2002. Division of Migratory Bird Management, Arlington, Virginia, USA. 99pp. Online at http://migratorybirds.fws.gov/reports/bcc2002.pdf.

Walkinshaw, L. H., and W. Dyer. 1953. Nesting of the black-throated blue warbler in Michigan. Jack-Pine Warbler 31: 46-54.

TABLES

Table 1. DFA scores for nine habitat variables measured at points where BTBW both were present and not detected June1-July 15, 2004 in the Upper Peninsula of Michigan, USA.

Habitat Variable	Total Canonical Structure [a]
Percent Canopy Cover	0.1095
Basal Area	0.6477
Snag Abundance	0.0228
Percent Ground Cover	-0.0443
Sapling Height (m)	0.5795
Canopy Height (m)	0.2082
Percent Vertical Cover	-0.7691
DBH (cm)	-0.0296
Percent Conifer Overstory	0.2427

[a] Total Canonical Structure scores were calculated using the DISCRIM procedure in SAS.

Table 2. DFA scores for nine habitat variables measured at points where BTBW both were present and not detected June1-July 15, 2005 in the Upper Peninsula of Michigan, USA.

Habitat Variable	Total Canonical Structure [a]
Percent Canopy Cover	-0.0236
Basal Area	0.3227
Snag Abundance	0.0712
Percent Ground Cover	0.0322
Sapling Height (m)	0.6579
Canopy Height (m)	0.3974
Percent Vertical Cover	-0.1219
DBH (cm)	-0.1883
Percent Conifer Overstory	0.2087

[a] Total Canonical Structure scores were calculated using the DISCRIM procedure in SAS.

FIGURES

Figure 1. Map of the Ottawa National Forest in the Upper Peninsula of Michigan, USA (USDA Forest Service 2006).

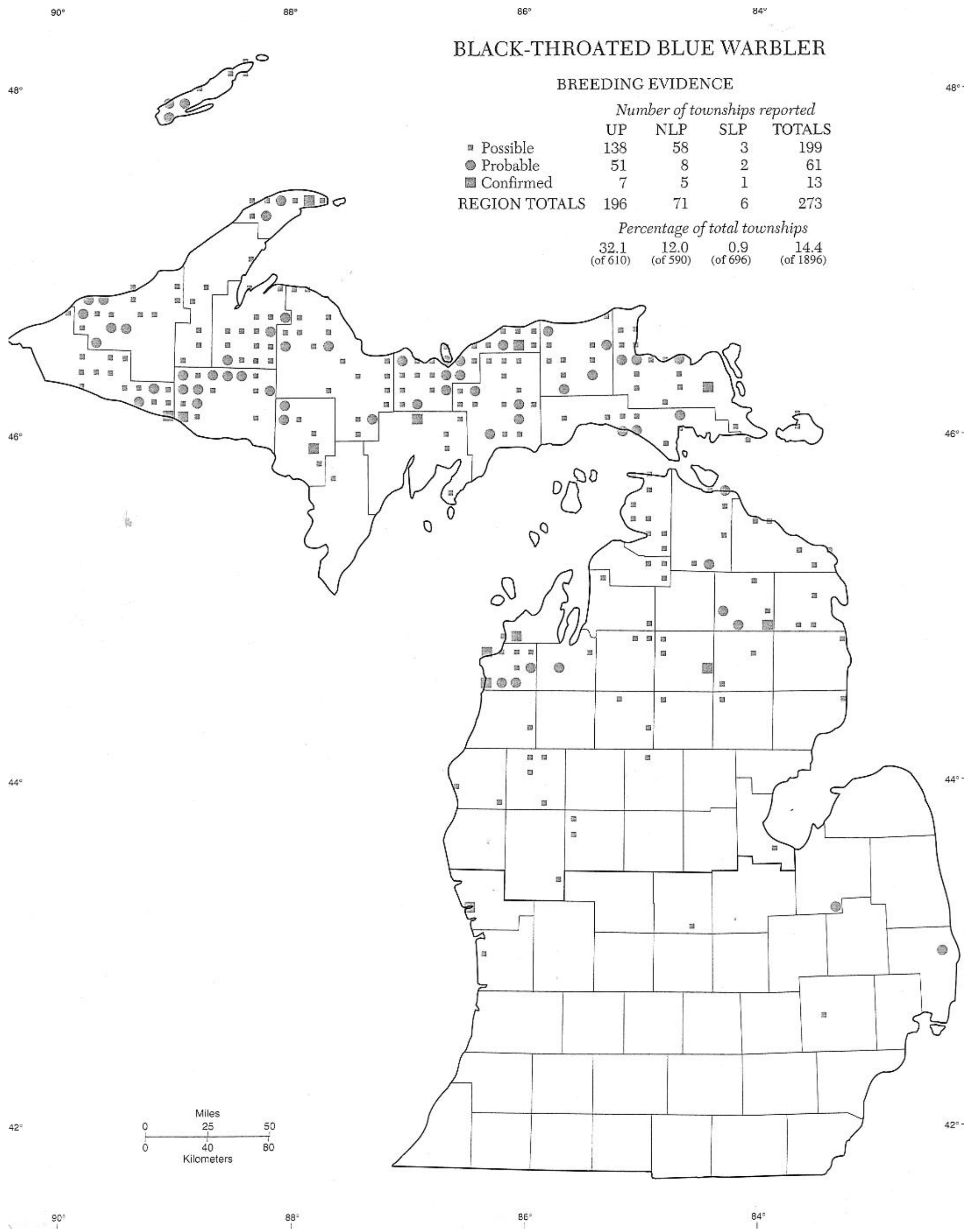


Figure 2. Breeding distribution of the Black-throated Blue Warbler in Michigan (Brewer et al. 1991).

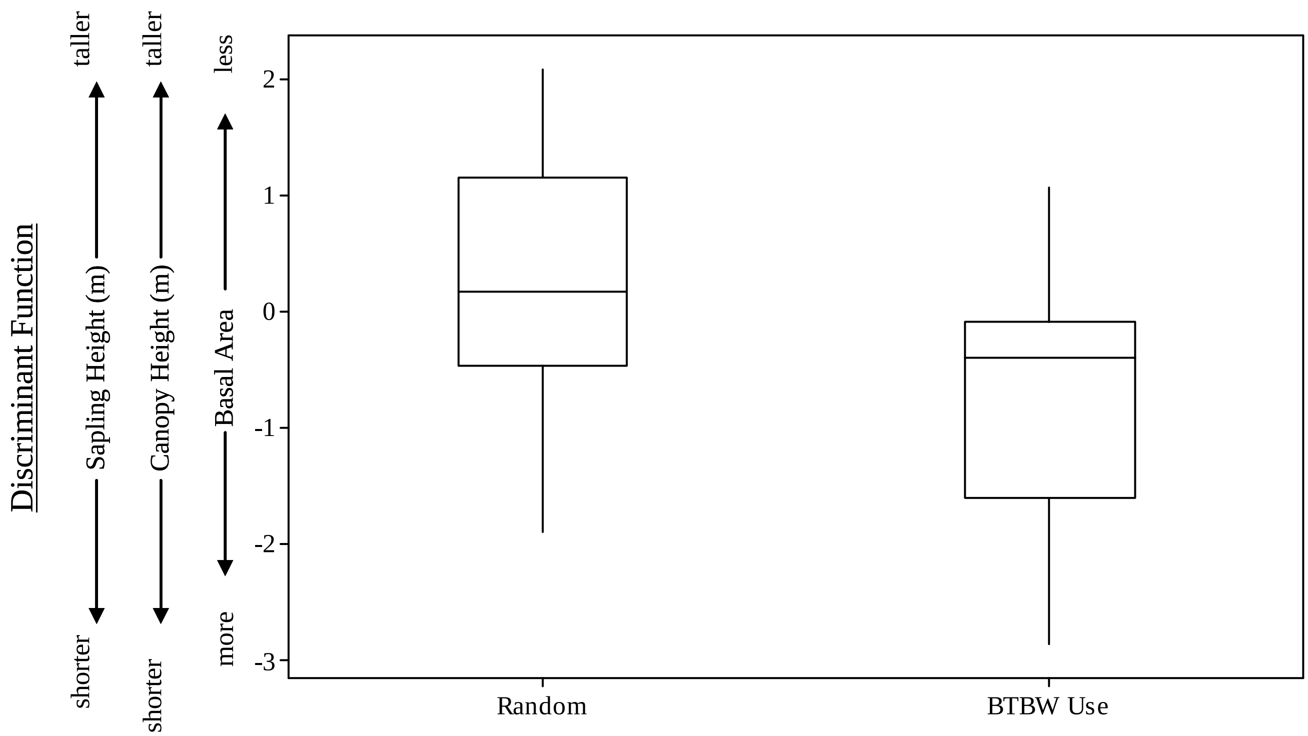


Figure 3. Discriminant function scores of random and BTBW-used sites June 1-July 15, 2004 in northern hardwood stands of the Ottawa National Forest, Upper Michigan, USA. Horizontal line represents the mean, the bar above and below mean is 1 S.E., and the vertical line represents the range of values.

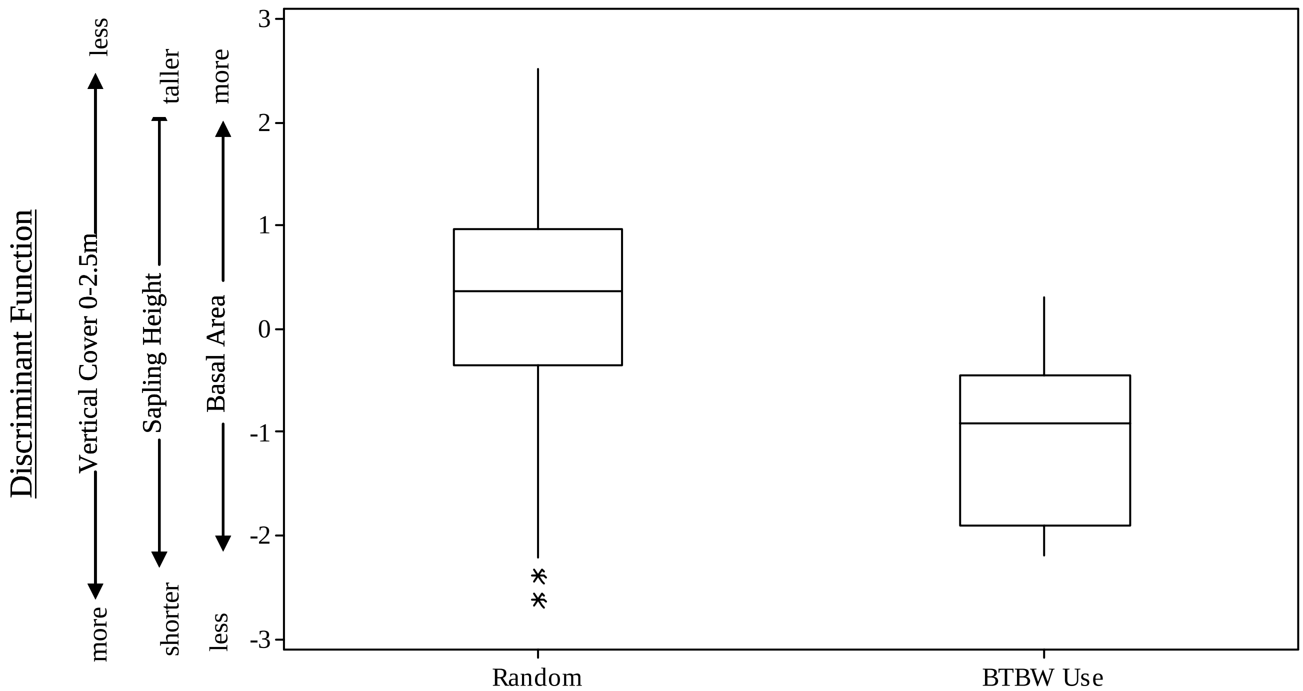
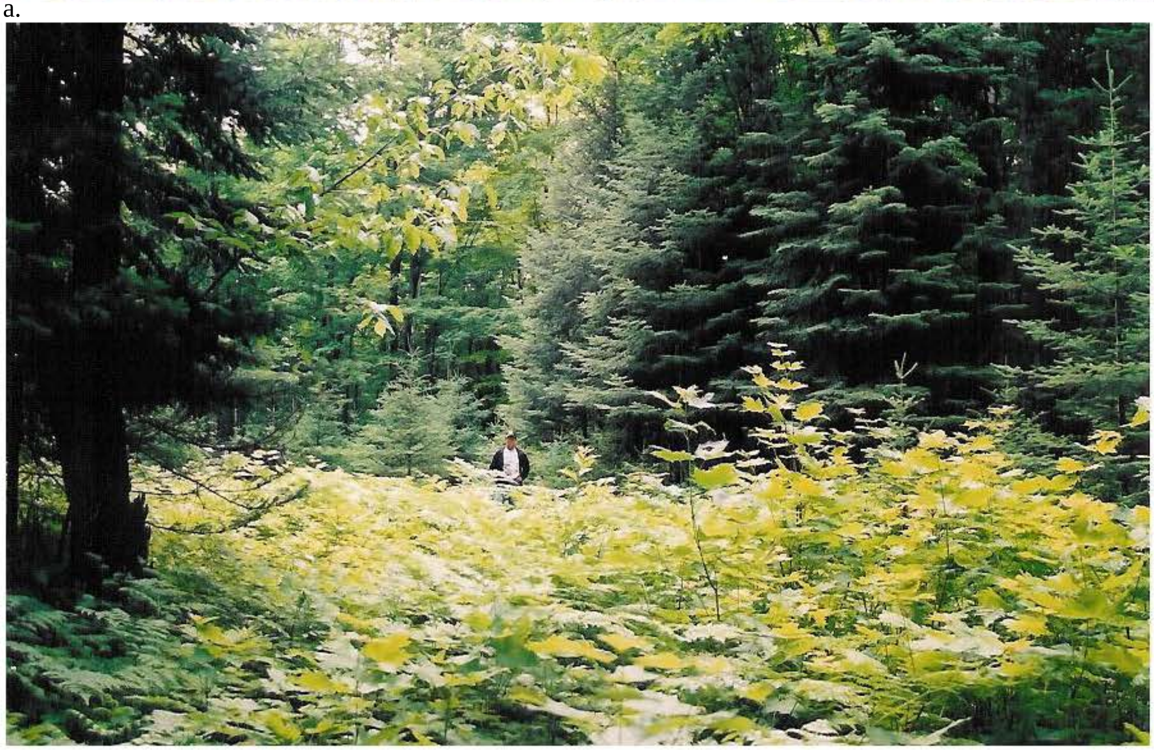


Figure 4. Discriminant function scores of random and BTBW-used sites June 1-July 15, 2005 in northern hardwood stands of the Ottawa National Forest, Upper Michigan, USA. Horizontal line represents the mean, the bar above and below mean is 1 S.E., and the vertical line represents the range of values.

a.

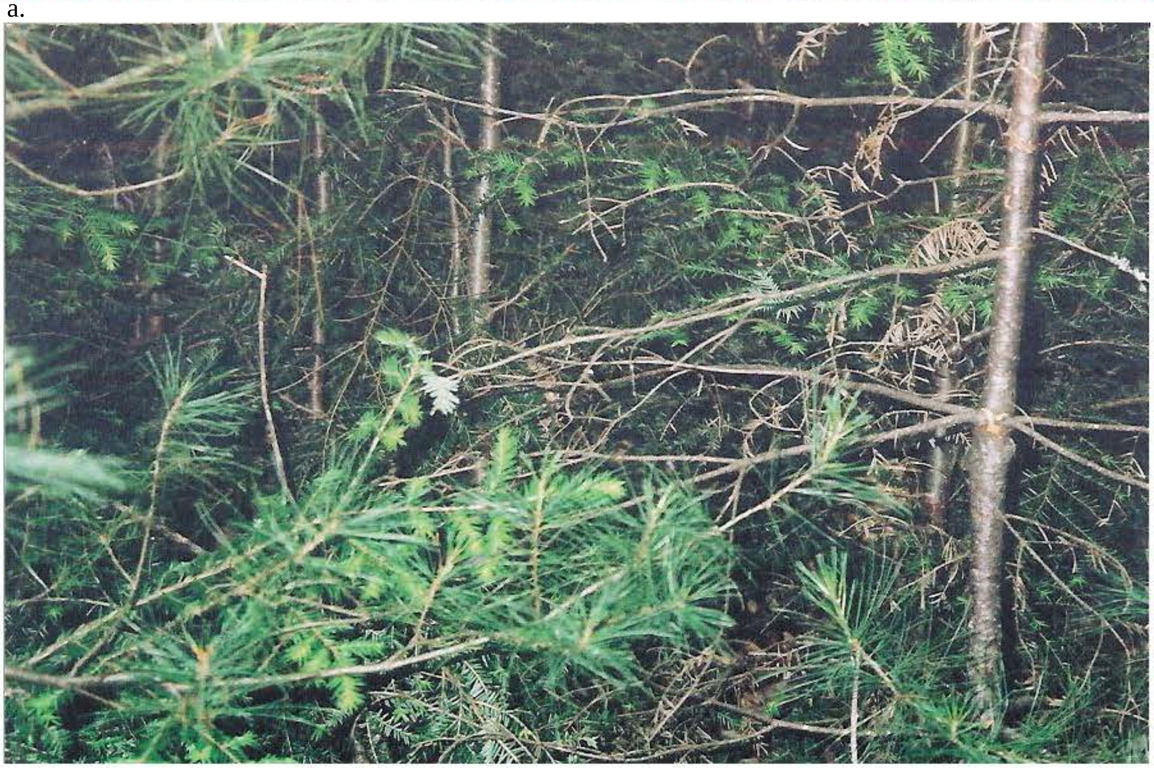


b.

Figure 5. BTBW Nest 1 was located in the blue-flagged White Spruce sapling (a) adjacent to a former logging road and surrounded by a dense, Sugar Maple sapling layer (b).

Figure 6. BTBW Nest 2 was affixed next to the trunk of a Balsam Fir sapling 0.3m above the ground in the crotch of a main lower branch.

a.



b.

Figure 7. BTBW Nest 3 contained 4 nestlings (a) and was located in a dense Eastern Hemlock sapling clump under a predominantly Sugar Maple canopy layer (b).

Appendix A. List of AOU codes, common names, and scientific names for all birds.

AOU Code	Common Name	Scientific Name
AMGO	American Goldfinch	*Carduelis tristis*
AMRE	American Redstart	*Setophaga ruticilla*
AMRO	American Robin	*Turdus migratorius*
BBCU	Black-billed Cuckoo	*Coccyzus erythropthalmus*
BCCH	Black-capped Chickadee	*Poecile atricapilla*
BHCO	Brown-headed Cowbird	*Molothrus ater*
BHVI	Blue-headed Vireo	*Vireo solitarius*
BLBW	Blackburnian Warbler	*Dendroica fusca*
BLJA	Blue Jay	*Cyanocitta cristata*
BRCR	Brown Creeper	*Certhia americana*
BTBW	Black-throated Blue Warbler	*Dendroica caerulescens*
BTNW	Black-throated Green Warbler	*Dendroica virens*
BWHA	Broad-winged Hawk	*Buteo platypterus*
CHSW	Chimney Swift	*Chaetura pelagica*
CSWA	Chestnut-sided Warbler	*Dendroica pensylvanica*
DOWO	Downy Woodpecker	*Picoides pubescens*
EAWP	Eastern Wood-Pewee	*Contopus virens*
HAWO	Hairy Woodpecker	*Picoides villosus*
HETH	Hermit Thrush	*Catharus guttatus*
LEFL	Least Flycatcher	*Empidonax minimus*
MOWA	Mourning Warbler	*Oporornis philadelphia*
MYWA	Yellow-rumped Warbler	*Dendroica coronata*
NAWA	Nashville Warbler	*Vermivora ruficapilla*
NOPA	Northern Parula	*Parula americana*
OVEN	Ovenbird	*Seiurus aurocapillus*
PIWO	Pileated Woodpecker	*Dryocopus pileatus*
RBGR	Rose-Breasted Grosbeak	*Pheucticus ludovicianus*
RCKI	Ruby-crowned Kinglet	*Regulus calendula*
REVI	Red-eyed Vireo	*Vireo olivaceus*
RUGR	Ruffed Grouse	*Bonasa umbellus*
SCTA	Scarlet Tanager	*Piranga olivacea*
SWTH	Swainson's Thrush	*Catharus ustulatus*
VEER	Veery	*Catharus fuscescens*
WBNU	White-breasted Nuthatch	*Sitta carolinensis*
WIWR	Winter Wren	*Troglodytes troglodytes*
WOTH	Wood Thrush	*Hylocichla mustelina*
WTSP	White-throated Sparrow	*Zonotrichia albicollis*
YBSA	Yellow-bellied Sapsucker	*Sphyrapicus varius*

Appendix B. First documented breeding of Wood Thrush population in Gogebic County, MI (submitted to *Michigan Birds and Natural History*, in review)

First documented breeding of the Wood Thrush (*Hylocichla mustelina*) in Gogebic County, Michigan

K.E. Brashear[1], T.F. Ginnett[1], B.A. Bogaczyk[2], J. Edde[2], and R.A. Evans[2]

[1]*College of Natural Resources, University of Wisconsin-Stevens Point, Stevens Point, WI 54481*
[2]*USFS, Ottawa National Forest, E6248 US 2, Ironwood, MI 49938*

Point count surveys May-July 2004 and 2005 revealed a presumed spill-over population of Wood Thrushes (WOTH) in the Ottawa National Forest, approximately five miles north of Bessemer in Gogebic County, Michigan. Singing males (n = 5 in 2004; n = 8 in 2005) were detected and recorded in presumed territorial locations within shelterwood-harvested northern hardwood forest stands during both survey periods. On 14 July 2005 a single Wood Thrush nest (Figure A) was confirmed by the authors at 0900 at lat 46° 33.165'N, long 89° 59.972'W (location recorded using a WGS 84 Garmin® GPS unit). The nest was located at a height of eight feet (2.44 m) in the main crotch of a Sugar Maple (*Acer saccharum*) sapling under a predominantly Sugar Maple canopy. Roth et al. (1996) state that WOTH breeding pairs select a suitable nest location based on shrub/sapling growth characteristics, suitable shade, dense vegetation cover within 19.7 ft (6 m) of the actual nests, and most often in the crotch or fork of horizontal branches. Additionally, the nest was constructed with a mud layer lining the inner surface and finer materials woven for the outer surface (Roth et al. 1996). Upon further inspection, we discovered a single WOTH egg covered by a maple leaf (Figure B). We also recorded a singing male adjacent to the nest, presumably guarding it, but we were unable to detect a brooding female during the nest investigation period.

The Michigan Breeding Bird Atlas (Brewer et al. 1991) lists the Wood Thrush as a potential nester in Gogebic County, making this the first record of confirmed breeding by this species. We suspect this isolated population in the Ottawa National Forest is a spill-over from the populations just south of the border in Wisconsin. Perhaps the habitat features resulting from alternative forestry practices (e.g., group selection, shelterwood, single tree selection) represent source habitat for WOTH in an otherwise unsuitable landscape (Fauth 2001). The northern hardwood forest stands containing this Wood Thrush population are mostly unfragmented, relative to most Midwest landscapes (citation). However, presence of presumed breeding Brown-headed Cowbirds (*Molothrus ater*) within the same shelterwood-harvested stands may pose a threat to the viability of this small population. The extent of cowbird nest parasitism of WOTH is still not fully understood, and some researchers suggest the WOTH is an infrequent host (Longcore and Jones 1969). Reports of WOTH in the western Upper Peninsula are not common, with occurrences more often just north of the Wisconsin border (Brewer et al., 1991). Continued detections of this species in the western Upper Peninsula could alter perceptions of this species' currently accepted infrequent status.

Literature Cited

Brewer, R., G.A. McPeek, and R.J. Adams, Jr. 1991. Wood Thrush *In* The atlas of breeding birds of Michigan. Michigan State University, East Lansing, Michigan.

Fauth, P.T. 2001. Wood thrush populations are not all sinks in the agricultural Midwestern United States. Conservation Biology 15: 523-527.

Longcore, J.R., and R.E. Jones. 1969. Reproductive success of the wood thrush in a Delaware woodlot. Wilson Bulletin 81: 396-406.

Roth, R.R., M.S. Johnson, and T.J. Underwood. 1996. Wood Thrush (*Hylocichla mustelina*). *In* The Birds of North America, No. 246 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington, D.C.

Figure A. Wood Thrush nest found on 14 July 2005 in Sugar Maple sapling within the Ottawa National Forest, Gogebic County, Michigan.

Figure B. Single Wood Thrush egg discovered upon closer inspection of the nest on 14 July 2005 within the Ottawa National Forest, Gogebic County, Michigan.